NATIONAL CERTIFICATE III

SEWERAGE SYSTEM OPERATION & MAINTENANCE

Student Learning Materials

TVET Authority

Ministry of Environment

ACKNOWLEDGEMENT

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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

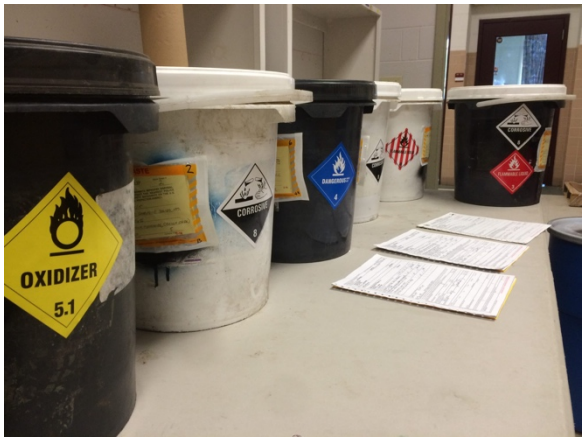
Oil, water and fuel spillages are potential Health and Safety Hazards in a home, workshop, garage or any workshop. It is vital that such spillages are quickly attended prior to slipping or falling that may injure you or your colleagues. Following are the basic steps of attending such spillages.

- ✓ 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
- ✓ the ladder must only be used on firm, level ground.

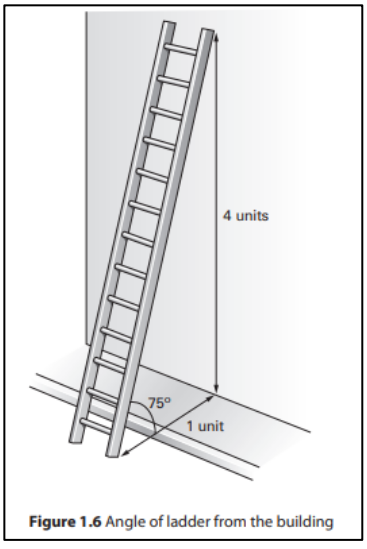


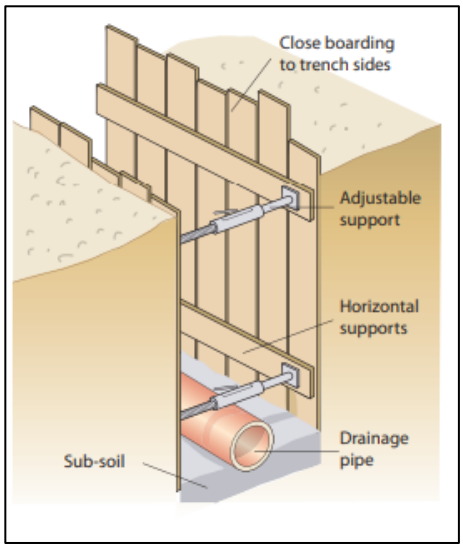
Figure 1.6 Angle of ladder from the building

- ✓ 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

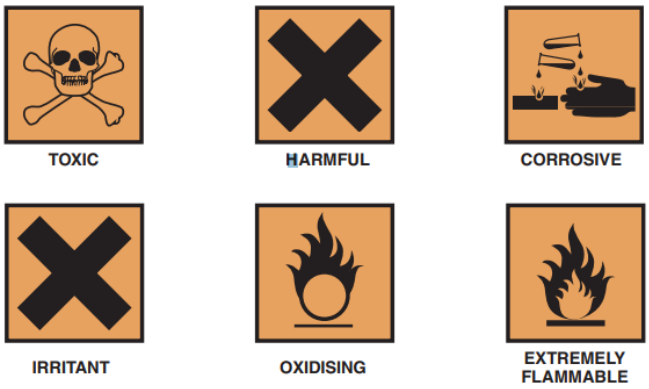
Work in excavations can be particularly hazardous and therefore a risk assessment must be conducted before the work is commenced to ensure that proper control measures are applied to safely do the work. The following are typical measures:

- ✓ 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:

1. find a telephone in a safe environment, well away from the emergency
2. dial the emergency service number
3. keep calm, and when asked by the operator, give the name of the emergency service required, e.g. fire
4. 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

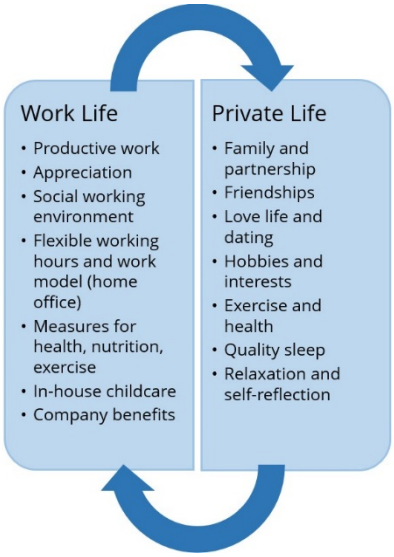
It is important that we have developed purpose to work and provide meaning to the work we do as they add values to the different jobs we perform. It is also believed that clear identification of the purpose and meaning to work are example of good work values and these values have a significant impact 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 work-life balance and implementing targeted measures to promote this. The



Personal and professional life should complement each other

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

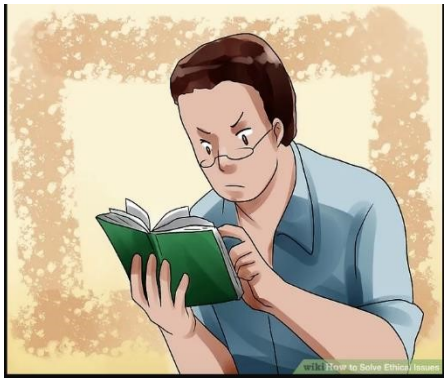
Identify the parties involved and determine who else is involved in this issue. Involvement can be direct or indirect and on a direct level, those participating in the ethical violation are certainly involved. On an indirect level, those who will be impacted regardless of having no say in the issue are 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.

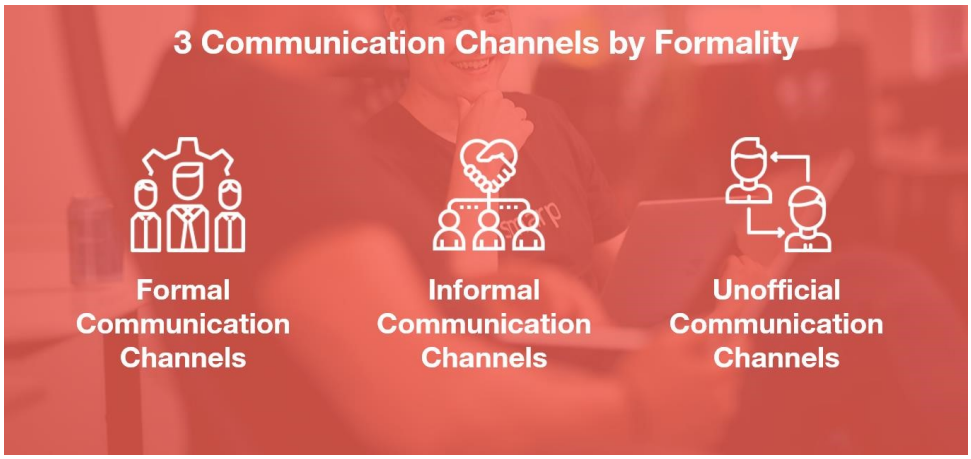
Types of Communication Channels

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.

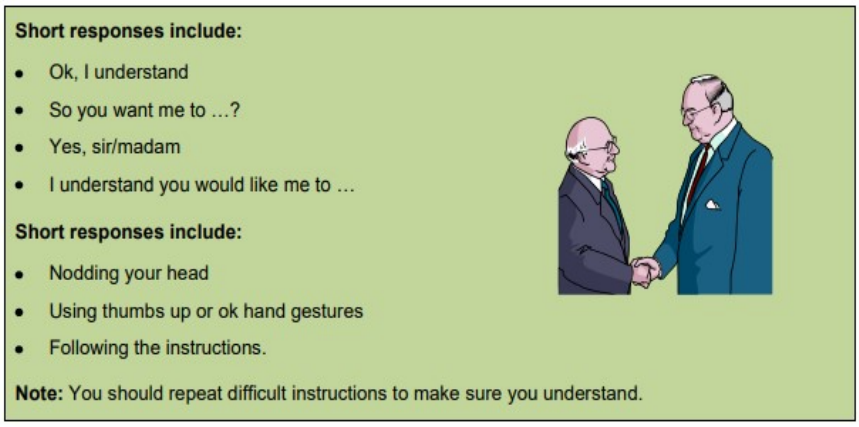
When you are given instructions it is important to confirm that you understand them and respond appropriately.

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.

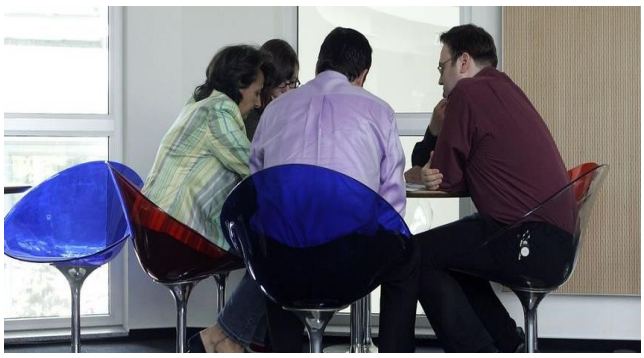
And what about your actual message?

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.

Analyse 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

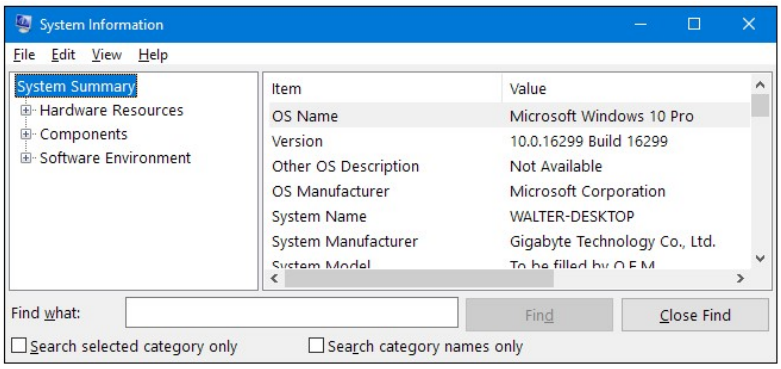
PERFORM COMPUTER OPERATIONS

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.

PERFORM COMPUTER OPERATIONS

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.

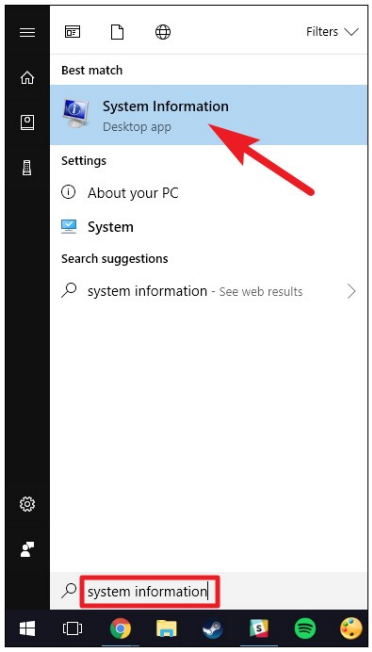
START COMPUTER, SYSTEM INFORMATION AND FEATURES



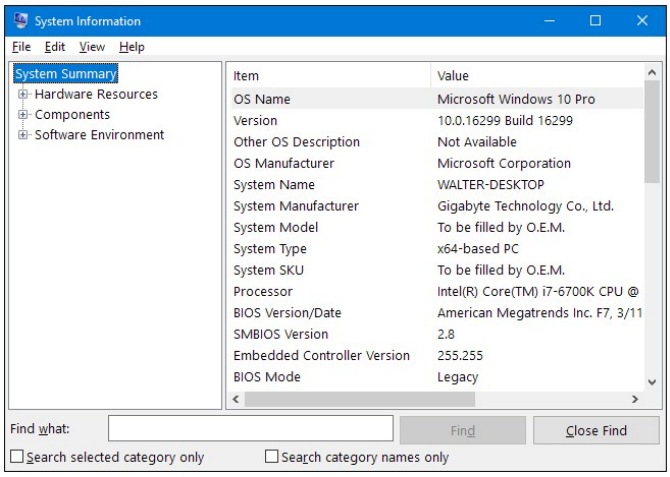
The System Information provides a quick way get information about your system, but how you open it depends on what version of Windows you're using. Here's how to do it.

Windows 7 or 10: Use the Start Menu

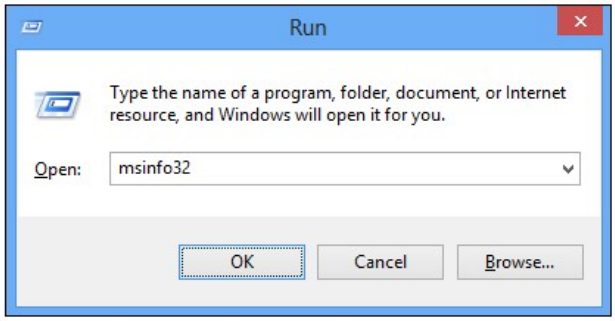
If you're using Windows 7 or 10, hit Start, type "system information" into the search box, and then select the result.



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



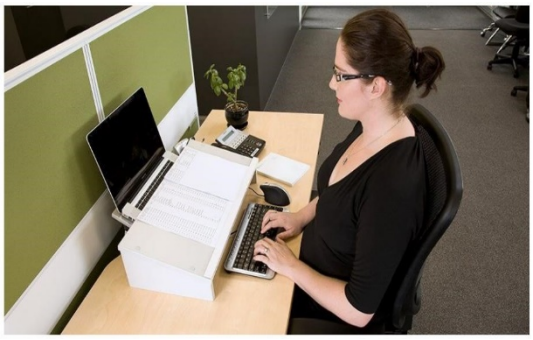
For some reason, typing "system information" into a Start search doesn't work in Windows 8. Instead, you'll have to use the Run box, which you can also use in Windows 7 or 10 if you prefer.

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.

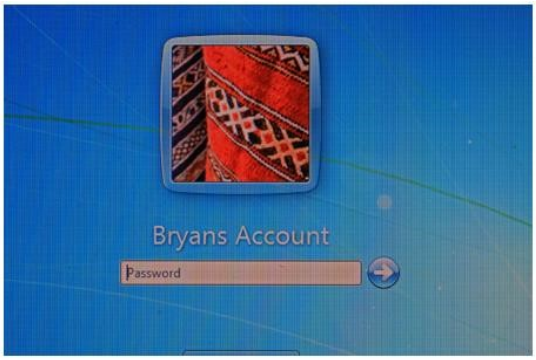
If nothing happens, there are a few things you can check easily:

- ✓ 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.



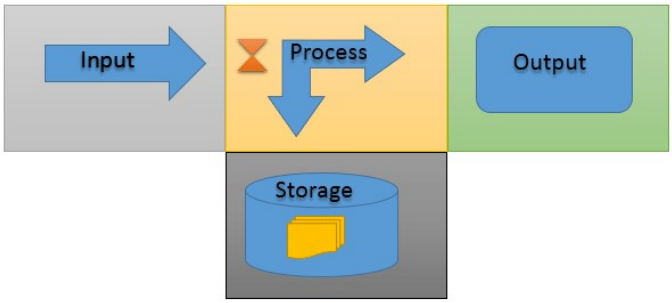
Top tip: surge protectors

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.

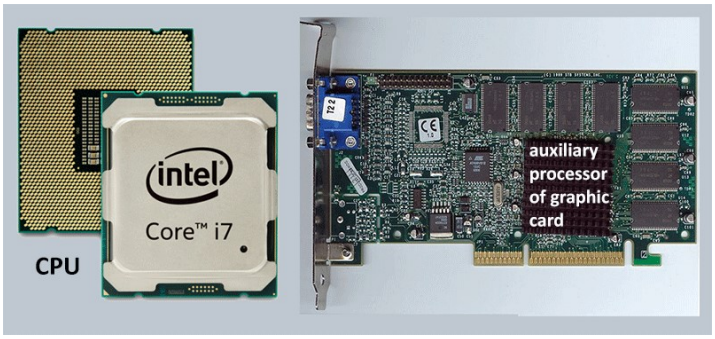
Process function and devices

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

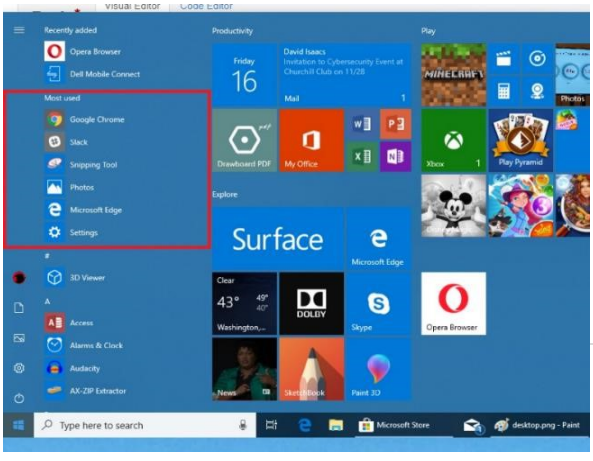
to it is the Search box, where you can type an app name to launch it. And right next to that is the Taskbar, where you can pin frequently used apps for easy access. (Your currently active windows will also show up in the Taskbar.)

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 -

1. Open the document or file you want to print.
2. 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

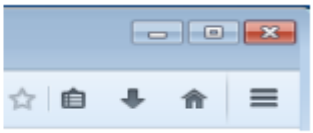
A web browser is a program that lets you see information and images on web sites. A browser reads the information on a web page and displays it on your computer screen. The three most popular web browsers are called "Microsoft Internet Explorer", "Mozilla Firefox", and "Google Chrome". You should be 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:

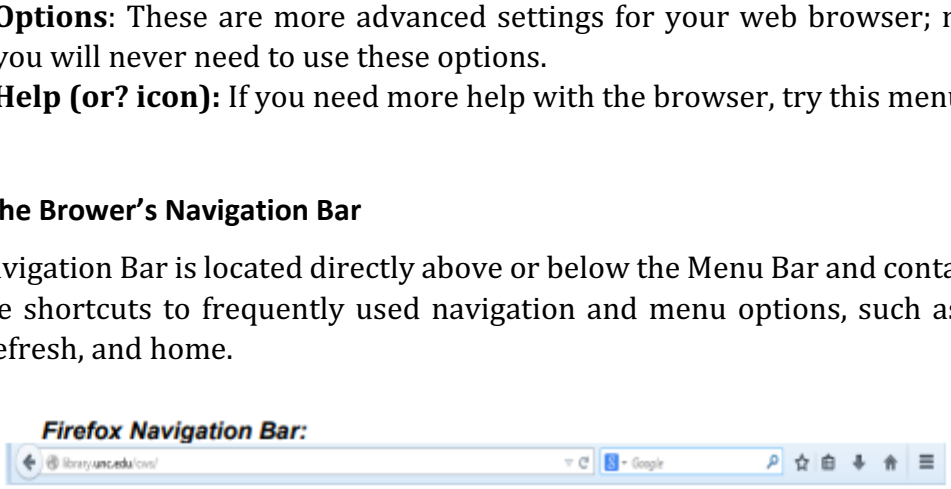
- ✓ **Print**: Use this option to print your current web page.
- ✓ **File**: Here you can change your browser to and from Full Screen, Save, Find a word or phrase in a web page, and view suggested sites.
- ✓ **Zoom**: Zoom in or out to more easily view pages in your web browser.
- ✓ **View**: You can 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:

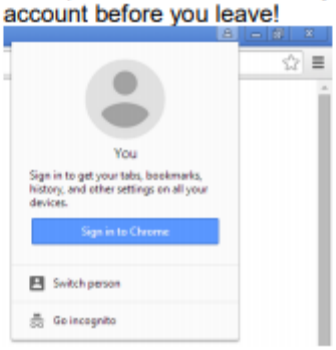
The **Back** button takes you back to the previous web page that you viewed.

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.

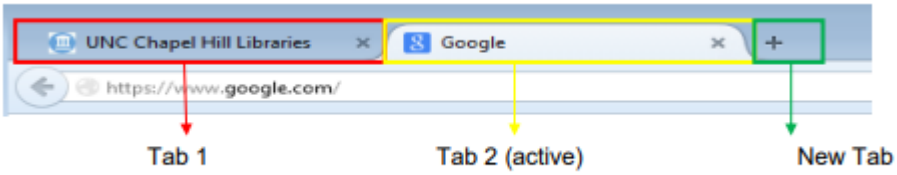
The **Home** button will take you to the webpage that opened when you first opened your browser window. If you are at a library, this is most likely the library's home page. It is possible to change your web browser's settings to open a different Home site. In Google Chrome, you will need to sign into 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

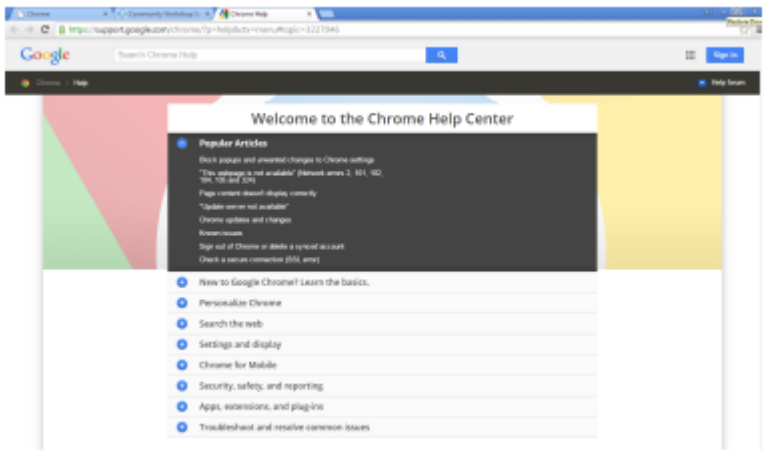
Tabs work just like tabbed dividers in a filing cabinet or a binder—they allow you to organize different pages while keeping them all accessible. You can open a new tab by going to File◊New Tab, OR by clicking the small button with the plus sign (+) to the right of the last tab, OR by holding down the 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

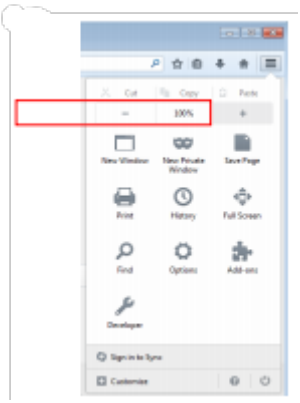
If you are not comfortable with the text size on a web page, you can zoom in or out according to your preferences. (Most browsers are defaulted to a 100% zoom – zooming in (+) makes things larger, and zooming out (-) makes them smaller).

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:

4. Left-Click once on the three horizontal lines icon to open the menu options.
5. 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.



6. 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:

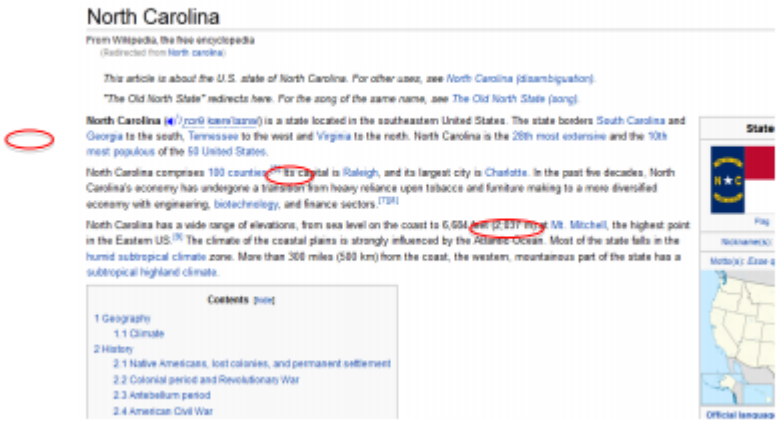
Following Links on a Web Page

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

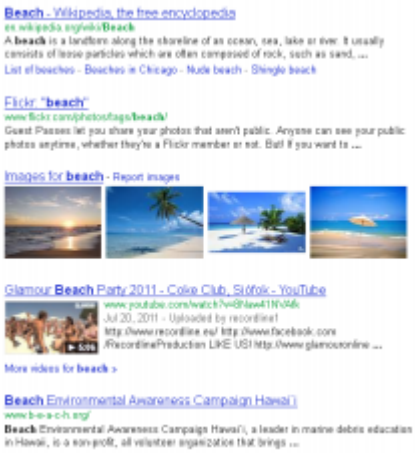
Finding Information with a Search Engine

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.

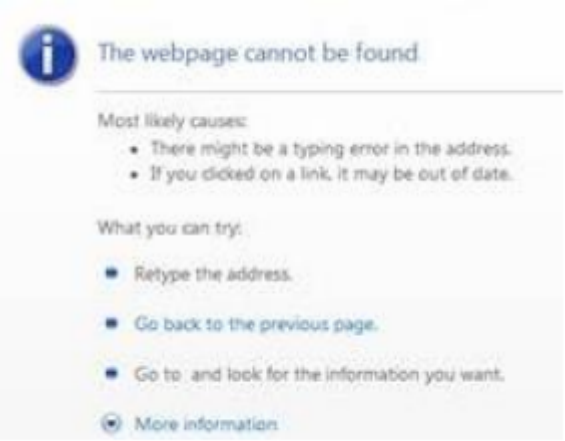
- ✓ Put phrases in quotation marks, e.g. “North Carolina governors,” “Al Pacino,” or “Orange County Main Library.” This will find only those pages that contain these exact phrases.

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?

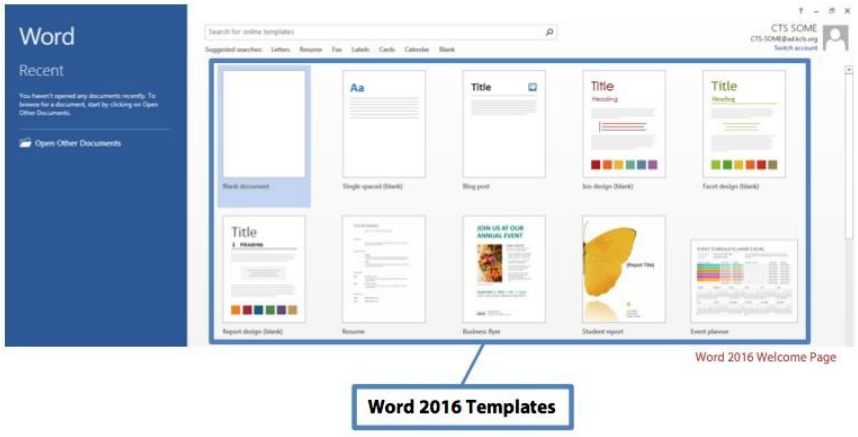
Word is used to "create beautiful documents, easily work with others, and enjoy the read." The types of documents you can create with Word include:

- ✓ 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.

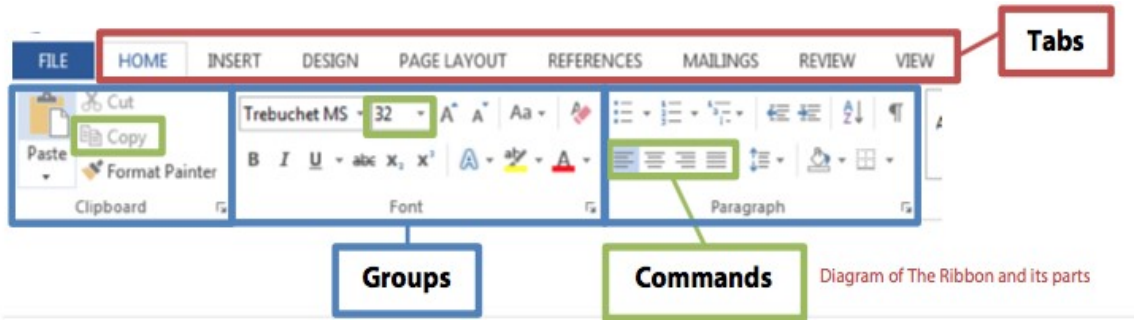


Diagram of The Ribbon and its parts

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."

Quick Access Toolbar & "Undo" button

File Menu

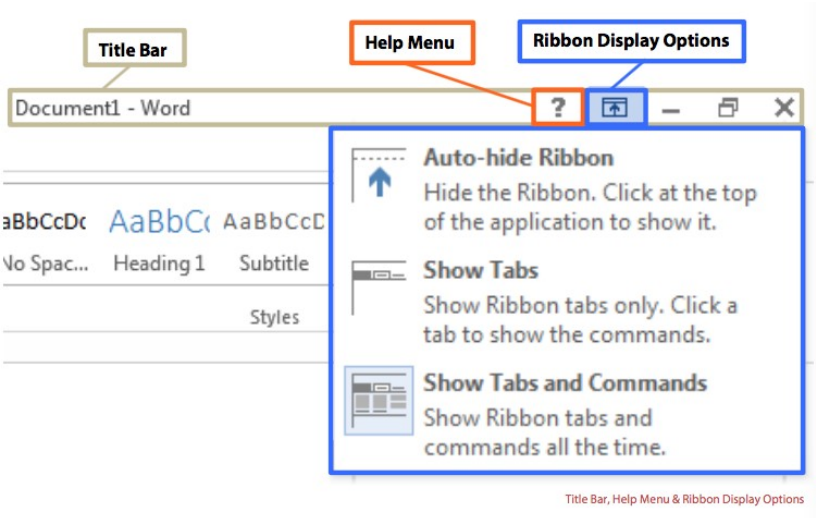
The File Menu contains actions at the file level. Click the blue "File" tab to the far left of the tabs. What you'll see is the "backstage" area. From here, you can create a **New** document, **Open** an existing one, **Save** changes to the current document, **Save As** a different file with a different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

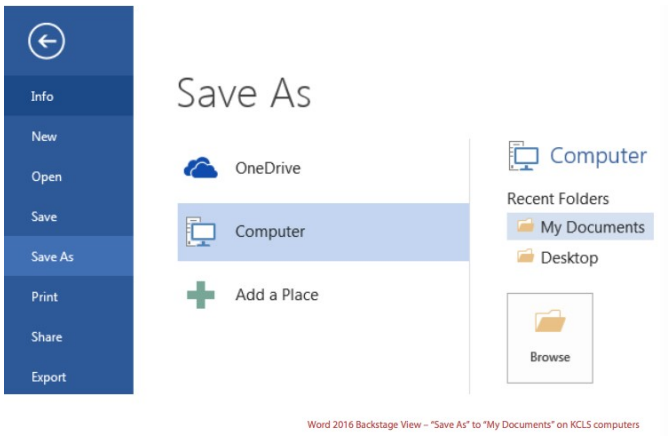
The **Help Menu** has articles on using the software. Not sure how to perform a certain action or where to find a command? Click the question mark icon to browse Help articles, or search for specific topics.

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.



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 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.

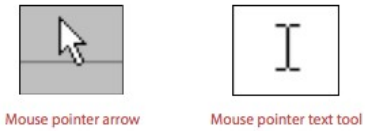
Get Ready for Typing

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):

3. Place mouse pointer arrow in left margin next to line of text (arrow will point to the right).
4. Left-click once to select that line of text.

- ✓ To select several lines or a paragraph:

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

6. Press (hold down) the left mouse button.
7. 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.

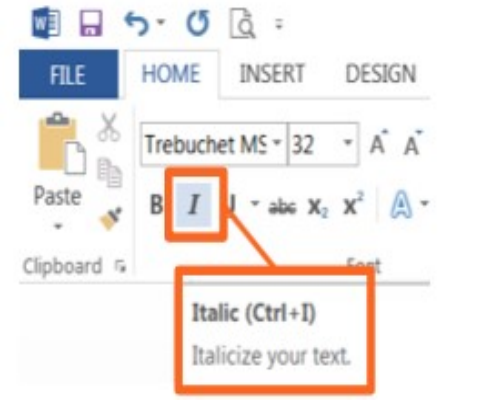
Home Tab

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

4. Font Group

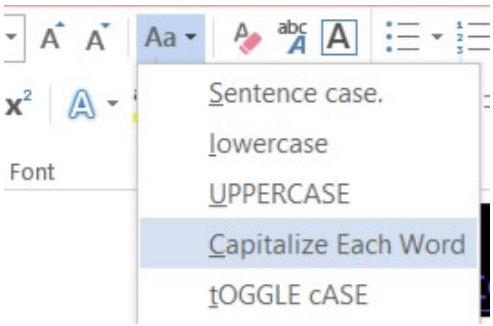
The Font Group contains commands that change the appearance of the font. Font is the set of characters (letters, numbers, punctuation, etc.) in a particular style. For example, the document you created from the "Facet design" template on the Welcome page uses "Trebuchet MS" font, but you can still use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



5. Style Group

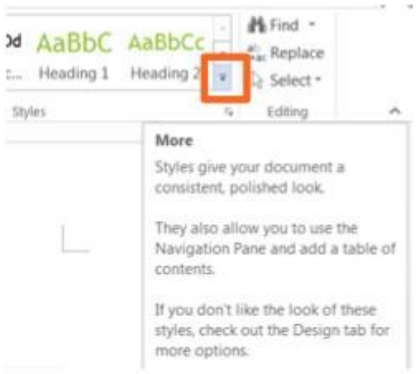
A document created from a template, like the one you opened earlier (Facet design blank), has pre- designed styles for different parts of the document, such as paragraphs and headers. To apply a different paragraph style:

- ✓ 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):

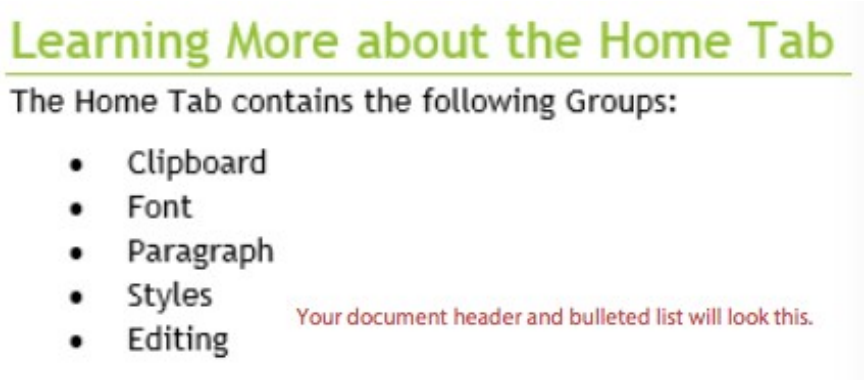
- ✓ Click "More" button in Styles Group.
- ✓ Click "Heading 1".
- ✓ Type "Learning more about the home tab".
- ✓ Press "Enter" once.
- ✓ Type "The Home Tab contains the following Groups:"
- ✓ Press "Enter" once.



"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.

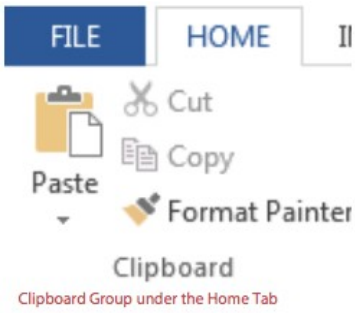
Bullets are good for general lists of items. A numbered list is good for steps in a procedure or order. The steps to make a numbered list are the same, ex cept the icon for numbering is

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**:**

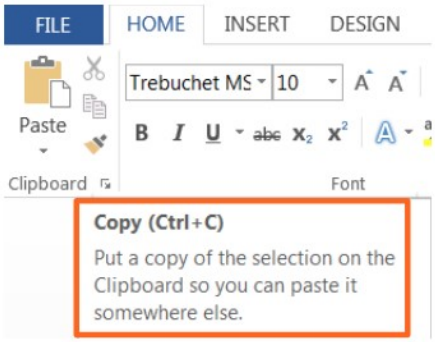
- ✓ Select the text (the sentence "I am moving...").
- ✓ Click "Cut" icon in Clipboard Group.
- ✓ Move cursor to area where you want to paste (at beginning of first sentence on same line).
- ✓ Click "Paste" icon.

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

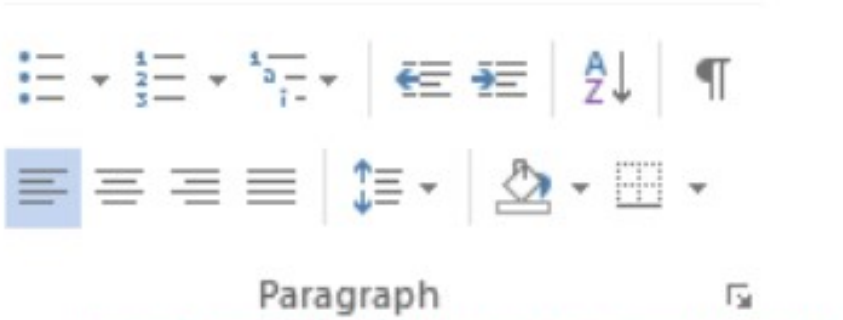
Paragraph Group

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.

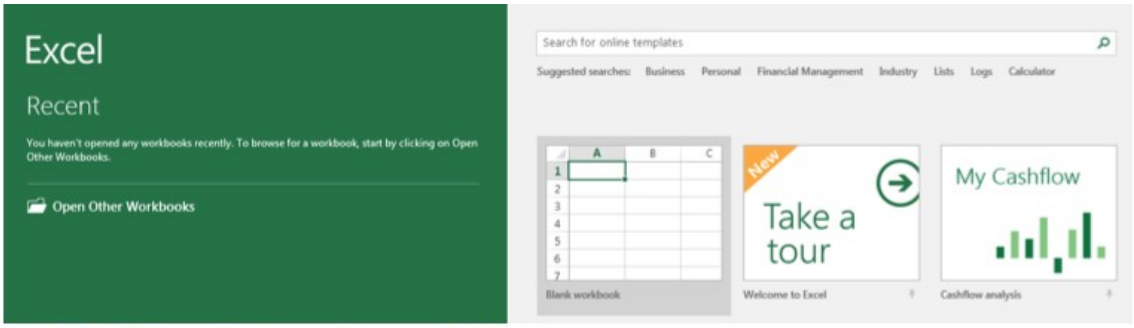


Figure 2 - Excel Welcome Page (zoomed in to upper left side)

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.

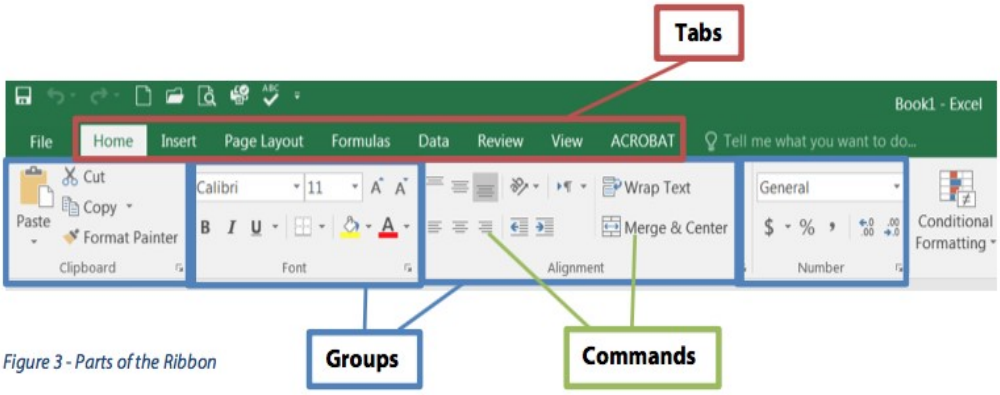


Figure 3 - Parts of the Ribbon

Quick Access Toolbar

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

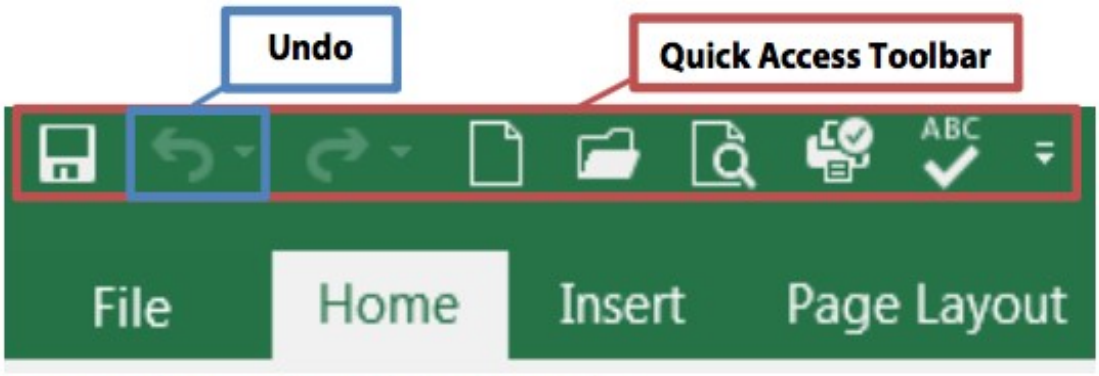


Figure 4 - Quick Access Toolbar & Undo button (zoomed in)

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.

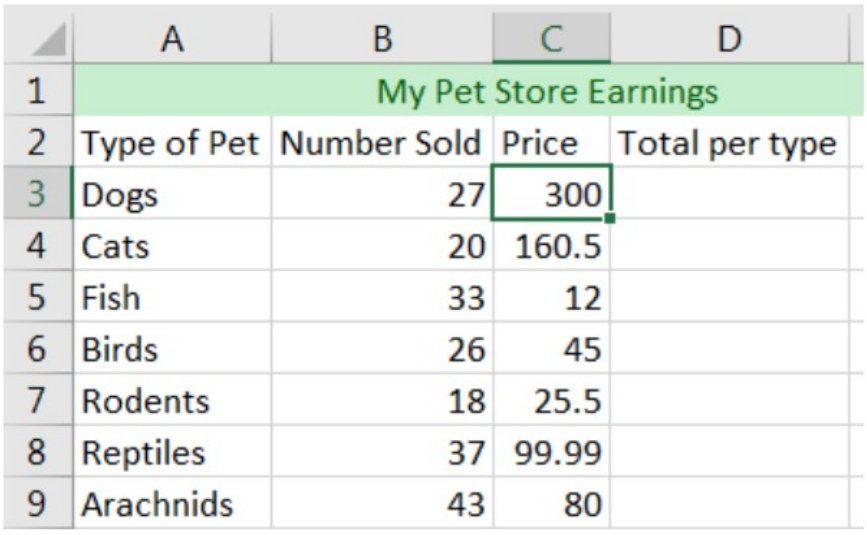
Try it! Place the mouse pointer on the thin line between column letters "B" and "C". Double click, and the columns will automatically adjust to fit the text in column "B". Make the text in every column easy to read. Your worksheet should look like Figure 7. You may also click and drag to adjust the width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

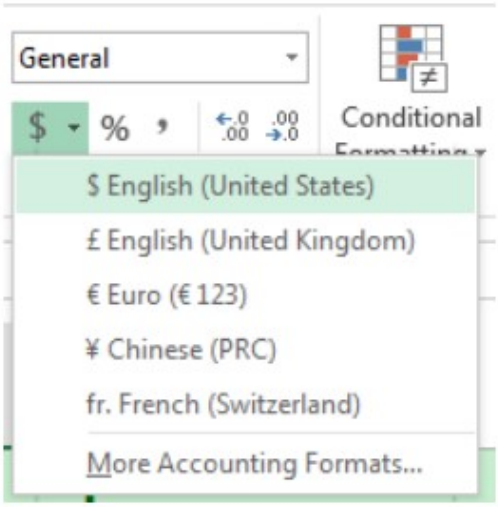


Figure 9 - "Accounting Number Format"

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.

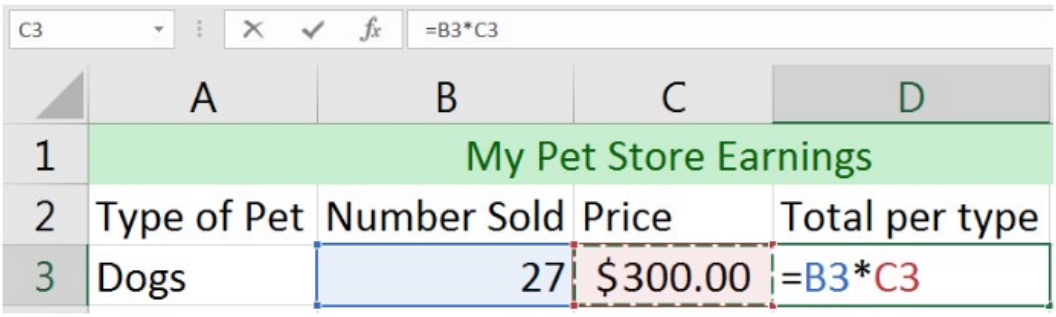


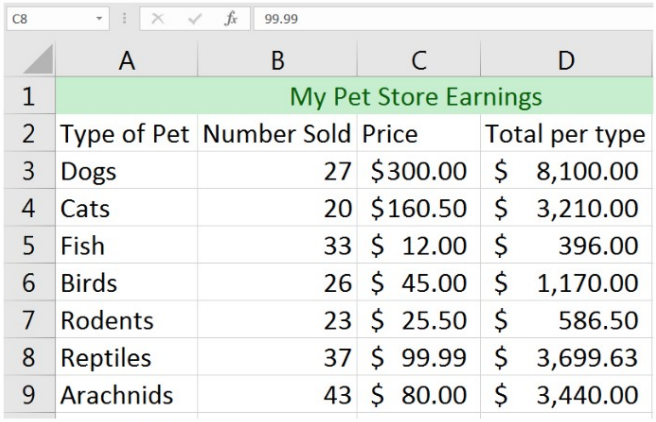
Figure 10 - Basic multiplication formula

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).



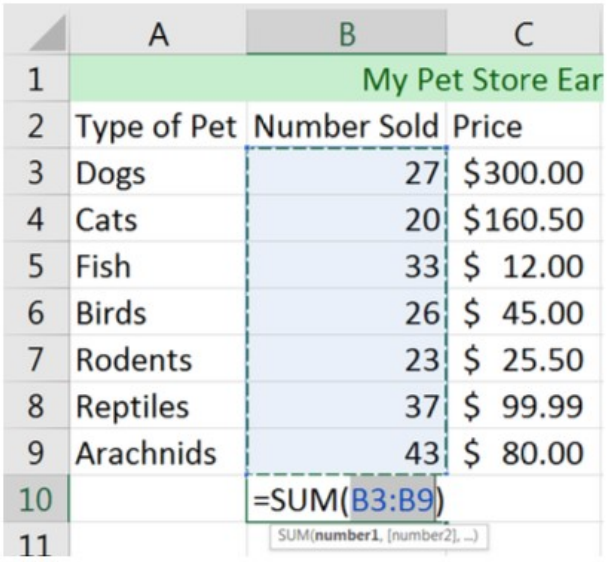
	A	B	C	D
1	My Pet Store Earnings			
2	Type of Pet	Number Sold	Price	Total per type
3	Dogs	27	$300.00	$ 8,100.00
4	Cats	20	$160.50	$ 3,210.00
5	Fish	33	$ 12.00	$ 396.00
6	Birds	26	$ 45.00	$ 1,170.00
7	Rodents	23	$ 25.50	$ 586.50
8	Reptiles	37	$ 99.99	$ 3,699.63
9	Arachnids	43	$ 80.00	$ 3,440.00

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:

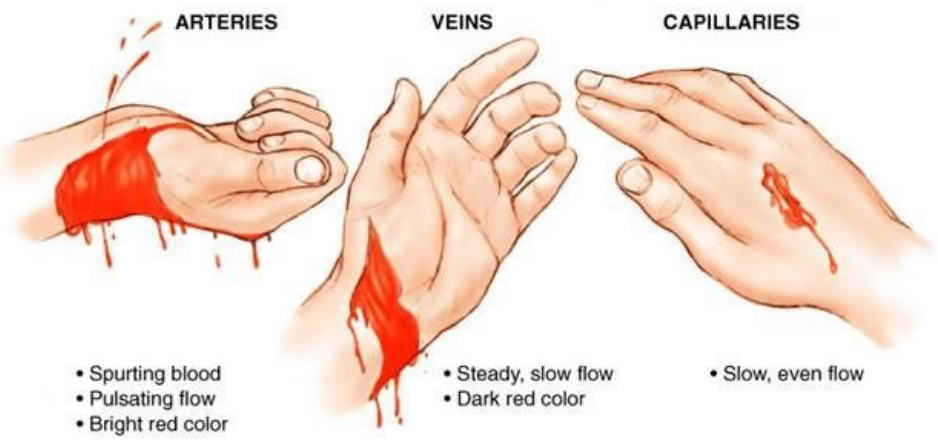
- ✓ If the wound is in the head, chest or abdomen
- ✓ (unless it is minor).
- ✓ If there is blue, white or cold skin, numbness, tingling, loss of feeling, or the person is unable to move a limb below the wound.
- ✓ If your tetanus shots are not up to date, especially if the object that caused the puncture 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:

4. **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.
5. **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.

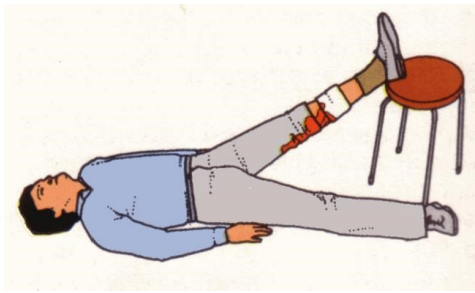
Almost any organ or blood vessel can be damaged by trauma and cause internal bleeding. The most serious sources of internal bleeding due to trauma are:

- ✓ 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.

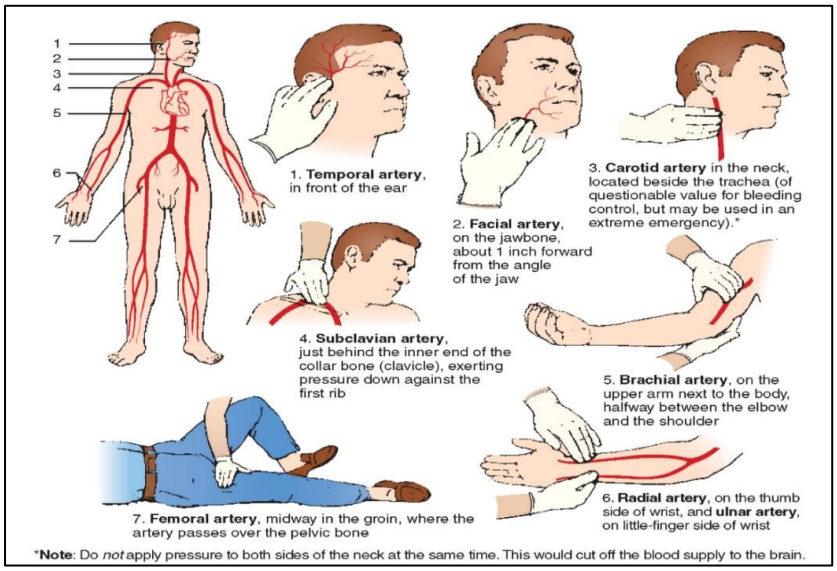
Apply pressure directly on the wound until the bleeding stops

- ✓ 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 thearea.
2. Squeeze the main artery in these areas against the bone. Keep your fingersflat.
3. With your other hand, continue to exert pressure on the woundItself.



2. Immobilize the injured body part once the bleeding has stopped

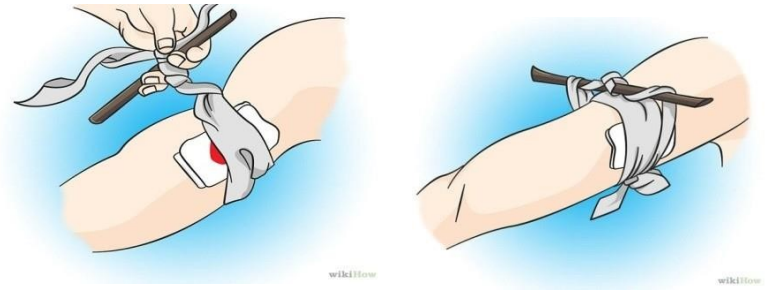
1. Leave the bandages in place and get the injured person to the emergency room as soon as possible.

3. 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

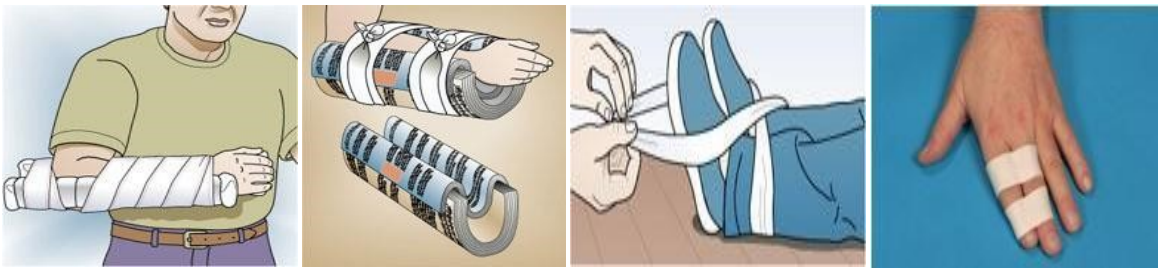
The following measures need to be taken in giving first aid to a victim with bone injury:

- ✓ 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

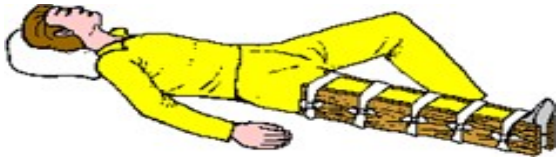
- ✓ Don't try to realign the bone or push a bone that's sticking out back in.
- ✓ If you've been trained in how to splint and professional help isn't readily available, apply a splint to the area above and below the fracture sites.

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

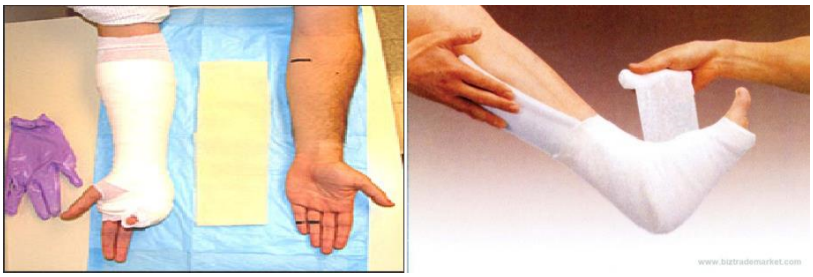
Splint must be well padded on the sides touching the body; if they are not properly padded, they will not fit well and will not adequately immobilize the injured part. Before applying splint open wounds must be covered. We have to immobilize in position found.
A basic rule of splinting is that the joint 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.

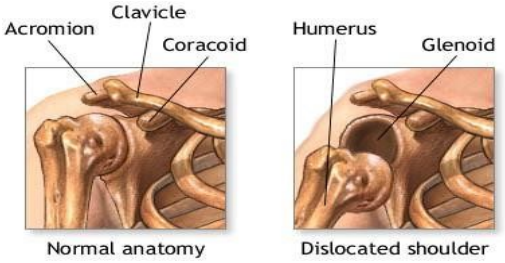


Figure 22. Normal and dislocated shoulder

A dislocation is likely to bruise or tear the muscles, ligaments, blood vessels, tendons, and nerves near a joint.

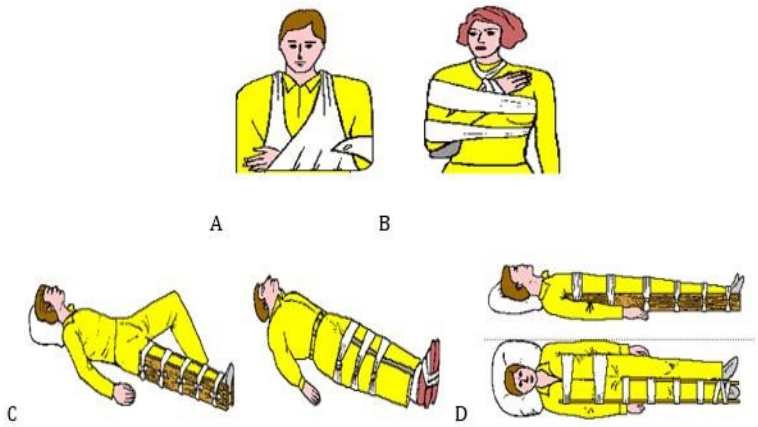
Rapid swelling and discoloration, loss of ability to use the joint, severe pain and muscle spasms, possible numbness and loss of pulse below the joint, and shock are characteristic symptoms of dislocations. The fact that the injured part is usually stiff and immobile, with marked deformation at the joint, 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).



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

American 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:

1. 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.

2. 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).

3. Check for signs of circulation (breathing, coughing or movement).

- ✓ If there is no breathing or other sign of circulation, begin CPR.

4. Elevate the burned body part or parts.

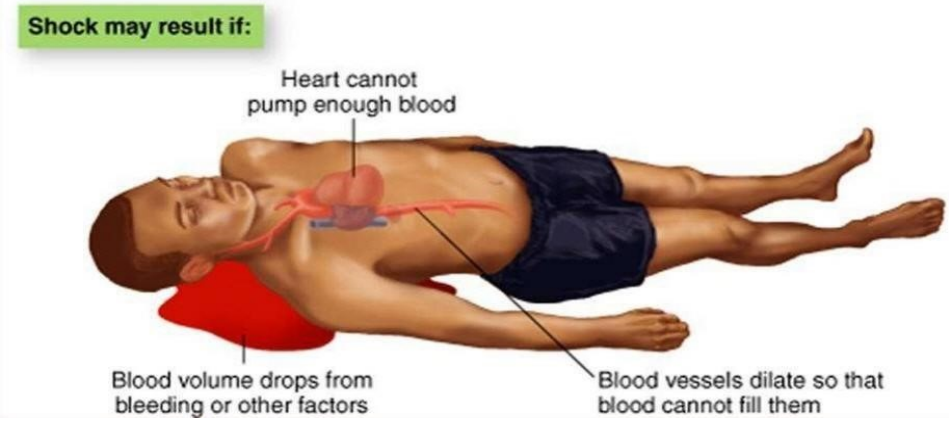
- ✓ Raise above heart level, when possible.

5. 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

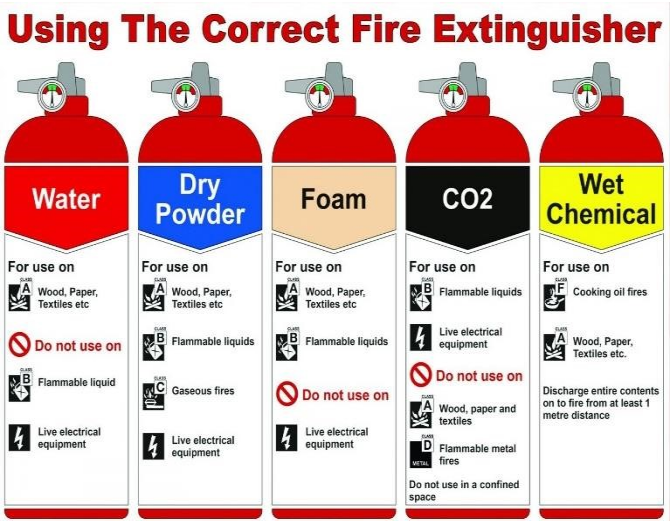
Selection of fire extinguisher

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.

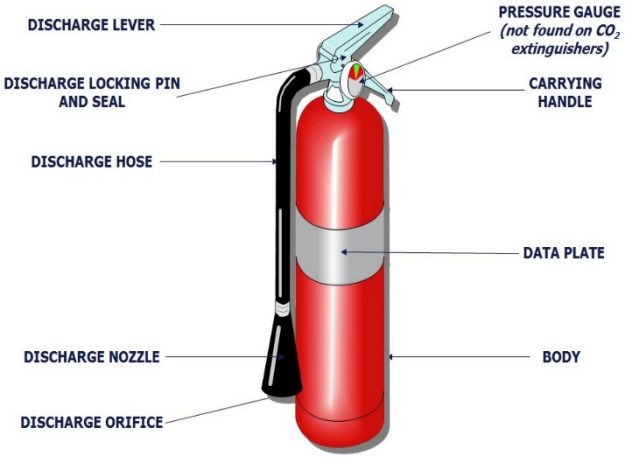
There are different 'classes' of fire, for which each extinguisher is designed to tackle. These classes are based on which fuels a fire starts with. It is the presence of these fuels within your business premises that will help determine which types of fire extinguisher you need and in which locations.

We also need the right type of fire extinguisher; you'll also need the right size and weight of each extinguisher.



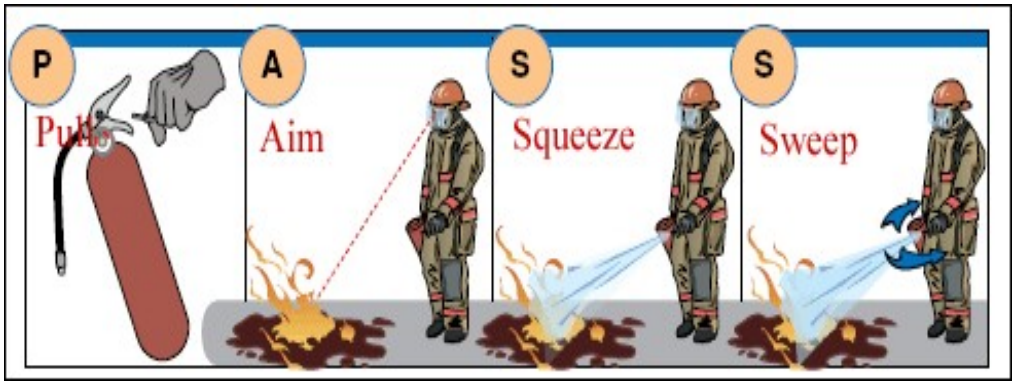
Components of fire extinguishers

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

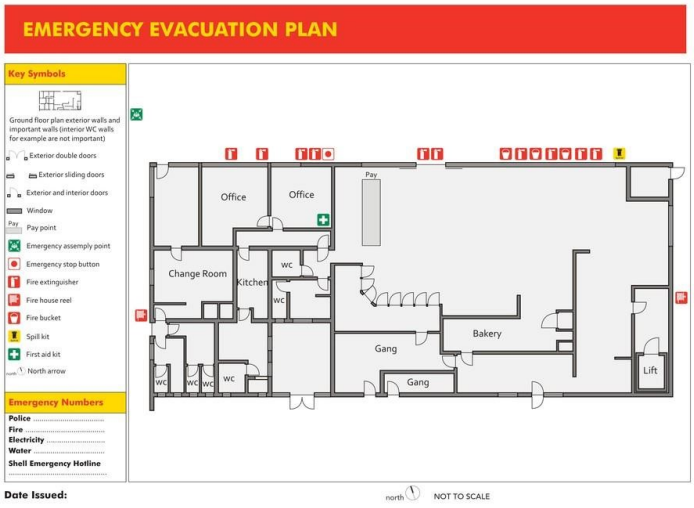
Protective hoods should be worn whenever there is a risk of injury from heat and/or flame to exposed skin. Helmet liners should be used in addition to protective hoods.

4. Boots and gloves

Fire fighters exposed to the hazard of foot or hand injury must wear protective boots or gloves appropriate the circumstances

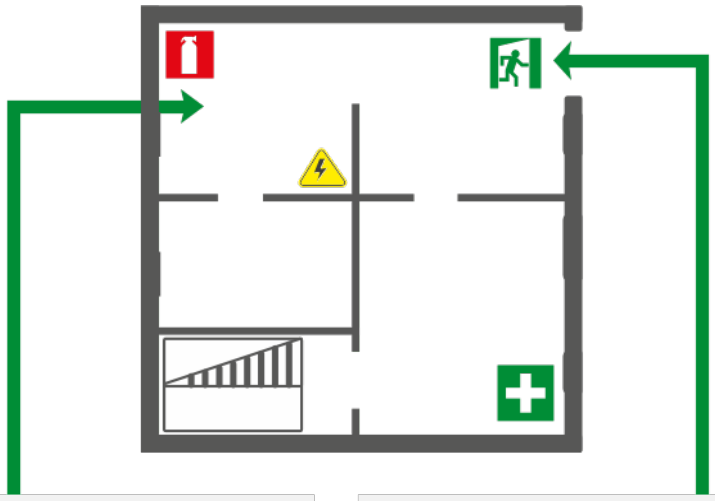
Apply emergency evacuation procedures

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 ENGINEERING MATHEMATICS

Perform simple calculations on: fractions and decimals, calculations to a number of significant figures, decimal places

Definition of Fractions

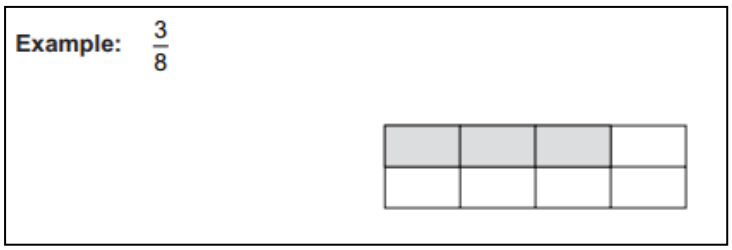
There are two types of fractions, both of which describe less than a whole object. The object can be an inch, a foot, a mile, a ton, a bundle of weld rods, other measurements, etc. The two types of fractions are:

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

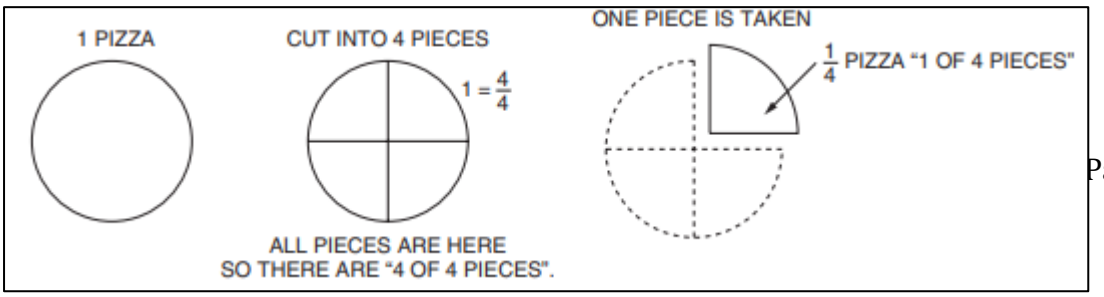
Basic Principles

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.

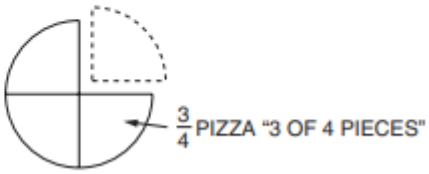


3 is the numerator, and 8 is the denominator. This fraction shows that an object has been divided into 8 equal pieces, and that 3 of those 8 pieces are shaded.

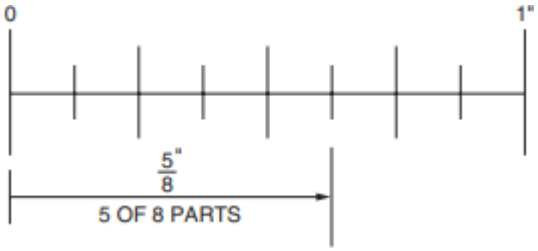
Let's work with other simple examples. If we have one whole unsliced pizza, we can divide it into pieces, and then make fractions about the pizza. This example is cut into 4 pieces (quarters). Fractions concerning this pizza will have the bottom number 4. To describe 1 of those pieces, the fraction is written 1 /4, ("1 of 4 pieces").



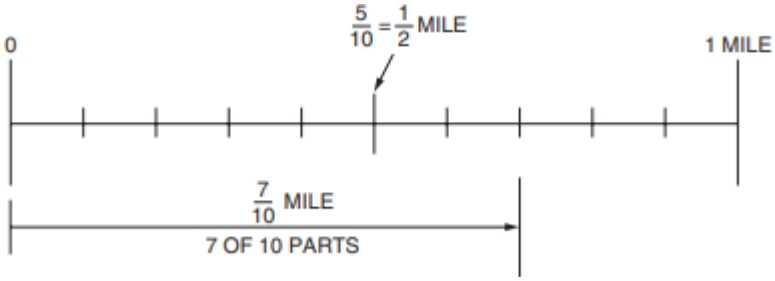
¾ indicates that "3 of 4 pieces" are still available.



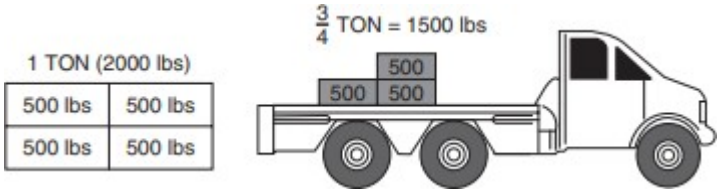
1. 5/8″ (five-eights inch) shows that an inch is divided into 8 parts and that 5 of those 8 parts have been measured.



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:

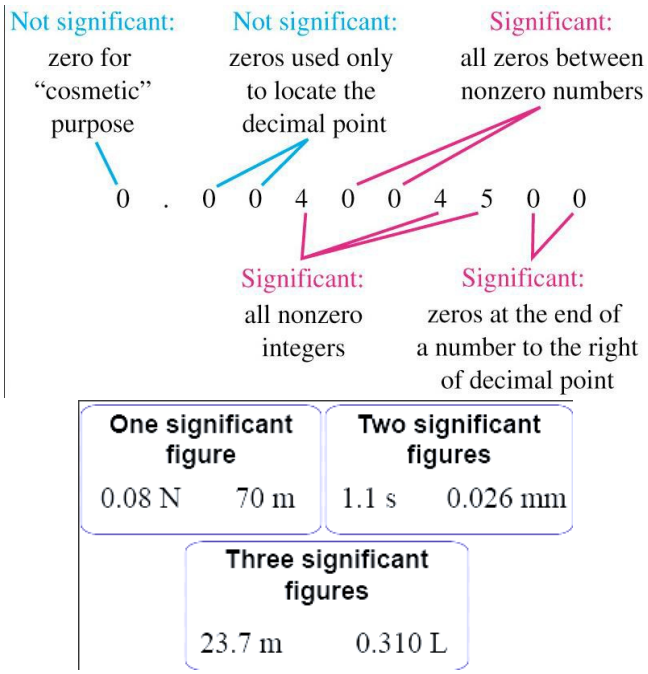
If the number directly to the right is 5 or more, increase the hundredth-place number by 1. If the number directly to the right is 4 or less, the hundredth-place number stays the same.

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

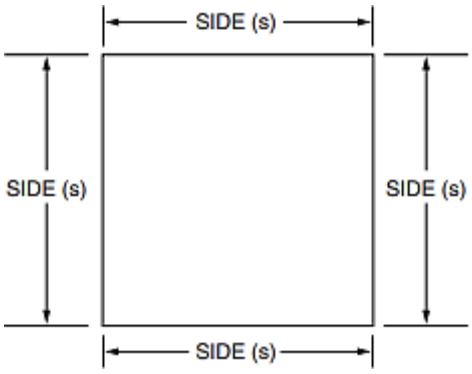
Table 1.2 Derived quantities and their units

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

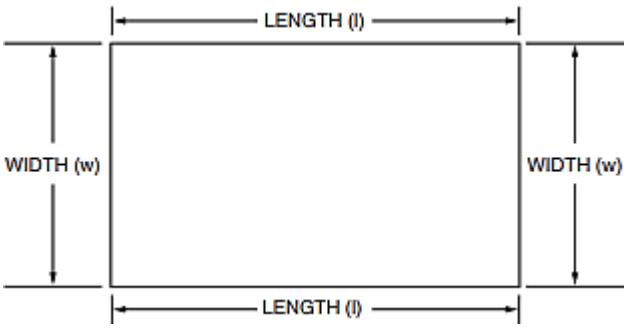
Perform calculations on: Perimeter and Area

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°.

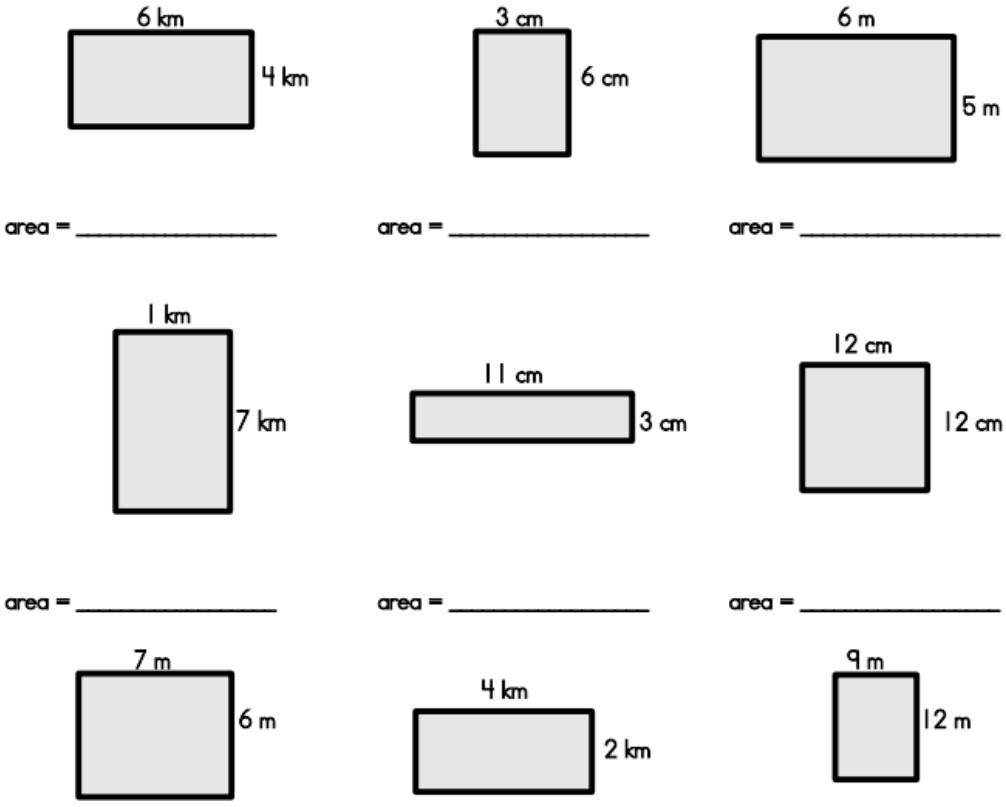


Area of Square

Formula: A= Side x Side

Area of Rectangle Formula: A= L x H

Find the area of each rectangle by multiplying.

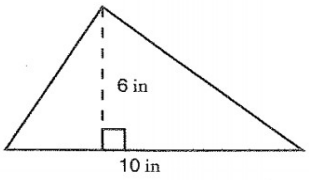


Area of triangle

Formula $A = \frac{1}{2}bh$

Examples: Find the area.

(a)

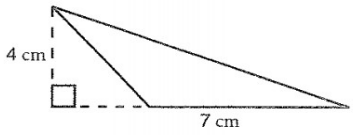


$A = \frac{1}{2}bh$

$A = \frac{1}{2}(10)(6)$

$A = 30 \text{ in}^2$

(b)



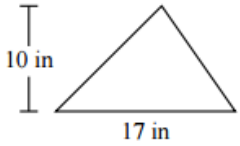
$A = \frac{1}{2}bh$

$A = \frac{1}{2}(7)(4)$

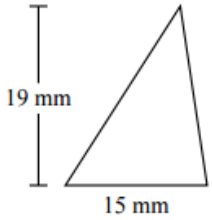
$A = 14 \text{ cm}^2$

Find the area of each triangle. Units are not to scale.

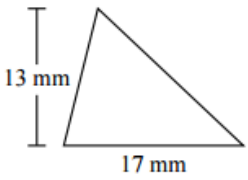
1)



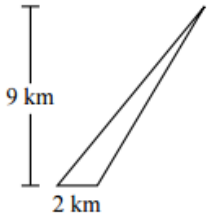
2)



3)



4)



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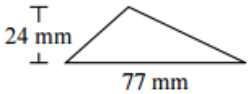

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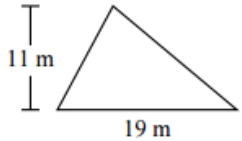
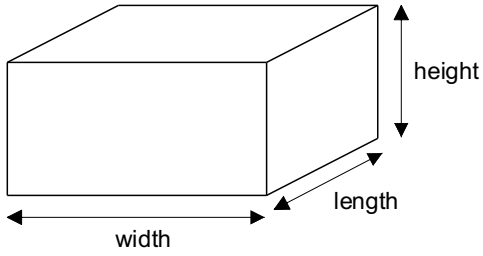
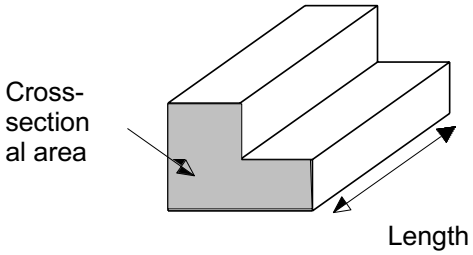


Volume and Surface Area

- ✓ Volume of **cuboid** = length × width × height

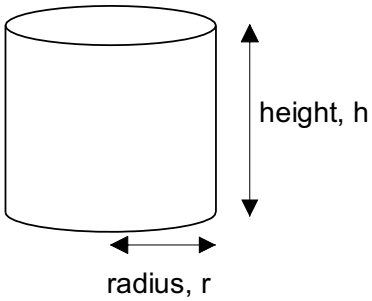


- ✓ Volume of **prism** = cross-sectional area × length



- ✓ 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.

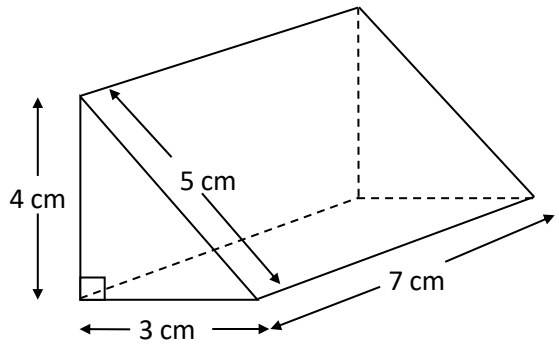
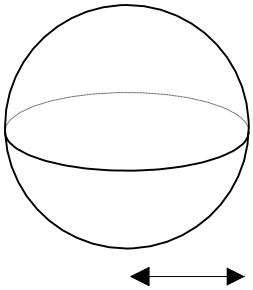


Diagram **NOT** accurately drawn

Volume of a sphere

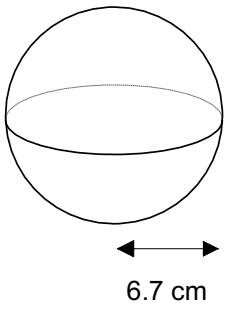
Volume of a **sphere** = $\frac{4}{3}\pi r^3$



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

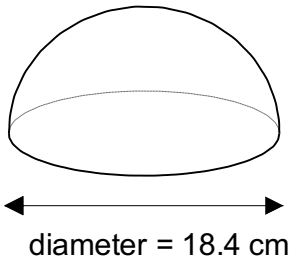
Volume = $\frac{4}{3}\pi r^3$

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 $86.5 = 4.18879 r^3$

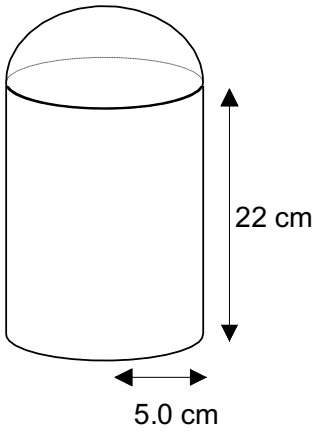
i.e. $20.65035 = r^3$

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

$$= \frac{1}{2} \times \frac{4}{3} \pi r^3$$

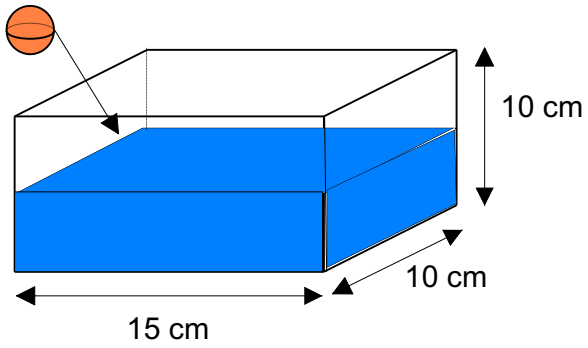
$$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 5^3$$

$$= 262 \text{ cm}^3$$

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 = $\frac{4}{3} \pi r^3 = \frac{4}{3} \times \pi \times 2^3 = 33.51 \text{ cm}^3$.

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.

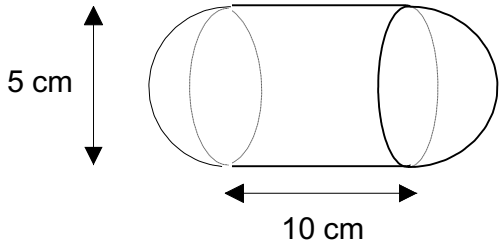
Examination question

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.

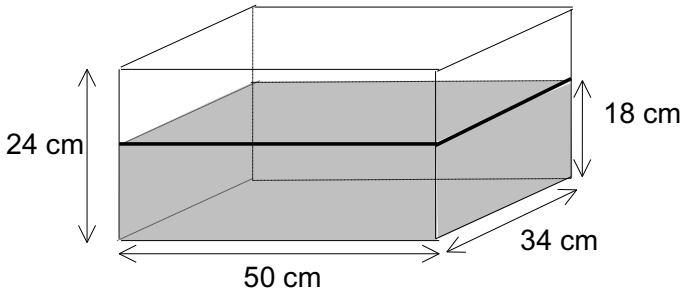
The length of the cylindrical part of the toy is 10 cm.

Calculate the volume of plastic needed to make the toy. Give your answer correct to three significant figures.



Examination question

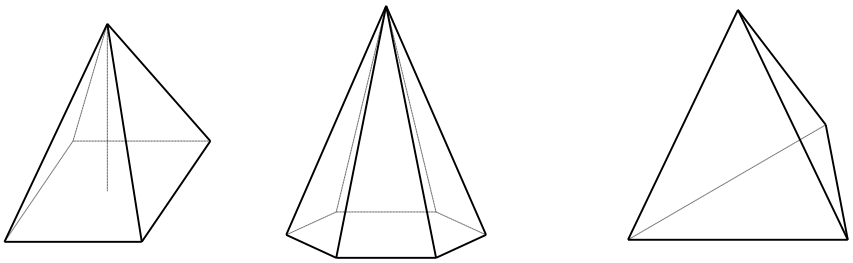
A water tank is 50 cm long, 34 cm wide and 24 cm high. It contains water to a depth of 18 cm.



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.

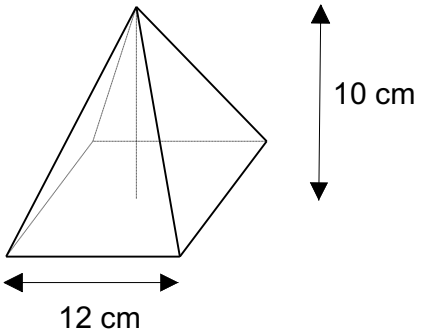


The volume of any **pyramid** can be found using the formula:

$$\text{Volume of } \textbf{pyramid} = \frac{1}{3} \times \text{base area} \times \text{height}$$

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.



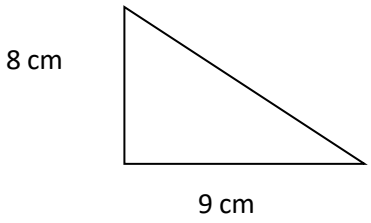
Solution:
The area of the square base is $12 \times 12 = 144$ cm^2
So, the volume of the pyramid is:

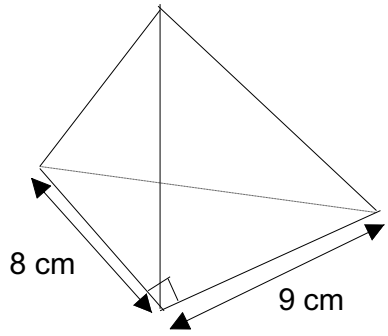
$$\text{Volume} = \frac{1}{3} \times 144 \times 10$$
$$= 48 \times 10$$
$$= 480 \text{ cm}^3.$$

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).

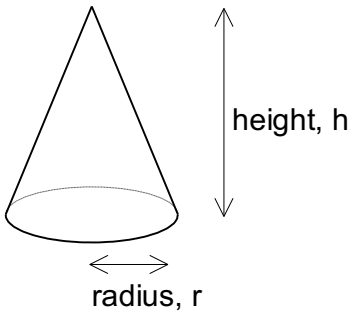
Volume of a cone

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

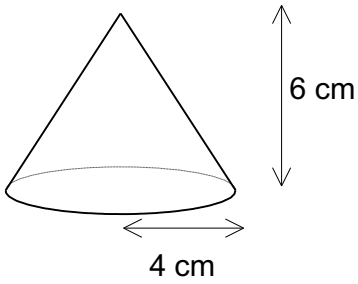
The base of a cone has a radius of 4 cm. The height of the cone is 6 cm.
Find the volume of the cone. Leave your answer in terms of π.
Solution:
Substitute the information into the formula for the volume of a cone:

Volume of cone = $\frac{1}{3}\pi r^2 h$

$= \frac{1}{3} \times \pi \times 4^2 \times 6$

$= 2 \times \pi \times 16$ (start by finding 1/3 of 6)

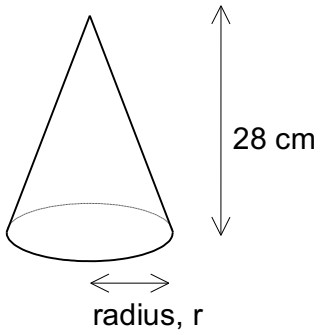
volume = 32π cm^3.



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:



Volume of cone = $\frac{1}{3}\pi r^2 h$

$1650 = \frac{1}{3} \times \pi \times r^2 \times 28$

$1650 = 29.32153 r^2$ (evaluating $\frac{1}{3} \times \pi \times 28$)

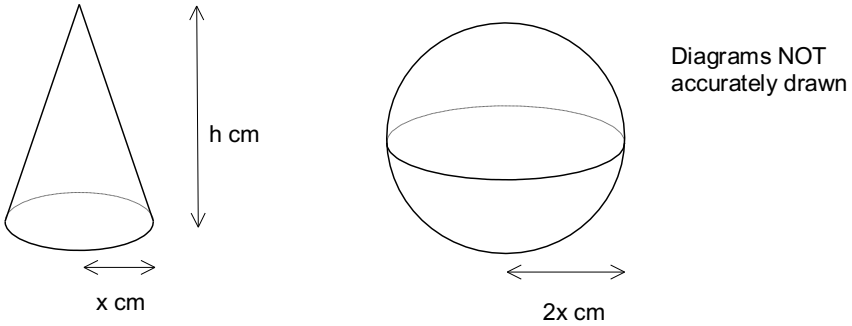
$r^2 = 56.2726$

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 2*x* 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)

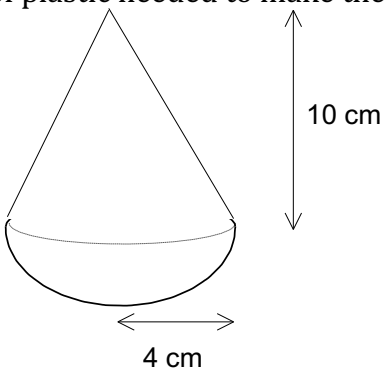
$x^2 h = 32x^3$ (Dividing both sides by π)

$h = 32x$ (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.



APPLY FUNDAMENTAL OF ENGINEERING SCIENCE

KINETICS

Circular Motion

There are three mathematical quantities that will be of primary interest to us as we analyze the motion of objects in circles. These three quantities are speed, acceleration and force. The speed of an object moving in a circle is given by the following equation.

$$\text{Average Speed} = \frac{\text{distance}}{\text{time}} = \frac{2 * \pi * R}{T}$$

where R represents radius
T represents period

The acceleration of an object moving in a circle can be determined by either two of the following equations.

$$\text{Acceleration} = \frac{v^2}{R} \qquad \text{Acceleration} = \frac{4 * \pi^2 * R}{T^2}$$

where v represents speed
R represents radius
T represents period

The equation on the right (above) is derived from the equation on the left by the substitution of the expression for speed.

The net force ($\mathbf{F_{net}}$) acting upon an object moving in circular motion is directed inwards. While there may by more than one force acting upon the object, the vector sum of all of them should add up to the net force. In general, the inward force is larger than the outward force (if any) such that the outward force cancels and the unbalanced force is in the direction of the center of the circle. The net force is related to the acceleration of the object (as is always the case) and is thus given by the following three equations:

$$F_{net} = m * a \qquad F_{net} = m * \frac{v^2}{R} \qquad F_{net} = m * \frac{4 * \pi^2 * R}{T^2}$$

where m represents mass
v represents speed
R represents radius
T represents period

The equations in the middle (above) and on the right (above) are derived from the equation on the left by the substitution of the expressions for acceleration.

This set of circular motion equations can be used in two ways:

- ✓ as a "recipe" for algebraic problem-solving in order to solve for an unknown quantity.
- ✓ as a *guide to thinking* about how an alteration in one quantity would affect a second quantity.

These two ways are illustrated below

Equations as a Guide to Thinking

An equation expresses a mathematical relationship between the quantities present in that equation. For instance, the equation for Newton's second law identifies how acceleration is related to the net force and the mass of an object.

$$a = \frac{F_{net}}{m}$$

The relationship expressed by the equation is that the acceleration of an object is directly proportional to the net force acting upon it. In other words, the bigger the net force value is, the bigger that the acceleration value will be. As net force increases, the acceleration increases. In fact, if the net force were increased by a factor of 2, the equation would predict that the acceleration would increase by a factor of 2. Similarly, if the net force were decreased by a factor of 2, the equation would predict that the acceleration would decrease by a factor of 2.

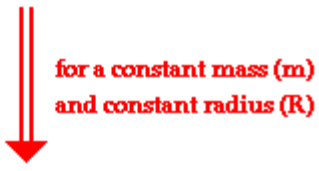
Newton's second law equation also reveals the relationship between acceleration and mass. According to the equation, the acceleration of an object is inversely proportional to mass of the object. In other words, the bigger the mass value is, the smaller that the acceleration value will be. As mass increases, the acceleration decreases. In fact, if the mass were increased by a factor of 2, the equation would predict that the acceleration would decrease by a factor of 2. Similarly, if the mass were decreased by a factor of 2, the equation would predict that the acceleration would increase by a factor of 2.

As mentioned previously, equations allow for predictions to be made about the effect of an alteration of one quantity on a second quantity. Since the Newton's second law equation shows three quantities, each raised to the first power, the predictive ability of the equation is rather straightforward. The predictive ability of an equation becomes more complicated when one of the quantities included in the equation is raised to a power. For instance, consider the following equation relating the net force ($\mathbf{F_{net}}$) to the speed ($\mathbf{v}$) of an object moving in uniform circular motion.

$$F_{net} = m * \frac{v^2}{R}$$

This equation shows that the net force required for an object to move in a circle is directly proportional to the square of the speed of the object. For a constant mass and radius, the $\mathbf{F_{net}}$ is proportional to the $\mathbf{speed^2}$.

$$F_{net} = m * \frac{v^2}{R}$$



$$F_{net} \sim v^2$$

The factor by which the net force is altered is the square of the factor by which the speed is altered. Subsequently, if the speed of the object is doubled, the net force required for that object's circular motion is quadrupled. And if the speed of the object is halved (decreased by a factor of 2), the net force required is decreased by a factor of 4.

Laws of Forces

The Meaning of Force

A **force** is a push or pull upon an object resulting from the object's *interaction* with another object. Whenever there is an *interaction* between two objects, there is a force upon each of the objects. When the *interaction* ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.

Contact versus Action-at-a-Distance Forces

For simplicity sake, all forces (interactions) between objects can be placed into two broad categories:

- ✓ contact forces, and
- ✓ forces resulting from action-at-a-distance

Contact forces are those types of forces that result when the two interacting objects are perceived to be physically contacting each other. Examples of contact forces include frictional forces, tensional forces, normal forces, air resistance forces, and applied forces.

Action-at-a-distance forces are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include gravitational forces. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation. Even when your feet leave the earth and you are no longer in physical contact with the earth, there is a gravitational pull between you and the Earth. Electric forces are action-at-a-distance forces. For example, the protons in the nucleus of an atom and the electrons outside the nucleus experience an electrical pull towards each other despite their small spatial separation. And magnetic forces are action-at-a-distance forces. For example, two magnets can exert a magnetic pull on each other even when separated by a distance of a few centimeters.

Examples of contact and action-at-distance forces are listed in the table below.

Contact Forces	Action-at-a-Distance Forces
Frictional Force	Gravitational Force
Tension Force	Electrical Force
Normal Force	Magnetic Force
Air Resistance Force	

Applied Force

Spring Force

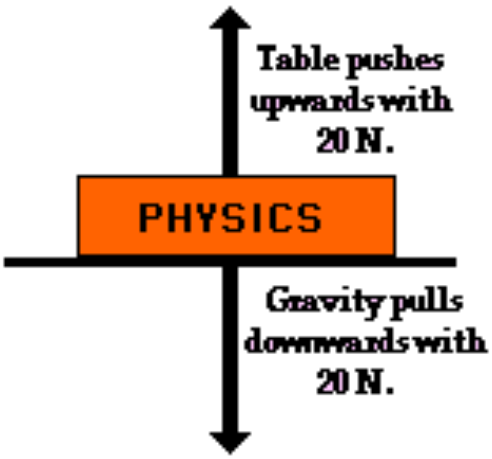
The Newton

Force is a quantity that is measured using the standard metric unit known as the Newton. A Newton is abbreviated by an "N." To say "10.0 N" means 10.0 Newton of force. One Newton is the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Thus, the following unit equivalency can be stated:

1 Newton = 1 kg • m/s^2

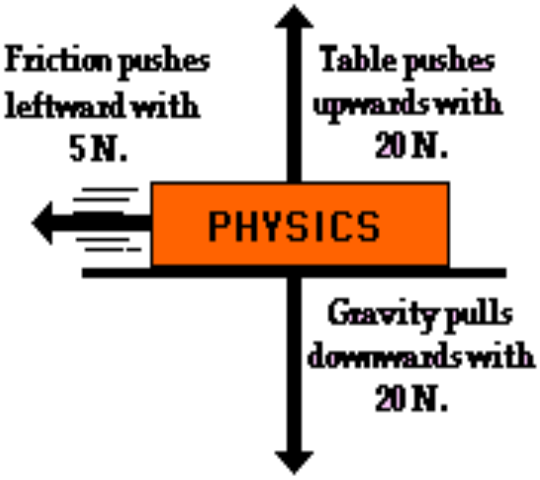
Force is a Vector Quantity

A force is a vector quantity. As learned in an earlier unit, a vector quantity is a quantity that has both magnitude and direction. To fully describe the force acting upon an object, you must describe both the magnitude (size or numerical value) and the direction. Thus, 10 Newton is not a full description of the force acting upon an object. In contrast, 10 Newton, downward is a complete description of the force acting upon an object; both the magnitude (10 Newton) and the direction (downward) are given.



Because a force is a vector that has a direction, it is common to represent forces using diagrams in which a force is represented by an arrow. Such vector diagrams were introduced in an earlier unit and are used throughout the study of physics. The size of the arrow is reflective of the magnitude of the force and the direction of the arrow reveals the direction that the force is acting. (Such diagrams are known as free-body diagrams and are discussed later in this lesson.) Furthermore, because forces are vectors, the effect of an individual force upon an object is often canceled by the effect of another force. For example, the effect of a 20-Newton upward force acting upon a book is *canceled* by the effect of a 20-Newton downward force acting upon the book. In such instances, it is said that the two individual forces *balance each other*; there would be no unbalanced force acting upon the book.

Other situations could be imagined in which two of the individual vector forces cancel each other ("balance"), yet a third individual force exists that is not balanced by another force. For example, imagine a book sliding across the rough surface of a table from left to right. The downward force of gravity and the upward force of the table supporting the book act in opposite directions and thus balance each other. However, the force of friction acts leftwards, and there is no rightward force to balance it. In this case, an unbalanced force acts upon the book to change its state of motion.



Types of Forces

A force is a push or pull acting upon an object as a result of its interaction with another object. There are a variety of types of forces. Previously in this lesson, a variety of force types were placed into two broad category headings on the basis of whether the force resulted from the contact or non-contact of the two interacting objects.

Type of Force (and Symbol)	Description of Force
Applied Force F_{app}	An applied force is a force that is applied to an object by a person or another object. If a person is pushing a desk across the room, then there is an applied force acting upon the object. The applied force is the force exerted on the desk by the person.
Gravity Force **(also known as Weight)** F_{grav}	the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object. All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: **Fgrav = m * g** where g = 9.8 N/kg (on Earth) and m = mass (in kg)
Normal Force	The normal force is the support force exerted upon an object that is in contact

F_{norm}	with another stable object. For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book. On occasions, a normal force is exerted horizontally between two objects that are in contact with each other. For instance, if a person leans against a wall, the wall pushes horizontally on the person.
Friction Force F_{frict}	The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - sliding and static friction. Though it is not always the case, the friction force often opposes the motion of an object. For example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula below: $F_{frict} = \mu \bullet F_{norm}$
Air Resistance Force F_{air}	The air resistance is a special type of frictional force that acts upon objects as they travel through the air. The force of air resistance is often observed to oppose the motion of an object. This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value). It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas.
Tension Force F_{tens}	The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension

	force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.
Spring Force F_{spring}	The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it. An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position. For most springs (specifically, for those that are said to obey "Hooke's Law"), the magnitude of the force is directly proportional to the amount of stretch or compression of the spring.

Confusion of Mass and Weight

A few further comments should be added about the single force that is a source of much confusion to many students of physics - the force of gravity. As mentioned above, the force of gravity acting upon an object is sometimes referred to as the weight of the object. Many students of physics confuse weight with mass. The mass of an object refers to the amount of matter that is contained by the object; the weight of an object is the force of gravity acting upon that object. Mass is related to how much stuff is there and weight is related to the pull of the Earth (or any other planet) upon that stuff. The mass of an object (measured in kg) will be the same no matter where in the universe that object is located. Mass is never altered by location, the pull of gravity, speed or even the existence of other forces. For example, a 2-kg object will have a mass of 2 kg whether it is located on Earth, the moon, or Jupiter; its mass will be 2 kg whether it is moving or not (at least for purposes of our study); and its mass will be 2 kg whether it is being pushed upon or not.

On the other hand, the weight of an object (measured in Newton) will vary according to where in the universe the object is. Weight depends upon which planet is exerting the force and the distance the object is from the planet. Weight, being equivalent to the force of gravity, is dependent upon the value of **g** - the gravitational field strength. On earth's surface **g** is 9.8 N/kg (often approximated as 10 N/kg). On the moon's surface, **g** is 1.7 N/kg. Go to another planet, and there will be another **g** value. Furthermore, the g value is inversely proportional to the distance from the center of the planet. So if we were to measure **g** at a distance of 400 km above the earth's surface, then we would find the **g** value to be less than 9.8 N/kg.

Sliding versus Static Friction

As mentioned above, the friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. For the purpose of our study of physics at The Physics Classroom, there are two types of friction force - static friction and sliding

friction. Sliding friction results when an object slides across a surface. As an example, consider pushing a box across a floor. The floor surface offers resistance to the movement of the box. We often say that the floor exerts a friction force upon the box. This is an example of a sliding friction force since it results from the sliding motion of the box. If a car slams on its brakes and skids to a stop (without antilock brakes), there is a sliding friction force exerted upon the car tires by the roadway surface. This friction force is also a sliding friction force because the car is sliding across the road surface. Sliding friction forces can be calculated from knowledge of the coefficient of friction and the normal force exerted upon the object by the surface it is sliding across. The formula is:

$$F_{frict\text{-}sliding} = \mu_{frict\text{-}sliding} \bullet F_{norm}$$

The symbol $\mu_{frict\text{-}sliding}$ represents the coefficient of sliding friction between the two surfaces. The coefficient value is dependent primarily upon the nature of the surfaces that are in contact with each other. For most surface combinations, the friction coefficients show little dependence upon other variables such as area of contact, temperature, etc. Values of $\mu_{sliding}$ have been experimentally determined for a variety of surface combinations and are often tabulated in technical manuals and handbooks. The values of μ provide a measure of the relative amount of adhesion or attraction of the two surfaces for each other. The more that surface molecules tend to adhere to each other, the greater the coefficient values and the greater the friction force.

Friction forces can also exist when the two surfaces are not sliding across each other. Such friction forces are referred to as static friction. Static friction results when the surfaces of two objects are at rest relative to one another and a force exists on one of the objects to set it into motion relative to the other object. Suppose you were to push with 5-Newton of force on a large box to move it across the floor. The box might remain in place. A static friction force exists between the surfaces of the floor and the box to prevent the box from being set into motion. The static friction force balances the force that you exert on the box such that the stationary box remains at rest. When exerting 5 Newton of applied force on the box, the static friction force has a magnitude of 5 Newton. Suppose that you were to push with 25 Newton of force on the large box and the box were to still remain in place. Static friction now has a magnitude of 25 Newton. Then suppose that you were to increase the force to 26 Newton and the box finally budged from its resting position and was set into motion across the floor. The box-floor surfaces were able to provide up to 25 Newton of static friction force to match your applied force. Yet the two surfaces were not able to provide 26 Newton of static friction force. The amount of static friction resulting from the adhesion of any two surfaces has an upper limit. In this case, the static friction force spans the range from 0 Newton (if there is no force upon the box) to 25 Newton (if you push on the box with 25 Newton of force). This relationship is often expressed as follows:

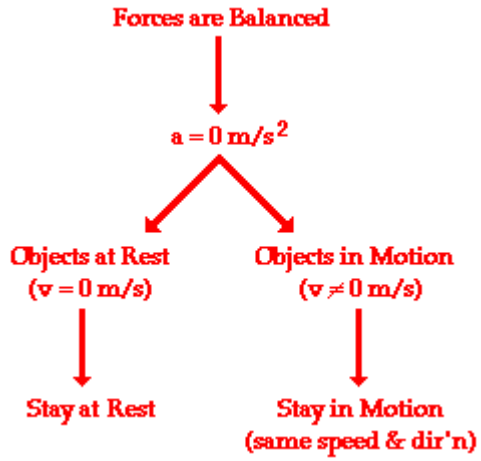
$$F_{frict\text{-}static} \leq \mu_{frict\text{-}static} \bullet F_{norm}$$

The symbol $\mu_{\text{frict-static}}$ represents the coefficient of static friction between the two surfaces. Like the coefficient of sliding friction, this coefficient is dependent upon the types of surfaces that are attempting to move across each other. In general, values of static friction coefficients are greater than the values of sliding friction coefficients for the same two surfaces. Thus, it typically takes more force to budge an object into motion than it does to maintain the motion once it has been started.

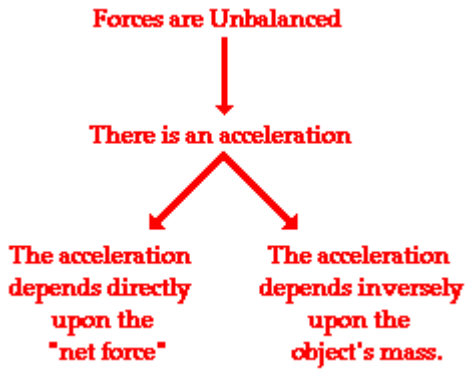
The meaning of each of these forces listed in the table above will have to be thoroughly understood to be successful during this unit. Ultimately, you must be able to read a verbal description of a physical situation and know enough about these forces to recognize their presence (or absence) and to construct a free-body diagram that illustrates their relative magnitude and direction.

Newton's Second Law

Newton's first law of motion predicts the behavior of objects for which all existing forces are balanced. The first law - sometimes referred to as the law of inertia - states that if the forces acting upon an object are balanced, then the acceleration of that object will be 0 m/s/s. Objects at **equilibrium** (the condition in which all forces balance) will not accelerate. According to Newton, an object will only accelerate if there is a net or unbalanced force acting upon it. The presence of an unbalanced force will accelerate an object - changing its speed, its direction, or both its speed and direction.



Newton's second law of motion pertains to the behavior of objects for which all existing forces are not balanced. The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased.



The BIG Equation
Newton's second law of motion can be formally stated as follows:

The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

This verbal statement can be expressed in equation form as follows:

$$a = F_{net} / m$$

The above equation is often rearranged to a more familiar form as shown below. The net force is equated to the product of the mass times the acceleration.

$$F_{net} = m \bullet a$$

is equal to a unit of mass times a unit of acceleration. By substituting standard metric units for force, mass, and acceleration into the above equation, the following unit equivalency can be written.

$$1\ \text{Newton} = 1\ \text{kg} \bullet \text{m/s}^2$$

The definition of the standard metric unit of force is stated by the above equation. One Newton is defined as the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s.

Acceleration

The process of determining the acceleration of an object demands that the mass and the net force are known. If mass (m) and net force (F_{net}) are known, then the acceleration is determined by use of the equation.

$$a = F_{net} / m$$

Newton's Third Law

A force is a push or a pull that acts upon an object as a results of its interaction with another object. Forces result from interactions!

According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body. There are two forces resulting from this interaction - a force on the chair and a force on your body. These two forces are called *action* and *reaction* forces and are the subject of Newton's third law of motion. Formally stated, Newton's third law is:

For every action, there is an equal and opposite reaction.

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Examples of Interaction Force Pairs

A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. Since forces result from mutual interactions, the water must also be pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim.

Consider the motion of a car on the way to school. A car is equipped with wheels that spin. As the wheels spin, they grip the road and push the road backwards. Since forces result from mutual interactions, the road must also be pushing the wheels forward. The size of the force on the road equals the size of the force on the wheels (or car); the direction of the force on the road (backwards) is opposite the direction of the force on the wheels (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for cars to move along a roadway surface.

Gravity

Gravity is a force that attracts a body towards the centre of the earth, or towards any other physical body having mass.

$$F = G\frac{m_1 m_2}{r^2}$$

Where,

- ***F*** is the force,
- m1 and m2 are masses of the objects interacting
- ***r*** is the distance between the center of the masses
- ***G*** is the gravitational constant (6.674×10^{-11} $m^3 \cdot kg^{-1} \cdot s^{-2}$)

This equation gives the magnitude of the force and since it is an attractive force it will always be directed towards the other object. From the above equation, we can come to the conclusion that anything that has mass has gravity. Objects with heavier mass have more gravity. The closer the two objects are, the heavier the gravitational pull between them. Gravity gets weaker with distance. The above formula is used to calculate the gravitational force between two objects.

Relationship Between Gravity and Weight

Weight is defined as the force with which a body is attracted to the earth by gravitation. It is just another word for the force of gravity F_g. Weight is a force that acts on all objects near earth. The weight of an object can be calculated by multiplying the mass of the body with the magnitude of the acceleration due to gravity (g = 9.8 m/s^2).

Mathematically, it is represented as:

$$F_g = mg$$

Many people confuse mass with weight. One has to keep in mind that mass is the measure of how much the body resists velocity, in other words, the inertia of the object. Although they are closely related to each other, they mean different things. The mass has units of kg, whereas, the weight is a force and has units of N.

Gravity is very important to us, it wouldn't have been possible for us to live on earth if it weren't for gravity. The sun's gravity is what keeps the earth revolving around it, keeping us at a comfortable distance to enjoy the sun's warmth and light. Ultimately, gravity is the glue that holds the cosmos together!

Matter

States of Matter

Gases, liquids and solids are all made up of microscopic particles, but the behaviors of these particles differ in the three phases. The following figure illustrates the microscopic differences.

Note that:

- ✓ Particles in a:
    - gas are well separated with no regular arrangement.
    - liquid are close together with no regular arrangement.

- solid are tightly packed, usually in a regular pattern.

✓ Particles in a:

- gas vibrate and move freely at high speeds.
- liquid vibrate, move about, and slide past each other.
- solid vibrate (jiggle) but generally do not move from place to place.

Liquids and solids are often referred to as ***condensed phases*** because the particles are very close together.

The following table summarizes properties of gases, liquids, and solids and identifies the microscopic behavior responsible for each property.

Some Characteristics of Gases, Liquids and Solids and the Microscopic Explanation for the Behavior		
gas	**liquid**	**solid**
assumes the shape and volume of its container particles can move past one another	assumes the shape of the part of the container which it occupies particles can move/slide past one another	retains a fixed volume and shape rigid - particles locked into place
compressible lots of free space between particles	not easily compressible little free space between particles	not easily compressible little free space between particles
flows easily particles can move past one another	flows easily particles can move/slide past one another	does not flow easily rigid - particles cannot move/slide past one another

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.

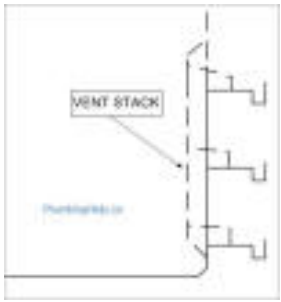
As your sketches become more refined additional information should be added; such as pipe sizes, fixture location, dimensions and plumbing fittings until your confident that someone else would understand your sketch and be able to follow it's design.

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.

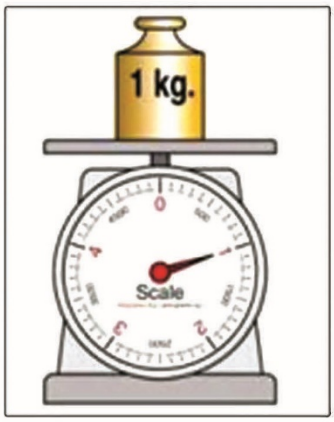
Although an isometric drawing is the most complex to draw, it has definite advantages; such as showing both horizontal and vertical piping on a single drawing. Making an isometric sketch is accomplished by imagining yourself at the lowest point

(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

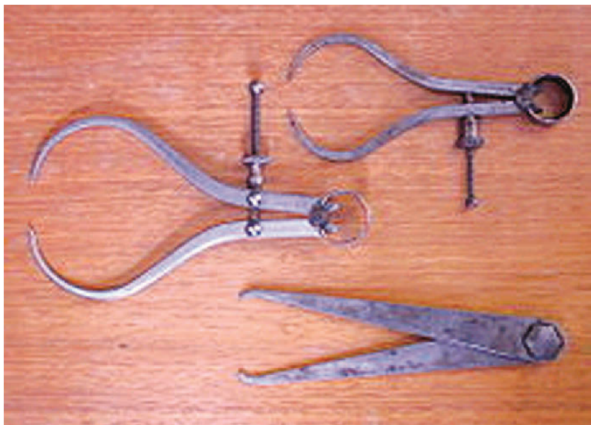


Fig. 4.3: Outside callipersFig. 4.4: Inside callipers

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

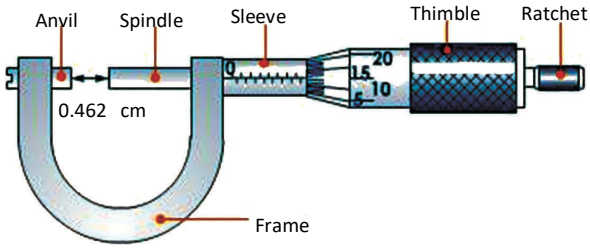


Fig. 4.5: Screw gauge

Fig. 4.6: Measuring tape

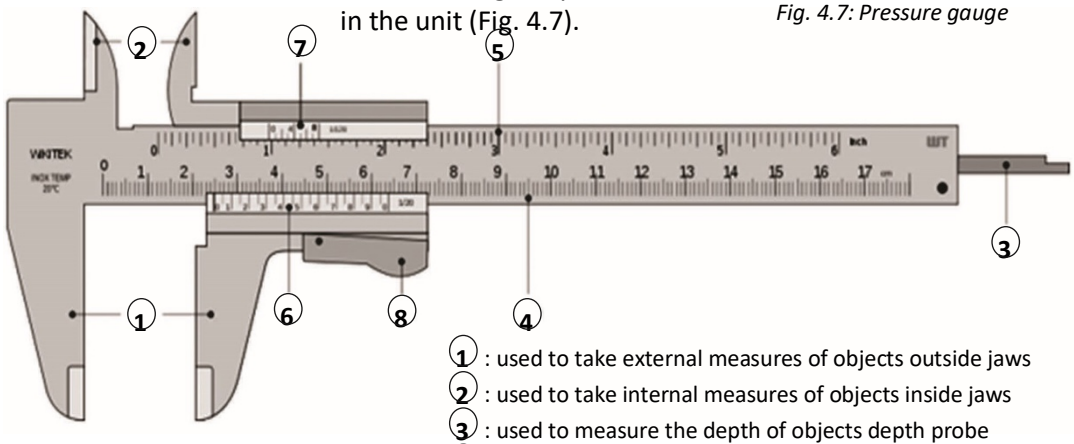
Measuring tape

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

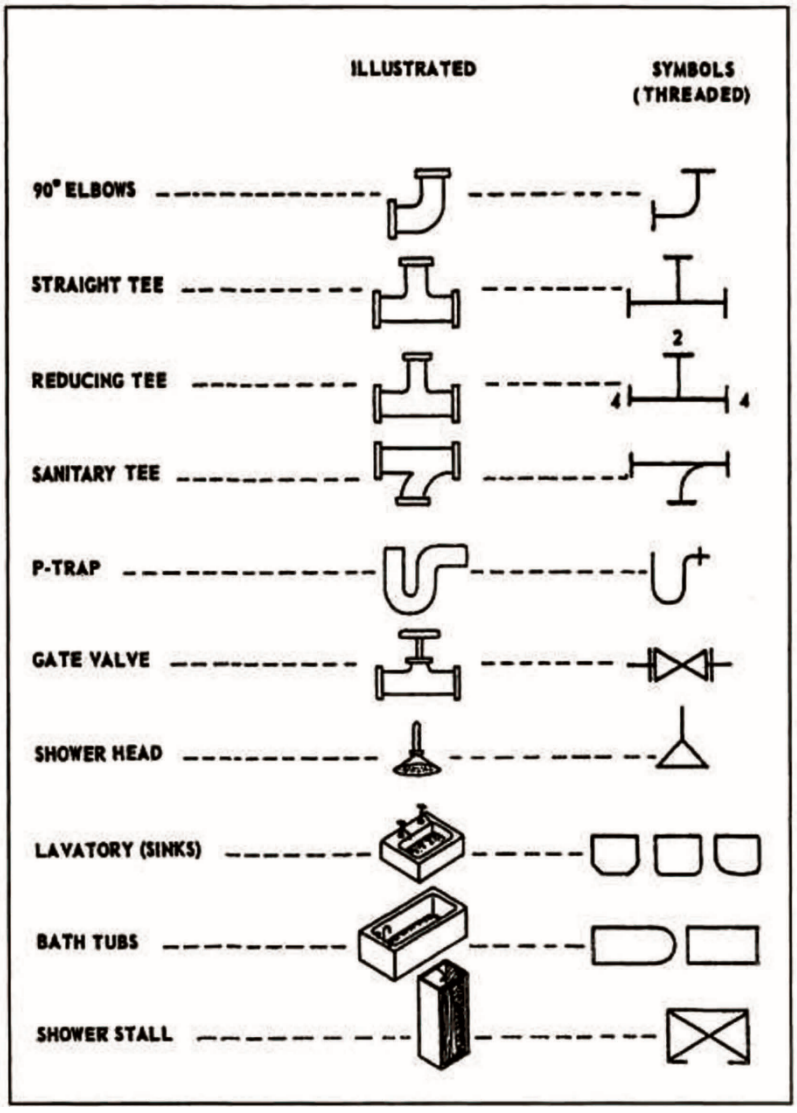
Vernier calliper

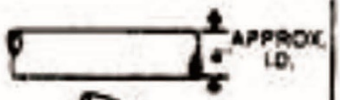
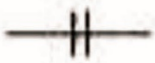
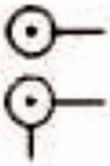
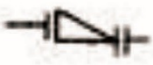
The metre scale is used to measure the length to the nearest millimetre only. For measuring smaller lengths precisely, Vernier calliper is used. **Vernier calliper** is a precision instrument used to measure the internal and external lengths. It is usually a manual calliper, as shown in Fig. 4.8 and 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
WC Water Closet	LAV Lavatory
WH Water Heater	DW Dishwasher
C/W Clothes Washer	Floor Drain
Clean Out	VTR Vent Thru Roof
90 degree Elbow	Pipe Turns Up
Pipe turns Down	Tee
Union	Cap

Read and interpret drawings

Engineering drawings (also sometimes known as blueprints, manufacturing blueprints, prints, manufacturing prints, dimensional prints, drawings, mechanical drawings, and more) are a rich and specific outline that shows all the information and requirements needed to manufacture an item or product. It is more than simply a drawing, it is a graphical language that communicates ideas and information.

Unlike a 3D model, an engineering drawing offers a lot more specific information and requirements, including:

- ✓ Dimensions
- ✓ Geometry
- ✓ Tolerances
- ✓ Material type
- ✓ Finish
- ✓ Hardware

3D models are good to have and are usually (especially nowadays) used in conjunction with drawings. They are a good visual representation of the desired item, but do not contain all the information that drawings do.

Information blocks

These blocks contain essential information about the assembly. They are usually located in the bottom right-hand corner of the drawing. These blocks provide details about what the drawing is for, for whom, part number and description, as well as information about the material and finish.

These are the main information blocks:

Title block

Start off by reading the title block found at the bottom right-hand corner of the drawing. There are other information blocks like it, but the title block serves as the context in which the drawing should be perceived.

The title block contains information such as:

- ✓ Name and address of the company or agency who prepared or owns the drawing
- ✓ Part number and description
- ✓ Material
- ✓ Mass
- ✓ Finish
- ✓ General tolerances
- ✓ Projection details
- ✓ Scale used in the drawing

- ✓ Revision numbers
- ✓ Status of the drawing (Preliminary, Approved, etc.)
- ✓ Units used in the drawing

Note that any information in the notes outside the title block that conflicts with the information in the title block should be considered as the right information and supersede the title block information.

Revision block

The revision block, located in the upper right hand corner, shows details about the changes that were made to roll the revision. The Revision Block includes the revision, the description of what changes were made, the date of the revision, and approval of the revision.

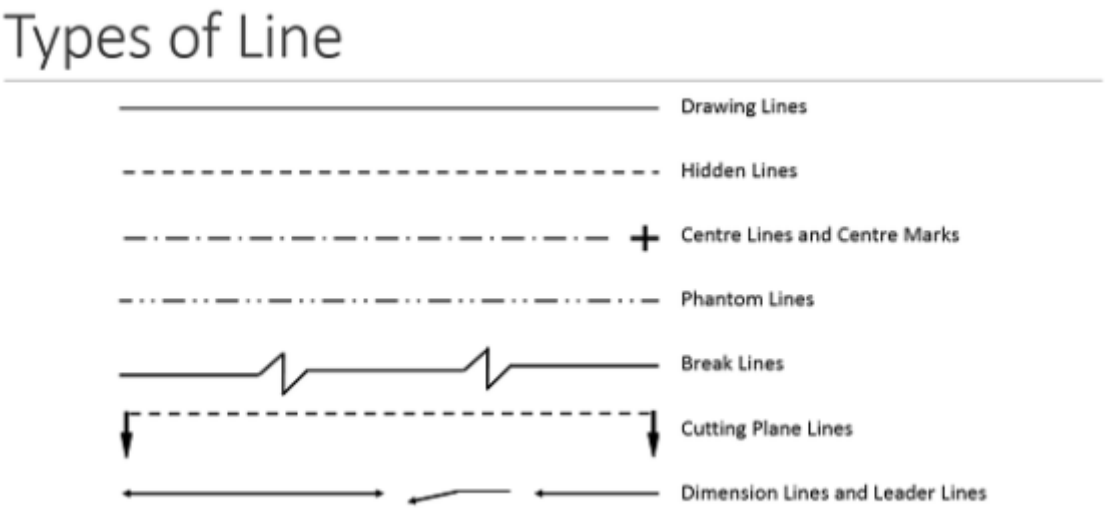
Bill of Materials (BOM) Block

Located usually either just above the title block or in the upper left-hand corner, the Bill of Materials block (also known as a BOM, Schedule or Parts List) contains a list of all the items and quantities that are required for the project or assembly. This is used for parts that either require assembly or when hardware should be added to the part.

Lines

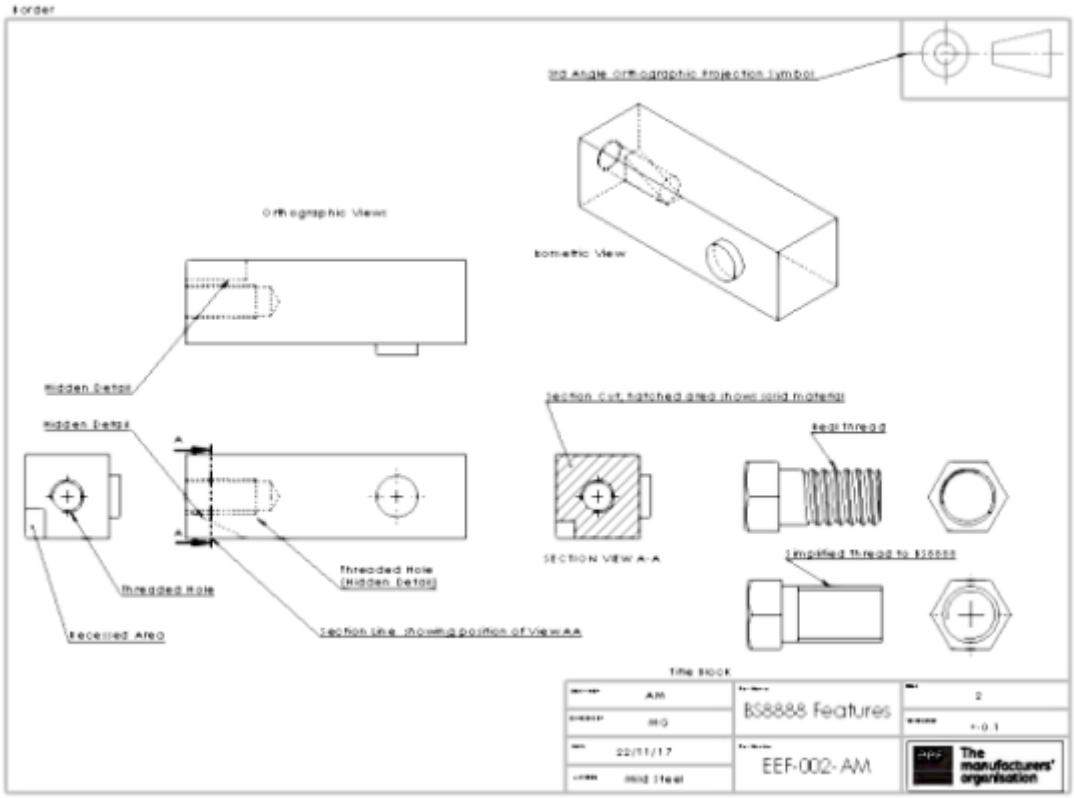
It is important to understand what each line type is and what they mean. There are three types of lines:

- ✓ Visible line: Indicates an edge is visible in relevant view
- ✓ Hidden line: Indicates the edge is behind a face
- ✓ Phantom line: Mostly used to indicate an alternate position of a moving part. Also used to indicate a break when the nature of the object makes the use of the conventional type of break unfeasible.
- ✓ Centre lines: drawn to indicate the exact geometric centre of the assembly. They are made from a series of lighter long and short dashes.



Reading engineering drawings - What's next?

Now it's time to try to visualize how the assembly is supposed to look like in 3D (for this you can ignore the exact dimensions). Most new drawings will have an isometric view to guide you. You can use the Bill of Materials to find the components in the drawing in order to understand the role they play in the assembly.



Remember that reading an engineering drawing can take a long time, depending on the complexity of the assembly and the experience of the reader.

UNIT 09

PERFORM WORKSHOP PRACTICES

Students commencing a career in sewerage need to develop a good basic knowledge of mechanical fittings practices prior to proceeding to the development of sewerage knowledge and skills

IDENTIFY AND EXPLAIN FUNCTIONS TOOLS USED IN MECHANICAL WORKSHOP

TOOLS IN MECHANICAL WORKSHOP

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

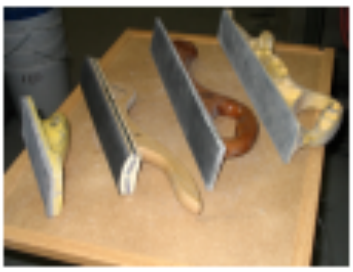
Usage: The nylon hammer with brass center offers mass and weight for use on softer metals.

Dead Blow Hammer

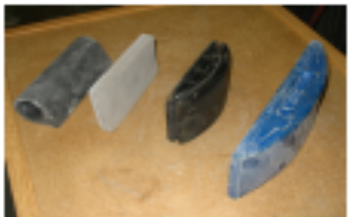
Usage: Dead Blow hammers have a plastic exterior with lead filler material, or shot, in the center. This gives weight and mass for moving softer metals without damage.

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.

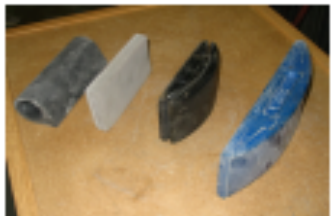
Side Cut Pliers

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.

PROPERTIES OF PIPES AND THEIR APPLICATIONS

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.
- ✓ **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.

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

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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

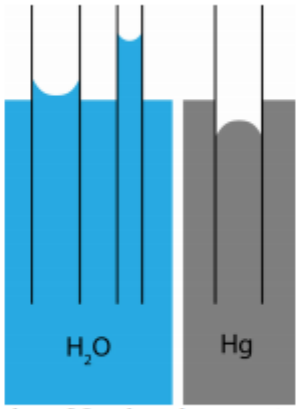
Many different materials are used for pipe and tube systems. The reason for their selection for different applications has been dealt with in Module 3, Unit
1, Piping Materials. For the purpose of this unit we will be dealing with the following materials:

- ✓ 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:

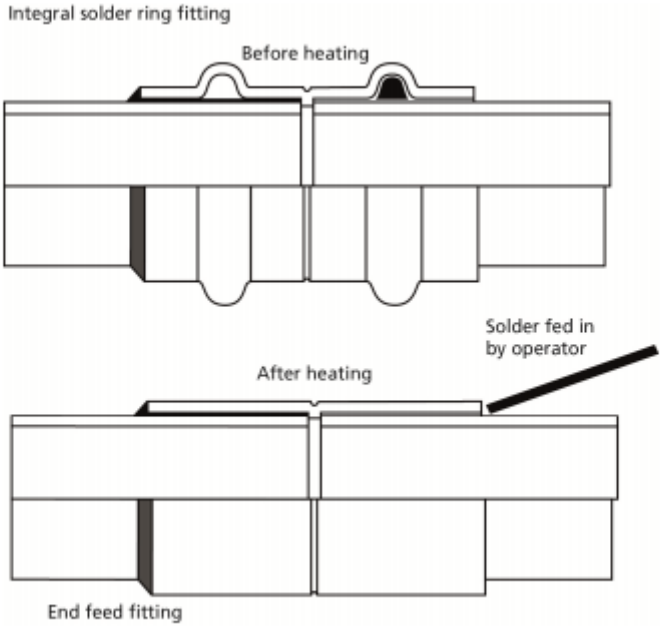
- ✓ Hard Soldering
- ✓ Soft Soldering

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.



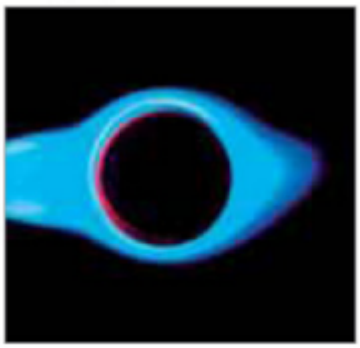
Soldered joints demonstrating capillary action (top joint integral solder ring, bottom joint solder fed by operator)

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

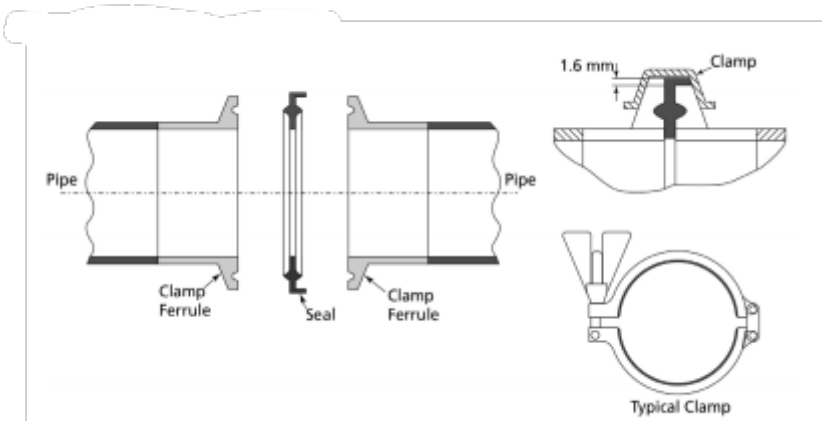
Tri-clamp and Compression Joints for Tube Systems

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

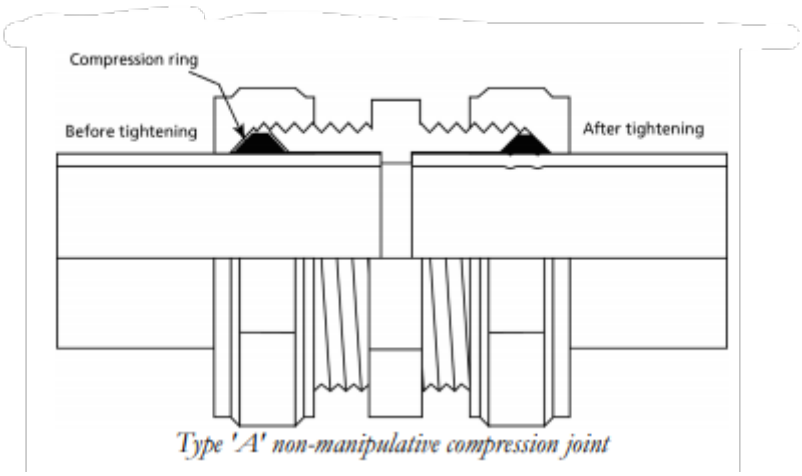
The compression fitting is composed of an outer compression nut and an inner ring called a compression ring. This brass ring is referred to as a ferrule or olive. This is usually made of brass or copper. When the nut is tightened, it clamps down on the ferrule, causing it to conform to the circumference 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.

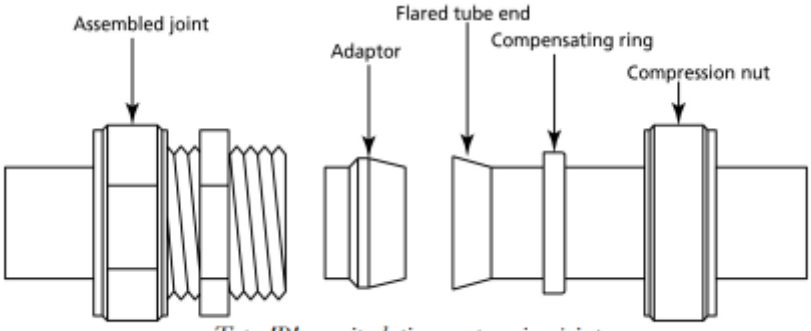
Non-Manipulative Compression Joint

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.

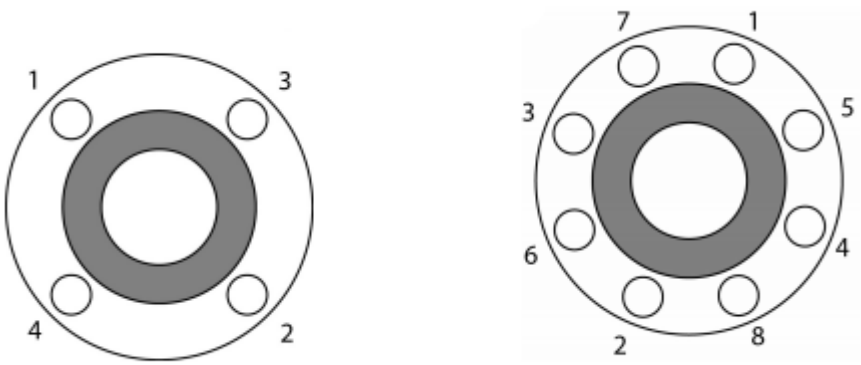
Flanged Pipe Joints

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.

2. Always use flat washers on both sides of the connection.
4. Tighten all bolts until finger tight and ensure that joint and gasket are correctly aligned.
5. 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.

6. 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.)
7. Using this pattern, tighten the bolts in 20% increments of the final bolt torque until 80% of final bolt torque has been achieved.
8. 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.
9. 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.

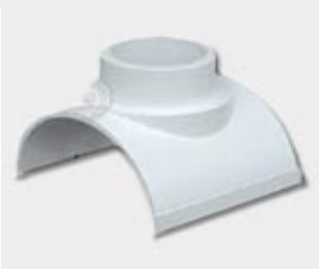
Tees are offered in ABS, brass, chrome-plated brass, copper, CPVC, malleable (galvanized and black), PVC, and stainless steel.

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.

USING MEASURING INSTRUMENTS PROPERLY

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 and effectively. The tool must be in good working condition and free from fracture and jagged edges. Repair or replace as necessary. 2. Carry out regular tool maintenance to maximise the service life and to ensure ongoing accuracy of the tool. 3. Read the tool manufacturer's operating instructions. Tools can vary from
Correct tool for the job	4. To reduce down time in searching for tools always return the tools to their correct position on the shadow board or in their container. 5. Ensure that tools are kept clean and free from grease or oil. This will prevent the grease or oil from being transferred to the customer's vehicle and will also assist the technician to maintain a firm grip of the tool. 6. Ensure that the tool is correctly calibrated before use. A faulty measuring tool will provide inaccurate readings which could prove to be expensive if relied upon.
Tag faulty tools	7. Tools that are faulty, damaged or in need of calibration should be removed from service, tagged and reported to the workshop supervisor. 8. Only use tools for their intended purpose. Measuring tools are precision instruments that have been designed for specific purposes. Using them outside specifications may cause damage, premature wear or give unreliable results. 9. Always double check measurements. Refer to conversion charts for imperial and metric measurements
Very Important Safety Points	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 bevel 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 is important to appreciate their construction. They are constructed of two scales:

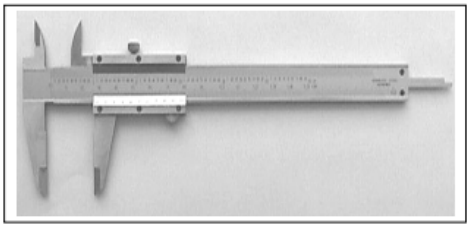
- ✓ Main scale, which is measured in millimetres or inches.
- ✓ Vernier scale, which is measured in fractions of a millimetre or an inch

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)



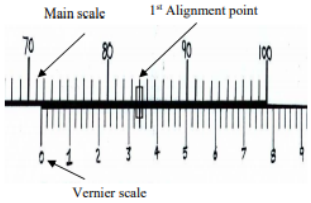
The three main applications of a Vernier scale are to measure outside diameters, inside diameters and depth.

Vernier Scale

Reading the Vernier scale
Step 1

From the main scale (top row) take the reading in whole millimetres up to the zero point on the Vernier scale.

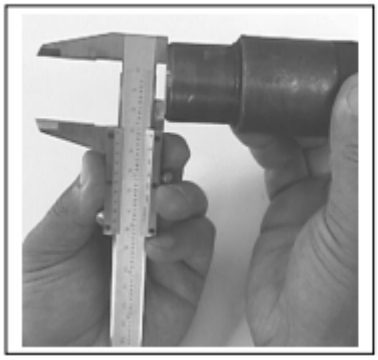
Step 2
Using the Vernier scale (bottom row) locate the first point at which the Vernier scale is in alignment with the main scale.



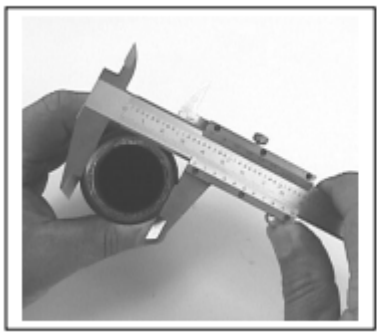
Step 3
Add the readings together. A thumb lock is used to clamp the caliper sliding bars to enable the user to inspect closely when measuring in awkward places. Calipers are also available with a dial indicator gauge. It is recommended that eye protection be worn when operating a Vernier caliper.

Internal Reading

Correct use of Vernier calipers

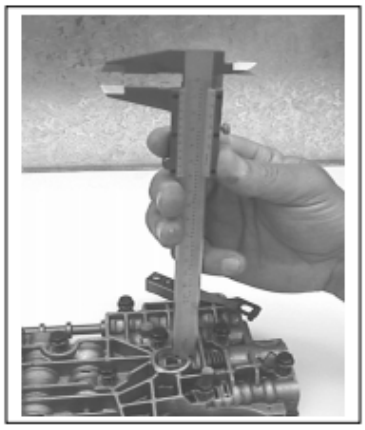


Ensure that both of the internal jaws are placed d into the object to be measured.



When measuring outside diameter the work must placed fully into the Vernier jaws.

Depth Reading

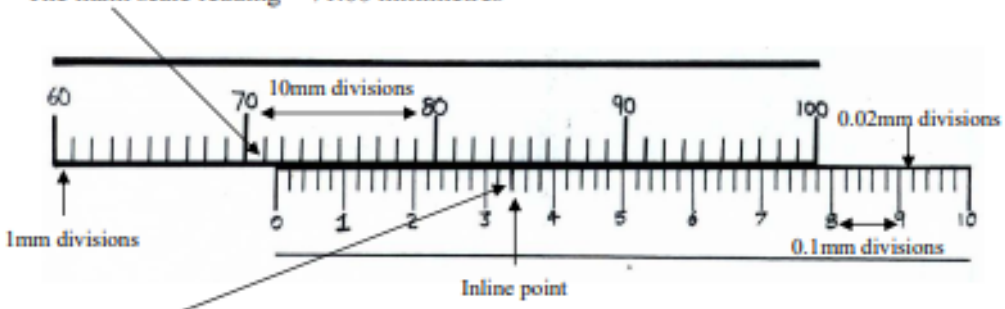


To measure depth, ensure that the Vernier measuring scale is flush against the side of the work

Reading the Vernier scale

Example One

The main scale reading = 71.00 millimetres

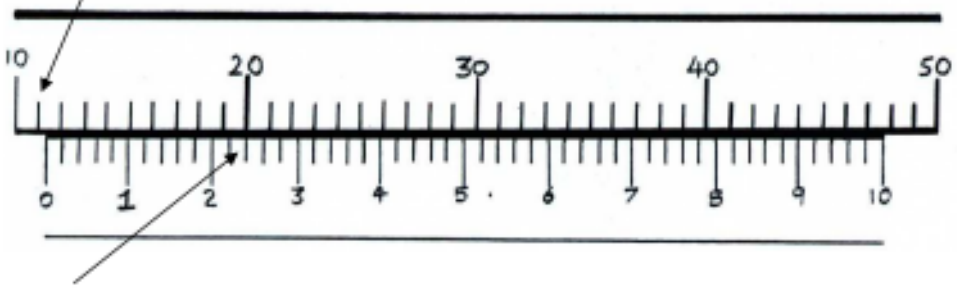


The Vernier scale reading =0.34 millimetres

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

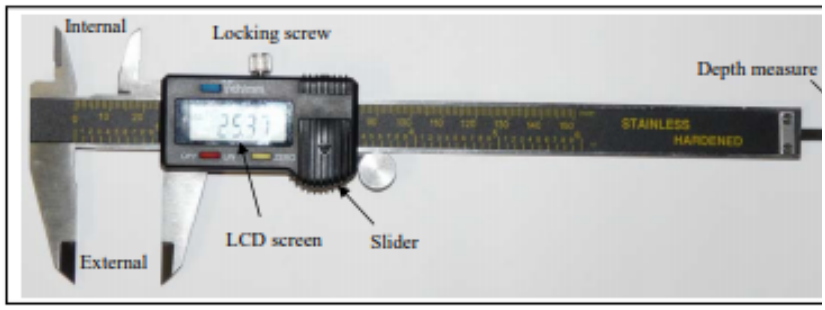
Storage and handling of Vernier calipers

- Handle calipers carefully. Avoid dropping or bumping. Calipers are precision tools and any damage will affect the accuracy of readings taken.
- 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

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.

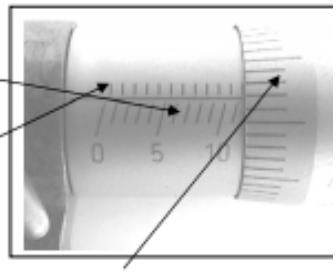
Turn the ratchet clockwise until the ratchet clicks, (two or three attempts are required to ensure the work is centralised).

Centralise the Work

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.

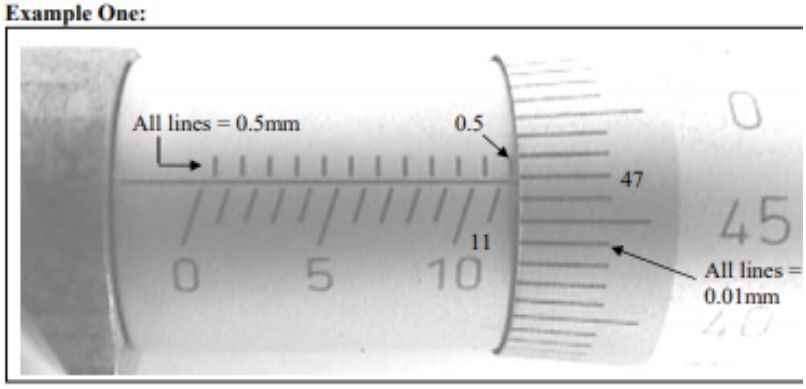


The next reading is taking from the scale on the thimble (this scale is measured 0.01mm graduations).

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.

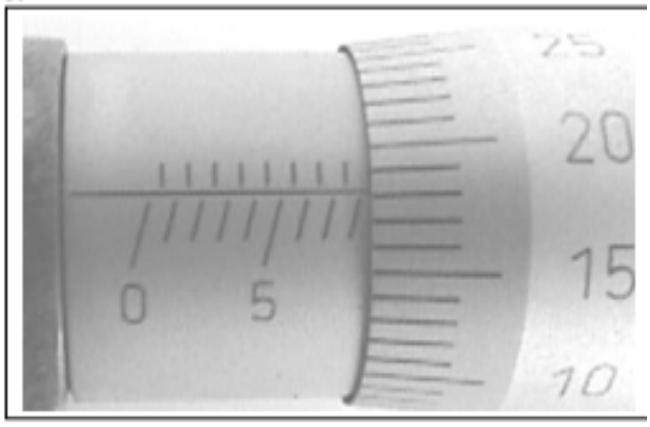
Example One:



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:



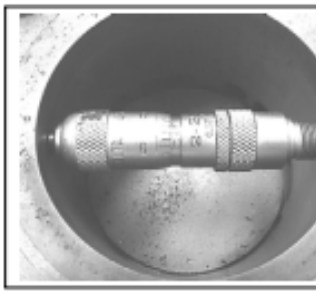
Lower scale reading = 8.00 millimetres
Upper scale reading = 0.00 millimetres
Thimble scale reading = 0.18 millimetres

Outside Micrometer reading = 8.18 millimetres

The inside micrometer is a precision tool designed to measure the inside diameter of an object.

An inside micrometer consists of:

- Spindle
- Thimble
- Anvils
- Extension piece (if required).



Using an inside micrometer

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.

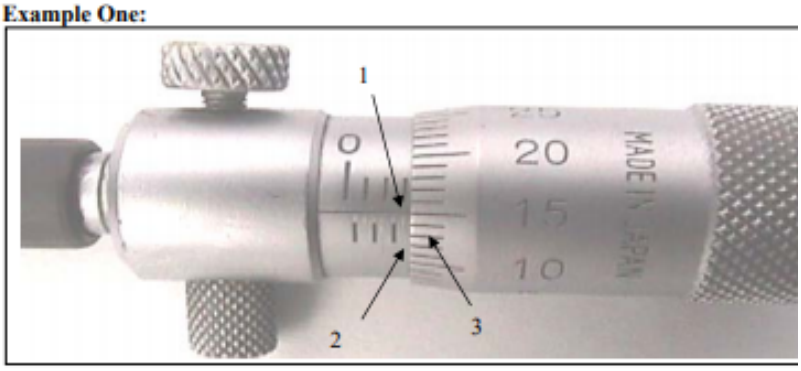
Remove the inside micrometer to allow a close inspection of the measuring scale.

The reading is taken in the same way as an outside micrometer reading.

Internal Micrometer Reading

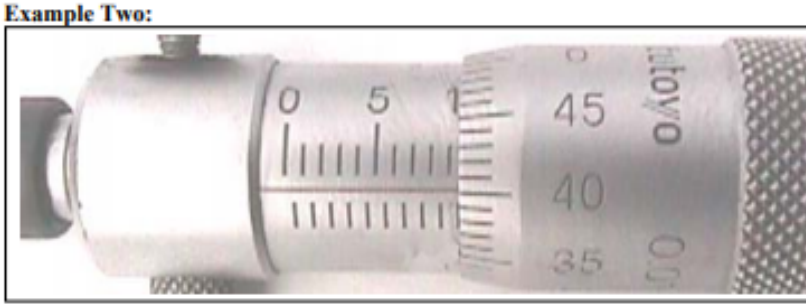
1. The upper scale on the sleeve indicates the distance in whole millimetres.
2. The lower scale on the sleeve indicates the distance in 0.5mm graduations. upper and lower scales are read from left to right.
3. The thimble scale indicates the distance in 0.01 millimetre graduations and is from bottom 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

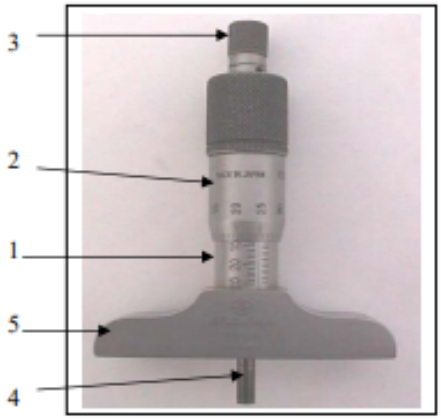
Depth Micrometers

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.

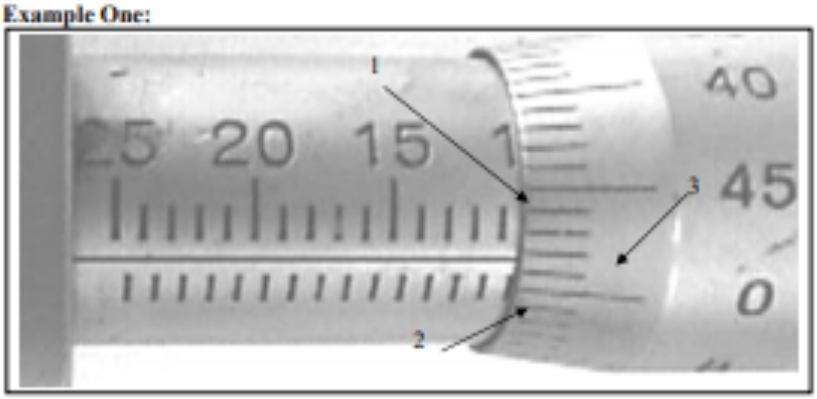
The measuring scale on the sleeve is read from right to left and the measuring scale on the thimble is read anti-clockwise.

Using a Depth Micrometer

The upper scale on the sleeve indicates the distance in whole millimetres.

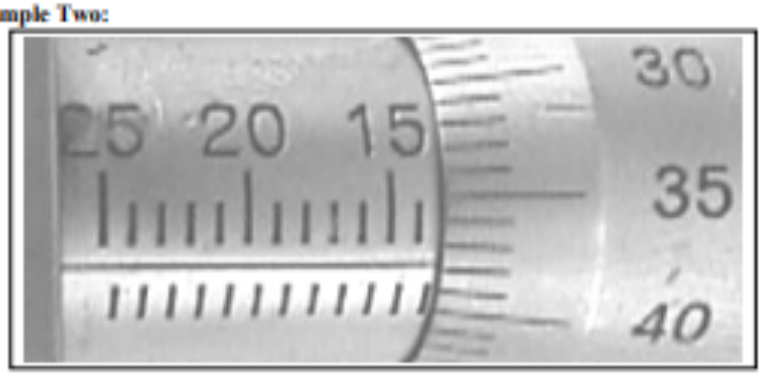
1. The lower scale indicates the distance in 0.5 millimetre graduations. The upper and lower scales are read from right to left.
2. The thimble scale indicates the distance in 0.01 millimetre graduations as in read from top to bottom.

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

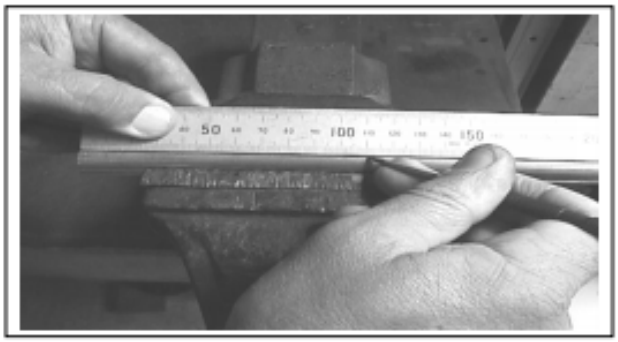
- ✓ Handle micrometers carefully. Avoid dropping or bumping. Micrometers are precision tools and any damage will affect the accuracy of readings taken.
- ✓ Before use wipe off any dust from the spindle, anvil and measuring faces.
- ✓ Allow the micrometer some time to adjust to room temperature.
- ✓ After 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 Measuring



Using a Steel Rule to measure work.

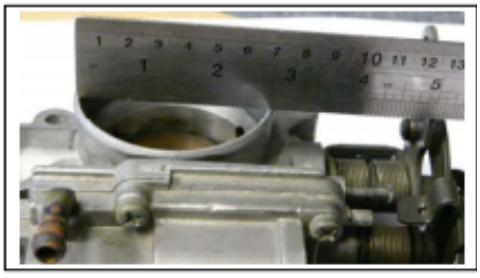
It is important that the steel rule is perfectly flat and straight with straight edges.

Flush with 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.

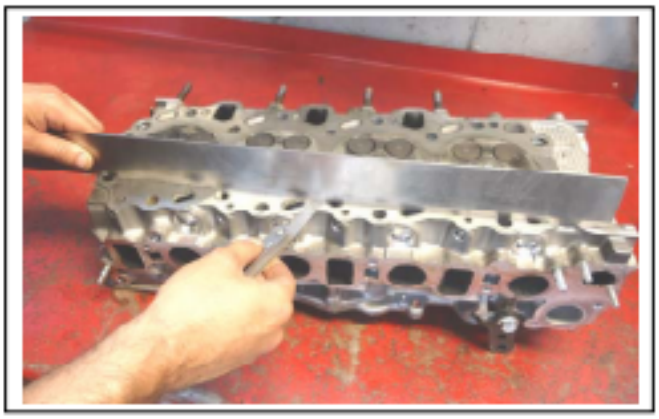


Steel rules should be oiled to prevent rusting when not in use.

Straight Edges

Determine Warpage

A standard straight edge is approximately one metre long. It is constructed from precision machined steel and has two straight edges and a measuring scale on one edge. The straight edge is used with a feeler gauge to determine warp in cylinder heads, engine blocks and manifolds.



Using a Straight Edge with a Feeler Gauge to measure warp on a cylinder head.

Take Note

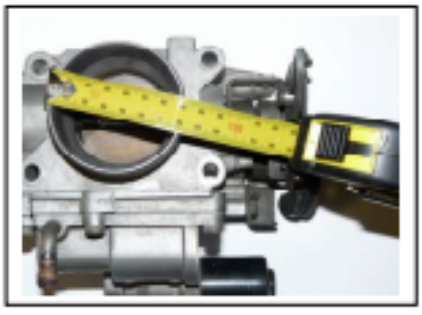
Storage and handling of steel rules and straight edges

- Handle rules and edges carefully. Avoid dropping or bumping. Remember these are precision tools and any damage will affect the accuracy of readings taken.
- Rules and edges must never be exposed to an electrical supply.
- After use, rules and edges should be cleaned and dried thoroughly.
- Steel rules should be stored in their protective plastic covering provided by the manufacturer when not in use.
- Store rules and edges their protective cover and hang on a 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 in 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 is important to remove any moisture from the surface of the square.
- Apply a thin layer of oil before storing. Store in original case away from other tools.

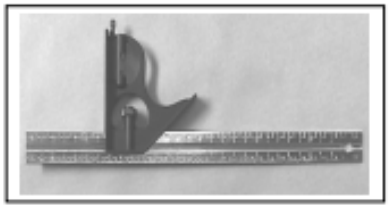
Combination Squares

Multipurpose Measure and Level

A combination square is a hand held tool that is precision made and is designed as a multipurpose measure and level. It has a 30cm steel rule blade with metric and imperial measurements, a groove through the centre of the blade and a spirit level attachment that travels along the groove.

The spirit level attachment has a precision machined surface that runs at 90 degrees to the steel rule blade and a thumb screw to lock the spirit level attachment to the steel rule blade. A 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.

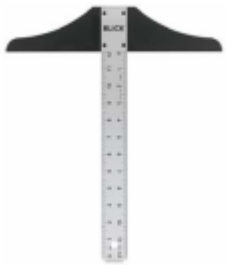
Scribing a 45° angle on a piece of work.

Take Note

Storage and handling of engineer's squares

- Wipe clean and dry with a rag. To prevent rusting it is important to remove any moisture from the surface of the 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 from 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.

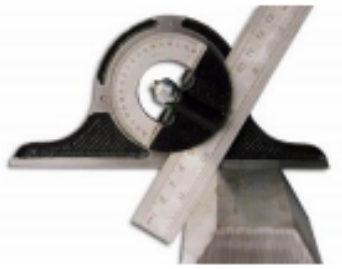
A T-square has two components - the long shaft called the "blade" and the short shaft called the "stock" or "head".

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

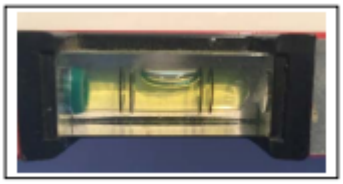
- Store by hanging.
- Keep free from oil and grease. Wipe clean with rag.
- Ensure that the work is securely held.
- Loosen securing bolts for the swivel plate before adjustments

- 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.

UNDERTAKE BASIC ARC WELDING

Safety in Welding

Welding Hazards

1. Electric shock can kill.

Touching live electrical parts can cause fatal shocks or severe burns. The electrode and work circuit is electrically live whenever the output is on. The input power circuit and machine internal circuits are also live when power is on. In semiautomatic or automatic wire welding, the wire, wire reel, drive roll housing, and all metal parts touching the welding wire are electrically live. Incorrectly installed or improperly grounded equipment is a hazard**.**

- ✓ Do not touch live electrical parts.
- ✓ Wear dry, hole-free insulating gloves and body protection.

- ✓ Insulate yourself from work and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground.
- ✓ Do not use AC weld output in damp, wet, or confined spaces, or if there is a danger of falling.
- ✓ Use AC output ONLY if required for the welding process.
- ✓ If AC output is required, use remote output control if present on unit.
- ✓ Additional safety precautions are required when any of the following electrically hazardous conditions are present: in damp locations or while wearing wet clothing; on metal structures such as floors, gratings, or scaffolds; when in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or accidental contact with the workpiece or ground. For these conditions, use the following equipment in order presented: 1) a semiautomatic DC constant voltage (wire) welder, 2) a DC manual (stick) welder, or 3) an AC welder with reduced open-circuit voltage. In most situations, use of a DC, constant voltage wire welder is recommended. And, do not work alone!
- ✓ Disconnect input power or stop engine before installing or servicing this equipment.
- ✓ Properly install, ground, and operate this equipment according to its Owner's Manual and national, state, and local codes.
- ✓ Always verify the supply ground – check and be sure that input power cord ground wire is properly connected to ground terminal in disconnect box or that cord plug is connected to a properly grounded receptacle outlet.
- ✓ When making input connections, attach proper grounding conductor first – double-check connections.
- ✓ Keep cords dry, free of oil and grease, and protected from hot metal and sparks.
- ✓ Frequently inspect input power cord and ground conductor for damage or bare wiring – replace immediately if damaged – bare wiring can kill.
- ✓ Turn off all equipment when not in use.
- ✓ Do not use worn, damaged, undersized, or repaired cables.
- ✓ Do not drape cables over your body.
- ✓ If earth grounding of the workpiece is required, ground it directly with a separate cable.
- ✓ Do not touch electrode if you are in contact with the work, ground, or another electrode from a different machine.
- ✓ Do not touch electrode holders connected to two welding machines at the same time since double open-circuit voltage will be present.
- ✓ Use only well-maintained equipment. Repair or replace damaged parts at once. Maintain unit according to manual.
- ✓ Wear a safety harness if working above floor level.
- ✓ Keep all panels and covers securely in place.
- ✓ Clamp work cable with good metal-to-metal contact to workpiece or worktable as near the weld as practical.
- ✓ Insulate work clamp when not connected to workpiece to prevent contact with any metal object.
- ✓ Do not connect more than one electrode or work cable to any single weld output terminal. Disconnect cable for process not in use.

- ✓ Use GFCI protection when operating auxiliary equipment in damp or wet locations.

2. Hot parts can burn.

- ✓ Do not touch hot parts barehanded.
- ✓ Allow cooling period before working on equipment.
- ✓ To handle hot parts, use proper tools and/or wear heavy, insulated welding gloves and clothing to prevent burns.

3. Fumes and gases can be hazardous.

Welding produces fumes and gases. Breathing these fumes and gases can be hazardous to your health.

- ✓ Keep your head out of the fumes. Do not breathe the fumes.
- ✓ Ventilate the work area and/or use local forced ventilation at the arc to remove welding fumes and gases. The recommended way to determine adequate ventilation is to sample for the composition and quantity of fumes and gases to which personnel are exposed.
- ✓ If ventilation is poor, wear an approved air-supplied respirator.
- ✓ Read and understand the Safety Data Sheets (SDSs) and the manufacturer's instructions for adhesives, coatings, cleaners, consumables, coolants, degreasers, fluxes, and metals.
- ✓ Work in a confined space only if it is well ventilated, or while wearing an air- supplied respirator. Always have a trained watchperson nearby. Welding fumes and gases can displace air and lower the oxygen level causing injury or death. Be sure the breathing air is safe.
- ✓ Do not weld in locations near degreasing, cleaning, or spraying operations. The heat and rays of the arc can react with vapors to form highly toxic and irritating gases.
- ✓ Do not weld on coated metals, such as galvanized, lead, or cadmium plated steel, unless the coating is removed from the weld area, the area is well ventilated, and while wearing an air-supplied respirator. The coatings and any metals containing these elements can give off toxic fumes if welded.

4. Arc rays can burn eyes and skin.

Arc rays from the welding process produce intense visible and invisible (ultraviolet and infrared) rays that can burn eyes and skin. Sparks fly off from the weld.

- ✓ Wear an approved welding helmet fitted with a proper shade of filter lenses to protect your face and eyes from arc rays and sparks when welding or watching.
- ✓ Wear approved safety glasses with side shields under your helmet.
- ✓ Use protective screens or barriers to protect others from flash, glare and sparks; warn others not to watch the arc.
- ✓ Wear body protection made from durable, flame−resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.

5. Welding can cause fire or explosion.

Welding on closed containers, such as tanks, drums, or pipes, can cause them to blow up. Sparks can fly off from the welding arc. The flying sparks, hot workpiece, and hot equipment can cause fires and burns. Accidental contact of electrode to metal objects can cause sparks, explosion, overheating, or fire. Check and be sure the area is safe before doing any welding.

- ✓ Remove all flammables within 35 ft (10.7 m) of the welding arc. If this is not possible, tightly cover them with approved covers.
- ✓ Do not weld where flying sparks can strike flammable material.
- ✓ Protect yourself and others from flying sparks and hot metal.
- ✓ Be alert that welding sparks and hot materials from welding can easily go through small cracks and openings to adjacent areas.
- ✓ Watch for fire, and keep a fire extinguisher nearby.
- ✓ Be aware that welding on a ceiling, floor, bulkhead, or partition can cause fire on the hidden side.
- ✓ Do not cut or weld on tire rims or wheels. Tires can explode if heated. Repaired rims and wheels can fail.
- ✓ Do not weld on containers that have held combustibles, or on closed containers such as tanks, drums, or pipes unless they are properly prepared.
- ✓ Do not weld where the atmosphere can contain flammable dust, gas, or liquid vapors (such as gasoline).
- ✓ Connect work cable to the work as close to the welding area as practical to prevent welding current from traveling long, possibly unknown paths and causing electric shock, sparks, and fire hazards.
- ✓ Do not use welder to thaw frozen pipes.
- ✓ Remove stick electrode from holder or cut off welding wire at contact tip when not in use.

- ✓ Wear body protection made from durable, flame−resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.
- ✓ Remove any combustibles, such as a butane lighter or matches, from your person before doing any welding. After completion of work, inspect area to ensure it is free of sparks, glowing embers, and flames.
- ✓ Use only correct fuses or circuit breakers. Do not oversize or bypass them.

6. Flying metal or dirt can injure eyes.

- ✓ Welding, chipping, wire brushing, and grinding cause sparks and flying metal. As welds cool, they can throw off slag.
- ✓ Wear approved safety glasses with side shields even under your welding helmet

7. Buildup of gas can injure or kill.

- ✓ Shut off compressed gas supply when not in use.
- ✓ Always ventilate confined spaces or use approved air-supplied respirator.

8. Electric and Magnetic Fields (EMF) can affect Implanted Medical Devices.

- ✓ Wearers of Pacemakers and other Implanted Medical Devices should keep away.
- ✓ Implanted Medical Device wearers should consult their doctor and the device manufacturer before going near arc welding, spot welding, gouging, plasma arc cutting, or induction heating operations.

9. Noise can damage hearing.

Noise from some processes or equipment can damage hearing. Wear approved ear protection if noise level is high

10. Cylinders can explode if damaged.

Compressed gas cylinders contain gas under high pressure. If damaged, a cylinder can explode. Since gas cylinders are normally part of the welding process, be sure to treat them carefully.

- ✓ Protect compressed gas cylinders from excessive heat, mechanical shocks, physical damage, slag, open flames, sparks, and arcs.
- ✓ Install cylinders in an upright position by securing to a stationary support or cylinder rack to prevent falling or tipping.
- ✓ Keep cylinders away from any welding or other electrical circuits.
- ✓ Never drape a welding torch over a gas cylinder.
- ✓ Never allow a welding electrode to touch any cylinder.
- ✓ Never weld on a pressurized cylinder − explosion will result.
- ✓ Use only correct compressed gas cylinders, regulators, hoses, and fittings designed for the specific application; maintain them and associated parts in good condition.
- ✓ Turn face away from valve outlet when opening cylinder valve. Do not stand in front of or behind the regulator when opening the valve.
- ✓ Keep protective cap in place over valve except when cylinder is in use or connected for use.
- ✓ Use the proper equipment, correct procedures, and sufficient number of persons to lift, move, and transport cylinders.

PERFORM BASIC WORKSHOP PRACTICES

Keeping record of measurements

An understanding of the equipment capabilities and the ability to keep proper records form the foundation of laboratory experiments. In today's experiment you will learn the importance of equipment precision, significant figures, and units of measurement. These are concepts that you will carry with you for the rest of your engineering career.

Instrument Precision and Significant Digits

The instruments used in the ECE 110 Lab have a great deal of precision. This means that they have the potential to measure data to many significant digits. It is important to recognize that the number of digits available in the instrument's precision is not necessarily equal to the number of significant digits gained by a measurement. Measured data should have no more significant digits than the instrument's precision allows. In fact, the recorded data will typically have fewer digits than shown on the instrument display. Most measurements we make in the lab are noisy so that not all the digits displayed on an instrument will "hold still". When one or more of the instrument's digits fluctuates, you should record all the non-fluctuating digits and the average value of the first fluctuating digit you encounter. For example, a 4-digit measurement that fluctuates between 1.314 and 1.351 volts might be recorded as 1.33

V (three significant digits). The last digits of these numbers have no meaningful value in this case and so they are ignored.

Units

In science and engineering, numbers are used to represent physical quantities. The physical quantity being represented is made unambiguous by its units. Therefore, when recording a measurement, you must always include the corresponding units. You cannot just assume that you will remember later or that the person reading your report will "just know what you meant". In addition, the units used must be clear – this is why we use standardized units of measurement like volts (V), millivolts (mV), seconds (s), and amps (A).

Tables of Data

In the field of engineering, you will often need to characterize the behavior of various devices utilized in larger systems. This is often done by varying a parameter of the circuit (e.g. voltage supplied to a device) and measuring some other parameter (e.g. current flowing through that device). This process typically requires filling tables with measurements, performing calculations and generating graphs with the collected data. Throughout this process, you will need to provide proper units and significant figures for each measurement in a table. To avoid confusion, it is useful to write all your measurements in the same units and make note of the units in the column header.

In addition to keeping track of the details of your measurements, it is equally important to make detailed notes. In this course, the tables provided in your procedures will have a column for comments. The notes you make while recording measurements can describe the behavior of the device you're testing (eg. The wheel just started turning!), events in the surrounding environment (eg. Something smells burnt.), or actions taken by the experimenter that might have had an effect on the measurement (eg. I knocked my motor off the table, but it still seems to work.).

Graphical Representation of Data

How can we depict our measurements in a manner that is easy to read, understand, and draw conclusions from? We can use graphs! But we must take care when creating a graph in order to avoid ambiguity. Well-measured data, when poorly plotted, can lead to erroneous conclusions and be very confusing to someone reading your report. Even your future self will likely have difficulty interpreting your own report.

Graphs (and charts) are very concise and useful methods of depicting a large amount of data. This portion of the lab outlines the necessary components for an informative graph. You will be required to draw a few graphs by had, but most will be produced using a powerful computing platform – MATLAB. So, in addition to an introduction to "good plotting habits", you will get a quick introduction to plotting graphs using MATLAB. MATLAB is a high-level programming language and computing environment

that has become a very common tool among engineers. It is important that you get comfortable with it early in your academic career.

Plotting Graphs

Below are the details that are necessary when plotting a graph. Without these details, a person reading your lab report might not understand what your graph means and you will not receive full credit.

Title/Caption

The title of your graph should give the reader an idea of what is plotted and why it matters. In a lab course like ECE110, it should be made clear which step (or question) in the procedure is being addressed by the graph.

Axes labels and Units

The labels for your axes should tell the reader what physical quantity is being plotted. Calling your axes x and y is uninformative and is considered inadequate in a quantitative experimental setting. Common labels in ECE110 include time (in seconds) as the horizontal axis and voltage (in Volts) as the vertical axis or voltage (V) as the horizontal axis and current (mA) as the vertical axis. Always, where appropriate, include the units in the axis label.

Axes scales

The scale of your axes is usually depicted by labeling three or more divisions with a numerical value. Sometimes your scale will be integer-valued and in other cases it might not be. Keep in mind that the scale of your graph should be chosen to show critical detail. If you choose a scale too large, the plot will be too small and the reader will have a hard time seeing important aspects of the curve.

Legend/plot labels

Legends are necessary when you have multiple curves on one graph. Each plot should be clearly labeled so that is clear what data are represented by each curve on your graph.

UNIT 10

APPLY ELECTRICAL SKILLS

This unit of competency specifies the outcomes required to install and troubleshoot single phase and three phase electrical equipment. Starting with fundamentals, the unit will facilitate development of electrical knowledge and skills to undertake electrical connections to diagnosis of faults in electrical systems

DEVELOP FUNDAMENTALS OF ELECRICITY

Electrical Safety

We rely on electricity, but sometimes underestimate its capability of causing injury. Even household current (120 volts) can stop your heart. UW personnel need to be aware of the hazards electricity poses, such as shock, fire and explosion, and either eliminate or control those hazards.

Shock

Electrical shock happens when current passes through the body. Electricity travels through closed circuits, and people, sometimes tragically, can become part of the circuit. When a person receives a shock, electricity flows between parts of the body or through the body to a ground. This can happen if someone touches both wires of an energized circuit, touches one wire of the circuit while standing unprotected or touches a metal part that has become energized.

Electrocution refers to the injury or lethal dose of electrical energy. Electricity can also cause forceful muscle contraction or falls. The severity of injury depends on the amount of current flowing through the body, the current's path through the body, the length of time the body remains in the circuit and the current's frequency.

Fire/Explosion

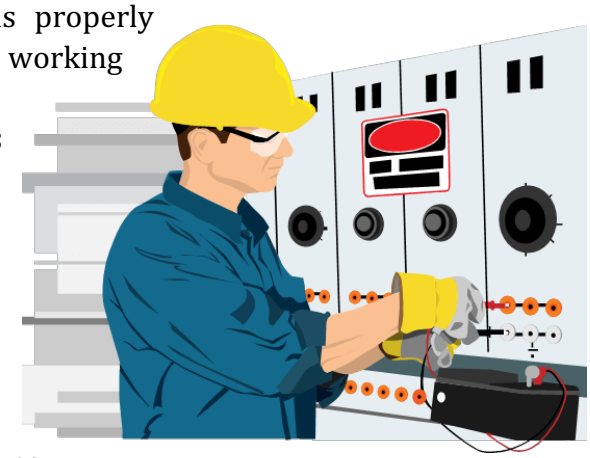
Electrical fires may be caused by excessive resistance that generates heat from any of the following:

- ✓ Too much current running through wiring where overcurrent protection fails or does not exist
- ✓ Faulty electrical outlets resulting in poor contact or arcing
- ✓ Poor wiring connections and old wiring that is damaged and cannot support the load

An explosion can occur when electricity ignites a flammable gas or combustible dust mixture in the air. Ignition from a short circuit or static charge is possible.

Electrical Safety Basics

- ✓ Don't work with exposed conductors carrying 50 volts or more.
- ✓ Make sure electrical equipment is properly connected, grounded and in good working order.
- ✓ Extension cords may not be used as permanent wiring and should be removed after temporary use for an activity or event.
- ✓ Surge suppressors with built-in circuit breakers may be used long-term and are available with three, six and 15 foot-long cords.



- ✓ High amperage equipment such as space heaters, portable air conditioners and other equipment must be plugged directly into permanent wall receptacles.
- ✓ Do not access, use or alter any building's electrical service, including circuit breaker panels, unless you are specifically qualified and authorized to do so.
- ✓ Wet environments can increase the risk of an electrical shock.

Housekeeping and Maintenance

- ✓ Maintain at least 30 inches of clearance in front of electrical panels to ensure a safe environment for facilities workers.
- ✓ Make sure that all junction boxes are covered.

Avoid Activities That Requires Training

- ✓ Working with exposed conductors carrying 50 volts or more
- ✓ Making repairs or alterations to any electrical equipment
- ✓ Opening up the case, or removing barrier guards, of any equipment that utilizes electricity
- ✓ Using any tools or a meter to measure for the presence of electricity
- ✓ Resetting a tripped circuit breaker, or replace a blown fuse

Ask a qualified person to perform these tasks.

Grounding

To prevent electrical hazards, always make sure equipment is properly grounded. Electrical grounding provides an alternate path for electricity to follow, rather than going through a person. Equipment with a grounding prong must be plugged into an extension cord with a ground; the grounding plug should not be removed from the equipment.

Wet Locations

When using electricity in a wet or damp location, including outdoor locations, a Ground Fault Circuit Interrupter (GFCI) must be used. The GFCI ensures that any electrical shock is brief. Although painful, it wouldn't be fatal because the GFCI creates a ground fault or leak in the current.
Additional information about GFCI devices can be found in the Ground Fault Circuit Interrupter Focus Sheet.

Lockout/Tagout

When servicing and maintenance tasks involve electricity and electrical equipment, you must prevent the unexpected startup of equipment

What is Electricity and How Electricity is Generated and Used

There are some inventions that changed human civilization. The first invention was the **wheel**, the second invention was **electricity**, the third invention was **telecommunication**s, and the fourth invention was the **computer**. We will discuss the basic **introduction of electricity**. Each substance in this universe is made of plenty of atoms and each atom has the same number of negative electrons and positive protons.
As a result, we can say that each neutral substance has the same number of electrons and protons in it. The protons are immovable and strongly attached to the nucleus of the atoms. Electrons are also bounded to atoms and orbiting around the nucleus at different distinct levels. But some of the electrons can move freely or can come out from their orbit due to external influences. These free and as well as loosely bonded electrons cause **electricity**.
In neutral condition, the number of electrons and protons is the same in any piece of substance. But if somehow the number of electrons in a substance becomes more than the number of protons, the substance becomes negatively charged as the net charge of each electron is negative. If the number of electrons in a substance becomes less than the number of protons, the substance becomes positively charged.
The concentration of free electrons always tries to be uniform. This is the only reason for electricity. Let us explain in detail. If two dissimilarly charged conductive bodies come in contact, the electrons from the body of higher electron concentration will move to the body of lower electron concentration to balance the electron concentration of both bodies. This movement of charge (as electrons are charged particles) is electricity.

Related Terms in Electricity

Electric Charge

As we told earlier that the number of electrons and number of protons are equal in a neutral body. The amount of negative charge and positive change is also equal in a neutral body since the electric charge of an electron and a proton is numerically equal but their polarity is opposite. But for any reason, the balance of the number of electrons and protons in a body gets distributed the body becomes electrically charged. If the number of electrons more than that of protons the body becomes negatively charged and the amount of charge depends on the number of excess electrons in the body. In the same manner, we can explain the positive change of a body. Here the number of electrons becomes lesser than that of protons. The positivity of the body depends on the difference between protons and electrons in the body.

Electric Current

When charge flows from one point to another to make uniform charge distribution then the rate at which the charge is flowing called electric current. This rate mainly depends on the difference between the charged condition of two points and the conditions of the pathway through which the charge is flowing. The unit of electric current is Ampere and it is nothing but coulomb per second.

Electric Potential

he level of charged condition of a body is known as electric potential. When a body is charged it gets the ability to do some work. Electric potential is the measurement of the ability of a charged body to do work. The current flowing through a conductor is directly proportional to the difference of electric potential between at two ends of the conductor. The electric potential can be visualized as the difference of water level in two water tanks linked with a pipeline. The speed of water flowing from the higher headed tank to lower headed tank depends on the level difference or head difference of the water in the tanks not on the quantity of water stored in the tanks. In the same way, the electric current between two bodies depends on the potential difference between two bodies not on the

Electric Field

There is always a force between two nearly placed charged bodies. The force may be either attractive or repulsive depending on the nature of the charge of two bodies. When a charged body enters the nearby zone of another charged body the force is practically experienced. Space surrounds a charged body where another charged body can experience a force is called the electric field of the former body.

How is Electricity Generated

There are three basic ways by which we generally **produce electricity**

Electromechanical Process

When a conductor moves in a magnetic field and the conductor cuts the field flux lines electricity is produced in the conductor. Depending on this principle all electrical generators work such as DC generators, alternators, and all kinds of dynamos.

Electrochemical process

In all types of battery electricity is produced due to chemical reactions. Here chemical energy gets converted to electrical energy.

Solid State Electric **Generation**

This is the most modern process of electricity generation. Here, free electrons and holes are generated at a PN junction and distribution of charge carriers gets imbalanced across the PN junction when the junction is exposed in the light. These free electrons and holes and their imbalanced distribution across the junction cause electricity in an external circuit. On this principle, PV solar cells work.

Types of Electricity

- ✓ When electricity produced in the armature of a generator it is always alternating. That means polarity of electricity alters in a periodic interval. In DC generators the produced electricity in armature gets rectified through commutator. In alternators, the AC produced in the armature supplied to the external circuit through slip rings.
- ✓ When electricity does not change its direction it is called DC electricity. Batteries and solar cells produce DC electricity.

Generation and Transmission and Distribution of Electricity

After electricity gets generated in an electrical power plant it gets stepped up by step up transformer for transmitting purpose. The generation of electricity at a low voltage level is practical and economical. But low voltage transmission is not economical. But for electrical transmission, the generated electricity first gets stepped up, and then after transmission it is stepped down by step down transformers for electrical distribution purpose.

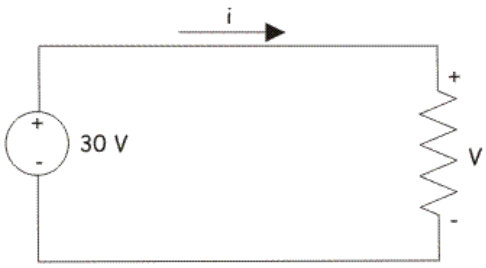
The generation of electricity, the transmission of electricity, and the distribution of electricity are normally with three-phase system. Very ultra-high voltage ac transmission is not economical always and that is why DC transmission is sometimes used. The supply system of domestic houses may be a single-phase AC but all commercial, industrial and bigger house supplies are of three phase system.

What is an Electric Circuit?

The interconnection of various active and passive components in a prescribed manner to form a closed path is called an electric circuit. The system in which electric current can flow from the source to the load and then back to the other terminal of the source is referred to as an electric circuit. The main parts of an ideal electric circuit are:

1. Electrical sources for delivering electricity to the circuit and these are mainly electric generators and batteries
2. Controlling devices for controlling electricity and these are mainly switches, circuit breakers, MCBs, and potentiometer like devices etc.
3. Protection devices for protecting the circuit from abnormal conditions and these are mainly electric fuses, MCBs, switchgear systems.
4. Conducting path to carry electric current from one point to other in the circuit and these are mainly wires or conductors.
5. Load.

Thus, voltage and current are the two basic features of an electric element. Various techniques by which voltage and current across any element in any electric circuit are determined is called electric circuit analysis. The figure shows a simple electric circuit containing a battery and resistor.



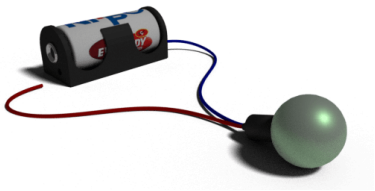
Basic Properties of Electric Circuits

- ✓ A circuit is always a closed path.
- ✓ A circuit always contains at least an energy source which acts as a source of electrons.
- ✓ The electric elements include uncontrolled and controlled source of energy, resistors, capacitors, inductors, etc.
- ✓ In an electric circuit flow of electrons takes place from negative terminal to positive terminal.
- ✓ Direction of flow of conventional current is from positive to negative terminal.
- ✓ Flow of current leads to potential drop across the various elements.

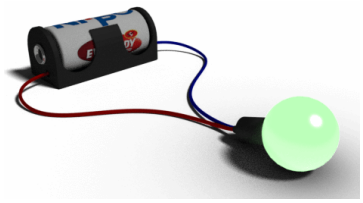
Types of Electric Circuits

Open circuit

If due to disconnection of any part of an electric circuit if there is no flow of current through the circuit, is said to be an open circuited.

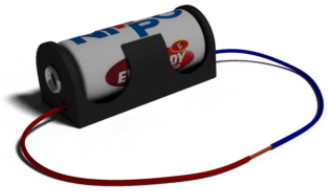


Closed circuit



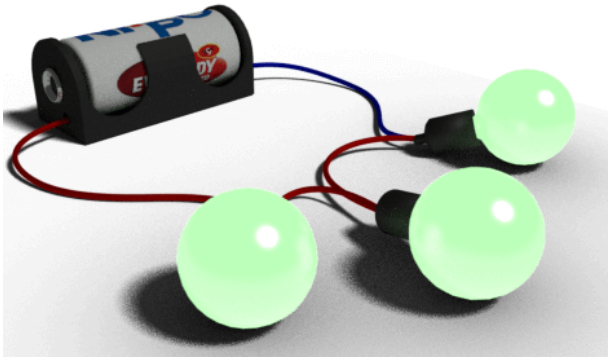
If there is no discontinuity in the circuit and current can flow from one part to another part of the circuit, the circuit is said to be closed circuit.

Short circuit



If two or more phases, one or more phases and earth or neutral of AC system or positive and negative wires or positive or negative wires and earth of DC system touch together directly or connected together by a zero impedance path then the circuit is said to be short circuited.

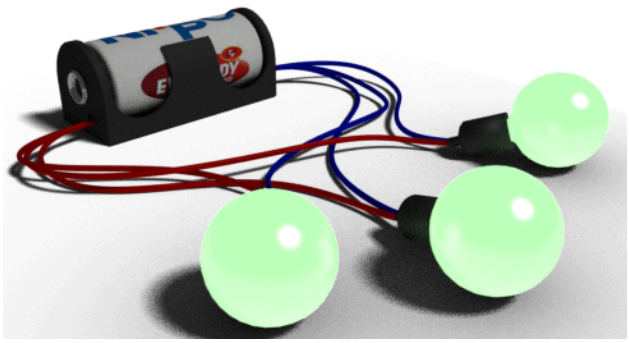
Series Circuits



When all elements of a circuit are connected one after another in tail to head fashion and due to which there will be only one path of flowing current then the circuit is called series circuit. The circuit elements then are said to be series connected. In the series electrical circuit, same current flows through all element connected in series.

Parallel Circuits

If components are connected in such a way that the voltage drop across each component is same then it is known as parallel circuit. In parallel circuit the voltage drop across each component is same but the currents flowing through each component may differ. The total current is the sum of currents flowing through each element.



An example of a parallel circuit is the wiring system of a house. If one of the electric lamp burns out, current can still flow through the rest of the lights and appliances.
In a parallel circuit the voltage is the same for all elements.

- ✓ To find the total resistance of all components, add the reciprocals of the resistances of each component and take the reciprocal of the sum.
- ✓ Total inductance of non-coupled inductors in parallel is equal to the reciprocal of the sum of the reciprocals of their individual inductances.

The capacitors connected in parallel acts as series combination.

- ✓ The total capacitance of capacitors in parallel is equal to the sum of their individual capacitance.

Series Parallel Circuits.

An electrical circuit in which some of the elements are connected in series and some of the elements are connected in parallel is called a series parallel circuit. Most of the practical circuits are series parallel circuits. A very common example is the connection of conductors in the rotor of DC motor.

Electrical Tools

Pliers

Pliers are available in different types, shape, and sizes. They are also available in both insulated and uninsulated handles. An insulated handle should be used when working on or near hot wires. It is also used for cutting big and small wires.

Screw Drivers

A screwdriver comes in various sizes and with several tip shapes. Screwdrivers used by electricians should have insulated handles. Using a screwdriver for a particular job, the width of the screwdriver tip should match the width of the screw slot.

Drilling Equipment

Drilling equipment is needed to make holes in building structure passages of conduits and wires.

Sawing and Cutting Tools

Saws commonly used by electricians include the crosscut, keyhole, and hacksaw

Soldering Equipment

In doing electric wiring, splices and taps (connections made to wire) should be soldered, unless you use solderless connectors. Typical equipment available for soldering are shown below.

Hammers

Hammers are used with chisels and for nailing and fitting. Below are examples of carpenter's claw hammer, lineman's hammer, and machinist's ball-peen hammer.

Measuring Tools

To measure wire length and other items, the electrician finds considerable use for measuring tools such as the extension or zigzag rule, push-pull rule and a steel tape as shown below.

Voltmeter or Multimeter

A voltmeter is used to read voltage levels and verify that circuits are "live" or off. Unlike a circuit tester, this tool gives you reading on *how much* voltage is being carried. More sophisticated forms of the tool are known as multimeters, and they can not only read voltage levels but also amperage, resistance, and DC voltage and amperage. They do, however, require practice to learn how to use them properly.
This specialty tool is used mostly by advanced DIYers and professional electricians. Casual DIYers may not need to own this tool, but those who do a lot of electrical work on appliances and electronics may find it essential.

Troubleshooting Electrical problems

To expertly troubleshoot electrical equipment, problems must be solved by replacing only defective equipment or components in the least amount of time. One of the most important factors in doing this, is the approach used. An expert troubleshooter uses a system or approach that allows them to logically and systematically analyze a circuit and determine exactly what is wrong.

The approach described here is a logical, systematic approach called the 5 Step Troubleshooting Approach. It is a proven process that is highly effective and reliable in helping to solve electrical problems.

This approach differs from troubleshooting procedures in that it does not tell you step by step how to troubleshoot a particular kind of circuit. It is more of a thinking process that is used to analyze a circuit's behavior and determine what component or components are responsible for the faulty operation. This approach is general in nature allowing it to be used on any type of electrical circuit.

In fact, the principles covered in this approach can be applied to many other types of problem solving scenarios, not just electrical circuits.

The 5 Step Troubleshooting Approach consists of the following:

- ✓ Preparation

- ✓ Step 1 Observation
- ✓ Step 2 Define Problem Area
- ✓ Step 3 Identify Possible Causes
- ✓ Step 4 Determine Most Probable Cause
- ✓ Step 5 Test and Repair
- ✓ Follow-up

Preparation

Before you begin to troubleshoot any piece of equipment, you must be familiar with your organization's safety rules and procedures for working on electrical equipment. These rules and procedures govern the methods you can use to troubleshoot electrical equipment (including your lockout/tagout procedures, testing procedures etc.) and must be followed while troubleshooting.

Next, you need to gather information regarding the equipment and the problem. Be sure you understand how the equipment is designed to operate. It is much easier to analyze faulty operation when you know how it should operate. Operation or equipment manuals and drawings are great sources of information and are helpful to have available. If there are equipment history records, you should review them to see if there are any recurring problems. You should also have on-hand any documentation describing the problem. (i.e., a work order, trouble report, or even your notes taken from a discussion with a customer.)

Step 1 - Observe

Most faults provide obvious clues as to their cause. Through careful observation and a little bit of reasoning, most faults can be identified as to the actual component with very little testing. When observing malfunctioning equipment, look for visual signs of mechanical damage such as indications of impact, chafed wires, loose components or parts laying in the bottom of the cabinet. Look for signs of overheating, especially on wiring, relay coils, and printed circuit boards.

Don't forget to use your other senses when inspecting equipment. The smell of burnt insulation is something you won't miss. Listening to the sound of the equipment operating may give you a clue to where the problem is located. Checking the temperature of components can also help find problems but be careful while doing this, some components may be alive or hot enough to burn you.

Pay particular attention to areas that were identified either by past history or by the person that reported the problem. A note of caution here! Do not let these mislead you, past problems are just that, past problems, they are not necessarily the problem you are looking for now. Also, do not take reported problems as fact, always check for yourself if possible. The person reporting the problem may not have described it properly or may have made their own incorrect assumptions.

When faced with equipment which is not functioning properly you should:

- ✓ Be sure you understand how the equipment is designed to operate. It makes it much easier to analyze faulty operation when you know how it should operate;
- ✓ Note the condition of the equipment as found. You should look at the state of the relays (energized or not), which lamps are lit, which auxiliary equipment is energized or running etc. This is the best time to give the equipment a thorough inspection (using all your senses). Look for signs of mechanical damage, overheating, unusual sounds, smells etc.;
- ✓ Test the operation of the equipment including all of its features. Make note of any feature that is not operating properly. Make sure you observe these operations very carefully. This can give you a lot of valuable information regarding all parts of the equipment.

Step 2 - Define Problem Area

It is at this stage that you apply logic and reasoning to your observations to determine the problem area of the malfunctioning equipment. Often times when equipment malfunctions, certain parts of the equipment will work properly while others not.

The key is to use your observations (from step 1) to rule out parts of the equipment or circuitry that are operating properly and not contributing to the cause of the malfunction. You should continue to do this until you are left with only the part(s) that if faulty, could cause the symptoms that the equipment is experiencing.

To help you define the problem area you should have a schematic diagram of the circuit in addition to your noted observations.

Starting with the whole circuit as the problem area, take each noted observation and ask yourself "what does this tell me about the circuit operation?" If an observation indicates that a section of the circuit appears to be operating properly, you can then eliminate it from the problem area. As you eliminate each part of the circuit from the problem area, make sure to identify them on your schematic. This will help you keep track of all your information.

Step 3 - Identify Possible Causes

Once the problem area(s) have been defined, it is necessary to identify all the possible causes of the malfunction. This typically involves every component in the problem area(s).

It is necessary to list (actually write down) every fault which could cause the problem no matter how remote the possibility of it occurring. Use your initial observations to help you do this. During the next step you will eliminate those which are not likely to happen.

Step 4 - Determine Most Probable Cause

Once the list of possible causes has been made, it is then necessary to prioritize each item as to the probability of it being the cause of the malfunction. The following are some rules of thumb when prioritizing possible causes.

Although it could be possible for two components to fail at the same time, it is not very likely. Start by looking for one faulty component as the culprit.

The following list shows the order in which you should check components based on the probability of them being defective:

- ✓ First look for components which burn out or have a tendency to wear out, i.e. mechanical switches, fuses , relay contacts, or light bulbs. (Remember, that in the case of fuses, they burn out for a reason. You should find out why before replacing them.)
- ✓ The next most likely cause of failure are coils, motors, transformers and other devices with windings. These usually generate heat and, with time, can malfunction.
- ✓ Connections should be your third choice, especially screw type or bolted type. Over time these can loosen and cause a high resistance. In some cases this resistance will cause overheating and eventually will burn open. Connections on equipment that is subject to vibration are especially prone to coming loose.
- ✓ Finally, you should look for is defective wiring. Pay particular attention to areas where the wire insulation could be damaged causing short circuits. Don't rule out incorrect wiring, especially on a new piece of equipment.

Step 5 - Test and Repair

Testing electrical equipment can be hazardous. The electrical energy contained in many circuits can be enough to injure or kill. Make sure you follow all your companies safety precautions, rules and procedures while troubleshooting.

Once you have determined the most probable cause, you must either prove it to be the problem or rule it out. This can sometimes be done by careful inspection however, in many cases the fault will be such that you cannot identify the problem component by observation and analysis alone. In these circumstances, test instruments can be used to help narrow the problem area and identify the problem component.

There are many types of test instruments used for troubleshooting. Some are specialized instruments designed to measure various behaviors of specific equipment, while others like the multimeters are more general in nature and can be used on most electrical equipment. A typical multimeter can measure AC and DC Voltages, Resistance, and Current.

A very important rule when taking meter readings is to predict what the meter will read before taking the reading. Use the circuit schematic to determine what the meter will read if the circuit is operating normally. If the reading is anything other than your predicted value, you know that this part of the circuit is being affected by the fault.

Depending on the circuit and type of fault, the problem area as defined by your observations, can include a large area of the circuit creating a very large list of possible and probable causes. Under such circumstances, you could use a 'divide and eliminate' testing approach to eliminate parts of the circuit from the problem area. The results of each test provides information to help you reduce the size of the problem area until the defective component is identified.

Once you have determined the cause of the faulty operation of the circuit you can proceed to replace the defective component. Be sure the circuit is locked out and you follow all safety procedures before disconnecting the component or any wires.

After replacing the component, you must test operate all features of the circuit to be sure you have replaced the proper component and that there are no other faults in the circuit. It can be very embarrassing to tell the customer that you have repaired the problem only to have him find another problem with the equipment just after you leave.

Follow Up

Although this is not an official step of the troubleshooting process it nevertheless should be done once the equipment has been repaired and put back in service. You should try to determine the reason for the malfunction.

- ✓ Did the component fail due to age?
- ✓ Did the environment the equipment operates in cause excessive corrosion?
- ✓ Are there wear points that caused the wiring to short out?
- ✓ Did it fail due to improper use?
- ✓ Is there a design flaw that causes the same component to fail repeatedly?
- ✓ Through this process further failures can be minimized. Many organizations have their own follow-up documentation and processes. Make sure you check your organization's procedures.

Adopting a logical and systematic approach such as the 5 Step Troubleshooting Approach can help you to troubleshoot like an expert!

PERFORMING ELECTRICAL MEASUREMENTS

Ammeter

Introduction to Ammeter

As we know a word “meter” is associated with the measurement system. Meter is an instrument which can measure a particular quantity. As we know, the unit of current is Ampere. Ammeter means Ampere-meter which measures ampere value. Ampere is the unit of current so an ammeter is a meter or an instrument which measures current.

Working Principle of Ammeter

The main principle of ammeter is that it must have a very low resistance and also inductive reactance. Now, why do we need this? Can’t we connect an ammeter in parallel? The answer to this question is that it has very low impedance because it must have very low amount of voltage drop across it and must be connected in series connection because current is same in the series circuit.

Also due to very low impedance the power loss will be low and if it is connected in parallel it becomes almost a short circuited path and all the current will flow through ammeter as a result of high current the instrument may burn. So due to this reason it must be connected in series. For an ideal ammeter, it must have zero impedance so that it has zero voltage drop across it so the power loss in the instrument is zero. But the ideal is not achievable practically.

Voltmeter

What is a Voltmeter?

Voltmeter is a voltage meter. Which measures the voltage between the two nodes. We know the unit of potential difference is volts. So it is a measuring instrument which measures the potential difference between the two points.

Working Principle of Voltmeter

The main principle of voltmeter is that it must be connected in parallel in which we want to measure the voltage. Parallel connection is used because a voltmeter is constructed in such a way that it has a very high value of resistance. So if that high resistance is connected in series than the current flow will be almost zero which means the circuit has become open.

If it is connected in parallel, then the load impedance comes parallel with the high resistance of the voltmeter and hence the combination will give almost the same the impedance that the load had. Also in parallel circuit we know that the voltage is same so the voltage between the voltmeter and the load is almost same and hence voltmeter measures the voltage.

For an ideal voltmeter, we have the resistance is to be infinity and hence the current drawn to be zero so there will be no power loss in the instrument. But this is not achievable practically as we cannot have a material which has infinite resistance.

Multimeter

Multimeters as the name suggest the meters that we use to measure multiple quantities with the same instrument. The most basic multimeter measures voltage, current, and resistance. Since we use it for measuring current (A), voltage (V) and resistance (Ohm), we call it as AVO meter. We can categorise the multimeters into two groups, namely analog multimeter and digital multimeter. We will discuss here in this article about analog multimeter.

Advantages of Analog Multimeter

- ✓ A sudden change in signal can detect by analog multimeter more swiftly than a digital multimeter.
- ✓ All measurements are possible by using one meter only.
- ✓ Increase or decrease in signal levels can be observed.

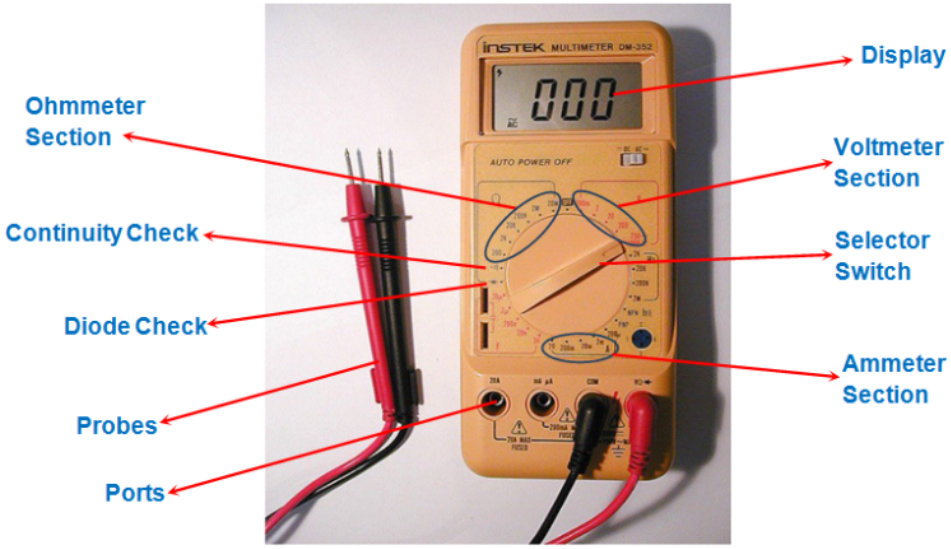
Disadvantage of Analog Multimeter

- ✓ Analog meters are bulky in size.
- ✓ They are bulky and costly.
- ✓ The pointer movement is slow, can't be used to measure voltages with frequencies higher than 50 HZ.
- ✓ Inaccurate due to the effect of earth magnetic field.
- ✓ They are vulnerable to shock and vibration.

How to use digital multimeter?

Digital Multimeter is a device which has two words in its name: Digital and Multimeter. Let's first try to analyze why do we have them there i.e. what do each of them actually convey which in turn helps us understand what does a multimeter do. The first word – digital – indicates that the meter has a digital or liquid crystal display while the next word – multimeter – indicates that this single device can be used for multipurpose i.e. to measure more than one parameter. A typical digital multimeter will be as shown by Figure 1 and comprises of selection switch, display, ports and probes as its major parts.

Here the probes are to be inserted into appropriate ports and are to be connected across the parameter which needs to be inspected. Meanwhile one should ensure that the selection switch is to be kept at the position which is appropriate for the measurement. When done so, the multimeter displays the value of the parameter which is being analyzed.



Generally digital multimeters are used to measure three important parameters viz., current, voltage and resistance. Apart from these, they can also be used to perform special functions like diode check, capacitance measurement, Transistor hFE or DC current gain, frequency measurement and continuity check. In this article, we present a brief note on the most frequently used applications of multimeter which are for current, voltage and resistance measurement along with diode and continuity checks.

Current Measurement by Digital Multimeter

Under this category, the digital multimeter mimics the behavior of an ammeter as it is used to measure current. To accomplish this, insert the red probe of the multimeter to one of the current measuring sockets: mA (to measure low level of current) or 20 A (to measure larger current). Connect the meter along the line through which the current is to be measured (nothing but series connection). Next set an approximate range around which we expect the current to be in the ammeter section of Figure 1. In this state, if we switch on the power supply, then the meter will read the current flowing through the circuit.

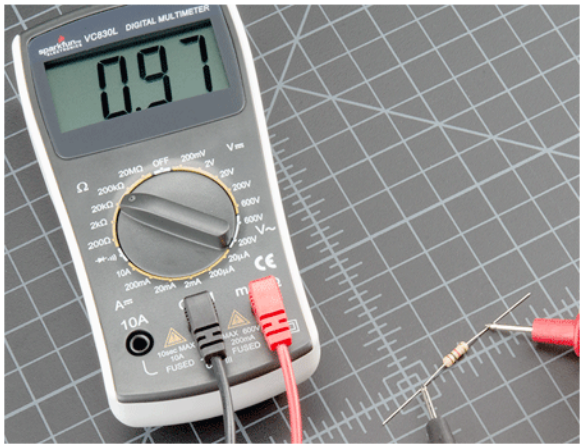
Voltage Measurement by Digital Multimeter

When set to measure the voltage, the multimeter acts like a voltmeter. To start with, one has to insert the red and the black probes of the multimeter to the sockets marked as 'V' and 'COM', respectively. Then we have to select the expected range in which our voltage would be. Simultaneously, even AC or DC should also be selected in the voltmeter section of Figure 1. On doing so, the meter reads the value of the voltage, provided one connects the leads across the

component (in parallel fashion) or at the point at which the voltage needs to be measured.

Resistance Measurement by Digital Multimeter

In this case, we configure the multimeter to act like an ohmmeter. Here the red and the black probes of the multimeter are inserted into the sockets marked as 'V' and 'COM', respectively while the selection switch is set to an expected range in ohmmeter region (Figure 1). Now, the leads need to be connected across the component whose resistance is to be known. On doing so, we get a reading in the display part of the multimeter which reads the value of the resistance.



Diode Check by Using a Digital Multimeter

For this case, insert the probes into the sockets as that in the case of voltage measurement and set the selection switch to point towards diode check position shown in Figure 1. Now when the red lead of the multimeter is connected to positive terminal of the diode while its negative lead is connected to the negative terminal of the diode, then we have to get a low reading on the multimeter. On the other hand, if we connect the red lead to the negative terminal of the diode and the black to the positive terminal, then we have to get a high value. If the readings obtained are as per our expectation, then we say that the diode is working properly; else no. More information regarding this can be found in the article "Diode testing".

Continuity Check by Using a Digital Multimeter

Continuity check is used to know whether there exists any low resistance path via two points i.e. to check whether the points are short or not. To accomplish this task, the probes are inserted into the sockets as that in the case of voltage measurement and selector switch is made to point towards continuity check position (Figure 1). Then, the points to be tested are touched with the leads of the probes. Now, if the multimeter beeps out, then it means that the points are shorted or else the resistance between them can be read out from the display.

Megger

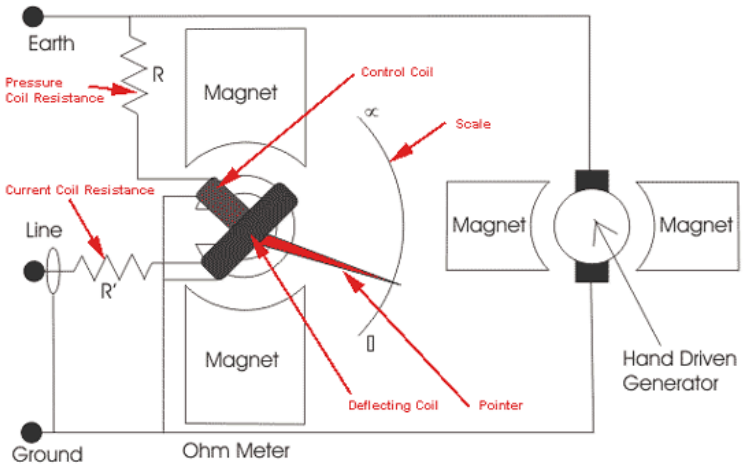
The device is being used since 1889, popularity raised during 1920s since the long back device is same in its uses and purpose of testing, few real improvements appeared in recent years with its design and quality of tester. Now high-quality options are available which are easy to use and quite safe.

Insulation resistance IR quality of an electrical system degrades with time, environment condition, i.e., temperature, humidity, moisture and dust particles. It also gets impacted negatively due to the presence of electrical and mechanical stress, so it's become very necessary to check the IR (Insulation resistance) of equipment at a constant regular interval to avoid any measure fatal or electrical shock.

Types of Megger

- ✓ Electronic Megger (Battery operated)
- ✓ Manual Type (Hand Operated

Construction of Megger



1. Deflecting and Control coil : Connected parallel to the generator, mounted at right angle to each other and maintain polarities in such a way to produced torque in opposite direction.
2. Permanent Magnets : Produce magnetic field to deflect pointer with North-South pole magnet.
3. Pointer : One end of the pointer connected with coil another end deflects on scale from infinity to zero.
4. Scale : A scale is provided in front-top of the megger from range 'zero' to 'infinity', enable us to read the value.

5. D.C generator or Battery connection : Testing voltage is produced by hand operated DC generator for manual operated Megger. Battery / electronic voltage charger is provided for automatic type Megger for same purpose.
6. Pressure Coil Resistance and Current Coil Resistance : Protect instrument from any damage because of low external electrical resistance under test.

Working Principle of Megger

- ✓ Voltage for testing produced by hand operated megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.
- ✓ 500 Volt DC is sufficient for performing test on equipment range up to 440 Volts.
- ✓ 1000 V to 5000 V is used for testing for high voltage electrical systems.
- ✓ Deflecting coil or current coil connected in series and allows flowing the electric current taken by the circuit being tested.
- ✓ The control coil also known as pressure coil is connected across the circuit.
- ✓ Current limiting resistor (CCR and PCR) connected in series with control and deflecting coil to protect damage in case of very low resistance in external circuit.
- ✓ In hand operated megger electromagnetic induction effect is used to produce the test voltage i.e. armature arranges to move in permanent magnetic field or vice versa.
- ✓ Where as in electronic type megger battery are used to produce the testing voltage.
- ✓ As the voltage increases in external circuit the deflection of pointer increases and deflection of pointer decreases with a increases of current.
- ✓ Hence, resultant torque is directly proportional to voltage and inversely proportional to current.
- ✓ When electrical circuit being tested is open, torque due to voltage coil will be maximum and pointer shows 'infinity' means no shorting throughout the circuit and has maximum resistance within the circuit under test.
- ✓ If there is short circuit pointer shows 'zero', which means 'NO' resistance within circuit being tested.

Work philosophy based on ohm-meter or ratio-meter. The deflection torque is produced with megger tester due to the magnetic field produced by voltage and current, similarly like 'Ohm's Law'.

The torque of the megger varies in a ration with V/I, (Ohm's Law:- V = IR or R = V/I). Electrical resistance to be measured is connected across the generator and in series with deflecting coil.

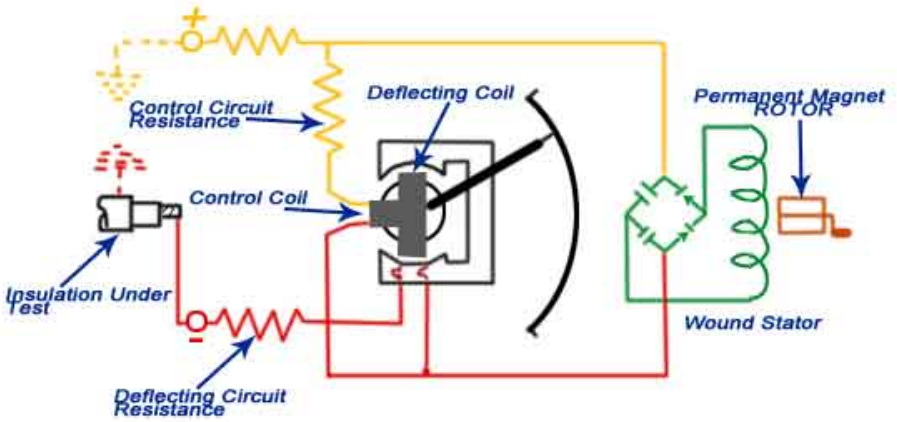
Produced torque shall be in opposite direction if current supplied to the coil.

1. High Resistance = No Current :- No current shall flow through deflecting coil, if resistance is very high i.e. infinity position of pointer.
2. Small Resistance = High Current :- If circuit measures small resistance allows a high electric current to pass through deflecting coil, i.e. produced torque make the pointer to set at 'ZERO'.

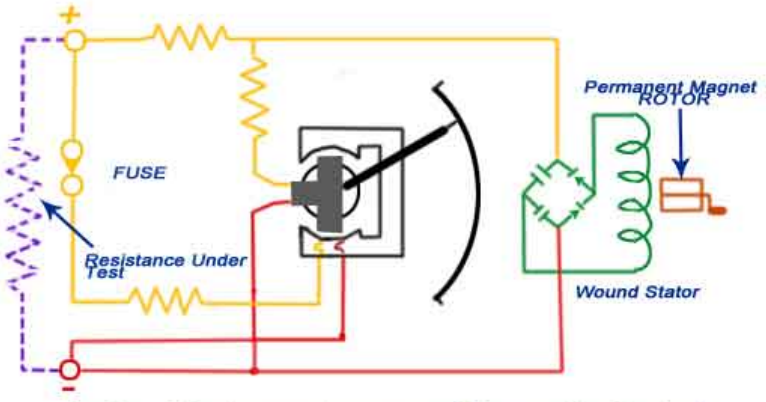
3. Intermediate Resistance = Varied Current: - If measured resistance is intermediate, produced torque align or set the pointer between the range of 'ZERO to INIFINITY'.

Connection Diagram of Megger for Testing

Instrument Arrangement for insulation test



Instrument Arrangement for continuity test



Electrical Drawings

An electrical schematic is a diagram that shows how all of the wires and components in an electronic circuit are connected. They're like a map for building or troubleshooting circuits, and can tell you almost everything you need to know to understand how a circuit works.

The ability to read electrical schematics is a really useful skill to have. To start developing your schematic reading abilities, it's important to memorize the most common schematic symbols. Each physical component (i.e resistor, capacitor, transistor) has a unique schematic symbol. The main goal of this tutorial is to show you the essential schematic components you should know.

It is not enough to just be able to recognize the components in a schematic. You should also be able to get a rough idea of how the circuit works, just by looking at the schematic. After this article, I recommend reading How to Analyze Circuits, where we

discuss more advanced circuit analysis techniques like Kirchhoff's Current Law and Kirchhoff's Voltage Law.

Power Sources

Power sources supply electrical energy to a circuit in the form of voltage and current. Every functional electronic circuit needs to have a DC or AC power source.

DC Power Sources

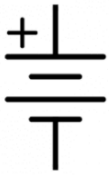
Direct current (DC) power sources provide electric current that flows in a constant direction. This is the schematic symbol for a DC power source:

AC Power Sources

Alternating current (AC) power sources provide electric current that flows in two directions. This is the schematic symbol for an AC power source:

Batteries

A battery is a common type of DC power source. The schematic symbol for a battery is made up of short and long parallel lines. The longer line represents the positive terminal of the battery, while the shorter line represents the negative terminal:



Ground

Ground is the common return path of a circuit, where current returns to its source. This is often referred to as the negative side in a circuit. This is the schematic symbol for a ground connection:

Terminals

Terminals are connection points to external circuits. For external connections, terminals are denoted by empty circles:

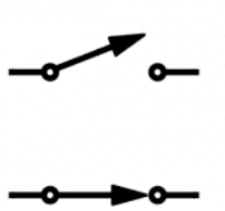
Terminal connections are different from nodes or junctions which have solid circles:

Switches

Switches make or break a connection in a circuit. They also let you change the path of current flow.

SPST Switches

A SPST (single pole, single throw) switch is an on and off switch. The two schematic symbols below show the different states of an SPST switch. The top symbol indicates that the switch is in the off position, which blocks the path of current. The right symbol indicates that the switch is on, which allows current to flow through the switch.

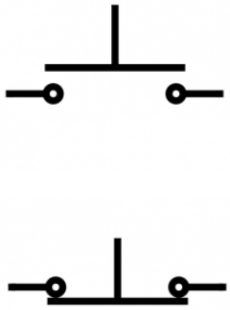


SPDT Switches

SPDT (single pole, double throw) switches can direct the path of current to different parts of a circuit. There are two routes for the current to flow in this switch, depending on the position of the switch:

Momentary Switches

Momentary switches only remain open or closed while being pressed. Push button switches are the most common type of momentary switch. These switches are either normally open or normally closed. The top schematic symbol on the right shows a normally open push button switch in the open position, while the bottom symbol shows a normally closed push button switch in the closed position:

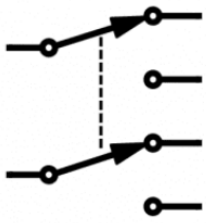


Multi-Point Switches

Multi-point switches let you switch the path of an input current to multiple different output paths.

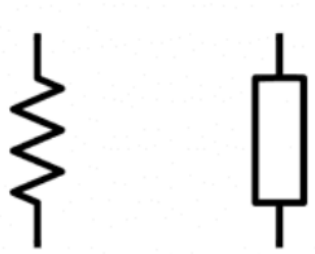
DPST (double pole, single throw) switches have 2 inputs and 2 outputs. These switches let you control the current flow to two outputs. Since the switches are single throw, the two output terminals will both be switched on and off at the same time. The schematic symbols above shows an open DPST switch (left), and a closed DPST switch (right):

DPDT (double pole, double throw) switches have two terminals for input current and four terminals for output current. These switches let you switch the path of two input currents to four separate output paths. Here is the schematic symbol for a DPDT switch:



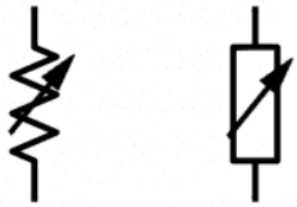
Resistors

A resistor is one of the most basic passive circuit components. Resistors have electrical resistance, which restricts current flow. The schematic symbol for a resistor is shown below. The symbol on the left is the convention used in the United States, while the symbol on the right is the international standard:



Variable Resistors

A variable resistor can increase or decrease its resistance depending on an external input. Analog sensors like photoresistors and thermistors are types of variable resistors because their resistance changes with varying levels of light or temperature. The schematic symbol of a variable resistor is similar to a fixed resistor, but a diagonal arrow is placed across the middle:



Potentiometers

A potentiometer is a three-terminal variable resistor that is used to adjust the voltage and current in a circuit. The two terminals of the resistor are V+ and ground. The arrow represents the potentiometer's wiper, where the output voltage is taken from:

Photoresistors

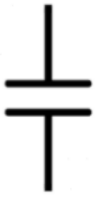
Also known as light dependent resistors (LDR), photoresistors are light-sensitive variable resistors that change resistance with varying levels of light. This is the schematic symbol of a photoresistor:

Capacitors

Capacitors are passive electronics components that store electrical charge. There are two common types of capacitors – non-polarized and polarized.

Non-Polarized Capacitors

Non-polarized capacitors don't have polarity, so it doesn't matter which side is connected to positive and which side is connected to negative. These capacitors usually have smaller values than polarized capacitors:



Polarized Capacitors

Polarized capacitors do have polarity, so it matters which side is connected to positive and which side is connected to ground. Polarized capacitors generally have higher capacitance values compared to non-polarized capacitors. Here's the schematic symbol of a polarized capacitor:

Inductors

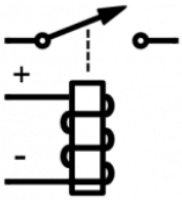
Inductors are passive components that create a magnetic field when current flows through them. Inductors can be as simple as a coil of wire. The schematic symbol of an inductor looks similar to a coil:

Transformers

Transformers are used to step up or step down voltages. They are made up of two wire coils wrapped around an iron core, so the schematic symbol has two coils with straight lines between them. The lines represent the iron core:

Relays

A relay is an electrically operated switch. Relays are basically electromagnets connected to an actuator that opens and closes a switch when current is applied to the coil:

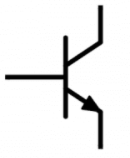


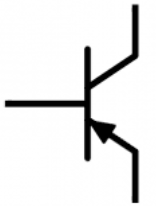
Diodes

A diode is a polarized device that only lets current flow in one direction. Being polarized, it has a positive lead (anode) and a negative lead (cathode). The flat edge of the triangle is the anode, while the line is the cathode:

Transistors

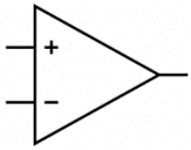
Transistors are used to either amplify voltage or to switch electric currents. The most common transistors are the bipolar junction transistors (BJT). There are two basic types of BJT transistors – NPN and PNP. NPN transistors turn on when current flows through the base of the transistor, while PNP transistors turn on when there is no current at the base of the transistor. The top schematic symbol shows an NPN transistor, while the bottom symbol shows a PNP transistor:





Operational Amplifiers

Operational amplifiers are voltage amplifiers with inputs and usually one output. They are also referred to as op-amps. The schematic symbol for an op-amp looks like this:

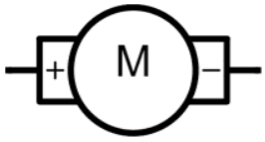


Fuses

Fuses are safety devices that provide over-current protection in an electrical circuit. The main element of a fuse is a narrow gauge wire that melts when there is too much current flowing through it. Here's the schematic symbol for a fuse:

Motor

A motor converts electrical energy into kinetic energy. Its schematic symbol is a circle with the letter "M", and positive and negative terminals on the left and right:

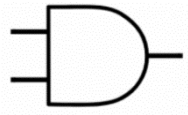


Logic Gates

Logic gates are electronic circuits that process signals that represent true or false values. The four standard logic functions are AND, OR, NOT, and XOR. In addition to these functions, there are also NAND, NOR, and XNOR logic gates.

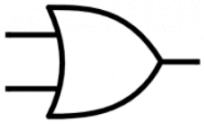
And

The output of the AND gate is true when all of its inputs are true. Here's the schematic symbol of an AND gate:



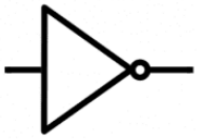
Or

he output of the OR gate is true when at least one of its inputs is true. Here's the schematic symbol of an OR gate:



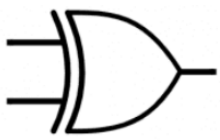
Not

The NOT gate outputs the opposite of its input, which is why it's also called an inverter. Therefore, the output is true when the input is false. Here's the schematic symbol of a NOT gate:



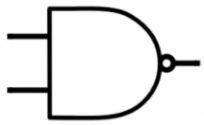
Xor

The "exclusive-OR", or XOR gate has two inputs. The output of the XOR gate can only be true when one input is true and the other input is false. Here's the schematic symbol of an XOR gate:



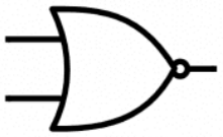
NAND

The “NOT-AND”, or NAND gate can have two or more inputs. The output of the NAND gate is true if any of the inputs are false. Here’s the schematic symbol of a NAND gate:



NOR

The “NOT-OR”, or NOR gate has two or more inputs. The output of the NOR gate is true when all of its inputs are false. Here’s the schematic symbol of a NOR gate:



XNOR

The “exclusive-NOR”, or XNOR gate has two inputs. The output of the XNOR gate is true only when both of its inputs are true, or when both of its inputs are false. Here’s the schematic symbol of an XNOR gate:

PERFORM ELECTRICAL CONNECTION

Performing cable crimp

- ✓ Choose a supplier that provides crimp tooling, die sets and cable lugs that are compatible and designed to work together to give the optimum crimping performance.
- ✓ Each lug/terminal should have a reference clearly marked on the palm or barrel which enables the user to verify that it is the correct size and type for the conductor it is to be used on. The crimp lug should also feature the manufacturer’s name or logo to enable the use of the correct tooling and die set, which can be selected from its published die set selector charts.
- ✓ Prepare the aluminium or copper conductor for crimping by stripping back the insulation to a length equal to that of the lug barrel. This ensures that no insulation is trapped in the barrel of the lug when assembled.
- ✓ Insert the conductor into the terminal barrel. If applicable, use the inspection hole to check the conductor is fully inserted.
- ✓ Perform the crimp paying careful attention to the positioning of the die on the barrel and, if multiple compression actions are required, the sequence in which they should be performed. If using an hydraulic crimping tool, it is vital to make sure the correct tool is used with a compatible die set. Care should also be taken to keep the tool well maintained, working properly and with an up to date calibration certificate.
- ✓ Once the crimps have been performed, check the completed termination to ensure:
    - No insulation is trapped in the barrel.

- The conductor has been fully inserted (check the inspection hole to confirm this).
- There is no over-crimping. If the barrel is over-crimped it will cause excessive stress on the conductor and flash or burrs on the lug.
- There is no under-crimping. There should be no air voids between the strands of the conductor. They should be tightly compacted to ensure maximum performance.

Over-crimped and under crimped lugs

Both these incorrectly crimped terminals can cause overheating and ultimately lead to termination failure or fire. The over-crimped lug is easily identifiable by the 'ears' or 'wings' created on the barrel of the terminal. The undercrimped lug is identifiable by inspection of the lug and conductors.

UNIT 11

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

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

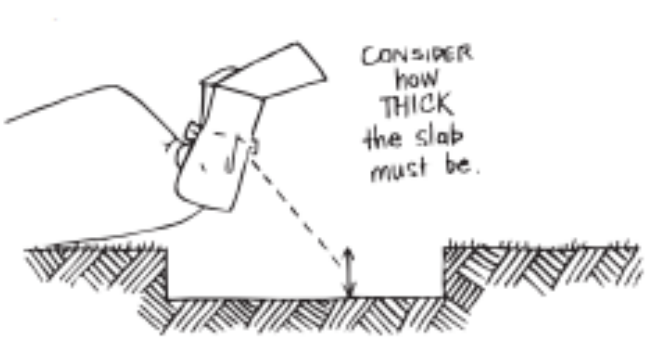
Workers on the site should always wear protective clothing, strong boots, helmets and eye protection. Always avoid direct contact with cement and never kneel in or touch the plastic concrete directly. Wear gloves and use barrier creams.

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).

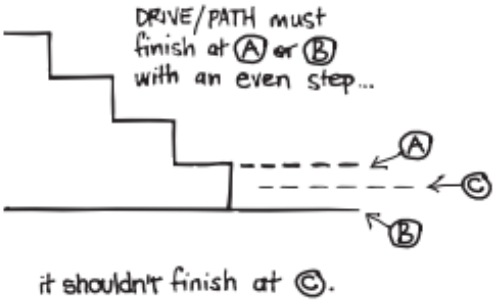


The Finished Level

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.

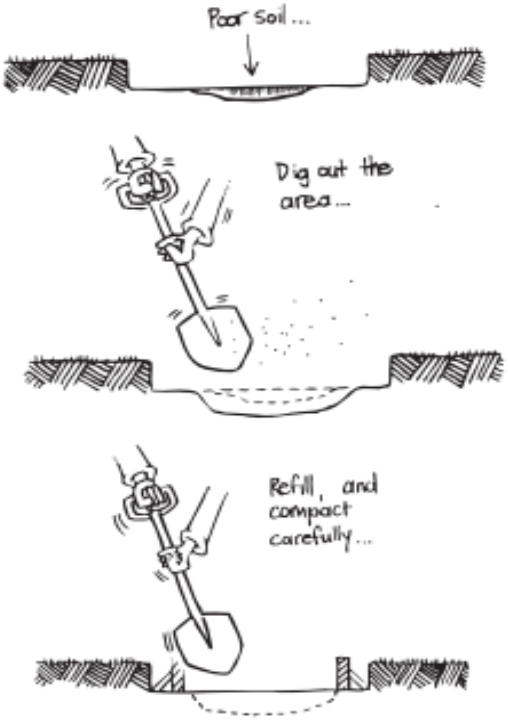
Steps

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.

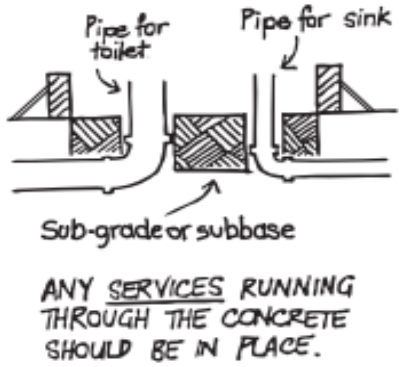


Subgrade

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.

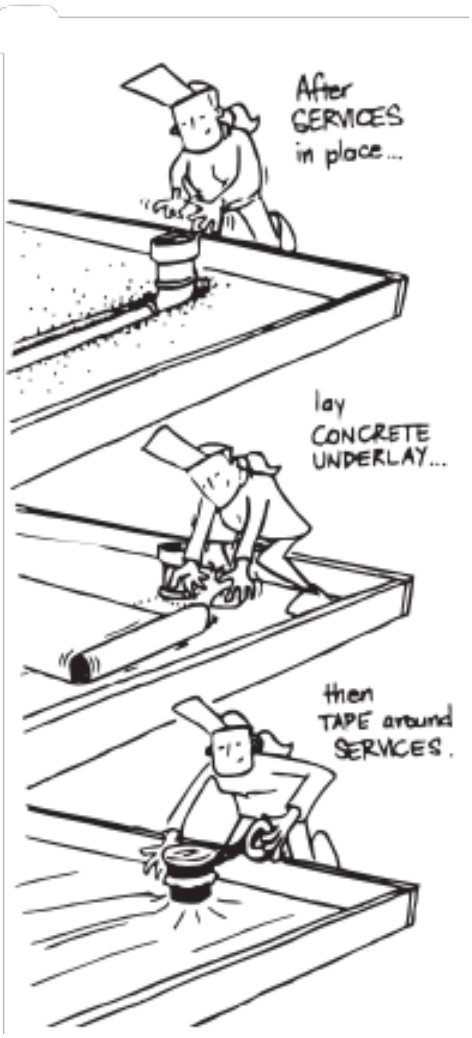
Formwork

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.

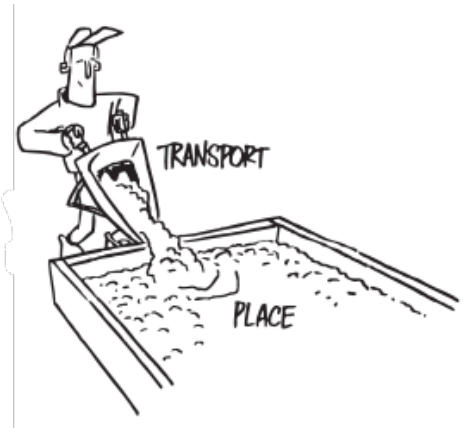
Transporting and Placing

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

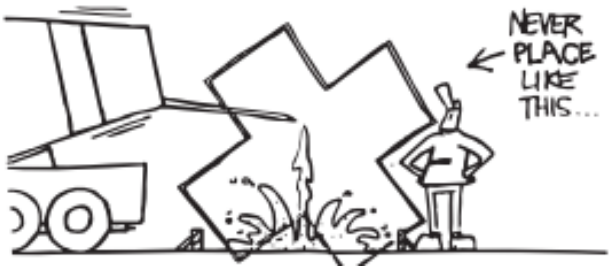
Segregation is when the coarse and fine aggregate, and cement paste, become separated. Segregation may occur when the concrete is mixed, transported, placed or compacted.

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

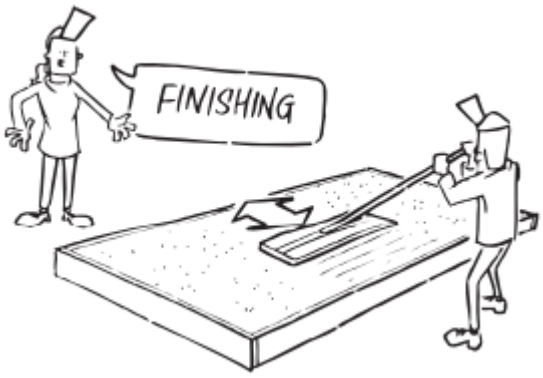
Form Oil should be applied to the inside of the formwork to stop it sticking to the concrete and thus make removal easier. Coat BEFORE the reinforcement is put in place.

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.

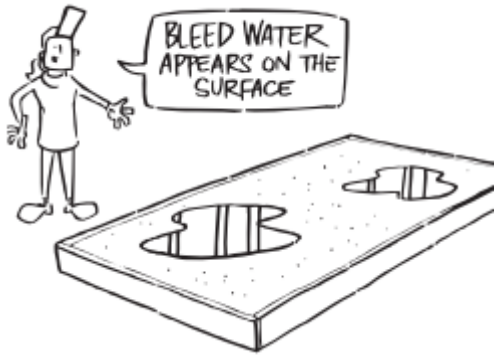
Finishing

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

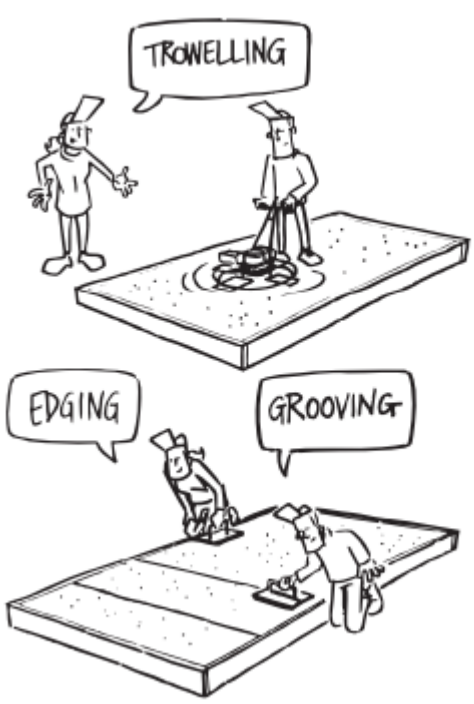
There may be two stages in floating:

- ✓ 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

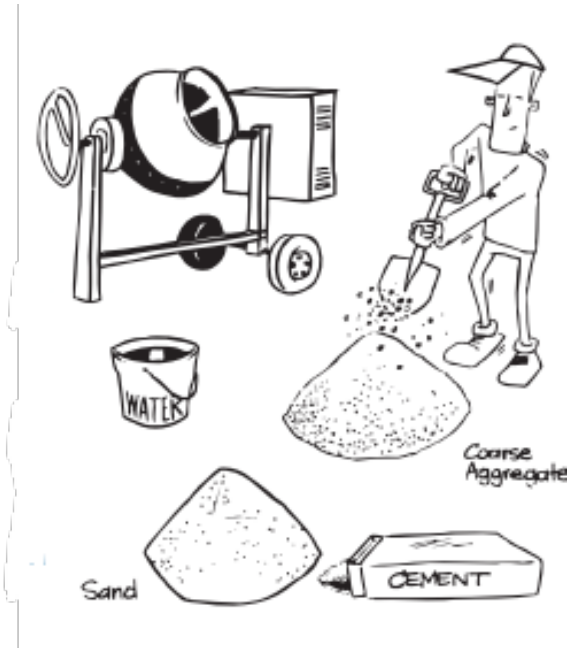
All the edges of a slab should be finished with a special edging tool. This gives a neater and stronger edge, less prone to chipping. Joints should be planned before placing and are usually formed into the concrete during finishing.

Once any surface has been finished the concrete MUST be cured.

PLACE CONCRETE

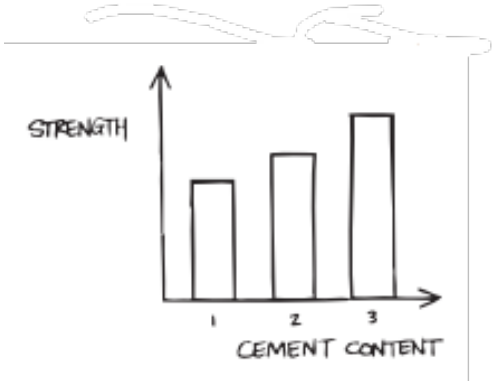
Proportioning and Mixing

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.

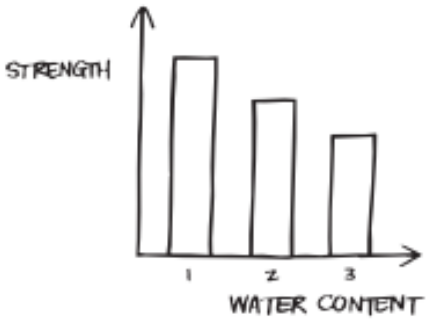


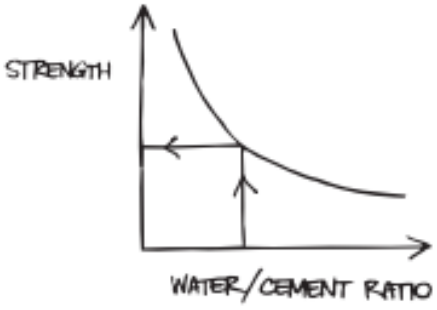
Cement Content

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.



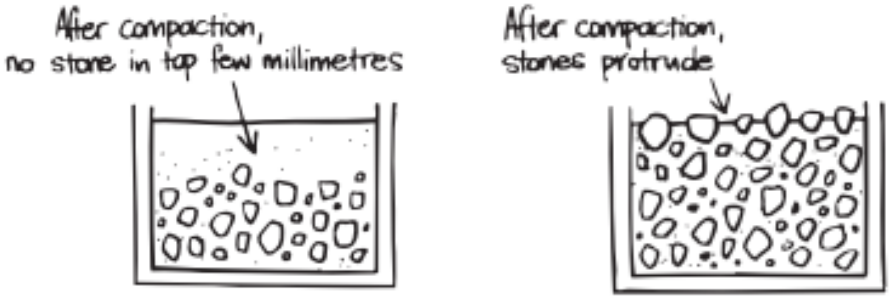


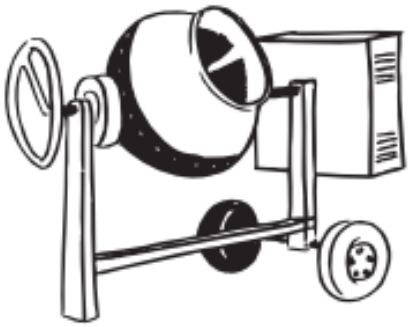
Water to Cement Ratio

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.

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 stronger backgrounds
1:1:6	External	Moderate strength for porous and weaker backgrounds
1:2:8	External	Final coat for weak backgrounds in sheltered 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 12

PREPARE ESTIMATES AND READ LAYOUT

This unit covers the competencies required to plan and prepare estimates for and reading layouts. This unit typically helps to prepare a work plan for the clients to their needs

DETERMINE CUSTOMER REQUIREMENTS

Producing a Detailed Estimate

Estimating a project is one of the most important aspects of project management. Projects are by definition temporary endeavors with a defined beginning and end, hence stakeholders need to know how much expenditure they are committing to.

Thus, project estimates tend to start before the project even begins and are usually updated throughout the project life cycle.

Before doing a detailed estimate make sure you identify the following

1. Review the Project Scope

Don't start writing your estimate until you understand what your client wants. Often, clients don't know exactly what they want, in which case you'll need to ask the right questions.

Here are some questions to ask your client:

- ✓ Do you want to see a complete breakdown of costs?
- ✓ Do you want to see an itemized breakdown of services?
- ✓ What services do you require?
- ✓ What services do you not require?
- ✓ What's your expected completion date?
- ✓ What expectations do you have for this project?
- ✓ Some clients may not know the specifics of a job and can only tell you what the final result should be. In this case, you'll need to make suggestions. If you're a contractor, visit the job site to fully understand what the project will involve.

An initial discussion is also a great relationship-builder with your client. You'll make sure you're both on the same page and eliminate any surprises down the road that could hurt your working relationship.

2. Estimate a Timeline

An estimate only needs an approximate timeline. But it's important to provide a rough completion date both for your client's sake and so you know how much to charge based on how much time it'll take you.

With that in mind, stay on the conservative side when providing a timeline. It's important to manage client expectations so they know exactly how much time you need to complete the project and prevent disputes later on. Don't lowball the completion date.

You should also mention any possible factors that could delay your project. For example, a contractor should mention possible delays and red tape with obtaining permits.

You should also keep in mind other projects you plan to take on and if the timeline will interfere with their completion.

3. Price out Subcontractors

Big jobs may require subcontractors, especially if you normally work alone and not in a team. Be realistic about what you can and can't do. For example, a website designer may need to hire a copywriter to write copy such as blog posts, the about page and more.

The client might also ask for the project to be completed extra quickly. For example, a client asks a painter to paint her entire first floor in a day in preparation for a party. Normally, this would take the painter a week on his own. So he must hire a team so he can complete the job on time.

It might also be best to hire subcontractors if you're swamped with additional projects. That way you can meet the deadline without burning out.

Detailed Estimate

The Detailed Estimate is generally considered the third out of five project estimate types. It represents the complete (or almost complete) project or product design. The five estimate types are:

- ✓ **Conceptual**, or Rough Order of Magnitude estimates are produced prior to project initiation, to prioritize the project or decide whether to proceed with it.
- ✓ **Preliminary** estimates are used to decide between several options, within the project.
- ✓ **Detailed** estimates utilize the complete (or almost complete) design of the product or project. Hence, the quantities of resources are known but not the costs.
- ✓ **Definitive** estimates utilize firm cost information, for example, quotes or tenders.
- ✓ **Final** estimates are performed after the project is complete. They are more of a summary of project costs.

How to Produce a Detailed Estimate?

Detailed estimates utilize bottom up estimating techniques to estimate individual project tasks and roll them up into an overall project estimate. The process is as follows:

✓ **Calculate Quantities**

Each project task is estimated by calculating the quantities of resources, materials, tools, and incidentals necessary to perform the task.

✓ **Estimate each task**

Analogous or parametric techniques are used to estimate the task. Expert judgment is consulted when available.

✓ **Produce Project Estimate**

Each task estimate is rolled up into an overall project estimate.
Quantities of materials and resources need to be calculated to the best possible extent. In the construction industry (where I hail from), detailed estimates utilize all of the building design information, that is, quantities of every door and window are itemized and placed into a spreadsheet.

To the extent that quantities of resources are not calculated to precision, the estimate is that much less accurate.

Analogous Estimating

Analogous estimating refers to the estimation by comparing to similar projects. You cherry pick a project that's deemed similar enough to give you the best cost information.

For a detailed estimate, analogous estimating happens on the task, as opposed to the project, level. Each task is compared to actual costs for that task in the previous project. For example, the new building has 15 doors, and a certain previous building that was built had 10 of the same doors, therefore we will add 50% to the actual cost for that item to produce the new estimate.

Parametric Estimating

Parametric estimating utilizes unit rates which are usually averages of many different projects. They account for alot of different variables that have occurred on many

projects, and can often be obtained from industry associations that track average costs (each organization's cost data are usually top secret). They can also be obtained from internally tracked cost information.

For example, we might know that installing doors costs $450/door, therefore we simply multiple by the number of doors to be installed.

Adjustments

Adjustments to the analogous or parametric information are important to get the estimate just right and utilize all the information you have.

For analogous estimating, adjustments to the estimate are based on known differences between the current project and the cherry-picked previous project. For example, if the doors were 10% larger than the previous project, you could add 10% to the estimate.

For parametric estimating, you are analyzing the deviation of your project from the average of many projects, so you need to consider how the current project is different from the average. For example, if these doors are 25% smaller than the average door, you may want to reduce the estimate by 25%.

Accuracy

Detailed estimates are generally accepted to be in the range of -5% to +10%. That is, a $100,000 estimate has an acceptable final cost range of $95,000 to $110,000.

How do you obtain this accuracy, or know what it is? This is a good question, without an easy answer. This is because there is an art and a science to it.

The science is relatively simple. When you know that each task has a variance of -5% to +10% when performed many times, you know that the overall estimate has the same variance. However, each task needs to be analyzed accordingly. In many cases it is possible to look at the same task which has been performed many times. If not, you can usually break it down even further and analyze subtasks until you get to a unit that's small enough to put an accuracy range on.

The overall project estimate accuracy is the weighted average of each task. For example, if a project contains only two tasks, Task A and Task B, and they are the exact same size:

- ✓ If Task A has an estimate with an accuracy of 10%, and
- ✓ If Task B has an estimate with an accuracy of 20%,
- ✓ The accuracy of the project estimate is (10 + 20) / 2 = 15%
- ✓ This is valid as long as the number of hours/resources in each task is the same. But that's not usually the case. If the tasks are not the same size, the accuracy of the project is the average of the tasks, weighted to the task size.

AccuracyProject = [(Estimate_A x Accuracy_A) + (Estimate_B x Accuracy_B)] / [(Estimate_A + Estimate_B) x 2]

Any tasks that are not within the acceptable range must be refined until they are in the acceptable range. There isn't really any alternative, because the overall estimate cannot be more accurate than its constituent parts.

However, in practice the process is as follows: The detailed estimate takes into account all of the available design information for the project. If there is still too much uncertainty to assign an accuracy of -5% to +10%, the loss of accuracy is communicated to the project stakeholders as necessary.

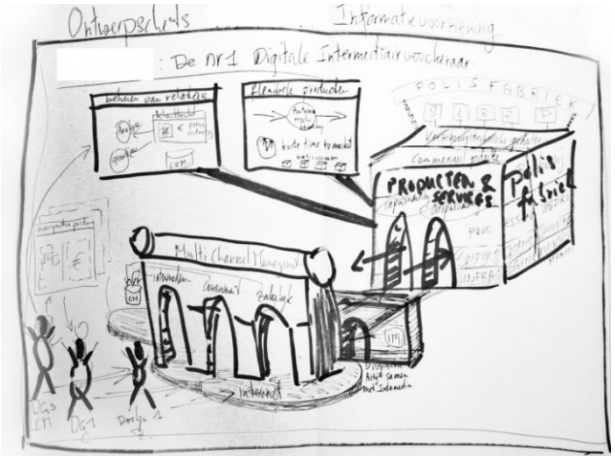
Examples

- ✓ An engineering firm is tasked with the design of a building. They itemize each component and use cost information from previous projects for each component to produce a detailed estimate, which the owner can use to update their budget prior to obtaining tenders for the project.
- ✓ A software development firm receives a project to develop a web application. The number of pages and programming requirements are planned out and itemized in a detailed estimate, which is presented to the client's board for a decision to proceed.
- ✓ A manufacturing plant has grown and begins to hit its plant capacity regularly. The expansion of the assembly lines are planned out and each piece of necessary equipment is itemized. Published cost data is used to determine the detailed estimate, which is used to make a decision to proceed to the next level: Obtaining quotes for the work. Once the quotes are obtained, the estimate becomes a definitive estimate.

DEVELOP SKETCH AND PREPARE ESTIMATES

As an Enterprise Architect, everyone is looking at you to be able to give an overview of strategic changes in a split second. Fortunately, there is a defined architecture product that fills that need: the Design Sketch of a Total Concept.

This sections shows HOW TO in conceptual design, enabling you to communicate your innovative ideas much more effectively.



A Design Sketch is an informal visualization that with sketching techniques shows the context, borders, features, benefits and costs of an enterprise structure at a conceptual, logical or physical level.

What is a Design Sketch?

A Design Sketch of a Total Concept (aka Architecture) shows at a conceptual level the context, borders, features, benefits and costs of an enterprise structure and how to realize this enterprise structure. So in Dragon1 terms with a Design Sketch of a Total Concept of an enterprise structure in your hands, you are looking at a perspective (aligned views) of the architecture of an enterprise: the enterprise architecture, for a certain period in time.

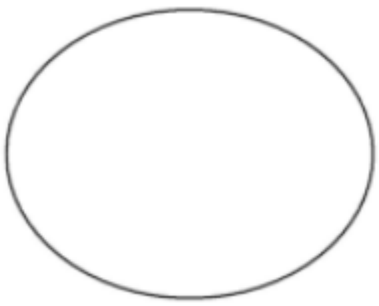
A design is a plan of how to build a structure. A design sketch is a graphical sketched representation of a design plan.

A design sketch, see example figure, is a visualization showing the total concept or architecture of a structure.

Structure of the Design Sketch

It may contain ovals for every concept, but also metaphoric images depicting the concepts much more meaningful.

Important of using sketch symbols or real handwriting sketches is that the visualization looks more informal and decisions are not yet finally been made, as opposed to drawings, diagrams or even artist impressions. And that is often because in a sketch concept a lot of irrelevant details are left out.



How to Create a Total Concept

Here is an overview of the process steps to take:

There are five steps and each step has an input, list of activities and output.

It is important for the sake of higher output quality that every step is done and a taken decision is logged on paper (or digital document) and that every input and output of a step is put in writing on paper or digital document. This enables collaboration and discussing with others effectively, coaching of you by more experienced architects and track/trace and improve the decisions taken along the road of concept design.

Step 1: Defining Context and Scope
Input of step 1:

You as an enterprise architect, the owner/client or a stakeholder of an enterprise has the intention or the need to communicate and discuss a fundamental strategic change of an enterprise. The fundamental change will lead to an integral business & IT solution to be implemented. But as everyone knows, this solution is almost a completely new company. And it has to fit in or collaborate with the current company. So dealing with the impact of implementing the new concept is very important.

Maybe the owner/client or you have been inspired by a beautiful enterprise structure, an integral solution or know of a new trend. Look information up about it and take a visit, and you can use this information and experience a great deal in the following activities.

Activities in step 1

1. It is a good practice to try to name and define the fundamental strategic change or integral business IT solution that is subject and at the same time try to name and define an enterprise structure that needs to be created with it. Below are some examples or common total concepts in various industries:
    - Industry, Type of organization, 3 Total Concepts
    - Government, Municipality/City, eGovernment - Case Management - The paperless office
    - Healthcare, Hospital, eHealth, Chain Reversal
    - Retail, Supermarkets, eRetail - Seamless Retailing - Digitizing
    - Logistics, Distributor, eFulfilment - Return Logistics
    - Finance, Bank, SEPA
    - Telco's, Phone Companies, Service Delivery Automation
2. You have to be aware that there is a difference in how in theory is thought and spoken of a total concept and how that total concept is applied onto a structure.
3. The way a total concept is applied is ALWAYS different from theory. Also in your case.
4. First you need to know the theoretical total concept (architecture) that has to be designed or re-architectured and you have to know the structure (the project) that has to be build/realized with it.
5. And what are they? Write them down, and define them. And it is often the case you start out with three different total concepts:

- minimal scenario (doing hardly anything)
- average scenario (what is realistic in terms of resources, time and money)
- maximum scenario (to change the world)

Give the total concept a name for the generic unapplied total concept and a name for the specific applied total concept onto the enterprise. As an enterprise is unique, often the total concept applied is also unique.

For example:

- ✓ eCommerce vs the City of New York way of doing eCommerce
- ✓ eHealth vs the London Hospital way of doing eHealth
- ✓ Online business services company vs the Google way of doing online business

As an example: The Colosseum is a building structure in Rome and the underlying total concept (architecture) can be named an Amphi Theatre. The only thing is that the Colosseum is quite a unique Amphi Theatre. It is one of its kind. In fact Colosseum today is the name of a unique total concept of its even so called structure. Today Colosseum is a specialization as total concept of Amphi Theatre.

It is like that in Enterprise Architecture. Google is an online business services company, but Google is one of a kind online innovative company. Google has now become a total concept for an enterprise and many other organization try to copy it.

Output of step 1:

- ✓ '''A documented list containing the following items:'''
- ✓ '''Name (+ definition + literature reference) of the theoretical Total Concept''':
- ✓ '''Name (+ definition + literature reference) of the (to be) applied Total Concept''':
- ✓ '''Name (+ definition + literature reference) of the reference structure''':
- ✓ '''Name (+ definition) of the (to be) realized structure''':

Step 2: Making it Visual in one picture

Make your first visualization by real hand sketching in one metaphoric picture, the total concept (the theoretical one or applied one) and the structure.

But how to make a one-picture-sketch?

Activities in step 2

- ✓ Take a good look at the definitions of the concept.
- ✓ Write down words of associations you or other people have or see reading the definition.
- ✓ Try to sketch the archetypes of the properties of the concepts or associations of words. And also write down the names of the archetypes and try to specialize or generalize the archetypes to find the right one to draw. It helps.
- ✓ Switch between drawing real world versions and abstract version. Test what works and what does not work.
- ✓ Draw at a large A1-size (flip over chart). Later on you can scan the picture and minimize it (at A4 size).
- ✓ Make sure only the properties that are mentioned come back in your concept sketch and appeal to the interest of the owner/client and most important stakeholders.
- ✓ Use the images tab of a search engine to if you are out of inspiration. Also check out colleagues what ONE-PICTURE-associations they have with a certain total concept.

Note: A CxO of bank once said: my total concept is easy, our bank must be bigger than the competition. Then he took two cups, a large and a small one and wrote his companies name on the largest one (with #1 because of customer centric approach in brackets below) and on the other small cup the name of the competition. Made a photograph of it and put it on the wall. And he said: there you have it: "my total concept within the context of globalization!"

Output of step 2:

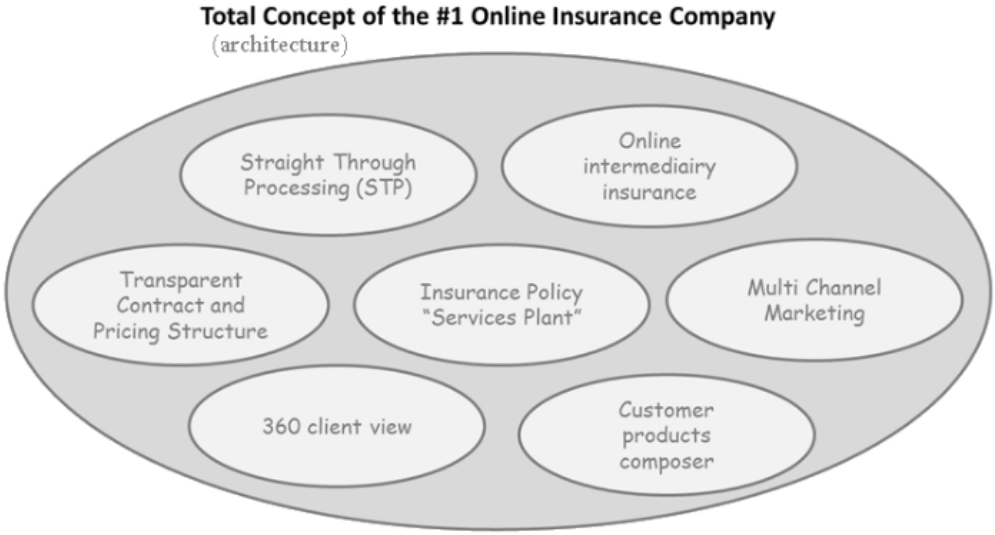
- ✓ '''A one-picture-sketch of the total concept'''

Step 3: Exploring the Oval

In this step we create our second visualization: the oval sketch.

It is a pre-form of our final design sketch. It contains a context box, with that an oval for the total concept and with that per concept an oval.

Activities in step 3



1. The ovals placed next to each other and/or (partially) on top of each other. It is wise to use a maximum of five levels deep.
2. Take your definition of the total concept and look at the nouns (entities) and verbs (relations).
3. In these two lists you need to identify the fundamental concepts and sub/partial concepts and sub-subconcepts of the total concept. And make a list of these concepts.
4. The list MUST contain concepts or subconcepts or sub-subconcepts that are NOT used by the competition. Else you have a hard time arguing why your unique or will be better than the competition.
5. Organize this list in three levels (fundamental concepts, subconcepts and sub-subconcepts)
6. Now per concept do the same as what you have for the total concept: look its literature up, check out references/best practices, and collect the definition of it.
7. And make a distinction between the concepts part of the theoretical total concept and the version that will be applied. Note: make use of generalization vs specialization of concepts, work with and generic and specific concepts.

Output of step 3:

- ✓ '''A list of the concepts per total concept, subconcepts per concept and sub-subconcepts per sub concept + their definitions and literature references.'''
- ✓ '''An oval sketch'''

Step 4: Create your Library

In the previous step we have create a list of all concepts. Now it is time to try to sketch every concept based on its definition. Basically you can follow the description of step

2. for how to draw a metaphoric sketch symbol of concept, but as you are creating a set of symbols it is important to work with a set of certain visualization standards.

Activities in step 4:

- ✓ Be sure the size of the metaphoric symbols are related or equal
- ✓ Be sure the line style and texture of areas is the same
- ✓ Try to add your own unique style in it (f.i. using shades, corners, colors or comical elements)
- ✓ Look up some examples of sketch libraries on the web
- ✓ Us as few arrows or lines as possible. Ban crossing lines if possible.
- ✓ Know that after practice also you can do this! Know also that if you do not practice, you will never learn it!

Output of step 4:

- ✓ '''A set / library of sketch symbols per concept that fit together'''

Step 5: Stand and Deliver

Activities in step 5:

1. With the name and definition of our total concept and list of metaphoric symbols ready we can now compose our design sketch.
2. A best practices is to divide the context (and the context must be given a name + period) in six equal areas: four on top and four on the bottom. Or to draw circles or ovals to divide to context. See the example drawing for this.
3. Just like taking a picture you could place the most important symbols on the right hand side line crossing (#3 and #4) and place the other important symbols on the other line crossing.
4. Use symbols to connect the important symbols. And write down words to telle or explain function, benefits or costs.
5. Be sure there is a flow, motion or movement in your picture that is logical and intuitive (left to right, top to bottom, inside-out. But keep it simple. Simple is better.

Output of step 5:

- ✓ ''Now you have your first Design Sketch!''

Note: Do not ever forget to give your sketch a title, author, date, version, status and write down the communication message it should have.

The Benefits

When done correctly this Design Sketch of a Total Concept will be put on the wall in the boardroom to be seen as a marker why, when and how it all started, and what is the purpose.

So, therefore really every architect should ASAP create one or more conceptual sketches of total concepts or scenarios of total concepts.

Three very good reasons to do so are:

1. You capture who is the owner/client, what the initial need and requested functions are and what the (initial) estimated costs are.
2. Throughout the project everyone will keep remembering how and why it all started using the conceptual sketches. So everyone is kept on track.
3. It saves time, money and resources of the project at any given moment.

When

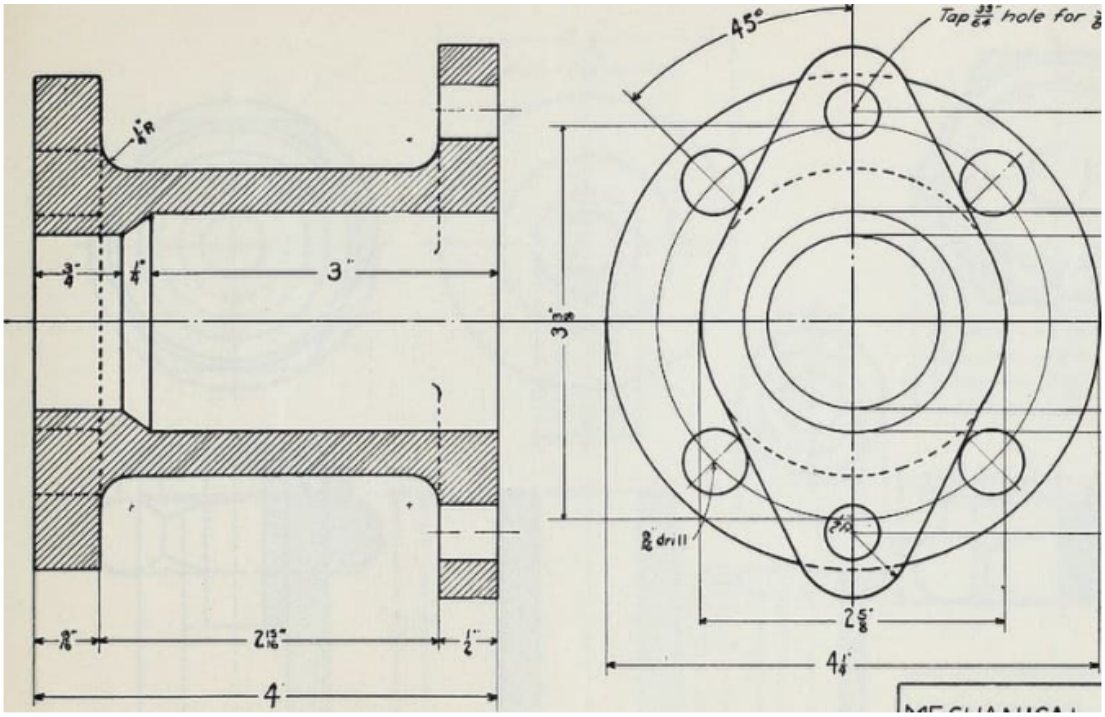
One of the very first visualizations to create as an Enterprise Architect is a Design Sketch of a Total Concept for the owner/client of a structure or project with its context/environment.

The sketch can be part of the design assignment to help the owner/client choose what total concept for what structure has to be designed and realized.

Also after the design assignment has been given a Design Sketch of a Total Concept (aka an architecture vision) should be always present.

Important never to forget is that a Design Sketch of a Total Concept MUST include the top benefits, features, costs and actions for it to be useful.

Engineering Drawings Basics



An engineering drawing is a subcategory of technical drawings. The purpose is to convey all the information necessary for manufacturing a product or a part.

Engineering drawings use standardised language and symbols. This makes understanding the drawings simple with little to no personal interpretation possibilities.

So let's look at the different line and view types you will come across in the engineering discipline.

The Purpose of Engineering Drawings

As already said, such a technical drawing has all the information for manufacturing a part or welding and building an assembly. The info includes dimensions, part names and numbers, etc. So once a manufacturing engineer gets the drawing, he can start the production process without a second thought.

First, we have to pause for a second and address our own customers here to avoid confusion. The drawings you submit for instant pricing and manufacturing in our system do not need any of this. The same applies to 3D models. CAD files and drawings made according to our design tips include all the necessary information for making your product. The only time we ask for a drawing is if you want to specify tolerances.

Still, knowing all the rules and basics of formatting is an absolute must in the industry, as traditional manufacturing companies still need detailed drawings.

How to Make Drawings

A few decades ago, you would have had to sit down at a drawing board covered with papers of different size, rulers, callipers, etc. Today, all these instruments are still good for manual drafting but no contemporary manufacturer really wants such drawings.

Why? Because most of the machinery uses CNC systems that can read the information straight from the files and produce a cutting program accordingly. Drawings done by hand would just add a lot of manual work for manufacturing engineers.

So, we are left with only one option really – every engineer should use CAD (computer aided design) software because of its many advantages.

You can, of course, use CAD for making drawings from scratch. But the easier option is to first make a 3D model and create the drawings from that, as the programs generate the views with only a few clicks. All you need to do is add the dimensions. Having models also makes updating the drawings for revisions simple.

Basic Components of an Engineering Drawing

Let's see what makes up an engineering drawing. A single drawing includes many elements with quite a few variations to each of them. So let's take a closer look here.

Different Types of Lines

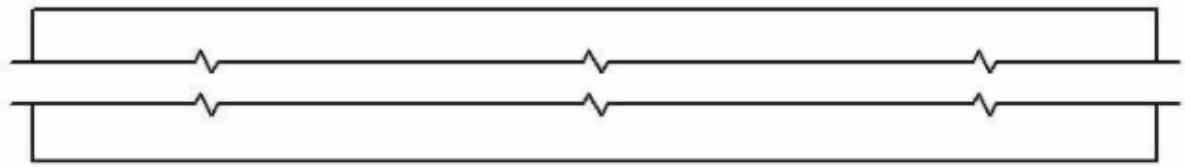
Not every line on an engineering drawing is equal. The different options make it possible to show both visible and hidden edges of a part, centre lines, etc.

The most common is a continuous line, also known as a drawing line. This represents the physical boundaries of an object. Put simply, these lines are for drawing the objects. The line thickness varies – the outer contour uses thicker lines and inner lines are thinner.

Hidden lines can show something that would not be otherwise visible on the drawings. For example, hidden lines may show the length of an internal step in a turned part without using a section or a cutout view (we explain both later).

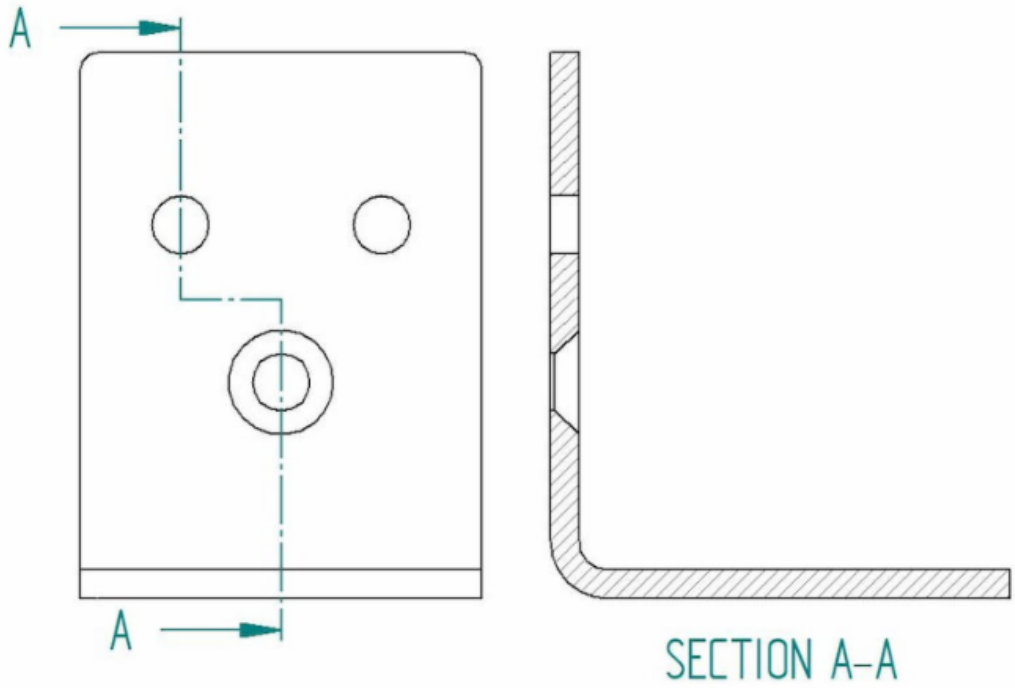
Centre lines are used to show hole and the symmetric properties of parts. Showing symmetricity can reduce the number of dimensions and make the drawing more eye-pleasing, thus easier to read.

Extension lines annotate what is being measured. The dimension line has two arrowheads between the extension lines and the measurement on top (or inside, like in the image above) the line.



Break lines indicate that a view has been broken. If you have a part that is 3000 mm long and 10 mm wide with symmetric properties, using a break-out makes gives all the info without using as much space.

While a good way for giving information to people, CNC machines need full views in order to cut the parts. Otherwise, the manufacturing engineer has to reconstruct the whole part from the measurements.



When using a cutout view, the cutting plane lines show the trajectory of the cutout. Here you can see that the A-A cutting line brings both types of holes into the view.

Types of Views

So let's take a closer look at the different types of views that are often present in a manufacturing drawing. Each serves a certain purpose. Bear in mind that adding views

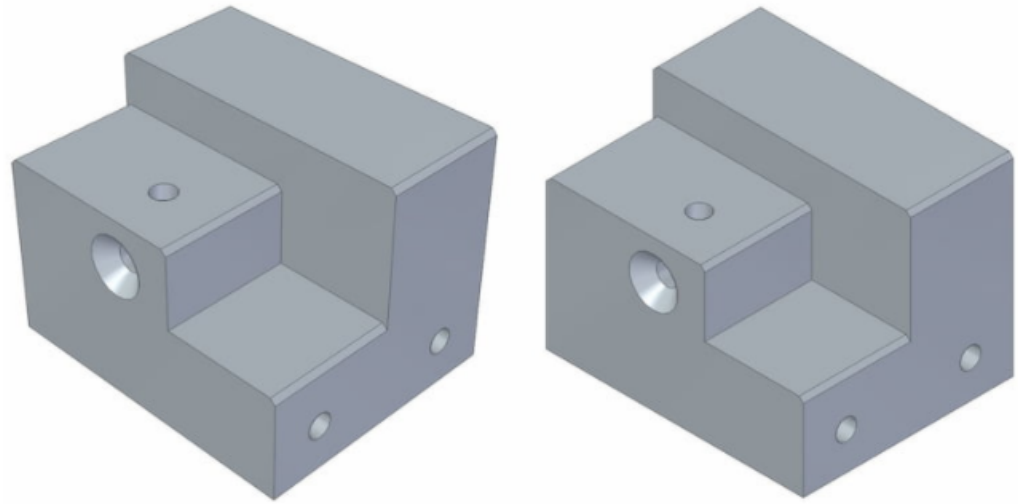
should follow the same logic as dimensioning – include as little as possible and as much as necessary.

A tip for good engineering practice – only include a view if it contributes to the overall understanding of the design.

Isometric View

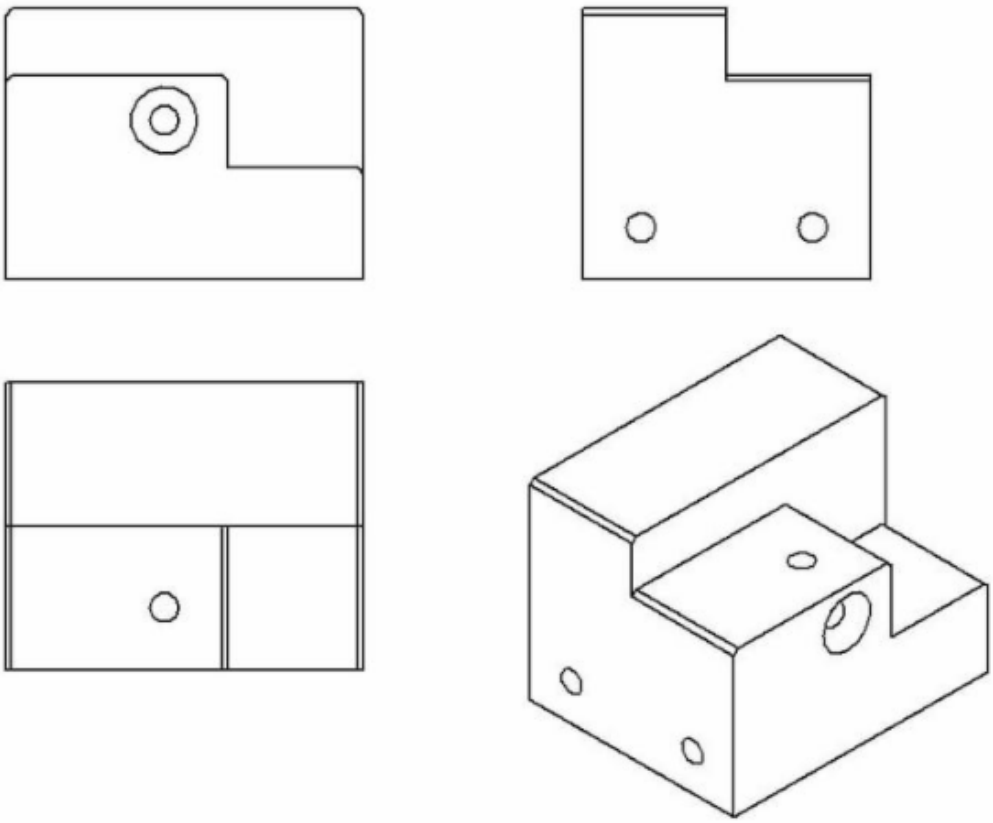
Isometric drawings show parts as three-dimensional. All the vertical lines stay vertical (compared to front view) and otherwise parallel lines are shown on a 30-degree angle.

The lines that are vertical and parallel are in their true length. Which means you can use a ruler and the scaling of the drawing to easily measure the length straight from a paper drawing, for example. The same does not apply to angled lines.



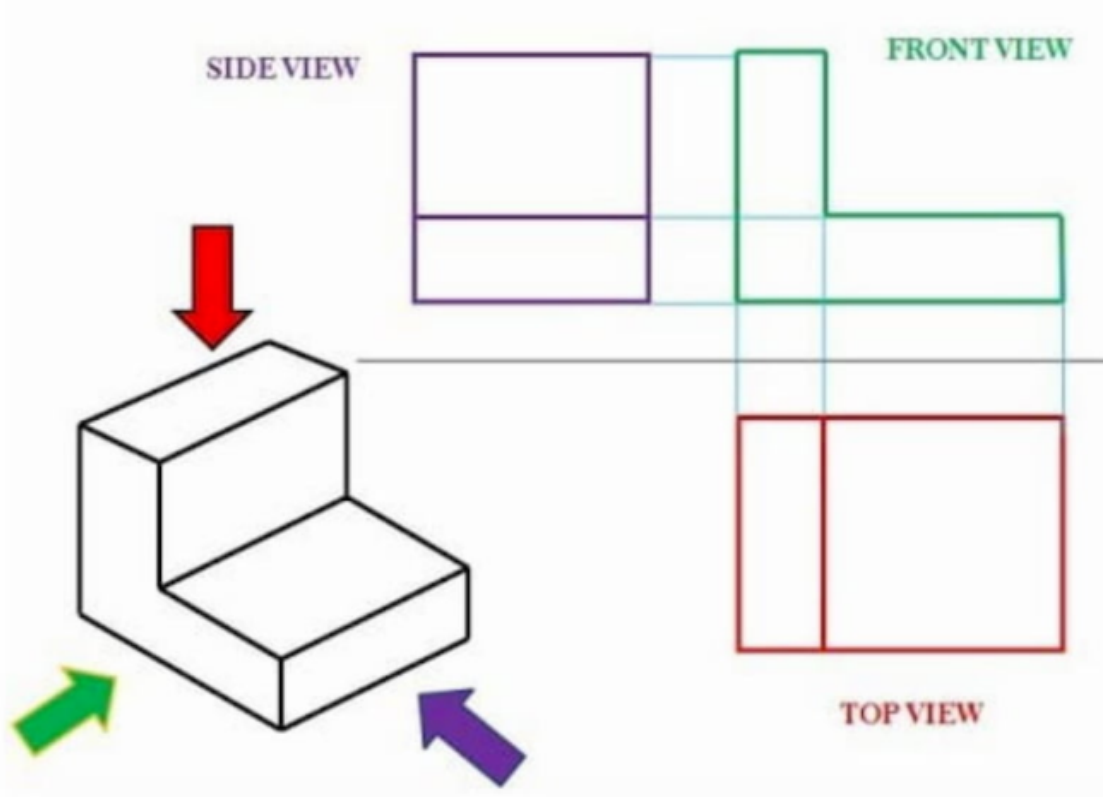
Left – perspective; right – isometric
It is important to distinguish the isometric view from a perspective view. A perspective view is an artistic one that represents an object as it seems to the eye. Engineers stay true to the dimensions rather than optical illusions.

Orthographic View



This is the bread and butter of an engineering drawing. An orthographic view or orthographic projection is a way of representing a 3D object in 2 dimensions.

Thus, a 2D view has to convey everything necessary for part production. This kind of representation allows avoiding any kind of distortion of lengths.



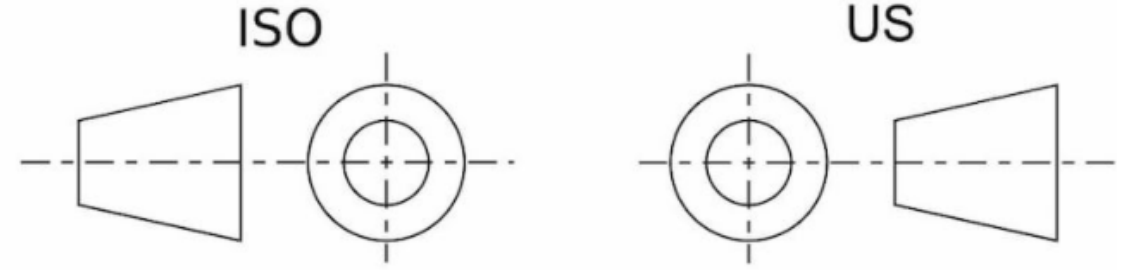
Orthographic projection (ISO standard)

The most common way to communicate all the information is by using three different views in a multiview drawing:

- ✓ Front view
- ✓ Top view
- ✓ Side view

It may be possible that some additional views are necessary to show all the info. But again, less is more.

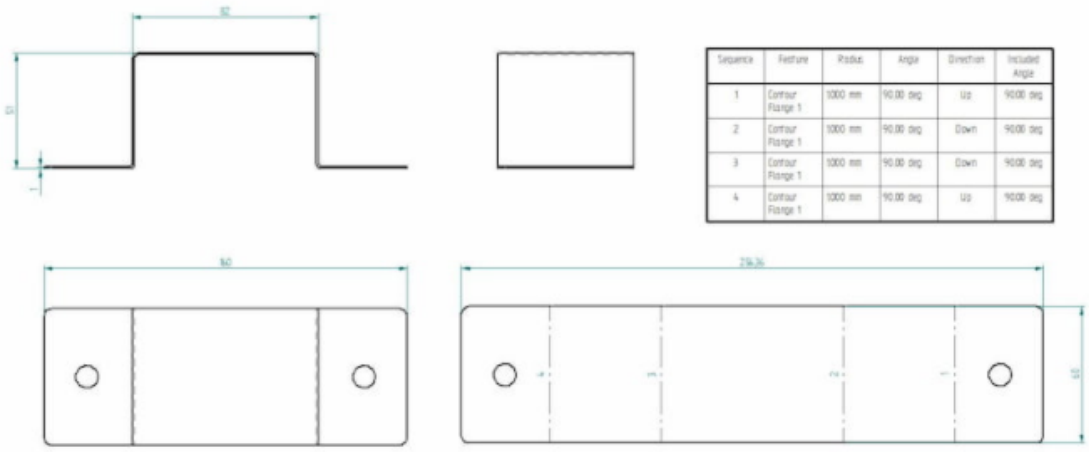
The positioning of the views differs a bit regionally. For example, look at the image below to compare the US and ISO layouts.



The one on the left is called first-angle projection. Here, the top view is under the front view, the right view is at the left of the front view, etc. The ISO standard is primarily used in Europe.

On the right, you can see a third-angle projection. The right view is on the right, top view on the top of the front view, etc. This system is especially popular in the US and Canada.

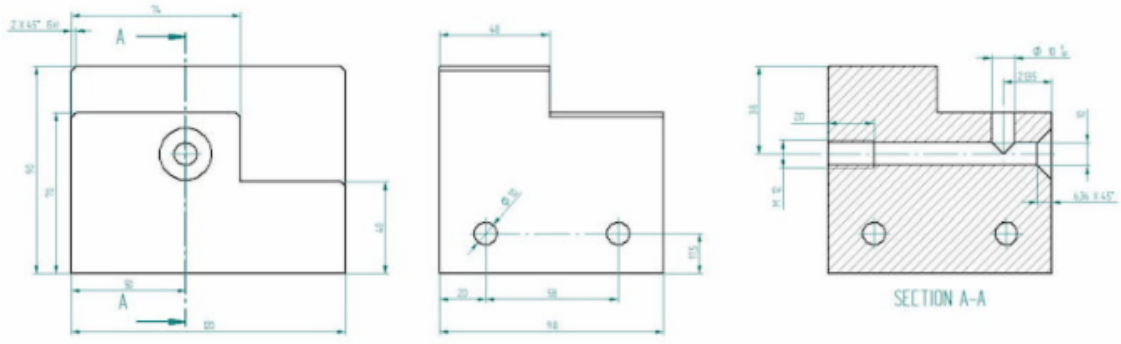
Flat Pattern



Creating a flat pattern view is usually pretty simple. Just be aware that you are using the sheet metal environment when making sheet metal parts in CAD. There you have the option to "generate a flat pattern" which you can easily add to the main drawing.

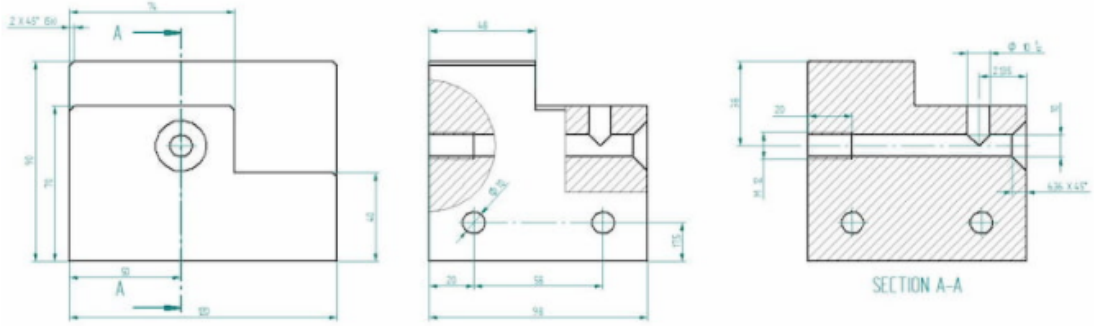
If you are using the standard part environment, the same option is not available. Still, many CAD programs have the possibility to convert a standard part into sheet metal if the part properties correspond to sheet metal (e.g. uniform thickness, inside radius, etc.).

Section View



A section view can easily display some of the part features that are not evident when looking just from the outset. Cross section is the preferred option compared to hidden lines as it brings more clarity. The cross hatching feature is and indicator for cross sectional views.

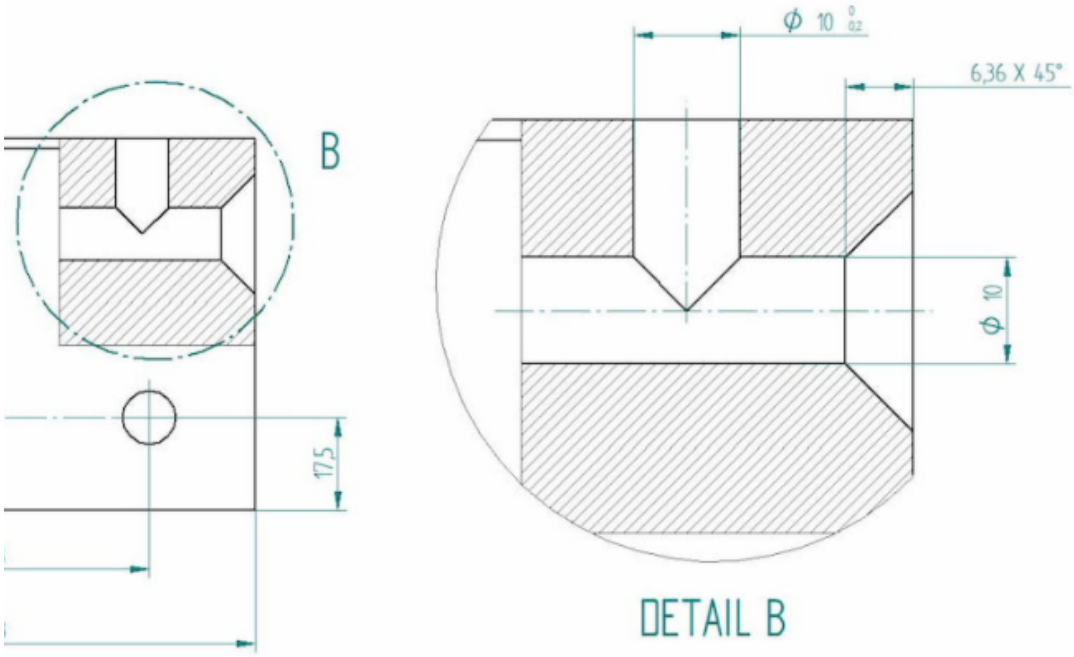
Cutout View



This is the same image we used for illustrating the section view. With one slight difference – the side view includes cutouts. Cutouts can reduce the number of different views on a single drawing.

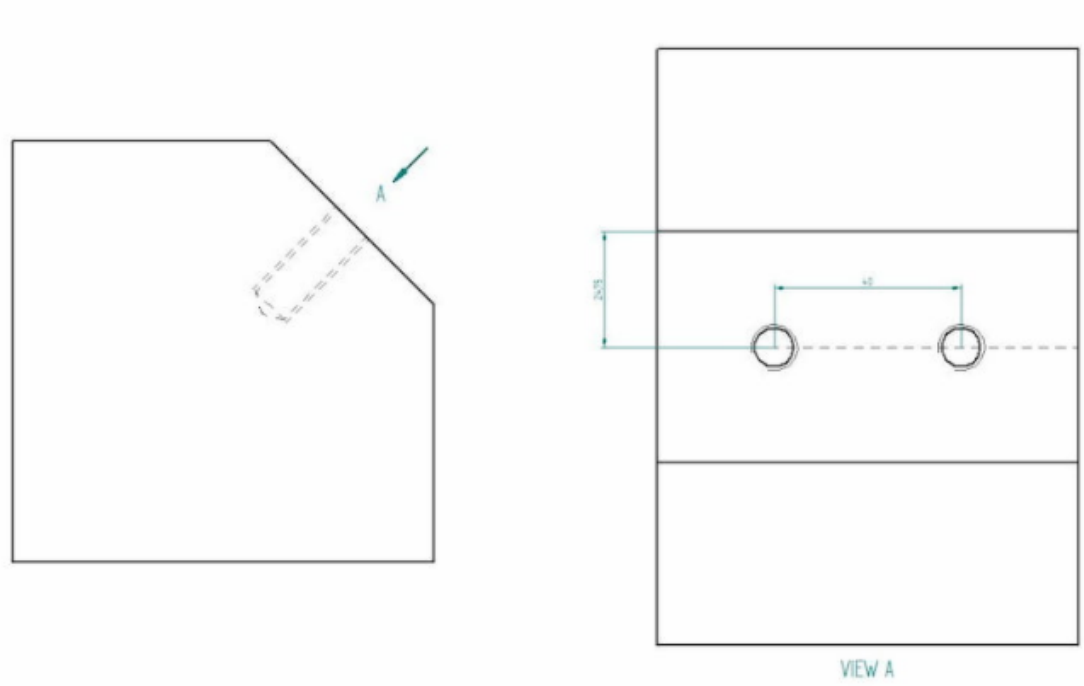
Thus, we could easily delete the section view and add all the necessary dimensions to cutouts.

Detail View



The detail view gives us a close-up of a selected section of a larger view. This can be especially useful if an otherwise large part includes many important dimension in a small area. Using the detail view improves the readability of these measurements.

Auxiliary View



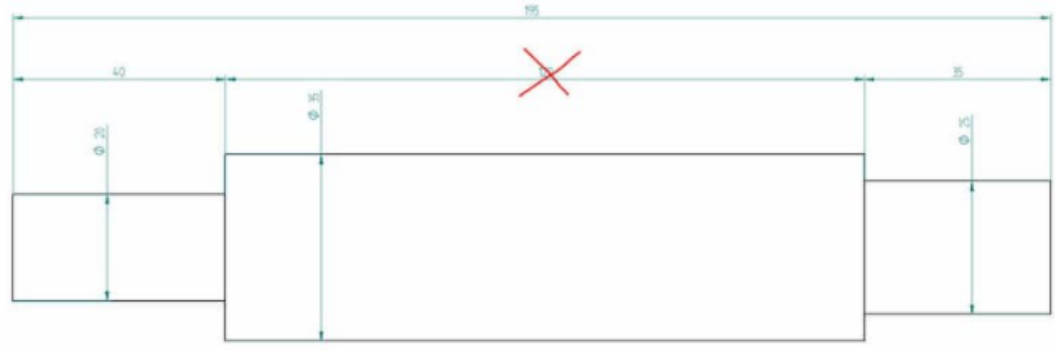
An orthographic view to represent planes that are not horizontal or vertical. It helps to show inclined surfaces without any distortion.

Dimensions

As said before, new CNC machines are actually able to read the dimensions straight from the lines. But a traditional manufacturing drawing shows all the necessary dimensions for producing the parts.

The keyword here is necessary. Avoid using the auto-dimensioning feature that a lot of CAD programs offer because they tend to show everything they can find. For a beginner, it may seem like adding it all ensures that no mistakes can be made.

Actually, it can result in a confusing web of measurements that is left for the manufacturing engineer to untangle. Also, adding all dimensions you can find makes it hard to pinpoint which ones are the most important.



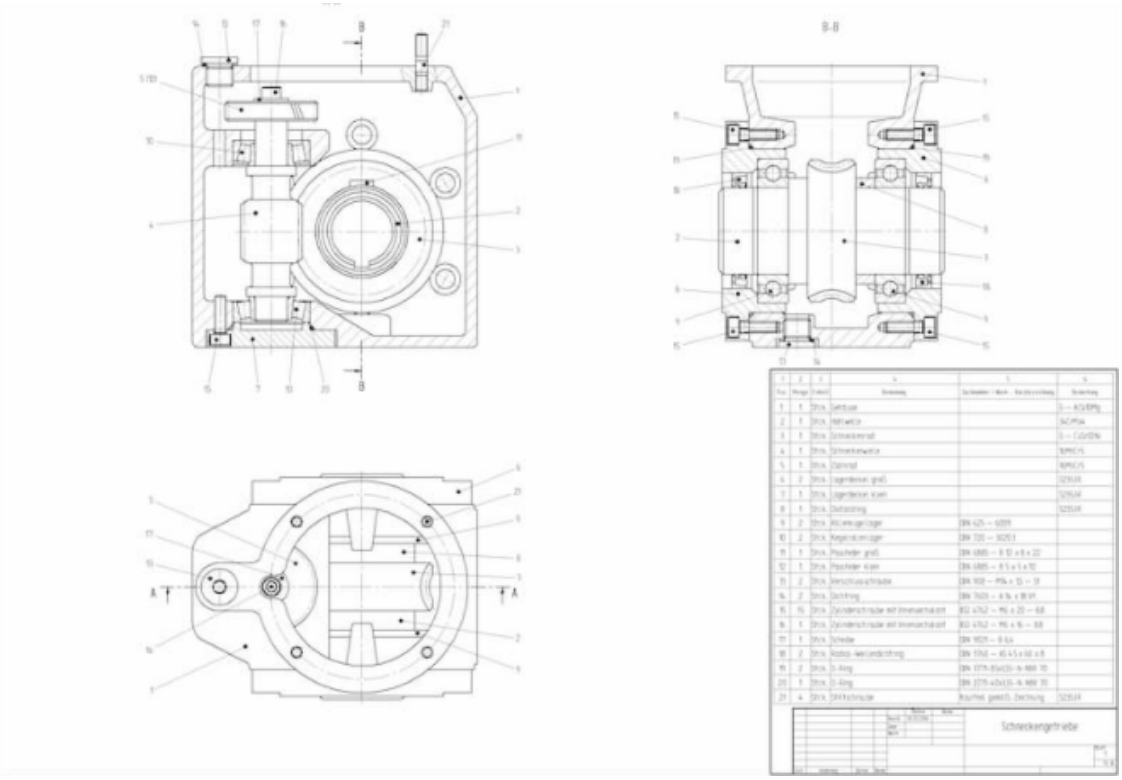
The image above shows a shaft with all the measurements. In reality, it creates a closed system whereby the manufacturer cannot guarantee all these dimensions 100%. Therefore, you have to determine the most important ones. In our case, we chose the end steps to be more important than the length of the central part. Thus, we should delete the 120 mm dimension.

One crucial bit of information that is missing from CAD models is geometric dimensioning and tolerancing (GD & T). For example, when looking to produce a shaft for a bearing system, limits and fits are of high importance. The right dimensions can guarantee a longer lifetime with less maintenance.

While you can fetch all the dimensions automatically by clicking the measure button, adding engineering tolerances needs manual action.

Therefore, adding dimensions with lower and upper limits or fit classes is still important. Regarding Fractory's service, we would ask you to enclose a separate drawing with these parameters. Note that you do not have to provide the whole dimensioning – only include the tolerances of a single hole on your engineering drawings if necessary.

Information Blocks



BOM and title block in the lower right corner

The little boxes in the bottom right corner show additional information. The title block includes the author's name, part name, part number, quantity, coating, scale, etc. There can be much more info on there but the title blocks vary widely between different companies.

Information blocks also include a bill of materials, or BOM for short. These blocks list all the components used in the assembly, along with additional information like quantities, part names, etc.

Assembly Drawings

Many engineers' drawings make the mistake of trying to include all the information about each individual part in an assembly drawing. To avoid this, remember the purpose of these engineering drawings during the creation process – they must make the assembling easy.

Exploded views, section views, numbered parts, general dimensions, cutouts, detail views (or close-ups) are all tools you can use to achieve this goal.

It should be clear where each part goes and how it is attached – whether it needs welding, bolted connections, riveting or something else. The bill of materials is there to help you, so make sure the information available there is correct regarding part numbers, names and quantities.

Keeping everything above in mind will help you create assembly drawings that make life easier on the shop floor. A piece of great advice I once received goes like this – keep the thinking in the drawing-room. Avoiding multiple interpretation possibilities at later steps will significantly decrease the number of errors.

PREPARE WORK PLAN AND COMMENCE WORK

Flowcharts Symbols Meanings

Whether you're trying to read a flowchart or creating a flowchart, knowing the most common flowchart symbols and conventions is going to make it a lot easier. Here, we've got the four flowchart symbols you've got to know, plus a rundown on some more intermediate process symbols if you're looking for extra credit.

An End or a Beginning

The oval, or terminator, is used to represent the start and end of a process. Use the Gliffy flowchart tool to drag and drop one of these bad boys and you've got yourself the beginning of a flowchart. Remember to use the same symbol again to show that your flowchart is complete.

A Step in the flowcharting Process

The rectangle is your go-to symbol once you've started flowcharting. It represents any step in the process you're diagramming and is the workhorse of the flowchart diagram. Use rectangles to capture process steps like basic tasks or actions in your process.

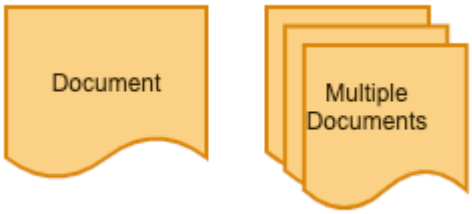
Indicate Directional Flow

The arrow is used to guide the viewer along their flowcharting path. And while there are many different types of arrow tips to choose from, we recommend sticking with one or two for your entire flowchart. This keeps your diagram looking clean, but also allows you to emphasize certain steps in your process.

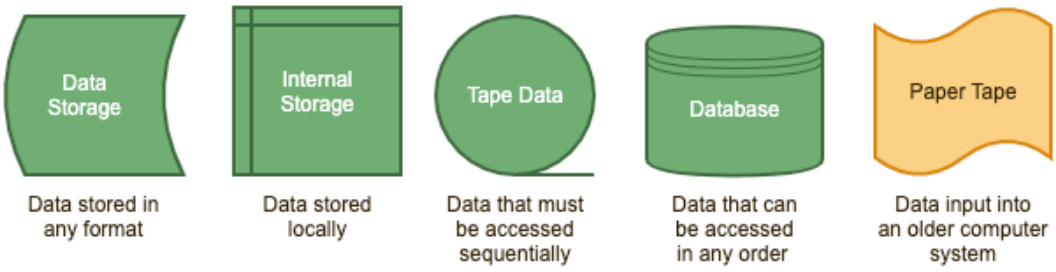
The diamond symbolizes that a decision is required to move forward. This could be a binary, this-or-that choice or a more complex decision with multiple choices. Make sure that you capture each possible choice within your diagram.

Document Symbols

Single and multiple document icons show that there are additional points of reference involved in your flowchart. You might use these to indicate items like "create an invoice" or "review testing paperwork."

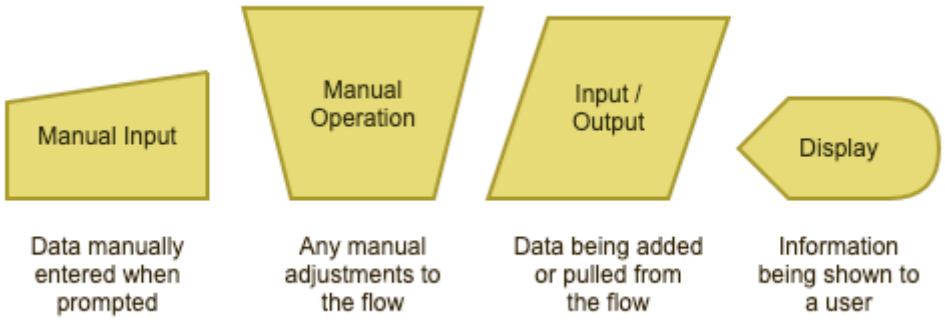


Data Symbols



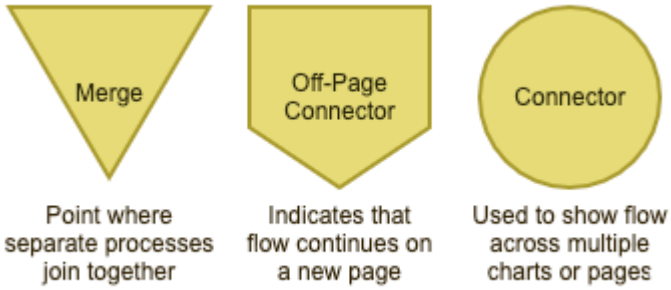
Data symbols clarify where the data your flowchart references is being stored. (You probably won't use the paper tape symbol, but it definitely came in handy back in the day.)

Input & Output Symbols



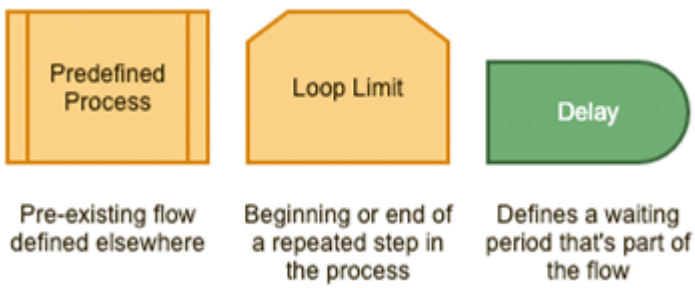
Input and output symbols show where and how data is coming in and out throughout your process.

Merging & Connecting Symbols



Agreed-upon merging and connector symbols make it easier to connect flowcharts that span multiple pages.

Additional Useful Flowchart Symbols



The above are a few additional symbols that prove your flowcharting prowess when put to good use.

Flowchart Example: Should I Bring an Umbrella

This example show how a person decides whether he/she should bring an umbrella when living home. This simple diagram demonstrates the uses decisions and processes.

Visual Paradigm Online offers an online platform for users creating flowchart and others. Start making your flowchart by clicking Create Blank or Use This Diagram.

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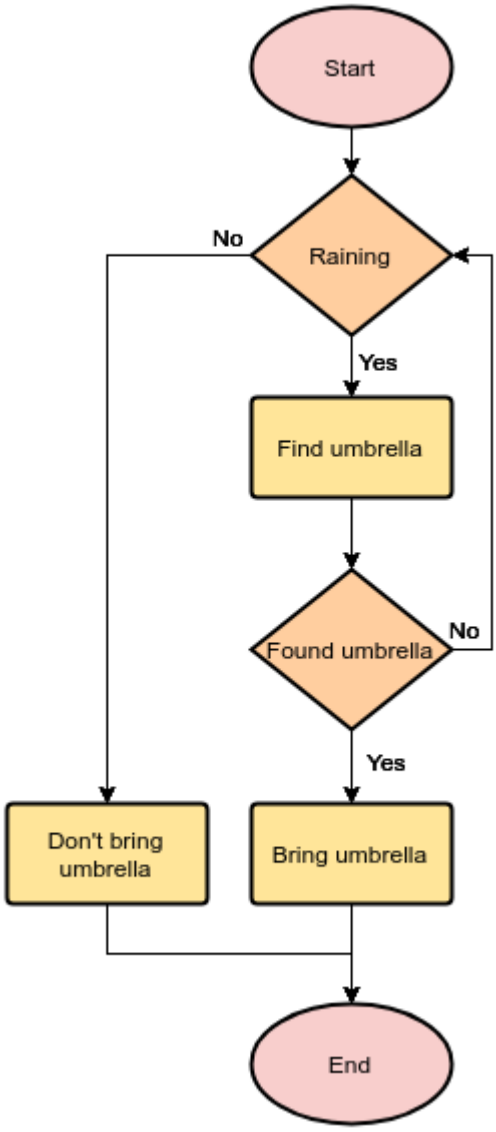


UNIT 13

INSTALL SEWERAGE SYSTEMS

This unit of competency specifies the outcomes required to install seweragepumps, and install sewerage pipes. Properly installed sewerage pipe systems will ensure safe and smooth operation of the sewerage networks

Introduction

This unit focus on the development of knowledge and skills related to undertaking domestic sewerage system.

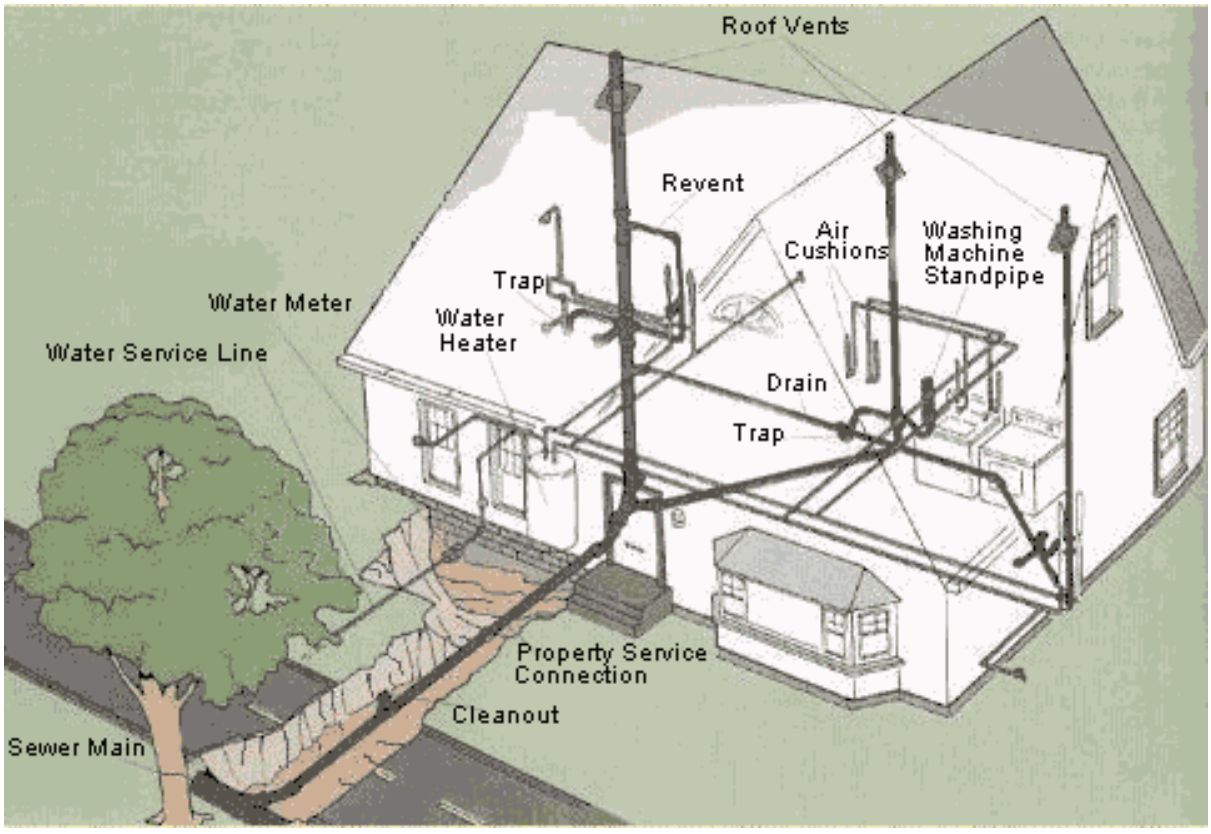
Sewerage system of homes predominantly include wastewater that enters the septic tank, which separates solids from liquids. Solids are held in the septic tank and liquids are conveyed to the final soil treatment site. Gases are vented off while solids are composed of both scum and sludge. Scum is lighter than water and floats to the surface in the septic tank. The solid parts are heavier than water and sink to the bottom of the tank.

The five parts of a sewage disposal system are: (1) the house plumbing, (2) the sewer line from house to septic tank, (3) the septic tank, (4) the septic tank outlet sewer pipe, and (5) the final soil treatment unit, which may be a soil absorption unit or lagoon.

In the Maldives, domestic sewerage system includes up to number-3 while 4 and 5 falls into the main sewerage lines that are installed by the utility providers.

House Plumbing for Sewage

The house plumbing system includes waste pipes, water traps and connect both toilet and kitchen waste water to the septic tank installed within the boundary of the home. Referred septic tank will be connected to the septic tank installed outside and subsequently to the main sewerage line.



PREPARE FOR WORK

Prepare the Installation Site

Before you begin setting up your new sewage pump, consider the following:

- ✓ **Read the user manual**: The appropriate method for installing your sewage pump depends on the specific product you purchased. Aside from these tips, it's also helpful to consult the installation guide that comes with your sewage pump. The manual may also advise you about which accessories are most compatible with your unit.
- ✓ **Consult your regional building regulations**: Depending on your location, you may have to follow unique building and plumbing codes, including acquiring a permit. Ensure correct installation of this essential component so you can make sure you're following any applicable guidelines. Before you start, consult your local building department about the rules in place for this setup.
- ✓ **Requirements for proper ventilation**: Know how to provide adequate airflow for your specific product. The sewage pump needs a vent to maintain a balance of pressure as it functions so sewer gasses can escape. This vent travels up from the sump pit and connects to the existing vent or goes out through the roof.
- ✓ **Standards for appropriate piping**: To allow proper water flow of your drainage system, consider how to install the outlet or discharge pipe. This component should measure about 2 inches in diameter to accommodate the solid waste, attaching to the main sewer line. You also need to install a check valve to prevent wastewater from draining back into the basin.

Gather Your Tools

To set up your new sewage pump, you'll need the following equipment besides your new unit:

- ✓ **Safety equipment**: Use personal protective equipment (PPE), such as goggles, gloves, shoes and a mask to guard against potential waste contamination.
- ✓ **Old rags or towels**: Clean up possible waste accumulation with an old cloth that you don't mind getting dirty.
- ✓ **Boxcutter**: This tool can cut the pit's seal so you can remove your outdated sewage pump.
- ✓ **Bucket**: A 5-gallon bucket can store your old pump and collect waste that could drain out of it.
- ✓ **Polyvinyl chloride (PVC) piping**: Make sure you find PVC piping that complies with local building standards.
- ✓ **Hacksaw**: Use a hacksaw to cut any pipes that need to be shortened or opened.

- ✓ **Pipe wrench**: Attach your PVC piping to the sewage pump using a pipe wrench.
- ✓ **Power drill**: A power drill can create a weep hole in the discharge pipe to prevent it from drying out.
- ✓ **Primer and PVC cement**: Connect the pipes and any fittings to your unit with these adhesive materials.
- ✓ **Male-threaded adapter**: This fitting allows you to attach your discharge pipe to the pump.
- ✓ **Coupling**: Use this component to connect your new check valve to the pump and the various piping.
- ✓ **Zip ties**: Secure electrical wiring slack with zip ties.
- ✓ **Electrical cord grommets**: These pieces protect wiring from potential water damage.
- ✓ **Replacement gasket**: If you need a new gasket for your sewage pump basin, have it on hand before installing the whole system.
- ✓ **Donut gaskets**: These components attach the basin cover to the pipes.

Remove the Old Sewage Pump

If your home already has an old sewage pump, you can follow these steps to remove it without damaging or soiling your property:

- ✓ **Disconnect the vent pipe**: If your old basin doesn't come off at the center, you need to remove the vent pipes so you can slide it over them. In some cases, you'll have to use a hacksaw to cut the vent and discharge piping to take off the cover — then you'll have to replace them.
- ✓ **Take off the basin cover**: The cover may have a strong seal with silicone or bolts over it to prevent sewage gas leaks and odors. If your old basin still has the seal on it, you'll need to cut it with a boxcutter and remove the screws holding the cover in place.
- ✓ **Remove the check valve**: You must take the check valve off the pump to pull all the components out of the pit. Consider replacing the check valve whenever you install a new sewage pump so you know the drainage system will work properly. For your protection, wear gloves and proper PPE to deal with any remaining wastewater after disconnecting the valve.
- ✓ **Take out the old pump**: After you've detached the pump, take the discharge pipe and lift the whole unit out of the water, being careful not to let the remaining water inside of it stain your clothes or the floor. Put the old sewage pump in a bucket to control the possible waste accumulation and prevent it from dripping onto your property.
- ✓ **Check the pipe**, **connectors and basin**: Inspect these accessories to find out if you can reuse them in your new system. You may need to replace them if they have cracks or stubborn stains.

IDENTIFY INSTALLATION REQUIREMENTS

Pumping stations handle sewage either as in-line for pumping the sewage from a deeper sewer to a shallow sewer or for conveying to the STP or outfall. They are required where sewage from low lying development areas is unable to be drained by gravity to existing sewerage infrastructure, and / or where development areas are too remote from available sewerage infrastructure to be linked by gravity means.

Location of pump

The proper location of the pumping station requires a comprehensive study of the area to be served, to ensure that the entire area can be adequately drained. Special consideration has to be given to undeveloped or developing areas and to probable future growth. The location of the pumping station will often be determined by the trend of future overall development of the area. The site should be aesthetically satisfactory. The pumping station has to be so located and constructed such that it will not get flooded at any time. The storm-water pumping stations have to be so located that water may be impounded without creating an undue amount of flood-damage, if the flow exceeds the pumping station capacity. The station should be easily accessible under all weather conditions.

Pump base requirements

Pumping stations are typically located near the lowest point in a development. However, the siting and orientation of each pumping station shall be considered individually and based on the following criteria

- ✓ Local topography as slope of the ground and above and below ground obstructions
- ✓ Proposed layout of the particular development and of future developments
- ✓ Proximity of proposed and/or existing sewerage infrastructure
- ✓ Size and type of the pumping station
- ✓ Access considerations for O&M needs including operators health and safety issues
- ✓ Visual impact, particularly the vent tube, odours, noise problems, etc.,
- ✓ Vulnerability of the site for inundation
- ✓ Compatibility to neighbouring residences by suitable dialogues.

Materials and equipment required

1. Level Instruments

As the name suggests, these instruments are used to maintain specific liquid or gas levels in pipes, tanks, or silos in wastewater treatment systems. Because treatment pipes are typically opaque and difficult to access, it's impossible to determine the amount of liquid or gas present based on visual cues alone. Instead, system operators rely on level radar, sensors, and transducers to monitor current water levels. Instruments like radar, transducers, and switches are often connected to alarms, pumps, or controllers to automatically adjust water and gas flow based on incoming

data. Whereas continuous level instruments are designed to provide consistent measurements, point level instruments transmit readings only in the event that water levels reach preset extremes as a means of preventing overflow.

2. Flow Instruments

Flow instruments are used to determine the amount of fluid or gas that's present in an enclosed pipe as well as the rate at which it's moving through the vessel in question. These instruments are typically installed into wastewater treatment pipes and are designed to measure volume and mass at regular time intervals. Using this data, operators are able to monitor flow volume and mass flow to maintain the safety and functionality of their treatment equipment. Examples of flow instruments include variable area meters, mechanical flow meters, magnetic flow meters, thermal flow meters, and pressure-based meters. The data provided by flow meters is often used to trigger flow switches, pumps, or supply valves.

3. Pressure Instruments

This blanket category includes pressure transmitters, sensors, transducers, and gauges. Like flow instruments, pressure instruments are typically installed into the pipes, pumps, and reservoirs of wastewater treatment systems. Some pressure instruments will measure flow rate and fluid levels in addition to pressure, filling the function of both a flow and pressure instrument. In doing so, they help industrial facilities maintain safe pressure levels and prevent equipment failure. The type of pressure instruments required depend on the testing conditions, the accuracy required, and the specific type of pollutants in the wastewater.

4. Water Quality Monitoring Instruments

Water quality monitoring instruments are integral to industrial wastewater treatment. Before treated water can be recycled back into the manufacturing process or released into sanitary sewers, it must meet national and local water quality standards of cleanliness. Inline water quality instruments are installed into wastewater treatment vessels to provide continuous readings at different points in the treatment process. The type of meter required at each treatment phase depends on the testing environment and the system in question. For example, reverse osmosis systems are designed to remove total dissolved solids (TDS) from water, so the inline meter installed in this system should be capable of measuring TDS.

In addition to inline meters, industrial facilities often require manual water quality spot checks to provide greater accuracy and quality assurance. These readings can be taken using portable meters or conducted in on-site laboratories using benchtop meters.

INSTALL SEWERAGE PUMP EQUIPMENT

Install the New Sewage Pump

- ✓ **Clean debris out of the basin:** If you took out an old sewage pump, look into the pit for damage and other abnormalities. Carefully get rid of any materials or waste that may have accumulated on the basin walls. Use a scraping tool to take off the old seal so the new one will be strong and prevent gas leaks and odors.
- ✓ **Position the basin:** To prevent potential leaks, secure the container with hard hold glue before attaching the pump. Ensure the unit is stable so it doesn't tip or fall when water hits against it. Since this basin operates by gravity, you need to position it lower than the ground so the wastewater can flow into the tank.
- ✓ **Install the new check valve**: Set up the new check valve before putting the pump in the sewage basin. You may want to position it so the water can pass upward into the main sewer line. To glue this component to the pump, apply primer inside the fitting and outside the discharge pipe. Slide the coupling on top of the pipe, then attach the fitting to the discharge pipe with PVC cement. Twist it slightly and hold for a few seconds to secure the bond.
- ✓ **Set up the float switch**: Install the float switch on top of the pump and secure it with heavy-duty glue. Position it so the trigger is pointing at the basin and has a free range of motion. Open the vent outlet enough to release as much water as possible each time this component activates the sewage pump. Adjust the float so the tank's wastewater level doesn't get too low below the drain inlet.
- ✓ **Test the pump and float switch**: Connect the new pump to a dedicated circuit and test it by activating the float switch and making sure it turns on the system. Only allow the pump to run long enough to hear it working, or else it could become damaged. Make sure you've installed the float switch at the right height so the system can operate properly.
- ✓ **Measure and cut the PVC pipe**: If you need to install a brand-new discharge pipe, measure the old one and consider the proper dimensions given the new check valve's installation. Use a hacksaw to cut it on a raised surface, and smooth out the edges with a deburring tool.
- ✓ **Drill a weep hole**: A weep hole prevents the pump from drying out due to air locking in the pipe. It also controls the flow of water and air away from the pit, allowing the system to flow freely every time it needs to empty the basin. You may want to lean the pump at an angle and measure a few inches above the adapter. Drill a three-sixteenths-inch gap into the piping for the best results.
- ✓ **Connect the adapter and pump to the discharge pipe**: With primer and PVC cement, secure the male-threaded adapter to one side of the PVC pipe. Thread the side of the pipe attached to the adapter into the sewage pump, tightening it with a wrench. Be careful not to overtighten it so you don't crack the fittings.

- ✓ **Lower sewage pump into the pit**: After you've cut the discharge pipe and attached it to the sewage pump, bring both components into the basin. Position the float switch so it's away from the wastewater inlet. It may help to install the discharge pipe to block the inlet water from covering the pump directly. When you've confirmed every piece is in the right position, secure the electrical wiring with zip ties to prevent snagging.
- ✓ **Connect the discharge pipe to the check valve**: Using the primer and PVC glue, connect the coupling to the top of the PVC pipe. Slide the adapter from the check valve over the coupling before securing it to the discharge pipe. Connect the coupler with glue to the discharge pipe and attach it to the check valve. Slide the adapter up and tighten the check valve with your hands. Overtightening the system may crack the fittings, so avoid this.
- ✓ **Test the sewage system**: After you've securely placed the pump inside the basin, make sure the float switch can move freely within it. Connect the sewage pump to the designated electrical outlet and fill the basin with a bucket, putting in enough water to activate the float switch. Piggyback the pump plug off the float switch to ensure proper operation.
- ✓ **Confirm proper placement of all components**: Prepare the new gasket for connecting to the basin cover. Loosen the discharge pipe so you can slide the cover over it. Pull all electrical wires through the basin cover holes before sealing the top. Pull the wire slack up with an electrical wire grommet and fill the gap. Once you've placed the cover, make sure the vent pipe is about 2 or 3 inches below the cover when it's inside the basin.
- ✓ **Secure the sewage basin cover**: Permanently attach the cover to the basin with a bead of silicone around the opening's edge. Slide it over the discharge pipe and press it into place. Screw the new bolts and washers in place to hold the cover down. If you notice any additional wire slack, pull it above the cover and zip tie it to the discharge pipe, ensuring the wires are below the electrical outlet. Slide the donut gasket over the discharge pipe and lock the gasket into the grooves.
- ✓ **Connect the vent pipe to the top of the basin cover**: You must attach your sewage pump system's piping to the basin to vent odors and gases. These pipes need to vent outside or connect to the main stack in the home where your other piping connects. Make sure your system complies with all local and regional building codes. Once you've attached both pipes securely and safely, fill the remaining gaps with a bead of silicone to produce a proper seal.

CLEAN UP

It’s not uncommon to see signs in workplaces reminding employees to clean up after themselves. If doing so is important in office kitchens, it’s doubly important on construction sites. Keeping sites orderly and removing waste can help avert accidents, prevent damage and even boost morale among workers.

The strategies below are a good starting point for keeping a jobsite clean.

Establish a housekeeping program

Set up a housekeeping system that involves everyone on the team. Focus on the importance of cleaning and removing debris after it has been created, and assign specific tasks to specific people to create accountability.

To keep the site tidy, use the 5S system, a method of workplace organization invented in Japan that includes making sure everything has a designated place and removing items not in use. To encourage compliance, use toolbox talks to remind everyone of the benefits of a clean, organized jobsite, such as improved safety and efficiency.

Separate the scraps

Construction companies may be required to recycle materials like metal, wood and sometimes, concrete. In addition to federal regulations, you may need to follow state or regional recycling rules. And the contract might stipulate which materials or debris should be diverted from landfills, along with target diversion rates for non-hazardous solid waste.

Observe the rules and designate piles, bins and containers for leftover materials. Do this ahead of time so nothing that should be kept or recycled is accidentally thrown away. In general, while recycling containers should be easy to access, the fewer containers for each type of material the better in terms of keeping transportation costs low and minimizing jobsite obstructions. Consider hiring a company that does waste and recycling management for construction firms.

Eliminate waste at the source

The less waste that arrives or is created at the site, the less disposal and cleanup is necessary. Choose products with minimal packaging. Measure carefully so you order only the materials you need, in the optimal sizes. Buy quality materials so you throw out fewer warped studs, for instance. Embrace the use of prefabricated elements when possible.

Keep waste properly contained

Keeping a lid on waste, literally, is important, especially when the waste could spill, evaporate or smell. Containers and product drums should be sealed tightly. Use the right container for the type of hazardous waste. Mark the container to indicate its contents, and make sure the container is in good condition. Containers of used oil should be free of leaks, structural defects and severe rusting, for example. Use a locked compound if you're storing one near water or a drain.

All workers must be trained in the management of hazardous waste as it relates to their job function. Make sure everyone knows where to discard flammable and combustible materials.

Oily rags aren't just tripping hazards; they're also flammable. In fact, they can spontaneously combust. That's why they should be stored in a metal container with a cover, preferably a self-closing lid. Schedule frequent removal of hazardous waste to keep areas clean and prevent fires and accidents.

To discourage dumpster divers and any unauthorized use of your dumpster, consider a lock for it.

Manage dust safely

Use engineering and work practice controls such as dust collection systems to limit dust in the air during certain tasks, such as sawing or grinding concrete, stone or mortar. Reduce the amount of dust created by installing water systems that steam or spray a cutting blade.

The last sweep

Last impressions count. Performing a final cleaning during closeout will leave a good impression on the client and possibly help you win more projects in the future. Create a checklist of tasks, such sweeping, mopping, cleaning all surfaces, washing windows and removing any remaining stickers. And don't forget trash removal.

If you established a good housekeeping routine at the beginning of the job, cleanup should be a relatively easy final step.

UNIT 14

INSTALL BELOW GROUND DOMESTIC SEWERAGE SYSTEMS

This unit of competency specifies the outcomes required to install below ground sanitary drainage systems for sewerage and waste discharge from sanitary fixtures to the authorities' approved point of connection

PREPARE FOR WORK

Having a properly installed foundation drainage system is imperative to maintaining the structural integrity of your home. Not only can foundation drainage issues lead to standing water in your yard, but they can also lead to foundation cracks, mold, and other severe property damage. On top of that, much of the damage caused by poor drainage is not covered by insurance because it's often preventable.

Installing a foundation drainage system on your own can be extremely difficult, time-consuming, and occasionally dangerous. Make sure you're prepared for the challenge or call in the professionals to take care of it for you.

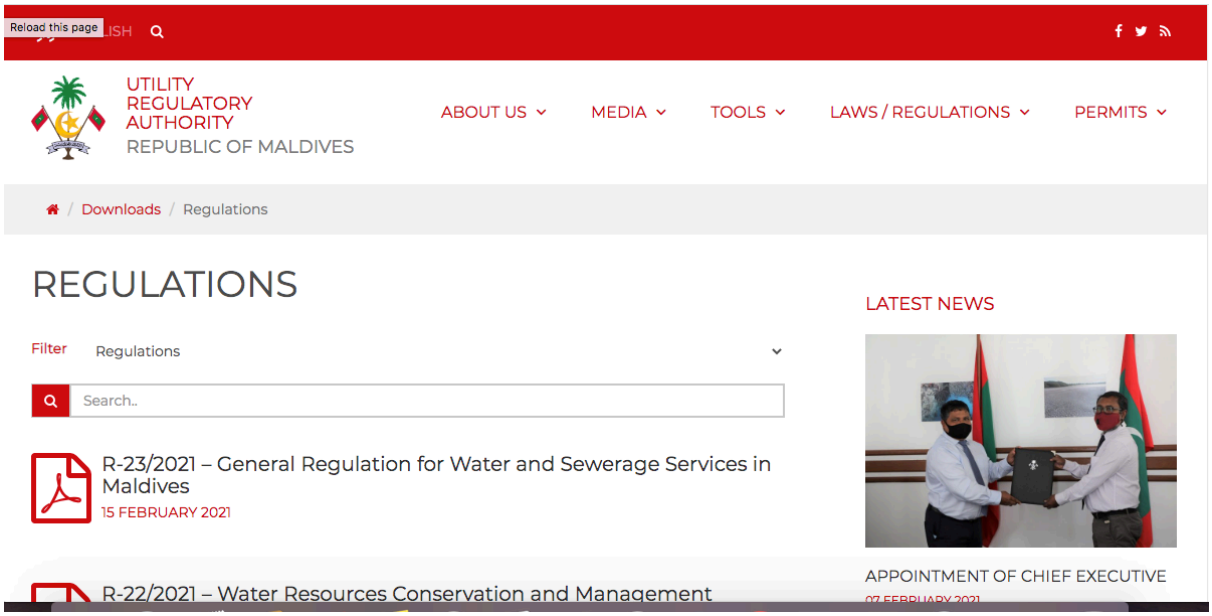
What type of foundation drainage solution is required?

Before considering how to install a foundation drainage system, you must first consider which type of drainage solution you'll need. Often building service drawing are prepared and make sure the drainage system to be installed is aligned to the service drawing that's approved from the relevant authorities.

Know what the regulations are in your area

Maldives has developed relevant Acts and Regulations that need to be followed while installing the below ground domestic drainage system.

Make sure, you access referred regulations and guidelines from the Utility Regulatory Authority of the Maldives prior to practically installing the domestic sewerage system within domestic settings.



IDENTIFYING INSTALLATION REQUIREMENTS

What are the excavation requirements?

First, make sure your landscaping is done at the proper slope. A slope that is too steep will cause erosion issues. A flat yard will lead to standing water. A proper slope is 1 foot in rise (the difference between the highest and lowest points in the slope) per 50 feet of run (the horizontal length of the slope). This is ideal for drainage.

To install drain, you'll need to do some digging — digging up most of your yard, unfortunately! During this step, make sure to avoid any buried power lines, gas lines, or sewage. You'll have to dig a trench around the perimeter of your footing. This trench must be at least two feet wide and six feet deep. For a slab-on-grade home, the trench can be as shallow as two feet.

Exterior drains can get clogged in a few years and require you to redo this project. In order to make sure this doesn't happen; you'll have to place a permeable mesh sock over the drain pipe. Your other option is to install an interior drain. This requires breaking up your basement floor, installing the drainage system, and then rebuilding the floor.

At this point, you may be thinking the install job might take a little more time and attention to detail than originally thought. That's ok. The team at Superior has the experience and expertise to install foundation drainage systems correctly and

What are the required materials for proper foundation drainage?

Different drainage solutions can require different materials. There are many questions that need to be answered. What is the preferred placement of stone around foundation drainage? What kinds of stone can I use? Where can I get stone? What kind of pipe or tile is required?

Acquiring the correct materials will help inform you of how to install a foundation drainage system. For a basic french drain, you'll need perforated pipe, a geotextile cloth/cover such as a permeable mesh sock, and gravel. Not sure what those materials are or where to find them? Let's break them down.

- ✓ **Perforated Pipe**: A perforated pipe is simply a plastic pipe, such as corrugated drain tile, with small exterior perforations that help collect and redirect water in the soil.
- ✓ **Geotextile cloth/cover**: Geotextiles are permeable mesh fabrics which, when used in the soil as part of a foundation drainage system, have the ability to separate, filter, reinforce, protect, or drain. They help to filter soil and prevent the perforated pipe from clogging with dirt over time.
- ✓ **Proper backfill material**: There are several varieties of proper backfill materials that are used in different scenarios. When installing a basic french drain, you'll need to use pea stone or washed gravel to cover the pipe and fill

in the trench. Superior provides and installs a variety of backfill media. Our stone slinger trucks easily install peastone without any heavy lifting or ruining your landscaping.

- ✓ **Extras**: Tools for excavating, hammer, stakes, string, line level, tamper, tape measure, rake

Before buying materials, find out which kind of drain pipe is best suited for the job. We break down several of the options and descriptions of other related terms here in our glossary.

INSTALLING SANITARY DRAINAGE SYSTEMS

How to install a Perforated Drainage Pipe

Step 1: Dig the trench

Prior to doing any digging, you'll have to prepare your property. First, call your utility companies and have them mark where your utility lines are buried to make sure you don't hit them while digging.

Next, make sure that the trench will use elevation properly to direct water away from the structure. Once you've prepared your yard and made your plan, it's time to start digging.

Make a trench around 2 feet wide, or twice the width of the drainage pipe. Make sure the trench is deep enough that the entire pipe lies below the frost line.

A trench that is 6 feet deep should generally work for a regular basement. You'll have to check local laws and regulations to make sure your trench is in compliance. If you have a large property, manually creating the trench could be a huge project. Consider renting equipment to make the job a little easier.

Step 2: Create a proper slope

Use a sledgehammer to drive stakes/markers into the soil in the trench every four feet or so. Take a string and tie it where the pipe should start. Next, run that string to the next stake and wrap it around.

Use a line level to make sure your string is level. Slide the string down half of an inch to create the slope and ensure that the water runs down the drainage pipe and away from the structure. Repeat this process until you've tied every stake.

Step 3: Level the soil

Using a tamper, pack the soil in the trench to create a solid base. Measure to make sure that the distance between the string and the soil in the trench is the same at every stake. Adjust the trench by adding or removing soil to create the slope.

After you've tamped down all of the soil in the trench, you can go ahead and remove the stake and string guides.

Step 4: Add geotextile and gravel

Geotextile should be laid to make sure that soil doesn't clog your drainpipe and force you to redo this project in a few years due to drainage problems. Simply place the fabric along the trench. You'll need the fabric to be wide enough to eventually wrap around the drainage pipe and gravel that will surround it. Pour a 2-inch layer of gravel onto the fabric and, using a rake, level it.

Step 5: Place the pipe

Lay the perforated drainage pipe on the gravel. Again, check the area laws and regulations. Some areas require the use of "sock tile," or a drain pipe that is covered in permeable mesh. This mesh acts as a second barrier to prevent the pipe from clogging with dirt.

Step 6: Finish

After you've placed your drainage pipe, you'll need to cover it with a second layer of gravel. Place enough to bury the pipe 4 to 6 inches deep. Use the geotextile you placed in Step 4 to wrap the pipe and gravel. Cover the wrapped pipe with a few inches of dirt to hold the fabric in place.

Finish filling the trench and replacing any affected landscaping.

Connecting to the right Drains

Drain for rainwater

This drain collects rainwater from:

- ✓ roofs
- ✓ driveways
- ✓ roads

Rainwater is untreated. It's also described as 'storm water'. The surface water drain takes it directly to rivers and beaches.

Drain for wastewater

Wastewater comes from:

- ✓ toilets
- ✓ sinks
- ✓ baths and showers
- ✓ washing machines
- ✓ dishwashers

This drain takes the foul water to the local wastewater treatment works.

Drain connections

Wastewater must not flow into the surface water drain. Unless your house is on a combined drains system, it needs separate drain connections to collect wastewater and rainwater. Homeowners and landlords are responsible for checking they have separate drain connections from their home.

Combined drains

If your property was built before 1970, you might have a combined drains system. This is a single pipe collecting your wastewater and rainwater runoff. You don't need to replace the single pipe with separate drains.

Separate drains

Most properties built since 1970 have separate drains for rainwater and wastewater.

How your home could cause pollution

If wastewater from your home flows into the rainwater drain, this takes untreated water to the nearest river. This pollutes:

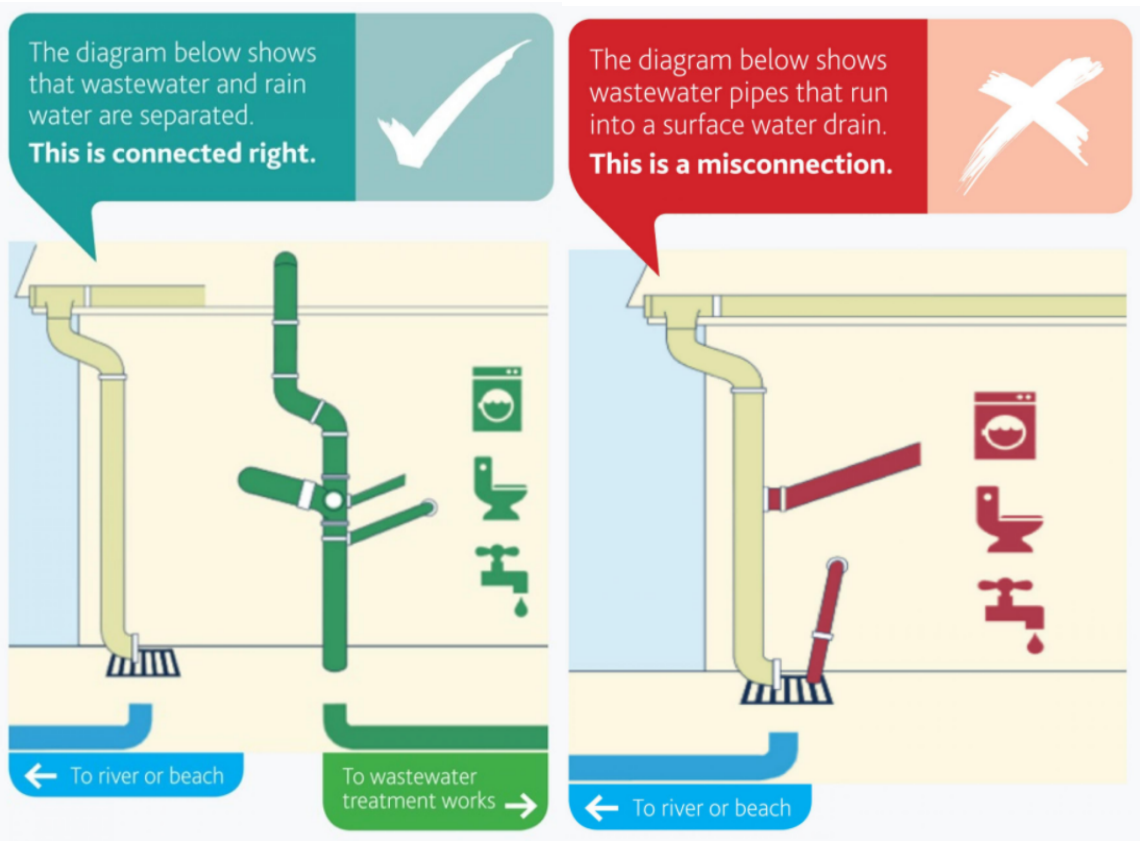
river water
the sea
local beaches
Your house could have the wrong drain connections because:

you or a plumber installed a new appliance
you renovated or extended your home
When your home was originally built, it's possible the builder or owner might have installed connections to the wrong drains.

Connecting gutters and gullies

Gutters and gullies should only collect rainwater and connect to the rainwater drain. Wastewater pipes should not be connected to the rainwater system. If the rainwater gutters and gullies are connected to the wastewater drain, rainwater could overwhelm the drain and cause flooding.

How to recognise right or wrong drain connections
The diagram shows a property with separate drain connections for wastewater and rainwater. This house has the right drain connections.



Checking drain connections

If you're a homeowner or landlord, check your home has the right connections for all rainwater and wastewater plumbing.

You need to connect:

- ✓ toilets
- ✓ sinks
- ✓ baths and showers
- ✓ washing machines
- ✓ dishwashers

to the wastewater drain. If your home is on a separate drains system but has the wrong drain connections, you should put them right. You could be causing water pollution in a local waterway or beach.

Installing drain connections

You should ask a plumber to check your drain connections. If they discover the wrong drain connections, ask them to install the right connections.

Drain connections in a rented property

If you rent your home and the property has the wrong connections, you aren't responsible for installing the right connections. You should ask your landlord to install the right connections for rainwater and wastewater plumbing.

Checking drain connections before you buy a property

It is important to check a property has the right drain connections before you buy. Ask your surveyor or contractor to include drain connections in their survey report.

How to avoid blocked drains

Household waste can block drains. Don't put cleaning liquids or cooking waste in rainwater drains or road gullies including:

- ✓ cooking fat, oil and grease
- ✓ chemicals
- ✓ paint
- ✓ detergent
- ✓ bleach

You might be able to bring some of these items to a recycling centre. Ask the local council about what they accept at their recycling centres.

Don't put household waste down the toilet such as:

- ✓ nappies
- ✓ cotton buds
- ✓ cleaning wipes
- ✓ baby wipes
- ✓ sanitary items
- ✓ syringes
- ✓ razors

Put this waste in your household bin for landfill. If this waste is in the wastewater drain, it can block drains and cause sewers to overflow. The overflow can cause pollution and health hazards.

Installing Sanitary Fixtures

Sanitary fittings should be easy to locate and identify with their operation easy to understand and suitable for both standing and seated users.

Location of fittings

Most building users will appreciate when fittings are in logical positions and contrasted against their background. White fittings on a white background make identification difficult irrespective of the light conditions.

Some people with low vision may use their residual vision to see the fittings if they contrast well while others may locate sanitary fittings by searching with their hands.

Sometimes it is difficult (in low light or for those who have low vision) to visually identify where the toilet pan is and if the toilet seat is up or down. This can be made much easier if a contrasting coloured toilet seat was installed. In existing buildings, matching toilet seats could be changed to one of a contrasting colour.

Design consideration

Ensure sanitary fittings are located in logical positions.
Ensure sanitary fittings and their operating component parts (flush mechanisms, toilet seats, taps, controls and buttons) contrast with the background they are seen against.

Operation of fittings

The purpose of a sanitary fitting and how it operates should be obvious and intuitive. While new designs may meet needs, until building users are familiar with them there could be misunderstanding.

Design consideration

- ✓ Ensure that the purpose of the fittings and its operation is obvious.
- ✓ Ensure fittings that do similar things but operate differently are differentiated from each other by visual and tactile means.
- ✓ Where possible, specify controls and features that operate without the use of a physical input (such as hands-free sensor operated flush, taps, hand dryers and soap dispensers).
- ✓ Ensure new products on the market are intuitive and easy to operate. Where visual and tactile signage indicating their function would be helpful, this should be provided.

Position of fittings

Sanitary fittings should be positioned where they are able to be approached and used by all building users. Effectively, this means suitability for standing and seated users or multiple fittings.
Significant force can be exerted on sanitary equipment when people use them as supports or to stop them falling.

Sanitary fittings that deliver items such as toilet paper should not be oversized. While this may reduce refilling time, there is a possibility that their bulk impacts on the use of the space and ease of use.

Design consideration

Fittings should be located in positions that are appropriate for all users.
Ensure structural supports are installed in wall structures for the attachment of proposed or possible sanitary fittings.
Ensure all sanitary fittings are of the strongest commercial quality and mounted on surfaces designed to support them.
Ensure sanitary fittings are of an appropriate size and do not affect the use of the space.

Number of fittings

The number of fittings installed needs to reflect the anticipated needs of building users. Establishing the likely proportion of male vs. female, adult vs. child etc., the numbers likely in each group and the likely time required for each operation, will inform this decision.

Toilet suites

Toilets in New Zealand are invariably designed for use in a sitting posture. However a squatting posture is widespread in many countries and tourists may think it is an acceptable practice here.

The height of the toilet seat will determine how easy it is to get on and off the seat. As building users vary in stature, and wheelchairs vary in size, the selected height should be a compromise that most users can accommodate. Children will require a lower seat than adults and wheelchair users a higher seat.

Where an adult seat height is too low, some building users will find difficulty in using it especially when trying to stand.

Design consideration

- ✓ Ensure toilet seat heights meet the needs of expected users.
- ✓ Ensure automatic activated flush systems are set to operate only when all toilet activity has been completed.
- ✓ Either install buffers each side of the seat or ensure the seat hinges have adequate lateral strength. Many proprietary hinges are not strong enough to support transfer from a wheelchair.
- ✓ Ensure toilets have colour contrast with their immediate background (walls and floors).

Urinals

Urinals are generally found in most male toilets but are not installed in some commercial developments.

For males, the urinal is generally the most used sanitary fitting so should be positioned where travel distances are shortest. It is important to shield sightlines from the door and via mirrors.

Urinals come in different designs and can be fixed at various heights. As long as the design is suitable, the lower the height the more males that can use it. Traditionally, urinals for children are fixed at lower heights.

Dividers or privacy screens are sometimes installed between urinals although opinions vary as to whether they are necessary or even effective.

Some male wheelchair users prefer to use accessible urinals as they are able to remain seated and not have to transfer to a toilet seat. Where an accessible urinal is installed in a male washroom, a suitable wash handbasin also needs to be provided.

Urinals should contrast with their background and have tactile features such as contrasting floor textures and colours at ground level to alert building users of their presence.

Design consideration

- ✓ Position urinals out of sight of external circulation space but near the toilet entry point.
- ✓ Ensure a level floor surface for approach to the urinal.
- ✓ Install a proportion of urinals at a lower height.
- ✓ Consider the installation of privacy screens or partitions between each urinal.
- ✓ At accessible urinals, ensure there is space available for approach and use by wheelchair users.
- ✓ Ensure urinals contrast in colour with their immediate background.

Wash basins

Wash hand basins should be in a logical position and convenient to use in all toilet facilities. This means that they may need to be installed at different heights to suit wheelchair users, children or standing adults. Wash handbasins will probably be approached head on by a wheelchair user so space under the basin is essential.

Larger washbasins enable people to have a full body-wash, to wash their hair and items of personal care equipment. If the taps are out of reach, wheelchair users may fill the basin with water before transferring to the toilet seat.

Where wheelchair users have a bowel accident, they will want to wash while seated on the toilet. Where wash basins are too far away from the pan, this is not possible unless a shower hose attachment is available.

Design consideration

- ✓ Position wash basins in logical positions that will not interfere with the use of the space.
- ✓ Ensure wash hand basins are at heights suitable for those expected to use them.
- ✓ Where building users could be expected to wash more than just their hands, provide additional floor space and a larger wash basin.
- ✓ Ensure there is space below wash basins to allow wheelchair users to approach head on.
- ✓ Ensure the basins contrast with the background – including bench tops.
- ✓ In existing buildings where the wash basin is too far away from the accessible toilet, consider the installation of a shower hose to allow washing while seated.

Taps

Wherever possible, taps should be automatic to reduce the spread of bacteria by minimising hand contact with surfaces.

Separate hot and cold taps with a plug for the basin are designed to allow the mixing of water in the bowl. This provision is only necessary where a quantity of water at a desired temperature is required (for instance, for washing hair in the basin). To mix water, a plug in the sink is essential.

Hands are generally placed under the flow of water from a single tap. The provision of individual hot and cold taps may therefore result in building users washing their hands in water at extremes of temperature.

Taps need to be clearly marked with temperature indications. While the general convention is that the hot tap is on the left, this has not always been followed in some existing buildings.

Taps should be easy to use. While cross head taps are familiar to some building users they need to be gripped and turned which can cause problems for others. Manually operated taps should be able to be operated with the flat of the hand or wrist.

The easiest facility to use is a sensor operated tap where water is automatically mixed to the correct temperature. While this will reduce the amount of water used it may confuse some building users who may not know how to operate it.

Generally, people prefer to put their hands under water that is being delivered towards them. However, in accessible toilets this means that the mixer tap may be out of reach at the far side of the wash basin from the toilet.

Taps need to extend far enough into the basin to allow hands to be placed underneath without touching the sides.

Central mixer taps can restrict the ability to fill containers or kettles or wash out urine bottles, especially where sinks are not very large or deep.

The water pressure supplied via the tap should be adjustable so that it does not spray or splash the person or adjacent surfaces.

The temperature of hot water delivered to the taps (and the delivery pipework) should be restricted to reduce the possibility of injury. However, the temperature at which it is stored and circulated needs to be higher to avoid the risk of Legionella. Thermostatic control is therefore needed at the delivery point.

Pipes can sometime reduce space in toilet facilities and if they are in a position where they could be used as a support (for instance, in an accessible toilet) are likely to be damaged.

Design consideration

- ✓ Consider sensor operated taps with water delivered at a pre-determined temperature.
- ✓ Where manual taps are used, install mixer taps with a lever operation able to be operated with the flat of the hand or wrist.
- ✓ Avoid the use of separate hot and cold taps for wash hand basins.
- ✓ Ensure taps have a long enough spout for people to be able to put their hands under the water flow without touching the basin sides.
- ✓ Avoid installing mixer taps where they may impact on the ability to fill containers or rinse out urine bottles.
- ✓ Ensure the pressure of the water supplied to taps is adjustable.
- ✓ Ensure the temperature of water supplied to hot taps is controllable.
- ✓ Ensure water delivered to taps in sanitary facilities is of drinking quality unless clearly marked.
- ✓ Ensure water supply and waste pipes are concealed wherever possible.
- ✓ Ensure taps are clearly marked with temperature indications.

Accessible showers

A wheelchair user will need to be sitting down to take a shower. As they will not want their own chair to get wet, they may need to transfer to another chair or fixed seat. Some people will be unable to make that transfer without the use of a hoist.

The fixed seat should be firmly attached to the wall and drop down to allow the most flexibility of use of the space. Drop down legs can also add to the security of the seat.

An effective shower curtain (able to be opened and closed from the seat) is required to prevent their wheelchair and other areas in the room from getting wet.

The entry into the shower area needs to be level but an effective drain is required. As the floor needs to slope away from the remainder of the room, this needs to be considered during the design phase to ensure that floor levels are set appropriately.

The shower controls and shower head need to be in a convenient place to allow operation from the seat.

The temperature of the water should be possible to confirm prior to the user getting under the flow of water.

While a fixed shower head is less vulnerable to vandalism or theft, it does not allow a user to direct the flow of water to where they want it.

Some public swimming pools have shower water controls on a timer to prevent people having lengthy showers. It is important that the button is reachable by a mobility-impaired user without them having to get up and move over to re-activate the button.

Fixtures and fitting should contrast with their background to assist location, identification and navigation around.

Design consideration

- ✓ Position shower controls away from the flow of water from shower heads.
- ✓ Provide a fold down seat suitable for transfer from a wheelchair.
- ✓ Ensure shower controls are easily operable from the shower seat.
- ✓ Consider an additional fold down seat clear of the shower to allow users to dry themselves.
- ✓ Ensure a suitable shower curtain is installed operable from the seat.
- ✓ Ensure level entry into the shower which is then set to falls to a drain.
- ✓ Ensure a hand held shower head is provided with the shower rail long enough for both standing and seated users.
- ✓ Provide structurally supported grab rails in reach of the shower seat.
- ✓ Ensure all fittings have colour contrast with the background.

Accessible baths

For a wheelchair user to have a bath, they need to be able to transfer from their chair into the bath. This can be done either with a hoist or a level extension at the end of the bath to form a transfer seat.

Prior to entering the bath, and to remain independent, a wheelchair user will need to be able to operate the plug and fill the bath to the desired temperature. This will require these features to be easy to use and within comfortable range of someone seated in a wheelchair.

Where possible, a securely fixed seat should be installed in the room to allow people to change their clothes or rest.

Design consideration

- ✓ Ensure a method of transfer is available for a wheelchair user into the bath.
- ✓ Provide a securely fixed seat to allow for rest or drying.
- ✓ Ensure baths have contrast with the background.
- ✓ Ensure taps and the plugs for the bath are usable from a wheelchair.

Grab rails

The purpose of a grab rail is to support a building user, so they need to be installed on structural supports able to resist the anticipated loads.

Provide grab rails where building users most need support (ie. in accessible toilets, shower rooms, bathrooms, a single sex cubicle and either side of one urinal).

In new buildings or refurbishments where the installation of grab rails is anticipated supports in the wall should be incorporated. The existence and the position of these supports should be recorded in the Building Manual and supported by photographs taken before the wall lining is installed.

The grab rail should contrast in colour to the background.

Design consideration

- ✓ Position grabrails where they are needed for support.
- ✓ Ensure the material and diameter of grab rails allows their safe use when wet.
- ✓ Consider the provision of grab rails to at least one standard toilet cubicle.
- ✓ Consider the provision of grab rails to the side of one urinal.
- ✓ Install structural supports in walls under construction if grab rails are anticipated.
- ✓ Record the position of structural supports in the Building Manual.
- ✓ Ensure grab rails are colour contrasted with the background.

Toilet paper dispensers

Toilet paper dispensers should be suitable for single handed use. They should be reachable and usable by people seated on the toilet and by men standing.

The paper in large commercial dispensers often gets trapped inside and is then difficult to find. This is a problem for all building users but especially those with dexterity or vision impairments.

Commercial dispensers are generally specified to reduce cost but can have a significant adverse effect on building users.

Toilet paper dispensers should contrast with the background.

Design consideration

- ✓ Ensure the toilet paper dispenser is positioned in front of the user within easy reach of a person in either a seated or standing position.
- ✓ Select commercial dispensers where the end of the roll is easy to find by visual and tactile means and where the unit cannot be over-filled.
- ✓ Ensure toilet paper can be obtained by the use of only one hand.
- ✓ In accessible toilet cubicles, ensure the position of toilet paper dispensers does not impact on the use of the grab rail or the movement of a seated user.
- ✓ In single sex toilet cubicles, ensure that the size of the commercial toilet paper dispenser selected is taken into account when choosing the size of the cubicle and the position of the pan on the back wall.
- ✓ Ensure toilet paper dispensers are a contrasting colour to the background.

Soap dispensers

Soap dispensers should be reachable from a standing or seated position.

Soap dripping on to the floor presents a slip hazard. Positioning the soap dispenser over the wash basin may prevent this.

It should be obvious from the design whether the dispenser is sensor operated or requires a pull or push action. The levers to operate the dispenser should be large enough for use by people with dexterity or reduced hand or arm movement.

Soap dispensers should contrast with the background.

Design consideration

- ✓ Position soap dispensers where they will not drip on the floor but be convenient for use.
- ✓ Ensure the method for obtaining soap is simple to establish and able to be completed easily with one hand.
- ✓ Ensure soap is available at each wash hand basin without having to move within the space.
- ✓ Ensure soap dispensers are in a contrasting colour to the background.

Towel dispensers

Towel dispensers should be reachable and usable from the position where a person has just washed their hands. For instance, someone using crutches will not want to have to use their crutches to move from the wash hand basin to dry their hands.

Towel dispensers located behind mirrors over wash basins are often difficult to locate because they cannot be seen from a standing position.

Slim line towel dispensers can be difficult to operate and may result in surfaces being touched when trying to obtain a towel.

Towel dispensers should contrast with the background.

Design consideration

- ✓ Ensure towel dispensers are easily visible, identifiable and located close to wash hand basins.
- ✓ Ensure hand towels can be obtained with the use of a single hand.
- ✓ Whether paper towels are dispensed on demand or manually grasped, ensure the operation is clearly marked and not reliant on touching part of the dispenser casing.
- ✓ If automatic hand dryers are provided, ensure they are in addition to paper towels.
- ✓ Ensure towel dispensers are a contrasting colour to the background.

Hand dryers

Like towel dispensers, hand dryers should be reachable and usable from the position where a person has just washed their hands. Noise levels from some hot air dryers can be excessive and may cause anxiety for some people.

Where hands need to be inserted into the top of the dryer, the installation height needs to take into account whether the user is seated, of small stature or standing. Where these dryers are planned, the size and layout of the facility may need to be adjusted to ensure they do not impact on space required for wheelchair movement.

Some building users may not be able to use these facilities so hand towel dispenser should always be installed.

Hand dryers should contrast with the background.

Design consideration

- ✓ Position hand dryers in a convenient location close to wash hand basins where they will not obstruct the use of the space.
- ✓ Ensure hand dryers are installed at convenient heights and not at a height where their use results in water running from the hands back towards the user.
- ✓ Ensure an adequate number of hand dryers are provided.
- ✓ Specify quiet hand dryers.
- ✓ Ensure hand dryers are a contrasting colour to the background.

Mirrors

Mirrors should be positioned where they can be comfortably used by occupants but will not cause confusion by seeming to distort the size or configuration of the room.

Some people may perceive a full height mirror as a wall opening.

Where soap dispensers are positioned over basins, mirrors could be tilted down to ensure wheelchair users and people of smaller stature are able to use them.

Design consideration

- ✓ Position mirrors in all toilets and changing areas at a height useable by everyone.
- ✓ Avoid the installation of full-height mirrors.
- ✓ Consider tilting mirrors over a wash basin if a soap dispenser is installed there.

Shelves

Shelves should be provided in positions where they are easy to reach (for instance, from a shower seat or by someone in a wheelchair).

Where the top of a toilet cistern is not flat, shelves are also required for people changing colostomy bags.

Shelves in accessible sanitary facilities should not be located where they will impact on the use of the space by wheelchair users.

Shelves should contrast with the background and not be placed where they will be a hazard for a person who is blind or has low vision. For example, do not place a shelf over basins where it is expected a person will bend forwards.

Design consideration

- ✓ Provide a shelf near the wash hand basin for personal effects.
- ✓ In accessible toilets provide a shelf for a colostomy bag if the cistern top is not flat and usable.
- ✓ In shower areas provide a 'wet' shelf for toiletries and personal items positioned within easy reach of a standing user and someone sitting on the fold-down shower seat.
- ✓ Consider the provision of wall hooks or larger shelves to keep items such as small bags or motorcycle helmets off toilet floors.
- ✓ Ensure the installation of shelves does not impact on the use of the space.
- ✓ Ensure shelves are a contrasting colour to the background.
- ✓ Ensure shelves are not located where they can be a hazard to building users.

Waste bins

Waste bins and sanitary disposal bins take up space and are best recessed into the wall. Sanitary disposal bins need to be large enough to be able to accommodate adult-sized pads. In accessible facilities especially, it is essential that waste bins do not impact on the use of the space. Movable bins can also be a hazard if they are not in the expected location.

In many countries, the sewage system is unable to cope with toilet paper thrown into the toilet pan. In these places, toilet paper is disposed of in a waste bin by the side of the toilet. Tourists from these locations may not realise that this is not necessary in New Zealand and use an adjacent waste bin. To avoid this happening, waste bins should be positioned accordingly (preferably under paper towel dispensers).

Waste bins should contrast in colour with the background.

Design consideration

- ✓ Provide general waste bins in single-sex and gender neutral toilets, accessible toilets, bathrooms, shower rooms, and changing areas.
- ✓ Decide the position of waste and sanitary disposal bins at the design stage to ensure they do not conflict with the use of the facility.
- ✓ In each female toilet cubicle provide a sanitary disposal bin which is easy to operate and large enough for incontinence pads.
- ✓ Ensure lids to bins are easy to operate.
- ✓ In toilet accommodation, avoid positioning the waste bin near the toilet pan.
- ✓ Ensure waste bins are a contrasting colour to the background.

Coat hooks

Coat hooks are essential for keeping items off the floor but need to be placed at heights suitable for their user. Invariably this means the provision of hooks at different heights.

Coat hooks should contrast with the background and not be placed to project into the room in a way that can present a hazard.

Design consideration

- ✓ Provide coat hooks in all toilet cubicles and in accessible toilets, bathrooms, shower rooms, and changing rooms.
- ✓ Ensure coat hooks are installed at heights suitable for users.
- ✓ Ensure coat hooks are a contrasting colour to the background and not projecting into the room in a way that creates a hazard.

Lockers

Lockers are essential for the storage of clothes and goods especially in places such as swimming pools. They need to be suitable for their intended use and positioned where they are reachable and lockable. Lockers for items such as crutches, callipers and artificial limbs need to be sized accordingly.

Lockers should be contrasting in colour and easy to use. Digital screens relying on touch are not fully accessible. Consider providing a range of alternative entry lockers.

Design consideration

- ✓ Install lockers for storage of personal effects in changing and shower facilities.
- ✓ Ensure lockers have acceptable security and are designed to store the variety of items expected in their location.
- ✓ Ensure lockers are easy to access and use especially for wheelchair users.
- ✓ Provide larger lockers to store items such as sticks, walking frames, crutches, or artificial limbs.
- ✓ Ensure locker doors are designed to swing shut after use so they do not present an obstruction or hazard.
- ✓ Ensure any numbering or coding system is easy to follow and includes large tactile letters or digits.
- ✓ Ensure locker locations do not impact on the use of the space.
- ✓ Ensure lockers are a contrasting colour to the background.

Hair dryers

Hair dryers should be specified and installed where they are reachable and usable by all building users.

Hair dryers should contrast in colour with the background and their controls should be easy to identify and use.

Design consideration

- ✓ Position hair dryers where they can be used by people in either a seated or standing position.
- ✓ If a number of hair dryers are provided in a changing area, ensure they are provided at a range of heights.
- ✓ Ensure any switches or controls are easy to operate and within reach of all users.
- ✓ Where hair dryers are coin-operated, ensure the coin slot and any other control is accessible to all users.
- ✓ Ensure a suitably positioned mirror is provided in conjunction with each hair dryer location.
- ✓ Ensure hair dryers and their controls are a contrasting colour to the background.

Vending machines

Vending machines should be equally accessible and usable by everyone. This includes those who are blind or have low vision. Tactile and larger print will enable many who are blind or have low vision to use the machines.

Design consideration

- ✓ Ensure vending machines are easy to identify, understand and use and do not cause any obstruction or safety issue.
- ✓ Where vending machines are provided in single-sex toilets, ensure they are also provided in unisex, gender neutral and accessible toilets.
- ✓ Provide accessible information to ensure the machines are able to be used by people who are blind or have low vision.

Alarms

People with disabilities are particularly vulnerable to falls and accidents. If they are in areas where they are alone and cannot be seen, the provision of an assistance alarm is essential to their safety.

Design consideration

- ✓ Consider assistance alarms in all accessible toilets, bathrooms, shower rooms, and changing rooms designed for independent use.
- ✓ Wherever assistance alarms are installed, establish procedures to ensure that someone will respond and that the person or persons are trained in giving assistance.
- ✓ Ensure activation of the alarm is possible by someone who is using the facility or who has fallen on the floor.
- ✓ Ensure the alarm indicator is noticeably different to fire or other alarms.
- ✓ Ensure confirmation of activation is available inside the room where it has been activated.
- ✓ Provide a visual and audible indicator (where it can be seen and heard by people able to respond).
- ✓ Ensure the alarm indicator will not cause discomfort.
- ✓ Install a reset button within the room reachable from both a wheelchair and the toilet.
- ✓ Provide an additional reset button outside the room for use by the person responding to the call for assistance.

Heaters and pipes

Design consideration

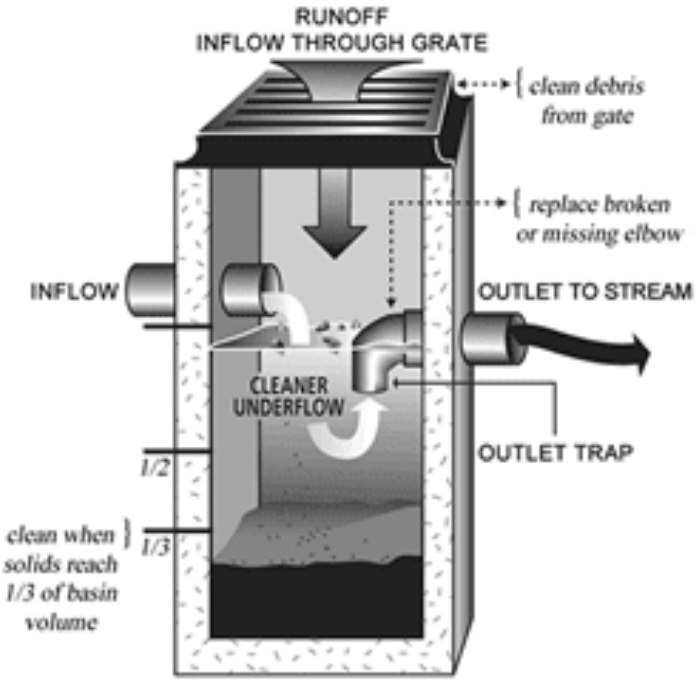
- ✓ Ensure room heaters do not have high surface temperatures and are positioned away from wheelchair maneuvering space.
- ✓ Avoid running pipework on the surface of a wall where it may be damaged or used as a support by building users.

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*

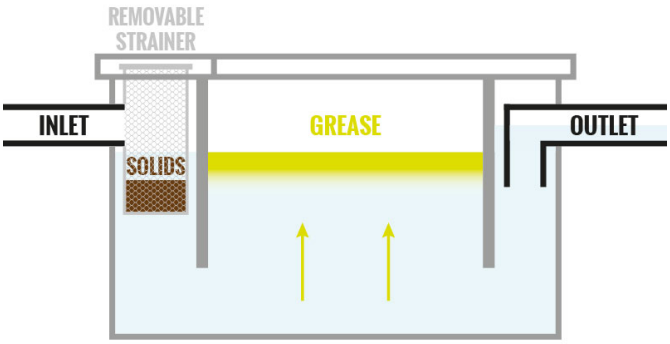
Catch pit remains as the last point of below ground domestic drainage system normally located within the boundary of the home within which the drainage pipelines are being installed.



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



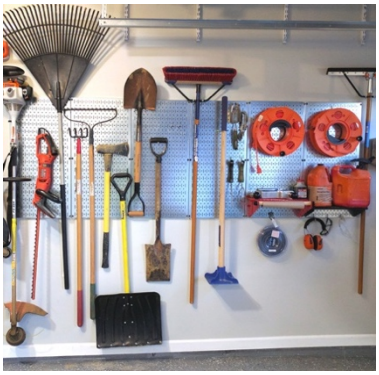
10 to 15 percent less dense than water and that grease won't mix with water. Thus, fats and oils float on top of water.

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 number 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

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 15

OPERATE SEWERAGE PUMP STATION AND SEA OUTFALL

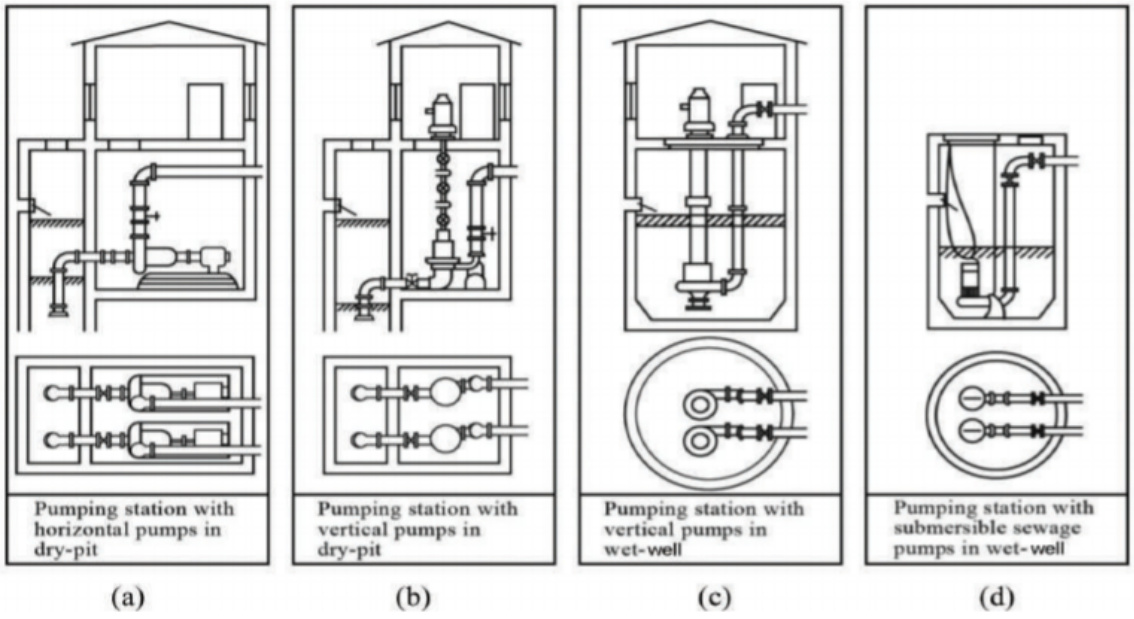
This unit of competency sets out the knowledge and skills required to operate and maintain pump station and sea outfall station

OPERATE SYSTEM ACCORDING TO PROCEDURE

Pumping stations are either as in-line for lifting the sewage from a deeper sewer to a shallow sewer or for pumping to the STP or the out fall. They are required where low lying development areas cannot be drained by gravity to existing sewerage infrastructure, and/or where development areas are too far away from available sewerage infrastructure to be linked by gravity. The O&M of pumping systems presented here applies to all such types of pumping stations.

Types and Structure of Pumping Stations

The type of pumping stations can be (a) Horizontal pumps in dry pit, (b) Vertical pumps in dry pit, (c) Vertical pumps in suction well and (d) Submersible pumps in suction sump. All these types include a sewage-receiving sump, which is called suction sump or wet well. These types of pump arrangements are shown in Figure.



Dry Pit

The size of the dry pit should be adequate for the number of pumps planned and should be such as to handle the sewage load at the desired pumping capacity. Allowance should also be made for future requirements of additional or larger pumps. In the configuration, (a) separate dry pit and wet well are required: one to hold the sewage, and one to house the pumps and appurtenances. This option is required for installations where the pumps will otherwise need separate priming and where-as otherwise long suction pipes are needed.

It is typically used to pump large volumes of raw sewage, where uninterrupted flow is critical and sewage solids could clog suction piping. It is also used to pump solids in pipe galleries between digesters or other solids-handling equipment. While construction costs may be higher and a heating, ventilation and cooling system is

necessary when installed below the floor level, this configuration is best for O&M activities because operators can see and touch the equipment.

Suction Pump or Wet Well

Sewage sump is a compartment or tank in which sewage is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well. Sewage sump design depends on the type of pumping station configuration (submersible or dry well) and the type of pump controls (constant or variable speed). Wet wells are typically designed to prevent rapid pump cycling but small enough to prevent a long detention time and associated odour release.

Sewage sumps should always hold some level of sewage to minimise odour release. Bar screens or grinders are often installed in or upstream of the wet well to minimise pump clogging problems. Instead of manually operated screens at the bottom, which requires the staff to get down into the screen sump, it is better to install mechanical bar screens, which can automatically remove the screenings and lift the same safely above the ground level. There can also be two such screens one after the other for coarse screenings and fine screenings. This will require rectangular channels to maintain longitudinal non-turbulent linear flow.

Lift Stations

In general, lift stations are invariably used in gravity sewer network where depth of cut of sewers poses a problem in high water prone areas. The procedure is to sink a wet well on the road shoulder or an acquired plot after the shoulder and divert the deeper sewer there. The submersible pump will lift the sewage and discharge it to the next on line shallow sewer. This is a very useful practice in such locations.

Equipment located in the wet well should be minimized, including suction and discharge valves, check valves, or other equipment that require routine, periodic maintenance. This equipment can be located in separate and suitable dry pits located adjacent to the wet well to facilitate accessibility and maintenance for the operator.

Operation and Maintenance

Pumping machinery is subjected to wear & tear, erosion and corrosion due to its nature of functioning, and therefore it is vulnerable to failures. Generally, failures or interruptions are mostly attributed to pumping machinery rather than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Obviously due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery.

Operation of the Pumps

The following points should be observed while operating the pumps.

- ✓ Dry running of the pumps should be avoided.
- ✓ Centrifugal pumps if installed with negative suction should be primed before starting.
- ✓ Pumps should be operated only within the recommended range of the head-discharge characteristics of the pump.
    - o If pump is operated at a point away from duty point, the pump efficiency normally reduces.
    - o Operation near the shut-off point should be avoided, as it causes substantial recirculation within the pump, resulting in overheating of sewage in the casing and consequently, overheating of the pump.
- ✓ As far as possible positive suction is to be provided to avoid priming during design itself.
- ✓ Voltage during operation of the pump-motor set should be within ±10 % of the rated voltage. Similarly, current should be below the rated current shown on the name plate of the motor.
- ✓ When parallel pumps are to be operated, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in the incoming feeder and should be adequate to allow the pump head to stabilise.
- ✓ When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep open the air vent of the pump next in sequence, before starting that pump.
- ✓ The stuffing box should allow a drip of leakage to ensure that no air passes into the pump and that the packing gets adequate wetness for cooling and lubrication. When the stuffing box is sealed with grease, adequate refill of the grease should be maintained.
- ✓ The running of duty pumps and standby pumps should be scheduled so that no pump remains idle for a long period and all pumps are in ready-to-run condition. Similarly, the running schedules should be ensured so that all pumps do not wear equally needing simultaneous overhaul.
- ✓ If any undue vibration or noise is noticed, the pump should be stopped immediately and the cause for vibration or noise should be checked and rectified.
- ✓ Generally, the number of starts per hour shall not exceed four. Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Although overloading lasts only for a few seconds, it reduces the life of the equipment.
- ✓ Troubles in a sewage pumping station can be mostly traced to the design stage itself. This is all the more true when too much grit is likely to come into the sewage pumping stations from sewage at monsoon time, which is difficult to handle. Hence, sewers should not collect any storm water.

Undesirable Operations

The following undesirable operations should be avoided:

- ✓ Operation at higher head A pump should never be operated at a head higher than the maximum recommended head otherwise such operation may result in excessive recirculation in the pump, and overheating of the sewage and the pump. Another problem that arises if a pump is operated at a head higher than the recommended maximum head is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft, which may cause failure of the pump shaft. As a useful guide, appropriate marking should be made on the pressure gauge. Efficiency at a higher head is normally low and such an operation is also inefficient.
- ✓ Operation at lower head If a pump is operated at a lower head than the recommended minimum head, the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft, which may cause premature wear of bearings and possibly shaft failure if persisted. As a useful guide appropriate marking should be made on both pressure gauge and ammeter. Efficiency at a lower head is normally low, hence such an operation is inefficient. In such cases, it is advisable to throttle the delivery side valve to create more head to work within safe head. This will also reduce the power. If this is a design flaw additional head has to be created at tail end by elevating the delivery. However, these are not energy efficient solutions; change of impeller to suit the actual head is the solution.
- ✓ Operation on higher suction lift If a pump is operated on suction lift higher than the permissible value, pressures at the eye of impeller and the suction side fall below vapour pressure. This results in flashing of sewage into vapour. These vapour bubbles collapse during passage, resulting in cavitation in the pump, causing pitting on the suction side of impeller and casing, and excessive vibrations. In addition to mechanical damage due to pitting, pump discharge also reduces drastically. Typical damage to impeller and sometimes to the casing is shown in Figure

- ✓ Operation of the pump with low submergence Minimum submergence above the bell-mouth or foot-valve is necessary to prevent entry of air into the suction of the pump, which gives rise to the vortex phenomenon, causing excessive vibration, overloading of bearings, reduction in discharge and in the efficiency. As a useful guide, the lowest permissible sewage level should be marked on the water level indicator. Usually the pump manufacturer indicates the minimum height of submergence. In the case of submersible pumps, the minimum depth is needed to ensure cooling of the motor while running.

- ✓ Operation with occurrence of vortices

If vibration continues even after taking all precautions, vortex may be the cause. Vortex should be stopped by using anti vortex fittings as described in chapter 4 of Part A of the manual:

A well-planned maintenance programme for pumping systems can reduce or prevent unnecessary equipment wear and downtime. (The following maintenance information applies to both sewage and solids pumping systems.)

The following is a maintenance checklist for a basic pumping-station:

- Check the wet well level continuously (whenever necessary).
- Record each pump's "run time" hours (as indicated on the elapsed-time meters) at least once in a day and confirm that the pumps' running hours are equal.
- Ensure that the control-panel switches are in their proper positions.
- Ensure that the valves are in their proper positions.
- Check for unusual pump noises.
- At least once a week, manually pump down the wet well to check for and to remove debris that may clog the pumps.
- Inspect the float balls and cables and remove all debris to ensure that they operate properly. Twisted cables are to be released that may affect automatic operations.
- If a pump is removed from service, adjust the lead pump selector switch to the number that corresponds to the pumps remaining in operation. (This allows the lead pump levels to govern the operating pump's starts and stops.).

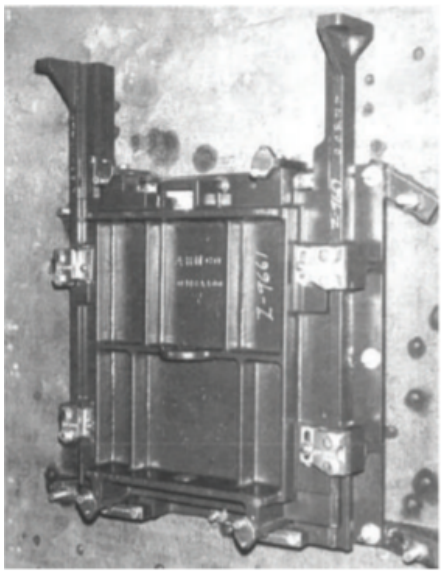
Piping and Appurtenance Maintenance

Properly maintaining pumping-station pipelines and other appurtenances can minimize pump loads.

Excessive head losses on either the suction or the discharge side of a pump can increase energy use and the wear rate and consequently, the O&M costs. Excessive head losses also may lead to process or treatment problems because solids move slower, so the proper solids balance is not maintained. Operators can monitor head losses by routinely checking the pressure gauges on both sides of the pumps.

When operators notice excessive head losses (indicated by a pressure drop on the suction side of the pump or an increase in pressure on the discharge side), they should determine whether the losses are a result of partial clogging, a restriction somewhere in the line, or materials built up on the pipe wall. To find clogs, operators should start by checking the pressure at various points in the suction and discharge piping, and look for spots with abrupt head loss (such as valves or other constrictions). If something is caught in a valve or other appurtenance, the operator should stop the pump and physically open out the valve head and remove the blockage. In smaller pumps, it is easier to remove the entire valve, disassemble and remove the blockage, reassemble and refit. During such time, other pumps shall be run. Scum build-up

problems typically are addressed via source control (for instance, by installing grease traps in the collection system at locations suspected or known to generate grease, such as restaurants, etc.).



Gate, Valves and Actuators

Sluice Gate

A sluice gate (Figure) is traditionally a wooden or metal plate, which slides in grooves in the sides of the guide channel.

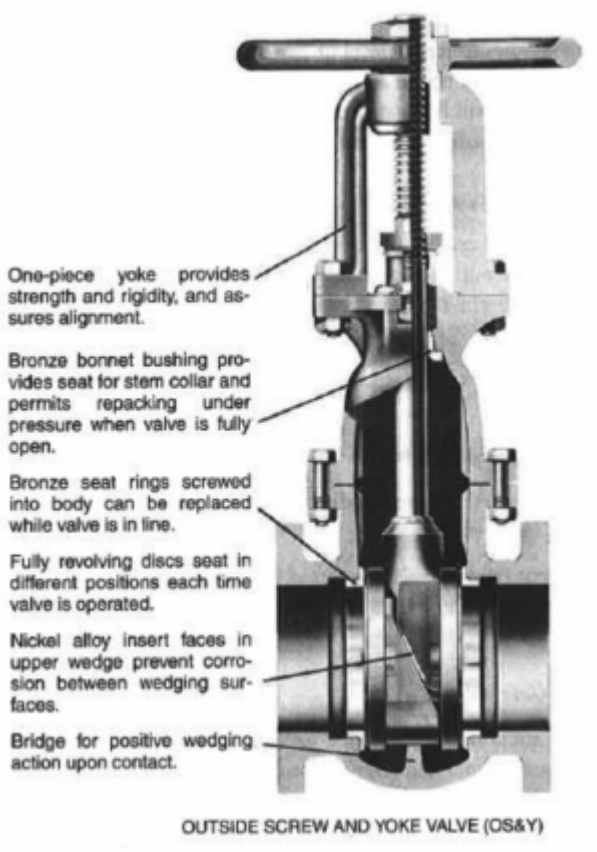
Sluice gates are commonly used to control sewage levels in STPs.

Attention should be paid to the following points for proper operation:

- ✓ Test for proper operation Operate inactive sluice gates by smearing grease on stem threads.
- ✓ Clean and paint Clean sluice gate with wire brush and paint with proper corrosion-resistant paint.
- ✓ Adjust for proper clearance.
- ✓ For gates seated against pressure, check and adjust top, bottom, and side wedges until each wedge applies nearly uniform pressure against gate in the closed position. This shall be done by the manufacturer and not the operator.
- ✓ Check for the following:
    - Ensure unobstructed operation of gate and headstock.
    - Ensure that the spindle is not touching the stem guide.
    - Remove foreign matter like paint, concrete, etc. in the fully open position of gate.
- ✓ Do's for sluice gates
    - Operate the gate at least once in every three months.
    - Check the nuts of all construction and foundation bolts once in a year. Tighten the bolts, if loose.
    - Examine the entire painted surface for any signs of damage to the protective paint.
- ✓ Don'ts for sluice gates
- ✓ Do not remove lock plates until the gate has been properly installed.
- ✓ Do not keep the gate out of operation for more than three months.
- ✓ Do not forget to set the stop nut in the correct position.
- ✓ Do not disturb the adjustment of wedge block bolts/studs.
- ✓ Do not over torque the crank handle/hand wheel.

Valve

On the delivery side of centrifugal pumps, a non-return valve is necessary to prevent back-pressure from the delivery head on the pump, when the pump is shut off. To avoid water-hammer, which is likely to be caused by the closure of the valve, the valve may be provided with an anti-slam device, which may be either a lever and dead-weight type, a spring-loading type or the dash pot type. Pumps may be run in parallel with different permutation of the standbys. Isolation valves would be needed to isolate those pumps, which are to be idle. Generally, the isolating valves are gate valves, which should preferably be of the rising stem type, since this type offers the advantage of visual indication of the valve-position. For exterior underground locations, gate valves area generally used.



OUTSIDE SCREW AND YOKE VALVE (OS&Y)

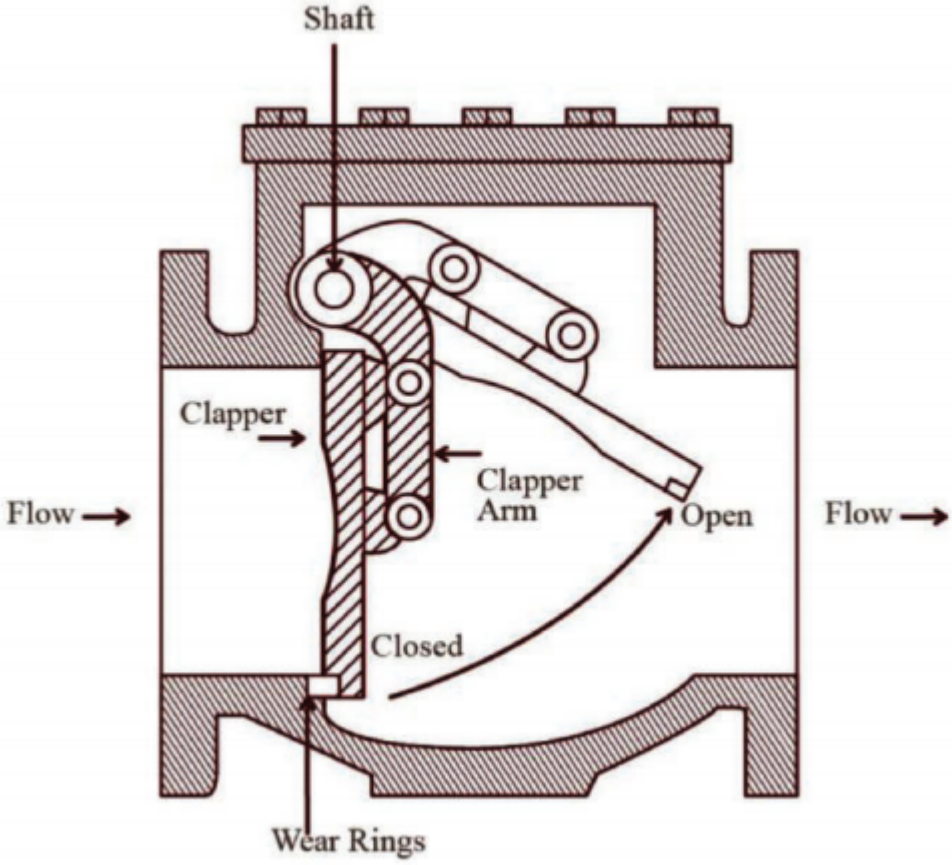
Gate Valve

A gate valve is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid as shown in Figure overleaf. The distinct feature of a gate valve is that the sealing surfaces between the gate and seats are planar. The gate faces can form a wedge shape or they can be parallel. Typical gate valves should never be used for regulating flow, unless they are specifically designed for that purpose. Gate valves require maintenance.

- ✓ Replace packing : Modern gate valves can be repacked without removing them from service. Before repacking, open the valve wide. This prevents excessive leakage when the packing or the entire stuffing box is removed. It draws the stem collar tightly against the bonnet bushing on a rising stem valve.
- ✓ Operate valve : Operate inactive gate valves to prevent sticking.
- ✓ Lubricate gearing : Lubricate gate valves as recommended by the manufacturer. Lubricate thoroughly any gearing in large gate valves. Wash open gears with solvent and lubricate with grease.
- ✓ Lubricate rising stem threads : Clean threads on rising stem gate valves and lubricate with grease.
- ✓ Lubricate buried valves : If a buried valve is hard for working, lubricate it by pouring oil down through a pipe that is bent at the top end oiling the packing follower below the valve nut.

Non-Return Valve (Check valve)

Normally, a check valve is installed in the discharge of each pump to provide a positive shutoff from force main pressure when the pump is shut off and to prevent the hydraulic force from draining back into the wet well. The most common type of check valve is the swing check valve, which is shown in.



This valve consists of a valve body with a clapper arm attached to a hinge that opens when the pump starts operating and closes to seal when the pump is shut off.

Check valves must close before the water column in the pipe reverses flow; otherwise, severe water hammer can occur when the clapper arm slams against the valve body seat. If this occurs, an adjustment of the outside weight or spring is usually required. A traditional clapper type of check valve has a lever on the extended shaft, which allows adjustment of the weight on the arm or spring to vary the closing time. Wear occurs within the valve primarily on the clapper hinge-and-shaft assemblies and should be checked annually for looseness.

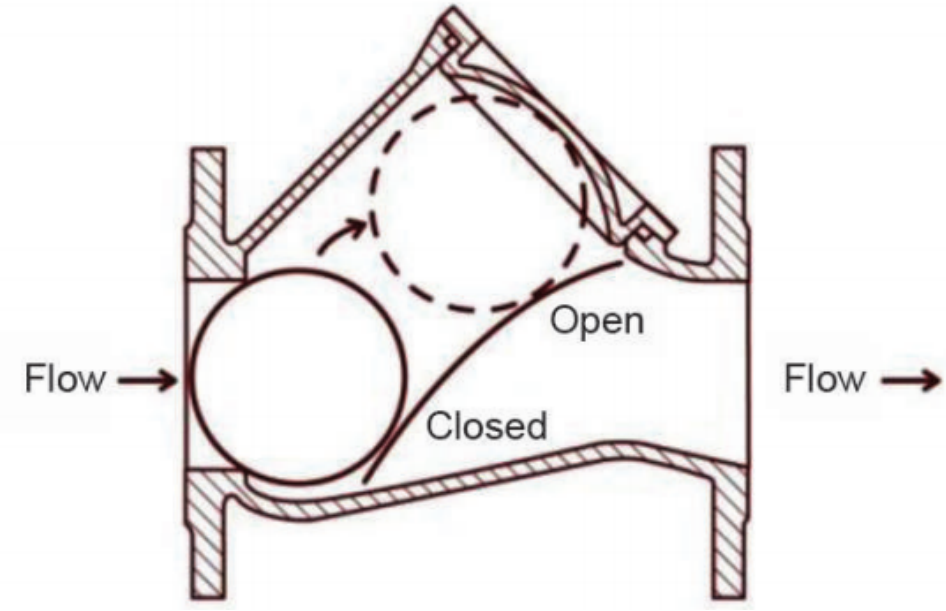
The preventive maintenance is to be done only by the manufacturer.

- ✓ Inspect Clapper Facing : Open valves to observe condition of facing on swing check valves equipped with neoprene seats on clapper. If metal seat ring is scarred, dress it with a fine file and lap with fine emery paper wrapped around a flat tool.

- ✓ Check Shaft Wear : Check shaft wear on balanced disc check valve since disc must be accurately positioned in the seat to prevent leakage.

Non-Return Valve (Ball Type)

Non-return valve depends on a light weight and suitable coated ball moving inside the flowing pipe to occupy an elevated angular position while the fluid is in pumping and dropping back to close the reverse flow through the pipe. Because it is a sphere sitting over a circular opening, it is expected to seat properly and seal the reverse flow. The material of the ball, the coating and its sturdiness against dents caused by the slide are important aspects. The ball is replaced by opening the top flange after switching off the pump. This can be installed in any position, vertical or horizontal. A non-return valve is shown in Figure.



When flow occurs, the ball is lifted into the angular piping and is held there because its weight is lighter than the sewage and the velocity of flow. When the flow stops, it slides back and seals.

Butterfly Valve

Butterfly valves are another type of valve that have been successfully used as suction and discharge isolation valves in pumping stations. They are frequently used in sewage plants where waste streams with a high solids content are encountered, such as in sludge pumping systems. A butterfly valve consists of the valve body and a rotating disc plug that operates through 90 degrees. This is usually a disc rotated by 90 degrees by external handle. In the open position, the disc is in line with the flow. In the closed position, the disc is at 90 degrees to the flow and it stops the flow. Usually, the axis is vertical although horizontal axis arrangement may also be used in smaller sizes.

The closing and opening can be manual or mechanized. The butterfly valves occupy less space and are generally preferred for pipe sizes larger than 150 mm.

Many agencies specify butterfly valves as opposed to gate valves because they are less susceptible to plugging.

Butterfly valves require the following preventive maintenance to be done by the manufacturer:

- ✓ Adjust gland : The adjustable gland holds the plug against its seat in the body and acts through compressible packing, which functions as a thrust cushion. Keep gland tight enough at all times to hold plug in contact with its seat. If this is not done, the lubricant system cannot function properly, and solid particles may enter between the body and plug and cause damage.
- ✓ Lubrication : Apply lubricant by removing lubricant screw and inserting stick of butterfly valve lubricant for stated temperature conditions. Be sure to lubricate valves that are not used often to ensure that they are always in operating condition. Leave lubricant chamber nearly full so that extra supply is available by turning the screw down. Use lubricant regularly to increase the valve efficiency and service, promote easy operation, reduce wear and corrosion, and seal valve against internal leakage.

Actuators

These are replacements for physical operation by the operators. Actuators are used for automation of valves. An actuator rotates the valve spindle or lifts and drops the same.

- ✓ Electric geared motor actuator : The actuator consists of a rotor stator unit driving an output shaft through a single stage-worm reduction gear, which incorporates an automatic mechanical device for changing manual drive to power drive. The actuator includes a travel-limit switch unit and a torque switch unit, and is of totally enclosed construction. When power fails, electric motor driven gear actuators retain their positions. When power supply returns, pay attention how the valves move. The electric motor driven gear actuator is shown in Figure.

- ✓ Solenoids : Solenoids are the most common actuator components. It consists of a moving ferrous core (a piston) that moves inside wire coil. Normally the piston is held outside the coil by a spring. When a voltage is applied to the coil

and current flows, the coil builds up a magnetic field that attracts the piston and pulls it into the centre of the coil. The piston can be used to supply a linear force. Diaphragm valve have small holes on it. The holes should be free from clogging by debris otherwise the diaphragm may not open

- ✓ Pneumatics : Pneumatic systems have much in common with hydraulic systems with a few key differences. The reservoir is eliminated as there is no need to collect and store the air between uses in the pneumatic system. Also because air is a gas, it is compressible and regulators are not needed to recirculate the flow; however, since the gas is compressible, the systems are not as stiff or strong. In general, the pneumatics are liable to cause accidents such as when the air hose suddenly pulls out of the hose clamp and jets high pressure air on persons nearby. This should be avoided. The electric geared motor type is to be preferred. The pneumatic valve is shown in Figure.

- ✓ Hydraulic System : Actuator (hydraulic motor and hydraulic cylinder) is operated by hydraulic fluids (hydraulic oil), which is pressurised by hydraulic pump driven by an electric motor. Generally, a smooth movement and variable speed can be achieved. Moreover, the installed relief valve can prevent the system from breakdown. It should be noted that hydraulic oil leaks as pressure increases. Check for oil leakage regularly. Hydraulic system should be kept clean because it is vulnerable to dust or rust. Take precautions to avoid fires because the hydraulic oil is combustible. In all cases, preventive maintenance by manufacturer shall be done periodically and a wall chart exhibited on site.

Screen

Screenings in sewage from the incoming sewer below the ground level need to be separated and lifted above ground level, and removed either by mechanical or manual method.

Types of Screens

Coarse Screens

Coarse screens are usually bar screens consisting of vertical or inclined bars spaced at equal intervals across a channel through which sewage flows. The openings are usually 25 mm. Hand-cleaned screens are usually inclined at 45 degrees to the horizontal.

Medium Bar Screens

Medium bar screens have clear openings of about 12 mm.

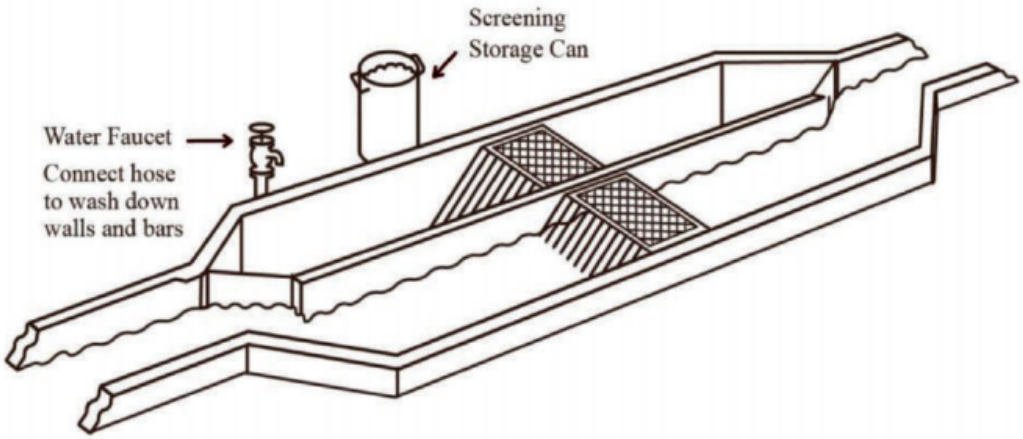
Fine Screens

Fine screens are mechanically-cleaned devices. Fine screens may be of the drum or disc type, mechanically cleaned and continuously operated. They are also used for protecting the beaches where untreated sewage may have to be discharged into the sea for disposal by dilution.

Screenings Removal Method

Manual Bar Screen

Hand cleaned screens should be cleaned as often as required to prevent backing up of sewage. A manually-cleaned bar screen is shown in Figure.



The following are important for O&M of manual bar screen:

- Preventive maintenance for checking and repairing the following once a week

Check whether the standing platform is at least 2 m wide with the first 1 m as slotted. An example of a risky platform is presented in Figure.

There is no space for the operator to stand after he has lifted and dumped screenings on the platform. Because of the lack of space, he may move backwards and fall into the sewage channel. Also, screens should be inclined to the horizontal by an angle of 60 degrees or more, otherwise, the operator has to bend forward. The rear side of the platform should have handrails. If handrails are not provided, enter this point in the site book.

1. Check the condition of ladders and paint them periodically.
2. Verify that there are no broken metal parts that protrude outside.
3. Once a month check the rigidity of handrails.

4. Verify the platform for its sturdiness by gently setting the foot on it.

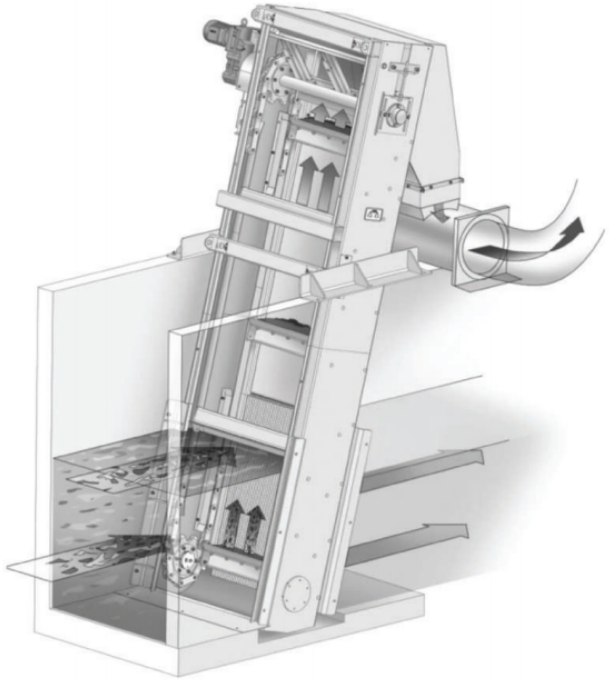
Verify that the lighting is not in front or behind the operator. It should be above the operator, at least 2.5m high and mounted on the sidewall or separate lamp posts. These lights should not have local on-off switches and must be fully lit in the nights. Verify that the operator platform and slotted platform have 3m head room and provided with roof so that the operator is not drenched and he can lift the cleaning rake freely.

- Regular maintenance on a daily basis and repairs
  1- Verify that the screen rods have not broken loose.
  2- Verify that the cleaning rake is well washed in running water after each use.
  3- Verify that gum boots are kept inside a locker covered with mesh.
  4- Verify that disposable gloves are available for all 3 shifts and a stock of one month is available.
  5- Verify that helmet is available.
- Operation
  1- Before daily operation, verify all the above. If these points are not met, do not enter the screen area. Enter all missing items in the site register.
  2- If all items are in order, do the cleaning once in four hours in each shift.
  3- Ensure that operators do not stand one behind the other. This may cause an accident because while pulling the rake backwards, the operator in the front may hit and push the operator in the rear into the sewage channel.
  4- Once the screens are cleaned and screenings are deposited on the slotted platform allow them to drip dry till the next cleaning after 4 hours.
  5- Push the screenings with the rake to the side of the platform to drop them into the tipper positioned there.
  6- Move the tipper to the vermin compost site, dump the contents in the pit and cover with earth as prescribed in Sec.3.4.4 “Disposal of Screenings.”

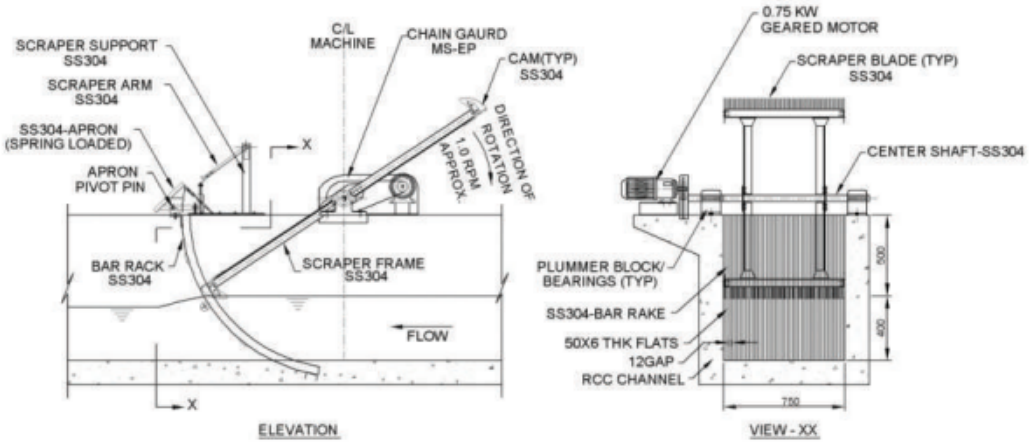
Mechanical Screen (Intermittent and Continuous)

Mechanically cleaned racks are generally erected almost vertically. Additional provision should be made for manual raking in case the mechanical rakes are temporarily out of order. Plants using mechanically cleaned screens have controls for:

a- Manual start and stop
b- Automatic start and stop by clock control
c- High level switch
d- High level alarm
e- Starting switch or overload switch actuated by loss of head and
f- Overload alarm.



There are various types of mechanisms in use, the more common being traveling rakes that bring the screenings up out of the channel and drop them into hoppers or other debris containers. A typical mechanically cleaned bar screen is shown in Figure. The rotary drum screen otherwise known as arc screen by United Nations Industrial Development Organization (UNIDO) is shown in Figure.



In the drawing, the screening rods are in the form of arc. The cleaning takes place when the meshing teeth at both ends of a diametrical rotating arm plough through the screen openings and push the screenings upwards. Upon exiting the upper end of the screen, which is well above the operating sewage level, a built in spring loaded arrangement in the diametrical rods jacks out the meshing teeth gently, which pushes the screenings gently into a collection trough.

The screenings can be manually removed or a conveyor belt can collect the screenings and drop them into a container on the ground through a drop chute.

- Preventive Maintenance
  1- Verify the equipment manufacturer's manual for preventive maintenance instructions and carry out the same (if permitted to be done by the operator).
  2- Switch off electrical power before doing any work on the mechanical screen.
- Regular maintenance on a daily basis and repairs
  1- Before start of the day's work, check for any friction between metal parts. If friction exists and the sound is disturbing, disconnect the electric supply and

divert all sewage to manual screens. Enter this action in the site register. Do not perform repairs by unauthorized personnel because it is dangerous.

2- Check the alignment of the tipper plates. If the screenings are slipping back and are not going up, allow the machine to work and do not stop it. Enter the abnormality in the site register and request for visit by the manufacturer's engineer. Do not perform repairs by unauthorized personnel because it is dangerous.

- Operation
  1- Before start of the day's work, do not approach the mechanical screen unless you are wearing, electrical gloves, safety helmet and safety boots.
  2- Before start of the day's work, switch off the mechanical screen and restart it. Watch for any friction or sparks. If you notice sparks, disconnect the electric supply and divert all sewage to manual screens. Enter the abnormality in the site register. Sometimes, these sparks can be dangerous and may cause electrocution.
  3- Follow the procedure for disposing screenings as described earlier.

Accessories (Conveyors)

Belt conveyors are used in conveying the screenings to the trolley parked by the side of the screen chamber. Generally, these are meant only for mechanical screens. For manually operated screens, the water content has to first drip out fully before the screenings can be put on the conveyor. In the case of mechanical screens, the angle is close to vertical, the height is more and dewatering is automatic, but this is not the case with manual screens. If it is to be used, then the conveyor belt has to be behind the operator. The operator first picks up the screenings, drops it on the slotted platform and allows four hours for the screenings to drip fully. Thereafter, he can lift it by the same fork and turn it around 180 degrees and place it on the conveyor belt behind him. On the other hand, in smaller plants he can directly push the screenings to the slotted platform and into the trolley on the ground after the sidewall. All the guidelines for preventive maintenance, regular day-to-day maintenance and operation, and site register entries by the operator are the same as before .

Disposal of Screenings

Screenings generally consist of non-bio degradable stuff like plastic sachets, milk packets, shampoo packets, etc., with very little organic content. Hence, it is best disposed of as a secure landfill, which should be prevented from direct rainfall and flow of overland rainwater. The procedure specified by the pollution control authority should be adhered to without fail.

Grit Removal

The different types of grit removal equipment are given in chapter 5 of Part-A of the manual. These are velocity controlled channels, detritors, aerated grit chambers, vortex type, etc.

Preventive Maintenance

Almost all of these equipment are patented. Each manufacturer has proprietary schedules for preventive maintenance. These schedules should be followed. Preventive maintenance should be done only by the manufacturer or the erection contractor who has installed the equipment, and not by the operators.

Regular Day to Day Maintenance

The operator should hose the mechanical parts using the high-pressure hose, and pump the final treated sewage so that slime does not accumulate. Where flap gates or turnstiles are provided, the operator should necessarily "exercise" these once a day.

The operator should not enter the chambers unless the sewage entry is blocked, the chamber has been dry for at least two hours and the operator is wearing an oxygen mask. In the case of velocity-controlled channels, the trip switch controlled traveling bridge with suspended suction hoses for each channel connected to a vacuum pump set are standard items. If this system fails and grit accumulates in the channel, each channel should be taken out of sewage flow. The scour valve should be opened below the chamber and the sewage after filtering through the in-built filter port should be allowed to drain to the site drain. Thereafter, the chamber should be allowed to air dry for at least two hours, high pressure water jetting, draining and air drying cycle carried out at least three times.

Subsequently, labourers can be deployed to scrap the grit, provided the labourers wear goggles, gloves, safety shoes and oxygen masks.

In general the vacuum pump is the main source of failure and these types of channels are to be used only in large STPs where other such equipment are also functioning and qualified operators are available in all the shifts.

The vortex type grit separators described in chapter 5 of part A manual are simpler devices to lift and clean the grit and discharge at a convenient elevation above the ground level.

Disposal of Grit

The grit is usually pre-rinsed in the grit removal chamber itself before it is evacuated from it. Figure shows a typical grit chamber.

Clean grit is characterized by the lack of odour. Washed grit may resemble particles of sand and gravel, interspersed with inert materials from households. Grit washing

mechanism has to be included whenever the detention time is more and flow through velocity is less. Unless washed, it may contain considerable amount of organic matter. This becomes an attraction to rodents and insects and is also unsightly and odorous. The grit should be contained in a secure landfill as directed by the local pollution control authority or disposed along with the municipal solid wastes, if permitted.

Pump Equipment

The types of pumps are dealt with in chapter 4 of Part-A of the manual. These are horizontal centrifugal, vertical shaft centrifugal, dry submersible and wet submersible pumps.

Preventive Maintenance

This shall be done only by the manufacturer / his authorized service agency / properly trained staff. The operator shall not carry out preventive maintenance.

Regular Day-to-Day Maintenance

This should include the tasks as given in the Table.

Description	Comments	Maintenance Interval			
		D	W	M	Y
Earthing	Check whether earthing is proper	yes			
Visual Appraisal	Check that safety aids and first aid are in place		yes		
Gland packing	Check for leaks & condition of mechanical seals			yes	
Alignment	Check alignment using computerized monitor				yes
Oil & Grease	Check for lubrication as per manufacturer			yes	
Motors	Check vibration and temperature		yes		
Mountings	Check for vibrations from foundation bolts			yes	
Bearings	Check for unusual sounds			yes	
Pump sequence	Start & stop the pumps as per duty condition	yes			
Foundation	Check for spalling or cracking			yes	

Proper operation of submersible pump systems requires that minimum submergence should always be maintained. This is for two primary reasons:

- ✓ Prevention of motor overheating

- ✓ Prevention of “vortex” and associated problems

The following should be inspected:

- ✓ Inspect seal for wear or leakage and repair, if required.
- ✓ Visually inspect the oil in the motor housing.
    - o Remove pipe plug from housing.
    - o Make sure oil is clean and clear, light amber in colour and free from suspended particles.
    - o Milky white oil indicates the presence of water. If the system fails to operate properly, carefully read the instructions supplied during the time of purchase and perform maintenance recommendations.

IDENTIFY AND RESPOND TO ABNORMAL SITUATIONS DURING OPERATION

Potential emergency situations

- ✓ Power supply failure
- ✓ Flooding / effluent overflow
- ✓ Fire breakout
- ✓ Abnormal discharge in an ETP tank
- ✓ Wastewater spill
- ✓ Etc.

Severity level according to potential impacts (minor, significant and major):

Example: for emergency “Wastewater spill”:

- ✓ Minor: minor spill, no risk of personnel injury, no contact with the soil and the breach in the pipeline/tank can be fixed within 24 hours;
- ✓ Significant: significant spill, contact with the soil/groundwater probable, important maintenance required to fix the problem so likely to take more than 24 hours;
- ✓ Major: massive disruption of the ETP (Emergency Response Plan) causing major leaks, ETP operations must be stopped for several days, maybe weeks to fix the problem.

Identify the potential emergency situations and what could be the severity of each emergency situation according to the potential impacts on the environment, the ETP disruption level, the time estimated to fix the issue, etc.

Write the ETP emergency response plan. It should cover the chapters as follow:

- ✓ General list of contacts with phone numbers of people to be notified in case of emergency;
- ✓ For each emergency situation:
- ✓ Actions to be taken to minimize the damage according to the level of severity (minor, significant and
- ✓ major) and who should be notified in this specific situation. See example below:
- ✓ How to report the incident and to notify it to the responsible authorities;.

Emergency situation 1			
Level of severity	**What it means ?**	**Actions to be taken**	**Who should be notified?**
Minor	Ex : minor spill, no risk of personnel injury, no contact with the soil and the breach in the pipeline/tank can be fixed within 24 hours	Ex: contact the technician for the maintenance of the pipeline leaking, request him to identify what could be the origin of the breach, clean-up the spill, etc.	Ex: ETP manager/in charge, Compliance Manager, Utility manager
Significant			
Major			

- ✓ Measures taken to prevent or minimize the recurrence of incidents
- ✓ How to report the incident and to notify it to the responsible authorities;

Communicate the ETP emergency response plan and Train the ETP operator and staff to make sure they understand the procedures to follow in case of emergency situation.

- ✓ Update the ETP emergency response plan: contact list to be updated yearly (or as soon as there is a change in the contact information) at least and overall document to be reviewed if there is any change in the ETP.
- ✓ Practice the ETP emergency response; an ETP emergency response drill should be conducted once a year

PREPARE SYSTEM FOR MAINTENANCE

Before starting the pump, check the following:

- ✓ Check insulation resistance by megger at free end of cable and verify with pump manual.
- ✓ Check continuity between ends of motor in the same phase and in all phases.
- ✓ Check resistance across moisture sensing wires and verify with pump manual.
- ✓ Physically rotate the coupling joint and verify smooth movement.
- ✓ Check for leaky oil plug and fix it before starting.
- ✓ Check for the bulbs indicating the on–off status of the pump and replace fused bulbs.
- ✓ Look for warning lamps for alerting the pumped liquid entering the oil chamber.
- ✓ Close the discharge valve before starting the pump. This is also taken care by check valve.
- ✓ Open the discharge valve gradually and not all of a sudden.
- ✓ While the pump is running at full flow, check the power consumed to be within the duty point.
- ✓ If the power consumed is very high, stop the pump and inform the manufacturer.
- ✓ Switch off the pump only after the discharge valve is closed.

Accessories

Oil and Grease

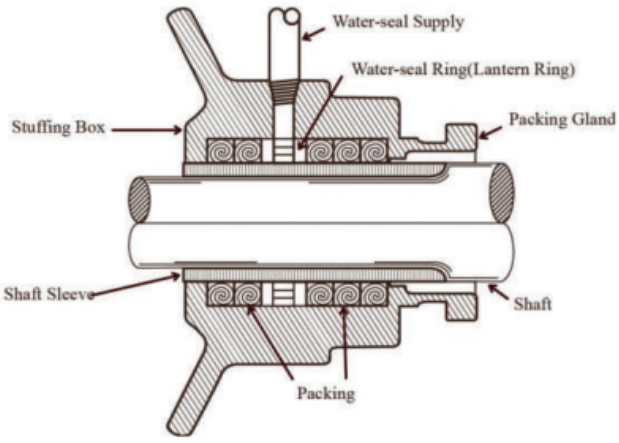
- ✓ Pumps, motors and drives should be oiled and greased strictly in accordance with the recommendations of the manufacturer. Cheap lubricants may often become the most expensive in the end.
- ✓ Oil should not be put in the housing while the pump shaft is rotating because a considerable amount of oil will be picked up and retained due to the rotary action of the ball bearings. When the unit comes to rest, an overflow of oil will occur around the shaft or oil will flow out of the oil cup

Bearing

- ✓ Pump bearings should usually last for many years if serviced properly and used correctly.
- ✓ There are several types of bearings used in pumps such as ball bearings, roller bearings and sleeve bearings. Each bearing has a special purpose, such as thrust load, radial load and speed. The type of bearing used in each pump depends on the manufacturer's design and application.
- ✓ Whenever a bearing failure occurs, the bearing should be examined to determine the cause and, if possible, to eliminate the problem.

Packing Gland

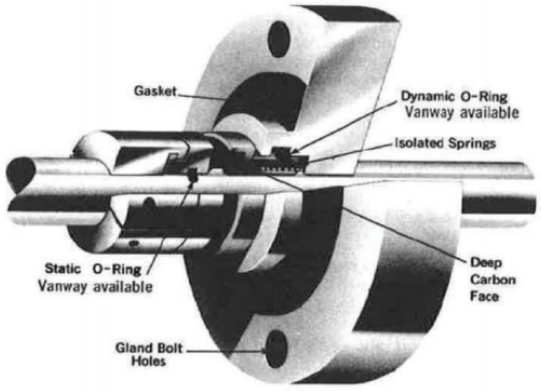
- ✓ Check packing gland, which is usually neglected and is a troublesome part as shown in Figure.
- ✓ If the stuffing box leaks excessively when gland is pulled up with mild pressure, remove the packing and examine the shaft sleeve carefully.
- ✓ Replace grooved or scored shaft sleeve because packing cannot be held in stuffing box with roughened shaft or shaft sleeve.
- ✓ Replace the packing a strip at a time, tamping each strip thoroughly and staggering the joints. Position the lantern ring (water sealing) properly



- ✓ If grease sealing is used, completely fill the lantern ring with grease before placing remaining rings of packing in place.
- ✓ The proper size of packing should be available in the plant's equipment files.

Mechanical Seal

- ✓ Many pumps use mechanical seals instead of packing as shown in Figure.
- ✓ Mechanical seals serve the same purpose as packing; that is, they prevent leakage between the pump casing and shaft. The seals have two faces that close tightly and prevent the sewage from passing through them.
- ✓ The different materials are selected for their best application.



Some of the factors for selection of material are:

- Liquid and solids being pumped
- Shaft speed
- Temperature
- Corrosion resistance
- Abrasives

- ✓ Initially, mechanical seals are more expensive than packing when installed in a pump. This cost is recovered through maintenance savings over a period of time.
- ✓ Some of the advantages of mechanical seals are as follows:
  - They last from three to four years without any maintenance, resulting in labour savings.
  - Usually, there is no damage to the shaft sleeve at the time of their replacement.
  - Continual adjusting, cleaning, or repacking is not required.

The construction of a mechanical seal is shown below.

- ✓ Whatever be the method used, the mechanical seal must be inspected frequently.
- ✓ Grease cups must be kept full at all times and inspected to make sure they are operating properly. When a pump is fitted with a mechanical seal, it must never run dry or the seal faces will be heated up and ruined.
- ✓ Mechanical seals should not leak from the gland. If a leak develops, the seal may require resurfacing or it may have to be replaced.
- ✓ Repair or replacement of mechanical seal requires the pump to be removed and dismantled.
- ✓ Seals are quite delicate and special care must be taken when installing them. Mechanical seals differ widely in their construction and installation, and the manufacturer's instructions must be followed.

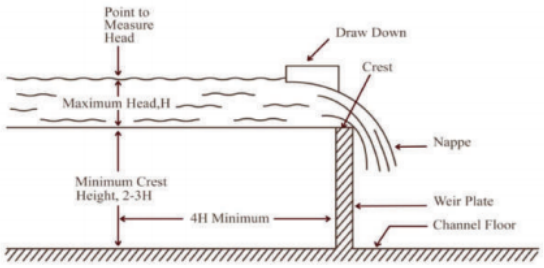
Flow Measuring Devices

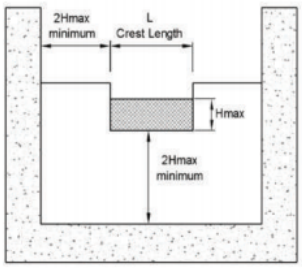
Flow, similar to water level, is one of the most important parameters to be measured. The various types of flow-measuring devices have three basic criteria that determine their performance namely: area, velocity, and device characteristics. The two basic types of flow measurements are open-channel and closed-pipe. For good measuring

device performance, both types require approach conditions free of obstructions and abrupt changes in size and direction. Obstructions and abrupt changes produce velocity-profile distortions that lead to inaccuracies.

Weir Flow-meter

A weir measures the liquid flowing in open channels or partially filled pipes under atmospheric pressure as shown in Figure.
This device causes the flow to take on certain characteristics (such as shape and size) depending on the device used. Changes in flow-rate produce a measurable change in the liquid level near or at the device.
This level is related to flow-rate by an appropriate mathematical formula. The specific device determines the location and accuracy of level measurements and is extremely important for accurate performance.

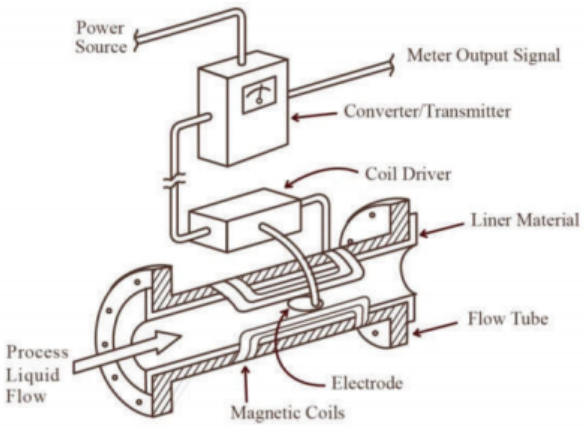




Measurement errors occur if the actual crest height differs from the designed height due to accumulated matter on the channel floor. The sediments must be removed.
Floating matter or surface wave may cause incorrect level measurements and lead to errors in flow measurements. Therefore, floating matter should be removed immediately.

Electromagnetic Flow-Meter

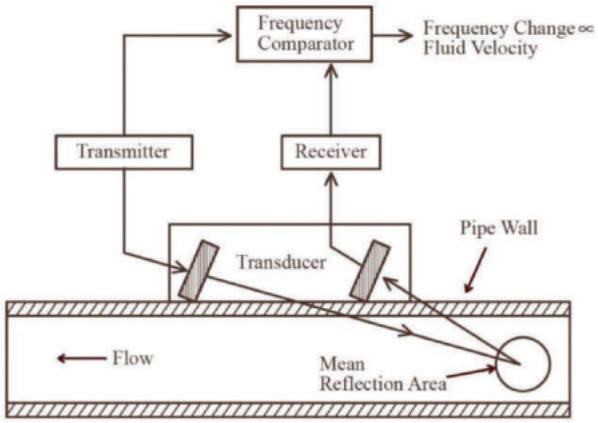
Magnetic flow meters are used extensively in applications ranging from filtered sewage to thickened or digested solids. They function by electromagnetic induction, in which the induced voltage generated by a conductor moving through a magnetic field is linearly proportional to the conductor's velocity. As the sewage (the conductor) moves through the meter (generating the magnetic field), the voltage produced is measured and converted to a velocity and, thus, a flow-rate. Magnetic meters require a full pipe flow for proper operation. Proper grounding is important for certain brands. In applications where greasing of electrodes is likely, additional equipment for degreasing the electrode may be required. Magnetic flow meters provide no obstructions and are manufactured with abrasion- and corrosion-resistant liners, which



is why they are frequently used in solids metering. Repairs should be done only by the manufacturer's representatives. Electromagnetic flow meters rarely break down because they have no moving parts. Dirt on sensors should be cleaned because that may cause error in measurements. The working principle is shown in Figure.

Ultrasonic Flow-Meter

Ultrasonic flow meters are based on the measurement of ultrasonic wave transit time or frequency shift caused by the flowing fluid. An instrument that measures wave-transit time is called a time-of-flight or counter-propagation ultrasonic flow meter. Ultrasonic waves of known frequency and duration are beamed across the pipe at known angles. The waves are sensed either directly by an opposing receiver or indirectly as reflected waves. The changes in wave transit time or frequency caused by the flowing liquid are linearly proportional to the liquid velocity. This velocity is converted from flow and output to a display by conversion electronics. The presence or absence of air bubbles and density of solids in the fluid being metered affect the meters. Operators should follow the manufacturer's specifications and carefully match the meters to the application. The working principle is shown in Figure.



Fluorescent Tracers

Florescent tracer method requires the use of a tracer like Rhodamine B Dye, which is injected using a peristaltic pump from a small volume of a known concentration of dye solution. The dye is injected into the gravity or pumping main. After traveling and getting mixed, the dye concentration is measured at a distance away. The mass of the dye is the same in the beginning and after traveling. The instrument used is called Fluorometer. The dye will automatically degrade and it does not affect the water body.

Preventive Maintenance

Equipment has become more complex with the application of advanced technologies and automation systems in recent years. Thus, high technical knowledge is required and technicians, technical tools and special instruments are necessary for implementing preventive maintenance of the equipment. Unlike O&M contractors, manufacturers can provide such skilled staff and special tools. The manufactures can provide safe and secure maintenance based on their long experience and abundant information on their products. Preventive maintenance after expiry of warranty period should be availed from the manufacturers continuously.

A good maintenance programme is essential for a pumping station to operate continuously at peak design efficiency. A successful maintenance programme will cover everything from mechanical equipment, such as pumps, valves, scrapers and

other moving equipment, to the care of the plant grounds, buildings and structures. For preventive maintenance, it is advisable to follow a schedule for the maintenance of the equipment.

The schedule covers recommendations for checks and remedial actions to be observed at different intervals such as daily, monthly, quarterly, bi-annually and annually. Operators should receive training to obtain more knowledge of characteristics and structure of machinery and to improve their maintenance skill.

- ✓ Mechanical Maintenance: Mechanical maintenance is of prime importance, as the equipment must be kept in good operating condition for the plant to maintain peak performance. Manufacturers provide information on the mechanical maintenance of their equipment. Operators should thoroughly read manuals on the plant equipment, understand the procedures, and contact the manufacturer or the local representative if there are any questions. The instructions should be followed very carefully when performing maintenance on equipment. Operators also must recognise tasks that maybe beyond their capabilities or repair facilities, and should request assistance when needed.
- ✓ Maintenance of Civil Structures: Building maintenance is another programme that should be maintained on a regular schedule. Buildings in a treatment plant are usually built of sturdy materials to last for many years.

Buildings must be kept in good condition by repairs. For selecting paint for a treatment plant, it is always a good idea to have a painting expert help the operator select the types of paint needed to protect the buildings from deterioration. The expert also will have some good ideas as to colour schemes to help blend the plant in with the surrounding area. Consideration should also be given to the quality of paint. A good quality, more expensive material will usually give better service over a longer period of time than the economy-type products. Building maintenance programmes depend on the age, type and use of a building. New buildings require a thorough check to ensure that essential items are available and are working properly. Older buildings require careful observation and prompt attention to detect leaks, breakdowns and replacements beforehand. Attention must be given to the maintenance requirements of many items in all plant buildings, such as electrical systems, plumbing, heating, cooling, ventilating, floors, windows, roofs, and drainage around the buildings. Regularly scheduled examinations and necessary maintenance of these items can prevent many costly and time-consuming problems in the future.

In each plant building, periodically check all stairways, ladders, catwalks and platforms for adequate lighting, head clearance, and sturdy and convenient guardrails. Protective devices should be around all moving equipment.

Whenever any repairs, alterations or additions are made, avoid building accident traps such as pipes laid on top of floors or hung from the ceiling at head height, which could create serious safety hazards.

Keep all buildings clean and orderly. Supervisory work should be done on a regular schedule.

All tools and plant equipment should be kept clean and in their proper place. Floors, walls and windows should be cleaned at regular intervals to maintain a neat appearance.

- ✓ Valve Maintenance: Valves should be lubricated regularly (according to the manufacturer's instructions), and valve stems should be rotated regularly to ensure ease of operation. These activities should be part of a regular pump-maintenance programme.
- ✓ Electric Actuator Maintenance
    - Declutch and operate the manual hand wheel.
    - Check oil level and top up, if required.
    - Re-grease the grease lubricated bearing and gear trains, as applicable.
    - Check the insulation resistance of the motor.
    - Check for undue noise and vibration and take necessary rectification measures.
    - Tighten limit switch cam ends. Check for setting and re-adjust, if necessary.
    - Examine all components and wiring thoroughly and rectify as necessary.
    - Change oil or grease in the gearbox and thrust bearing.
    - Check the condition of the gears and replace them if teeth are worn out.
- ✓ Flow Meter Maintenance: Each individual sensing meter will have its own maintenance requirements. The single most important item to be considered in sensor maintenance is good housekeeping. Always keep sensors and all instrumentation very clean. Good housekeeping and the act of providing preventive maintenance for each of the various sensors, includes ensuring that foreign bodies do not interfere with the measuring device. Check for and remove deposits that will build up from normal use. Repair the sensor or measuring device whenever it is damaged.

External connections between the sensing and conversion and readout devices should be checked to ensure such connections are clean and connections are firm. Be sure no foreign obstruction will interfere or promote wear. On mechanical connections, grease as directed; on hydraulic or pneumatic connections, disconnect and ensure free flow in the internal passage.

- ✓ Maintenance of Pumps: The maintenance schedule should list out items to be attended to at different periods, such as daily, semi-annually, annually and as needed.
    - Daily Observations
        - Leakage through packing
        - Bearing temperature
        - Undue noise or vibration
        - Pressure, voltage and current readings
    - Semi-annual Inspection
        - Free movement of the gland of the stuffing box
        - Cleaning and oiling of the gland bolts
        - Inspection of packing and repacking, if necessary
        - Alignment of the pump and the drive

        - Cleaning of oil-lubricated bearings and replenishing fresh oil.
        - If bearings are grease-lubricated, the condition of the grease should be checked and replaced with correct quantity, if necessary.
        - An anti-friction bearing should have its housing packed with grease so that the void spaces in the bearings and the housing are 1/2 to 2/3 filled with grease. A fully packed housing will cause the bearing to overheat and will result in reduced life of the bearing.
    - Annual Inspection
        - Cleaning and examination of all bearings for flaws developed, if any
        - Examination of shaft-sleeves for wear or scour.
        - Checking clearances

Clearances at the wearing rings should be within the limits recommended by the manufacturer. Excessive clearances indicate a drop in the efficiency of the pump. If the wear is only on one side, it means misalignment. Not only should the misalignment be corrected, but also the causes of the misalignment should be investigated and the clearances reset to the values recommended by the manufacturers. If the clearance on wear is seen to be 0.2 or 0.25mm more than the original clearance, the wearing ring should be renewed or replaced to obtain the original clearance.
These are to be done by the equipment representative.

- Impeller-hubs and vane-tips should be examined for any pitting or erosion.
- End-play of the bearings should be checked.
- All instruments and flow-meters should be re-calibrated.
- Pump should be tested to ensure proper performance is being obtained.
- In the case of vertical turbine pumps, the inspection can be bi-annual. Annual inspection is not advisable because it involves disturbing the alignment and clearances.

    - Annual Maintenance and Repairs
        - Consumables and lubricants

Adequate stock of items as packing glands, belts, lubricating oils, greases should be maintained.

- ✓ Replacement of spares: To avoid downtime, a stock of fast-moving spares should be maintained. A set of recommended spares for two years of trouble-free operation should be ordered along with the pump.
- ✓ Repair workshop: The repair workshop should be equipped with tools such as bearing-pullers, clamps, pipe-wrenches, and other general-purpose machinery such as welding set grinder, blower, drilling machine, etc.

Record Keeping

The purpose of recording data is to track operational information that will identify and avoid duplicating optimum operating conditions. A record of equipment performance and repairs allow O&M personnel to properly evaluate equipment's effectiveness and

determine if the equipment meets the objectives to justify its purchase and installation.

Pumping station annual inspection report					
Date					
Mechanical	General condition of equipment				
	Sewage pump			Sump pump	Remarks
	No.1	No.2	No.3		
1. Pump					
Bearings					
2. Gates					
Gate operator (manual)					
Gate operator (motor)					
Stems					
3. Crane and hoist					
4. Siphon breaker					
5. Trash racks					
Drive chain					
Bearings					
Gear reducers					
Electrical	Date				
1. Motors					
2. Motor bearing					
3. Switchgear controls					
4. Control panels					
General					
1. Water levels	Elevation		Remarks		
Forebay					
Sumps					
Building and grounds	Date				
	Remarks				
1. Sump					
2. Forebay					
3. Discharge chamber					
4. Gatewell to river outlet					
5. Structure					
6. Fire extinguishers					
7. Tools and cabinets					
8. Painting					
9. Caulking					
10. Grating, rails and ladders					
11. Water system and plumbing					
12. Louvers and ventilators					
13. Windows					
14. Doors					
Remarks					

As a minimum, the following basic information should be maintained for each equipment in the pumping station:

- ✓ Plant equipment identification number
- ✓ Manufacturer
- ✓ Model number and serial number
- ✓ Type
- ✓ Dates of installation and removal from service
- ✓ Reasons for removal
- ✓ Location when installed
- ✓ Calibration data and procedures

- ✓ Hours required to perform maintenance
- ✓ Cost of replacement parts
- ✓ O&M manuals, references and their locations
- ✓ Apparatus failure history

Inspection reports should be prepared for each sewage pumping station according to the equipment installed.
An example of an annual inspection report for pumping station is shown in the Table.

Recommended maintenance/inspection tasks for equipment in pumping stations are summarised by frequencies and are listed in the Table. Because the required maintenance / inspection and their frequencies may differ depending on the equipment installed, maintenance plans should be prepared according to manufacturer's instruction manuals of related equipment.

	start up	monthly	3 month	6 month	1 year	5 year	Oper hrs
Trash rake		GI,O,CL			CL		
Motors				AL	PG	CL	
Heaters	GI						
Gear reducers		GI		CH			
Drive chain	PG						PG
Pillow blocks				PG			
Torque limit coupling					PG		
Shear pin & sprocket		GI					
Trip cam		GI					
Control panel					GI,CL		
Sub-station drainage					GI		
Building structure			GI				
Trash-rack				GI			
Toilet facility				GI			
Domestic water				GI			
Holding tank			GI		PO		
Siphon breakers			GI				
Unit heaters					GI		
Fire extinguishers		GI		GI			
Switch gear	GI						
Bus & connections					GI,CL		
Instruments & lamps	GI				GI,CL		
Heaters					GI		
Lighting panel	GI				GI		
Control panel	GI				GI		
Grounding					GRT		
Float control	GI				GI		
Main pump motors							
Entrance channel						GI,RS	
Sump					GI,RS		
Gates				GI,O,CL			
Stem	GI			CL,SG			
Thrust nut	GI			CL,SG			
Manual operators					PG		
Motor operators					GI,CL		

.egend

O	Operate	GRT	Ground resistance test	MR	Megger and record
CH	Change	TO	Test oil	PG	Pressure grease
CL	Clean	GI	General inspection	SG	Surface grease
AL	Add lubricant	PO	Pump out	TS	Test
RS	Remove silt	RC	Remove condensate		

Duties of site engineer in charge

The site engineer should first check the entries of the operator in the previous three shifts and take corrective action, or alert the supervisor by e-mail and make an entry in the site register. If the site engineer cannot correct the problem within two weeks, he should directly send an e-mail message to the plant incharge. If no action is taken even after two weeks, the complete responsibility will rest with the plant incharge from then onwards, including the responsibility for any accidents/fatalities caused by not taking the requisite action.

If the pumping station is under O&M by the contractor

The references to operator, site engineer and plant incharge inevitably apply to the staff of the contractor also. The engineer in charge of supervising the contractor's work should review the site register once a fortnight and institute such remedies as available under the contract.

Summary

The most important thing for O&M of pumping stations is to minimize suspension time due to equipment failures and to maximize the life of pumps. For accomplishing these targets, the following causes of breakdown of pumps should be eliminated:

- ✓ Inflow of screenings into pumping stations
- ✓ Overloading of pumps

Preventive maintenance is also essential for detecting abnormalities in their early stages

PREPARE AND START SYSTEM

A well-defined plan is critical to successful testing and startup. This process begins with factory performance testing of the equipment (where applicable) and is completed with final approval of all checklist items and successful operation of the pump station through the test period.

Factory Performance Testing

Factory performance testing should be conducted for all water and wastewater pumps installed that have motors 5 hp and greater. For pumps smaller than 5-hp, the pump manufacturer may provide equipment based on previously performed tests for the specified pump design and similarly sized impellers to determine the operating characteristics. Pumping equipment may be accepted based on the manufacturer's normal quality assurance/quality control (QA/QC) testing, except for:

- ✓ For pumps in excess of 30 hp or 2,000 gpm, non-witness factory performance testing is required.
- ✓ For large pumping equipment with motors that exceed 200 hp or that have a capacity of more than 5,000 gpm, factory performance testing is required. Witnessed testing is preferred. The witnessed test should be observed by a representative of SPU that is familiar with the project and is qualified to understand the technical aspects of the factory test.
- ✓ Pump manufacturer should guarantee pump performance at the flow, head, brake hp, and efficiency specified.
- ✓ Testing setup should conform to the requirements and (HI standards (ANSI/HI 1.6 – latest edition). Testing must have a performance tolerance consistent with acceptance level 1U, as defined in the HI standards.

- ✓ Factory performance test should include at least five data points evenly spaced from minimum to maximum flow to define the shape of the pump curve.
- ✓ For variable speed pumps, testing should be conducted at full speed. Affinity laws can be used to establish reduced speed operating conditions.
- ✓ Pump curves developed during the factory test should be certified to guarantee performance.
- ✓ It is acceptable to test performance with a factory calibrated motor as opposed to the job motor. However, for large equipment that will have witnessed factory tests, SPU may decide it is more appropriate to use the job motor for the testing. Submersible pumps should be tested with the job motors.

If the equipment does not meet the specified operating conditions during the factory performance test, the pump manufacturer should make the necessary modifications to the pumps until the specified operating conditions are met. In general, it is not recommended that motors or VFDs be transported to the pump manufacturer's factory for performance testing. Although testing the motor and VFD at the factory with the pump could turn up operational problems, this testing approach is costly. It also presents unnecessary risk that the equipment could be damaged in transport.

Field Operational Testing

Field operational testing tests pump performance and the hydraulic design of the entire pumping facility. Field testing allows evaluation of pump intake design, force main hydraulics, pump and piping installation, and pump field performance. The initial field test of a pump system should be done with the manufacturer's representative present. All acceptance criteria must be demonstrated under the full range of design flow and head conditions. Testing should be documented and signed off by the Contractor, vendor, engineer, and owner. The test will require that test equipment similar to that used for the factory testing be available. Much of the test equipment may be installed as part of the pump station design and should include:

- ✓ Flow meter
- ✓ Pressure gages on the pump suction and discharge piping
- ✓ Tachometer
- ✓ Power analyzer

Because the level of environmental controls is lower in field testing as opposed to factory testing, care must be taken to obtain a reasonable level of accuracy during field testing. Field data should be compared to factory testing data to confirm pump performance. Minor changes from factory performance should not cause alarm. Many factors affect performance, including data collection inconsistencies and differences in pump intake hydraulics. Significant differences between field tests and factory tests would be a more than 5% change in head and should be evaluated further. Field testing results should be used as a baseline condition to determine change in performance during future testing. On large installations, specifications may require an independent company to do vibration testing. These tests document that equipment

vibration does not exceed limits outlined in the equipment specifications. Many factors can cause excessive vibration: misalignment or imbalance of rotating equipment, improper pump support, or natural frequency of the pump and piping that is coincident with the pump rotating speed or a multiple of the rotating speed. If vibration levels exceed specified values, the root cause of the vibration should be identified and corrected promptly before it can cause long-term damage to the equipment.

Training

Project specifications should require the pump manufacturer to provide training for proper O&M of the pumping equipment. The trainer should have complete knowledge of this subject and should train for a minimum of two 8-hour sessions for small equipment and up to five 8- hour sessions for larger, more complex equipment. Training should be provided to representatives of the owner's O&M and engineering staff. The content of the training should include proper O&M of the equipment with both classroom and hands-on experience.

Checklists

Many items are confirmed during startup of a pumping system and each system varies. Whenever possible, particularly on large installations, a startup expert should be provided with a copy of the mechanical layout, specification information, and control write-up. The startup expert should develop a site-specific checklist for installation.

Pre-Operational Checklist

A pre-operational checklist is a tool for all parties to ensure that the pumping system has been correctly installed, checked by the Contractor, vendor, and owner's representative, and is ready for operation. It should be completed by the construction manager for the owner.

Initial Operational Checklist

The initial operational checklist compares actual pump performance to its advertised factory performance. The certified pump curve should be used for this comparison. During the test, pressures and flows at different operating points are plotted over the certified performance curve. These values should be checked to make sure they are within design tolerances. This checklist is also used to ensure that auxiliary systems that support pumping operation are operating effectively at their designed set points. Information collected during the test should be used as baseline pump performance data for maintenance purposes.

Post-Operational Test Checklist

Once the pumping system is put into operation and has operated for a test period (typically seven days), a post-operational test is done. This test should ensure that flow rates, have not been compromised and no detrimental grout cracking, or vibration have occurred

CLEAN UP

- ✓ Work area is cleared and materials are disposed of.
- ✓ Tools and equipment must be cleaned, checked and maintained and stored.
- ✓ All the necessary documentations must be completed

UNIT 16

OPERATE AND MAINTAIN SEWERAGE TREATMENT PLANT

This unit of competency specifies the outcomes required to monitor and maintain sewage systems and address environmental concerns and associated hazards, including the disposal of waste

Introduction

Sewage treatment is a multi-stage process designed to clean water and protect natural water bodies. Municipal sewage contains various wastes. If untreated or improperly collected and treated, this sewage and its related solids could hurt human health and the environment. A treatment plant's primary objectives are to clean the sewage and meet the plant's permit requirements. Treatment plant personnel do this by reducing the concentrations of solids, organic matter, nutrients, pathogens, and other pollutants in sewage. The plant must also help protect the receiving water body, which can only absorb so many pollutants before it begins to degrade, as well as the human health and environment of its employees and neighbours. One of the challenges of sewage treatment is that the volume and physical, chemical, and biological characteristics of sewage continually change. Some changes are the temporary results of seasonal, monthly, weekly, or daily fluctuations in the sewage volume and composition. Other changes are long-term, the results of alterations in local populations, social characteristics, economies, and industrial production or technology. The quality of the receiving water and the public's health and well-being may depend on a treatment plant operator's ability to recognize and respond to potential problems. These responsibilities demand a thorough knowledge of existing treatment facilities and sewage treatment technology.

OPERATING SEWERAGE TREATMENT PLANT

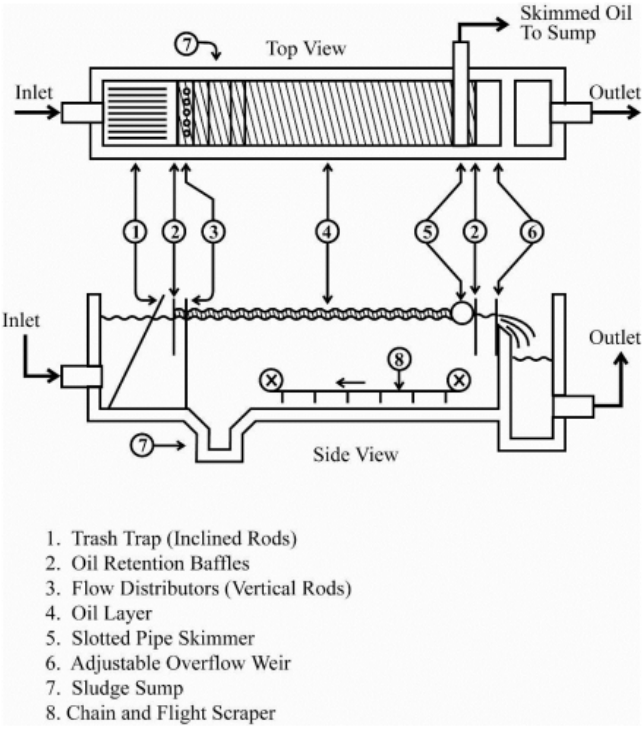
Oil and Grease Removal

Manual Process

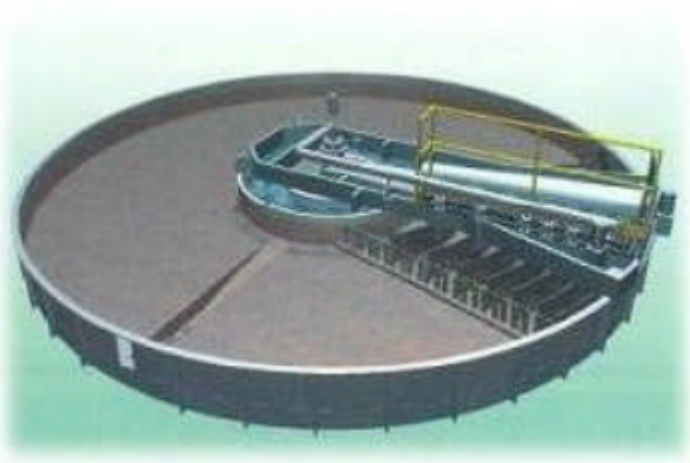
The oil and grease removal unit consists of are simple tanks with an underflow baffle where the floating oil and grease is detained on top of the sewage. These are fit only for small STPs of about 1 MLd capacity or less. The floating oil and grease is removed by a rotating slotted pipe as in the Figure. In actual operation, the scum of oil and grease is removed by rotating the slit pipe so that the scum flows over the slit, through the pipe and goes to a holding high-density polyethylene tank below the pipe on the outside. The scum is then sold to pollution board-authorized oil re-refining firms. The grit that settles in the trough below is drained to a sump and pumped to the beginning of the grit chamber. The maintenance is very simple and requires periodic cleaning only.

Floatation Process

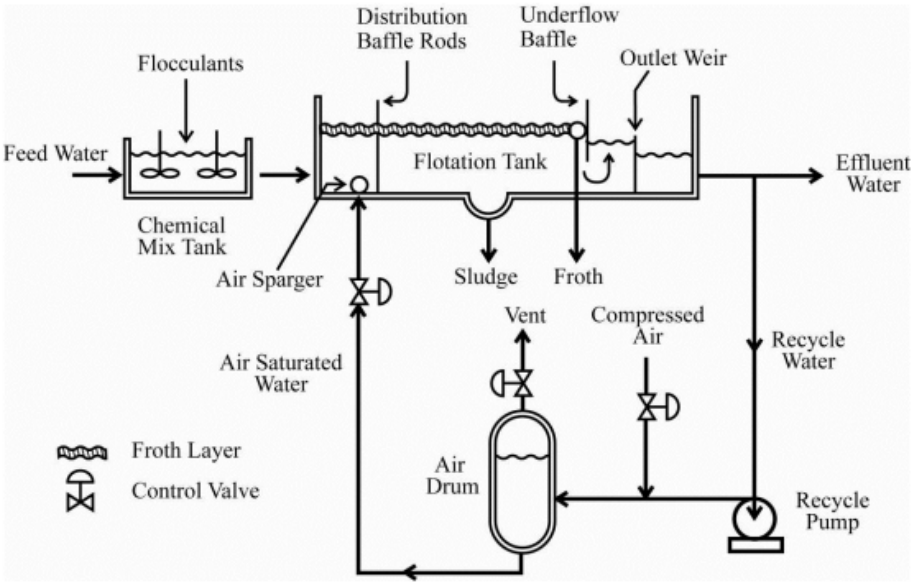
This process involves floating the oil and grease by either fine bubbles of compressed air or directly by steam liberated near the floor. The same figure as in Figure can also be used by releasing fine bubbles of compressed air at the floor or steam near the floor.



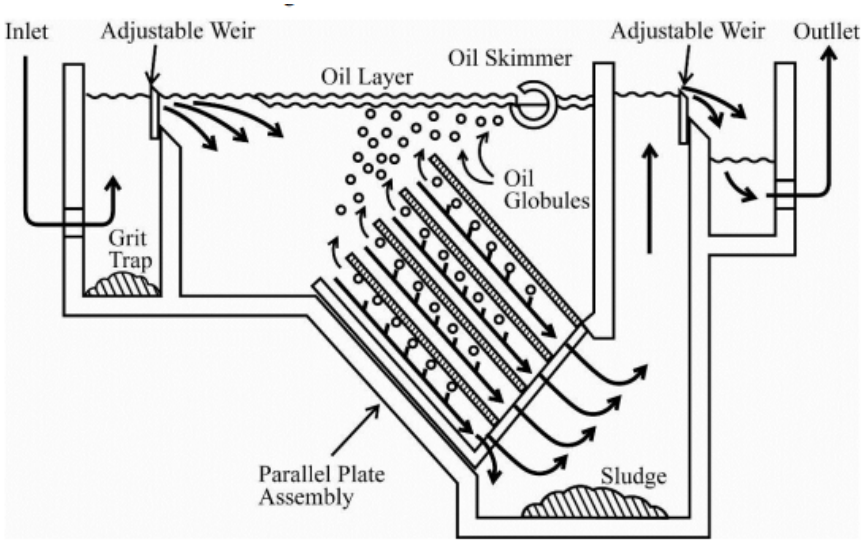
Commercially, the air is dispersed into very fine particles with the raw sewage and released under gravity in a shallow tank where the fine bubbles take the oil along with them to the surface and are skimmed off by a scoop pips as in Figure.



The unit is typically called a dissolved air floatation (DAF) unit. The schematic of this is shown in the Figure.



A parallel plate separator is shown in schematic in Figure.



All these units are almost patented types and there are no fixed O&M guidelines. Each unit has to follow the guidelines of the respective manufacturer.

Equalization

Flow equalization can be either inline or offline. With inline flow equalization, all of the flow enters the flow equalization basin, and a constant outflow rate is maintained. With offline flow equalization, only that portion of the flow above a given flow rate (typically the average flow) is diverted into the flow equalization basin. The accumulated flow is then released during low-flow periods to bring the total flow to average flow for the day.

The inline flow equalization is the easiest to control. Typically, the flow is pumped out using flow-controlled variable-speed pumps or is pumped in and flows out by gravity using a flow control valve and flow meter. If the latter is used, careful selection of the

flow control valve is needed to prevent clogging, even if screened or primary treated sewage is to be equalized. For offline flow equalization, flow control gates or variable speed pumps can be used. If a constant elevation side weir is used, achieving a controlled flow rate over the side weir is difficult and is not recommended. Variable speed pumps are a better choice.

Operation

Fill-and-draw mode is the most efficient method of operating an equalization basin for flow dampening. The basin is filled during the day when peak flows are occurring, and then it is drawn down at night when the plant is receiving low flows and, hence, is more capable of treating excessive flow. If an equalization basin is not operated in fill-and-draw mode, it will act as a mass loading equalization basin only, assuming the basin is completely mixed.

The successful operation of equalization basins requires proper mixing and aeration. Design of mixing equipment provides for blending the contents of the tank and preventing deposition of solids in the basin.

Mechanical aerators, which offers one method of providing both mixing and aeration, have oxygen transfer in clean water under standard conditions, but the oxygen-transfer efficiency (OTE) in sewage is lower. Minimum operating levels for floating aerators typically exceed 1.5 m and vary with the power and design of the unit. Low-level shutoff controls are needed to protect the unit. If the equalization basin floor is subject to erosion (earthen basins), concrete pads on the basin floor are recommended. Baffling may be necessary to ensure proper mixing, particularly with a circular tank configuration.

Below are some of the recommended monitoring elements required in flow equalization basins.

- ✓ Basin liquid level
- ✓ Basin dissolved oxygen level
- ✓ Influent pH
- ✓ Mixers and/or aeration blower status
- ✓ Influent/effluent status pumps
- ✓ Influent/effluent flow

IDENTIFY POTENTIAL PROBLEMS AND FAULTS WITH SEWAGE SYSTEMS

Sewage systems use water to carry waste away in pipes. They can improve community health, especially in crowded urban areas. But to prevent health problems, sewage must be treated to make the water safe to return into waterways and for reuse.
Sewage treatment is costly, and more often than not, sewage is dumped without being treated. This spreads waste and all the germs, worms, and toxic chemicals it may contain, causing health problems such as hepatitis, cholera, and typhoid in places where sewage is dumped.

Even with costly sewage treatment, using water to carry away waste is often not sustainable and can lead to problems such as:

- ✓ Contamination of drinking water sources downstream.
- ✓ Contamination of land where people live and farm.
- ✓ Loss of nutrient resources (fertilizer) for farming.
- ✓ Contamination of water sources used for drinking, bathing, and farming.
- ✓ Bad smells.

Sewage systems also cause health problems when different kinds of waste are mixed together, such as when factories dump toxic chemicals into sewers. This contamination makes the treatment and safe reuse of wastewater very difficult.

The safest low cost way to manage sewage is to treat it close to where it is produced, and then to allow the water to absorb into the soil and nourish plants. The most common way to do this is to use a septic tank (a large container underground where solids collect and decompose) and a leach field (where liquid flows out and into the soil).

MAINTAIN AND REPREARE SEWERAGE SYSTEMS

Maintenance

Because grit removal is rarely provided ahead of equalization, grit will accumulate in the basins. Therefore, provisions for collecting these solids should be made in the design. If the primary purpose of the equalization basin is flow dampening, then after the basin has been emptied following the peak flow event, primary sludge solids will be present on the basin bottom. Water cannons or strategically placed cleaning hoses, ideally supplied with plant effluent water, will allow for cleaning the basins. Other equalization basin types that do not operate in a fill/draw mode still will accumulate solids after a time and will have to be emptied for cleaning. The time between cleanings is dependent on the influent sewage characteristics and will likely have to be established by plant operation staff based on operational experience.

Primary Treatment

Primary Sedimentation Tank Management

This is a simple gravity controlled separation for removing the settleable solids and the Biochemical Oxygen Demand (BOD) that is removed along with it.

Preventive Maintenance

Preventive maintenance of the equipment should be done by the equipment supplier as per the manual.

Day to Day Maintenance

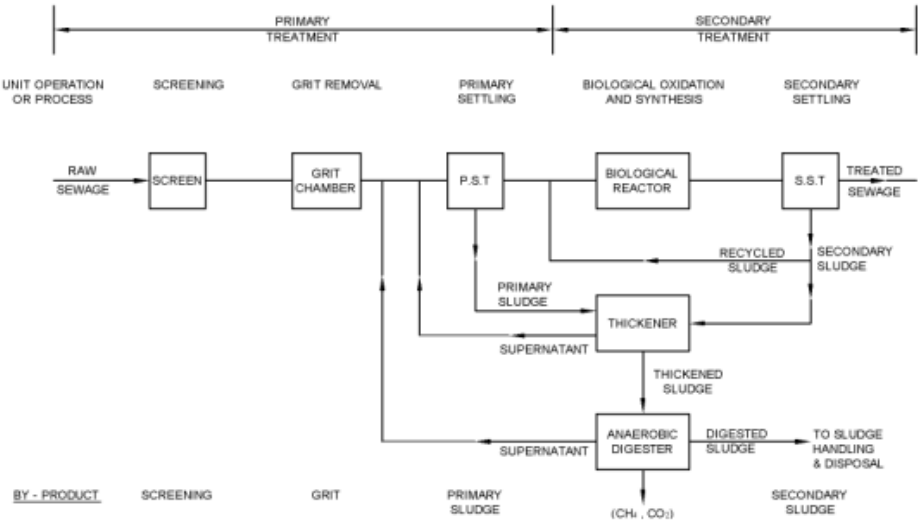
The most important is the daily cleaning of the overflow weirs and the weekly scraping of the floor and walls of the launder. Also periodical checking of the walkway for

corrosion is important. In actual day to day working, the operator should not lean or put his weight on the handrails.

Activated Sludge Process (ASP)

The activated sludge process is still the most widely used biological treatment process for reducing the concentration of organic pollutants in sewage. Well-established design standards based on empirical data have evolved over the years.

The activated sludge process has been designed in many different modifications. The process selected depends on the treatment objectives, site constraints, operational constraints, etc. The process can be categorized by loading rates, reactor configuration, feeding and aeration patterns, and other criteria including numerous biological nutrient removal (BNR) processes. Typical plan layout is illustrated in Figure.



Description of Activated Sludge Process (ASP)

Biological Treatment Processes

In the biological treatment of sewage, the stabilisation of organic matter is accomplished biologically using a variety of microorganisms, principally bacteria. Microorganisms convert the colloidal and dissolved carbonaceous matter into gases and non-degradable matter and incorporate it into their cell tissue. The resulting cell tissue, having a specific gravity slightly greater than that of treatment achieved, is only to the extent of the portion of organic matter that has been converted to various gaseous and non-degradable end products because the cell tissues, which itself is organic, and will be measured as BOD in the effluent.

Conversion of organic matter can be accomplished aerobically, anaerobically or facultatively. Oxidation of organic matter to various end products is carried out to obtain the energy required for the synthesis of new cell tissues. In the absence of organic matter, the cell tissue is endogenously respired to obtain energy for maintenance. In most treatment systems, these three reactions, oxidation, synthesis and endogenous respiration occur simultaneously.

The microbial mass comprises a heterogeneous population of microorganisms, mostly heterotrophic bacteria. Various groups of organisms carry out their metabolic reactions independently as well as sequentially. The selection of organism in the treatment process occurs naturally, depending upon the sewage characteristics and the environmental conditions maintained.

Design and Operational Parameters

The ASP operation is commonly controlled by maintaining the design Mixed Liquor Suspended Solids (MLSS), or sometimes, by maintaining design Food to Microorganisms (F/M) ratio. The latter approach takes care of fluctuations in the quality of raw sewage. If actual F/M is to be assessed, then measurement of active biomass measured as Mixed Liquor Volatile Suspended Solids (MLVSS) – is needed, which is often difficult to measure and may also give an erroneous result in case of industrial effluent containing suspended organic waste solids. The solid retention time (SRT), which is directly related to F/M, is not being used for operational control. Some of the important design and operational parameters are described and discussed in following sections.

Choice between SRT and F/M as Operation Control Parameter

The evaluation of the active mass of microorganism often makes the use of F/M as a control parameter impractical. Biological solids are commonly measured by measuring volatile suspended solids. This parameter is not entirely satisfactory because of the variety of volatile matter not related to active cellular material. On the other hand, the evaluation of SRT as a plant control parameter is simple. Since SRT is the ratio of total suspended solids in the system and that wasted per day, it requires only measurement of total suspended solids. The proportion of active biomass in solids in the system and that in solids wasted, either from the aeration tank or from the recycle line, is the same. Use of SRT as a plant controlling parameter becomes simpler if sludge wasting is done directly from aeration tank, as the ratio of "total solids in system to solids wasting per day" reduces to the ratio of "aeration tank volume to volume of sludge wastes per day," provided the mass of solids escaped in treated effluent is negligible.

Effect of ϑc on Settling Characteristics and Drainability of Sludge

It has been established that as a system is operated at higher solids retention time, the settling characteristics of the biological floc improve. For domestic sewage, SRTs of the order of 3 to 4 days are required to achieve effective settling. Further, it is established that drainability of waste sludge also improves when a system is operated at higher SRT. The SRT at which a process is operated approximately represents the average age of biomass present in the process. As the biomass ages, it contains increasing proportion of dead cells and inert matter. Presence of higher proportion of mineralised sludge in a process operated at high SRT is responsible for better setting characteristics and better drainability of sludge.

Effect of θc on Excess of Sludge Production

SRT is inversely related to F/M ratio. A higher operational SRT represents a low F/M ratio, a condition of limiting substrate. Bacteria undergo endogenous respiration or decay under a limiting substrate environment. More biomass undergoes endogenous respiration, resulting in less net bacterial growth. Therefore, excess sludge production is reduced as a system is operated at high SRT. Further, since the settling characteristic of sludge improves at high SRT, concentrated underflow can be withdrawn from the secondary sedimentation tank. This also results in reduction in volume of excess sludge as for a fixed mass of excess sludge.

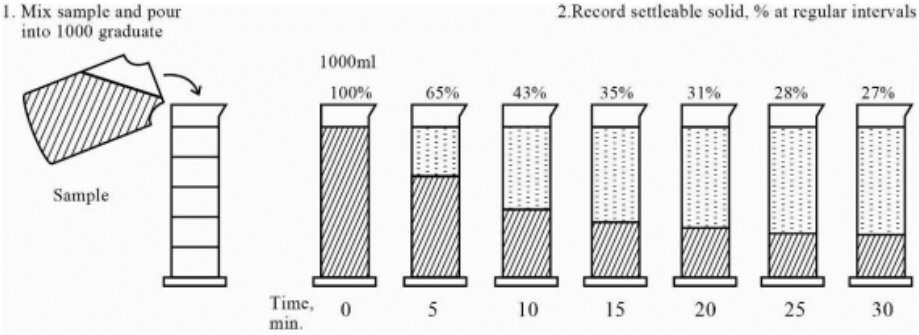
Excess Sludge Wasting

Excess bio-sludge is commonly wasted from return sludge line. It can also be wastes directly from aeration tank. If excess bio-sludge is directly wasted from aeration tank, then increased volume of sludge is a disadvantage. However, if excess bio-sludge is mixed with influent of primary settling tank and wasted as mixed sludge of primary settling tank, then direct wasting from aeration tank has no influence on final volume of sludge and therefore, can easily be adopted. The operator of a plant needs to have an idea of actual volume of excess sludge wasting required.

Return Sludge Flow

Sufficient return sludge capacity should be provided if the biological solids are not to be lost in the effluent. However, a return flow rate higher than that is required unnecessarily increases solids loading on settling tank and results in withdrawal of dilute sludge. The ratio of return sludge flow to average flow can be set on the basis of sludge volume index (SVI). SVI is defined as the volume in mL occupied by one gram of activated sludge mixed liquor solids, dry weight, after settling of 30 min. in a 1,000 mL graduated cylinder. The procedure of SVI measurement is as follows (as shown in Figure).

- ✓ Collect a sample of mixed liquor or return sludge.
- ✓ Carefully mix sample and pour into 1,000 mL graduate cylinder. Vigorous shaking or mixing tends to break up floc and produces slower setting or poorer separation.
- ✓ Record settleable solids percentage at regular intervals.

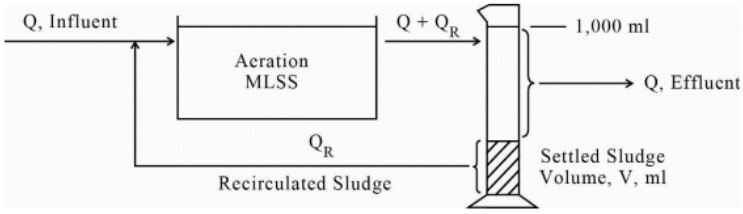


$$\text{SVI (ml/g)} = \frac{\text{Sludge in settled mixed liquor in 30 min(ml / L)}}{\text{Suspended matter in mixed liquor (mg / L)}} \times \frac{1{,}000\ \text{mg}}{1\text{g}}$$

Table below provides SVI values and probable indication of settling properties of activated sludge.

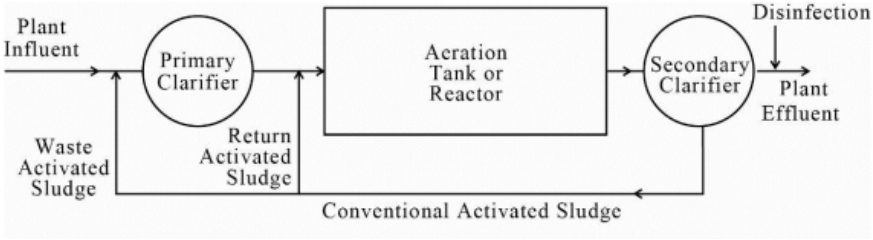
SVI	Indication
Less than 50 ml/g	Pin floc potential
50 to 100 ml/g	Good range
100 to 150 ml/g	Filament growth
150 to 200 ml/g	Bulking at high flows
200 to 300 ml/g	Bulking
More than 300 ml/g	Severe bulking

Quantity of return sludge flow is keyed to settled sludge volume. The ratio of recirculated sludge flows to the settled sludge volume. V30 should be equal to the flow entering the clarifier to the clarifier volume (Figure below).



Conventional Activated Sludge Process

The conventional activated sludge process typically consists of a concrete biological reactor followed by a concrete clarifier. Sewage and return activated sludge (RAS) enter together at one end of the reactor and leave mixed at the other end. This mixed liquor flows into the clarifier where it is allowed to settle and the treated effluent separates from the activated sludge. The effluent from the process flows over the clarifier weirs while the settled activated sludge is either recycled to the reactor or wasted out of the system. (Figure below)



Start Up

Start-up help should be available from the design engineer, vendors, nearby operators, or other specialists. The equipment manufacturers or contractor should be under contractor start-up instruction and assistance. During start-up, they should be present to be sure that any equipment breakdowns are not caused by improper start-up procedures.

The operator may have several options in the choice of start-up procedures with regard to number of tanks used and procedures to establish a suitable working culture in the aeration tanks. The method described in this section is recommended because it provides the longest possible aeration time, reduces chances of solids washout, and

provides the opportunity to use most of the equipment for a good test of its acceptability and workability before the end of the warranty.

First, start the air blowers and have air passing through the diffusers before primary effluent is admitted to the aeration tanks. This prevents diffuser clogging from material in the primary effluent and is particularly important if fine bubble diffusers are used.

Fill both aeration tanks to the normal operating water depth, thus allowing the aeration equipment to operate at maximum efficiency. Using all of the aeration tanks will provide the longest possible aeration time. The operators are trying to build up a micro organism population with a minimum amount of seed organisms, and you will need all the aeration capacity available to give the organisms a chance to reach the settling stage.

After a biological culture of aerobes is established in the aeration tanks, sufficient oxygen must be supplied to the aeration tank to overcome the following demands:

- ✓ DO usually is low in both influent sewage and return sludge to the aerator.
- ✓ Influent sewage may be septic, thus creating an immediate oxygen demand.
- ✓ Organisms in the presence of sufficient food create a high demand for oxygen.

The effluent end of the aerator should have a dissolved oxygen level of at least 1.0 mg/L. DO in the aerator should be checked every two hours until a pattern is established. Thereafter, DO should be checked as frequently as needed to maintain the desired DO level and2770 to maintain aerobic conditions in the aerator. Daily flow variations will create different oxygen demands. Until these patterns are established, you will not know whether just enough or too much air is being delivered to the aeration tanks. Frequently, excess air is provided during early mornings when the inflow waste load is low. Air supply may be too low during the afternoon and evening hours because the waste load tends to increase during the day.

If sewage enters the tank before air is coming out of the diffusers, the diffusers could become plugged. If the plant is the diffused-air type with air lift pumps for return sludge, the air line valve to the air lifts (pumps) will have to be closed until the settling compartment is filled. Otherwise, all the air will attempt to go to the empty compartment and no air will go to the diffusers. Once the settling compartment is filled from the overflow from the aeration tank, the air lift valves may be opened. They will have to be adjusted to return a constant stream of water and solids to the aeration tank. This adjustment is usually two to three turns open on the air valve to each air lift.

There may be a build-up of foam in the aeration compartment during the first week or so of start-up. A 25-mm water hose with a lawn sprinkler may be used to keep it under control until sufficient mixed liquor solids are obtained.

Try to build up the solids or mixed liquor suspended solids (MLSS) as quickly as possible during start-up. This can be achieved by not wasting sludge until the desired level of MLSS is achieved.

Routine Operation and Maintenance

Aeration Tanks

The operational variables in an activated sludge plant include:

- ✓ Rate of flow of sewage,
- ✓ Air supply
- ✓ MLSS,2795
- ✓ Aeration period,
- ✓ DO in aeration and settling tanks, and
- ✓ Rate of sludge return and sludge condition.

The operator should possess a thorough knowledge of the type of system adopted, namely, conventional, high rate, extended aeration or contact stabilisation so that effective control of the variables can be exercised to achieve the desired efficiency of the plant.

Inspection of mechanical aerators should be done for:

- ✓ Bearings,
- ✓ Bushes, and
- ✓ Transmission gears

and they should be lubricated as per the schedule suggested by the manufactures.

The whole unit should be thoroughly inspected once a year, including replacement of worn out parts and painting with anti-corrosive paints to achieve the desired efficiency of the plant. A record of operations should be maintained. When inhibitory substance for activated sludge (such as industrial sewage) is contained in influent, treatment in reactors may be affected. To avoid such an inhibition, colour and odour of plant influent should be checked through daily inspections such as at the grit chambers or the primary sedimentation tanks where sewage flows in at first. If any abnormal condition is observed, report to a person in charge of water quality or the plant manager.

Sewage Flow

Since the activated sludge treatment is biochemical in nature, conditions in the aeration tank should be maintained uniform at all times. A sudden increase in the rate of flow or sludge of flow should be avoided. If supernatants from digester containing more than 3,000 mg/L of SS are taken into the settling tank, then they should be pre-treated as otherwise heavy load will be imposed on the activated sludge system. Measurement of sewage flow and the BOD applied to2820 the aeration tank should be made.

Air Supply

Frequent checks of DO at various points in the tank and at the outlet end should be made; it should not be less than 1 mg/L. It will help in determining the adequacy of the air supply. The uniformity of air distribution can be easily checked by observing bubbling of the air at the surface, which should be even over the entire surface area of

the tank. If the bubbling looks uneven, clogging of diffusers is indicated. Clogging is also confirmed by the increase of 0.1 to 0.15 kg/cm2 in the pressure gauge reading. Adding chlorine gas to air may help in removing clogging of diffusers on air side if it is due to organic matter. Other methods of cleaning will have to be resorted to if this procedure does not clear up the clogging. Air flow meters should be checked periodically for accuracy; air supply and air pressures should be recorded hourly and daily, respectively, to avoid over-aeration or under-aeration. Mechanical or surface aerators should be kept free from fungus or algae growths by cleaning them periodically.

Mixed Liquor Suspended Solids

Control of the concentration of solids in the mixed liquor of the aeration tanks is an important2835 operating factor. It is most desirable to hold the MLSS constant at the suggested concentration. The test of MLSS should be done at least once a day on large plants, preferably during peak flow. As the MLSS will be minimum when the peak flow starts coming in and will be maximum in the night hours when the flow drops, operating MLSS value would be the average hourly value in a day; the same should be verified at least once a month. In case of very large plants, regular daily check is desirable.

Return Sludge

The return sludge pumps provided in multiple units should be operated according to the increase or decrease in return sludge rate of flow required to maintain the necessary MLSS in aeration unit, based on the SVI. The SVI should be determined daily to know the condition of sludge. A value of over 200 definitely indicates sludge bulking. A good operation calls for prompt removal of excess sludge from the secondary tanks to ensure that the sludge is fully aerobic. This should be measured daily and recorded. The excess sludge is taken to the digester directly or through the primary settling tank.

Foaming

Foaming or frothing is sometimes encountered in activated sludge plants when the sewage contains materials which reduce the surface tension, the synthetic detergents being the major offender. Froth, besides being unsightly, is easily blown away by wind and contaminates all the surfaces it comes into contact with. It is a hazard to workmen because it creates a slippery surface even after it collapses. Foam problems can be overcome by the application of a spray of screened effluent or clear water, increasing MLSS concentration, decreasing air supply or addition of other special anti-foam agents. The presence of synthetic anionic detergents in sewage also interferes with the oxygen transfer and reduces aeration efficiency.

Microscopic Examination

Routine microscopic examination of solids in aeration tank and return sludge to identify the biological flora and fauna present will enable good biological control of the aeration tanks.

Records

Activated sludge operation should include recording of flow rates of sewage and return sludge, DO, MLSS, MLVSS, biota, SRT (sludge age), air, BOD, COD and nitrates in both influent and effluent.

Biological Uptake Rate Procedure

After deaerating the sample of at least 250 ml of mixed liquor with sodium meta bi sulphite start the diffuser and record the dissolved oxygen with time by a dissolved oxygen probe and plot the saturation deficit with time in semi log paper. The slope of the graph is the uptake rate. Generally this is not for a plant control test. It is used for alpha value by comparing it with the value for tap water.

Air Blowers

The blower system is designed to provide sufficient airflow to meet the system process requirements. Blower systems are available with either positive displacement (PD) or centrifugal type units. Typically, PD units are used for plants with smaller air volume requirements. Output airflow from a PD blower remains relatively constant with varying discharge pressure. Centrifugal blower systems are generally equipped with additional controls to regulate the flow as the discharge pressure varies.

a- Positive Displacement Blowers: The positive displacement blower provides a constant volume (cubic meters) output of air per revolution for a specific set of rotors or lobes. Blower output is varied by changing rotor or lobe speed (RPMs or revolutions per minute). The higher the RPM, the greater is the air output. Small positive displacement blowers ranging from 3 to 28 m3/min. are usually installed to be operated at a fixed volume output. These smaller units are directly driven by electric motors through a direct coupling or through sheaves and belts. If a change in air volume output is required, it is accomplished by changing the motor to one with a higher or lower RPM or by changing sheaves to increase or decrease blower rotor or lobe rotation (RPM), thus increasing or decreasing air output.

Large positive displacement blowers ranging from 57 to 570 m3 /min. may also be driven by internal combustion engines or variable speed electric motors in order to change blower volume outputs as required in activated sludge plants. By increasing or decreasing engine or motor RPM, the positive displacement blower output can be increased or decreased. The air lines are connected to the blower through a flexible coupling in order to keep vibration to a minimum and to allow for heat expansion. When air is compressed, heat is generated; thus increasing the discharge temperature as much as 56 °C or more.

A check valve follows next, which prevents the blower from operating in reverse should other blowers in the same system be operating while this blower is off.

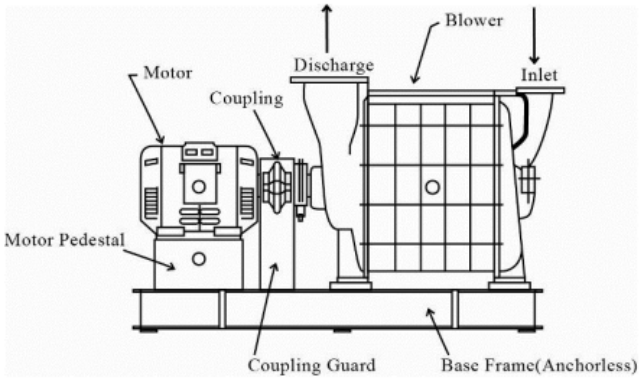
The discharge line from the blower is equipped with an air relief valve which protects the blower from excessive back pressure and overload. Air relief valves are adjusted by weights or springs to open when air pressure exceeds a point above normal operating range, around 0.4 to 0.7 kg/cm2 in most sewage treatment plants. An air discharge silencer is also installed to provide decibel noise reduction. Ear protective devices should be worn when working near noisy blowers.

The impellers are machined on all exterior surfaces for operating at close tolerances; they are statically and dynamically balanced. Impeller shafts are made of machined steel and are securely fastened to the impellers. Timing gears accurately position the impellers.

Lubrication to the gears and bearings is maintained by a lube oil pump driven from one of the impeller shafts. An oil pressure gauge monitors the system oil pressure. An oil filter is located in the oil sump to ensure that the oil is free from foreign materials.

An oil level is maintained in the gear housing so that gears and bearings will received splash lubrication in case of lube oil pump failure. Air vents are located between the seals and the impeller chamber to relieve excessive pressure on the seals.

b- Centrifugal Blowers: The centrifugal blower is a motor connected to a speed-increasing gear-driven blower (Figure 4.9) that provides a variable air output. Minimum through maximum air output is controlled by guide vanes, which are located on the intake side of the blower. These vanes may be positioned manually by operating personnel or may be controlled by plant instrumentation based on either DO levels in the aeration tanks or the plant influent flows.



The blower consists of an impeller, volute casing, shaft and bearings, speed-increasing gear box and an electric motor or internal combustion engine to drive unit. Air enters the volute casing through an inlet nozzle and is picked up by the whirling vanes of the impeller where it is hurled by centrifugal force into the volute casing. Air enters the volute in its smallest section and moves in a circular motion to the largest section of the volute where it is discharged through the discharge nozzle.

Air lines are connected to the blower through flexible couplings in order to keep variation to a minimum and to allow for heat expansion. The air suction line is usually equipped with a manually operated butterfly valves are usually electrically or pneumatically operated. The impeller is machined on all surfaces for operating at close tolerances and is statically and dynamically balanced.

The impeller shaft is supported in a shaft bearing stand which contains a thrust bearing and journal bearings.

Lubrication to the bearings and gears is maintained by a positive displacement main oil pump that is driven by the speed-increasing gear unit. An auxiliary electrically operated centrifugal oil pump is also used to provide oil pressure in the event of failure of the main oil pump and to lubricate the blower shaft bearings before start-up and after shutdown. The oil reservoir is located in the blower base plate. Cartridge type or disc-and–space type oil filter is based on the degree of filtration required. Due to the very high speeds at which these blower units operate and the resultant high oil temperature, an oil cooler unit is installed. This unit, in most cases, is a shell and tube, oil-to water heat exchanger.

c- Air Filters: Filters remove dust and dirt from air before it is compressed and sent to the various plant processes. Clean air is essential for the protection of blowers and downstream equipment

- ✓ Large objects entering the impellers or lobes may cause severe damage on blowers.

- ✓ Deposits on the impellers or lobes reduce clearances and cause excessive wear and vibration problems on blowers.
- ✓ Clean air prevents fouling of air conduits, pipes, tubing or dispersing devices on diffusers. The filters may be constructed of a fibre mesh or metal mesh material that is sandwiched between the screen material and encased in a frame. The filter frames are then installed in a filter chamber. Other types of filters include bags, oil-coated travelling screens and electrostatic precipitators.

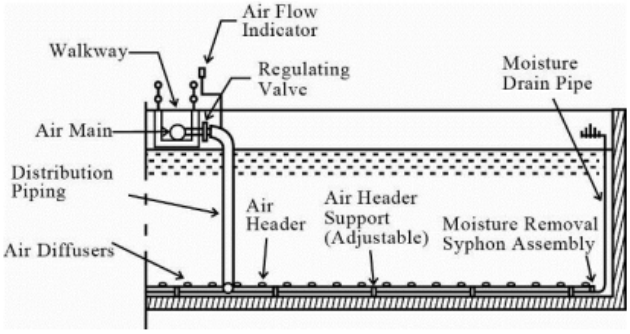
The preventive maintenance schedule for the blowers is as follows:

- ✓ Weekly
  - o Maintain proper lubricant level
- ✓ Quarterly
  - o Check for abnormal noises and vibration
  - o Check if air filters are in place and not clogged2970
  - o Check motor bearing for rise in temperature
  - o Check that all covers are in place and secure
  - o Lubricate motor ball bearings
  - o Check that electrical connections are tight
  - o Check wiring integrity
- ✓ Biannually
  - o Lubricate motor sleeve bearing
  - o Inspect and clean rotor ends, windings and blades
  - o Check that electrical connections are tight and corrosion is absent
- ✓ Annually
  - o Check bearing oil

Air Distribution

The air distribution system (Figure) is to deliver air from the blowers to air headers in the aeration tanks and other plant processes and consists of:

- ✓ Pipes,
- ✓ Valves, and
- ✓ Metering devices



An air metering device should be located in a straight section of the air main on the discharge side of the blower.

Air headers are located in or along the aeration tank and are connected to the air distribution system from which they supply air to the diffusers. The two most common types of air headers are the swing header and the fixed header.

The swing header is a pipe with a distribution system connector fitting, a valve, a double pivot upper swing joint, upper and lower riser pipes, pivot elbow, levelling tee and horizontal air headers. An air blow off leg, as an extension of the lower tee connection, is fabricated with multiple alignment flanges, gaskets, and jack screws for levelling of the header.

The fixed header is a pipe with a distribution system connector fitting, a valve, union, a riser pipe, horizontal air headers and header support "feet." These headers are generally not provided with adjustable levelling devices; they rely on the fixed levelling afforded by the "feet" attached to the bottom of the horizontal air headers. Raising and lowering the air header is commonly found in package plants, channel aeration and grit chamber aeration. Header valves are used to adjust the air flow to the header assembly and to block the air flow to the assembly when servicing the header or diffusers.

Diffusers

An air diffuser or membrane diffuser is an aeration device used to transfer air and oxygen with oxygen into sewage. Oxygen is required by microorganisms/ bacteria resident in the water to break down the pollutants. Diffusers use the followings to produce fine or coarse bubbles.

- ✓ Rubber membrane, or
- ✓ Ceramic elements.

The shapes of the diffusers can be:

- ✓ Disc,
- ✓ Tube, or
- ✓ Plate.

a- Bubble size

The subject of bubble size is important because the aeration system in a sewage treatment plant consumes an average of 50 to 70 per cent of the energy of the entire plant. Increasing the oxygen transfer efficiency decreases the power the plant requires to provide the same quality of effluent water.

- ✓ Fine bubble
  - o Fine bubble diffusers produce a plethora of very small air bubbles which rise slowly from the floor of tank and provide substantial and efficient mass transfer of oxygen to the water.
  - o Fine bubble diffusers evenly spread out (often referred to as a "grid3025 arrangement") on the floor of a tank and provide the operator of the plant a great deal of operational flexibility.
  - o This can be used to create zones with high oxygen concentrations (oxic or aerobic), zones with minimal oxygen concentration (anaerobic) and zones with no oxygen (anoxic). This allows for more precise targeting and removal of3030 specific contaminants.
- ✓ Coarse bubble
  - o There are different types of coarse bubble diffusers from various manufactures, such as the stainless steel wide band type coarse bubble diffuser.

- Fine bubble diffusers have largely replaced coarse bubble diffusers and mechanical aerators in most of the developed world and in much of the developing world.

b- Maintenance The preventive maintenance schedule of bubble diffusers is as follows:

- ✓ Daily maintenance
  - Check biological reactor surface pattern.
  - Check air mains for leaks.
  - Check and record operating pressure and airflow.
- ✓ Weekly maintenance
  - Purge water and moisture from distribution piping.
  - Bump diffuser system.
- ✓ Annual maintenance
  - Drain biological reactor.
  - Remove excess solids that may accumulate in the reactor.
  - Clean diffusers.
  - Check that retaining rings are in place and are tight.
  - Check that fixed and expansion joint retaining rings are tight.

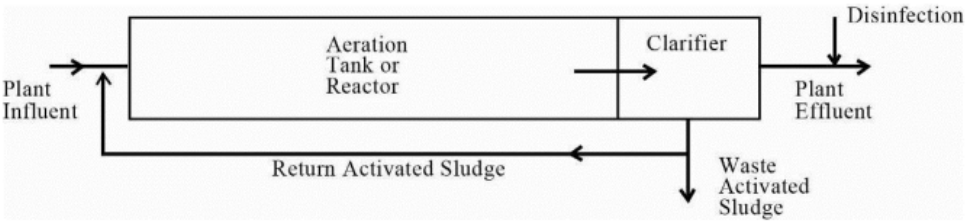
Surface Aerators

A surface aerator is a mechanical aeration device for various types of aerobic sewage treatment systems. Surface aerators may be either stationary or floating. The major components of the mechanical surface aerators are motor, gear box and impeller/ aerator/ propeller. More commonly, these components come combined; but for the purpose of maintenance, they can be easily separated.

Floating aerators generally employ reinforced fibreglass foam filled pontoons connected to the aerator platform by a triangular tubular structural frame. The platforms are sized to provide adequate work area around the drive. Pontoons are placed to minimise any interference with the flow pattern and maximise stability. Each of the pontoons has a ballast compartment which can be filled with water or other liquid or other suitable material to adjust submergence and level the unit. 3065

Extended Aeration Process

This is a modification of the activated-sludge process using long aeration periods to promote aerobic digestion of the biological mass by endogenous respiration (Figure). The process includes stabilization of organic matter under aerobic conditions and disposal of the gaseous end products into the air. Effluent contains finely divided suspended matter and soluble matter. Extended aeration is similar to a conventional activated sludge process except that the organisms are retained in the aeration tank longer and do not get as much food. The organisms get less food because there are more of them to feed. Mixed liquor suspended solids (MLSS) concentrations are from 3000 to 5000 mg/L and F/M ratio is 0.1 to 0.18. In addition to the organisms consuming the incoming food, they also consume any stored food in the dead organisms. The new products are carbon dioxide, water, and a biologically inert residue. Extended aeration does not produce as much waste sludge as other processes; however, wasting still is necessary to maintain proper control of the process.



Operation of Aeration Equipment

Aeration equipment should be operated continuously. In a diffused-air system, the operator controls air flow to the diffuser with the header control valve. This valve forces excess air to the air lifts in the settling compartment. Good treatment rarely results from interrupted operation and should not be attempted. The operator can judge how well the aeration equipment is working by the appearance of the water in the settling compartment and the effluent that goes over the weir. If the water is murky or cloudy and the aeration compartment has a rotten egg (H2S) odour, not enough air is being supplied. The air supplied or aeration rate should be increased slightly each day until the water is clear in the settling compartment. If the water is clear in the settling compartment, the aeration rate is probably sufficient. Try to maintain a DO level of around 2 mg/L throughout the aeration tank, if the operator has a DO probe or lab equipment to measure the DO. Try to measure the DO at different locations in the aeration tank as well as from top to bottom.

Operation and Maintenance

Two methods are commonly used to supply oxygen from the air to the bacteria-mechanical aeration and diffused aeration. Both methods are mechanical processes with the difference being3095 whether the mechanisms are at or in the aerator or at a remote location. Mechanical aeration devices agitate the water surface in the aerator to cause spray and waves by paddle wheels mixers, rotating brushes or some other method of splashing water into the air or air into the water so that oxygen can be absorbed. Mechanical aerators in the tank tend to be lower in installation and maintenance costs. Usually, they are more versatile in terms of mixing, production of surface area of bubbles, and oxygen transfer per unit of applied power. Diffused air systems use a device called a diffuser to break up the air stream from the blower system into fine bubbles in the mixed liquor. The smaller the bubble, the greater is the oxygen transfer due to the greater surface area of rising air bubbles surrounded by water. Unfortunately, fine bubbles will tend to regroup into larger bubbles while rising unless they are broken up by suitable mixing energy and turbulence.

Record the pumping time and weekly waste solids for this time period if results are satisfactory. If the extended activated sludge plant does not have an aerobic digester, applying waste activated sludge to drying beds may cause odour problems. If odours from waste activated sludge drying beds are a problem, consider the following solutions:

- ✓ Waste the excess activated sludge into an aerated holding tank. This tank can be pumped out and the sludge disposed of in an approved sanitary landfill. If aerated long enough, the sludge could be applied to drying beds.

- ✓ The excess or waste activated sludge can be removed by a septic tank pumper and disposed of in an approved sanitary landfill.
- ✓ Arrange for disposal of the excess activated sludge at a nearby treatment plant. Annually, check the bottom of the hoppers for rocks, sticks, and grit deposits. Also, check the tail pieces of the air lifts to be sure that they are clear of rags and rubber goods and in proper working condition.

Frequency and amount of wasting may be revised after several months of operation by examining:

- ✓ The amount of carryover of solids in the effluent
- ✓ The depth to which the solids settle in the aeration compartment when the aeration device is off (should be greater than one-third of the distance from top to bottom)
- ✓ The appearance of floc and foam in the aeration compartment as to colour, settleability, foam makeup, and excess solids on the water surface of the tank
- ✓ Results of laboratory testing; a white fluffy foam indicates low solids content in the aerator while a brown, leathery foam suggests high solids concentrations. If the operator notices high effluent solids levels at the same time each day, the solids loading may be too great for the final clarifier. Excessive solids indicate the mixed liquor suspended solids concentration is too high for the flows and more solids should be wasted.

Normal Operation

Extended activated sludge plants should be visually checked every day. Each visit should include the following:

- ✓ Check the appearance of the aeration and final clarification compartments.
- ✓ Check the aeration unit for proper operation and lubrication.
- ✓ Check the return sludge line for proper operation. If air in the air lift is not flowing properly, briefly close the outlet valve, which forces the air to go down and out the tail piece. This will blow it out and clear any obstructions. Reopen the discharge valve and adjust to desired return sludge flow.
- ✓ Check the comminuting device for lubrication and operation.
- ✓ Hose down the aeration tank and final compartment.
- ✓ Brush the weirs when necessary.
- ✓ Skim off grease and other floating material such as plastic and rubber goods.
- ✓ Check the plant discharge for proper appearances, grease, or material of sewage origin that is not desirable.

Abnormal Operation

Remember that changing conditions or abnormal conditions can upset the microorganisms in the aeration tank. As the temperature changes from season to season, the activity of the organisms speeds up or slows down. Also, the flows and waste (food as measured by BOD and suspended solids) in the plant influent change seasonally. All of these factors require the operator to gradually adjust aeration rates,

return sludge rates, and wasting rates. Abnormal conditions may consist of high flows or solids concentrations as a result of storms or weekend loads.

Countermeasures

Extended aeration plant problems may be caused by solids in the effluent, odours, and foaming. These problems could be caused by under-or- over aeration, too little or too much solids in the aeration tank, improper return sludge rate, improper sludge wasting or disposal of waste activated sludge, and abnormal influent conditions such as excessive flows or solids or toxic wastes. When problems develop in the activated sludge process, try to identify the problem, the cause of the problem, and select the best possible solution. Remember that the activated sludge process is a biological process and may require from three days to a week or longer to show any response to the proper corrective action. Allow seven or more days for the process to stabilize after making a change in the treatment process.

a- Solids in the Effluent
- ✓ If effluent appears turbid (muddy or cloudy), the return activated sludge pumping rate is out of balance. Try increasing the return sludge rate. Also, consider the possible presence of something toxic to the microorganisms or a hydraulic overload washing out some of the solids.
- ✓ If the activated sludge is not settling in the clarifier (sludge bulking), several possible factors could be causing this problem. Look for too low a solids level in the system, low dissolved oxygen concentrations in the aeration tank, strong, stale, septic influent, high grease levels in influent, or alkaline wastes from a laundry.
- ✓ If the solids level is too high in the sludge compartment of the secondary clarifier, solids will appear in the effluent. Try increasing the return sludge pumping rate. If odours are present and the aeration tank mixed liquor appears black as compared with the usual brown colour, try increasing aeration rates and look for septic dead spots.
- ✓ If light-coloured floating sludge solids are observed on the clarifier surface, try reducing the aeration rates. Try to maintain the dissolved oxygen at around 2 mg/L throughout the entire aeration tank.

b- Odours
- ✓ If the effluent is turbid and the aeration tank mixed liquor appears black as compared with the usual brown colour, try increasing aeration rates and look for septic dead spots.
- ✓ If clumps of black solids appear on the clarifier surface, try increasing the return sludge rate. Also, be sure the sludge return line is not plugged and that there are no septic dead spots around the edges or elsewhere in the clarifier.
- ✓ Examine the method of wasting and disposing of waste activated sludge to ensure this is not the source of the odours.
- ✓ Poor housekeeping could result in odours. Do not allow solids to accumulate or debris removed from sewage to sit around the plant in open containers.

c- Foaming/Frothing

Foaming is usually caused by too low a solids level while frothing is caused by too long a solids retention time.

- ✓ If too much activated sludge was wasted, reduce wasting rate.
- ✓ If over aeration caused excessive foaming, reduce aeration rates.
- ✓ If plant is recovering from overload or septic conditions, allow time for recovery.
- ✓ Foaming can be controlled by water sprays or commercially available defoaming agents until the cause is corrected by reducing or stopping wasting and building up solids levels in the aeration tank.
- ✓ Learn more about the operation of an activated sludge process under both normal and abnormal conditions. There operator will also find a troubleshooting guide for activated sludge plants.

Maintenance

Maintenance of equipment in extended aeration plants should follow the manufacturer's instructions. Items requiring attention include:

a- Plant Cleanliness

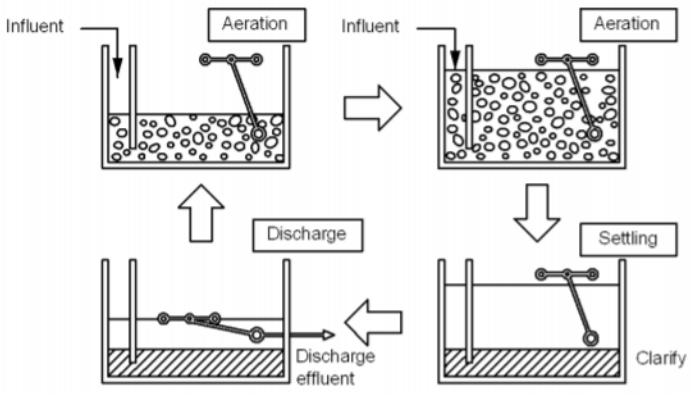
Wash down tank walls, weirs, and channels to reduce the collection of odour-causing materials.

b- Aeration Equipment:
- ✓ Air blowers and air diffusion units
- ✓ Mechanical aerators

c- Air Lift Pumps
d- Scum Skimmer
e- Sludge Scrapers
f- Froth Spray System
g- Weirs, Gates, and Valves
h- Raw Sewage Pumps

Sequencing Batch Reactor (SBR)

In SBR operations, the cycle processes Fill-react, React, Settle and Decant are controlled by time to achieve the objectives of the operation. Each process is associated with particular reactor conditions (turbulent/ quiescent, aerobic /anaerobic) that promote selected changes in the chemical and physical nature of the sewage. These changes lead ultimately to a fully treated effluent. Figure shows a typical SBR operation.



- ✓ Fill or Fill-react

The purpose of Fill-React operation is to add substrate (raw sewage) to the reactor. The addition of substrate can be controlled either by limit switches to a set volume or by a timer to a set time period. If the volume is set, the Fill-React process typically allows the liquid levels in the reactor to rise from 50-80 per cent to 100 per cent. If controlled by time, the Fill-React process normally lasts approximately 25 per cent to 50 per cent of the full cycle time. Period of aeration and/or mixing during Fill are critical to the development of organisms with good settling characteristics and to biological nutrient removal (Nitrogen (N), Phosphorus (P)). An advantage of the SBR system of time control is its ability to modify the reactor conditions during the phases to achieve the treatment goals. This phase ends when the liquid level in the tank reaches a predetermined level.

- ✓ Settle

The purpose of SETTLE is to allow solids separation to occur, providing a clarified supernatant to be discharged as effluent. In the SBR, this process is normally more efficient than in a continuous flow system, because in the Settle mode the reactor contents are completely quiescent. The Settle process is controlled by time and is usually fixed between 30 minutes to an hour so that the sludge blanket remains below the withdrawal mechanism during the next phase.

- ✓ Decant/Discharge

The purpose of the decantation is to remove the clarified, treated water from the reactor. Sludge wasting is another important step in SBR operation that greatly affects process performance. It is not included as one of the three basin processes because there is no set time period within the cycle dedicated to wasting. The amount and frequency of sludge wasting is determined by process requirements, as with conventional continuous flow systems. In an SBR operation, sludge wasting usually occurs during the Settle or Decant phases. A unique feature of the SBR system is that there is no need for a RAS system. Since the aeration and settling occurs in the same tank, no sludge is lost in the reaction phase and none has to be returned from clarifier to maintain the sludge content in the aeration tank. This eliminates the need for the hardware and controls associated with the conventional RAS system. The sludge volume and, thus, sludge age in the reactor of the SBR system is controlled by sludge wasting only. The manual given by the equipment supplier should be followed. Usually these units are controlled automatically by programmable logic controllers (PLCs). The precaution needed is to make sure that power supply is available continuously. If power supply fails, immediately bring the genset on-line. If there is no genset or if there is no diesel, do not operate the SBR and close it. Inform the plant in charge and also report to the. official responsible for overall O&M in the head office directly.

Process Control

The SBR has in built process control. Depending on the BOD load, it adjusts the Dissolved Oxygen (DO) supply by sensing the residual DO and varying the speed of air compressor and hence the rate of air supply. The most important thing for day to day

testing is to understand the SBR as designed. It may have fully aerobic or anoxic and aerobic or anaerobic, anoxic and aerobic.

If anaerobic cycle is there, check whether the floor level mixer is working and if it is out of order, start the installed standby mixer. If both are not in order, enter in the site register and inform the plant in charge. Make sure that hydrogen sulphide gas is not sensed in the ambient air near the SBR. If it is sensed by smell, then going near the tank is not advisable. Make sure it is entered in the site register and it is reported directly to the plant in charge. The operator should not try and remedy the position. The supervisor should institute and take steps to get the designer, contractor and O&M team together and rectify the situation. There is a theory that COD to sulphate ratio is deciding the process. This needs to be checked up and corrected. A method of correcting the imbalance will be to recycle the treated effluent from a treated sewage sump to dilute the COD of incoming sewage. The daily tests shall be pH, COD and dissolved phosphate measured by colorimetric method or Nessler Tubes of 50 ml with fresh standards prepared every week. BOD can be a weekly test.

In the anoxic cycle, check whether the floor level mixer is working and if it is out of order, start the installed standby mixer. If both are not in order, enter it in the site register and inform the. plant in charge. Daily tests will be nitrate estimated by Nesslerization procedure in 50 ml Nessler tubes. The test is to be done in the beginning, in the mid cycle and at the completion of the cycle of anoxic phase. If there is no reduction in the nitrate, then something is not in order. Proceed to check the MLVSS. It should be at least 75 %. If this is not so, enter the value in the site register and inform the plant in charge. The supervisor should institute and take steps to get the designer, contractor and O&M team together and rectify the situation.

In the aeration cycle, check the residual DO. This is to be indicated by the built in sensor. If the sensor is not working use the Winkler method by collecting the mixed liquor and filtering it through Whatman filter paper number 4 in a BOD bottle and with the tip of the funnel connected by a rubber tubing so that the filtrate enters the BOD bottle in the submerged condition always and avoids additional aeration. A procedure for easy use in the field for instantly testing the BOD is to use a “BOD tube”. This has been introduced in the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) by M/S Severn Trent of UK as part of a twinning arrangement. Details of the tube can be obtained from CMWSSB. A photograph of the CMWSSB chemist using the tube is shown in Figure 4.13.

The principle of the test is related to the BOD caused by colloidal and suspended organics as relatable to the BOD. The BOD

related to suspended solids is inbuilt in the calibration. This tube is developed only for sewage and not for industrial effluents. The test is performed by holding the tube as in the photo after filling the treated sewage to incremental heights and finding out at which point, the black coloured + mark at the bottom vanishes. There is a reading etched on the side of the tube and this is read at the sewage level when the + mark vanishes from sight. The principle is the colloidal solids and SS have their portion of BOD. The more the volume needed to "hide" the bottom + mark, the less is the colloidal solids and SS and hence, the lesser is the BOD due to this portion. It is a combination of nephelometry and theory. Usually the results are within 90%.

- ✓ The BOD tube

The Palintest Tube is a specially calibrated plastic tube and is the implest possible method of performing the instantaneous probable BOD and SS tests on secondary treated sewage in the field to help the operator to get a feel of these parameters quickly. The test kit is a tube graduated at 30 to 500 turbidity units. A double length tube with additional graduations from 5 to 25 turbidity units is optionally available. These were calibrated by the Department of Public Health Engineering, University of Newcastle upon Tyne. It has an etched black cross mark at bottom

- ✓ Procedure
    - Hold the tube vertically over a white surface and view downwards.
    - Gradually pour secondary sewage and watch the cross mark
    - Stop pouring when the cross mark is no longer visible
    - Read the graduation at the top of the sample in the tube.
    - This represents the turbidity in Jackson Turbidity units (JTU).
    - For secondary sewage, the graduation may also be taken as SS – Half the value of JTU plus 5 is also the probable BOD

If the DO is lesser than 20 % of the design value, enter it in the site register and inform the plant in charge. Check the MLVSS if the above situation occurs. This can be a weekly test. Check the COD.

In the settling cycle, check the SS of the decanted effluent and its COD. There is no need to check the BOD at the end of every cycle. Prepare a curve of BOD to COD for the treated sewage and verify the BOD by testing for the COD. This will show the trend every two hours itself instead of 3 days for BOD actual test. This can however be a weekly test. If the SS and BOD varies by more than 10 % in the treated sewage, enter the values in the site register and inform the plant in charge. The decanter cannot be subjected to preventive maintenance in a functioning SBR. The raw sewage has to be bypassed with prior permission of the supervisor before this is carried out. The electrical drive of the decanter will require its greasing in some equipment. Make sure there is a grease guard and grease does not fall into the SBR basin. Where the rope and pulley method is used, change the rope every month.

Records

The limited parameters as above and the flow rate and cycle times are the records.

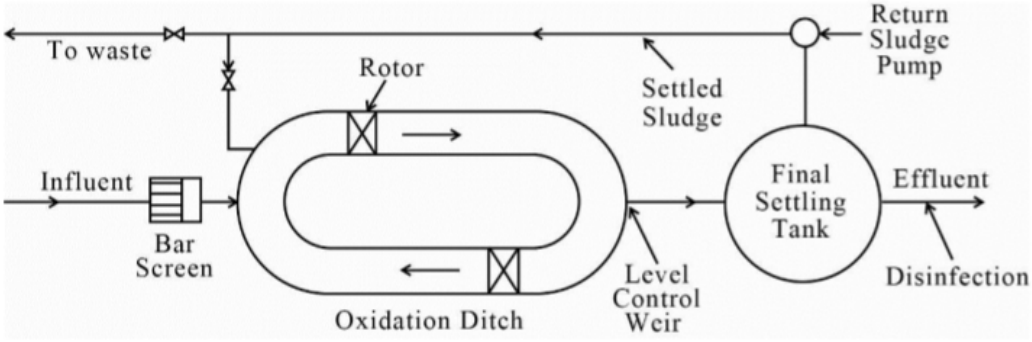
Housekeeping

In all SBR systems, verify build up of slime on the sidewalls in the freeboard. If noticed, scrub it down into the basin itself during the filling phase. This can be done by the operator standing on the peripheral walkway and using a long handle wire brush. If there is no such walkway, leave the slime as it is.

Oxidation Ditch

An oxidation ditch is a modified activated sludge biological treatment process that utilizes long Solids Retention Times (SRTs) to remove biodegradable organics. Oxidation ditches are typically complete mix systems, but they can be modified to approach plug flow conditions. (Note: As conditions approach plug flow, diffused air must be used to provide enough mixing. The system will also no longer operate as an oxidation ditch). Typical oxidation ditch treatment systems consist of a single or multichannel configuration within a ring, oval, or horseshoe-shaped basin. As a result, oxidation ditches are called "racetrack type" reactors. Horizontally or vertically mounted aerators provide circulation and aeration in the ditch.

Preliminary treatment, such as bar screens and grit removal, normally precedes the oxidation ditch. Primary settling prior to an oxidation ditch is sometimes practiced, but is not typical in this design. Flow to the oxidation ditch is aerated and mixed with return sludge from a secondary clarifier. A typical process flow diagram for an activated sludge plant using an oxidation ditch is shown in Figure. There is usually no primary settling tank or grit removal system used in this process. Inorganic solids such as sand, silt, and cinders are captured in the oxidation ditch and removed during sludge wasting or cleaning operations. The raw sewage passes directly through a bar screen to the ditch.



The bar screen is necessary for the protection of the mechanical equipment such as rotor and pumps. Comminutors or barminutors may be installed after the bar screen or instead of a bar screen. The oxidation ditch forms the aeration basin and here the raw sewage is mixed with previously formed active organisms. The rotor is the aeration device that entrains (dissolves) the necessary oxygen into the liquid for microbial life and keeps the contents of the ditch mixed and moving. The velocity of the liquid in the ditch must be maintained to prevent settling of solids, normally 0.3 to 0.45 m/sec. The ends of the ditch are well rounded to prevent eddying and dead areas, and the outside edges of the curves are given erosion protection measures.

The mixed liquor flows from the ditch to a clarifier for separation. The clarified water passes over the effluent weir and is chlorinated. Plant effluent is discharged to either a receiving stream, percolation ditches, or a subsurface disposal or leaching system. The settled sludge is removed from the bottom of the clarifier by a pump and is returned to the ditch or wasted. Scum that floats to the surface of the clarifier is removed and either returned to the oxidation ditch for further treatment or disposed of by burial.

Since the oxidation ditch is operated as a closed system, the amount of volatile suspended solids will gradually increase. It will periodically become necessary to remove some sludge from the process. Wasting of sludge lowers the MLSS (mixed liquor suspended solids) concentration in the ditch and keeps the microorganisms more active.

Operation

Process controls and operation of an oxidation ditch are similar to the activated sludge process. To obtain maximum performance efficiency, the following control methods must be maintained.

a- Proper Food Supply For the Microorganisms

Influent flows and waste characteristics are subject to limited control by the operator. Municipal ordinances may prohibit discharge to the collection system of materials that are damaging to treatment structures or to human safety. Control over wastes dumped into the collection system requires a pre-treatment facility inspection program to ensure compliance. Alternate means of disposal, pre-treatment, or controlled discharge of significantly damaging wastes may be required in order to permit dilution to an acceptable level by the time the waste arrives at the treatment plant.

b- Proper DO Levels

Proper operation of the process depends on the rotor assembly supplying the right amount of oxygen to the waste flow in the ditch. For the best operation, a DO concentration of 0.5 to 2.0 mg/L should be maintained just upstream of the rotors. Over oxygenation wastes power and excessive DO levels can cause a pinpoint floc to form that does not settle and is lost over the weir in the settling tank. Control of rotor oxygenation is achieved by adjusting the ditch outlet level control weir.

The level or elevation of the rotors is fixed but the deeper the rotors sit in the water, the greater the transfer of oxygen from the air to the water (greater DO). The ditch outlet level control weir regulates the level of water in the oxidation ditch.

c- Proper Environment

The oxidation ditch process with its long-term aeration basin is designed to carry MLSS concentrations of 3,000 to 5,000 mg/L. This provides a large organism mass in the system. Performance of the ditch and ditch environment can be evaluated by conducting a few simple tests and general observations. The colour and characteristics of the floc in the ditch as well as the clarity of the effluent should be observed and recorded daily. Typical tests are settleable solids, DO upstream of the rotor, pH, and residual chlorine in the plant effluent.

Laboratory tests such as BOD, COD, suspended solids, volatile solids, total solids, and microscopic examinations should be performed periodically by the plant operator or an outside laboratory. The results will aid operator in determining the actual operating efficiency and performance of the process.

Oxidation ditch solids are controlled by regulating the return sludge rate and waste sludge rate. Remember that solids continue to deteriorate as long as they remain in the clarifier. Adjust the return sludge rate to return the microorganisms in a healthy condition from the final settling tank to the oxidation ditch. If dark solids appear in the settling tank, either the return sludge rate should be increased (solids remaining too long in clarifier) or the DO levels are too low in the oxidation ditch.

Adjusting the waste sludge rate regulates the solids concentration (number of microorganisms) in the oxidation ditch. The appearance of the surface of the oxidation ditch can be a helpful indication of whether the sludge wasting rate should be increased or decreased. If the foam on the surface is white and crisp, reduce the wasting rate. If the foam on the surface is thick and dark, increase the wasting rate. Waste activated sludge may be removed from the ditch by pumping to a sludge holding tank, to sludge drying beds, to sludge lagoons, or to a tank truck. Ultimate disposal may be to larger treatment plants or to approved sanitary landfills.

Remember that this is a biological treatment process and several days may be required before the process, responds to operation changes. Make operator changes slowly, be patient, and observe and record the results.

d- Proper Treatment Time and Flow Velocities

Treatment time is directly related to the flow of sewage and is controlled by an adjustable weir. Velocities in the ditch should be maintained at 0.3 to 0.45 m/sec to prevent the deposition of floc. With this in mind, the ditch contents should travel the complete circuit of the ditch, or from rotor to rotor every 3 to 6 minutes. If the rotors are operated by time clocks (30 minutes off and 30 minutes on, for example), the velocities in the ditch must be sufficient to re-suspend any settled material.

e- Proper Water/Solids Separation

MLSS that have entered and settled in the secondary clarifier are continuously removed from the clarifier as return sludge, by pump, for return to the oxidation ditch. Usually, all sludge formed by the process and settled in the clarifier is returned to the ditch, except when wasting sludge. Scum that is captured on the surface of the clarifier also is removed from the clarifier and either returned to the oxidation ditch for further treatment or disposed of by burial.

f- Observations Some aspects of the operation of an oxidation ditch plant can be controlled and adjusted with the help of some general observations. General daily observations of the plant are important to help operator determine whether or not the oxidation ditch is operating as intended. These observations include colour of the mixed liquor in the ditch, odour at the plant site, and clarity of the ditch and sedimentation tank surfaces.

- ✓ Colour

Operator should note the colour of the mixed liquor in the ditch daily. Mixed liquor from a properly operating oxidation ditch plant should have a medium to rich dark brown colour. If the MLSS, following proper start-up, changes colour from a dark brown to a light brown and the MLSS appears to be thinner than before, the sludge

waste rate may be too high, which may cause the plant to lose efficiency in removing waste materials. By decreasing sludge waste rates before the colour lightens too much, operator can ensure that the plant effluent quality will not deteriorate due to low MLSS concentrations.

If the MLSS becomes black, the ditch is not receiving enough oxygen and has gone anaerobic. The oxygen output of the rotors must be increased to eliminate the black colour and return the process to normal aerobic operation. This is done by increasing the submergence level of the rotor.

- ✓ Odour

When the oxidation ditch plant is operating properly, there will be little or no odour. Odour, if detected, should have an earthy smell. If an odour other than this is present, operator should check and determine the cause. Odour similar to rotten eggs indicates that the ditch may be going anaerobic, requiring more oxygen or a higher ditch velocity to prevent deposition of solids. The colour of the MLSS could be black if this were the case. Odour may also be a sign of poor housekeeping. Grease and solids build-up on the edge of the ditch or sedimentation tank will go anaerobic and cause odours. In an oxidation ditch, odours are much more often caused by poor housekeeping than by poor operation.

- ✓ Clarity

In a properly operating oxidation ditch, a layer of clear water or supernatant is usually visible about a meter upstream from the rotor. The depth of this relatively clear water may vary from almost nothing to as much as five or more cm above the mixed liquor. The clarity will depend on the ditch velocity and the settling characteristics of the activated sludge solids.

Two other good indications of a properly operating oxidation ditch are the clarity of the settling tank water surface and the oxidation ditch surface free of foam build-up. Foam build-up in the ditch (normally not enough to be a nuisance) is usually caused by insufficient MLSS concentration. Most frequently foam build-up is only seen during plant start-up and will gradually disappear.

Clarity of the effluent from the secondary clarifier discharged over the weirs is the best indication of plant performance. A very clear effluent shows that the plant is achieving excellent pollutant removals. A cloudy effluent often indicates a problem with the plant operation.

Equipment Maintenance

Regularly scheduled equipment maintenance must be performed according to manufacturers' instruction manuals. Operator should check each piece of equipment daily to see that it is functioning properly. There may have very few mechanical devices in the oxidation ditch plant, but they are all important.

The rotors and pumps should be inspected to ensure that they are operating properly. If pumps are clogged, the obstructions should be removed. Listen for unusual noises. Check for loose bolts. Uncovering a mechanical problem in its early stages could prevent a costly repair or replacement at a later date.

Lubrication should also be performed with a fixed operating schedule and properly recorded. Follow the lubrication and maintenance instructions furnished with each piece of equipment. Make sure that the proper lubricants are used. Over lubrication is

wasteful and reduces the effectiveness of lubricant seals and may cause overheating of bearings or gears.

Chemical Clarification

Chemicals are used for a variety of municipal treatment applications, such as to enhance flocculation/sedimentation, condition solids, add nutrients, neutralize acid base, precipitate phosphorus, and disinfect or to control odours, algae, or activated-sludge bulking.
Chemical precipitation is a widely used, proven technology for the removal of metals and other inorganics, suspended solids, fats, oils, greases, and some other organic substances (including organophosphates) from sewage.
Precipitation is assisted through the use of a coagulant, an agent which causes smaller particles suspended in solution to gather into larger aggregates. Frequently, polymers are used as coagulants. The long-chain polymer molecules can be either positively or negatively charged (cationic or anionic) or neutral (non-ionic). Since sewage chemistry typically involves the interaction of ions and other charged particles in solution, these electrical qualities allow the polymers to act as bridges between particles suspended in solution, or to neutralize particles in solution. The specific approach used for precipitation will depend on the contaminants to be removed, as described below.

Metals Removal

Water hardness is caused primarily by the dissolution of calcium and magnesium carbonate and bicarbonate compounds in water, and to a lesser extent, by the sulphates, chlorides, and silicates of these metals. The removal of these dissolved compounds, called water softening often proceeds by chemical precipitation. Lime (calcium oxide), when added to hard water, reacts to form calcium carbonate, which itself can act as a coagulant, sweeping ions out of solution in formation and settling.

To do this with lime alone, a great deal of lime is typically needed to work effectively; for this reason, the lime is often added in conjunction with ferrous sulphate, producing insoluble ferric hydroxide. The combination of lime and ferrous sulphate is only effective in the presence of dissolved oxygen, however. Alum, when added to water containing calcium and magnesium bicarbonate alkalinity, reacts with the alkaline substances to form an insoluble aluminium hydroxide precipitate.

Soluble heavy metal ions can be converted into insoluble metal hydroxides or carbonates through the addition of hydroxide compounds. Additionally, insoluble metal sulphides can be formed with the addition of ferrous sulphate and lime.

Once the optimal pH for precipitation is established, the settling process is often accelerated by addition of a polymer coagulant, which gathers the insoluble metal compound particles into a coarse floc that can settle rapidly by gravity.

Phosphorus Removal

Metal salts (most commonly ferric chloride or aluminium sulphate, also called alum) or lime, have been used for the removal of phosphate compounds from water. When lime is used, a sufficient amount of lime must be added to increase the pH of the solution to at least 10, creating an environment in which excess calcium ions can react with the phosphate to produce an insoluble precipitate (hydroxyl apatite). Lime is an effective phosphate removal agent, but results in a large sludge volume.

When ferric chloride or alum is used, the iron or aluminium ions in solution will react with phosphate to produce insoluble metal phosphates. The degree of insolubility for these compounds is pH dependent.

Suspended Solids

Finely divided particles suspended in solution can escape filtration and other similar removal processes. Their small size allows them to remain suspended over extended periods of time.

More often than not, the particles populating sewage are negatively charged. For this reason, cationic polymers are commonly added to the solution, both to reduce the surface charge of the particles, and also to form bridges between the particles, thus causing particle coagulation and settling.

Alternatively, lime can be used as a clarifying agent for removal of particulate matter. The calcium hydroxide reacts in the sewage solution to form calcium carbonate, which itself acts as a coagulant, sweeping particles out of solution

Additional Considerations

The amount of chemicals required for treatment depends on the pH and alkalinity of the sewage, the phosphate level, and the point of injection and mixing modes, among other factors.

Competing reactions often make it difficult to calculate the quantities of additives necessary for chemical precipitation. Accurate doses should be determined by jar tests and confirmed by field evaluations. Chemicals are usually added by a chemical feed system that can be completely enclosed and may also include storage space for unused chemicals.

Choosing the most effective coagulant depends on jar test results, ease of storage, ease of transportation, and consideration of the operation and maintenance costs for associated equipment.

Chemical precipitation is normally carried out through a chemical feed system, most often a totally automated system providing for automatic chemical feeding,

monitoring, and control. Full automation reduces manpower requirements, allows for less sophisticated operator oversight, and increases efficiency through continuous operation.

An automatic feed system may consist of storage tanks, feed tanks, metering pumps (although pumpless systems do exist), overflow containment basins, mixers, aging tanks, injection quills, shot feeders, piping, fittings, and valves.

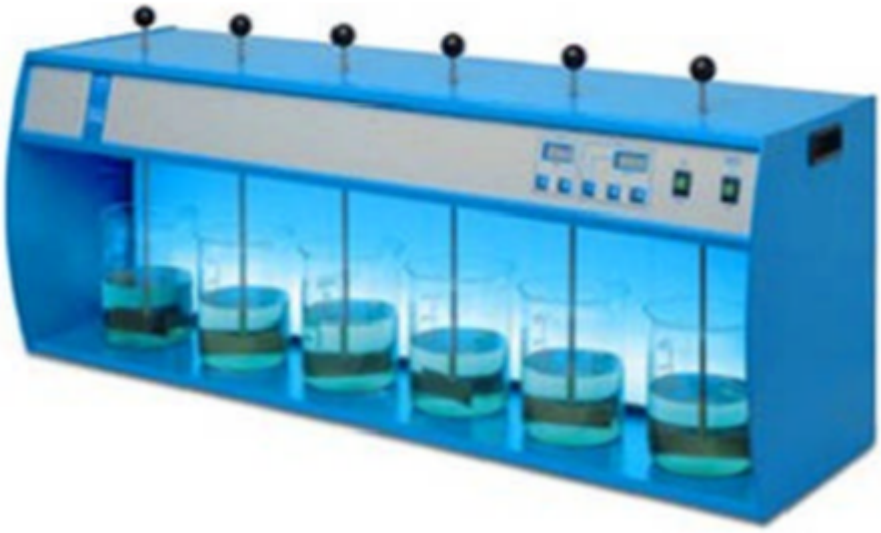
Chemical feed system storage tanks should have sufficient capacity to run for some time without running out and causing downtime. At least a one month supply of chemical storage capacity is recommended, though lesser quantities may be justified when a reliable supplier is located nearby, thus alleviating the need for maintaining substantial storage space. Additive3585 chemicals come in liquid and dry form.

Jar Testing

Secondary treated sewage from STPS may sometimes carry over the microbes from the clarifier. When chlorination of the treated sewage is to be carried out, these suspended microbes will consume the added chlorine before the organic matter in the treated sewage can be oxidized and pathogenic faecal organisms can be killed. Hence, it may be necessary to carry out coagulation, flocculation and sedimentation before chlorine is applied. For details of the theory of coagulation, flocculation and sedimentation, the CPHEEO Manual on Water Supply and Treatment may be consulted. The purpose of a jar test is to find out which chemical and at what dosage is needed to improve the clarity of secondary treated sewage. In general, such coagulation, flocculation and sedimentation is not recommended for raw sewage because the disposal of the resulting sludge becomes difficult due to a mix of biological and chemical sludge. At the same time, the phosphorous present in sewage at even as low as 1 mg/l is known to form a coating around the flocs and prevent them from settling and this in fact increases the turbidity of raw sewages. This is the reverse of addition of phosphate to cooling waters to prevent the precipitated scales from settling out in the heat exchanged surfaces.

Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw sewage held in jars or beakers. The sample is then stirred so that the formation, development, and settlement of floc can be watched just as it would be in the fullscale treatment plant. (Floc forms when treatment chemicals react with material in the raw sewage and clump together.) A typical laboratory bench scale jar test apparatus can be shown in Figure. The apparatus allows

for six samples each of 1-2 Litre in size, to tested simultaneously.



The procedure of jar testing is as follows;

The following jar test procedure uses alum (aluminum sulfate) a chemical for coagulation/ flocculation in sewage treatment, and a typical six jar tester.

a- First, using a 1,000 millilitre (mL) graduated cylinder, add 1,000 mL of raw water to each of the jar test beakers. Record the temperature, pH, turbidity, and alkalinity of the raw water before beginning.

b- Prepare a stock solution by dissolving 10.0 grams of alum into 1,000 mL distilled water. Each 1.0 mL of this stock solution will equal 10 mg/L (ppm) when added to 1,000 mL of water to be tested.

c- Using the prepared stock solution of alum, dose each beaker with increased amounts of the solution. See Table for an example of the increments and dosage.

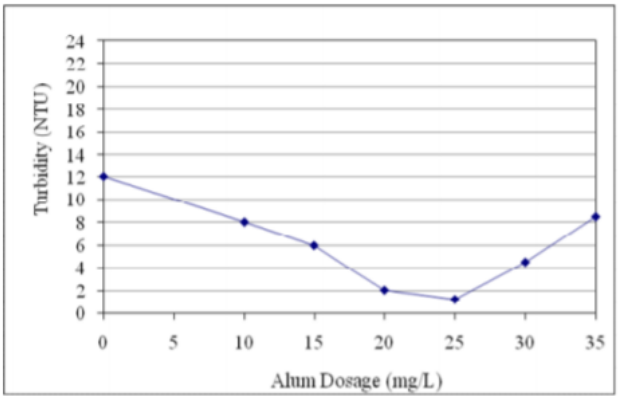
Jar No.	ml Alum Stock Added	mg/L Alum Dosage
1	1.0	10.0
2	1.5	15.0
3	2.0	20.0
4	2.5	25.0
5	3.0	30.0
6	3.5	35.0

d- After dosing each beaker, turn on the stirrers. This part of the procedure should reflect the actual conditions of the plant as much as possible. Meaning, if the plant has a static mixer following chemical addition, followed by 30 minutes in a flocculator, then 1.5 hours of settling time before the filters, then the test also should have these steps. The jar test would be performed as follows: Operate the stirrers at a high RPM for 1 minute to simulate the rapid mixer.

e- Reduce the speed of the stirrers to match the conditions in the flocculator and allow them to operate for 30 minutes. Observe the floc formation periodically during the 30 minutes.

f- At the end of the 30 minutes turn off the stirrers and allow settling. Most of the settling will be complete after one hour.

g- Use a pipette to draw a portion from the top of each beaker, and measure its turbidity.
h- Plot supernatant turbidity versus alum dose (Figure) for the sewage sample and comment on their shapes.
i- Find out the optimum alum dose. i.e, 25 mg/L from Figure



If none of the beakers appear to have good results, then the procedure needs to be run again using different dosages until the correct dosage is found.

Aerated Lagoon

The aerated lagoon process consists of aeration of the facultative pond of the stabilization pond by means of an aerator. Aerated lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the sewage to flow through while aeration is usually provided by mechanical means to stabilize the organic matter. The major difference between activated sludge systems and aerated lagoons is that in the latter settling tanks and sludge recirculation are absent.

Process Control

Daily tests will be for SS and COD. The BOD will be obtained from the standard curve made out for this sewage from a curve of BOD to COD. The BOD tube is also useful. There is nothing much to do by way of process control in aerated lagoon except making sure that all surface aerators are in working condition. Some aerated lagoons have a final section of the lagoon itself as the settling compartment. Some other lagoons have a dedicated clarifier outside the lagoon. In such a case, the return sludge is also provided in some STPs. This return sludge arrangement must run continuously. The excess sludge disposal is not provided for in aerated lagoons normally. In case of clarifiers it may be used. Mechanical dewatering facilities are generally not advised because the MLSS concentrations will be much lesser than in conventional ASPs. Sludge drying beds with green cover to prevent direct rainfall on the beds is the answer to such situations.

The DO concentration in an aerated lagoon is the best means to determine if the lagoon is operating properly. Typical practice is to maintain 1 to 2 mg/l DO in the lagoon. A minimum DO level of 1 mg/l should be maintained in the lagoon during the heaviest loading periods. Often the heaviest oxygen demand is during the night when the algae are respiring. The pH range in the lagoon should range from 7 to 8. The pH can exceed 9 during algal blooms, especially in low-alkalinity sewage. Surface mechanical aerators when used, should produce good turbulence and a light amount of froth.

Records

The limited parameters as above and the flow rate and cycle times shall be maintained as records.

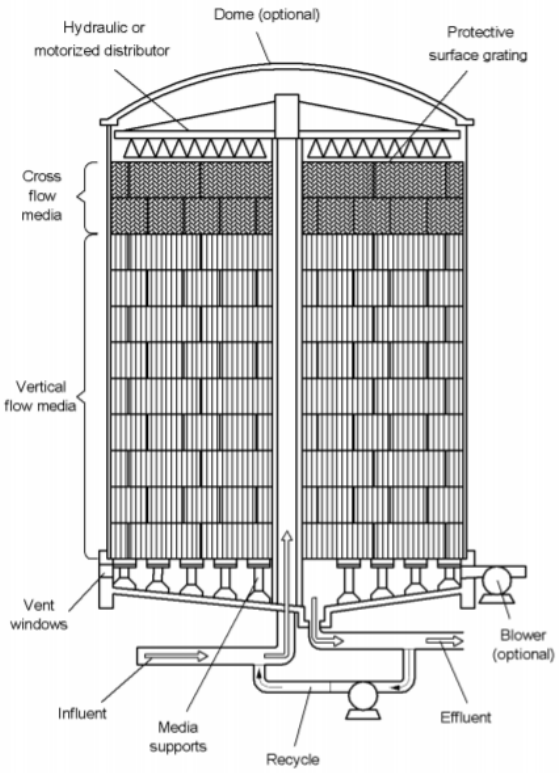
Housekeeping

Keep the bunds free of any grass or weeds. Do not allow tree branches of trees to hang over the lagoon. Follow all guidelines for motors. If high speed floating aerators are used, pull them out of the lagoon before attending to it. Check if the power cable is having sufficient slack. Verify that the power cable is tied at about 3-m centres to vertical secure posts. Do not enter the lagoon unless you are wearing a life vest and are on a boat with an aide if the aerators are not connected3680 by a platform. In all aerated lagoons, weeds and over hanging tree branches shall be avoided. A photo of such a situation is shown in Figure.

Figure Overhanging tree branches and the small area of the lined bund may be seen

- ✓ The tree roots will enter the lining and break the concrete slab joints easily.
- ✓ Once this occurs, the slabs will lose their strength and start falling down into the lagoon itself.
- ✓ Once this sets in, the earth in the bund will be easily eroded in rains and the bund will cave in.
- ✓ This leads to the lagoon sewage running out on land and polluting the land and water in wells and streams.
- ✓ The hanging tree branches will be dropping leaves which will support growth of mosquitoes.
- ✓ Manual scraping shall be done from the top of bund and not by persons entering the lagoon.
- ✓ In such cases, the branches shall be cut and the cut portions sealed with cow dung. The biggest danger is if the bund gets broken and sewage escapes; it is very difficult to control
- ✓ Reconstructing the bund is also a problem when raw sewage keeps coming daily.
- ✓ Stopping the sewage escaping from the broken bund can be done by the following:
    - Pack cement bags with mix of 90 % clay and 10% sewage and stack them one over the other.
    - These have to be dumped to form a cofferdam inside the sewage spread.
    - Thereafter, the reconstruction of the bund can be taken up easily. 3705

Attached Growth Systems



One of major attached growth systems adopted in sewage treatment lately is a "fixed film synthetic media filter", which consists of synthetic media such as inclined corrugated media placed in cube sized packs and the inclinations changed to opposite directions in successive layers as shown in Figure.

Primary sedimentation is a pre-requirement in these applications. In Figure, the applied sewage is distributed from the top of the media pack by stationary or hydraulically driven reverse jet arms on opposite radii or rotated by a mechanical drive. The requirements to apply the sewage on the entire plan are to uniformly and simultaneously allow the gas exchange by releasing at the top and fresh air automatically forcing itself from the bottom. The microbial films develop on the fixed media and bring about the metabolism as the sewage passes over them as a film. In due course of time, the thickness of the film increases and results in sloughing and getting carried away to secondary settling tanks. Recirculation of the treated effluent is sometimes practiced before sedimentation so that the enzymes released by the microbes are3720 returned to the reactor for solubilising the sewage organicmatter.

Operation

Many operating problems may be avoided by changing one or more of the following process control variables: distribution rates, and clarifier operation.

a- Distribution Rates

As a principal process control measure, operators can control the rates at which sewage and filter effluent are distributed to the filter media. Recirculation can serve several purposes, as follows:

- ✓ Reduce the strength of the sewage being applied to the filter.
- ✓ Increase the hydraulic load to reduce flies, snails, or other nuisances.
- ✓ Maintain distributor movement during low flows.
- ✓ Produce hydraulic shear to encourage solids sloughing and prevent ponding.
- ✓ Reseed the filter's microbial population.
- ✓ Provide uniform flow distribution.
- ✓ Prevent filters from drying out.

b- Clarifier Operation. The manner in which secondary clarifiers are operated can significantly affect the filter performance. Although clarifier operation with fixed

film reactors is not as critical as that with suspended-growth systems, operators must still pay close attention to final settling.

Sludge must be removed quickly from the final settling tank before gasification occurs or denitrification causes solids to rise. Use of the secondary clarifier as a principal means of thickening (rather than simply for solids settling) may not produce the best effluent quality, especially during summer months, when denitrification is likely to occur. The sludge blanket depth in the secondary clarifier should be limited to 0.3 to 0.6 m. Continuous pumping or intermittent pumping with automatic timer control are used to accomplish3745 solids wasting.

Maintenance

Planned maintenance will vary from plant to plant, depending on unique design features and equipment installed. Although this chapter cannot address all of these items, a summary of the most common and important maintenance tasks follows:

Rotary Distributors

- ✓ Observe the distributor daily. Make sure the rotation is smooth and that spray nozzles are not plugged.
- ✓ Lubricate the main support bearings and any guide or stabilizing bearings according to the manufacturer's instructions. Change lubricant periodically, typically twice a year. If the bearings are oil-lubricated, check the oil level, drain condensate weekly, and add oil as needed.
- ✓ Time the rotational speed of the distributor at one or more flow rates. Record and file the results for future comparison. A change in speed at the same flow rate indicates bearing trouble.
- ✓ Flush distributor arms monthly by opening end shear gates or blind flanges to remove debris. Drain the arms if idle during cold weather to prevent damage via freezing. Clean orifices weekly with a high-pressure stream of water or with a hooked piece of wire.
- ✓ Keep distributor arm vent pipes free of ice, grease, and solids. Clean in the same manner as the distributor arm orifices. Air pockets will form if the vents are plugged. Air pockets will cause uneven hydraulic loading in the filter, and nonuniform load and excessive wear of the distributor support bearing.
- ✓ Make sure distributor arms are level. To maintain level, the vertical guy wire should be taken up during the summer and let out during the winter by adjusting the guy wire tie rods. Maintain arms in the correct horizontal orientation by adjusting horizontal tie rods.
- ✓ Periodically check distributor seal and, if applicable, the influent pipe to distributor expansion joint for leaks. Replace as necessary. During replacement check seal plates for wear and replace if wear is excessive. Some seals should be kept submerged even if the filter is idle or their life will be severely shortened.
- ✓ Remove ice from distributor arms. Ice buildup causes nonuniform loads and reduces main bearing life.
- ✓ Paint the distributor as needed to guard against corrosion. Cover bearings when sandblasting to protect against contamination. Check oil by draining a

little oil through a nylon stocking after sandblasting. Ground the distributor arms to protect bearings if welding on distributor and lock out the drive mechanism at the main electrical panel. Adjust secondary arm overflow weirs and pan test sewage distribution on filter as needed.

Fixed nozzle distributors

- ✓ Observe spray pattern daily. Unplug block nozzles manually or by increasing hydraulic loading. Flush headers and laterals monthly by opening end plates. Adjust nozzle spring tension as needed.

Filter media

- ✓ Observe condition of filter media surface daily. Remove leaves, large solids and plastics, grease balls, broken wood lath or plastic media, and other debris. If ponding is evident, find and eliminate the cause. Keep vent pipes open, and remove accumulated debris.

Store extra plastic media out of sunlight to prevent damage via ultraviolet rays. Observe media for settling. After they are installed, media settle because of their own weight and the weight of the biofilm and water attached to its surface. Settling should be uniform and should stabilize after a few weeks. Total settling is typically less than 0.3 m for random plastic media, less for plastic sheet media, and nearly zero for rock. If settling is nonuniform or excessive, remove some of the media for inspection.

- ✓ Observe media for hydraulic erosion, particularly in regions where reversing jets hit the media.

Underdrains

- ✓ Flush out periodically if possible. Remove debris from the effluent channels.

Media containment structure

- ✓ Maintain spray against inside wall of filter to prevent filter fly infestation and to prevent ice buildup in winter.
- ✓ Practice good housekeeping. Keep fibreglass, concrete, or steel outside walls clean and painted, if applicable. Keep grass around structures cut, and remove weeds and tall shrubs to help prevent filter fly and other insect infestations. Remember, using insecticides around treatment units may have adverse effects on water quality or biological treatment units.

Filter pumps

- ✓ Check packing or mechanical seals for leakage daily. Adjust or replace as needed. Lubricate pump and motor bearings as per manufacturer's instructions. Keep pump motor as clean and dry as possible. Periodically check shaft sleeves, wearing rings, and impellers for wear; repair or replace as needed. Perform maintenance of speed reducer, coupling, and other appurtenant equipment maintenance according to manufacturer's instructions.

Secondary clarifier

- ✓ Lubricate drive motor bearings, speed-reducing gear, drive chains, work and spur gears, and the main support bearing for the solids-collection equipment according to the manufacturer's instructions. Flush scum troughs and grease wells daily. Maintain solids withdrawal equipment. Clean effluent wells and baffles at least weekly. Paint or otherwise protect equipment from corrosion as needed.

Appurtenant equipment

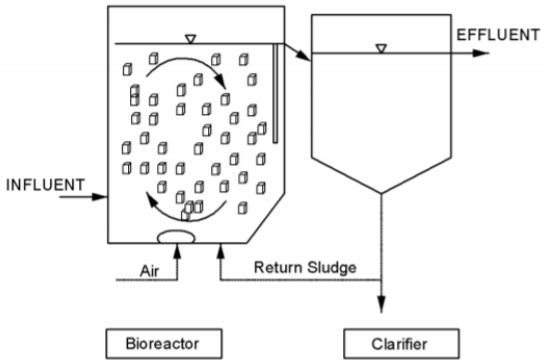
- ✓ Maintain piping, valves, forced draft blowers, and other appurtenant equipment according to the manufacturer's instructions.

The information provided above is not equipment or plant-specific. Therefore, both the manufacturer's literature and engineer's operating instructions should be consulted and followed. The frequency of maintenance procedures depends on sitespecific conditions. However, until operating experience is gained, frequent plant inspections and maintenance should continue. Maintenance schedules should consider the increased performance of fixed film synthetic media filters in warm weather months, which may reduce the effect of removing process units from service.

Moving Bed Bio Reactor (MBBR)

Configuration

The moving bed biofilm reactor (MBBR) is based on the biofilm carrier elements. Several types of synthetic biofilm carrier elements have been developed for use in activated sludge processes. These biofilm carrier elements may be suspended in the activated sludge mixed liquor in the reaction tank by air from the diffusers in aerobic reactors and by means of propeller mixers in anaerobic and anoxic reactors. The carrier elements are retained by suitably sized sieves or plates.



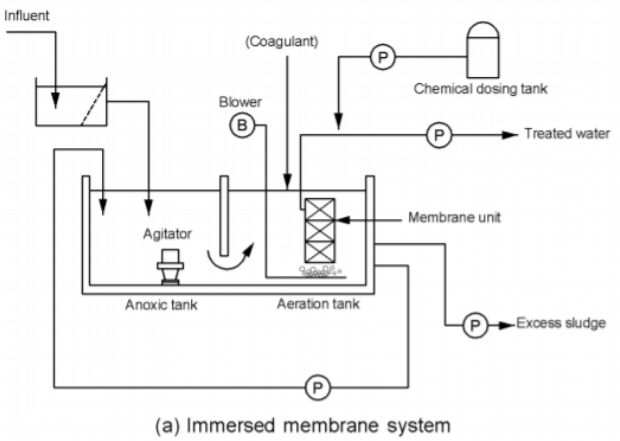
These processes are intended to enhance the activated sludge process by providing a greater biomass concentration in the aeration tank and thus offer the potential to reduce the basin size requirements. They have also been used to improve the volumetric nitrification rates and to accomplish the denitrification in aeration tanks by having anoxic zones within the biofilm depth. Because of the complexity of the process and issues related to understanding the biofilm area and activity, the process design is empirical and based on prior pilot-plant or limited full-scale results. Typical diagram of MBBR is shown in Figure.

Operation and Maintenance

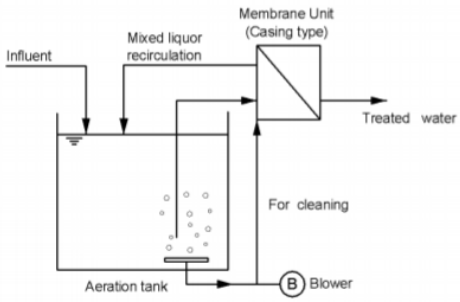
There are now more than 10 different variations of the processes in which a biofilm carrier material of various types is suspended in the aeration tank of the activated sludge process.

Differently varied processes have their own characteristics and require specific O&M. Therefore, operators should have thorough knowledge on their systems and implement daily O&M according to the manufacturers' instruction manuals.

Membrane Bio Reactor (MBR)



(a) Immersed membrane system



The membrane bioreactor (MBR) process is a combination of activated sludge process and membrane separation process. Low pressure membranes (ultra filtration or microfiltration) are commonly used. Membranes can be submerged in the biological reactor or located in a separate stage or compartment and are used for liquid-solid separation instead of the usual settling process. (Figure)

Basically, primary sedimentation tank, final sedimentation tank and disinfection facility are not installed in this process. The reaction tanks comprise an anoxic tank and an aerobic tank, and the membrane modules are immersed in the aerobic tank. Pre-treated, screened influent enters the membrane bioreactor, where biodegradation takes place. The mixed liquor is withdrawn by water head difference or suction pump through membrane modules in a reaction tank, being filtered and separated into solid and liquid. Surfaces of the membrane are continuously washed down during operation by the mixed flow of air and liquid generated by air diffuser set at the bottom of the reaction tank. Permeate from the membranes constitutes the treated effluent.

Operation

All MBR systems require some degree of pumping to force the water flowing through the membrane. One type of membrane systems uses a pressurized system to push the water through the membranes. The major systems used in MBRs draw a vacuum through the membranes so that the water outside is at ambient pressure. The advantage of the vacuum is that it is gentler to the membranes; the advantage of the pressure is that throughput can be controlled. Both systems also include techniques for continually cleaning the system to maintain membrane life and keep the system operational for as long as possible. All the principal membrane systems used in MBRs use an air scour technique to reduce build-up of material on the membranes. This is done by blowing air around the membranes out of the manifolds.

The permeate from an MBR has low levels of suspended solids, i.e., the levels of bacteria, BOD, nitrogen, and phosphorus are also low. Disinfection is easy and may not even be required, depending on permit requirements.

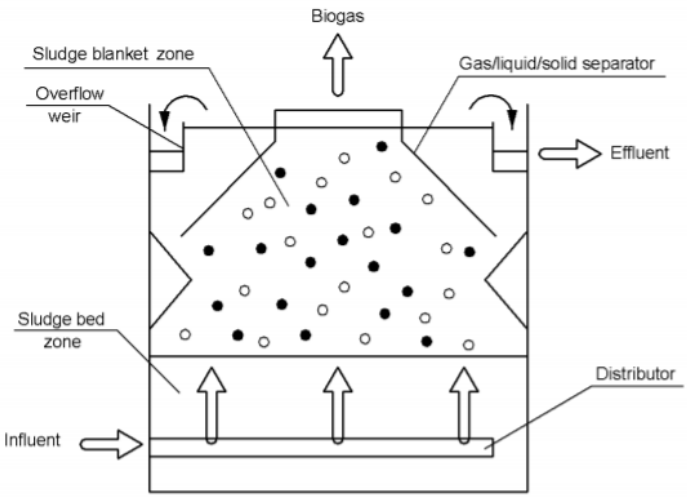
The solids retained by the membrane are recycled to the biological reactor and build up in the system. As in conventional biological systems, periodic sludge wasting eliminates sludge build-up and controls the SRT within the MBR system. The waste sludge from MBRs goes through standard solids-handling technologies for thickening, dewatering, and ultimate disposal. Chemical addition increases the ability of solids to settle. As more MBR facilities are built and operated, a more definitive understanding of the characteristics of the resulting sludge will be achieved. However, experience to date indicates that conventional sludge processing unit operations are also applicable to the waste sludge from MBRs.

Maintenance

The key to the cost-effectiveness of an MBR system is membrane life. If membrane life is curtailed such that frequent replacement is required, costs will increase significantly. Membrane life can be increased in the following ways:
Good screening of larger solids before the membranes to protect the membranes from physical damage.
Throughput rates that are not excessive, i.e., that do not push the system to the limits of the design. Low rates reduce the amount of material that is forced into the membrane, and thereby reduce the amount that has to be removed by cleaners or that will cause eventual membrane deterioration.
Mild cleaners - cleaning solutions most often used with MBRs include regular bleach (sodium) and citric acid, are regularly used. The cleaning should be in accordance with manufacturer's recommended maintenance protocols.

Up Flow Anaerobic Sludge Blanket Reactor (UASB)

The Up flow Anaerobic Sludge Blanket Reactor (UASB) (Figure), maintains a high concentration of biomass through formation of highly settleable microbial aggregates. The sewage flows upwards through a layer of sludge. Separation between gas-solid-liquid takes place at the top of the reactor phase. Any biomass leaving the reaction zone is directly recirculated from the settling zone. The process is suitable for both soluble wastes and those containing particulate matter. The process has been used for treatment of municipal sewage at few locations and hence performance data and experience available presently are limited.



Plant Commissioning and Operation

Two to three months are needed to build up a satisfactory sludge blanket without the addition of "seed" sludge from a working UASB. A shorter time is needed, if seeding is done.
During the start-up period, COD removal in the UASB gradually improves as sludge accumulation occurs. This may be called the sludge accumulation phase. The end of the sludge3850 accumulation phase is indicated by sludge washout. At this time, the reactor is shut down to improve the quality of the sludge. This may be called the sludge improvement phase. After sludge improvement, blanket formation starts. Once the blanket is formed, again some surplus sludge washout could occur and to stabilise the stable operation, the excess sludge needs to be removed periodically. The excess sludge so removed can be sent directly to the sludge treatment process.

The sludge accumulated in the UASB is tested for pH, volatile fatty acids (VFA), alkalinity, COD and SS. If the pH reduces while VFA increases, new material should not be fed until the pH and VFA stabilise.

Daily operation of the UASB requires minimum attention. No special instrumentation is necessary for control, especially where gas conversion to electric power is not practiced. As stated, surplus sludge is easy to dry over an open sand bed. The reactor may need to be emptied completely once in five years, while any floating material (scum) accumulated inside the gas collector channels may have to be removed every two years to ensure free flow of gas.

Daily Operation and Maintenance of UASB

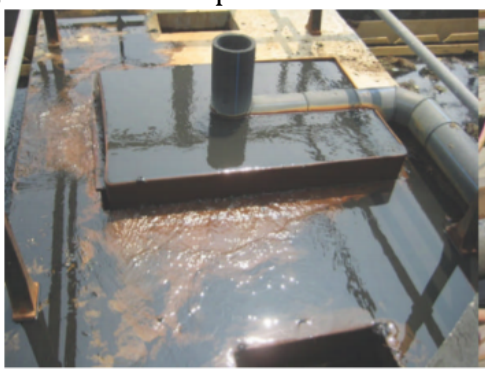
a- Cleaning of Effluent Gutters

All V-notches must be cleaned in order to maintain the uniform withdrawal of UASB effluent coming out of each V-notch. The irregular flow from each V-notch results in the escape of more solids washout. Similarly, blocking of the V-notches of the effluent gutters will lead to uneven distribution of sewage in the reactor. Therefore, the effluent gutters have to be inspected on a regular basis to remove any material blocking and even the outflow over the V-notches in the gutters. The regular maintenance involves cleaning of V-notches with a broom three times a day (Figure 4.22) and removing sludge with a brush or with a water jet once a day.

b- Unclogging Feeder Pipes

The feeder pipes should be checked regularly for clogging. Flexible iron rods can serve the purpose. A submersible pump can be used to unclog the feeder pipes (Figure 4.23).

These feeder pipes are generally clogged due to rags and floating material. It is necessary to3880 provide a fine screen or extra prevention at the screen to capture floating material at the pre-treatment unit itself.



Clogged inlet pipes

Submersible pump

Cleaning of feed pipes by submersible pumps

Clean feed pipes (equal flow distribution)

c- Removal of Floating Mat

Floating mat must be removed from the top of the surface of reactor with a rake. The removed material should be disposed at the dumping site.

d- Check of Leakage of Biogas

The gas collectors should be checked for leakage. Leakage is easily detected by applying soap solution to the piping. This should be done on a regular basis. If the gas collectors are leaking, the valve at the end of one bay in the gas leak should be first closed and then repaired as soon as possible. Regular maintenance includes opening of hatch boxes and removing floating layer inside the gas collectors.

e- Scrubbing of Biogas

Waste at the Top of UASB Reactor

The risk of the corrosion of dual fuel engine parts, as biogas contains H2S, can be minimised if biogas can be scrubbed before using it as fuel for dual fuel gas engines.

f- f. Check for Sludge Withdrawal Ports The ports of the sludge withdrawal must be free from any clogging which reduces the chances of checking of sludge height in reactor.

The feeder pipes should be checked regularly for clogging. Flexible iron rods can serve the purpose. A submersible pump can be used to unclog the feeder pipes.

g- Methanogenic Activity

Successful operation of a UASB reactor depends upon maintaining a satisfactory balance between methane and acidogenic bacteria. The methane formers are

susceptible to changes3910 in environmental conditions such as pH, temperature etc. The methanogenic activity must be analysed monthly.

h- Proper Sludge Wasting

Sludge must be removed or transferred from the UASB reactor occasionally based on the sludge yield or concentration of TSS or VSS. Higher sludge withdrawal points to a poor performance of the reactor in terms of treatment.

i- Biogas Analysis

The biogas analysis is used largely at sewage treatment plants where information on fuel value of gas is important. In addition, knowledge of gas composition can be of considerable help in the control of digestion units. Sudden changes in gas composition can signal a change either in the operation of the treatment unit or in the amount or composition of incoming sewage. Such changes can thus be used as a warning sign to suggest the need for closer observation and control of treatment unit.

j- H2S Determination

The determination of hydrogen sulphide will continue to be an important consideration wherever gas is used for fuel in gas engines, particularly in areas where the sulphate content of sewage is very high.

k- Sludge Pumping Station Maintenance

After every sludge withdrawal operation, clean the pipeline by opening the top flushing valve until all the sludge in the pipeline is washed out. The sump has to be cleaned with water.

Never keep the sludge in the sump, it may damage the pumps. Before getting into the sumps for any maintenance, keep the top cover open for an hour before anybody gets in so that any accumulated biogas will vent to the atmosphere. Keep the valve chamber dry and valves clean. Check the electrical components regularly.

l- Biogas Holder Operation and Maintenance

The biogas produced in the reactors is taken in the common FRP pipes to the biogas holder. The biogas before going to the gas holder passes through moisture trap. The gas coming to the gas holder is measured through gas flow metres connected to FRP pipe after the moisture trap.

The biogas before going to the holder is branched off. One branch is taken to the flaring system, the other to the biogas engine. Before going to the engine, the gas is measured from the flow meter provided on pipeline going to the engine. Sluice valves are provided on the lines to isolate the flow which is manually operated.

In case of sudden reduction in dome levels, the reactor FRP dome connector and its connection to the gas pipe header should be checked with soap water for any leakage of gas. This is one of the reasons for having a gas holder level trap.

The typical UASB preventive maintenance check list is below.

- ✓ Date and time
- ✓ Check and clean weir levels of division boxes
- ✓ Clean-up- feed inlet points
- ✓ Cleaning of V-notches
- ✓ Removal of sludge from effluent gutter by water jet or brush
- ✓ Removal of floating layer on the top of reactor
- ✓ Cleaning and scrubbing of effluent channels
- ✓ Check gas pipes for leakage

- ✓ Leakage greasing of spindle of sludge valves
- ✓ Cleaning of sludge sump

Routine Maintenance

Quarterly Maintenance

- ✓ The spindles of the valves have to be greased every three months.
- ✓ The glands and packing of the valves have to be checked every three months and replaced, if necessary.

Annual Maintenance

The reactor should be emptied after the first year of full operation to check the complete feeder and sludge withdrawal systems, especially the valves and the internal pipes for any accumulation of debris, sludge etc.

- ✓ A first check of the complete system including valves and holes should be made after one year, or earlier when required. Routine check can be established on the basis of the first inspection observation.
- ✓ The effluent gutters should be checked for levelling and alignment once a year. Each gutter should be horizontally levelled and all gutters in one reactor should be at the same level.
- ✓ Electrical wiring should be checked every year.
- ✓ Corrosion on electrical connections should be removed every year.
- ✓ The cement structures should be checked yearly and repaired when necessary.
- ✓ The sludge filtrate water pumps should be maintained.

Five-Yearly Maintenance

Every five years, the following maintenance should be carried out.

- ✓ Each reactor should be alternately put out of operation.
- ✓ Clean the inside concrete surface.
- ✓ Apply new coating of epoxy to the concrete surface.
- ✓ Check quality of feed inlet pipes and replace when necessary.
- ✓ Check fixing of the feed inlet pipes, both at the distribution boxes and at the bottom. Change corroded fixing material when necessary.
- ✓ Check position of PVC sheets.
- ✓ Check the fixing-material of the PVC sheets and replace when necessary
- ✓ Check the quality of gas collectors and carry out repairs where necessary.

Decision Schemes for Sludge Removal

The removal of sludge is subject to a number of choices-how much sludge should be removed, from where should be removed, etc.

Shut-Down and Standstill

At shutdown of the plant, the sludge will settle at the bottom of the reactor. The biological activity of the sludge decreases slowly during standstill. Care should be

taken to ensure that the sludge is not exposed to aerobic conditions. This might occur, for instance, when the reactor is flushed with clean water for prolonged periods.
At shutdown of the plant, the gas production will decrease. At a prolonged period of plant standstill, the pressure in the gas collection system can drop and air may enter into the system. In this situation, internal parts of the gas flare, the gas metre and the pressure/vacuum release valves that normally are not in contact with the atmospheric air start to corrode. These parts have to be protected, for instance by greasing.
If the water level in the tank is lowered during shutdown, the limited capacity of the vacuum release valves should be kept in mind. It is possible that imploding of the gas collectors may occur due to fast withdrawal of the reactor contents. At lowering of the water level in the reactor, it is advised to open the manholes on the top of the gas collectors. Only after re-establishing the maximum water level, the manholes can be closed and sealed.
In general, any type of work on the gas collectors requires the opening of the manholes as the explosive moisture of air and methane can develop in or around the gas collectors. When it is necessary to enter the reactor while sludge is present, it should be realised that methane is being formed continuously. A proper ventilation of the reactor is necessary. Very strict rules concerning open fire, spark emission, etc, should be followed. When entering the reactor plant, personnel should wear respiration equipment. Measurement of explosion risk and hydrogen sulphide concentration should be taken frequently when repair work is carried out.

Operational Cautions

- ✓ Do not get upon the UASB unless you have a gas mask, safety shoes, goggles and helmets.
- ✓ Do not carry any ignitable matters on your person.
- ✓ Once you reach the walking platform at top, check the H2S by hand held meter.
- ✓ Unless it registers safety, immediately climb down the UASB.
- ✓ Once all the above are ensured, proceed to check any overflows of sewage and if so, stop the UASB.
- ✓ Check for corrosion at least once in 6 months and get it rectified.

Final Polishing Unit (FPU)

Not much maintenance is required for this unit. The algal growth needs to be maintained, and the dead algae floating on the top of water surface has to be periodically removed. The baffles provided at the outlet unit have to be cleaned regularly. Keep the floating material away from the unit. See that dead algal do not pass out into the pond. These ponds should be de-sludged/de-silted regularly depending on the depth of sludge accumulation. Maintenance record should be maintained.

Waste Stabilization Pond (WSP)

Waste stabilization ponds are open, flow-through earthen basins specifically designed and constructed to treat sewage and biodegradable industrial wastes. Waste

stabilization ponds provide comparatively long detention periods extending from a few to several days.

There are three principal types of WSP:

- ✓ Anaerobic,
- ✓ Facultative, and
- ✓ Maturation ponds.

Anaerobic ponds and facultative ponds are designed for BOD removal, and maturation ponds are designed for faecal bacterial removal. These three types of WSP are arranged in a series – first an anaerobic pond, then a facultative pond, and finally (and if needed to achieve the required effluent quality) one or more maturation ponds.

Apart from the above three types, there is another type of WSP called aerobic pond, which are seldom used. When used, follow the same procedures as in facultative ponds.

Start-up Procedures

Pond systems should preferably be commissioned at the beginning of the hot season so as to establish as quickly as possible the necessary microbial populations to effect waste stabilization. Prior to commissioning, all ponds must be free from vegetation. Facultative ponds should be commissioned before anaerobic ponds: this avoids odour release when anaerobic pond effluent discharges into an empty facultative pond. It is best to fill facultative and maturation ponds with freshwater (from a river, lake or well; mains water is not necessary) so as to permit the gradual development of the algal and heterotrophic bacterial populations. Primary facultative ponds may advantageously be seeded in the same way as anaerobic ponds. If freshwater is unavailable, facultative ponds should be filled with raw sewage and left for three to four weeks to allow the microbial population to develop; a small amount of odour release is inevitable during the period.

Routine Maintenance

The maintenance requirements of ponds are very simple, but they must be carried out regularly. Otherwise, there will be serious odour, fly and mosquito nuisance. Maintenance requirements and responsibilities must therefore be clearly defined at the design stage so as to avoid problems later. Routine maintenance tasks are as follows:

- ✓ Removal of screenings and grit from the inlet works
- ✓ Cutting the grass on the embankments and removing it so that it does not fall into the pond (this is necessary to prevent the formation of mosquito-breeding habitats; the use of slow-growing grasses minimises this task)
- ✓ Removal of floating scum and floating macrophytes, such as. Lemna, from the surface of facultative and maturation ponds (this is required to maximize photosynthesis and surface re-aeration and prevent fly and mosquito breeding)
- ✓ Spraying the scum on anaerobic ponds (which should not be removed as it aids the treatment process), as necessary, with clean water or pond effluent, or a suitable biodegradable larvicide, to prevent fly breeding
- ✓ Removal of any accumulated solids in the inlets and outlets

- ✓ Repair of any damage to the embankments caused by rodents, rabbits or other animals
- ✓ Repair of any damage to external fences and gates

And precautions and practices are described below:

- ✓ The scum has a tendency to form at the corners of the ponds and supports mosquito growth.
- ✓ In anaerobic ponds, during times of low pH odour is produced. In such occasions, addition of sodium hydroxide is required to raise the pH to 7. The advantage of sodium hydroxide is it produces less sludge. In case production of sludge is not a concern then lime can be added to raise the pH to 7. Once the pH is raised to 7 odour can be eliminated.
- ✓ Anaerobic ponds, low pH produces odours.In such cases addition of NaOH it produces less sludge, or lime can be added to raise the pH to 7 to eliminate odour4085 caused by H2S
- ✓ The scum need not be taken out of the ponds at any cost.
- ✓ When scum has accumulated to dense zones in the corners, they need to be removed.
- ✓ What is needed is beating the surface of the scum by a light long pole while standing at the bank.
- ✓ This releases the gases that are supporting the scum layer and automatically the mat sinks back.
- ✓ These are dealt with like any other foods which are stabilized by the organisms of the pond.
- ✓ Fish shall not be allowed to breed in any of the ponds.
- ✓ The precautions of operating manually the scum removal shall be totally adopted.
- ✓ Sometimes sludge removal would become necessary.
- ✓ Thumb rule will be to verify the depth of sludge and de-sludge once it is about 30 % of depth.

De-Sludging

The biggest challenge to an operator in the management of pond systems is to identify when a pond requires de-sludging, and to carry out the de-sludging thereafter; it is more important to deal with the sludge thus taken out without giving rise to environmental problems. These issues are addressed in this section so as to help the operator develop adequate confidence in this task.

When to De-Sludge

When raw sewage without grit removal is admitted to the pond, a general rule of thumb to calculate the grit accumulation can be taken as 0.5 meters for a ten year period. Similarly, the accumulation of sludge can be taken as 0.7 meters for a ten year period. Thus, in the illustrative design, it can be seen that the total depth has adequate allowance for these plus the required minimum depth of liquid depth for the treatment. In the absence of adequate design reference, the build-up of sludge to a height wherein it will start overflowing through the outlet is the upper limit. However, if that is allowed, there is no space for the liquid holding capacity and treatment

efficiency will suffer. Hence, the operator must clearly know the basis on which the pond has been designed and commence de-sludging when that depth is reached by the sludge accumulating from the bottom. If even that information is not available, the operator must make a decision.

The white towel test

The white towel test is used to understand the depth of the sludge and this will help in deciding desludging Malan (1964). White towelling material is wrapped along one-third of a sufficiently long pole, which is then lowered vertically into the pond until it reaches the pond bottom; it is then slowly withdrawn. The depth of the sludge layer is clearly visible since some sludge particles will have been entrapped in the towelling material Figure. The sludge depth should be measured at various points throughout the pond, away from the embankments, and its mean depth calculated. Duncan Mara (2004)

De-Sludge Procedure

Measure the depth of the pond from the top of the bund to the bottom. To do this, use the effluent chamber that may be outside the pond. Usually, these chambers have the same or slightly larger depth than the pond. If there is no effluent chamber, assemble a long casuarina sturdy pole of about some 6 meters long and start sliding it slowly on the inside slope so that the pole follows the gradient and stops at the bottom of the pond which could be sensed by the strong reaction for a gentle push of the pole. Mark the top of the bund elevation on the pole with a gentle cut in the hacksaw. Pull the pole out and measure the distance of the cut from the bottom of the pole after laying the

pole flat on the ground. Record the distance. Repeat the measurement on all sides of the pond. If the readings are within plus or minus 5%, take the average. If not repeat the measurement at different locations until you get a reading within plus or minus 5%. Let us say this reading is 5 meters. Nail a perpendicular small pole to one end of the longer pole such that the distance of protrusion of this short pole is a meter. Then slide the long pole horizontally over the bund top by resting it on the bund top and checking the horizontality with a spirit level by placing it on the long pole such that the free end of the short pole touches the inner side of the bund. Mark the location with a gentle double cut by a hacksaw on the long pole where the inner side slope of the bund crosses the long pole. Measure this length. Let us say this is 2 meters. The total depth of the lagoon will now be calculated as [1 / 2] x [5] = 2.5 meters. Next, measure the inclined length of the waterline from the inner edge of the inside slope of the bund. Let us say this is 1.4 meters. The freeboard will now be calculated as [1.4 / 2] = 0.7 meters. The design liquid depth is 2.5-0.7 = 1.8 meters. In this depth, it is now necessary to measure the depth of sludge accumulation such that at least 1.2 meters of liquid depth is available for treating the sewage.

This measurement requires the use of the serrated glass tube as described earlier and in addition, support from fire service personnel, life vests for all those on board the paddle boat, minimum of two persons, a good fibreglass or wooden boat doubly checked for water tightness, an experienced boatman and oxygen masks for all those on board the boat. Once all these are assembled, the boat has to be rowed to the three or four random locations and the glass tube exercise has to be carried out. After driving the glass tube into the hardness of the bottom clay, rotate it gently in-situ and lift with an unscrewing motion. Do not pull straight. Gently release the tube from the clay by feeling it and raise by changing the grip on the tubes and allowing the tube to go up freely. Once out of the water surface, keep it on the floor of the boat vertically and allow the contents to settle down for 30 minutes. Thereafter paint on the glass tube with a good paint the level at which the sludge is seen. Then return to the shore and lay the tube horizontally over the ground and use a water jet or air jet to clear the tube contents. If the chemist requires it, collect the sludge and give it to him for analysis. On any account, do not use a mechanized boat. The methane gas present on the surface of the pond can be ignited by the spark of the motor with unpleasant consequences.

Another method is to take a slim bamboo pole with a height equal to the depth of the pond plus 2 m as the optimum. A white fluffy towel is wrapped around end of the pole for a height equal to the designed liquid depth of the pond. It should be tied securely and tightly in not less than three to four wrappings. Thereafter set sail on a good manual paddle boat over the pond as described earlier. Lower the pole with the white towel end into the pond till the pole has reached the bottom. Hold steady for about 15 minutes. Then raise the pole. The darkish or blackish colour at the bottom end as seen on the towel is the mark of the depth of sludge. Rinse it well by repeatedly dipping into the liquid upper layers before proceeding to the next random location and repeat the testing.

- ✓ Repeat the above depth measurements slowly without hurry. Always do this in clear non-rainy weather. Make sure you have at least four readings, which are fairly close.

- ✓ Once the sludge depth is thus measured, consult the chemist for any tendency of efficiency drop in the pond for BOD removal. If the chemist feels that there is a steady decline and efficiency is going down, consult the plant superintendent.
- ✓ As a rule of the thumb, if the liquid height is less than 1.2 meters in a facultative or anaerobic pond, it is time for de-sludging. Take the decision jointly and never by yourself.
- ✓ The best method of de-sludging is to take one pond out of operation during the beginning of summer and pump out the water portion to the other ponds. Thereafter, it normally takes two months for a sludge depth of about 2 meters to dry out.
- ✓ Deploy manpower equipped with oxygen mask to gently turn the dried sludge upside down uniformly over the whole area so that drying is hastened. Never use a machine during this operation as methane may get released.
- ✓ Once this is completed and the sludge is dried, deploy scraper equipment like a "Procaine" and evacuate the sludge over the bund and on to the ground on the earth side of the bund.
- ✓ The sludge can be heaped into a pile by manual labourers who should wash their hands thoroughly with soap after finishing their work.

Special cautions for anaerobic pond / maturation pond

All the points listed earlier in aerated lagoon and facultative ponds apply here also except that the depth of sludge before de-sludging will be according to the original design. The boat ride to measure the sludge depth shall not be used in these ponds. Instead, the white towel test shall be conducted and a long boom crate shall be used without making any person stand at the end of the boom.

Process Control

There is nothing much to control in the process of purification of sewage in WSP except making sure that the sludge accumulation does not exceed 30% of the total liquid depth or the design depth of sludge.

Record Keeping

Records necessary for Anaerobic Pond

- ✓ Daily tests and records will be the flow and SS
- ✓ Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH

Records necessary for Facultative Pond

- ✓ Daily tests and records will be the flow and SS
- ✓ Weekly tests will be identification of organisms as per "Standard Methods" drawings
- ✓ Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH

Records necessary for Maturation Pond

- ✓ Daily tests and records will be the flow and SS
- ✓ Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH
- ✓ Yearly test of faecal and total coliforms at the peak summer and peak monsoon shall be conducted.

Farm Forestry

Please hand over the O&M work to the local forestry department who are competent in this.

Fish Pond

These ponds shall not be used henceforth except in the case of the Mudiali farm.

Secondary Sedimentation Tank

A typical plant may have clarifiers located at two different points. The one that immediately follows the bar screen, comminutor, or grit channel is called the primary sedimentation tank, merely because it is the first sedimentation tank in the plant. The other, which follows other types of treatment units, is called the secondary sedimentation tank or the final sedimentation tank. The two types of sedimentation tanks operate almost exactly the same way. The function of a primary clarifier is to remove settleable and floatable solids. The reason for having a secondary sedimentation tank is that other types of treatment following the primary sedimentation tank convert more solids to the settleable form, and they have to be removed from the treated sewage. Because of the need to remove these additional solids, the secondary clarifier is considered part of these other types of processes.
The main difference between primary and secondary sedimentation tanks is in the density of the sludge handled. Primary sludge is usually denser than secondary sludge. Effluent from a secondary clarifier is normally clearer than primary effluent.
Solids that settle to the bottom of a sedimentation tank are usually scraped to one end (in rectangular clarifiers) or to the middle (in circular clarifiers) into a sump. From the sump, the solids are pumped to the sludge handling or sludge disposal system. Systems vary from plant to plant and include sludge digestion, vacuum filtration, filter presses, incineration, land disposal, lagoons, and burial.
Disposal of skimmed solids varies from plant to plant. Skimmed solids may be buried with material cleaned off the bar screen, or pumped to the digester. Even though pumping skimmed solids to a digester is not considered good practice because skimmings can cause operational problems in digesters, it is a common practice.4245

Operation

Of all the different types of clarifiers that an operator must regulate, secondary clarifiers in the activated sludge process are the most critical and require the most attention from the operator.

- ✓ Levels of sludge blanket in the clarifier
- ✓ Concentration of suspended solids in the clarifier effluent
- ✓ Control and pacing of return sludge flows

- ✓ Concentration of dissolved oxygen (DO) in the clarifier effluent
- ✓ Level of pH
- ✓ Concentration of RAS

Maintenance

Annually, during periods of low flow, each clarifier should be shut down for inspection, routine maintenance, and any necessary repairs. Even though the clarifier and all equipment are working properly, an annual inspection helps to prevent serious problems and failures in the future when harmful consequences can result. During normal operations, operator should schedule the following daily activities:

a- Inspection: Make several daily inspections with a "stop, look, listen, and think" routine.
b- Cleanup: Using water under pressure, wash off accumulations of solid particles, grease, slime, and other material from walkways, handrails, and all other exposed parts of the structure and equipment.
c- Lubrication: Grease all moving equipment according to manufacturer's specifications and check oil levels in motors where appropriate.

Advanced Treatment

Advanced sewage treatment processes typically are used to further reduce the concentrations of suspended solids, nutrients (nitrogen or phosphorus) and soluble organic chemicals in secondary treatment effluent. These processes may be physical, chemical, biological, or a combination of

Sand Filtration

Sand filters have influent and effluent distribution systems consisting of pipes and fittings. Head loss is a measure of solids trapped in the filter. As the filter becomes filled with trapped solids, the efficiency of the filtration process falls off, and the filter must be backwashed. Filters are backwashed by reversing the flow so that the solids in the media are dislodged and can exit the filter; sometimes air is dispersed into the sand bed to scour the media. Sand filters can be automatically backwashed when the differential pressure exceeds a preset limit or when a timer starts the backwash cycle.

Multimedia Filtration

A multimedia filter operates with the finer, denser media at the bottom and the coarser, less dense media at the top. A common arrangement is given as below.

- ✓ Top: Anthracite
- ✓ Middle: Sand
- ✓ Bottom: Garnet

These media can be used alone, such as in sand filtration, or in a multimedia combination.

Some mixing of these layers occurs and is anticipated. During filtration, the removal of the suspended solids is accomplished by a complex process involving one or more mechanisms, such as:

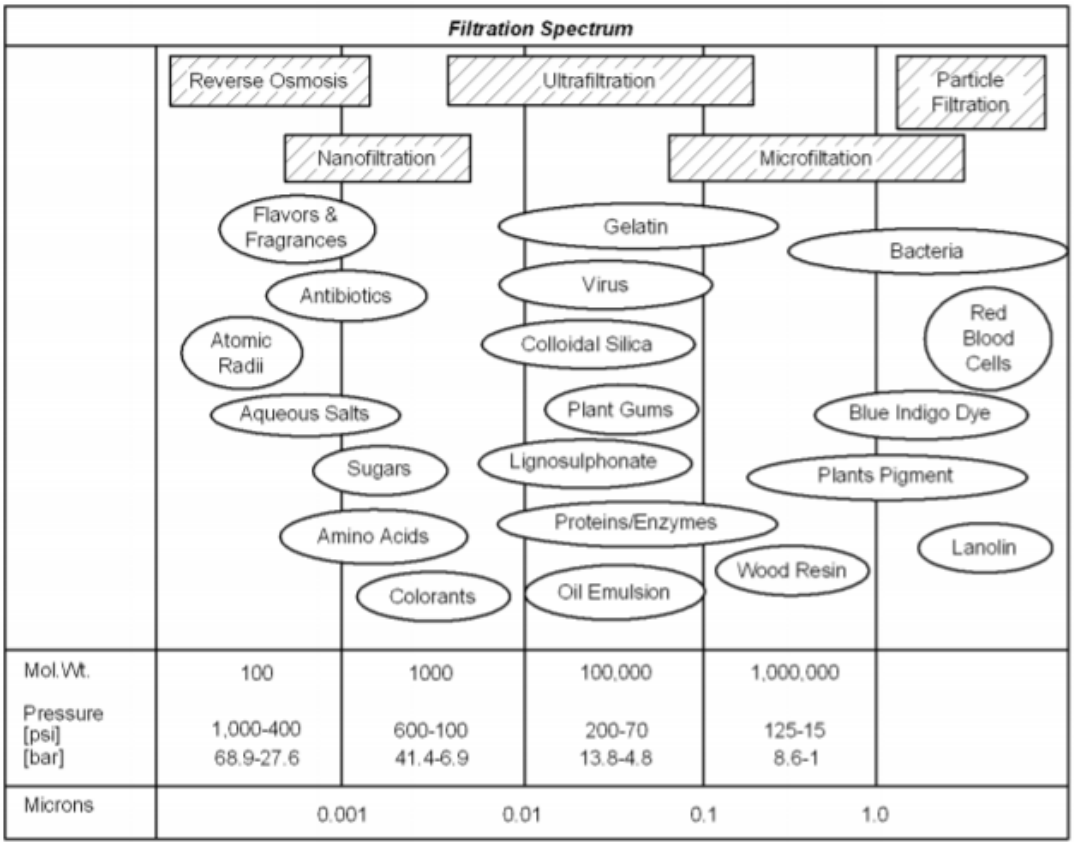
- ✓ Straining,
- ✓ Sedimentation,
- ✓ Interception,
- ✓ Impaction, and
- ✓ Adsorption.

The size of the medium is the principal characteristic that affects the filtration operation. If the medium is too small, much of the driving force will be wasted in overcoming the frictional resistance of the filter bed. If the medium is too large, small particles will travel through the bed, preventing optimum filtration. As same as "sand filtration", back wash is required to keep adequate filtration efficiency.

Membrane Filtration (MF, UF, NF, RO)

Membrane filtration is used for polishing water for specific uses like industry process water, or for aquifer infiltration. In India, membrane filtration is widely used in the water and sewage sectors. (Figure)

MF – Microfiltration membranes are porous membranes with pore sizes between 0.1 and 1 micron (1 micron=1000 nanometre). They allow almost all dissolved solids to get through and retain only solids particles over the pore size.



UF – Ultra filtration membranes are asymmetric or composite membranes with pore sizes4310 around between 0.005 and 0.05 micron. They allow almost mineral salts and organic molecules to get through and retain only macromolecules
NF – Nano filtration membranes are reverse osmosis membranes with pore sizes around 0.001 micron. They retain multivalent ions and organic solutes that are larger than 0.001 micron.
RO – Reverse osmosis membranes are dense skin, asymmetric or composite membranes that let water get through and rejects almost all salts.

CLEAN UP

a- Operational Unit Processes

All membrane filtration systems have associated operational unit processes that are essential for maintaining and optimizing system performance and therefore critical to the successful implementation of the technology. These operational processes include backwashing, chemical cleaning, and integrity testing. For the purposes of this discussion, pre-treatment and post-treatment are also considered operational unit processes associated with membrane filtration. Each of these processes and its role in the operation of a membrane filtration system are described in the following sections. Although not every membrane filtration system utilizes all of these processes, many utilize each process to some degree.

b- Pre-treatment

Pre-treatment is typically applied to the feed water prior to entering the membrane system in order to minimize membrane fouling, but in some cases may be used to address other water quality concerns or treatment objectives. Pre-treatment is most often utilized to remove foulants, optimize recovery and system productivity, and extend membrane life. Pre-treatment may also be used to prevent physical damage to the membranes. Different types of pre-treatment can be used in conjunction with any given membrane filtration system, as determined by site-specific conditions and treatment objectives. Pilot testing can4335 be used to compare various pre-treatment options, optimize pre-treatment, and/or demonstrate pre-treatment performance. Several different types of commonly used pre-treatment for membrane filtration systems are discussed in the following subsections.

c- Pre-filtration

Pre-filtration, including screening or coarse filtration, is a common means of pre-treatment for membrane filtration systems that are designed to remove large particles and debris. Pre-filtration can either be applied to the membrane filtration system as a whole or to each membrane unit separately. The particular pore size associated with the pre-filtration process (where applicable) varies depending on the type of membrane filtration system and the feed water quality. For example, although hollow-fibre microfiltration (MF) and ultra filtration (UF) systems are designed specifically to remove suspended solids, large particulate matter can damage or plug the membrane's fibres.
Because nanofiltration (NF) and reverse osmosis (RO) utilize non-porous semi permeable membranes that cannot be backwashed and are almost exclusively

designed in a spiral-wound configuration for municipal water treatment applications, these systems must utilize much finer pre-filtration in order to minimize exposure of the membranes to particulate matter of any size.

Membrane System		Pre-filtration Requirements	
Classification	Configuration	Size (µm)	Type(s)
Membrane Cartridge Filtration (MCF)*	Cartridge	300 - 3,000	Strainers; Bag Filters
Microfiltration (MF) / Ultra filtration (UF)	Hollow-Fibre, Inside-Out	100 - 300	Strainers; Bag Filters
	Hollow-Fibre, Outside-In	300 - 3,000	Strainers; Bag Filters
Nanofiltration (NF) / Reverse Osmosis (RO)	Spiral-Wound	5 - 20	Cartridge Filters

A summary of the typical pre-filtration requirements associated with the various types of membrane filtration is presented in Table

d- Backwashing

The backwash process for membrane filtration systems is similar in principle to that for conventional media filters and is designed to remove contaminants accumulated on the membrane surface. Each membrane unit is backwashed separately and in a staggered pattern so as to minimize the number of units in simultaneous backwash at any given time. During a backwash cycle, the direction of flow is reversed for a period ranging from about 30 seconds to 3 minutes. The force and direction of the flow dislodge the contaminants at the membrane surface and wash accumulated solids out through the discharge line. Membrane filtration systems are generally backwashed more frequently than conventional media filters, with intervals of approximately 15 to 60 minutes between backwash events. Typically, the membrane backwash process reduces system productivity in the range of 5 to 10 percent due to the volume of filtrate used during the backwash operation.

Backwashing is conducted periodically according to manufacturer's specifications and site-specific considerations. Although more frequent backwashing allows for higher fluxes, this benefit is counterbalanced by the decrease in system productivity. In general, a backwash cycle is triggered when a performance-based benchmark is exceeded, such as a threshold for operating time, volumetric throughput, increase in transmembrane pressure (TMP), and/or flux decline. Ideally, the backwash process restores the TMP to its baseline (i.e., clean) level; however, most membranes exhibit a gradual increase in the TMP that is observed after each backwash, indicating the accumulation of foulants that cannot be removed by the backwash process alone. These foulants are addressed through chemical cleaning. Because the design of spiral-wound membranes generally does not permit reverse flow, NF and RO membrane systems are not backwashed. For these systems, membrane fouling is controlled primarily with chemical cleaning, as well as through flux control and cross flow velocity. The inability of spiral-wound membranes to be backwashed is one reason that NF and RO membranes are seldom applied to directly treat water with high turbidity and/or suspended solids.

e- Chemical Cleaning

Chemical cleaning is another means of controlling membrane fouling, particularly those foulants such as inorganic scaling and some forms of organic and biofouling that are not removed via the backwash process. As with backwashing, chemical cleaning is

conducted for each membrane unit separately and is typically staggered to minimize the number of units undergoing cleaning at any time. While chemical cleaning is conducted on both MF/UF and NF/RO systems, because non-porous, semi-permeable membranes cannot be backwashed, chemical cleaning represents the primary means of removing foulants in4395 NF/RO systems. Although cleaning intervals may vary widely on a system-by-system basis, the gradual accumulation of foulants makes eventual chemical cleaning virtually inevitable. Membrane cartridge filters are an exception, however, in that cartridge filters are usually designed to be disposable and thus are typically not subject to chemical cleaning (Table).

Category	Chemicals Commonly Used	Typical Target Contaminant (s)
Acid	· Citric Acid ($C_6H_8O_7$) · Hydrochloric Acid (HCl)	Inorganic scale
Base	· Caustic (NaOH)	Organics
Oxidants / Disinfectants	· Sodium Hypochlorite (NaOCl) · Chlorine (Cl_2) Gas · Hydrogen Peroxide (H_2O_2)	Organics; Biofilms
Surfactants	· Various	Organics; Inert particles

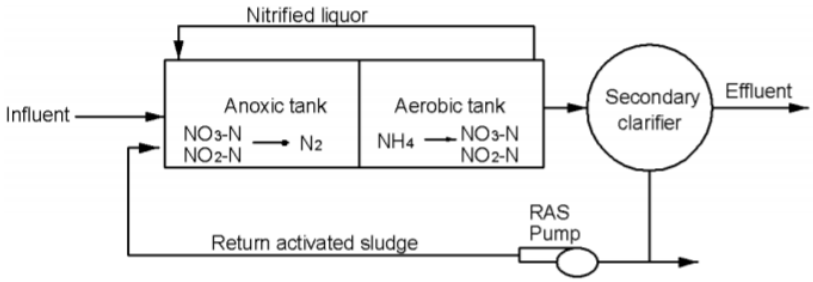
As with backwashing, the goal of chemical cleaning is to restore the TMP of the system to its baseline (i.e., clean) level. Any foulant that is removed by either the backwash or chemical cleaning process is known as reversible fouling. Over time, membrane processes will also typically experience some degree of irreversible fouling which cannot be removed through either chemical cleaning or backwashing. Irreversible fouling occurs in all virtually membrane systems, albeit over a wide range of rates, and eventually necessitates membrane replacement.

Integrated Nutrient Removal

Nutrient Removal

Sewage may contain high levels of the nutrients nitrogen and phosphorus. Excessive release of these nutrients to the environment can lead to a buildup of nutrients, called eutrophication, which can in turn encourage the overgrowth of weeds, algae, and cyanobacteria (blue-green algae). This may cause an algal bloom, a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing deoxygenation, some algal species produce toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

Nitrogen Removal



Nitrogen is removed through the biological oxidation of nitrogen from ammonia to nitrate (nitrification), followed by denitrification, i.e., the reduction of nitrate to nitrogen gas. (Figure)

Nitrogen gas is released into the atmosphere and thus removed from the water. Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria. The oxidation of ammonia (NH3) to nitrite (NO2 –) is most often facilitated by Nitrosomonas spp. (nitroso referring to the formation of a nitroso functional group). Nitrite oxidation to nitrate (NO3 –), though traditionally believed to be facilitated by Nitrobacter spp. (nitro referring the formation of a nitro functional group), is now known to be facilitated in the environment almost exclusively by Nitrospira spp.

Denitrification requires anoxic conditions to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagoons and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job the most easily. Since denitrification is the reduction of nitrate to nitrogen gas, an electron donor.

This can be, depending on the sewage, organic matter (from faeces), sulphide, or an added donor like methanol. Sometimes the conversion of toxic ammonia to nitrate alone is referred to as tertiary treatment. Many sewage treatment plants use axial flow pumps to transfer the nitrified mixed liquor from the aeration zone to the anoxic zone for denitrification. These pumps are often referred to as Internal Mixed Liquor Recycle (IMLR) pumps.

Process Control

Operators of biological nitrogen removal (BNR) facilities need more process-control knowledge4445 than those of conventional treatment facilities to keep them operating smoothly. The key operating parameters for a BNR facility typically include:

a- SRT: SRT is the key to understanding whether the BNR process has enough time to function effectively. When evaluating SRT, operators should answer such questions as:
   - ✓ Is the SRT long enough to establish nitrification?
   - ✓ How much sludge should be wasted to maintain a desired SRT?
   - ✓ Can the SRT be increased by maintaining a higher MLSS?

b- F/M Ratio: The F/M ratio is a good indicator of how well selector reactors will promote the growth of floc-forming bacteria. When the F/M ratio is high, floc-forming bacteria have a competitive advantage over filamentous bacteria. Selector loading also helps ensure that nuisance bacteria will not cause operating problems. The selector cells should be arranged so BOD is taken up rapidly.

c- HRT: Although not used in daily BNR operations, HRT indicates whether the plant is operating within a normal contact time. Nitrifying facilities, such as conventional activated sludge and A2O, typically have an HRT between 5 and 15 hours.
d- Oxygen Levels: When a conventional activated sludge system is converted into a BNR facility, its dissolved oxygen requirements typically increase, requiring changes in the aeration equipment or diffuser layout.
e- Alkalinity and pH Control: Every time 1 mg of ammonia-nitrogen is oxidized to nitrate, 7.14 mg of alkalinity is consumed. Likewise, every time 1 mg of nitrate is converted to nitrogen gas, 3.57 mg of alkalinity is recovered.
f- ORP (Oxidation–Reduction Potential): Automated control systems for the internal anoxic mixing process measure the ORP so they can detect nitrate depletion in the mixed liquor. This variable indirectly measures nitrate availability in an aqueous media, although there is no direct correlation between any specific ORP value and nitrate concentration.

Oxidation–reduction potential measures the net electron activity of all oxidation–reduction reactions occurring in sewage. It is affected by temperature, pH, biological activity, and the system's chemical constituents, but its response pattern to changes in a solution's oxidative state is reproducible in a specific system. In continuous-flow suspended-growth systems, the control system's ORP breakpoints must be constantly reviewed and revised. In batch systems (e.g., SBR or cyclic aeration systems), however, a characteristic "knee" (change in ORP values) indicates when the system is changing from an oxidized state to a reduced one.

g- Recycle Flows: For sewage facilities with either ammonia and/or nitrate limitations, it will be necessary to adjust recycle flows (typically RAS flow) to achieve operational goals.
h- Secondary Clarification: It is essential that the secondary clarifier be able to both separate biological solids from the treated effluent and also concentrate the solids without a build-up of sludge within the clarifier. Parameters of concern with clarification are the hydraulic loading rate (HLR) and the solids loading rate (SLR).

Phosphorus Removal

Phosphorus removal is important as it is a limiting nutrient for algae growth in many fresh water systems. It is also particularly essential for water reuse systems where high phosphorus4495 concentrations may lead to fouling of downstream equipment such as reverse osmosis.

Phosphorus removal in excess of metabolic requirements can be achieved by using enhanced biological phosphorus removal (EBPR) or chemical addition.

Phosphorus can be removed biologically in a process called enhanced biological phosphorus removal In this process, specific bacteria, called Polyphosphate Accumulating Organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20 percent of their mass). When the biomass enriched in these bacteria is separated from the treated water, these biosolids (sludge) have a high fertilizer value.

The EBPR process consists of anaerobic and aerobic zones. By definition, an anaerobic zone contains no usable dissolved oxygen or nitrate. In this zone, PAOs do not grow, but consume and convert readily available organic material (i.e. VFAs) to energy-rich carbon polymers called poly-hydroxyalkanoates (PHA). The energy required for this reaction is generated through breakdown of the stored polyphosphate (poly-P) molecules, which results in phosphorus release and an increase in the bulk liquid soluble phosphorus concentration in the anaerobic stage. Magnesium and potassium ions are concurrently released to the anaerobic medium with phosphate. In addition, for a substantial amount of reducing power is required PAOs to produce PHA. The breakdown of glycogen, another form of internal carbon storage, generates the reducing power.

Phosphorus removal can also be achieved by chemical precipitation, usually with salts of iron (e.g. ferric chloride), aluminium (e.g. alum), or lime. This may lead to excessive sludge production as hydroxides precipitate and the added chemicals can be expensive. Chemical phosphorus removal requires significantly smaller equipment footprint than biological removal, is easier to operate and is often more reliable than biological phosphorus removal. Another method for phosphorus removal is the use of granular laterite. Once removed, phosphorus, in the form of a phosphate-rich sludge, may be stored in a land fill or resold for use in fertilizers.4520

Disinfection Facility

Disinfection of effluent from water reclamation facilities (WRFs) is required to decrease the disease risks associated with the discharge of sewage containing human pathogens (disease causing organisms) into receiving waters. These microorganisms are present in large numbers in sewage effluents.

The chlorine gas is controlled, metered, introduced into a stream of injector water and then conducted as a solution to the point of application. The primary advantage of vacuum operation is safety. If a failure or breakage occurs in the vacuum system, the chlorinator either stops the flow of chlorine into the equipment or allows air to enter the vacuum system rather than allowing chlorine to escape into the surrounding atmosphere. In case the chlorine inlet shutoff fails, a vent valve discharges the incoming gas to the outside of the chlorinator building.

The operating vacuum is provided by a hydraulic injector. The injector operating water absorbs the chlorine gas and the resultant chlorine solution is conveyed to a chlorine diffuser through corrosion resistant conduit. A vacuum chlorinator also includes a vacuum regulating valve to dampen fluctuations and allow smooth operation. Vacuum relief prevents excessive vacuum within the equipment.

Chlorine gas flows from the chlorine container to the gas inlet. After entering the chlorinator, the gas passes through spring-loaded pressure regulating valve which maintains the proper operating pressure. A rotameter is used to indicate the rate of gas flow. The rate is controlled by V-notch variable orifice. The gas then moves to the injector where it dissolved in water and leaves the chlorinator as a chlorine solution (HOCl) ready for application.

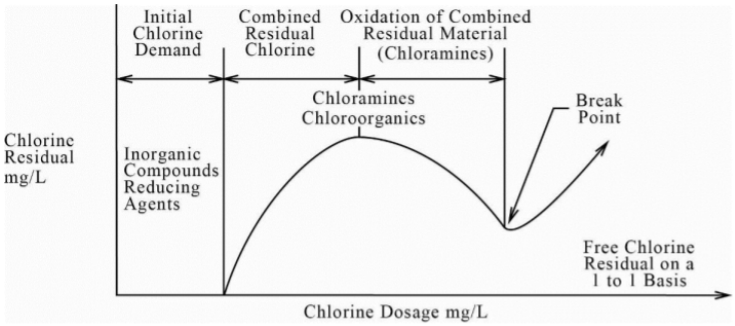
Operational Variables

The process-control variables associated with chlorination systems are:

a- Detention (Contact) Time: The chlorine solution is best injected into the effluent via a diffuser or, preferably, a flash mixer. Otherwise, some of the chlorine gas could come out of solution undissolved (stratification). This would impair the efficiency of disinfection and increase its costs. Typically, depending on the STP's (sewage treatment plant's) permit requirements or the state or regional regulatory requirements, chlorine detention time should range from 30 to 60 minutes at the average daily flow (ADF) and should equal or exceed 15 minutes at peak flows. Such detention times allow a safety factor for possible hydraulic inefficiency of the contact chamber, thus maximizing pathogen inactivation.

b- Chlorine Residual: Depending on the effluent-disposal method (receiving-water discharge or reclaimed-water4555 reuse) the permit may require a chlorine residual in the contact chamber effluent. The three types of chlorine residuals are combined, free, and total. Free and total residuals are typically monitored.

The combined residual consists of chloramines and chloro-organic compounds that are formed by the reaction of chlorine with ammonia and organic compounds in the secondary or tertiary effluent. Each milligram per litre of ammonia consumes 10 mg/L of chlorine. The chlorine dose that satisfies the ammonia's chlorine demand is called the breakpoint. Note that the combined residual decreases slightly as the chloramines and chloro-organic compounds are oxidized at a narrow range of chlorine doses less than the breakpoint (Figure)



c- Indicator Bacteria Results Regardless of the chlorine residual method employed enough chlorine solution must be injected into the effluent to sufficiently destroy or inactivate the indicator bacteria that signal the likely presence of pathogens. The primary objective of chlorination is to destroy pathogenic organisms; however, the coliform bacteria often used as indicators are not pathogenic. The indicator bacteria inactivation concept works because coliform and other indicator bacteria are much easier to detect than pathogens and more difficult to destroy than most pathogens, except possibly viruses.

Testing directly for pathogens is complex and costly. If the coliform count has been sufficiently reduced through disinfection, a corresponding proportion of pathogens has probably been inactivated.

Operational Hazards

a- Chlorine Hazards: Chlorine is a gas, 2.5 times heavier than air, extremely toxic, and corrosive in moist atmospheres. Dry chlorine gas can be safely handled in steel containers and piping, but with moisture it must be handled in corrosion-resisting materials such as silver, glass, Teflon, and certain other plastics.

Chlorine gas at container pressure should never be piped in silver, glass, Teflon, or any other plastic material. Even in dry atmospheres, the gas is very irritating to the mucous membranes of the nose, to the throat, and to the lungs; a very small percentage in the air causes severe coughing. Heavy exposure can be fatal.

b- Warning When entering a room that may contain chlorine gas, open the door slightly and check for the smell of chlorine. Never go into a room containing chlorine gas with harmful concentrations in the air without a self-contained air supply, protective clothing, and help standing by. Help may be obtained from your chlorine supplier and your local fire department.

Maintenance

Routine operations and troubleshooting Table lists routine operational checks of chlorination equipment and remedies if these checks indicate potential problems.

Items	What to check	Potential problems	Corrective actions
Record scale reading	Usage	Degrading effluent increases chlorine demand (nitrite demand increases use)	Monitor dose and demand. Adjust process to improve effluent quality.
		Low scale weight, chlorine about to run out	Replace container or cylinder before scale reaches zero to prevent sediment from entering system.*
Chlorine lines, valves, and Unions	Erratic reading	Scale not tared out properly	If necessary, retare or calibrate scale.
	Presence of chlorine leaks	Personal injury (potential death), evacuation logistics, and corrosion of nearby equipment and electronics	Work with a trained assistant, wear SCBAs (Self-Contained Breathing Apparatus), and follow all appropriate safety procedures when closing container or cylinder main valve and evacuating chlorination pipe network. Repair all leaks immediately; they will only get worse. Notify emergency response teams if required.
	Iced container or cylinder	Chlorination rate too high	Reduce chlorination rate, or manifold containers or cylinders together. If an evaporator is being used, be certain liquid chlorine is being withdrawn from the container's bottom valve.
Solution lines	Leaks	Chlorine evaporating	Repair all leaks immediately. Evacuate chlorine network and repair PVC pipes. Follow all appropriate safety procedures when working with any chlorine leak.
System gauges	Gauges	Chlorination system downtime	Correct all potential problems immediately.
	Main manifold pressure	Could break rupture disk?	If necessary, evacuate network and replace rupture disk. Check all network valves for correct positioning.

Operation & Maintenance of DEWATS and Johkasou

The package treatment plants like Johkasou and also DEWATS have to be maintained as per the in accordance with the instructional procedures of the respective vendors of these systems.

Preventive Maintenance

Preventive Maintenance addresses the civil, mechanical, electrical, instrumentation and automation aspects. In respect of civil works, follow the local rules, regulations and guidelines of the local Public Works Department (PWD). These procedures are mostly annual. It will be better to hand over such maintenance to the PWD and remit the costs to that department. In respect of mechanical equipment, it is better to enter into a contract with the contractor who has built the STP to do this as per the directions of the equipment suppliers and retain the equipment supplier to check and certify the work. In respect of the electrical installations, it is better to entrust this work to the local Electricity Department, similar to civil works. In respect of instrumentation and automation, similarly, entrust the work to the contractor who supplied and erected these and retain a third party agency to certify the proper completion of the work.

Record Keeping

The importance of maintaining adequate O&M records cannot be overemphasized. The purpose of recording data is to track operational information that will identify and duplicate optimum operating conditions. Records of the volume and concentration of waste sludge fed to the digester and volume and concentration of digested solids removed from the digester should be kept. Additional information that needs to be maintained, include DO concentration and pH. Keep a monthly report form. In plants where the aeration system capacity is marginally adequate in providing desirable DO concentration in the digester, record DO concentration data on a trend chart. If chemicals are added to the digester for pH or odour control, record the type and amount of chemicals added. If mechanical aerators are used, record the power usage. In the case of diffused-air systems, air flow records may be of interest. If airflow meters are not available, records of power consumption may be useful. Experimenting with the aeration system often leads to significant savings in power costs.

A record of instrument performance and repairs allow operations or maintenance personnel to properly evaluate an instrument's effectiveness and determine if the instrument meets the objectives used to justify its purchase and installation. As a minimum, the following basic information should be maintained for each instrument in the sewage treatment plant:

- ✓ Plant equipment identification number
- ✓ Model number and serial number
- ✓ Type
- ✓ Dates placed into and removed from service
- ✓ Reasons for removal
- ✓ Location when installed
- ✓ Calibration data and procedures

- ✓ Hours required to perform maintenance
- ✓ Cost of replacement parts
- ✓ Operations and maintenance manual references and their locations
- ✓ Apparatus failure history

UNIT 17

LOCATE AND CLEAR BLOCKAGES WITHIN DOMESTIC SEWERAGE SYSTEMS

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 draincleaning tools and equipment where required

PREPARE FOR WORK

Common Causes of clogged drains & How to fix drain clogs

Whether they carry water or waste, nobody likes the idea of clogged plumbing pipes. If plumbing water encounters a full or partial obstruction, that water will redirect itself and cause reactions that may include anything from backups and flooding to slow drainage and low pressure.

Some issues may cause minor headaches and hassle, while others inflict major damage and expense. Many people want to know how to prevent all types of clogged plumbing situations, or they seek solutions to some type of existing problem. More knowledge about the causes of clogged drains is the best insurance against mishaps, and is always a great preventative measure to take against harmful blockage. What you know can then help to both avoid and identify problems.

It seems like it should be a fairly simple task to find a drain clog and remove it, but fixing clogged pipes can be complex and involved, depending on where the clog is located, what it consists of and what must be done to access and remove it.

LOCATE AND CLEAR BLOCKAGE

Sewer and water drainage systems in a house are configured a little bit like a tree and its branches. There's a main line that's usually biggest in diameter, and sublines run off it that are typically a bit smaller in size. While the toilet is probably the most common place where clogs originate, they can start, build and disrupt function in and from any location in the system.

A blockage can build and lodge itself anywhere, but analysis will help narrow down the possibilities. You'll be able to see what's happening and what exactly the problem affects. If some part of the water or sewer main is clogged, the issue likely affects the whole household or building. If something is stuck in one of the sublines, whatever is happening will more than likely be isolated to one area or section of the building.

Tree roots

Tree roots are widely recognized as the number one cause of blockage and clogs in water and sewer mains. While it's more common to find tree roots invading the pipes of older homes, the roots can find their way into systems of any age. Some experts say the first sign of tree root invasion into the sewer or water line is a gurgling sound.

As living things, the tree roots seek moisture and are more or less naturally drawn to the water in waste and sanitary sewer pipes, especially if one has a crack or springs some other kind of leak.

If you live in a wooded area, or where there are many trees nearby, it's important to be on the lookout for any tree root invasion. Some people decide to have a video inspection done every few years, since the cost for the service is dramatically lower than addressing a neglected issue.

"Flushable" wipes

Flushable wipes can be a detriment to the system. Some cities and other entities responsible for wastewater processing and management have begun to discourage people from using the supposedly flushable wipes. A 2015 report indicated that the City of New York had spent $18 million over five years to deal with all the wipes clogging up the wastewater system.

These moist bathroom wipes, which have grown popular in recent years, have also prompted lawsuits over claims that the products disintegrate after they're flushed. Allegedly, they don't break up when flushed, and are only called "flushable" due to their ability to physically fit into the pipe.

From small cities to the Federal Trade Commission, wipes and their impact on public systems have become a big deal — so much so that millions of dollars are said to be at stake, and public-education campaigns are active in multiple states and cities. Some water treatment entities have dealt with the problem by buying expensive industrial shredders to process the wipes.

The truth about thick toilet paper, paper towels, facial tissue, light cardboard and other paper products is that they're not made to be flushed down the toilet. Home and

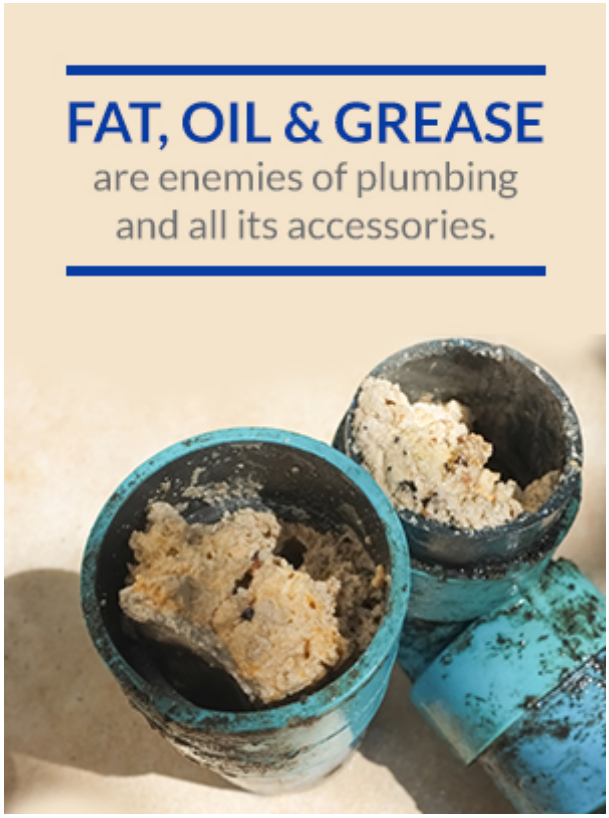
commercial plumbing systems have the capacity to accept and process water, human waste and biodegradable toilet paper. That's it.

Feminine hygiene

Feminine hygieneproducts and baby diapers pose a danger to plumbing pipes because they do not biodegrade and contain cotton and other fibers that have tremendous capacity to clog and attract other clogging agents. Neither are biodegradable, and both pose a threat to public and private systems alike.

The sewer treatment contains microorganisms that break down the human waste, but they do not disintegrate anything but that — even when pad wrappers and tampon applicators may claim to be "flushable."

Fat, oil and grease



Fat, oil and grease are enemies of plumbing and all its accessories. Another increasingly publicized movement is one to educate consumers about the benefits of keeping oily substances from going down the drain, where they can build up and cause clogs. Employees in a commercial establishment must have specialized training on what does and does not belong in the drain and public system, but people in many private places could benefit from the same knowledge.

We like to think that most of us know better than to pour a pan of bacon grease down the drain or garbage disposal, but we may not think of some of the other things that contain fat, oil or grease. For examples: trimmings from a steak or other meat, butter, vegetable oil, chocolate, cream and more.

It's easy to think that water just washes everything along, but fats are sticky, binding substances that are prone to causing buildups and eventually clogs. The trash can is a far better place to dispose of fat, oil or grease. Bacon grease and many other fats and oils can be left to cool and will solidify or congeal for easy cleanup. Another preferred practice is to pour the oil or grease into a disposable container and then toss it in the trash.

Pipe scale

Pipe scale is a product of nature that interacts with your pipes and can actually build to the point where you have a clog or blockage from the mineral deposits water leaves behind. Scale deposits usually result from dissolved calcium and magnesium and sometimes other metallic elements that are left behind as water flows.

These particles react to temperature as well as constant wet-dry conditions. The scale begins to collect in one spot, which attracts more scale until it grows to an obstructive size. Not only does mineral scale build up inside pipes, but it can also affect other water-using appliances, such as the clothes and dish washers.

Food

Food bits and chunks should be placed in the garbage — never in the sink, bathtub or laundry drains. It especially should not be flushed down the toilet. None of these drains tolerate much of it, because that isn't what they were designed to carry. Edibles can be sticky, stringy, sharp or hard, none of which will be good in a water pipe.

While we'll discuss garbage disposals in greater detail a bit later, know that certain foods are wholly incompatible with even powerful garbage disposal systems. The key to disposals is that they cut the material into tiny pieces that will travel through the drainage pipe without accumulation. Unfortunately, many of the foods we eat aren't easily shredded.

Disintegration

Disintegration of the pipes can happen, especially with older homes or homes that may have aging concrete, clay or terra cotta pipes. Joints can come apart and drop and soil can erode away, which allows the pipe to sag.

Where it freezes hard in the winter, there exists the possibility that pipes can shift under the continuous pressure and heave of the freeze-thaw process. Even with

modern pipes that are usually made of a super-hardened plastic, damage is possible simply from natural soil shifts and seasonal changes.

Nature

Nature sometimes works its way into sewer or water lines, especially where pipes have separated. Leaves, sticks, dirt, rocks and even rodents can create blockages underground that are difficult to detect. Leaves are pervasive and efficient clogging agents, so it's generally a good practice to keep the yard clear of them and definitely not wash them down the storm sewer drain.

We've all seen a tiny weed sneak through the smallest of cracks, and any breach in the plumbing pipes is an opportunity for roots, plants and soil to invade, build and end in blockage.

Objects

Objects such as bar soap can break off in chunks and become lodged in the drain, as well as other things that should not end up in there, such as jewelry, children's toys, condoms, dental floss and food. Again, nothing but water, human waste and degradable toilet paper should go down the system.

The importance of that concept is proven by many articles and entire programs on "how to train" small, learning children and by numerous, humorous bathroom signs that remind adults to only deposit the basics.

Combinations

Combinations of materials can also team up and stick together to form a big, gooey ball of blockage that leads to strange sounds, slow drains and, eventually, backups. Soaps

and detergents can build up, attract other materials and create a clog, especially in septic system drain fields.

The recommendation from laundry experts is to use soaps that do not contain phosphates and which have natural (or no) surfactants, as opposed to ones developed from a petrochemical product. They also advise that those with a septic drain field pace the rate at which they wash clothes, instead of washing them one load after the other, so the system has time to work and doesn't get overwhelmed.

Slope

Slope of the sewer and water pipes must be correct, or it will cause drainage problems and possibly blockage. Gravity drives most of the function of water systems, so it's crucial that the pipes have the correct slope to flow properly. The standard pitch of any drainage pipe should be at least 1/4 inch per foot, and sometimes more if some other characteristics of the terrain or household demand more slope to properly process the water and waste.

Undersized

Undersized sewer pipes can be the root cause of blockage and clogs. Unless you've been the sole owner of a property since its structures were newly built, it might be difficult or impossible to ascertain its complete plumbing history. Sometimes, people add onto a home or building without compensating for the added plumbing load, and there are plenty of instances where an unlicensed technician or inexperienced do-it-yourselfer miscalculated the system loads.

The size of sewer drain piping used in a home or other building is determined by the number of water-using units, such as toilets, sinks and bathtubs, that discharge to it. A widely accepted minimum standard for the main drain of a home is four inches in diameter, but many plumbers and consumers will go with one bigger than that based on household needs and usage.

Overload

Overload is also possible, even when the sewer main is properly sized — particularly if the household is on a septic system and its waste capacity has grown. The drain field and other workings of a septic system can become overwhelmed and fail to drain, which usually produces bad smells and/or backups.

Leaks

Leaks are an enemy of the sewer and main drains, because if water is leaking out underground, the soil will erode as well as become soaked, which will allow the pipe to drop, sag or otherwise change position. The leaking water changes the chemical composition of the soils around it, so the pipe becomes displaced and may even break.

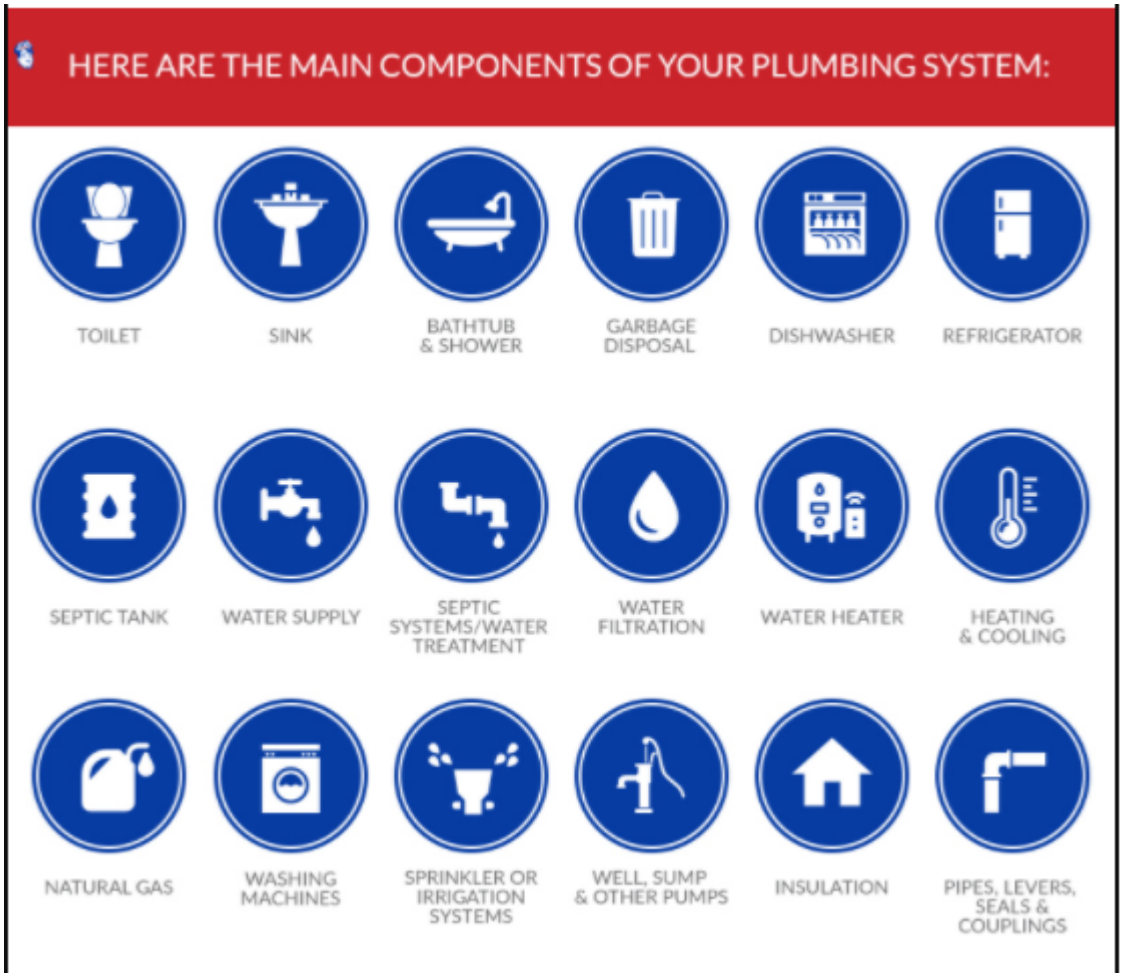
Cat litter

Cat litterbelongs in the trash and not down the toilet or any drain, and the same is true for dog waste in a bag. All kitty litter is made of clay-based material that can actually harden like concrete when it's been wet and dry enough times. The litter pieces are sharp and can easily catch on other things, which only increases the chances of a clog.

Ask An Expert

Know the Main Components and How They Work Together

Modern plumbing concerns the many interconnected systems within a home that we rely on for comfort, convenience, cleanliness and, to a certain extent, safety. Here are the main components of your plumbing system:



- ✓ Toilet
- ✓ Sink
- ✓ Bathtub and shower
- ✓ Garbage disposal
- ✓ Dishwasher
- ✓ Refrigerator
- ✓ Septic tank
- ✓ Water supply (both public and private wells)
- ✓ Septic systems/water treatment
- ✓ Water filtration
- ✓ Water heater
- ✓ Heating and cooling
- ✓ Natural gas
- ✓ Washing machines
- ✓ Sprinkler or irrigation systems
- ✓ Well, sump and other pumps
- ✓ Insulation
- ✓ Pipes, levers, seals and couplings

When any of these utilities cease to function, or don't work as well as they should, this not only disrupts our comfort, but may also cause enormous expenses if damage occurs. More good preventative actions we can take against clogs and their ensuing problems include keeping a watchful eye on all the systems and reacting quickly,

rather than procrastinating or ignoring it, when one shows signs of trouble or substandard performance.

Inspections, regular maintenance and a general awareness of overall operations will help keep your plumbing systems running smoothly. A professional, knowledgeable, service-minded plumbing partner such as Mr. Rooter Plumbing of Greater Syracuse can give assistance with repairs and maintenance, as well as overall plumbing system service plans.

There are two main types of drainage systems found in homes and buildings: those for water used by humans and those for water that falls as rain.

We tend to think of wastewater as only what we flush down the toilet, but it also includes the used water from our washing machines, sinks, showers and other water-using utilities and appliances. That water gets drained from each area of the house or other building to a house or main drain, which then routes it to either a private septic system or to a public wastewater treatment plant.

Water that falls as rain in urban areas usually runs into a storm sewer system that's eventually routed to a water body, such as a lake or river, or sometimes a retention pond designed to hold and filter the water. In both commercial and residential settings, there can be private utilities for outdoor drainage, such as a dry well or catch basin, to help route and naturally filter storm water.

The storm water and wastewater systems are typically separate, but there are conditions under which storm water is also routed to a septic system or wastewater treatment facility. Since wastewater drainage pipes are buried beneath the frost line of an area, they're required to have cleanout points every 50 feet. These usually consist of a capped piece of white pipe that visibly sticks out of the ground.

While most of us would agree that a sewage backup is probably the bigger nightmare, both storm water and wastewater drainage systems can develop clogs and cause headaches.

Signs of a Possible Clog

Clogs can develop in any part of the plumbing system, including drain blockage outside or inside. Some clues are more obvious than others, partly because so much of the system exists under the ground or in the walls where we don't see it.

For example, water spraying from a pipe joint or standing in the sink would be easy to spot, but it's not as easy to determine why a drain has slowed over time, or to discover the existence of an underground leak.

Particularly in the parts of the system that handle waste, our worst fear may be that water backs up and overflows from the toilet, septic or sewer system. Clogged and blocked drainage systems most often cause this nightmare scenario, which would include possible damage to the sewage line, septic system or other components. The possibility of a mishap make it even more practical to become savvy about drain blockage causes.

To get to the cause, you first have to realize and detect the problem. There are several signs that might indicate you have a clog, or that one may be developing.

- ✓ When water or sewage backs up into a toilet, sink, bathtub or anywhere inside or outside, especially in low spots, such as basement toilets and showers.
- ✓ When the drain makes a gurgling noise as other plumbing functions take place. Under normal circumstances, when the water flows unimpeded through the pipe, it shouldn't make a lot of noise other than maybe a smooth flowing sound. However, when there's a clog in the sewer or water pipe, water hits it and releases oxygen, causing bubbles that make noise and even release smelly gases.
- ✓ When the shower, tub or sink drains slowly — for example, if your feet are submerged during the shower.
- ✓ When there's poor pressure in parts or all of the system, which could be noticeable in the sink or shower and probably produce a weak toilet flush.
- ✓ If the utilities that use water react to each other, such as the toilet making noise when the washer stops or starts.
- ✓ When there's a foul odor present, it sometimes means there's a wad of goop or something accumulating within the drain. As you can imagine, whatever is causing the blockage probably doesn't have a pleasant smell.
- ✓ When water backs up in drains as other utilities are used.
- ✓ When you run water in the sink closest to the toilet for a few minutes and it produces bubbles in the toilet, this can indicate that the problem is in the sewer main and not the toilet itself.
- ✓ If the system becomes overwhelmed easily — for example, when only one utility at a time can drain well.
- ✓ When water gathers around the floor drain in a basement, or there's saturated soil or pooling water in the yard.

Preventative Measures: What You Can Do

The list of things to do that may help reduce the chance of a clog or blockage could go on, but we've included some precautionary information that comes from a place of

experience and is based on what plumbers see and treat in the commercial and residential service world.

Camera inspection: One of the most unnerving thing for homeowners is having some of the plumbing components underground and out of sight. Sewer and house main drains exist beneath the frost level, which, for the Syracuse area, is 42 inches. If a clog does develop, it may seem impossible to determine its location.
The subsurface cameras of today eliminate that concern, since they can be placed into the system to see what we cannot, including the exact location and even composition of the troublesome clog or blockage.

In the way of maintenance, there's no clearer picture than a subsurface video inspection to make sure no cracks or other breaches have developed in any of the pipes. A thorough video inspection can help prospective home buyers to know that elusive plumbing history, or help someone find and retrieve a lost item of value. Cameras have all but replaced all the digging, ripping and disruption of past clog-clearing and problem-finding techniques.

The accuracy of a video inspection eliminates guesswork and expense repairs, since service or other attention can be directed to exactly where it's needed. The camera can run through the entire system of pipes or look at a particular section. It can illuminate the area and pan around to show nearby conditions.

Toilet tendencies: It can hardly be overemphasized that the only materials that belong in a toilet are water, waste and biodegradable toilet paper. Still, things happen and stuff gets flushed, but a few things can help prevent foreign objects from getting flushed and potentially causing a clog or backup.
You might consider placing lid locks on your toilets to keep out toys and all the other imaginative things young children decide to flush.

It can also help to take precautions and place a lined trash can within arm's reach of the toilet. This is a common feature in commercial settings, where customers expect to be able to change their children at a designated area and dispose of the refuse quickly and without fuss. Maintaining this standard in your bathroom will discourage anyone from being tempted to "just flush" a feminine hygiene product or baby diaper.

In addition, place a plunger beside each toilet so it's never far away when needed. Of all the ways a plumbing system can react to a problem, a toilet overflow is among the least-desired situations. If something weird does go down, it may be better to call a plumber right away rather than to plunge, which could just drive the object farther down the line or lodge it even more tightly in the pipe.

If the object does manage to make it out of your pipes and into either the private or public system, it has the potential to cause damage that might have a high price tag.

Water main awareness: The basic message here: Know where the water main is and how to shut it off, because it will be the most damage-saving step you can take if and when there's a backup or something bursts under pressure.
It might be a lever or wheel-type handle attached to the main water line in the basement, garage or utility closet, depending on how a home is configured. Each individual home has a shutoff valve within it and usually somewhere outside, too — especially those with a public water supply.

Many times, you can learn where the main is located just by looking around and doing some logical testing after you turn the lever or handle, and in some cases, it's conveniently marked "main." If you look but aren't sure about the water main location, a plumber or the local utility professionals can show you where it is and how to turn it on and off.

Most of the water-using appliances in a home or building will also have an individual cutoff valve so each one can be turned off individually, including toilets and sinks.

Provide pressure: Some experts say a well-kept secret of healthy plumbing is to fill each sink with water once or twice a month and let them drain to create pressure that flushes the pipes and removes debris. A full tub would have the same effect. To help fat, oil and grease get off the sides of pipes and traveling through the treatment system, it's helpful to occasionally pour a pan of boiling water down the kitchen sink drains.
Disposal defense: It can literally pay to know what not to put down the disposal. Many food items — even "natural" ones — are tough and fibrous and may not shred the way you expect them to when you toss them in the disposal. Avoid the following:

- ✓ Celery
- ✓ Egg shells
- ✓ Meat, skin and bones
- ✓ Tough fruit rinds, such as watermelon or cantaloupe
- ✓ Pumpkin
- ✓ Potato peels

Garbage disposals are nice to have, but some of us mistake them for trash cans that can pretty much take on anything. In reality, there's a variety of things that the blades don't chop well and are better going in a compost pile or the garbage.

Clogs can also result from simply too much material at once being fed into the disposal, since it's best to feed them gradually and let water run before, during and after operation.

Clean pipes: When it comes to drain cleaning, this term and suggested action may sound like an impossibility because it's hard to think of the sewer pipes or drain as clean, but periodic cleaning ensures proper function. Sewer pipe and drain cleaning service can usually be found for about $150, depending on the area, plumber and travel time involved.
There are several techniques used to clean pipes and clear clogs, including winding snakes, augers, steam and water pressure.

You'll also find many kinds of home remedies, both to clear clogs and to serve as a maintenance cleaning between professional cleanings (see DIY section toward the end). Various combinations of vinegar, lemon juice and baking soda are recommended, and it doesn't hurt to try any of these natural ingredients that have a bubbly, cleansing, chemical reaction when mixed together.

An important point to keep in mind is this: Multiple applications of chemical drain cleaner should be avoided, because too much of the harsh ingredients too often will degrade the inside of pipes and drains.
Compare appliances: Sometimes the behavior of water drainage can be telling, such as how toilets flush and sinks drain when the clothes washer and other appliances are running. Does water back up anywhere when a major water-using appliance is draining its used water? This may indicate a clog or blockage.
Relieve pressure: When the clog or blockage causes a backup of the main line, it's possible to release some of the pressure on the system by removing the cap on the sewer cleanout pipe. If one exists, it will be in the yard — typically a white pipe sticking up outside not far from the building. This can also be a way to check and see if there's a clog or blockage in the main. If you remove the cap and water flows out, that could mean the main is blocked.
Snake or auger: There are tools you basically stick into the proper pipe and they work to loosen and clear the blockage or clog. There are other, similar tools used for the task, such as a kinetic water ram, but most have the goal of clearing the clog. A plumbing auger or snake is typically made of steel and has some kind of aggressive-grab tip.

An auger or a snake can be powered manually, electrically or hydraulically. If you rent or borrow this tool, be sure it has enough power and feet of line to serve your needs.

Analyze water quality and usage: Easy at-home tests can give you good data on the plumbing system. The first is to watch the water bill for increases that don't measure up to usage. If the gallon number spikes with no explanation, it can indicate an underground leak, and sprinkler lines are often where the problem is found.
It's also easy to take some of your water for a test to one of several entities that can tell you exactly what it contains. Many people like the peace of mind once a year from

knowing that the water quality has not changed — especially consumers who are looking to treat their water.

Sooner is better: The best time to investigate any problems is right when you suspect you might be having the problem, because procrastination does not pay when it comes to plumbing. If there's slow drainage, low pressure, gurgling or some of the other signs present in a system, it's much better to pay for a cleaning of the pipes than to pay for cleanup after toilet overflow or complete failure of the sewer main.

DIY Things to Try

Beyond having a solid, basic knowledge of the plumbing system, there are a few things to try when you suspect a clog:

- ✓ Check the visible parts of the drain for hair, scale or foreign objects.
- ✓ Try pouring a panful of boiling water down sinks.
- ✓ Pour a pitcher of water down a toilet that won't flush.
- ✓ Use the recommended amount of drain cleaner, avoiding multiple applications of it.
- ✓ Use a plunger, taking care to use the correct plunger for the job, since a toilet plunger won't work on a sink and vice-versa.
- ✓ Start by pouring one gallon of hot water followed by 1/2 cup baking soda and then wait a few minutes before mixing one cup vinegar with one cup hot water and pouring that in last. This mixture is also good for occasional at-home pipe cleaning.
- ✓ If you suspect the clog is in the p-trap (that U-shaped piece of pipe under most sinks), turn the water off to the sink and place a bucket under the pipe before unscrewing the joints at either end of the U.

CLEAN UP

- ✓ Work area is cleared and materials disposed of, reused or recycled according to legislation, regulations, codes of practice and job.
- ✓ Tools and equipment must be cleaned, checked and maintained and stored.
- ✓ All the necessary documentations must be completed

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