NATIONAL CERTIFICATE III

WATER SUPPLY SYSTEM OPERATION & MAINTENANCE

Student Learning Materials

TVET TVET Authority

Ministry of Environment

ACKNOWLEDGEMENT

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

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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.

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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.

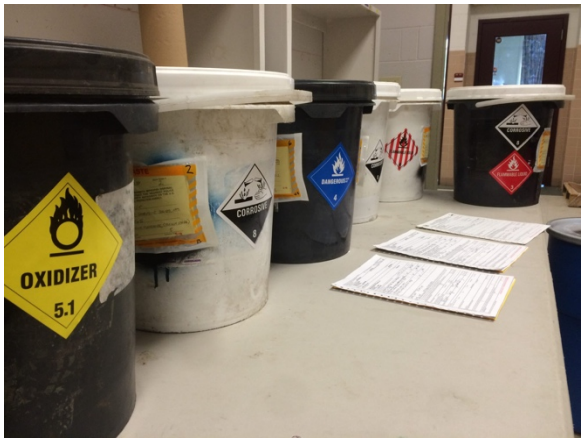
How to clean spillages across work area floors

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:

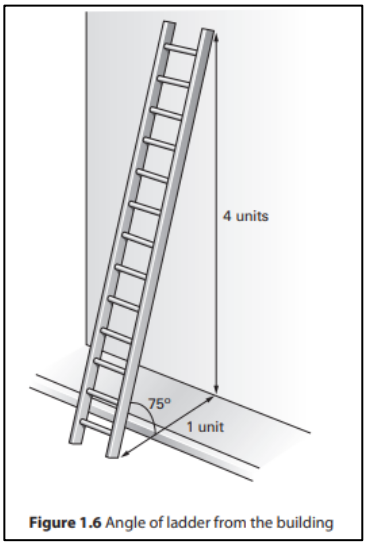
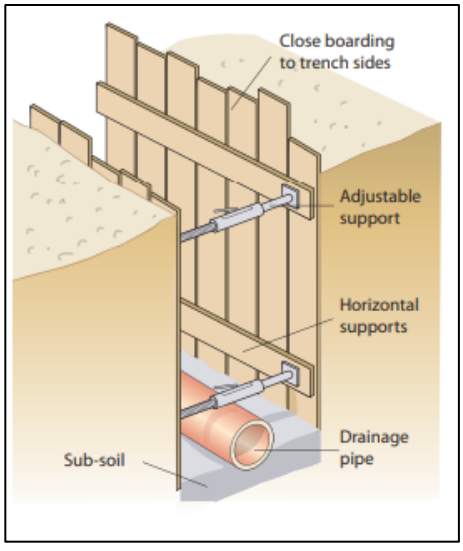


Figure 1.6 Angle of ladder from the building

- ✓ 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.
- ✓ 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

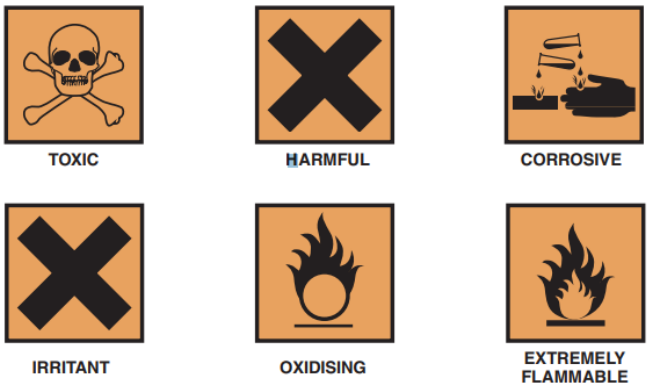
Work in excavations can be particularly hazardous and therefore a risk assessment must be conducted before the work is commenced to ensure that proper control measures are applied to safely do the work. The following are typical measures:



- ✓ 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 you 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 colored 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

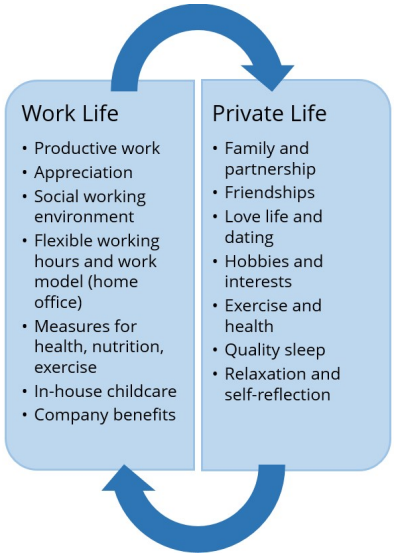
It is important that we have developed purpose to work and provide meaning to the work we do as they add values to the different jobs we perform. It is also believed that clear identification of the purpose and meaning to work are example of good work values and these values have a significant impact 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 goal is not only to make employees more productive, but also happier and more balanced.



Personal and professional life should complement each other

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.

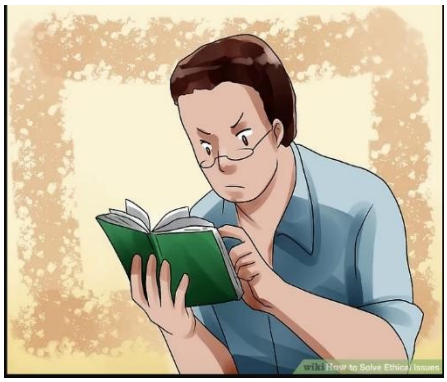
3. **Pinpoint the ethical issues involved.**

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.

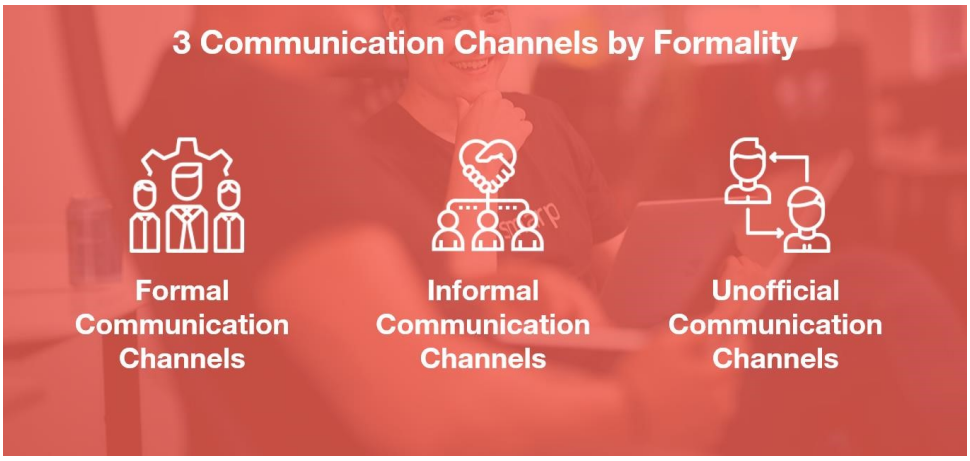
Types of Communication Channels

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.

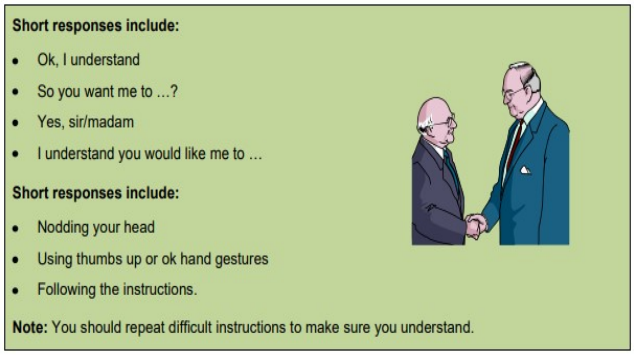
Verbal instructions or requests are responded to at an operational level

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.

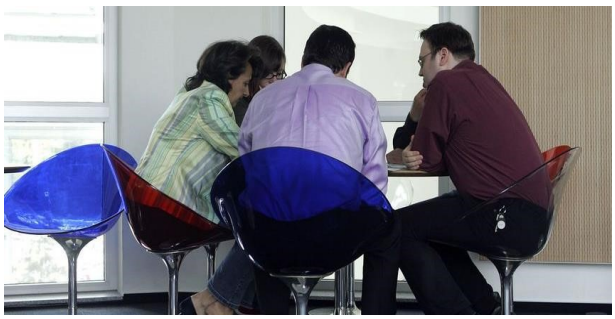
And what about your actual message?

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
- ✓ Realize 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
    - o Value-for-money for the customer
    - o What the opposition is doing
    - o Identified customer expectations
- ✓ Incorporate the standards into a formal plan – this plan should identify:
    - o 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

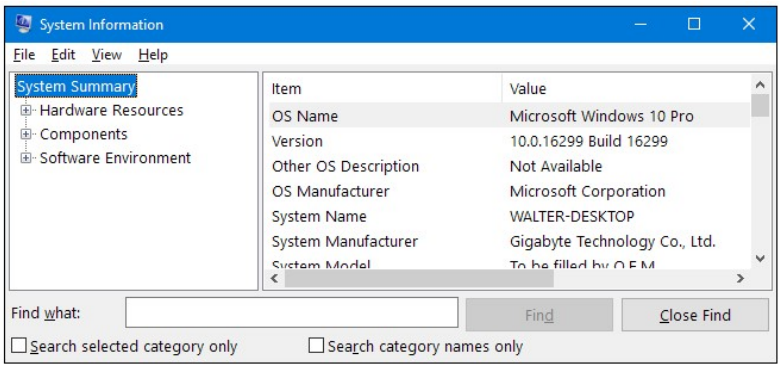
PERFORM COMPUTER OPERATIONS

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.

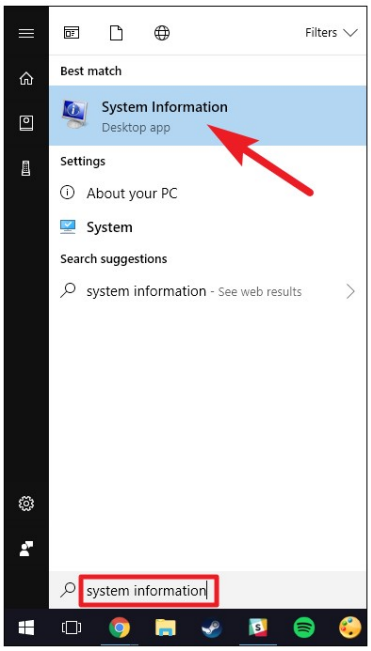
START COMPUTER, SYSTEM INFORMATION AND FEATURES



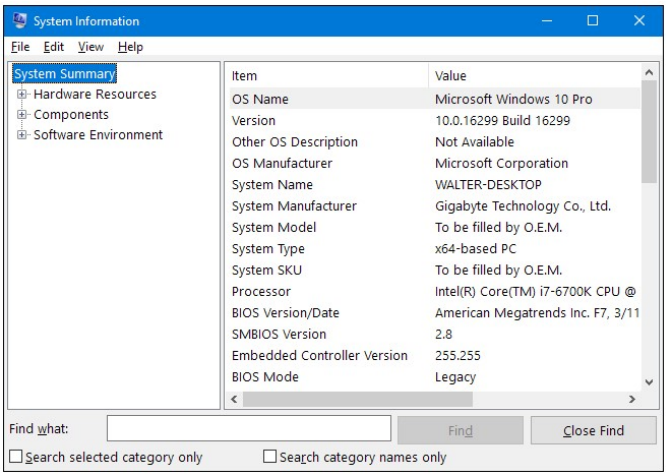
The System Information provides a quick way get information about your system, but how you open it depends on what version of Windows you're using. Here's how to do it.

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.

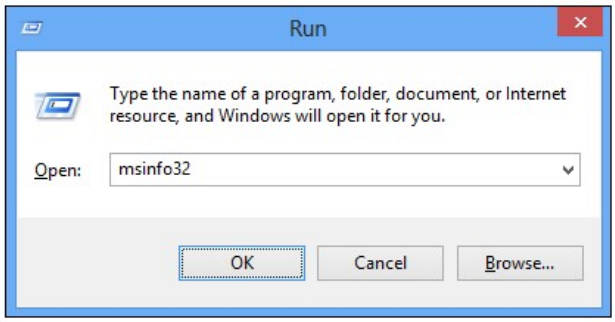


The System Information window opens, giving you access to all kinds of great information about your PC's hardware and software environment.



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.

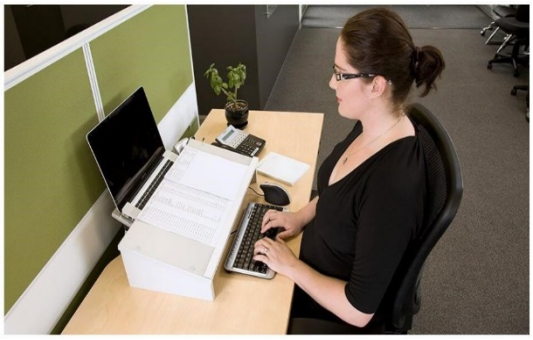
You should immediately see the System Information panel.

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*
   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.
6. *Positioning the armrest height*
   If the armrest can be adjusted, position them so that they fit under the desk.
   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

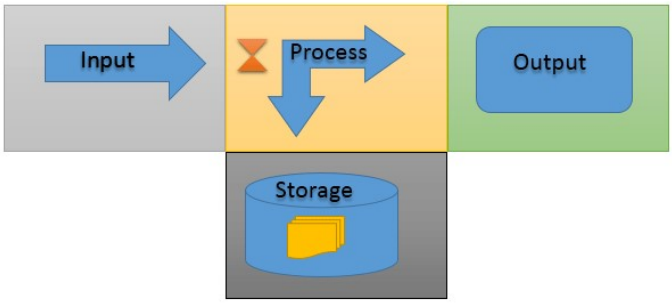
If you have a PC, it's a good idea to buy a 'surge protector'. This prevents your computer being damaged if there's a sudden problem with your electricity supply. You can buy surge protectors that let you plug all your separate pieces of equipment into them, in addition to your computer. Then when you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

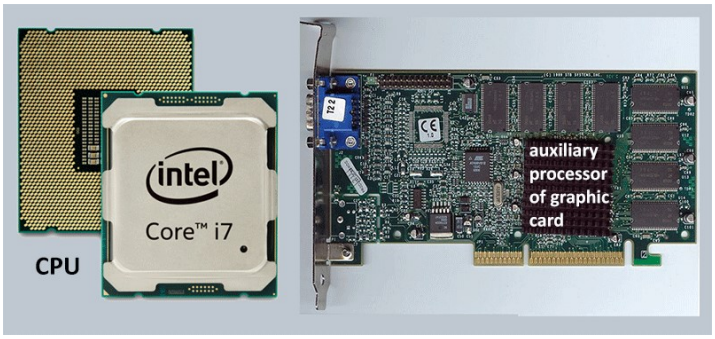
Process function and devices

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.

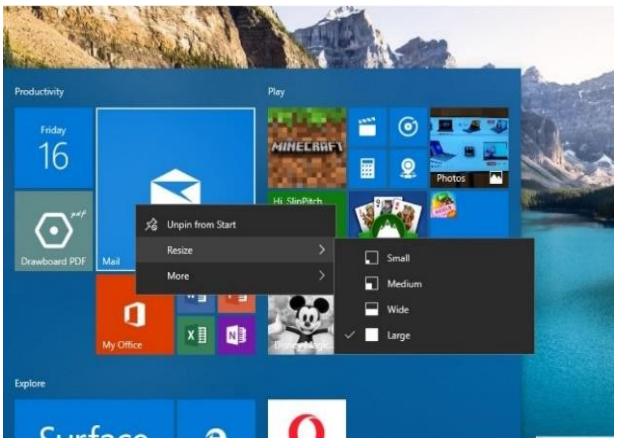
Windows offers many different ways to do the same thing—in this case, launch apps. The Windows 10 Start menu (accessed by clicking the Windows icon in the bottom-left corner) is an amalgamation of Windows 7's list of apps and the tiled interface of Windows 8. Right next to it is the Search box, where 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 icons you pin, the less space you'll have for shortcuts to active windows. If you hover over the Taskbar icons, you'll see 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

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

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.

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.

1. 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.
2. Click apply filter.
3. 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 applicable

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

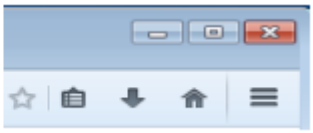
A web browser is a program that lets you see information and images on web sites. A browser reads the information on a web page and displays it on your computer screen. The three most popular web browsers are called "Microsoft Internet Explorer", "Mozilla Firefox", and "Google Chrome". You should be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

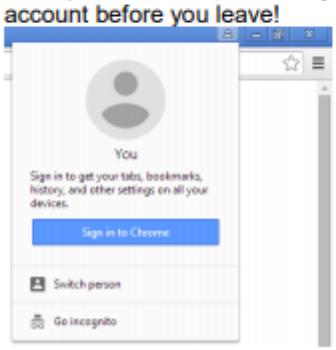
The **Back** button takes you back to the previous web page that you viewed.

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.

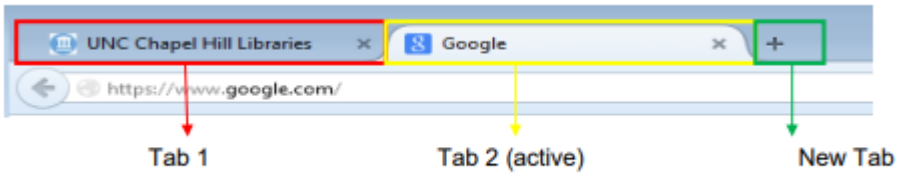
The **Home** button will take you to the webpage that opened when you first opened your browser window. If you are at a library, this is most likely the library's home page. It is possible to change your web browser's settings to open a different Home site. In Google Chrome, you will need to sign into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

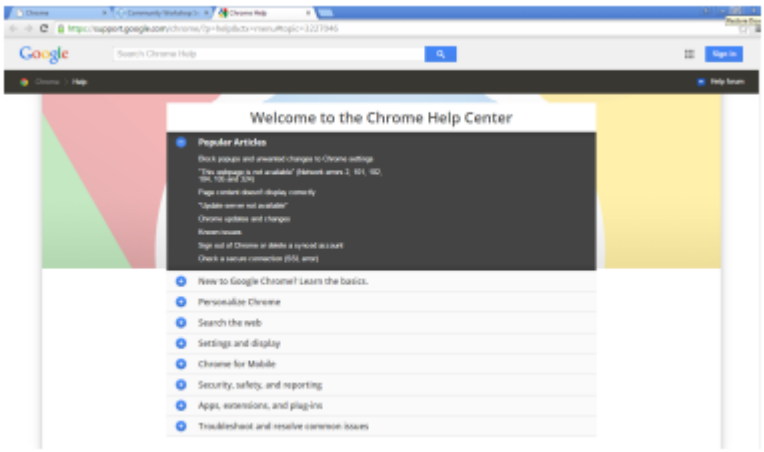
Tabs work just like tabbed dividers in a filing cabinet or a binder—they allow you to organize different pages while keeping them all accessible. You can open a new tab by going to File◊New Tab, OR by clicking the small button with the plus sign (+) to the right of the last tab, OR by holding down the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

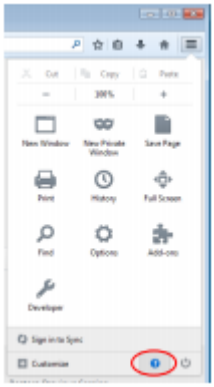
Using the Browser's Help Feature

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

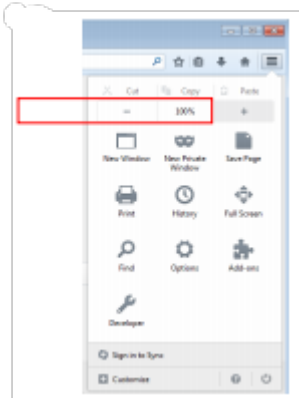
If you are not comfortable with the text size on a web page, you can zoom in or out according to your preferences. (Most browsers are defaulted to a 100% zoom – zooming in (+) makes things larger, and zooming out (-) makes them smaller).

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:

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



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

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

WEBSITE ADDRESSES/URLS

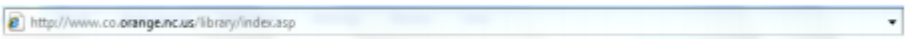
Going to a Specific Web Address Every day, you are probably bombarded with web addresses. Web addresses are also called URLs, which stands for Universal Resource Locator. On the radio, on television commercials, in the newspaper and magazines: "Visit us online at www.businessname.com!" Almost every business and organization has a website now. You can recognize websites because they will almost all start with "www" or "http" and end with ".com" ".org" ".edu" or ".gov" (these endings are called "extensions"). Recently, new specialized extensions were made available such as ".bike" and ".technology" and ".photography".

Here is an example of a typical web address: www.google.com

You would type this into your address bar to access Google's website.

Let's take a look at the anatomy of a web address:

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



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

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

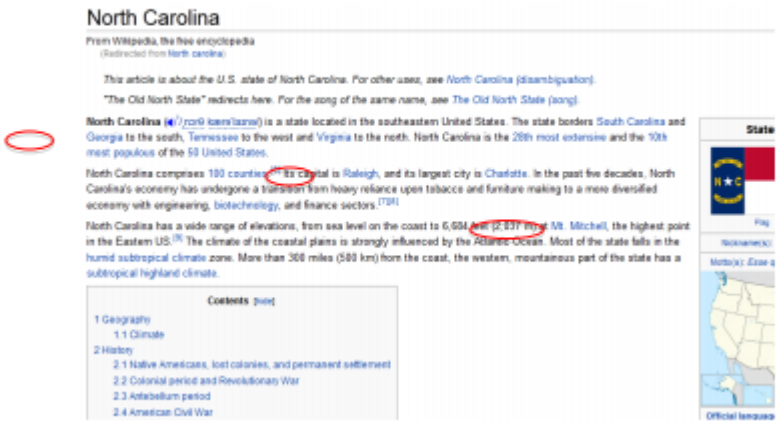
Following Links on a Web Page

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

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

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

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



Here is how to do it:

1. Slide the mouse down to a word that is blue, or an image that causes your mouse pointer to turn into a hand.
2. When the pointer turns into a hand, click once with the left mouse button. You should now see a new page with text and other links. You can go back to the previous page by clicking on the "Back" button on the browser's toolbar.
3. 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

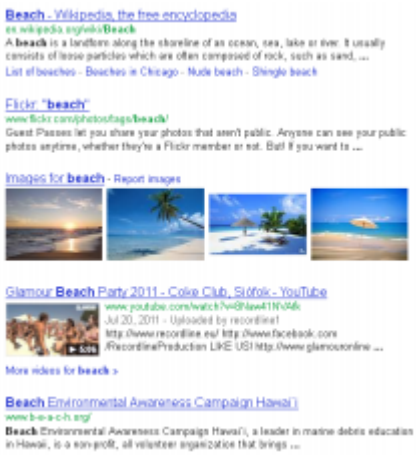
Finding Information with a Search Engine

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.

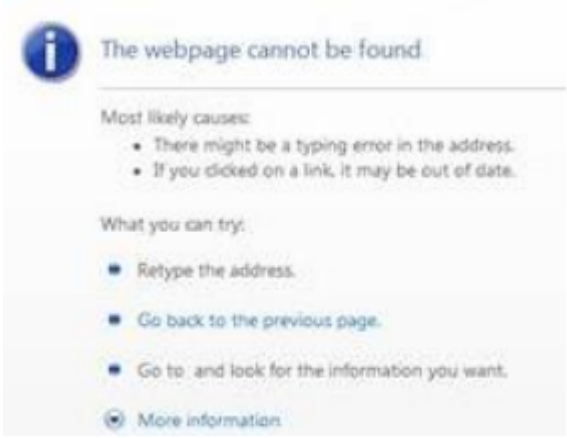
- ✓ Put phrases in quotation marks, e.g. “North Carolina governors,” “Al Pacino,” or “Orange County Main Library.” This will find only those pages that contain these exact phrases.

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?

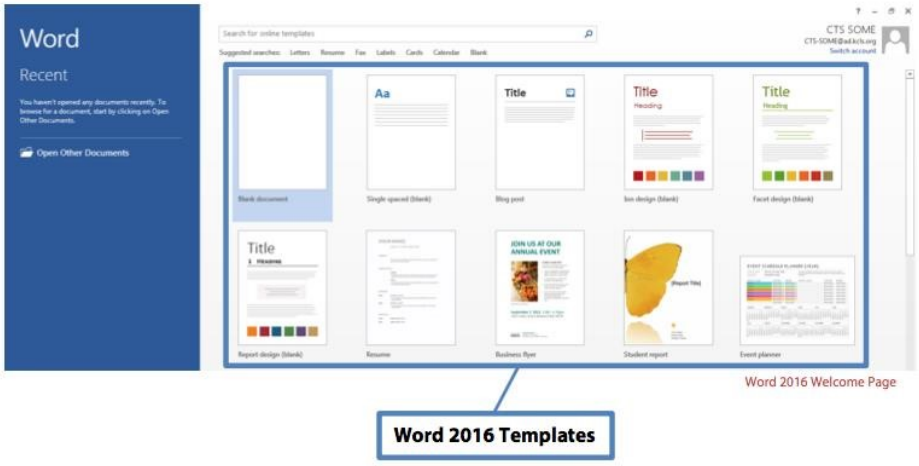
Word is used to "create beautiful documents, easily work with others, and enjoy the read." The types of documents you can create with Word include:

- ✓ 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.

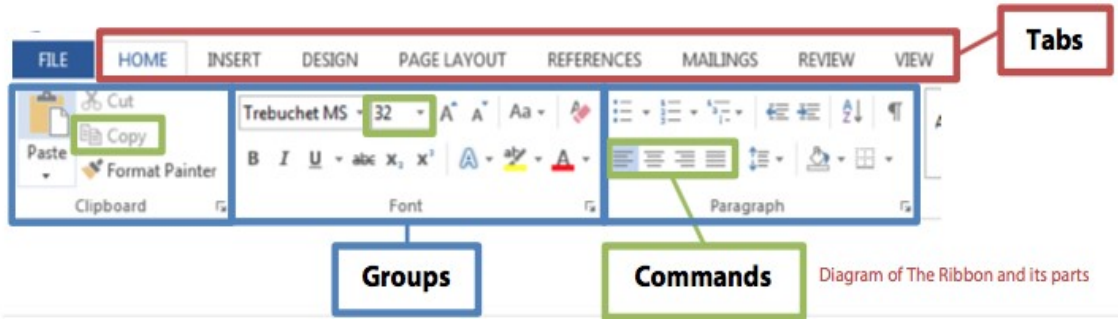


Diagram of The Ribbon and its parts

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

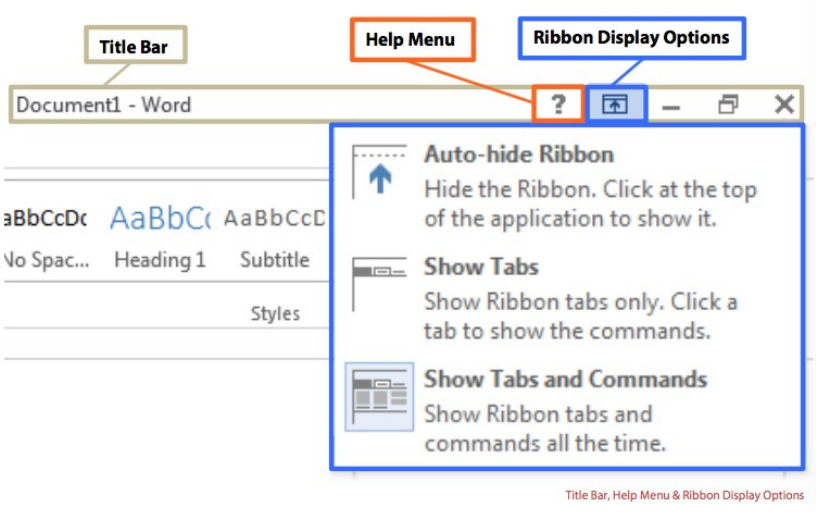
The File Menu contains actions at the file level. Click the blue "File" tab to the far left of the tabs. What you'll see is the "backstage" area. From here, you can create a **New** document, **Open** an existing one, **Save** changes to the current document, **Save As** a different file with a different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

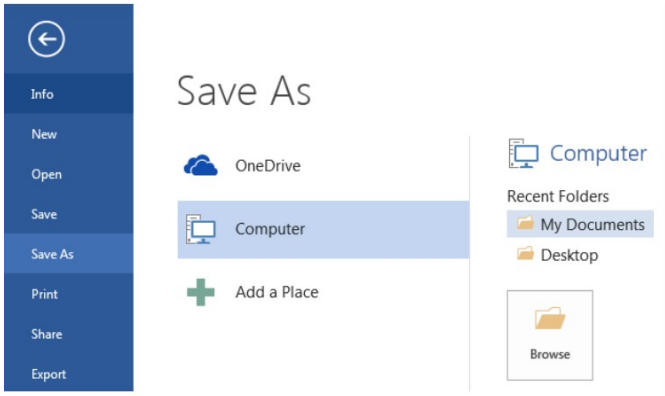
The **Help Menu** has articles on using the software. Not sure how to perform a certain action or where to find a command? Click the question mark icon to browse Help articles, or search for specific topics.

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.



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

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.

The Cursor

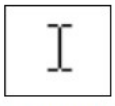
The cursor indicates where text will appear as you type; it also indicates font size for that spot. Earlier, you created a document from the "Facet design (blank)" template on the Welcome Page. Note the size of the cursor next to the word "Title". What is the font size value for the word "Title"? (Look 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?

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


Mouse pointer arrow


Mouse pointer text tool

key Groups and Commands in the Word Ribbon. Let's select and change text in your document.

Selecting Text

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

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

Selecting Lines and Paragraphs

- ✓ To select a complete line of text (use paragraph in your practice document):
  1. Place mouse pointer arrow in left margin next to line of text (arrow will point to the right).
  2. Left-click once to select that line of text.
- ✓ To select several lines or a paragraph:
  3. Place mouse pointer arrow in left margin next to line of text (arrow will point to the right).
  4. Press (hold down) the left mouse button.
  5. 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

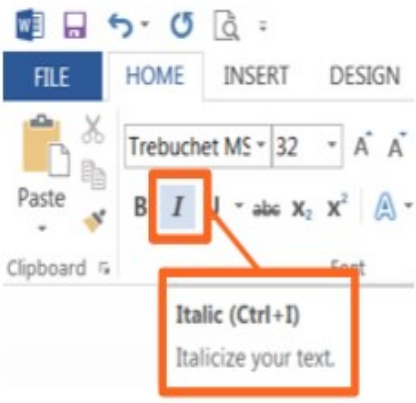
The Home Tab has the groups of commands that people use most often.

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.

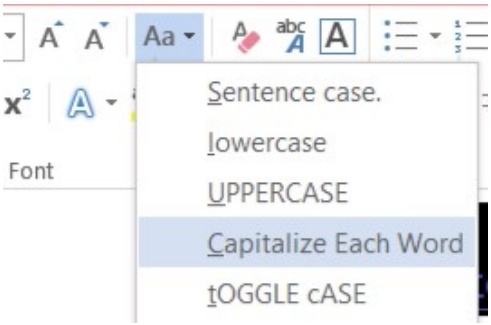
Here's how to italicize text

- ✓ 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.



Style Group

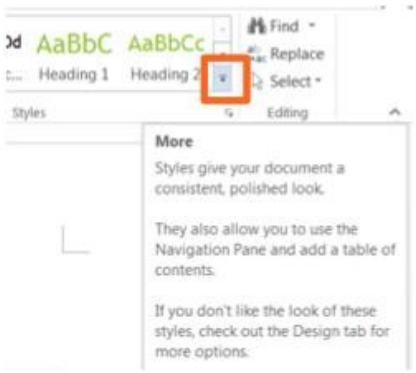
A document created from a template, like the one you opened earlier (Facet design blank), has pre- designed styles for different parts of the document, such as paragraphs and headers. To apply a different paragraph style:

- ✓ 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.

Learning More about the Home Tab

The Home Tab contains the following Groups:

- Clipboard
- Font
- Paragraph
- Styles
- Editing

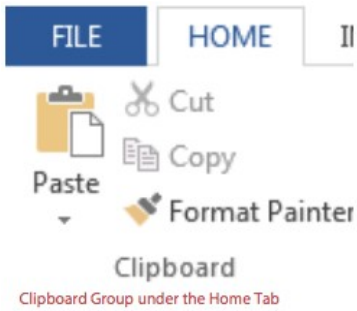
Your document header and bulleted list will look this.

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, except 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:**

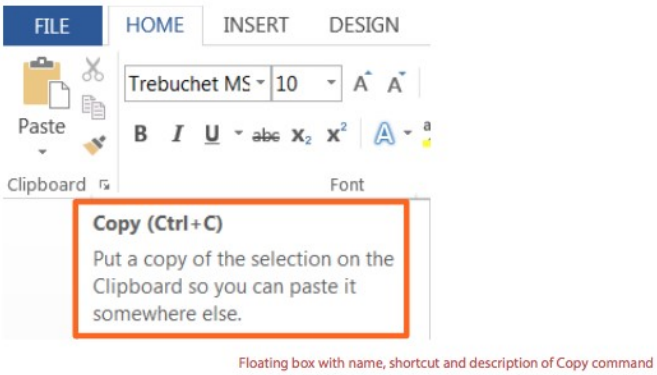
- ✓ Make a new sub-heading in your practice document.
- ✓ Use "Heading 2" style from Styles Group.
- ✓ Type "Clipboard Group".
- ✓ Press "Enter" once.
- ✓ Type two sentences on one line.
- ✓ "I want to live in a warm place. I am moving to Hawaii."



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.



Floating box with name, shortcut and description of Copy command

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.

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.

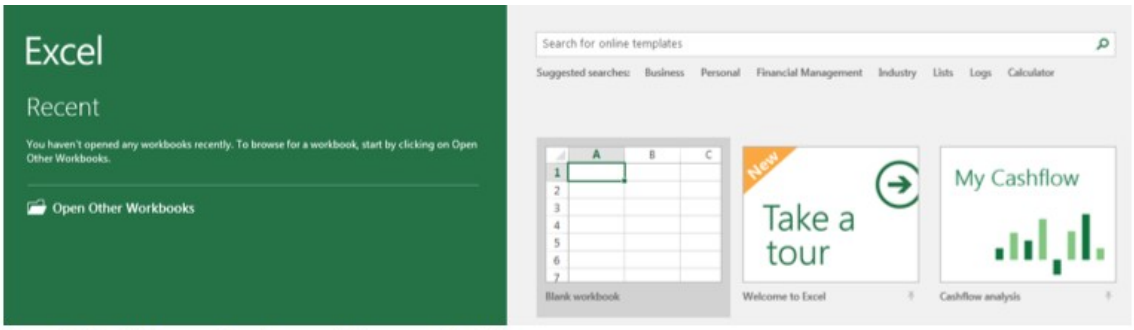


Figure 2 - Excel Welcome Page (zoomed in to upper left side)

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.

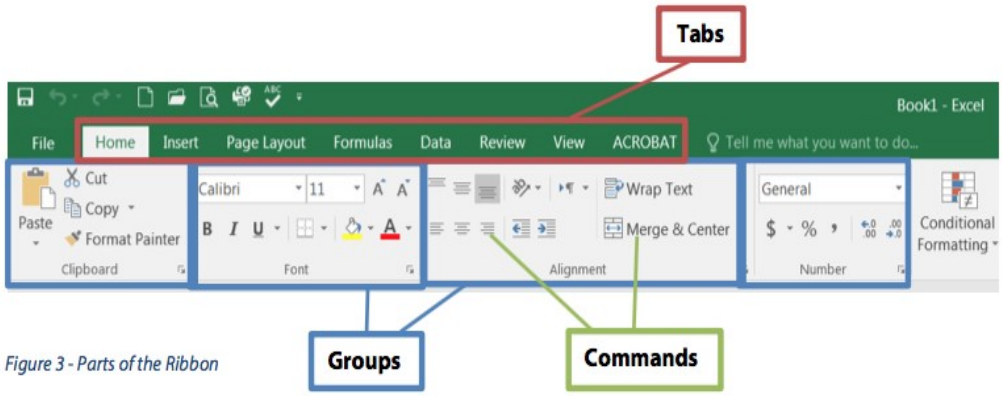


Figure 3 - Parts of the Ribbon

Quick Access Toolbar

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

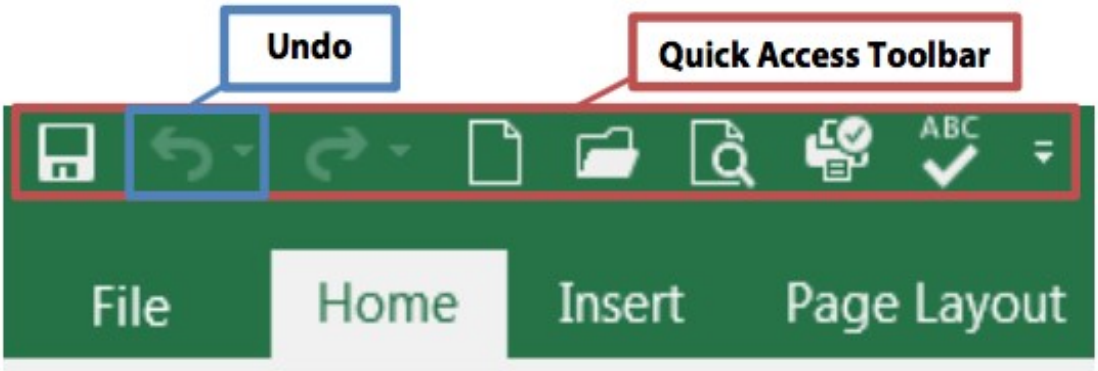


Figure 4 - Quick Access Toolbar & Undo button (zoomed in)

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.

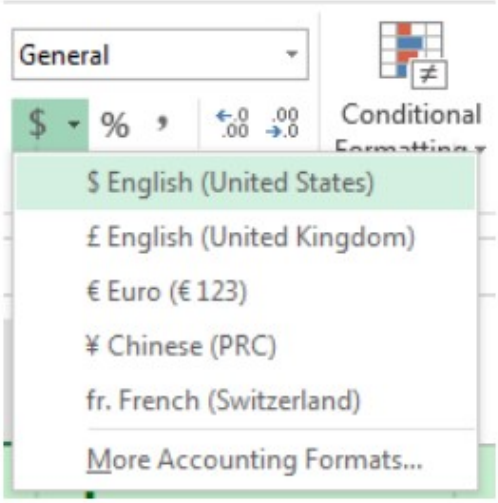


Figure 9 - "Accounting Number Format"

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.

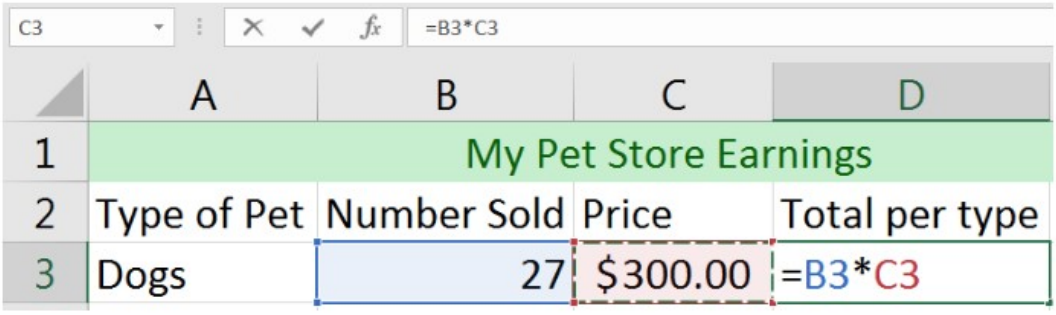


Figure 10 - Basic multiplication formula

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).

C8 | 99.99

	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

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.
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.

The following measures need to be taken in giving first aid to a victim of a closed wound:

1. 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.
2. Elevation of the affected region will also support in reducing the pressure as well as the re-absorption process and it should be practiced as and when appropriate.

When to seek help from health professional:

- ✓ If the wound is in the head, chest or abdomen
- ✓ (unless it is minor).
- ✓ If there is blue, white or cold skin, numbness, tingling, loss of feeling, or the person is unable to move a limb below the wound.
- ✓ If your tetanus shots are not up to date, especially if the object that caused the puncture was dirty, such as a rusty nail or farm implement.
- ✓ If a deep wound to the foot occurred through a shoe.
- ✓ If an animal bite is severe and may need stitches, or if it is on the hand or face.
- ✓ If you are unable to remove an object from the wound.
- ✓ If signs of infection develop – increased pain, swelling, redness, tenderness – heat or red streaks extending from the wound – discharge of pus – fever of 38 °C with no other cause.

First aid for bleeding

Bleeding is the loss of blood escaping from the circulatory system. It arises due to either traumatic injury, underlying medical condition, or a combination and can occur *internally*, where blood leaks from blood vessels inside the body, or *externally*, either through a natural opening such as the mouth, nose, ear, urethra, vagina or anus, or through a break in the skin.

External bleeding is generally described in terms of the origin of the blood flow by vessel type. The basic categories of external bleeding are:

1. **Arterial bleeding**: As the name suggests, blood flow originating in an artery. With this type of bleeding, the blood is typically bright red to yellowish in color, due to the high degree of oxygenation. Blood typically exits the wound in spurts, rather than in a steady flow. The amount of blood loss can be copious, and can occur very rapidly.
2. **Venous bleeding**: This blood is flowing from a damaged vein. As a result, it will be blackish in colour (due to the lack of oxygen being transported) and will flow in a steady manner. Caution is still indicated; while the blood loss may not be arterial, it can still be quite substantial, and can occur with surprising speed without intervention.
3. **Capillary bleeding**: Capillary bleeding usually occurs in superficial wounds, such as abrasions. The colour of the blood may vary somewhat (distal portion of circulation with oxygenated and unoxygenated blood mixing), and will generally ooze in small amounts, as opposed to flowing or spurting.

Internal Bleeding is one of the most serious consequences of trauma. It may occur after any significant physical injury. There are two main types of trauma, and either may cause internal bleeding:

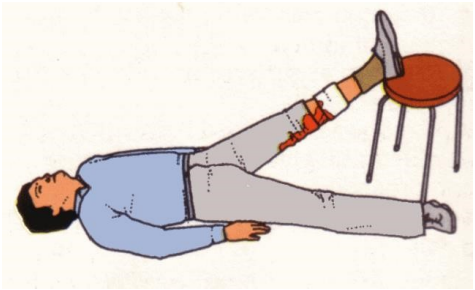
1. **Blunt trauma** - This kind of trauma happens when a body part collides with something else, usually at high speed. Blood vessels inside the body are torn or crushed either by shear forces or a blunt object. Examples are car accidents, physical assaults, and most falls.
2. **Penetrating trauma** - This happens when a foreign object penetrates the body, tearing a hole in one or more blood vessels. Examples are gunshot wounds, stabbings, or falling onto a sharp object.

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

- ✓ Head trauma with internal bleeding (intracranial hemorrhage)
- ✓ Bleeding around the lungs (hemothorax)
- ✓ Bleeding around the heart (hemopericardium and cardiac tamponade)
- ✓ Tears in the large blood vessels near the center of the body (aorta, superior and inferior vena cava, and their major branches)
- ✓ Damage caused by trauma to the abdomen such as liver or spleen lacerations or perforation of other soft organs

Any of these signs of internal bleeding after a trauma should be treated as a medical emergency. The injured person needs to be evaluated in a hospital emergency room. The following measures need to be taken in giving first aid to a victim of external bleeding:

1. Wash your hands to avoid infection and put on gloves
2. Lay on the injured person down and cover the person to prevent loss of body heat.
3. If possible, position the person's head slightly lower than the trunk or elevate the legs and elevate the site of bleeding
4. While wearing gloves, remove any obvious dirt or debris from the wound.
5. Don't remove any large or more deeply embedded objects. Your principal concern is to stop the bleeding.

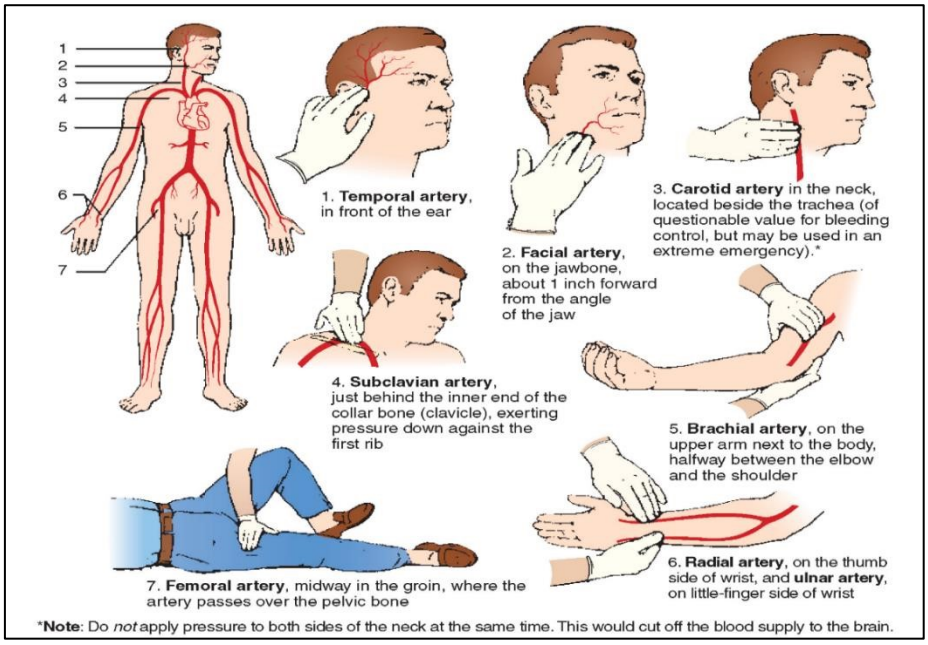


Apply pressure directly on the wound until the bleeding stops

- ✓ Use a sterile bandage or clean cloth and hold continuous pressure for at least 20 minutes without looking to see if the bleeding has stopped.
- ✓ Maintain pressure by binding the wound tightly with a bandage or clean cloth and adhesive tape.
- ✓ Use your hands if nothing else is available.

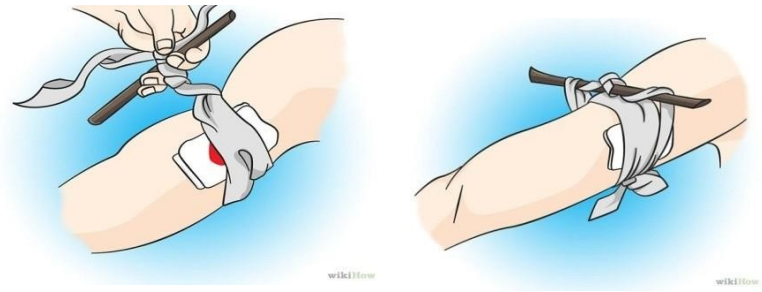

- ✓ If the bleeding continues and seeps through the gauze or other material you are holding on the wound, don't remove it. Instead, add more absorbent material on top of it


1. **Squeeze a main artery if necessary**
   1. If the bleeding doesn't stop with direct pressure, apply pressure to the artery delivering blood to the area.
   2. Squeeze the main artery in these areas against the bone. Keep your fingers flat.
   3 With your other hand, continue to exert pressure on the wound itself.



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.



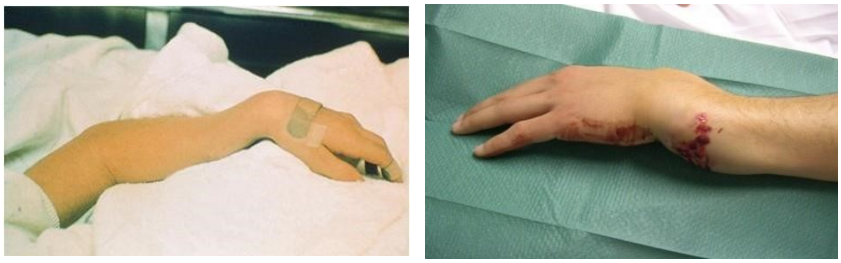
First aid for bone and joint injuries

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

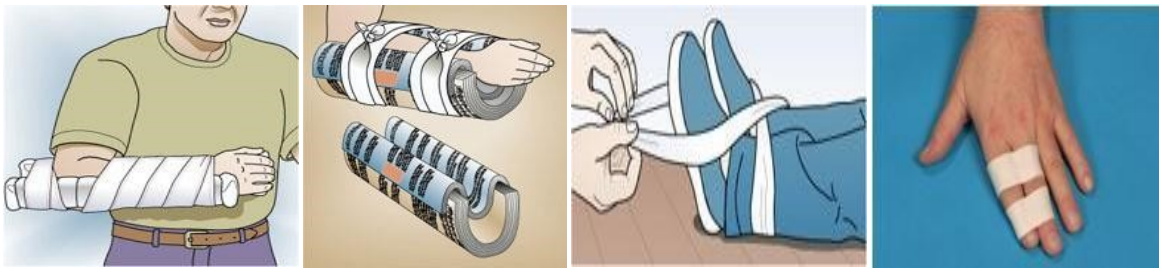
The following measures need to be taken in giving first aid to a victim with bone injury:

- ✓ 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.

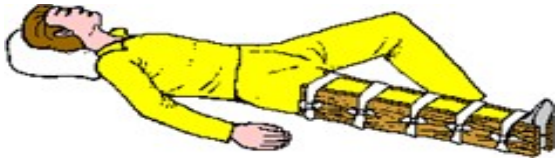
Splinting reduces pain, prevents further damage to muscles, nerves and blood vessels, prevents closed fracture from becoming open fracture and reduces bleeding and swelling. In an emergency, almost any firm object or material can serve as a splint such as sticks, boards, or even rolled up newspapers. 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.

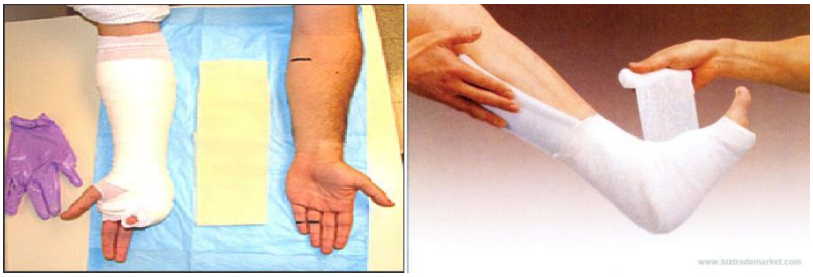
A basic rule of splinting is that the joint above and below the broken bone should be immobilized to protect the fracture site. For example, if the lower leg is broken, the splint should immobilize both the ankle and the knee.



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.

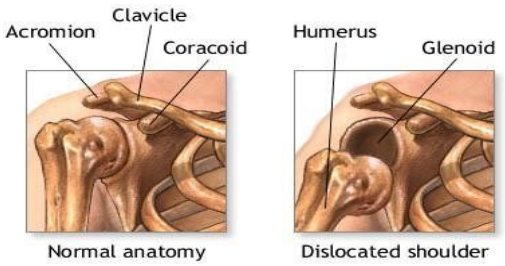


Figure 22. Normal and dislocated shoulder

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

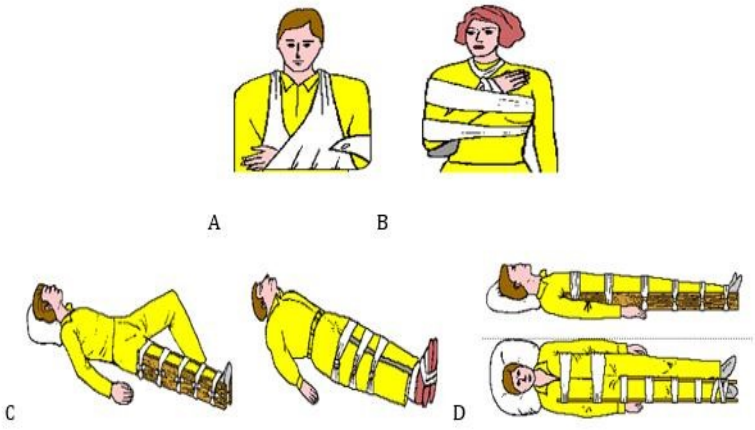
Rapid swelling and discoloration, loss of ability to use the joint, severe pain and muscle spasms, possible numbness and loss of pulse below the joint, and shock are characteristic symptoms of dislocations. The fact that the injured part is usually stiff and immobile, with marked deformation at the joint,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

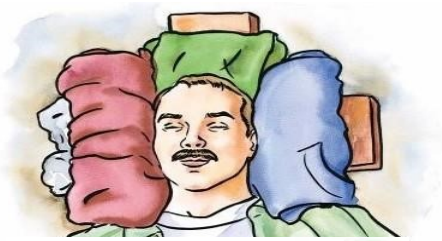


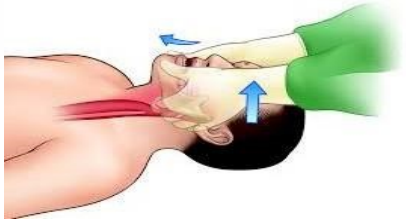
First aid for back and neck injury (spinal cord injury)

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

ιAmerican 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.

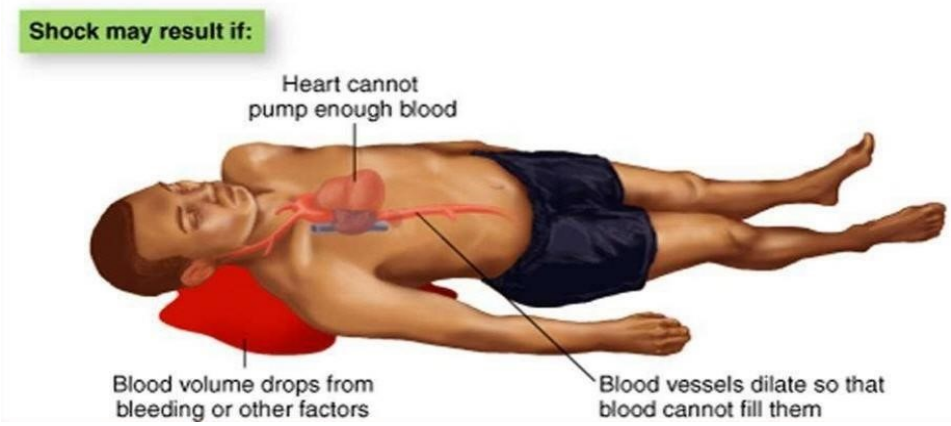
- ✓ Raise above heart level, when possible.

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
2. 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.
3. Lessons learned within the organisation and benchmarks between industries
4. 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.

5. Reporting is cheaper than the costs of a major incident
6. 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.
7. Incident reporting is a key habit that creates culture
8. 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.

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 fire 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.

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

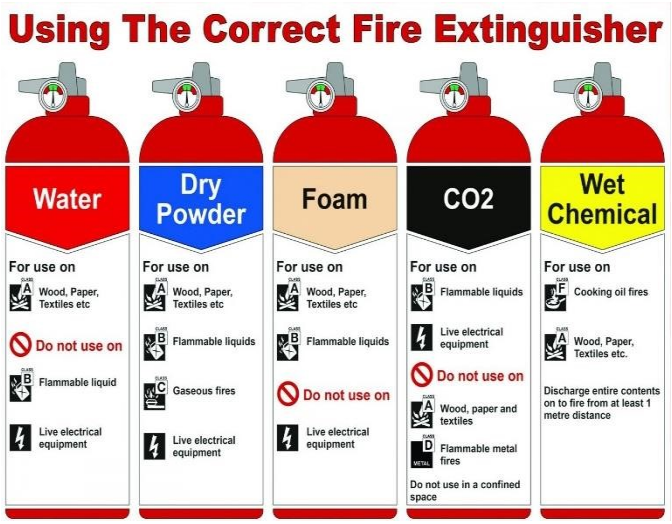
Selection of fire extinguisher

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.

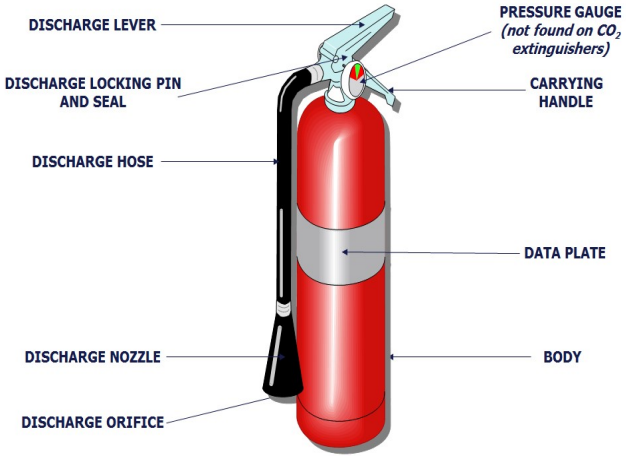
There are different 'classes' of fire, for which each extinguisher is designed to tackle. These classes are based on which fuels a fire starts with. It is the presence of these fuels within your business premises that will help determine which types of fire extinguisher you need and in which locations.

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



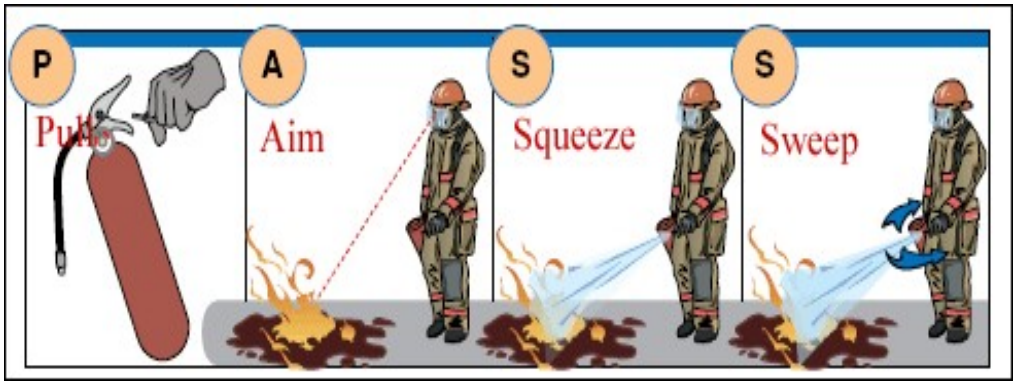
Components of fire extinguishers

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**

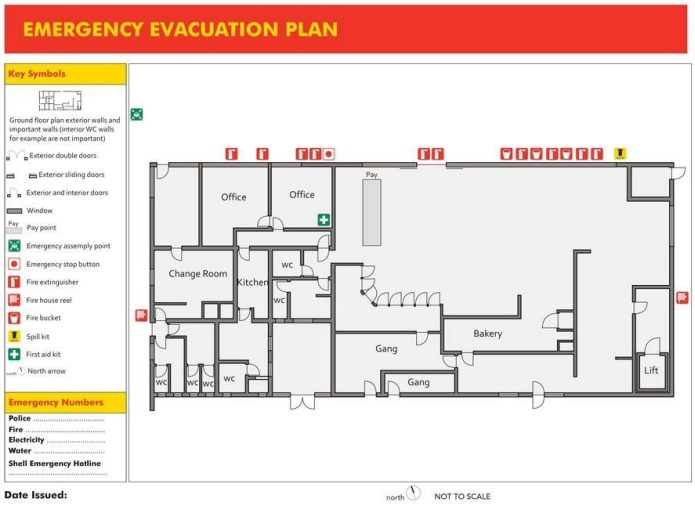
Protective hoods should be worn whenever there is a risk of injury from heat and/or flame to exposed skin. Helmet liners should be used in addition to protective hoods.

4. **Boots and gloves**

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

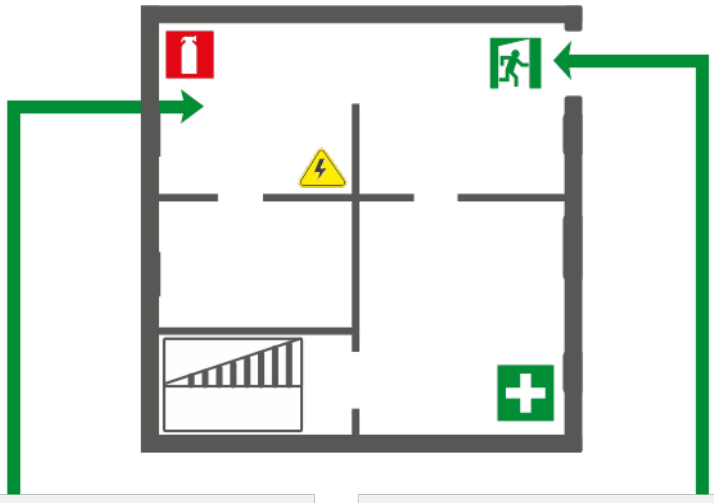
Apply emergency evacuation procedures

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 fire 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

Perform Simple Workshop Calculations

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

Definition of Fractions

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

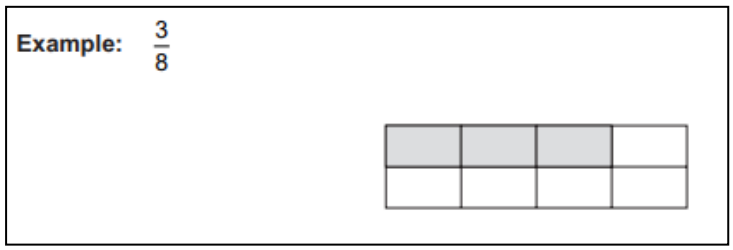
6. Common fractions (fractions)
7. Decimal fractions (decimals)

Common fraction examples are: $\frac{1}{2}, \frac{3}{4}, \frac{5}{8}$

Decimal fraction examples are: .50, .75, .625

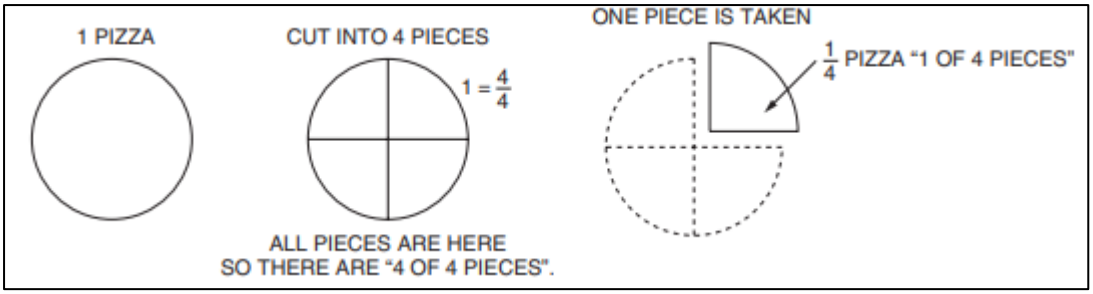
basic principles

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.

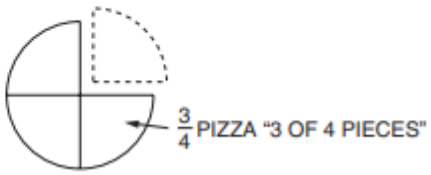


3 is the numerator, and 8 is the denominator. This fraction shows that an object has been divided into 8 equal pieces, and that 3 of those 8 pieces are shaded.

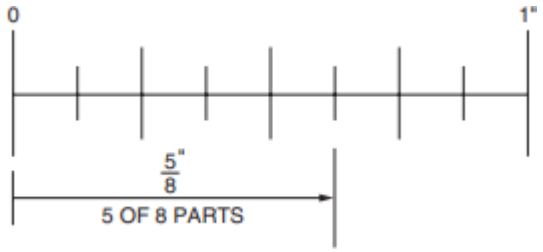
Let's work with other simple examples. If we have one whole unsliced pizza, we can divide it into pieces, and then make fractions about the pizza. This example is cut into 4 pieces (quarters). Fractions concerning this pizza will have the bottom number 4. To describe 1 of those pieces, the fraction is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



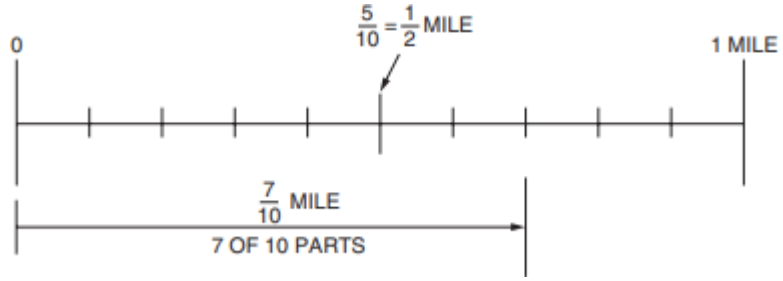
¾ indicates that "3 of 4 pieces" are still available.



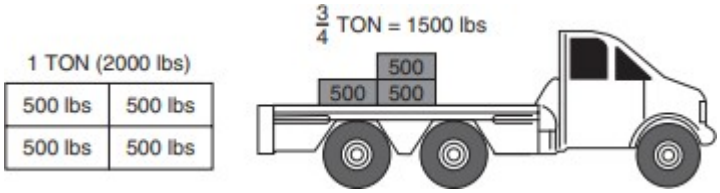
8. 5/8″ (five-eights inch) shows that an inch is divided into 8 parts and that 5 of those 8 parts have been measured.



- 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.



- 3/4 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.

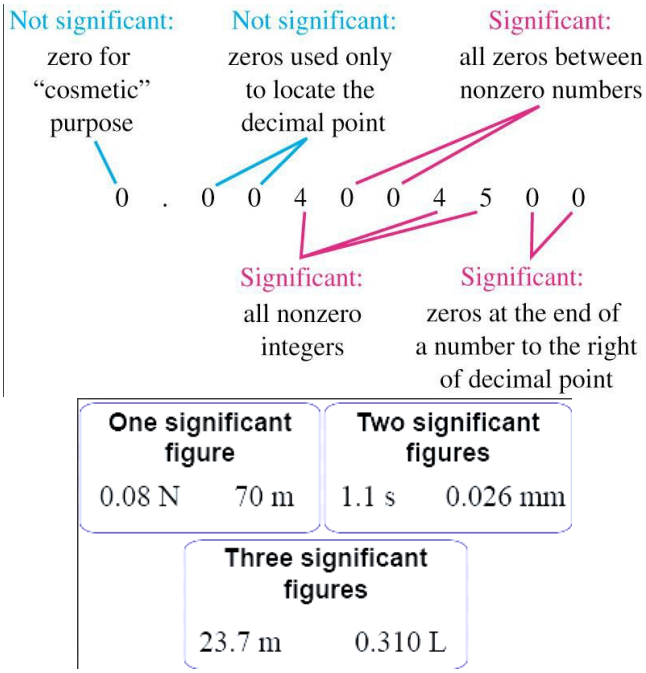
Rounding to hundredths:
If the number directly to the right is 5 or more, increase the hundredth-place number by 1. If the number directly to the right is 4 or less, the hundredth-place number stays the same.

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

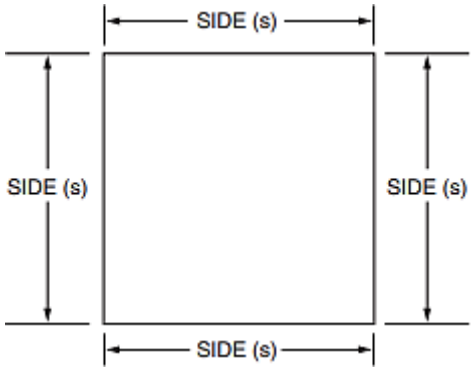
Prefix	Abbreviation	Meaning	Example
Giga	G	10^9	1 gigameter (Gm) $= 1 \times 10^9$ m
Mega	M	10^6	1 megameter (Mm) $= 1 \times 10^6$ m
Kilo	k	10^3	1 kilometer (km) $= 1 \times 10^3$ m
Deci	d	10^{-1}	1 decimeter (dm) $= 0.1$ m
Centi	c	10^{-2}	1 centimeter (cm) $= 0.01$ m
Milli	m	10^{-3}	1 millimeter (mm) $= 0.001$ 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

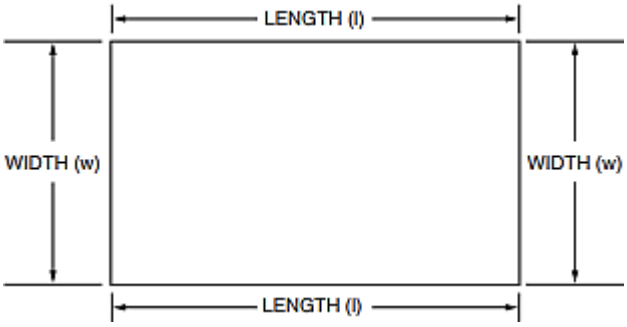
Physic Quantity	Expression	Unit
Area	length × breadth	m^2
Volume	area × height	m^3
Velocity	displacement/ time	$m\ s^{-1}$
Acceleration	velocity / time	$m\ s^{-2}$
Density	mass / volume	$kg\ m^{-3}$
Pressure	force / area	$N\ m^{-2}$ or Pa

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°.



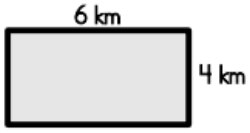
Rectangle
A four-sided figure, as shown below. The lengths are equal only to each other and the widths are equal only to each other. All four angles are 90°.



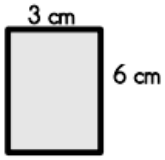
Area of Square
Formula: A= Side x Side

Area of Rectangle Formula: A= L x H

Find the area of each rectangle by multiplying.



area = _____



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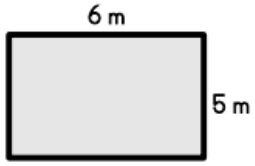
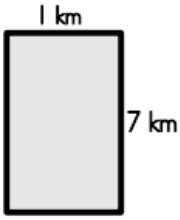
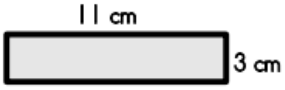


area = _____



area = _____



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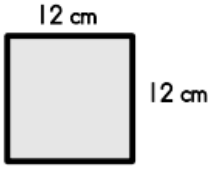
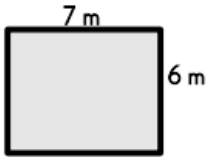
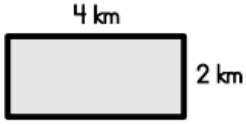
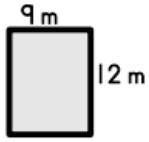


area = _____





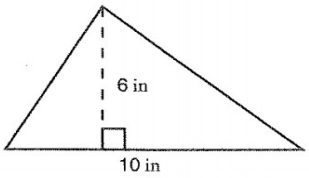


Area of triangle

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

Examples: Find the area.

(a)

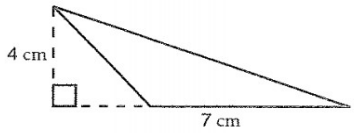


$A = \frac{1}{2}bh$

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

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

(b)



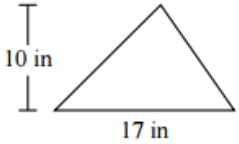
$A = \frac{1}{2}bh$

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

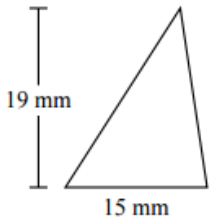
$A = 14 \text{ cm}^2$

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

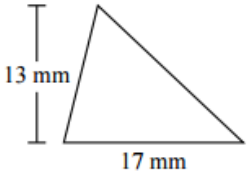
1)



2)



3)



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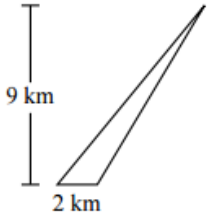
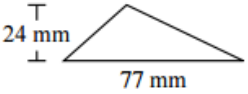
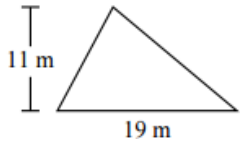


5)

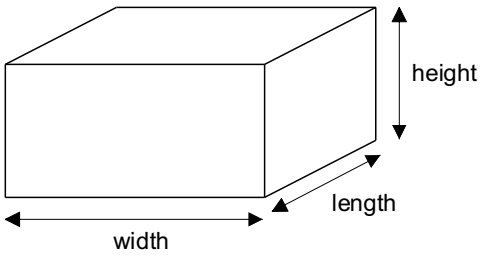


6)

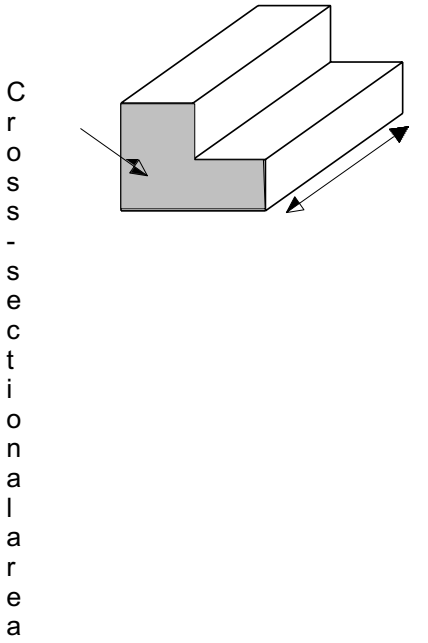


Volume and Surface Area

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

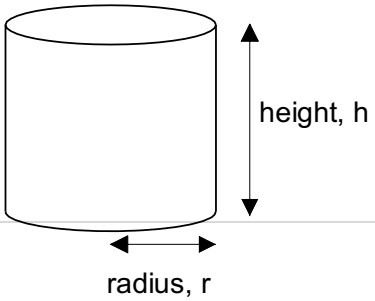


- ✓ Volume of **prism** = cross-sectional area × length



- ✓ Volume of cylinder = $\pi r^2 h$,

Where r is the radius and h is the height of the cylinder.



Example: 1

A cuboid measures 15 cm by 12 cm by 8 cm. Find the capacity of the cuboid. Give your answers in liters.

Solution:

Volume = 15 × 12 × 8 = 1440 cm^3.

As 1 litre = 1000 cm^3, the capacity of the cuboid = 1.44 litres.

Example: 2

A cylinder has a volume of 965 cm^3. If the height of the cylinder is 16 cm, find the radius. Give your answer to 2 significant figures.

Solution:

Substitute the information from the question into the formula for the volume of a cylinder:

Volume of cylinder = $\pi r^2 h$

$965 = \pi \times r^2 \times 16$

$965 = \pi \times 16 \times r^2$

$965 = 50.26548 \times r^2$

$19.198 = r^2$

$4.38156 = r$

So the radius of the cylinder is 4.4 cm (to 2 SF)

Exercise question

A can of drink has the shape of a cylinder. The can has a radius of 4 cm and a height of 15 cm. Calculate the volume of the cylinder. Give your answer correct to three significant figures.

Exercise question

Calculate the volume of the triangular prism.

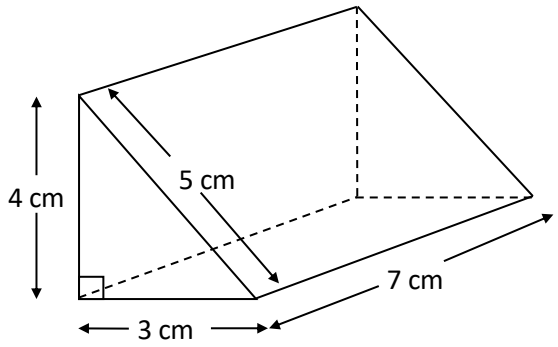
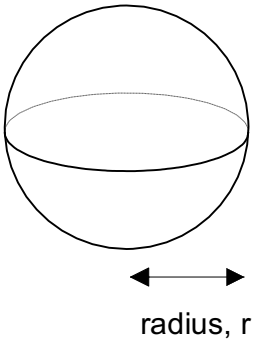


Diagram **NOT** accurately drawn

Volume of a sphere

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



Example: 3

A sphere has a volume of 86.5 cm^3. Find the radius of the sphere. Solution:

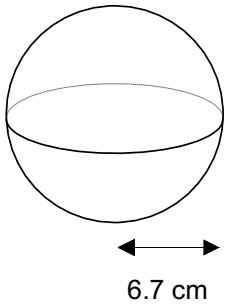
A **hemisphere** is half a sphere. Example

The radius of a sphere is 6.7 cm. Find the volume.

Solution:

Substitute r = 6.7 cm into the formula

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



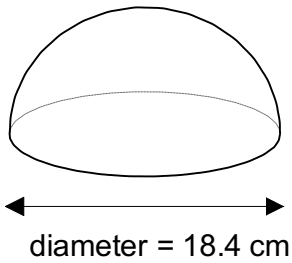
V = $\frac{4}{3} \times \pi \times 6.7^3$

V = 1259.833 (remember to use the cube button on your calculator)

V = 1260 cm^3 (to 3 SF)

Example: 2

Find the volume of the hemisphere shown in the diagram.



Solution:

The diameter of the hemisphere is 18.4 cm.

Therefore the radius is 9.2 cm.

Volume of the hemisphere = $\frac{1}{2} \times$ volume of sphere

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

$$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 9.2^3$$

$$= \frac{1}{2} \times 3261.76$$

= 1630 cm^3 (to 3 SF)

Example 3:

A sphere has a volume of 86.5 cm3. Find the radius of the sphere.

Solution:

Substitute into the formula for the volume of a sphere: Volume = $\frac{4}{3}\pi r^3$

$$86.5 = \frac{4}{3}\pi r^3$$

So $86.5 = 4.18879 r^3$

i.e. $20.65035 = r^3$

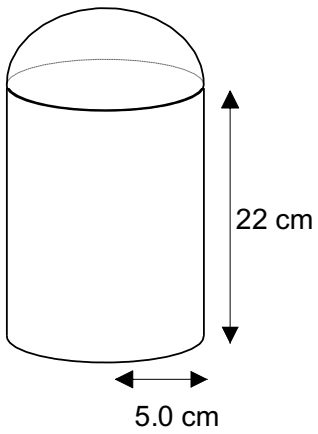
So r = 2.74 cm (to 3 SF) (cube rooting)

The sphere has radius 2.74 cm.

Examination style question

The object shown is made up from a cylinder and a hemisphere.

The cylinder has radius 5.0 cm and height 22 cm. Find the volume of the object.



Solution:

Volume of cylinder $= \pi r^2 h$

$$= \pi \times 5^2 \times 22$$

= 1728 cm^3 (to nearest whole number)

The hemisphere must also have radius 5 cm.

Volume of the hemisphere = $\frac{1}{2} \times$ volume of sphere

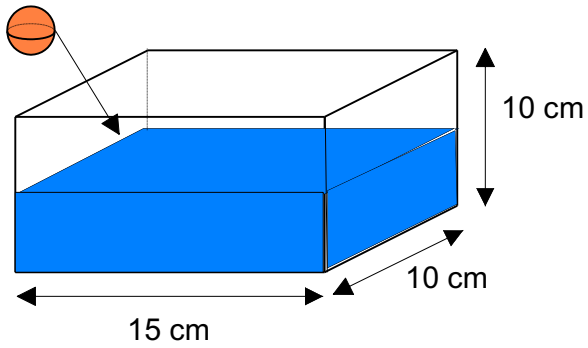
$$= \frac{1}{2} \times \frac{4}{3}\pi r^3$$

$$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 5^3$$
$$= 262 \text{ cm}^3$$

Therefore total volume of the object = 1728 + 262 = 1990 cm³.

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 = $\frac{4}{3}\pi r^3 = \frac{4}{3} \times \pi \times 2^3 = 33.51$ cm³.

Therefore, the water displaced is 33.51 cm³.

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.

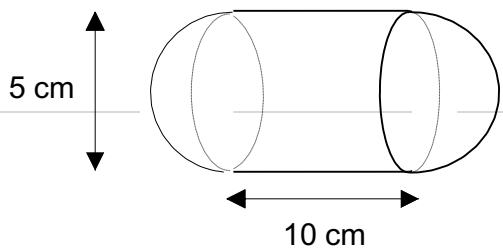
Examination question

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.

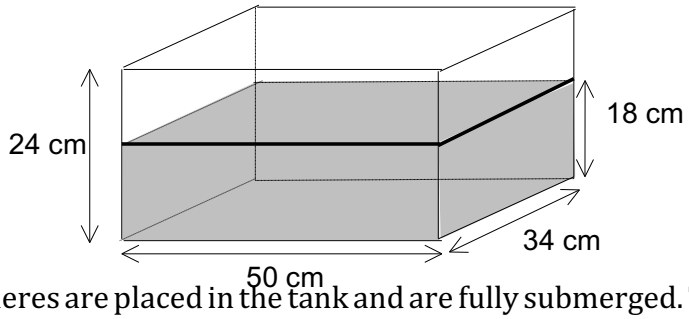
The length of the cylindrical part of the toy is 10 cm.

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



Examination question

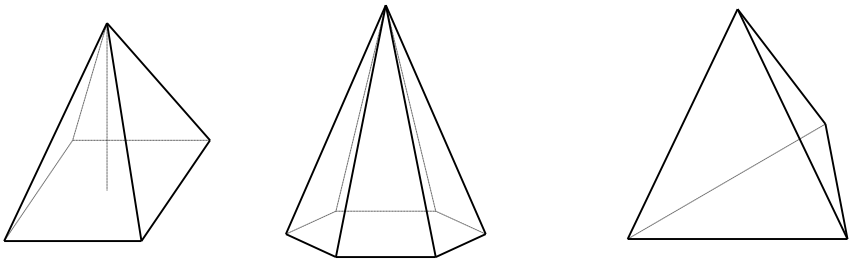
A water tank is 50 cm long, 34 cm wide and 24 cm high. It contains water to a depth of 18 cm.



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.

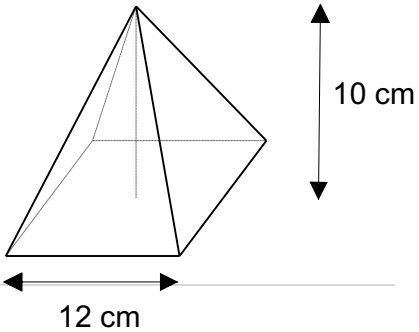


The volume of any **pyramid** can be found using the formula:

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

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:

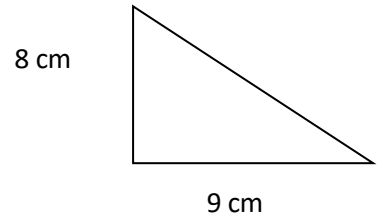
$$\text{Volume} = \frac{1}{3} \times 144 \times 10$$
$$= 48 \times 10$$
$$= 480 \text{ cm}^3.$$

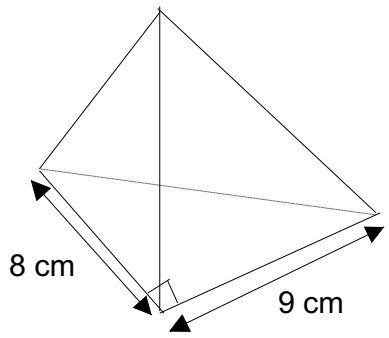
Example: 2

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 × height.

So, height = 325 ÷ 12 = 27.08 cm (to 4 SF).

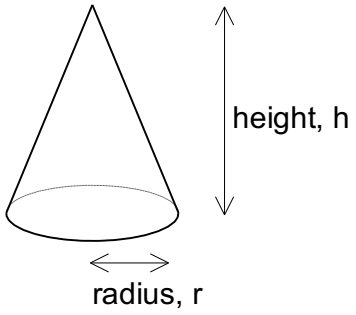
Volume of a cone

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:

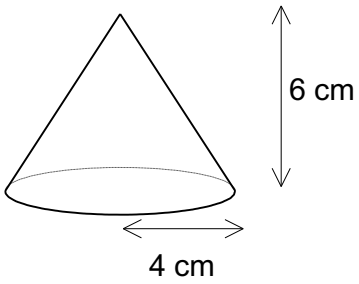
Substitute the information into the formula for the volume of a cone:

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)

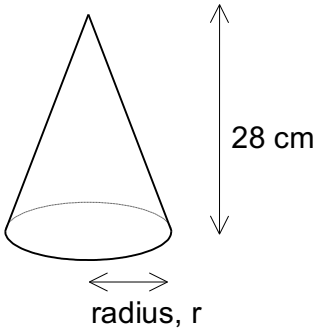
volume = 32π cm^3.



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:



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

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

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

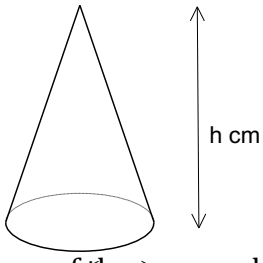
$$r^2 = 56.2726$$

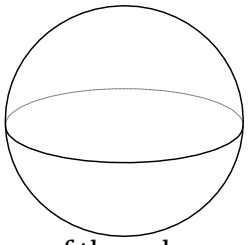
i.e. r = 7.5 cm (to 2 SF)

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.





Diagrams NOT accurately drawn

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)

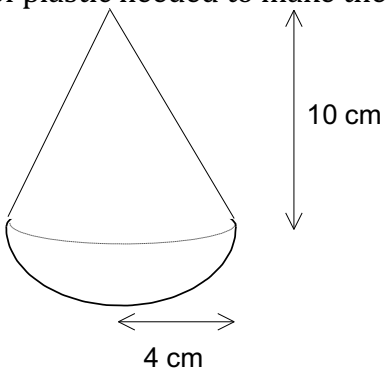
$x^2 h = 32x^3$ (Dividing both sides by π)

$h = 32x$ (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.



Geometry

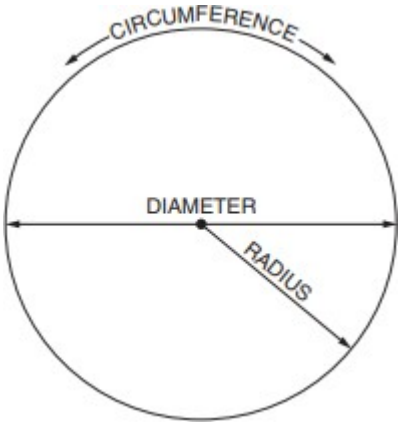
Geometry is essential to welding. Several welding projects require you to understand, calculate and measure welds at different angles accurately. Moderate knowledge of geometrical measurements will make it easier for you to connect metals together while advanced knowledge will make it possible to work on complex projects.
Welders also use geometrical knowledge for calculating the length and size of various shapes and calculate the radius, diameter, and circumference for pieces that have a round shape.

In order to use geometrical angles, welders will also need to have the right drafting

tools such as triangles. The triangles make it easier to connect 90, 45 & 60 degree angles together. A compass is also used for precise measurements and calculation of points between different angles. Both tools are helpful when creating joints and help ensure that they're square. They can also be used to determine the radius, diameter and circumference of a circle.

Identify the elements of a circle Parts

Circle: A circle is a closed curved object, all parts of which are equally distant from the center



Circumference: Circumference is the distance around a circle: it is similar in meaning to perimeter.
Symbol used is C.

Radius: The radius is a straight line measurement from the center, to the edge, of the circle: it is one-half the diameter. Symbol used is r.

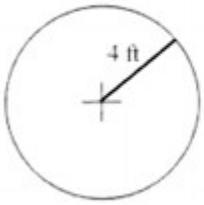
Diameter: The diameter is a straight line through the center of the circle, traveling from edge to edge. It divides the circle in half, and is equal in length to 2 radii. Symbol used is (D).
Diameter is designated on blueprints with the symbol Ø.

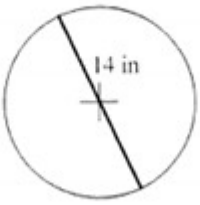
pi: The circumference of any circle is 3.1416 times the diameter of that circle. The number 3.1416 is represented by the Greek letter "pi". The symbol used is π. Welding shops round π to 3.14.

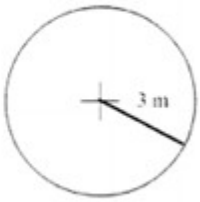
The formula for calculating the circumference of a circle is:

Area = πr^2

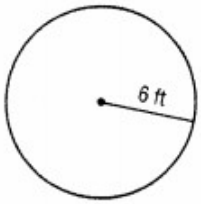
Examples: Find the area of the circle. Remember $\pi = 3.14$

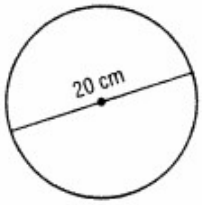
1. 

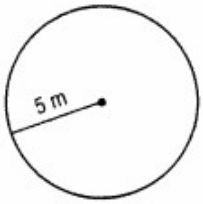
2. 

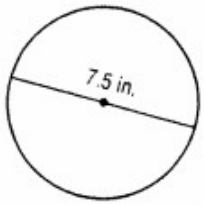
3. 

Find the circumference of each circle. Use 3.14 or $\frac{22}{7}$ for π. Round to the nearest tenth if necessary.

1. 

2. 

3. 

4. 

5. diameter = 15 km

6. radius = 21 mi

7. radius = 50 m

8. diameter = 600 ft

9. radius = 62 mm

10. diameter = 7 km

Identify and use the ratio of sides of 45° and 60° right angled triangles.

Trigonometry

Speaking of angles, welders must also possess a good understanding of trigonometry for creating angled structures. Trigonometry helps welders determine the area of the weld and the angle it should be created at for handling pressure under various environmental conditions.

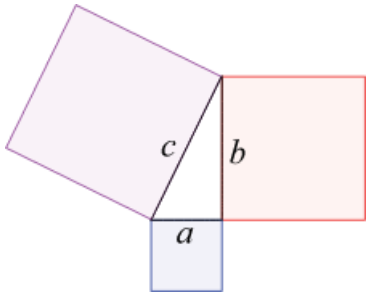
Trigonometry helps welders determine the strength of the weld and how joints should be made to ensure that they will not break with usage. The welder can test the strength of the joint without breaking it by applying module testing methods such as ultrasonic waves based on tangents, signs and cosigns. Testing methods help the welder determine imperfection in the weld and adjust it to create a durable structure.

Trigonometry is one of the more complex mathematical skills and takes time to master. It can be difficult to understand it if you aren't already good at geometry. The good part is that you can learn and improve your understanding of angled joints by taking a course in trigonometry.

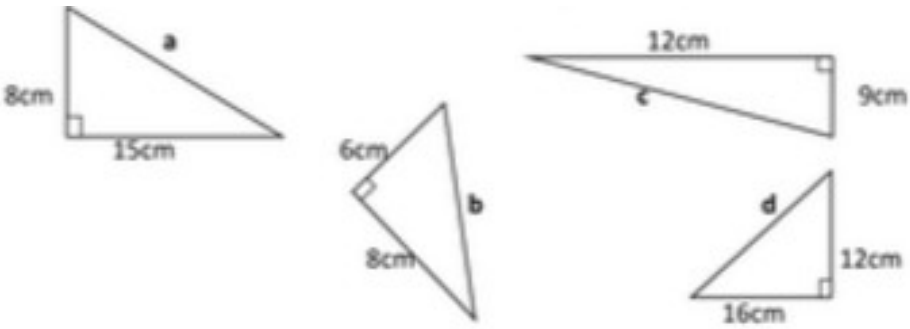
Pythagoras' Theorem

It states that the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides.

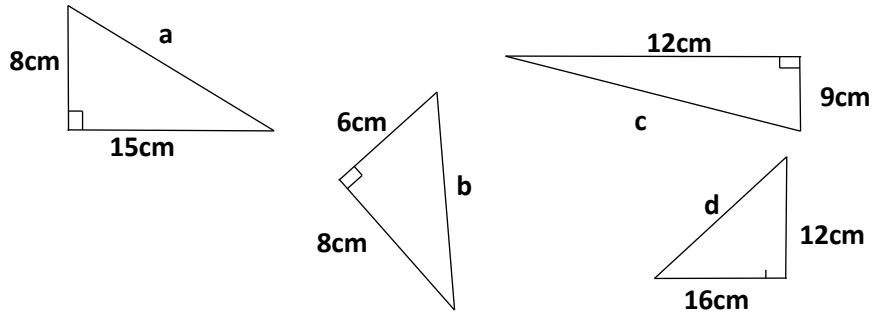
$a^2+b^2=c^2$



Find hypotenuse of following



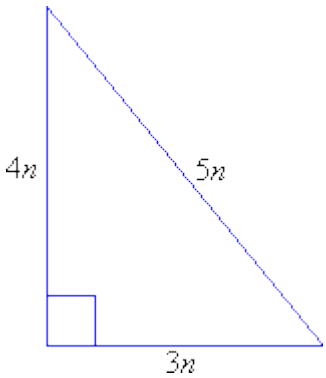
Using Pythagoras, find the length of the side labeled with letters.



3-4-5 Right Triangle

A 3-4-5 triangle is right triangle whose lengths are in the ratio of 3:4:5. When you are given the lengths of two sides of a right triangle, check the ratio of the lengths to see if it fits the 3:4:5 ratio.

Side1 : Side2 : Hypotenuse = 3n : 4n : 5n



Example 1:

Find the length of the hypotenuse of a right triangle if the lengths of the other two sides are 6 inches and 8 inches.

Solution:

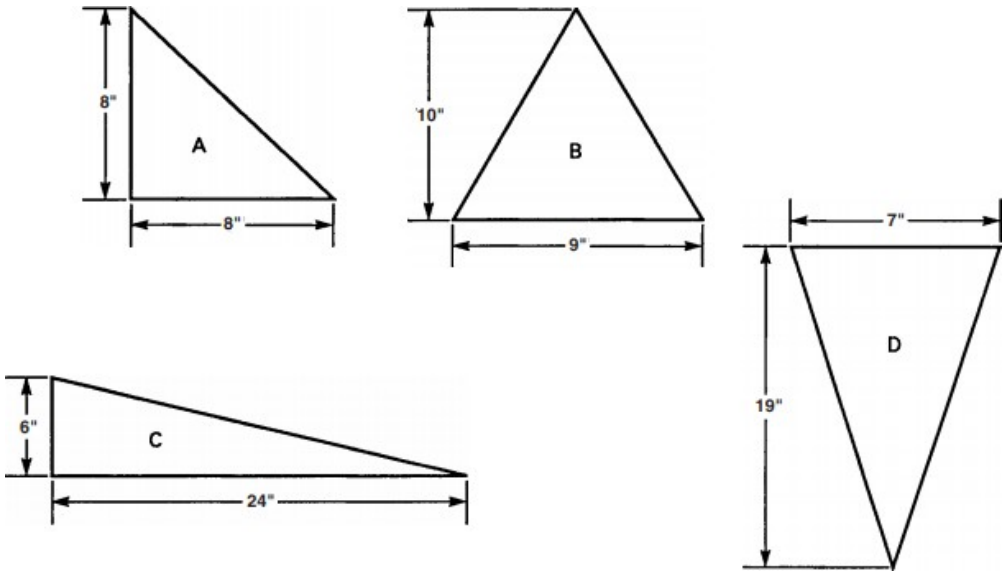
Step 1: Test the ratio of the lengths to see if it fits the $3n : 4n : 5n$ ratio. $6 : 8 : ? = 3(2) : 4(2) : ?$

Step 2: Yes, it is a 3-4-5 triangle for $n = 2$.

Step 3: Calculate the third side $5n = 5 \times 2 = 10$

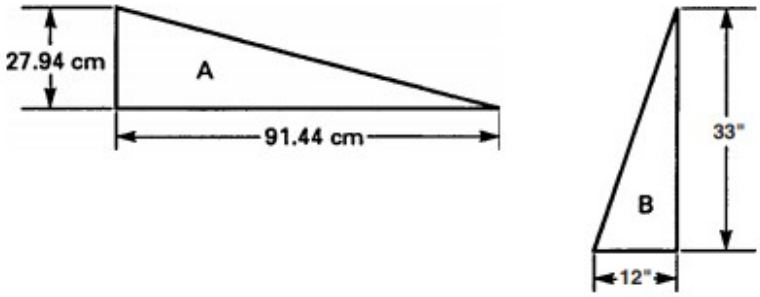
Answer:
The length of the hypotenuse is 10 inches.

Solve simple workshop problems involving Pythagoras and right-angled triangles. These four triangular shapes are cut from sheet metal. What is the area of each piece in square inches?



1. Triangle A _____
2. Triangle B _____
3. Triangle C _____
4. Triangle D _____

Two pieces of sheet metal are cut into triangular shapes.



5. Find, in square centimeters, the area of triangle A. _____
6. Find, in square inches, the area of triangle B. _____

Convert Degrees Minutes Seconds to Decimal Degrees

Latitude and Longitude coordinates are often presented in degrees, minutes, and seconds, such as 39° 45' 30" (39 degrees, 45 minutes, 30 seconds). However, we can only plot values in decimal degrees. So, for example, 39° 45' is referred to as 39.75°

Converting from degrees, minutes, and seconds is actually quite easy. Consider the latitude value 39° 25' 30". This value needs to be converted to use it in Strater. There are 60 minutes in one degree and 3600 seconds in one degree. To convert minutes and seconds to decimal degrees, divide minutes by 60, divide seconds by 3600, and then add the results to obtain the decimal equivalent. Use the following formula to make the conversion:

Decimal degrees = Degrees + (Minutes/60) + (Seconds/3600)

For Example, to convert 39° 25' 30" to decimal degrees

9. First, convert minutes and seconds to their degree equivalents and add the results
   25'/60=0.4167°
   30"/3600=.0083°
10. and 0.4167° + 0.0083° = 0.425°
11. Then, add this number to the number of degrees. 39° + 0.425° = 39.425°
    So, the final result is: 39° 25' 30" = 39.425°

APPLY FUNDAMENTAL OF SCIENCE

Relative Motion in One and Two Dimensions

Motion does not happen in isolation. If you're riding in a train moving at 10 m/s east, this velocity is measured relative to the ground on which you're traveling. However, if another train passes you at 15 m/s east, your velocity relative to this other train is different from your velocity relative to the ground. Your velocity relative to the other train is 5 m/s west. To explore this idea further, we first need to establish some terminology.

Reference Frames

To discuss relative motion in one or more dimensions, we first introduce the concept of reference frames. When we say an object has a certain velocity, we must state it has a velocity with respect to a given reference frame. In most examples we have examined so far, this reference frame has been Earth. If you say a person is sitting in a train moving at 10 m/s east, then you imply the person on the train is moving relative to the surface of Earth at this velocity, and Earth is the reference frame. We can expand our view of the motion of the person on the train and say Earth is spinning in its orbit around the Sun, in which case the motion becomes more complicated. In this case, the solar system is the reference frame. In summary, all discussion of relative motion must define the reference frames involved. We now develop a method to refer to reference frames in relative motion.

Relative Motion in One Dimension

We introduce relative motion in one dimension first, because the velocity vectors simplify to having only two possible directions. Take the example of the person sitting in a train moving east.

If we choose east as the positive direction and Earth as the reference frame, then we can write the velocity of the train with respect to the Earth as $\vec{v}_{TE} = 10\,\text{m/s}\,\hat{i}$ east, where the subscripts TE refer to train and Earth. Let's now say the person gets up out of /her seat and walks toward the back of the train at 2 m/s. This tells us she has a velocity relative to the reference frame of the train. Since the person is walking west, in the negative direction, we write her velocity with respect to the train as $\vec{v}_{PT} = -2\,\text{m/s}\,\hat{i}$. We can add the two velocity vectors to find the velocity of the person with respect to Earth. This relative velocity is written as $\vec{v}_{PE} = \vec{v}_{PT} + \vec{v}_{TE}$.

$$\vec{\mathbf{v}}_{PE} = \vec{\mathbf{v}}_{PT} + \vec{\mathbf{v}}_{TE}$$

Motion in Two Dimensions

Constant Velocity

An object moving with constant velocity must have a constant speed in a constant direction. Motion with constant velocity is one of the simplest forms of motion. This type of motion occurs when an object is moving (or sliding) in the presence of little or negligible friction, similar to that of a hockey puck sliding across the ice. To have a constant velocity, an object must have a constant speed in a constant direction. Constant direction constrains the object to motion to a straight path.

Newton's second law (F=ma) suggests that when a force is applied to an object, the object would experience acceleration. If the acceleration is 0, the object shouldn't have any external forces applied on it. Mathematically, this can be shown as the following:

$$\mathbf{a} = \frac{\mathbf{dv}}{\mathbf{dt}} = 0 \;\Rightarrow\; \mathbf{v} = \text{const.}$$

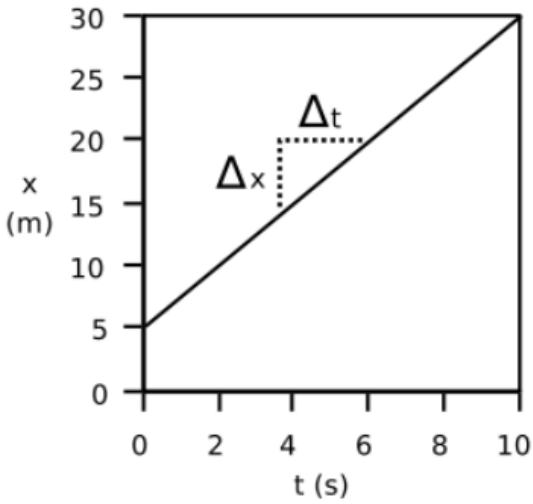
Key Points

- Constant velocity means that the object in motion is moving in a straight line at a constant speed.
- This line can be represented algebraically as: $x=x_0+vt$, where x_0 represents the position of the object at $t=0$, and the slope of the line indicates the object's speed.
- The velocity can be positive or negative, and is indicated by the sign of our slope. This tells us in which direction the object moves.

Key Terms

- **constant velocity**: Motion that does not change in speed nor direction.

If an object is moving at constant velocity, the graph of distance vs. time (x vs. t) shows the same change in position over each interval of time. Therefore, the motion of an object at constant velocity is represented by a straight line: $x=x_0+vt$, where x_0 is the displacement when t=0 (or at the y-axis intercept).

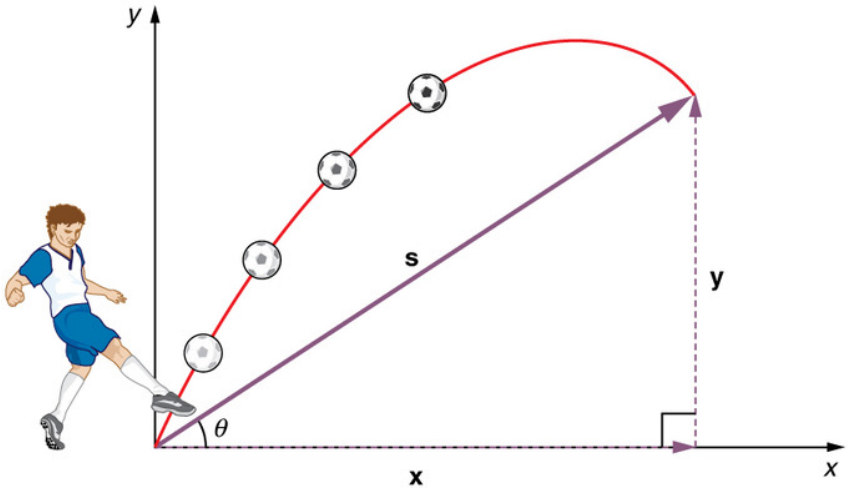


You can also obtain an object's velocity if you know its trace over time. Given a graph as in, we can calculate the velocity from the change in distance over the change in time. In graphical terms, the velocity can be interpreted as the slope of the line. The velocity can be positive or negative, and is indicated by the sign of our slope. This tells us in which direction the object moves.

Constant Acceleration

Analyzing two-dimensional projectile motion is done by breaking it into two motions: along the horizontal and vertical axes.

Projectile motion is the motion of an object thrown, or projected, into the air, subject only to the force of gravity. The object is called a projectile, and its path is called its trajectory. The motion of falling objects is a simple one-dimensional type of projectile motion in which there is no horizontal movement. In two-dimensional projectile motion, such as that of a football or other thrown object, there is both a vertical and a horizontal component to the motion.



The most important fact to remember is that motion along perpendicular axes are independent and thus can be analyzed separately. The key to analyzing two-dimensional projectile motion is to break it into two motions, one along the horizontal axis and the other along the vertical. To describe motion we must deal with velocity and acceleration, as well as with displacement.

We will assume all forces except for gravity (such as air resistance and friction, for example) are negligible. The components of acceleration are then very simple: $a_y=-g=-9.81\frac{m}{s^2}$ (we assume that the motion occurs at small enough heights near the surface of the earth so that the acceleration due to gravity is constant). Because the acceleration due to gravity is along the vertical direction *only*, $a_x=0$. Thus, the kinematic equations describing the motion along the x and y directions respectively, can be used:

$$x = x_0 + v_x t$$

$$v_y = v_{0y} + a_y t$$

$$y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$$

$$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$$

We analyze two-dimensional projectile motion by breaking it into two independent one-dimensional motions along the vertical and horizontal axes. The horizontal motion is simple, because ax=0 and vx is thus constant. The velocity in the vertical direction begins to decrease as an object rises; at its highest point, the vertical velocity is zero. As an object falls towards the Earth again, the vertical velocity increases again in magnitude but points in the opposite direction to the initial vertical velocity. The x and y motions can be recombined to give the total velocity at any given point on the trajectory.

DEMONSTRATE SIMPLE DRAWING

Making a plumbing sketch or pipe diagram is a necessary step in the design process. As residential building plans do not typically include plumbing diagrams a sketch will assist both the designer and provide important information to the one installing the plumbing.

Sketching basics

Sketches are simple line diagrams that are not intended to provide great amounts of detail, but simply place ideas into a graphical form. Sketches are not drawn to scale as with blueprints, but should be proportionate. The old saying "A picture is worth a thousand words" is completely true when talking about piping arrangements; just imagine trying to describe the intended location of pipes in three dimensions using only the written word.

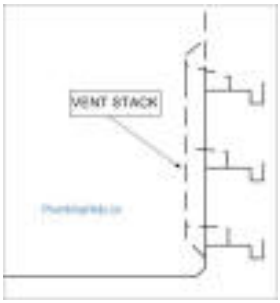
As your sketches become more refined additional information should be added; such as pipe sizes, fixture location, dimensions and plumbing fittings until your confident that someone else would understand your sketch and be able to follow it's design.

Types of plumbing sketches

There are two main types of plumbing sketches/drawings used by plumbers and mechanical designers to illustrate proposed plumbing layouts; which are, orthographic and isometric sketches.

Orthographic Sketching

Orthographic sketching is best described as a two dimensional drawing shown from a vantage point. Building plans for example are illustrated as if someone was looking down on them(top view), this is called a plan view and best describes horizontal features; such as underground piping for example.



Another common orthographic view is a front view; also called an elevation view. An elevation view is from the perspective of a person standing in front of a structure and best describes vertical features; such as a plumbing stack.

Isometric Sketching

An isometric sketch is a two dimensional drawing that creates the illusion of three dimensions using angular lines. This is the preferred drawing method for plumbers as it shows the most information about the piping layout.

Although an isometric drawing is the most complex to draw, it has definite advantages; such as showing both horizontal and vertical piping on a single drawing. Making an isometric sketch is accomplished by imagining yourself at the lowest point (downstream) in a plumbing system and drawing it as you would see it; if it was laid out from lower left to upper right.

When drawing on paper, an angle of 30 degrees (or increments thereof) is used to illustrate pipes running horizontally and vertical pipes are drawn straight up and down.

The one problem with an isometric sketch arises when pipes are on angles other than horizontal or vertical; such as 45 degree fittings. These "odd" angles are drawn as they would appear using 60 degree angles. When trying to draw circles in isometric drawings you will have to use an ellipse. A simple drawing tool called a triangle with the angles 30-60-90 will help you keep your drawing in the proper perspective. You can also purchase isometric graph paper or use printable graph paper.

UNDERTAKE RELEVANT MEASUREMENTS

In the previous Units, we have covered plumbing tools, material and pipes. Besides knowing the benefits and suitability of material in various tasks, a plumber must also be efficient in measurement of plumbing material with the help of measurement tools and be able to manage conversion of units easily. Similarly, a plumber should also be able to understand and read the various symbols used in plumbing drawings.

Plumbing material is needed as per the requirement of the plumbing work to be done and its plan. Plumbing fitting and fixtures are available in the market in different sizes and types. The size of the plumbing items can vary from inch to feet and metre in height. Plumbing items are also available as per volumetric capacity like water tanks, storage and flush tank, etc. Knowledge of various dimensions and sizes of plumbing items is crucial in the proper selection and purchasing of plumbing material in the market.

Measuring scale

Measurement of Length

A plumber uses the metallic tape, cloth tape, scale and foot rule for measuring. Metallic tape should be used for accuracy in the measurement. Metre and its divisions are printed on the measuring tape. The symbol of feet is (′) and the symbol of inch is (″). For example, the meaning of 4′-9″ is four feet nine inches. Both the systems, i.e., metric system and FPS (Foot-Pound-Second) system are used in plumbing measurement.

In metric systems:
metre = 10 decimetre (dm)

1 metre = 100 centimetre (cm)
1 metre = 1000 millimetre (mm)
10 millimetre = 1 centimetre (cm)
10 centimetre = 1 decimetre (dm)
10 decimetre = 1 metre (m)

In the FPS system:
feet = 12 inches

3 feet = 1 yard

Inter-relation of Metric and FPS system: Both type of systems can be interrelated, for taking length, in the following manner:
inch = 25.4 mm = 2.54 cm
1 metre = 39.37 inches = 1.09 yard

Measurement of Weight

Conversion Tables Weight

1 kilogram	= 10 hectograms
1 kilogram	= 100 decagram
1 kilogram	= 1000 gram
100 kilogram	= 1 quintal
1000 kilogram	= 1 metric ton
1 kilogram	= 2.2046 pounds

Length conversion

Length conversion is depicted in the following.

1millimetre (mm)	= 0.03937079 in, or about 1/25 in	
10 millimetre	= 1 centimetre (cm)	=0.3937079 in
10 centimetres	= 1 decimetre (dm)	=0.3937079 in
10 decimetres	= 1 metre (m)	= 39.37079 in, 3.2808992 ft, or 1.09361 yd

10 metres	= 1 decametre	= 32.808992 ft
10 decametres	= 1 hectometres	= 19.927817 rods
10 hectometres	= 1 kilometre (km)	= 1093.61 yd, or 0.621377 mile
10 kilometres	= 1 myriametre	= 6.21377 mile
1 inch	= 2.54 cm	1 foot = 0.3048 m 1 yard = 0.9144 m
1 rod	= 0.5029 decametre	1 mile = 1.6093 km

Measurement of Length

Length conversion is depicted in the following.

1 millimetre (mm) = 0.03937079 in, or about 1/25 in
10 millimetre = 1 centimetre (cm) = 0.3937079 in
10 centimetres = 1 decimetre (dm) = 3.937079 in
10 decimetres = 1 metre (m) = 39.37079 in, 3.2808992 ft, or 1.09361 yd
10 metres = 1 decametre = 32.808992 ft
10 decametres = 1 hectometres = 19.927817 rods
10 hectometres = 1 kilometre = 1093.61 yd, or 0.621377 metre

1 inch	**= 2.54cm, 1 foot = 0.3048 m, 1 yard = 0.9144 metre**
1 rod	**= 0.5029 decametre**
1 mile	**= 1.6093 kilometre**

Measurement of Volume

Conversion Table for Volume

Volume conversion is depicted in the following.
10 litres= 1 decilitre (dl) = 2.6417 gal, or 1.135 pk
10 decilitres = 1 hectolitre (Hl) = 2.8375 bu 10 hectolitres = 1 kilolitre (kl) = 61027.0515 cubic inch or 28.375 bu
1 cubic foot = 28.317
1 gallon (American) = 3.785 l
1 gallon (British) = 4.543 l
1 gallon = 4.546 litre

Measurement of density

Density conversion is depicted below.

1 lb/ft^3 = 16.018 kg/m^3
1 kg/m^3 = 0.0624 lb. /ft^3
1 lb/in^3 = 27.68 g/cm^3

Measurement of Pressure

Pressure conversion is depicted below.
1 lb/ft^2 = 4.8824 kg/m^3 = 1lb/$metre^2$ = 6.895 KgN/m^2
1 $lb/inch^2$ = 0.0703 kg/cm^3

Comprehensive Conversion Table

Millimetres	= 25.400	× inches
Metres	× 3.2809	= feet

Metres	= 0.3048	× feet
Kilometres	× 0.621377	= miles
Kilometres	= 1.6093	× miles
Square centimetres	× 0.15500	= square inches
Square centimetres	= 6.4515	× square inches
Square metres	× 10.76410	= square feet
Square metres	= 0.09290	× square feet
Square kilometres	× 247.1098	= acres
Square kilometres	= 0.00405	× acres
Hectares	× 2.471	= acres
Hectares	0.4047	× acres
Cubic centimetre	× 0.061025	= cubic inches
Cubic centimetre	= 16.3266	× cubic inches
Cubic metre	× 35.3156	= cubic feet
Cubic metre	= 0.02832	× cubic feet
Cubic metre	× 1.308	= cubic yard
Cubic metre	= 0.765	× cubic yard
Litres	× 61.023	= cubic inches
Litres	= 0.01639	× cubic inches

Litres	× 0.26418	= U.S. gallons
Litres	= 3.7854	× U.S. gallons
Grams	× 15.4324	= grains
Grams	= 0.0648	× grains
Grams	× 0.03527	= Ounces, avoirdupois
Grams	= 28.3495	× Ounces, avoirdupois
Kilograms	× 2.2046	= pounds
Kilograms	= 0.4536	× pounds

Tips

- ✓ To know the circumference of a circle, multiply its diameter by 3.1416.
- ✓ To calculate the diameter of a circle, multiply the circumference by 0.31831.
- ✓ To calculate the area of circle, multiply the square of the diameter by 0.7854.
- ✓ To calculate the circumference, multiply the radius of a circle by 6.283185.
- ✓ To calculate the area, multiply the square of the circumference of a circle by 0.07958.
- ✓ To calculate the area, multiply the half the circumference of a circle with half its diameter.
- ✓ To calculate the radius, multiply the circumference of circle with 0.159155.
- ✓ To calculate the radius, multiply the square root of the area of circle with 0.56419.
- ✓ To calculate the diameter, multiply the square root of the area of circle with 1.12838.
- ✓ To calculate the diameter of a circle equal in area to a given square, multiply a side of the square by 1.12838.
- ✓ To calculate the side of a square equal in area to a given circle, multiply the diameter by 0.8862.
- ✓ To calculate the side of a square inside a circle, multiply the diameter by 0.7071.
- ✓ To calculate the side of a hexagon inside in a circle, multiply the diameter of the circle by 0.500.
- ✓ To calculate the diameter of a circle inside in a hexagon, multiply the side of the hexagon by 1.7321.
- ✓ To calculate the side of an equilateral triangle inside in a circle, multiply the diameter of a circle by 0.866.
- ✓ To calculate the diameter of a circle inside in an equilateral triangle, multiply a side of the triangle by 0.57735.
- ✓ To calculate the area of the surface of a ball (sphere), multiply the square of the diameter by 3.1416.

- ✓ To calculate the volume of a ball (sphere), multiply the cube of the diameter by 0.5236.
- ✓ Doubling the diameter of a pipe increases its capacity four times.
- ✓ To calculate the pressure in pounds per square inch at the base of a column of water, multiply the height of the column in feet by 0.433.
- ✓ A gallon of water (U.S. standard) weighs 8.336 pounds and contains 231 cube inches. A cubic foot of water contains 7½ gallons, 1,728 cubic inches and weighs 62.425 pounds at a temperature of about 39°F. These weights change slightly and below this temperature.

Measuring instruments

Measuring tools

These are important tools in a workshop, which help the plumber to measure size and dimensions of various components of plumbing. Measuring tools are commonly used. A plumber should know the use and handling of these tools. The important measuring tools are steel rule, calliper, screw gauge, pressure gauge, etc.

Steel ruler

It is used to measure lengths and to draw straight lines (Fig. 4.2).

Steel ruler

Calliper

It is a tool used to determine the shorter lengths between two sides of an item. The tips of the calliper are kept to the distance to be measured; the calliper is then removed and the distance is measured between the tips with the ruler

Fig. 4.3: Outside callipersFig. 4.4: Inside callipers

Screw gauge (Micro metre)

It is a device incorporating a calibrated screw used widely for precise measurement of small lengths. Proper handling of this tool is important in measuring any dimension

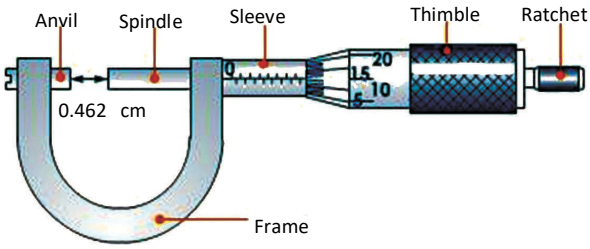


Fig. 4.5: Screw gauge

Fig. 4.6: Measuring tape

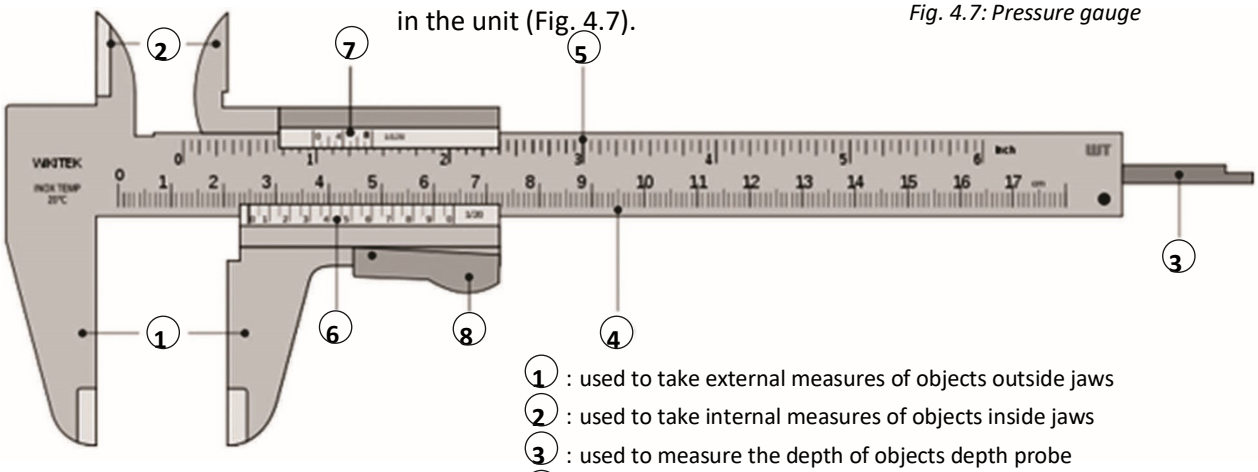
Measuring tape

It is used for measuring the dimension of plumbing items. Tapes are available in various lengths like 10 metres, 20 metres, etc.

Fig. 4.7: Pressure gauge

Pressure gauge

It is the instrument used for measuring the pressure in the unit (Fig. 4.7).



1 : used to take external measures of objects outside jaws
2 : used to take internal measures of objects inside jaws
3 : used to measure the depth of objects depth probe
4 : (cm) Main scale
5 : (inch) Main scale
6 : (cm) Vernier
7 : (inch) Vernier
8 : used to block movable part retainer

Fig. 4.8: Vernier calliper and its parts

Fig. 4.9: Vernier callipers

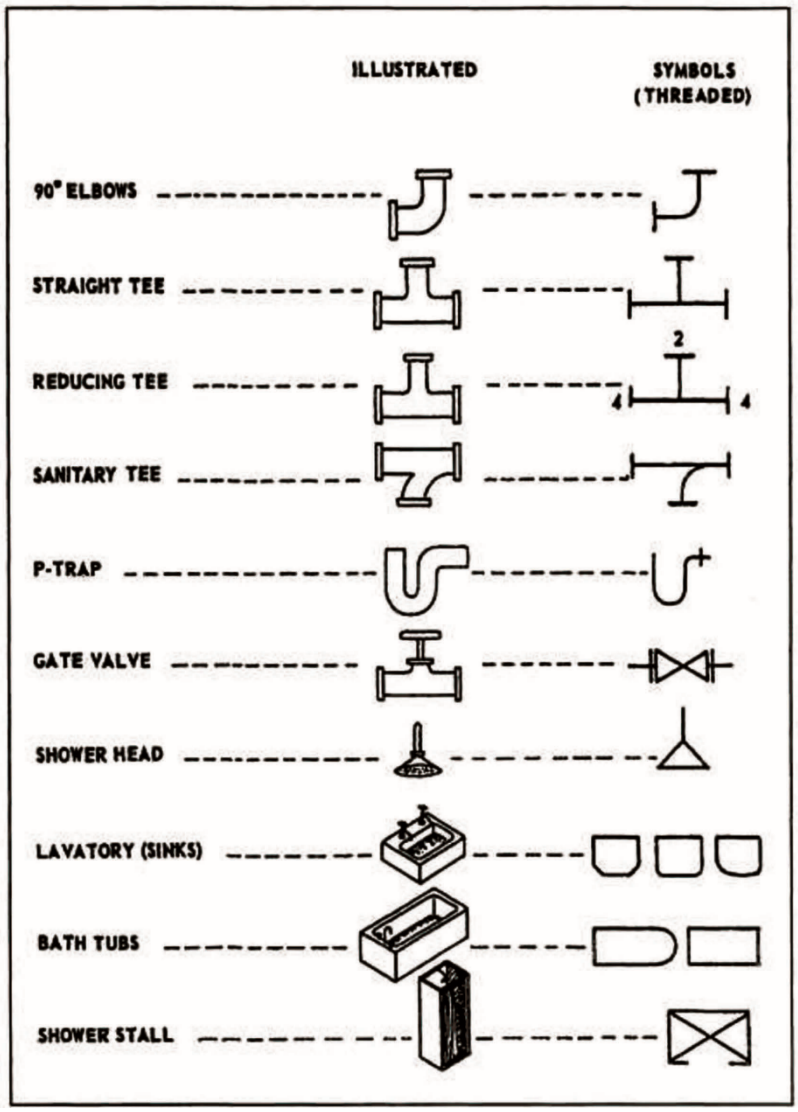
Vernier calliper

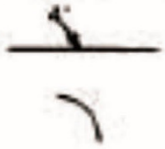
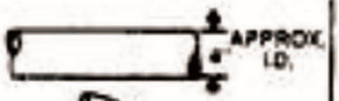
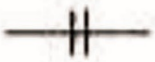
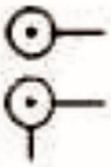
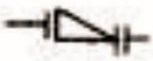
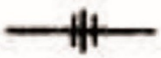
The metre scale is used to measure the length to the nearest millimetre only. For measuring smaller lengths precisely, Vernier calliper is used. **Vernier calliper** is a precision instrument used to measure the internal and external lengths. It is usually a manual calliper, as shown in Fig. 4.8 and Fig. 4.9.

Plumbing symbols

Importance of plumbing symbols

A well-trained plumber does the installation of the fittings and fixtures as per the drawing given in the assembly sheet of the plumbing fixtures in the manufacturer's catalogue. These drawings consist of symbols, assembly of fixture and installation method. Identification of the symbols given in the drawings of fixtures makes the installation work easy for the plumber. Plumbing symbols are given in this Unit. The students should identify and learn the symbols so that it will be helpful in future.



ITEM	SYMBOL	SAMPLE APPLICATION (S)	ILLUSTRATION
PIPE	SINGLE LINE IN SHAPE OF PIPE- USUALLY WITH NOMINAL SIZE NOTED		
JOINT- FLANGED	DOUBLE LINE		
SCREWED	SINGLE LINE		
BELL AND SPIGOT	CURVED LINE		
OUTLET TURNED UP	CIRCLE AND DOT		
OUTLET TURNED DOWN	SEMICIRCLE		
REDUCING OR ENLARGING FITTING	NORMAL SIZE NOTED AT JOINT		
REDUCER CONCENTRIC	TRIANGLE		
ECCENTRIC	TRIANGLE		
UNION SCREWED	LINE		
FLANGED	LINE		

 Water Meter	Cold Water
Hot Water	Vent Line
Sanitary Waste	G Gas Pipe
Gate Valve	Water Heater Shut Off
 Water Closet	 Lavatory
 Water Heater	 Dishwasher
 Clothes Washer	 Floor Drain
 Clean Out	 Vent Thru Roof
 90 degree Elbow	 Pipe Turns Up
 Pipe turns Down	 Tee
 Union	 Cap

UNIT 09

PERFORM WORKSHOP PRACTICES

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

IDENTIFY AND EXPLAIN FUNCTIONS TOOLS USED IN MECHANICAL WORKSHOP

Most common mechanical tools.
Here's a list of mechanics tools, divided into three categories, it gives you an idea of what the hobbyist, Diy expert and the Pro mechanics tool box might look like.

Why I Wear Hand Protection

A mechanics hands are pretty tough, but not as tough as some of the chemicals that get on your skin. While it appears that chemicals like gas and oil don't actually hurt your skin on contact, they will damage your hands. The skin will absorb them and the liver has to rid the body of the toxins.

Simple latex gloves will protect the skin and the rest of the body from unknown chemicals. My uncle was a argi machinery mechanic and never took to wearing gloves, his hands show it, dry and cracked.

If you use a lot of air tools, like air chisels, impact wrench's or any tool that vibrates, you'll need to think about anti vibration gloves.

Hand arm vibration syndrome (HAVS) is a condition that effects mechanics or any one using this type of equipment. The constant vibration causes hand nerve damage, it's a condition that's uncomfortable, reduces power in the hands and is irreversible.
You can check out this article on a medical website called "Patient.info".

This condition isn't widely know about in the industry, wearing anti vibration gloves with air tools or any vibrating tool should be as compulsory as a hard hat on a construction site.

Why Wd40 Is My Favourite Tool

This stuff is close to magic, you'll be amazed what you can fix with wd. It's great at preventative maintenance, drives out moisture and protects.

It's especially useful when working on old cars, corroded bolts usually means busted knuckles, rounded fastener heads, vice grips, blow torch, hammers, chisels, basically a right pain in the jacksie.

I always have lots of WD on hand, it's probably the most useful tool in a workshop, that's why it's the first tool on the list.

Is A Torque Wrench Essential?

A torque wrench is a tool that tightens fasteners to an adjustable specific measurement. All nuts, bolts and screws will have an exact torque specification, set out by the manufacturer.

Over-tightening and under-tightening can cause bolts to break and components to come loose, which obviously can endanger life if the component is part of the suspension, braking or steering systems.

Uses: If you're removing and fitting wheels, they'll need to be torqued to specification. Wheels tightened by feel is OK in an emergency, but ideally should be checked and torqued at the earliest opportunity.

A torque wrench is also needed when replacing a water pump, front engine cover, camshaft cover, oil pan etc. Over-tightening these components can lead to oil leaks and serous engine damage.

A Tool Box Needs To Be Mobile

When you're working on a car, its more efficient to take all your tools to the car, if you can't do that, prepare to burn a lot of time and shoe leather.

Walking over and back to a tool box all day can be sole destroying especially when a job isn't going your way.

Uses: A small transportable tool box is perfect for the hobbyist, it keeps everything in one place and you'll know where everything is. More drawers sometimes equals more hiding places for tools.

Not being able to lay your hand on the right tool quickly is annoying. A good tool box should have a wide range of storage space for standard tools while not being overly cumbersome.

Best Hammer For A Mechanic

A hammer is a hammer, right? Well not really. A mechanic needs a few different types, different metals and components need to be treated differently.

Hammers are graded by type, weight and material used. A mechanic will typically need 3 to 4 hammers. A large 3-4 lbs steel head hammer is great for loosening ball-joints, especially if your working on a truck.

The basic Peen hammer will have a ball head on one side and a flat face head on the other.

The peen head was traditionally used to harden metal. In the hands of a mechanic it will likely be used to repair, or shape sheet metal, fastener heads etc. The peen is the ball of the hammer, it leaves a smaller witness mark than a flat faced hammer.

The Rubber hammer, yea I know it sounds like a joke, but it's real. It's a metal hammer, with a lead filled head covered in heavy rubber. It's used to strike softer materials, like plastic, rubber and sheet metal.

A mechanic would likely use a rubber hammer to move a component rather than reshape it.

Uses:

Brass or copper head hammers are used in engine and transmission rebuilds. Brass and copper are soft metal, and that's important.

These hammers are designed to be used on harder materials, meaning the hammer face will deform instead of damaging the component.

Hammer heads are commonly made from brass, copper, lead, leather and plastic. The striking face of the hammer are often replaceable.

What Chisels Do Mechanics Use?

Chisels are not all the same, they come in lots of different sizes, and have different functions.

Mechanics use what's known as a cold chisel, named by blacksmiths as it's the best chisel to cut cold metal. The striking head is unique in that it's not heat treated like the shaft and tip. The softer metal in the head is less likely to shatter, and therefore safer to use.

Uses:

A mechanic will need a 3-4 different size cutting chisels, they're used for a variety of uses. When working on old cars often they'll be used to remove old rusty fasteners, cutting sheet metal, exhaust system repairs etc.

Punches:

A mechanic will also find plenty of uses for punches of various sizes. A punch is used in the removal of old bearings and other press fitted components. The flat faced tip instead of a chisel tip is perfect for catching a bearing lip.

Wire Brushes Types And Uses

A wire brush is exactly as it's name suggests. It's a basic tool that you'll use everyday as a mechanic.

Uses:

Useful for removing rust and dirt from bolt threads before removing them, cleaning brake components, brake lines, rusty sheet metal etc.

Wire brushes don't usually last longer than six months or so, the wire bristles wear down and become too flexible.

I especially like the wire brush adaptors for the power tools, they come in all shape and sizes, so'll easily get one that's perfect the job at hand, it saves a ton on elbow grease.

Screwdrivers Types And Uses

Can't be a mechanic without a good selection of screwdrivers, you'll need a wide variety of Philips (Star) head and flat heads. Long and short reach and with magnetic head which is always useful for stray screws.

Shock proof is preferred, you'll need to hit them with a hammer from time to time.
I don't have favourite screwdrivers because they tend to wear out and when they do they're useless, they slip and damage fasteners which makes a simple job a bigger one.

What's A Vice-grips?

I can't remember not having a Vice-grips, I been using them forever. They are the go to tool when things turn to s**t. The original vice grips is an American invention and is simply ingenious.

Uses:

Designed to be an extra hand, it's used mainly to grip and hold work materials.
It's clever design allows you adjust, clamp and unclasp the grips using one hand. The range expanded and come in many variations – chain, clamp, pointy nose, mini and many other varieties, I'd say I use my grips every day it's a must have tool.

What's An Adjustable Wrench?

The adjustable wrench is a tool box staple, it's especially popular with plumbers. Not a tool I would use very often, a mechanic will prefer to have a more precise wrench fit, the adjustable wrench, although very flexible, can be a little cumbersome to use.

Uses:

The adjustable wrench is a universal wrench, adjust it to fit any nut or bolt. They're pretty durable kit and can be struck with a hammer when called for.

I use them when working on high pressure hoses, the stout jaws fit the wide hose pipe fittings nicely, a plumber can't work without adjustable wrenches.

What's A Wrench Set?

Wrenches are precision tools, each one is a fixed size and will only fit its corresponding nut or bolt size. Commonly made using industrial-grade chromium-vanadium steel.

The standard wrench has an open end on one side and a box end on the other, known as a combination wrench.

The open end is great for easy fast use but grip is compromised, every mechanic has skinned his or her knuckles on a slipping open ended wrench, if you haven't, your not trying hard enough.

The box end offers the best grip and less likely to damage the fastener head or your knuckles.

In Europe wrench's are called spanners and the box end is called the ring end.

Double ring head, Stubby, Offset, Ratchet, Flare-nut wrench, C-Type, Double open ended and lots of other combinations.

Box end wrenches are available in 12 point and 6 point. The 12 point allows for greater access to a fastener head, the angel of attack is much wider than a 6 point. The 6 point however, will often grip the fastener more snugly and is much less likely to ring the fastener head.

Two standards are the norm and most mechanics will have both. Metric and standard (Imperial). Metric wrenches are measured in millimetres. Common sizes in a tool set range from size 8mm to 25mm with 8,10,13,17 being the most popular sizes.

Standard wrench sizes are more popular in the US, you'll find them on older cars, motorbikes and lawn mowers. Popular imperial sizes include 3/8, 7/16, 1/2, 11/16 and 3/4 inch.

Uses:

The wrench is obviously one of the most used tools in a mechanics tool box.
I use them everyday on various jobs, usually fasteners where you can't fit a ratchet and socket.

What's A Ratchet & Socket Set?

A ratchet is a tool used to drive sockets. It is much faster loosening and tightening fasteners than a spanner, however it is a lot bulkier.

The ratchets great advantage is its flexibility. A ratchet set will include a range of popular sizes but also long and short extensions. The set snaps together and allows the mechanic reach deep between components and manipulate nuts and bolts.

For those really awkward nuts and bolts the set includes the knuckle, this nifty kit allows the socket sit squarely on the fastener while the extension is offset.

Of course a ratchet set is useless without sockets. And sockets as you can imagine come in many different forms.

- ✓ Standard
- ✓ Deep set,
- ✓ Plug sockets
- ✓ O2 sockets
- ✓ Low profile sockets
- ✓ Impact sockets
- ✓ Wheel sockets
- ✓ Insulated sockets
- ✓ Crows feet

Many sockets are available in 1/2 inch, 3/8 and the smallest 1/4 inch drive.

Generally a 1/2 ratchet drive is used with the 1/2 sockets, but adaptors are allow you to mix and match between the sizes. The combinations are endless and if you're working on modern cars you'll use most of them and some!

The sockets just like wrenches are available in 12 point or six point, the six offering less flexibility but far greater grip.

The usual standard or metric sizes are also available and if your working on classic cars you'll need both.

Avoid if you can using an impact wrench with your regular sockets. The walls are thinner and they'll break or shatter, causing injury.

Uses:

Excellent for removing deep set fasteners such as spark plugs, header bolts, transmission bolts, starter motor bolts, anywhere your hand movement is restricted, which on modern cars – anywhere under the hood.

What's An Oil Filter Tool?

Older style car oil filters are a simple metal filter that screws onto an oil filter adaptor on the side of the engine block. Although oil filters are only fitted hand tight (oil filter tools are not needed for fitting), the filters do tight over time and so a tool is needed to remove them.

A strap or chain grips may be used for leverage but only useful when the real estate around the filter is vacant. If the filter is berried between components then you'll need a claw long extension and ratchet. It crushes the filter and looks kind of unprofessional but very effective.

Modern car oil filters use a cartridge set up and require a different type oil filter tool. Sockets and ratchets are used on later models and on earlier models oil filter removal tools resembling very large sockets were needed.

There are a few different oil filter tools for different applications and so you'll need a variety, a claw, chain or strap and a oil filter set.

IDENTIFY AND EXPLAIN PROPERTIES OF VARIOUS PIPES AND THEIR APPLICATIONS

Since plumbing was first invented, the material used for piping has been an important factor. In the early days of plumbing in the ancient world, lead and clay piping was used to transport water to homes and public buildings. In the early twentieth century, when plumbing began to move into homes in the U.S., materials like cast iron, terra-cotta, copper and galvanized steel were used. Lead piping was also common and was the material of choice for plumbing pipes until World War II.

However, as the understanding of lead poisoning increased, the popularity of lead piping fell off, particularly for water that was meant to be potable. After World War II, galvanized screw piping gained favor as the material of choice for plumbing pipes inside the home, and a few decades later, in the 1970s, copper became more popular. Later in the 1970s, polybutylene was introduced. It was found that this material is compromised by exposure to chlorine, though, so many building codes now ban the material.

Today, there are many types of plumbing pipes available — some old classics and some made from newer materials. There are pros and cons you should consider with each of these materials when selecting which type of pipes to use in your home's plumbing system. In this post, we will discuss some of the popular options to choose from and the selling points as well as the drawbacks associated with each one. The integrity of your home's plumbing can play an important role in your quality of life, so you want to make a well-informed decision.

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 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 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 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 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. If the piping is meant to transport drinking water, look for an "NSF-PW" or "NSF-61" label, which means the material meets the standards laid out by NSF/ANSI 61: Drinking Water System Components – Health Effects.

Pros and Cons of Polyvinyl Chloride Pipes

PVC pipes have gained popularity because of some important advantages they offer, including:

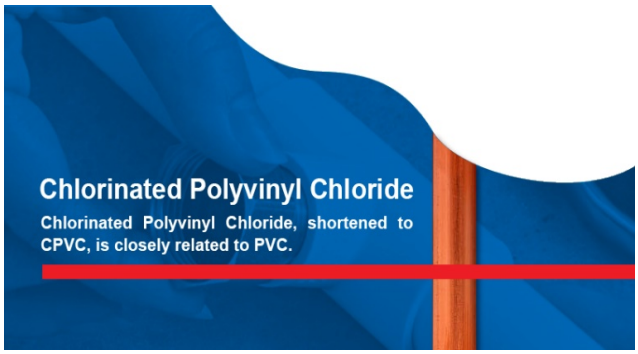
- ✓ Longevity: PVC is not subject to rust or corrosion, so unless it experiences some sort of unexpected damage, it can last indefinitely. Even the most durable metals used in plumbing pipes cannot live up to the impressive lifespan of PVC.
- ✓ Ability to Handle Pressure: PVC is often used for the main supply line that goes into your home because it is able to handle high water pressure.
- ✓ Ease of Use: PVC is extremely light compared to metal pipes, which makes it easy to transport and to work with. It is also easy to work with because there is no soldering required to connect pipes. Instead, pipes are essentially glued together.
- ✓ Low Cost: PVC is low in cost as well. Especially compared to copper, PVC is a very inexpensive option for plumbing pipes.

While PVC has some marked advantages, it has a couple of disadvantages, too. These include:

- ✓ Susceptibility to Warping: PVC is not equipped to transport hot water. This is because, like most plastics, heat can cause the material to warp and melt.
- ✓ Size: Sizing options for PVC pipes are limited, which can be an issue at times. Even if your PVC piping is the perfect size, fittings used to connect PVC pipes can tend to be bulky, which can be problematic in tight spaces.

4. Chlorinated Polyvinyl Chloride

Chlorinated Polyvinyl Chloride, shortened to CPVC, is closely related to PVC. Though both materials are made from the same basic elements, the key difference is that CPVC is chlorinated. This chemical difference makes CPVC able to withstand temperature differences in a way that PVC cannot. For this reason, some building codes call for CPVC in place of PVC for transporting hot water.



Whereas PVC is typically only available in a sizing system called Nominal Pipe Size (NPS), CPVC comes in this sizing system as well as in Copper Tubing Size (CTS). As the name suggests, this sizing system mimics the same size graduations used by copper piping.

Pros and Cons of Chlorinated Polyvinyl Chloride

CPVC pipes share many of the advantages of PVC, plus one more:

- ✓ Longevity: Like PVC, since CPVC is a plastic material, it does not react to corrosive substances and does not rust, so its lifespan is indefinite.
- ✓ Ability to Handle Pressure: CPVC shares PVC's ability to handle high water pressure, making it a good material for a main water supply line.
- ✓ Ease of Use: CPVC is also quite lightweight, which makes it easy to move and work with. CPVC is also somewhat flexible.
- ✓ Low Cost: Though CPVC costs more than PVC, it is still a budget option compared to metal piping materials.
- ✓ Temperature Tolerance: CPVC is able to withstand extreme temperatures up to 200 degrees Fahrenheit. This equips CPVC to handle hot water transport.
- ✓ CPVC does not have many clear disadvantages, though it may not always be the best choice. Cons include:
- ✓ Indoor Application Only: CPVC is vulnerable to breaking down if exposed to sunlight for extended periods of time.
- ✓ Cost Compared to PVC: Though cost was included as an advantage of CPVC, when comparing it directly to its close cousin, PVC, it does cost more.

5. Cross-Linked Polyethylene Pipes

Cross-Linked Polyethylene, or PEX for short, is another plastic material used for piping. Plastic pipes in general have become a popular type of pipe used in new homes. This particular plastic material is relatively new on the plumbing scene and can be used for a variety of plumbing applications. The major difference between PVC and PEX is that PEX pipes are flexible. This means they can be used in long, continuous runs.

In addition to being flexible, PEX is easy to cut and join together. The PEX system is designed to fit together with the combination of barbed fittings and crimping rings or cinch clamps. This method of joining pipes is in lieu of any soldering or gluing. The installation process is quick and easy, and the material is made to last. PEX piping can come coiled up in a flexible roll, wrapped in aluminum to keep its shape or in hard lengths.

Pros and Cons of Cross-Linked Polyethylene Pipes

To become the new favorite piping choice among many plumbers and homeowners, this material must come with some major advantages. These include:

- ✓ Longevity: PEX pipes, like PVC and CPVC, are completely rust and corrosion resistant. This means they can last indefinitely without needing to be replaced, unless they are broken somehow.
- ✓ Flexibility: PEX is flexible enough to make 90-degree turns with no problem. It can easily be snaked into walls — making it a great material for retrofitting — and it is able to extend across the length of a house with just one long piece.
- ✓ Ease of Use: PEX's flexibility makes it very easy to install. When joints are needed, no soldering or even gluing is required.
- ✓ Temperature Tolerance: Another important advantage of PEX over PVC is that PEX is able to withstand extreme temperatures. It can be used to transport hot water as well as cold.
- ✓ Low Cost: Like CPVC, PEX is more expensive than PVC, but, at about $30 per 100 feet of piping, is still significantly cheaper than copper.

PEX does have a few disadvantages, though one of these PEX plumbing disadvantages has largely been debunked. PEX pipe problems include:

- ✓ Indoor Application Only: PEX piping cannot be used in any outdoor applications since the plastic can be damaged by UV radiation. Of course, this is not really a disadvantage if you only plan to use PEX piping indoors.
- ✓ Water Taste and Odor: Some types of PEX pipes have been known to affect the taste and odor of drinking water, especially if the water has stayed in the pipes for some time.
- ✓ Possible Safety Concerns: There has been some concern and debate over whether PEX piping has the potential to contaminate drinking water due to the material's makeup. These concerns have largely been dispelled, however. Even the strictest

environmental regulations in the U.S. now approve PEX piping, and research has shown that drinking water from PEX pipes does not involve health risks.

Additional Plumbing Pipes

Now that we have looked at some of the most common types of plumbing pipes, let's take a quick look at several others that are not quite as common. These include stainless steel, cast iron, polybutylene (PB) and High Density Poly Ethylene (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 Poly Ethylene Pipes

High Density Poly Ethylene 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.

Types of Pipe Joints in Plumbing

Different types of pipe joints used in plumbing system are as follows.

- ✓ Threaded joint
- ✓ Brazed joint
- ✓ Soldered joint
- ✓ Welded joint (butt welded, socket welded)
- ✓ Flanged joint
- ✓ Compression joint

- ✓ Grooved joint

1. Threaded Joint in Pipe

Threaded joint means, pipes are connected by screwing with the help of threads provided for each pipe. One pipe having internal threads and the other one having threads externally. Cast iron pipes, copper pipes, PVC and G.I pipes are available with threads.

Threaded joints are available from 6mm diameter to 300mm diameter pipes. They are preferable for low temperature areas and low pressure flows. In the areas of high temperature, the joints may expands and leaked due to thermal expansion. Installation of threaded joint is easy but good maintenance required.

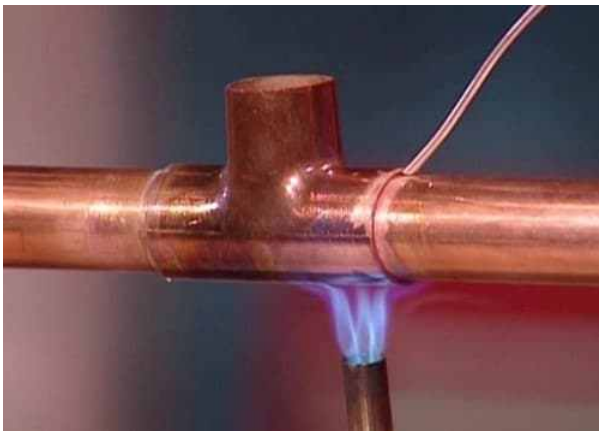
2. Brazed Joint in Pipe

Brazing is the process of jointing pipes using molten filler material at above 840oC. Brazing is generally used for joining copper pipes or copper alloy pipes. The filler material majorly consist tin which has great affinity towards copper. But because of its weak property tin is added to other materials like nickel, bismuth, silver and copper.

The melting point of parent metal should be higher than filler metal. Mechanical strength of brazed joint is low compared to other joints. This type of joint is suitable in moderate range of temperature areas.

3. Soldered Joint in Pipe

Soldering is also similar to brazing but the only difference is in case of soldering the filler metal melts at below 840oC. Soldering also used to joint copper and copper alloy pipes. Before proceeding to soldering flux called paste is applied to pipes and fittings to prevent them from oxidation from flame. Here also we require skilled workers for installation.



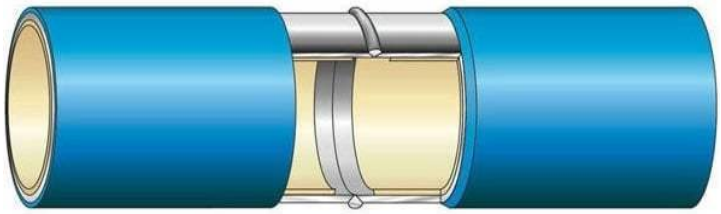
Soldered joints are suitable for low temperature areas. These are having low mechanical strength as brazed joints.

4. Butt Welded Joint in Pipe

When the pipes are of same diameter butt welding is to done to join the pipes. It is the most common type of welding. Skilled workers are required to install the joint. These joints are generally used for large commercials and industrial piping systems.

Butt weld provides good strength for the joint and it can resist high pressure because of smooth and continuous surface inside the joint. Butt weld joints are expensive, to make it economical sometimes internal weld backing rings are used, which joins the pipe with less amount of filler material. But these rings may fail under heavy stress and cracks are developed.

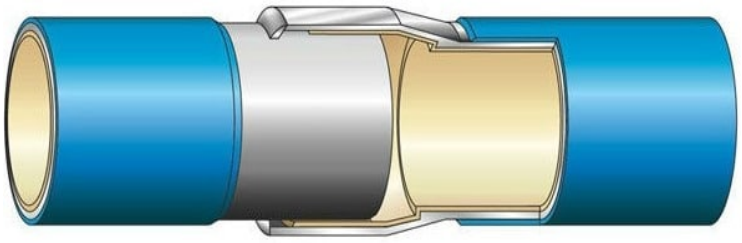
The joints are fixed and do not opened for maintenance purposes. External smoothing of welded portion will give good appearance to the piping system.



5. Socket Welded Joint in Pipe

Socket welded joints are used wherever there is a high chance of leakage in joints. Pipes are connected as putting one into other as shown below and welded around the joint. Pipes having different diameters are suitable for this type of joint.

If pipes having similar diameter, then required fittings are used. Welding cost is generally lower than butt welding. Fatigue resistance is lower for socket welded

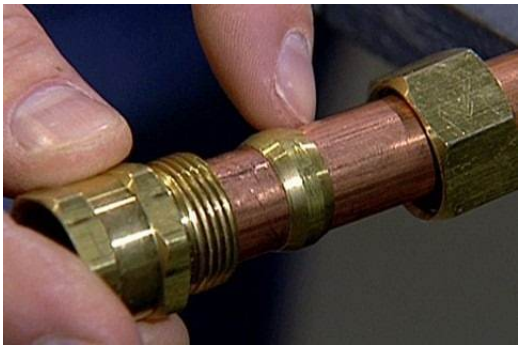


joints when compared to butt weld joints. However, socket welded joint give good results when compared with other mechanical joints.

6. Flanged Joint in Pipe

Flanged joints are used for high pressure flows and for large diameter pipes. In general they are used for plain end pipes or threaded pipes. Two flange components are connected by bolts at the pipe joint to prevent leakage.
Generally these are made of cast iron, steel etc. these are having good strength and do not fail against high pressure. Against high temperatures the bolts may fail under creep lost their grip so, fixing of bolts should be done properly while installing. They are also useful for repairing pipelines and maintenance purposes.

7. Compression Joint in Pipe



When the pipes have plain ends they are joined by installing some fittings at their ends then that type of joint is called compression joint. The pipe ends will be fitted with a threaded fittings or couplings hence they are connected.
So, in this case we can connect pipes of different materials and different sizes. But the joints should be properly fitted to resist flow pressure otherwise they may fail and leakage occurs. Compression fittings are available in different materials and selection of fittings may depend upon our requirement.

8. Grooved Joint in Pipe

In case of grooved joint, the pipe ends consist grooved edges which are connected by elastomer seal and then ductile iron made grooved couplings are used as lock for elastomer seal. This grooved couplings are connected by bolts. These joints are easy to install and economical.

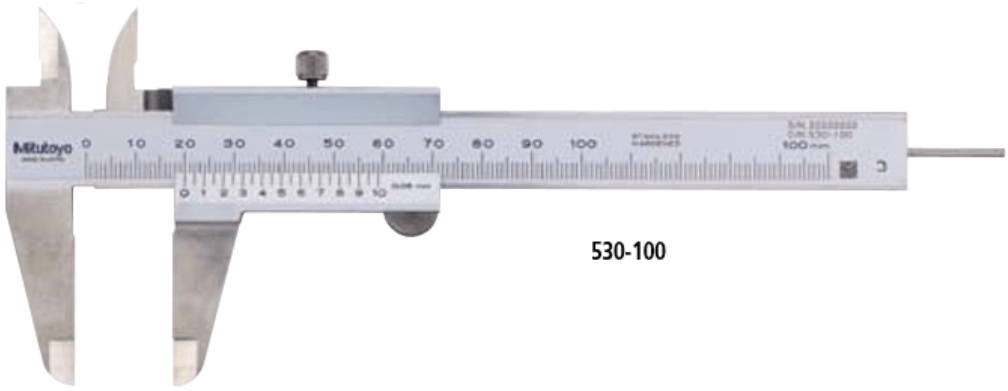
Grooved joints will give good resistance against pressure and allows moderate axial movement due to thermal expansion. But, in high temperature Areas elastomer seal may lost its strength and torsional failure occurs. So, these are permitted to moderate temperature areas.

Grooved joints are easily removable so, for maintenance purposes of pipes these joints are preferable.

USE MEASURING INSTRUMENTS PROPERLY

1. Vernier Caliper

Vernier Caliper is a widely used linear measurement instrument with a least count of 0.02 mm. It is used to measure linear dimensions like length, diameter, depth.
It is Basic Instrument of measurement, consist of two types of scale



The main scale and the Vernier scale that can slide along the main scale. Two types of measurement we can do, the first one is through external jaw (measure external dimensions) and another one is internal jaw (measure internal dimensions).

2. Micrometer

External Micrometer is also known as Outside Micrometer or External Micrometer.
It is used to check outside diameter of circle by the means of accuracy of 0.01 mm or up to 0.001 mm.

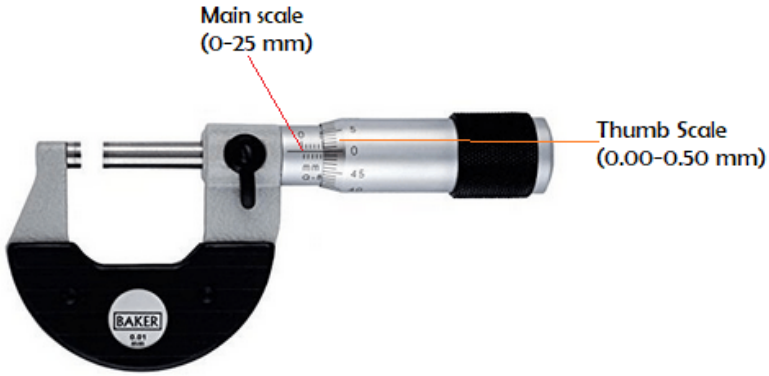


Image: Baker

Vernier type Micrometer gives highest acceptable accuracy of 1 micron such gauge is vernier type micrometer.

Difference between Micrometer and Vernier caliper

1. Usually Micrometer is more accurate and precise than Vernier caliper
2. Measurement range of micrometer is 25 mm while vernier caliper has wide range.
3. You can check depth by vernier caliper but in case of micrometer you have to use Depth Micrometer
4. Inside Micrometer is used for measurement of inner diameter but in case of vernier caliper it is checked by internal jaw.

03. Bevel Protractor

A simple protractor is a basic device used for measuring angles with a least count of 1° or ½°. Bevel Protractor is an angular measuring instrument capable of measuring angles with a least count of 5'.

The protractor dial is graduated in degrees with every tenth degree numbered. The sliding blade is fitted into this dial I.e. it may be extended to either direction and set at an angle to the base.

04. Dial Gauge (Plunger, Level)

The dial indicator or the Plunger dial gauge is one of the simplest and the most widely used mechanical comparator.

First of all the use of plunger dial gauge used to compare work-pieces against a master

Lever Dial Gauge also knew as Test Indicator. It used to measure sensitive contact.

Lever Dial gauge usually measure up to 0.80 mm. But some special type lever dial design for measurement up to 2 mm.

08. Engineering Square

A ruler can be used to draw straight lines but there is no guaranty that the line is drawn is accurate and exactly straight, this is where the engineering square is brought into use.

UNDERTAKE BASIC ARC WELDING

Working Principle & Types

The first arc welding method was developed in the 19th century, and it has become commercially significant within shipbuilding throughout II-World War. Nowadays it remains a significant process for vehicles as well as steel structure fabrication. This is one of the famous welding methods which are used for joining metals in industries. In this type of welding, the joint can be formed by melting the metal with the help of electricity. So due to this reason, it is named an electric arc. The main benefit of this welding is, a high-temperature can be easily developed for welding. The arc welding temperature range will be 6k degrees centigrade to 7k degrees centigrade. This article discusses an overview of electric arc welding.

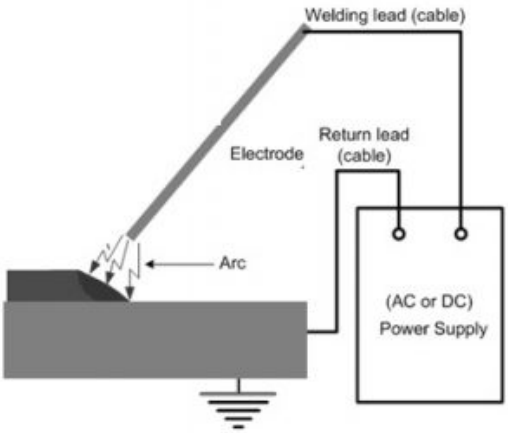
What is Electric Arc Welding?

The definition of arc welding is a welding process that is used for welding the metals with the help of electricity to generate sufficient heat for softening the metal, as well as when the softened metal is cooled then the metals will be welded. This kind of welding uses a power supply to make an arc among a metal stick & the base material to soften the metals at the end of the contact.

These welders can utilize either DC otherwise AC, & electrodes like consumable otherwise non-consumable. Generally, the welding location can be defended with some kind of shielding gas, slag, otherwise, vapor. This welding process could be manual, fully, or semi-automated.

Circuit Diagram

In Arc welding process, heat can be generated through an electric arc struck among an electrode as well as the workpiece. The electric arc is glowing electrical discharge among two electrodes using ionized gas.



Any type of arc welding technique depends on an electric circuit that mainly includes different parts like power supply, workpiece, welding electrode & electric cables to connect the electrode as well as workpiece toward the power supply.

The electric arc winding circuit can be formed by an electric arc among the electrode as well as the workpiece. The temperature of the arc may arrive at 5500°C (10000°F), which is enough to combine the edges of the workpiece.

Once a long join is necessary then the arc can be moved through the joint line. The weld pool of the front edge dissolves the welded surface once the back edge of the pool hardens to form the joint.

Once a filler metal is necessary for enhanced bonding, the wire can be used outside of the material which is fed to the arc region, which dissolves & loads the weld pool. A filler metal's chemical composition is related to that of the workpiece.

Molten metal within the weld pool can be active chemically & responds through the nearby atmosphere. Consequently, the weld may be infected through oxide as well as nitride inclusion to weaken its mechanical properties. So, the weld pool can be protected through Neutral shielding gases like helium, argon & shielding fluxes from contamination. Shields are supplied for the weld zone in the form of a flux coating for the electrode otherwise in other forms.

Working Principle

The working principle of arc winding is, in a welding process the heat can be generated with an electric arc strike among the workpiece as well as an electrode. This is glowing electrical discharge among two electrodes throughout ionized gas.
The arc welding equipment mainly includes an AC machine otherwise DC machine, Electrode, Holder for the electrode, Cables, Connectors for cable, Earthing clamps, Chipping hammer, Helmet, Wire brush, Hand gloves, Safety goggles, sleeves, Aprons, etc.

Types of Arc Welding

Arc welding is classified into different types which include the following.

- ✓ Plasma Arc Welding
- ✓ Metal Arc Welding
- ✓ Carbon Arc Welding
- ✓ Gas Tungsten Arc Welding
- ✓ Gas Metal Arc Welding
- ✓ Submerged Arc Welding
- ✓ SMAW – Shielded Metal Arc Welding
- ✓ FCAW (Flux Cored Arc Welding)
- ✓ ESW (Electro-Slag Welding)
- ✓ Arc Stud Welding

Plasma Arc Welding

Plasma arc welding (PAW) is similar to GTAW or gas tungsten welding. In this kind of welding process, the arc will generate among the work part as well as the tungsten electrode. The major dissimilarity between plasma arc welding and gas tungsten welding is that the electrode is located within the torch of Plasma arc welding. It can be heated the gas at the temperature of 30000oF & change it into the plasma to attack the welding region.

Metal Arc Welding

The metal arc welding (MAW) process mainly uses a metal electrode for the welding process. This metal electrode can be either consumable otherwise non-consumable based on the requirement. Most of the used consumable electrode can be covered with flux, and the main benefit of this type of welding process is that it requires low temperature compared with others.

Carbon Arc Welding

The Carbon arc welding (CAW) process mainly uses a carbon rod like an electrode for welding the metal joint. This kind of arc welding is the oldest arc welding process and requires high current, low voltage for generating the arc. In some cases, an arc can be generated among two carbon electrodes which are named twin carbon arc welding.

Gas Tungsten Arc Welding

The gas tungsten arc welding (GTAW) is also called Tungsten inert gas welding (TIGW). In this type of welding process, a tungsten electrode that is non-consumable can be employed for welding the material. The electrode which is used in this welding can be enclosed with gases such as argon, helium, etc. These gases will guard the weld region against oxidization. This kind of welding can be used for welding thin sheets.

Gas Metal Arc Welding

Gas metal arc welding (GMAW) is also called Metal inert gas welding (MIGW). It uses a fresh metal electrode that is protected by gas like helium, argon, etc. These gases will protect the join area from oxidation and generates multiple welding material layers. In this type of arc welding process, a filler wire can be fed constantly using a non-consumable metal electrode for welding the metal.

Submerged Arc Welding

The Submerged arc welding (SAW) can be extensively utilized within an automatic welding method. In this kind of welding process, an electrode is completely submerged by the granular coating of flux, and this flux can be an electric conductor that will not oppose the electric supply. The solid coating of flux stops the melted metal from ultra-violate radiation and atmosphere.

SMAW – Shielded Metal Arc Welding

The term SMAW stands for “Shielded Metal Arc Welding” which is also called stick welding; flux shielded arc welding or manual metal arc welding (MMA/MMAW). This kind of welding is used where the arc is struck among the workpiece as well as the metal rod. So the surface of both of these can dissolve to form a weld pool.

When the flux coating melts immediately on the rod then it will form slag & gas to protect the weld pool from the surroundings. This is a flexible method and suitable for connecting the materials like ferrous & non-ferrous through a thickness material in all locations.

FCAW (Flux Cored Arc Welding)

This kind of welding is an alternative to shield metal arc welding. This flux-cored arc welding works with an electrode as well as a stable voltage power supply so that it provides a stable arc length. This method works by using a shielding gas or the gas which is formed through the flux to give safety from contagion.

ESW (Electro-Slag Welding)

In this kind of welding, the heat is produced through current and passes among the filler metal as well as the workpiece using a molten slag to the surface of the weld. Here, welding flux is used to fill the gap between the two workpieces. This kind of welding can be started through an arc among the electrode as well as the workpiece.
The arc generates the heat to melt the fluxing powder & makes molten slag. Here the slag includes less electric conductivity that can be maintained within liquid condition because of the heat generated through the electric current. The slag gets a 3500°F of temperature and it is adequate for melting the edges of the workpiece and consumable electrode. Metal droplets will drop toward the weld pool & connects the workpieces. This kind of welding is mainly applicable to steel.

Arc Stud Welding

This type of welding is extremely reliable and used in a wide range of applications. This method is used to weld any size of metal with a workpiece through the highest weld penetration.

This type of welding can create tough, welds on a single side over base metals with 0.048-inch thickness. This arc can be formed by using a DC power supply; metal fasteners; ferrules & a stud welding gun. In this welding, there are three common methods used like drawn arc, short arc stud & gas arc stud welding.

The drawn arc method works with flux by fixed within the stud to clean the surface of metal throughout the welding. Throughout arcing, the flux can be vaporized & responds through the polluting elements within the environment to maintain the weld region clean.

The short arc method is similar to drawn arc, apart from that it utilizes no flux load otherwise ferrule. So, this method gives the shortest welding times of the arc stud welding

techniques. The gas arc stud method works through static shielding gas with no ferrule or flux which makes it easier to automate.

Other Types of Arc Welding

We know that most of the industries use metal design and the most commonly used weldings are discussed above. But, several other methods can also weld two or above metals together like the following.

Electronic Beam Welding

The EBM or Electronic beam welding is used to join metals wherever electron waves get fired up at high velocity for welding one metal surface to another. Once the electron wave strikes its objective, then the affected spot will melt just sufficient to combine the adjoining part into place.

This kind of welding is very popular in the industrial area. The technique is particularly useful for the manufacturers of aerospace & automotive, who use this welding to combine several metal parts within trucks, cars, planes & spacecraft. Because of the nature of electronic beam welding based on vacuum, the method is secure for crisis work in vacated houses and buildings.

Atomic Hydrogen Welding

The AHW or Atomic hydrogen welding is an old technique for connecting metals that has frequently fallen through the edge for more efficient techniques like gas metal arc welding. One region where automatic hydrogen welding is still familiar is in tungsten welding. Because tungsten is extremely responsive to heat, this welding is secure for this method.

Electroslag Welding

This is fast welding, invented during the 1950s. This kind of welding connects heavy metals to use in equipment and machines in industries. As the name suggests, it is taken from the copper water holders enclosed in the tool which is used for electroslag welding. The water discontinues liquid slag from seeping into other regions throughout a welding session.

Carbon Arc Welding

The CAW or Carbon arc welding is a bonding technique, used to connect metals by applying above 300 degrees Celsius temperatures. In this type of welding, an arc can form among the electrodes as well as the surfaces of metal. This technique was popular once, but now it was outdated by twin-carbon-arc welding.

Oxy-Fuel Welding

This kind of welding is a method that uses oxygen & liquid fuel to fuse metal into form. French engineers Charles Picard & Edmond Fouché was invented in the 20th century. In this

process, the oxygen-generated temperature is used in metal surface areas. This welding takes place in an indoor atmosphere.

Resistance Spot Welding

Resistance spot welding is used where heat connects the surfaces of metal. The heat can be generated from the resistance of electrical currents. This kind of welding belongs to a collection of welding techniques called electric resistance welding.

Resistance Seam Welding

Resistance seam welding is a technique that produces heat among the metal faying surfaces through related properties. This kind of welding begins on one face of a joint & works its mode to the other end. So, this method mainly depends on twin electrodes which are normally made of copper material.

Projection Welding

Projection welding is a method that restricts heat in a precise region for placing. This method is very common in projects that use studs, nuts & other threaded metal fasteners, wires & crossed bars.

Cold Welding

An alternate name of this welding is contact welding. This type of welding is used to connect the surfaces of metals without melting through heat.

Advantages of Arc Welding

The advantages of Arc welding mainly include the following.

- ✓ Arc welding has high speed as well as welding efficiency
- ✓ It includes a simple welding apparatus.
- ✓ It is simply moveable.
- ✓ Arc welding forms the physically powerful bond between the welded metals.
- ✓ It provides reliable welding quality
- ✓ Arc welding offers a superior welding atmosphere.
- ✓ The power source of this welding is not costly.
- ✓ This welding is a quick and consistent process.
- ✓ The welder can utilize ordinary domestic current.

Disadvantages of Arc Welding

The disadvantages of Arc welding include the following.

- ✓ A high expert operator is necessary to perform arc welding.
- ✓ The rate of deposition can be incomplete as the electrode covering tends to burn and decrease

- ✓ The length of the electrode is 35mm and needs electrode changing for the entire production rate.
- ✓ These are not clean for reactive metals such as titanium & aluminum

Applications

The applications of Arc Welding include the following.

- ✓ Used in the weldings of sheet metals
- ✓ For welding thin, ferrous & non-ferrous metals
- ✓ Used to design pressure & pressure vessels
- ✓ The developments of piping in industries
- ✓ Used in the domains of automotive and home furnishing
- ✓ Industries of Shipbuilding
- ✓ Used in the manufacturer of aircraft & aerospace
- ✓ Auto body restorations
- ✓ Railroads
- ✓ Industries like construction, automotive, mechanical, etc
- ✓ Gas Tungsten Arc Welding is used in aerospace industries to connect many areas like sheet metals
- ✓ These weldings are used for repairing dies, tools, and mostly on metals that are made with magnesium & aluminum.
- ✓ Most of the fabrication industries use GTAW to weld thin workpieces, particularly nonferrous metals.
- ✓ GTAW weldings are used where extreme resistance to corrosion as well as cracking over a long period of qualities are required.
- ✓ It is used in space vehicles manufacturing
- ✓ Used to weld small-diameter parts, thin wall tubing, making it applicable in bicycle industries

Thus this is all about electric arc welding, and it is the flexible welding method. The electric arc welding applications involve in manufacturing industries for generating powerful joints worldwide because of their features like ease & superior welding efficiency. It is most broadly used in different industries for the protection otherwise renovate works such as automotive, construction, shipbuilding, and aerospace.

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 INDUSTRIAL ELECTRICAL KNOWLEDGE AND SKILLS

This unit coves the competencies required to install industrial electrical control and protective switchgear, lay conduits/ trunking/ ducts and wire single and multiphase circuits, install electrical accessories, fixtures and fitting using specified tools, equipment and material, according to electrical layout plans, conforming with standards and regulations

What is Voltage?

Voltage, (V) is the potential energy of an electrical supply stored in the form of an electrical charge. Voltage can be thought of as the force that pushes electrons through a conductor and the greater the voltage the greater is its ability to "push" the electrons through a given circuit. As energy has the ability to do work this potential energy can be described as the work required in joules to move electrons in the form of an electrical current around a circuit from one point or node to another.

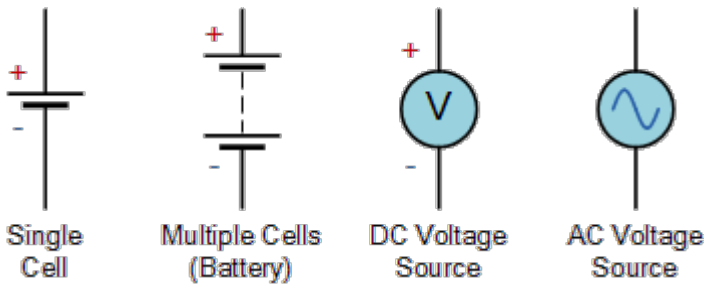
Then the difference in voltage between any two points, connections or junctions (called nodes) in a circuit is known as the **Potential Difference**, (p.d.) commonly called the **Voltage Drop**.

The Potential difference between two points is measured in **Volts** with the circuit symbol V, or lowercase "v", although **Energy**, E lowercase "e" is sometimes used to indicate a generated emf (electromotive force). Then the greater the voltage, the greater is the pressure (or pushing force) and the greater is the capacity to do work.
A constant voltage source is called a **DC Voltage** with a voltage that varies periodically with time is called an **AC voltage**. Voltage is measured in volts, with one volt being defined as the electrical pressure required to force an electrical current of one ampere through a resistance of one Ohm. Voltages are generally expressed in Volts with prefixes used to denote sub-multiples of the voltage such as **microvolts** (μV = 10^{-6} V), **millivolts** (mV = 10^{-3} V) or **kilovolts** (kV = 10^{3} V). Voltage can be either positive or negative.

Batteries or power supplies are mostly used to produce a steady D.C. (direct current) voltage source such as 5v, 12v, 24v etc in electronic circuits and systems. While A.C. (alternating current) voltage sources are available for domestic house and industrial power and lighting as well as power transmission. The mains voltage supply in the United Kingdom is currently 230 volts a.c. and 110 volts a.c. in the USA.

General electronic circuits operate on low voltage DC battery supplies of between 1.5V and 24V dc The circuit symbol for a constant voltage source usually given as a battery symbol with a positive, + and negative, – sign indicating the direction of the polarity. The circuit symbol for an alternating voltage source is a circle with a sine wave inside.

Voltage Symbols



A simple relationship can be made between a tank of water and a voltage supply. The higher the water tank above the outlet the greater the pressure of the water as more energy is released, the higher the voltage the greater the potential energy as more electrons are released.

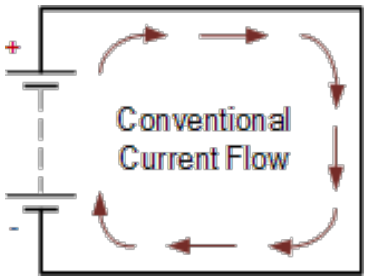
Voltage is always measured as the difference between any two points in a circuit and the voltage between these two points is generally referred to as the "**Voltage drop**". Note that voltage can exist across a circuit without current, but current cannot exist without voltage and as such any voltage source whether DC or AC likes an open or semi-open circuit condition but hates any short circuit condition as this can destroy it.

What is Current?

Electrical Current, (I) is the movement or flow of electrical charge and is measured in Amperes, symbol i, for intensity). It is the continuous and uniform flow (called a drift) of electrons (the negative particles of an atom) around a circuit that are being "pushed" by the voltage source. In reality, electrons flow from the negative (–ve) terminal to the positive (+ve) terminal of the supply and for ease of circuit understanding conventional current flow assumes that the current flows from the positive to the negative terminal.

Generally in circuit diagrams the flow of current through the circuit usually has an arrow associated with the symbol, I, or lowercase i to indicate the actual direction of the current flow. However, this arrow usually indicates the direction of conventional current flow and not necessarily the direction of the actual flow.

Conventional Current Flow

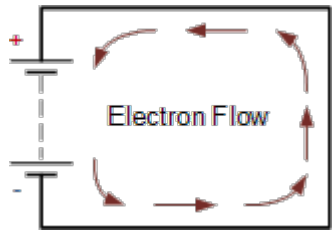


Conventionally this is the flow of positive charge around a circuit, being positive to negative. The diagram at the left shows the movement of the positive charge (holes) around a closed circuit flowing from the positive terminal of the battery, through the circuit and returns to the negative terminal of the battery. This flow of current from positive to negative is generally known as conventional current flow.

This was the convention chosen during the discovery of electricity in which the direction of electric current was thought to flow in a circuit. To continue with this line of thought, in all circuit diagrams and schematics, the arrows shown on symbols for components such as diodes and transistors point in the direction of conventional current flow.

Then **Conventional Current Flow** gives the flow of electrical current from positive to negative and which is the opposite in direction to the actual flow of electrons.

Electron Flow



The flow of electrons around the circuit is opposite to the direction of the conventional current flow being negative to positive. The actual current flowing in an electrical circuit is composed of electrons that flow from the negative pole of the battery (the cathode) and return back to the positive pole (the anode) of the battery.

This is because the charge on an electron is negative by definition and so is attracted to the positive terminal. This flow of electrons is called **Electron Current Flow**. Therefore, electrons actually flow around a circuit from the negative terminal to the positive.

Both *conventional current flow* and *electron flow* are used by many textbooks. In fact, it makes no difference which way the current is flowing around the circuit as long as the direction is used consistently. The direction of current flow does not affect what the current does within the circuit. Generally, it is much easier to understand the conventional current flow – positive to negative.

In electronic circuits, a current source is a circuit element that provides a specified amount of current for example, 1A, 5A 10 Amps etc, with the circuit symbol for a constant current source given as a circle with an arrow inside indicating its direction.
Current is measured in **Amps** and an amp or ampere is defined as the number of electrons or charge (Q in Coulombs) passing a certain point in the circuit in one second, (t in Seconds).

Electrical current is generally expressed in Amps with prefixes used to denote **micro amps** (μA = 10^{-6}A) or **milliamps** (mA = 10^{-3}A). Note that electrical current can be either positive in value or negative in value depending upon its direction of flow around the circuit.

Current that flows in a single direction is called **Direct Current**, or **D.C.** and current that alternates back and forth through the circuit is known as **Alternating Current**, or **A.C.**. Whether AC or DC current only flows through a circuit when a voltage source is connected to it with its "flow" being limited to both the resistance of the circuit and the voltage source pushing it.

Also, as alternating currents (and voltages) are periodic and vary with time the "effective" or "RMS", (Root Mean Squared) value given as I_{rms} produces the same average power loss equivalent to a DC current $I_{average}$. Current sources are the opposite to voltage sources in that they like short or closed circuit conditions but hate open circuit conditions as no current will flow.

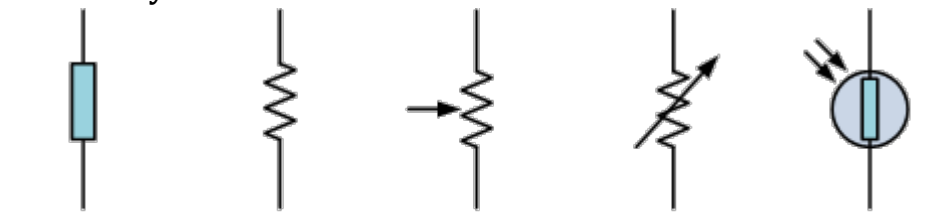
Using the tank of water relationship, current is the equivalent of the flow of water through the pipe with the flow being the same throughout the pipe. The faster the flow of water the greater the current. Note that current cannot exist without voltage so any current source

whether DC or AC likes a short or semi-short circuit condition but hates any open circuit condition as this prevents it from flowing.

What is Resistance?

Resistance, (R) is the capacity of a material to resist or prevent the flow of current or, more specifically, the flow of electric charge within a circuit. The circuit element which does this perfectly is called the "Resistor".
Resistance is a circuit element measured in **Ohms**, Greek symbol (**Ω**, Omega) with prefixes used to denote **Kilo-ohms** (kΩ = 10^3Ω) and **Mega-ohms** (MΩ = 10^6Ω). Note that resistance cannot be negative in value only positive.

Resistor Symbols



The amount of resistance a resistor has is determined by the relationship of the current through it to the voltage across it which determines whether the circuit element is a "good conductor" – low resistance, or a "bad conductor" – high resistance. Low resistance, for example 1Ω or less implies that the circuit is a good conductor made from materials such as copper, aluminium or carbon while a high resistance, 1MΩ or more implies the circuit is a bad conductor made from insulating materials such as glass, porcelain or plastic.

A "semiconductor" on the other hand such as silicon or germanium, is a material whose resistance is half way between that of a good conductor and a good insulator. Hence the name "semi-conductor". Semiconductors are used to make Diodes and Transistors etc.

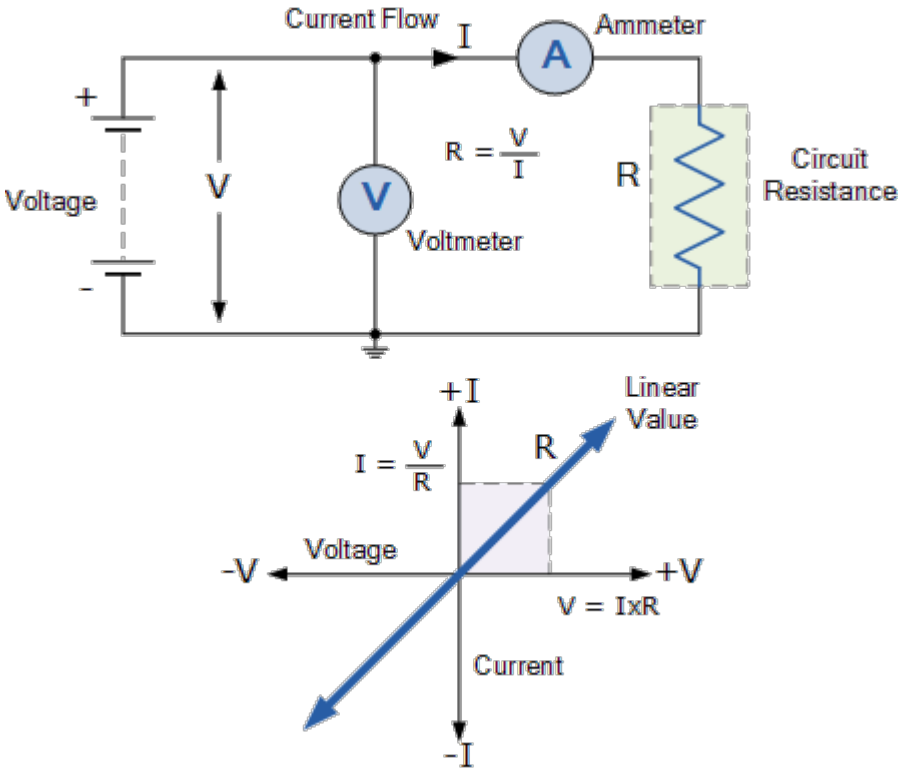
Resistance can be linear or non-linear in nature, but never negative. Linear resistance obeys Ohm's Law as the voltage across the resistor is linearly proportional to the current through it. Non-linear resistance, does not obey Ohm's Law but has a voltage drop across it that is proportional to some power of the current.
Resistance is pure and is not affected by frequency with the AC impedance of a resistance being equal to its DC resistance and as a result can not be negative. Remember that resistance is always positive, and never negative.

A resistor is classed as a passive circuit element and as such cannot deliver power or store energy. Instead resistors absorbed power that appears as heat and light. Power in a resistance is always positive regardless of voltage polarity and current direction.
For very low values of resistance, for example milli-ohms, (mΩ) it is sometimes much easier to use the reciprocal of resistance (1/R) rather than resistance (R) itself. The reciprocal of

resistance is called **Conductance**, symbol (**G**) and represents the ability of a conductor or device to conduct electricity.

In other words, the ease by which current flows. High values of conductance implies a good conductor such as copper while low values of conductance implies a bad conductor such as wood. The standard unit of measurement given for conductance is the **Siemen**, symbol (**S**).

The unit used for conductance is mho (ohm spelt backward), which is symbolized by an inverted Ohm sign ℧. Power can also be expressed using conductance as: $p = i^2/G = v^2G$.
The relationship between Voltage, (v) and Current, (i) in a circuit of constant Resistance, (R) would produce a straight line i-v relationship with slope equal to the value of the resistance as shown.



What is Ohms Law?

Georg Ohm found that, at a constant temperature, the electrical current flowing through a fixed linear resistance is directly proportional to the voltage applied across it, and also inversely proportional to the resistance. This relationship between the Voltage, Current and Resistance forms the basis of **Ohms Law** and is shown below.

Ohms Law Relationship

$$Current,(I) = \frac{Voltage,(V)}{Resistance,(R)} \; in \; Amperes,(A)$$

By knowing any two values of the Voltage, Current or Resistance quantities we can use **Ohms Law** to find the third missing value. **Ohms Law** is used extensively in electronics formulas and calculations so it is "very important to understand and accurately remember these formulas".

To find the Voltage, (V)

[V = I x R] V (volts) = I (amps) x R (Ω)

To find the Current, (I)

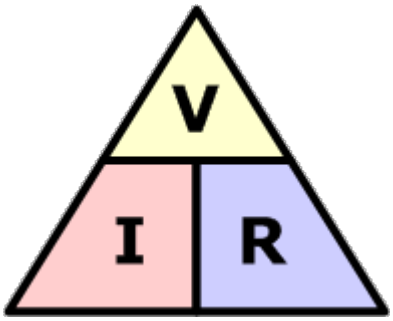
[I = V ÷ R] I (amps) = V (volts) ÷ R (Ω)

To find the Resistance, (R)

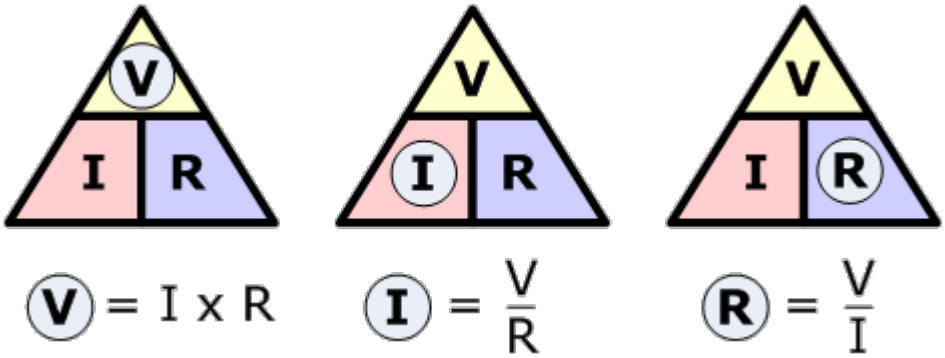
[R = V ÷ I] R (Ω) = V (volts) ÷ I (amps)

It is sometimes easier to remember this Ohms law relationship by using pictures. Here the three quantities of V, I and R have been superimposed into a triangle (affectionately called the **Ohms Law Triangle**) giving voltage at the top with current and resistance below. This arrangement represents the actual position of each quantity within the Ohms law formulas.

Ohms Law Triangle



Transposing the standard Ohms Law equation above will give us the following combinations of the same equation:



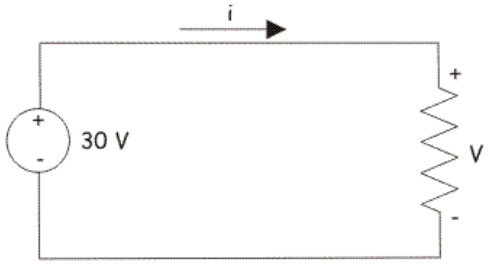
Then by using Ohms Law we can see that a voltage of 1V applied to a resistor of 1Ω will cause a current of 1A to flow and the greater the resistance value, the less current that will flow for a given applied voltage. Any Electrical device or component that obeys "Ohms Law" that is, the current flowing through it is proportional to the voltage across it (I α V), such as resistors or cables, are said to be **"Ohmic"** in nature, and devices that do not, such as transistors or diodes, are said to be **"Non-ohmic"** devices.

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.

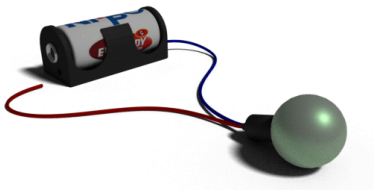


Basic Properties of Electric Circuits

- ✓ 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.

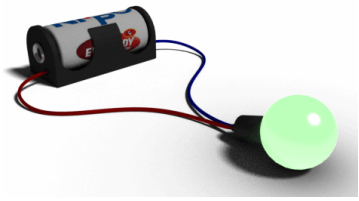
Types of Electric Circuits

Open circuit



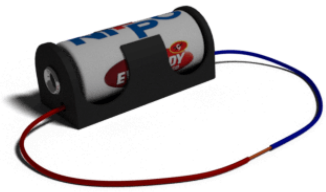
If due to disconnection of any part of an electric circuit if there is no flow of current through the circuit, is said to be an open circuited.

Closed circuit



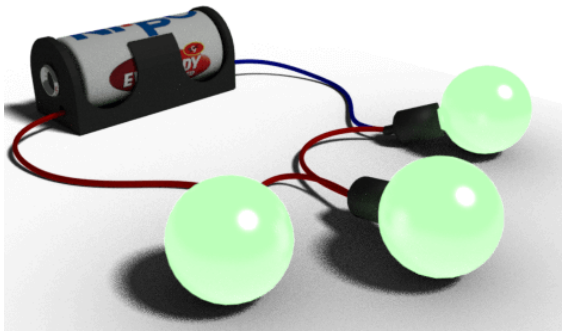
If there is no discontinuity in the circuit and current can flow from one part to another part of the circuit, the circuit is said to be closed circuit.

Short circuit



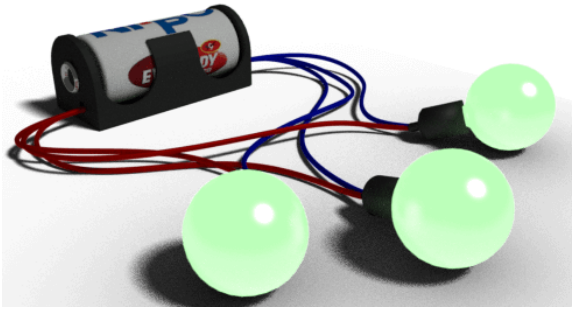
If two or more phases, one or more phases and earth or neutral of AC system or positive and negative wires or positive or negative wires and earth of DC system touch together directly or connected together by a zero impedance path then the circuit is said to be short circuited.

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.

LAY AND FIX ELECTRICAL CONDUITS/TRUNKING/DUCTS ETC

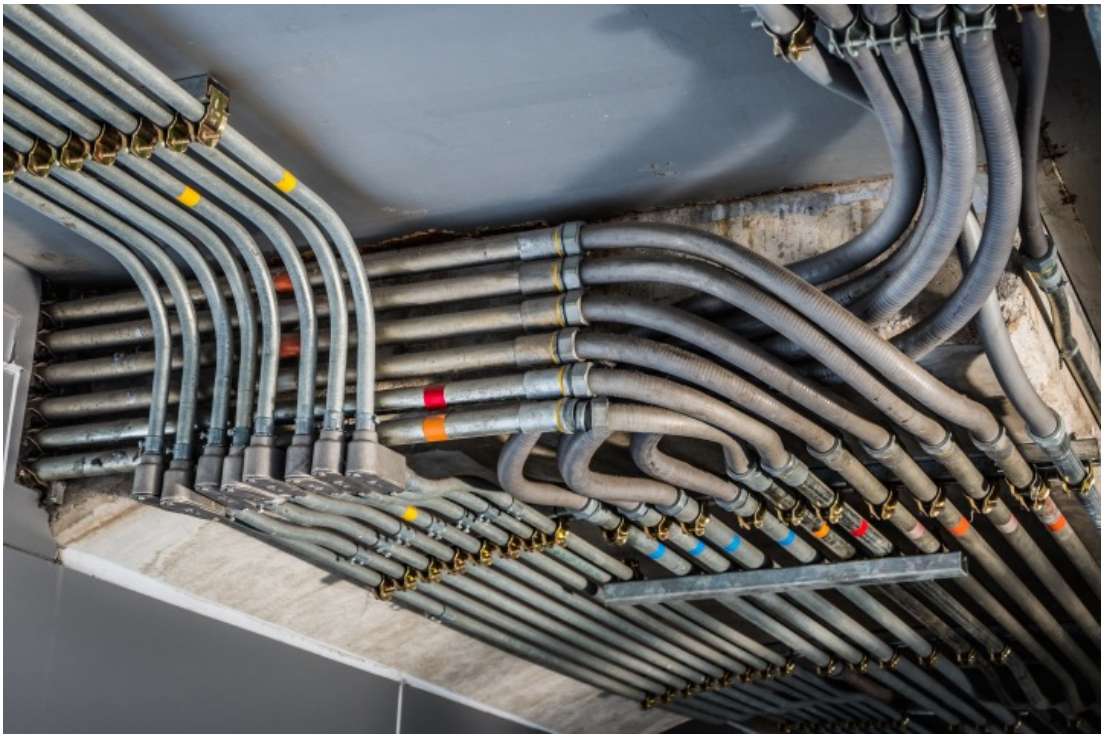
Concealed conduit electrical wiring systems are a popular choice in domestic premises as they are aesthetically appealing. They are the most commonly used house electrical wiring system as it protects the wires from external damage and increases their longevity.

The wires are installed in 4 steps.
Step 1: Laying the electrical conduits in the slab
Step 2: Laying the electrical conduits in the wall
Step 3: Installation of Switch Boards Back Boxes
Step 4: Installation of Distribution Boards

Let us look at the step-by-step installation procedure of a concealed conduit electrical wiring system.

Step-1: Laying of Electrical Conduits in Slab

- ✓ The slab conduits for house wiring should be 2 mm thick and 25 mm in size for PVC conduits. Lay the slab conduits between the top and bottom reinforcement.
- ✓ Use only deep junction boxes in slabs. Properly bind the PVC conduits using the binding wire.
- ✓ It would be ideal to follow the color coding for conduits for electrical wires and data such as LAN and telephone wire. Use grey PVC pipes for data, black PVC pipes for electrical wires and PVC solvent for joining the accessories
- ✓ Check the wall drops carefully and determine the concrete thickness.
- ✓ Check the conducting as per the service drawings and see where the switchboards are located and how many points need to be installed at each location
- ✓ Take special precautions while concreting the slab
- ✓ Replace all the broken pipes
- ✓ Ensure that all the joints are watertight
- ✓ Once the slab and beam are de-shuttered, pass the GI wiring immediately. Document any choke up or alternate route for future references
- ✓ Provide all the necessary sleeve in beams, columns prior to slab casting as per electrical & air-conditioning
- ✓ Provide the pull boxes at suitable locations
- ✓ Don't cluster the pull and junction boxes at one place. Arrange them so that they can't be seen easily from heavy movement areas as per the electrical drawings

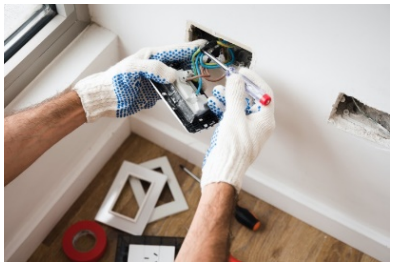


Step-2: Laying of Electrical Conduits in Wall

- ✓ Carry out the concealed conduit work after the construction of masonry walls but before the plastering work starts
- ✓ Once the curing of brickwork is completed, carry out the chasing work. Ideally, maintain a gap of 7 days between the two activities
- ✓ Do the wall chasing with wall cutters only as this would avoid damage to the walls
- ✓ Fix the electrical conduits with the approved clips to ensure proper routing and wiring
- ✓ Once the conduits, boxes and accessories are fixed, fill the chiseled surface with cement mortar and chick mesh wrapped around the conduits
- ✓ Start the wall conducting activity with level marking on the wall, keeping the height above FFL(Finished floor level) in mind
- ✓ Limit the width of chasing as per the number of conduits
- ✓ The depth of chasing should be at least 10 mm from the masonry wall to have the conduit recess
- ✓ Make sure that all the horizontal conduit runs are straight at the box level. The light point conduit should run straight vertically to the switch box. Make sure no wall conduit is taken haphazardly
- ✓ Don't use any elbows or bends. Use a spring to bend if you want to change the direction of the pipe.
- ✓ Don't run power conduits near any communication line
- ✓ Run the conduits above the false ceiling with proper support. Don't rest them on the false ceiling in any case. Seal the vertical runs with open ends at the top if you have false ceiling work

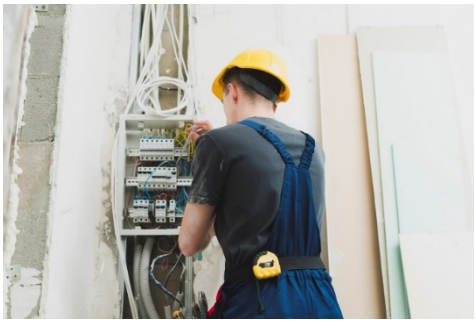
Step-3: Installation of Switch Boards Back Boxes

- ✓ Fix the concealed switchboard properly in level based on the architect's design, for example, distance and height from the finished floor level (FFL)
- ✓ Ensure that the gap between the concealed switchboards is uniform. Maintain the same uniformity across all the installations.
- ✓ The switchboards must be readymade modular type metal boxes of the approved make. Fix the concealed box 3 mm below the plastered surface.
- ✓ Finish the box fixing before the plastering work while doing the wall conduiting. Fill the boxes with thermocol while the plastering work is being done.



Step-4: Installation of Distribution Boards

- ✓ Conceal the distribution board before the plasterwork
- ✓ Fix the DB box in a proper line and level the recess provided in the brickwork
- ✓ Ready the box as per the design such as fixing the number of conduits entering the distribution box
- ✓ Place the PVC pipes from the given entry holes only

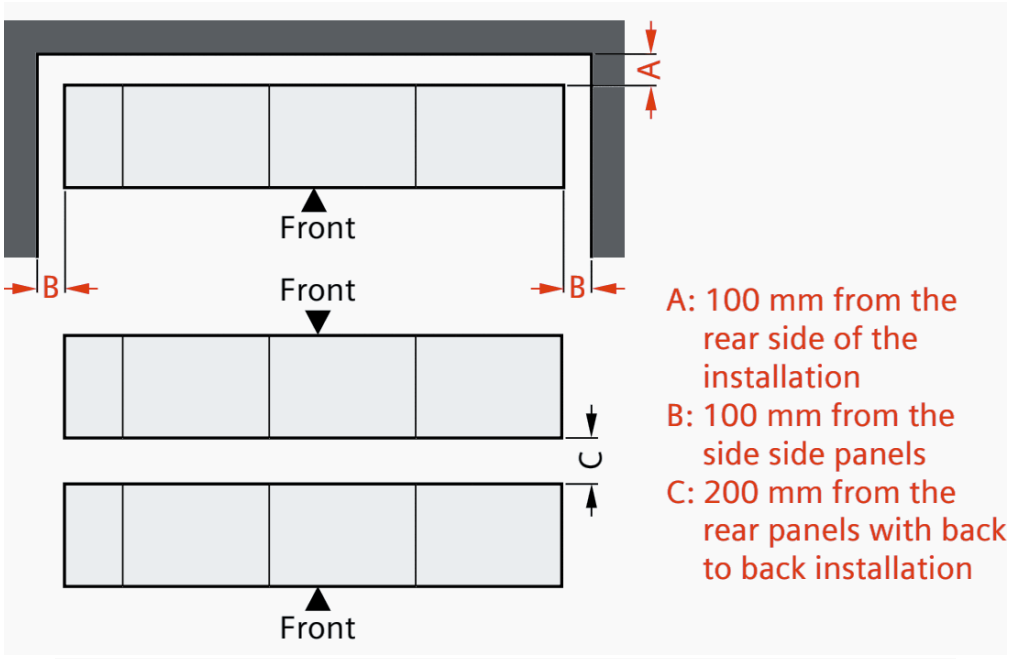


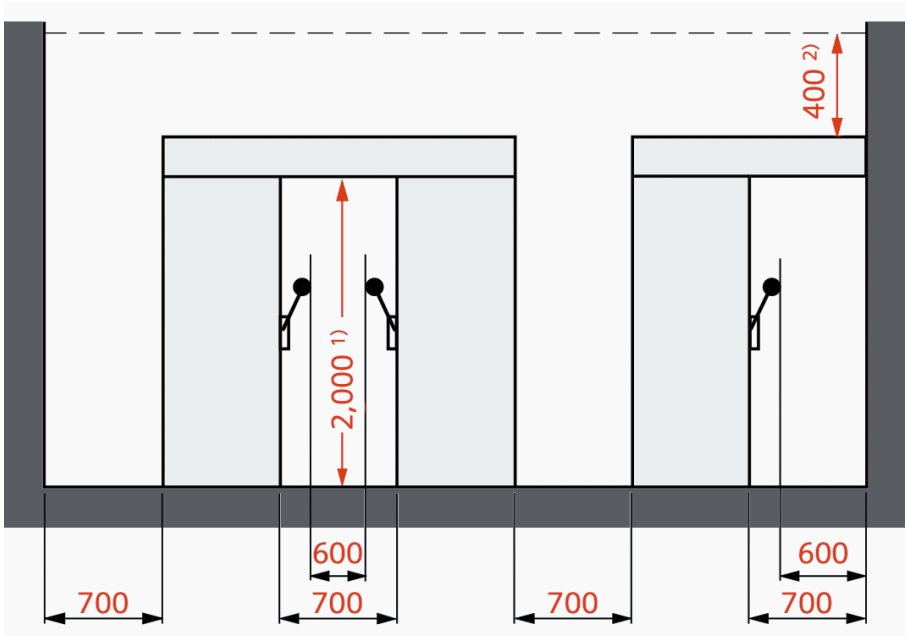
Make sure that you go through all these steps in an orderly manner for the successful installation of the concealed electrical wiring system.

INSTALL AND WIRE MAIN ELECTRICAL CONTROL AND PROTECTIVE SWITCHGEAR

1. Installation (clearances and corridor widths)

The minimum clearances between switchgear and obstacles specified by the manufacturer must be taken into account when installing low-voltage switchgear (Figure 1). The minimum dimensions for operating and servicing corridors in accordance with IEC 60364-7-729 must be taken into account when planning the space requirements (Figure 1, Figure 3).

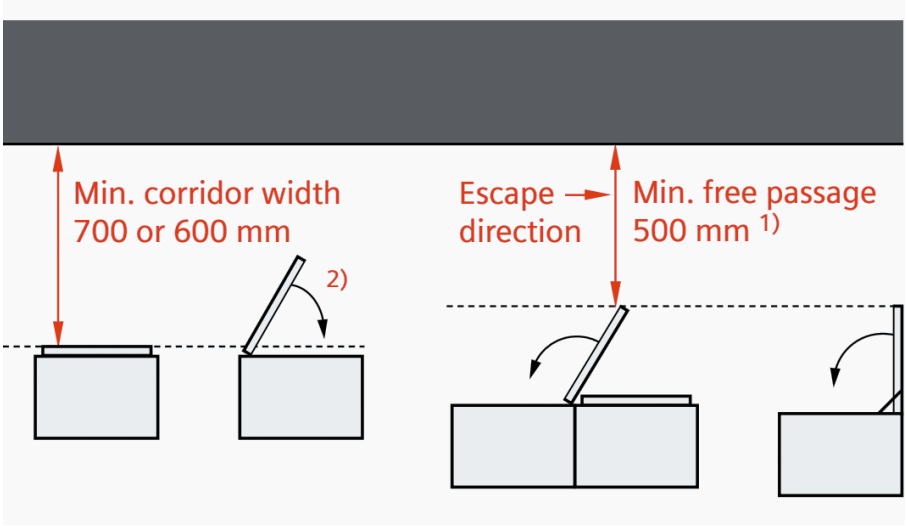




Where:

1. Minimum height of passage under covers or enclosures.

2. Attention: Above the panels, some space specified by the manufacturer MUST be free from obstacles to allow the pressure relief vents to open in the event of an arcing fault.



Where:

1. With switchgear fronts facing each other, the space requirements only account for obstruction by open doors from one side (i.e. doors that don't close in escape direction).
2. Take door widths into account, i.e. door can be opened at 90° minimum.

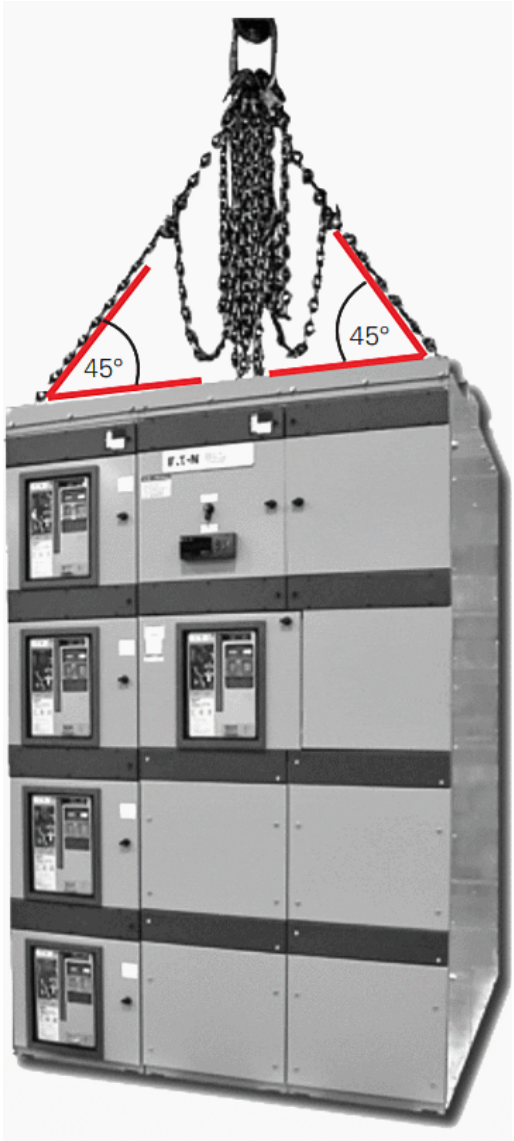
2. Important planning considerations

The following aspects should be considered in particular when planning low-voltage main distribution system:

Point № 1 – Maximum permissible panel equipment (for example, number of LV HRC in-line switch-disconnectors taking into account the disconnector size and load; the manufacturer specifications must be observed!)
Point № 2 – Minimum panel width taking into account the component density, cable connection cross sections and number of cables (possibly a wider terminal compartment needs to be selected or an additional panel be planned)
Point № 3 – The reduction factors of the devices according to the manufacturer specifications must be observed! Here, the mounting location, ambient temperature, and rated current play an important part.
This is particularly important for currents greater than 2,000 A!
Point № 4 – The dimensioning of compensation system largely depends on the installation site (office, production, etc.) and network conditions (harmonic content, distribution system operator specifications, audio frequency, etc.). As a rough estimate, approximately 30% (in the industry) of the transformer power can be expected if there are no concrete planning specifications.

Point № 5 – The decision between central or distributed compensation (see chapter 5) depends on the network topology (centre of the reactive current originators).
In the case of a distributed arrangement of the compensation systems, appropriate outgoing feeders (low voltage HRC in-line switch-disconnectors, circuit-breakers, etc.) are to be provided in the low-voltage main distribution system.
Point № 6 – Generator-fed networks must not be compensated if a regulated compensation could lead to problems in the generator control (deactivate compensation upon switching to generator mode or use fixed compensation matched to the generator is possible).
Point № 7 – Choking of a compensation system depends on the requirements of the network, the customer, and also the distribution system operator.

3. Transportation switchgear units



Depending on the access routes available in the building, one or more cubicles (or columns) can be combined into transportation units. The maximum length of a transportation unit should not exceed 2,400 mm. The panel weights are to be used for the transportation and dimensioning of building structures such as cable basements and false floors.

Attention! If a lift truck is used to insert circuit-breakers or withdrawable units, the minimum corridor widths must be adapted to the lift truck!

Lifting with a crane is the preferred method of handling (see Figure 4), however, overhead obstructions or low ceilings often dictate the method to be used.

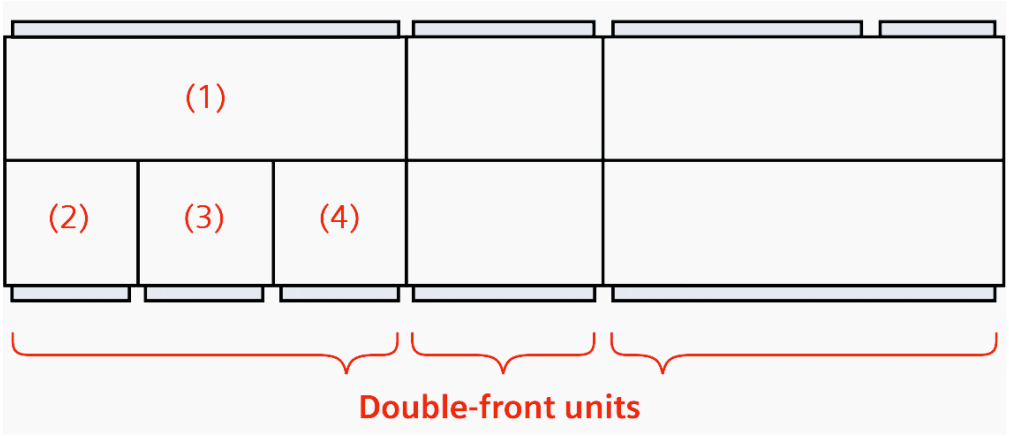
Moving switchgear in an obstructed area where a crane cannot be employed can be accomplished by the use of rollers (for indoor enclosure only).

4. Double-front installations

In a double-front installation, the cubicles are positioned in a row next to and behind one another. The main feature of a double-front installation is its extremely economic design, since the branch circuits on both operating cubicles are supplied by one main busbar system only.
The “double-front unit” structure is required for the assignment of certain modules.
A double-front unit in Figure 5 consists of a minimum of two and a maximum of four cubicles. The width of the double-front unit is determined by the widest panel (1) within the double-front unit. This cubicle can be placed on the front or rear side of the double-front unit. Up to

three more cubicles (2), (3), (4) can be placed on the opposite side. The sum of the cubicle widths (2) to (4) must be equal to the width of the widest cubicle (1).

The panel combination within the double-front unit is possible for all technical installations with some exceptions explained below.



Exceptions!

The following cubicles determine the width of the double-front unit and may only be combined with an empty panel:

- ✓ Busbar coupler, longitudinal (BCL)
- ✓ 5,000 A incoming/ outgoing feeder
- ✓ 6,300 A incoming/ outgoing feeder

5. Environmental conditions for switchgear

The climate and other external conditions (natural foreign substances, chemically active pollutants, and small animals) may affect the switchgear to a varying extent. Their effect depends on the heating and air-conditioning systems of the switchgear room.
If higher pollutant concentrations are present, reducing measures are required, for example:

- ✓ Air-intake for the operating room from a less contaminated point
- ✓ Slightly pressurizing the operating room (e.g. by blowing uncontaminated air into the switchgear)
- ✓ Switchgear room air conditioning (temperature reduction, relative humidity < 60 %, use of air filters, if necessary)
- ✓ Reduction of the temperature rise (oversizing of switchgear or components such as busbars and distribution bars)

6. Safety against arcing faults

As for transformers and medium-voltage switchgear, an arcing fault occurring in the low-voltage switchgear can lead to dangerous interferences with serious consequences and damage neighboring outgoing feeders, panels or even the entire installation.

Arcing faults may arise from wrong dimensioning, insulation deterioration such as pollution, but also from handling faults. High pressure and extremely high temperatures can have fatal consequences for the operator and installation, these consequences may even extend to the entire building.

The testing of low-voltage switchgear under arcing fault conditions is a special test in compliance with IEC TR 61641.

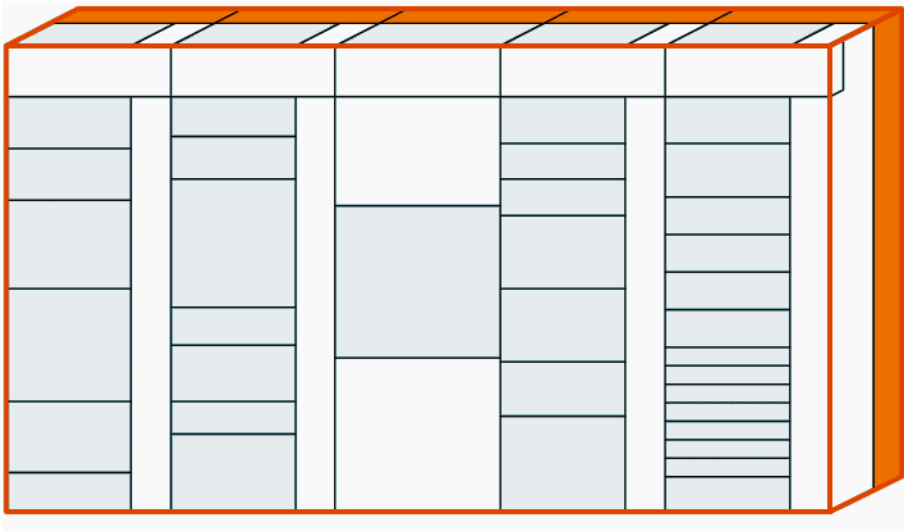
Active protective measures – Measures such as high-quality insulation of live parts (for example, busbars), uniform and easy handling, integrated operator fault protection, and correct switchgear dimensioning prevent arcing faults and hence personal injuries.

Passive protective measures – They increase operator and installation safety many times over. They include arcing-fault-proof hinge and lock systems, safe handling of withdrawable units or circuit-breakers only when the door is closed, and flap traps behind front air vents, arc barriers or an arcing fault detection system in combination with a fast interruption of arcing faults.

The arcing fault levels describe the classification according to the properties under arcing fault conditions and the limitation of the effects of an arcing fault on the installation or parts thereof.

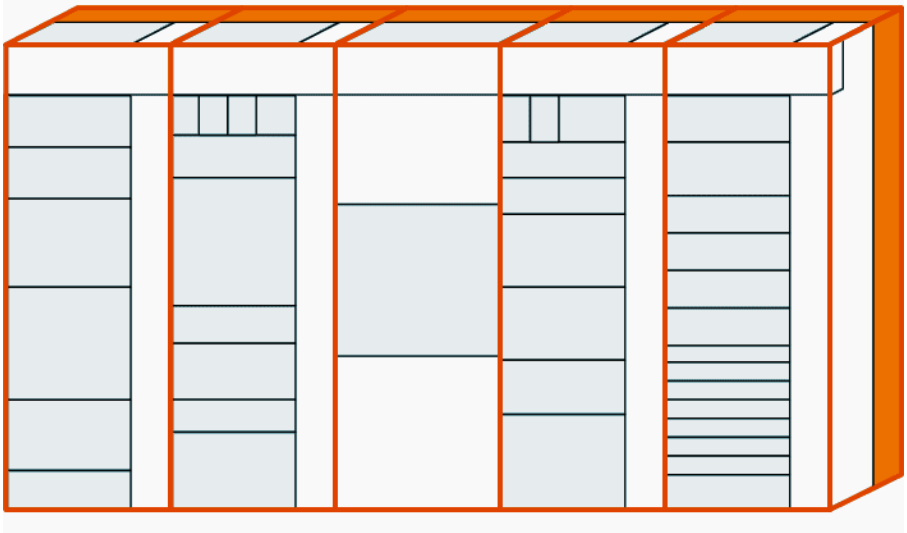
Arcing fault level 1

High degree of personal safety without extensive limitation of the arcing fault effects within the installation.



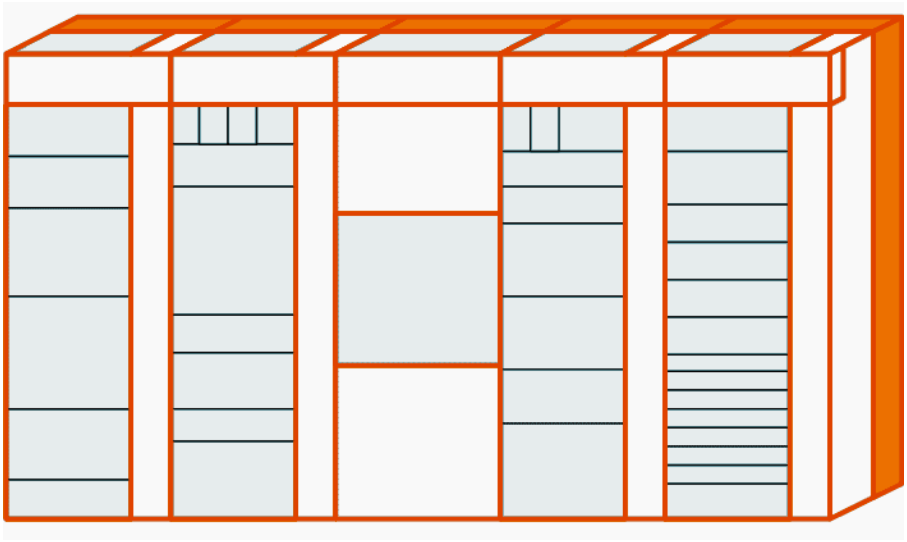
Arcing fault level 2

High degree of personal safety with extensive limitation of the arcing fault effects to one panel or double-front unit.



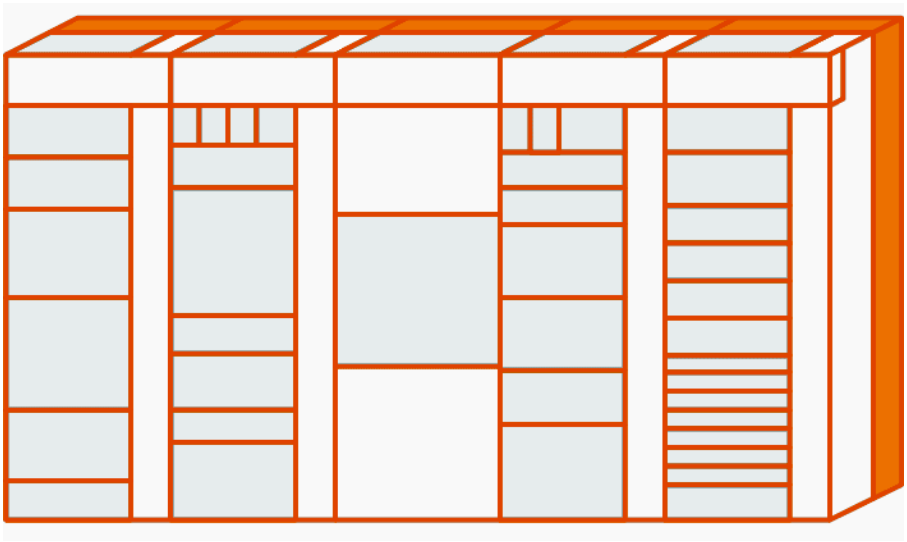
Arcing fault level 3

High degree of personal safety with limitation to the main busbar compartment on a panel or double-front unit and the device or cable connection compartment.



Arcing fault level 4

High degree of personal safety with limitation of the arcing fault effects to the place of origin.



6.1 Reducing the occurrence probability of an arcing fault

In the intensive discussion about arcing fault detection or interruption, technically elaborate and expensive solutions are readily propagated. Some manufacturers like Siemens, however, has for a long time preferred the prevention of arcing faults by means of complete insulation of all conductive parts inside the installation (busbars, connections, transfers, etc.).

Such passive precautions ensure that no arc is generated that would have to be detected and quenched. See Figure below.

Active systems for the detection and interruption of an accidental arc as a consequence of a fault need maintenance and do not provide any advantages with regard to the installation availability. The impacts of an arcing fault (pollution, metal splashes, etc.) might be minor, but they usually have to be cleared nevertheless.

Moreover, the interruption device of the active system has to be replaced. This work can be laborious and time-consuming.

Monitoring of the outgoing feeder areas of the switchgear is not recommended for active systems for reasons of reliability of supply, as arcing faults in these areas should be interrupted by the upstream protective device. Otherwise, such a fault would lead to a complete shutdown of the installation.

For feed-in monitoring (terminal compartment), the system must act on the upstream protective device. Thus, the advantage of a fast interruption by the active system is lost in the case of such a fault.

7. Other important things you should be aware

The following aspects are particularly important for the configuration of low voltage switchgear:

7.1 Environmental and installation conditions, mechanical stress

- ✓ Degree of protection in acc. with EN 60529 protection against contact, dust and water protection
- ✓ Ambient temperature and climatic conditions
- ✓ Corrosion
- ✓ Type of installation and fastening (for example, stand-alone, on the wall)
- ✓ Cover or doors (as appropriate transparent or nontransparent)
- ✓ Dimensions, weight:
- ✓ Maximum permissible outer dimensions of the switchgear
- ✓ Maximum permissible dimensions and weight of the switchgear for transport and erection at the site of installation
- ✓ Cable duct (base paneling, if required)
- ✓ Cable glands

- ✓ Type of cable laying (cable duct, cable racks, etc.)
- ✓ Device installation (fixed or plug-in /withdrawable units for quick replacement)
- ✓ Accessibility of devices:
  Parts that can be operated during operation (such as fuses or miniature circuit-breakers) are to be combined and arranged within the switchgear assembly in such a way that they are separately accessible (via a quick-release cover, for example). Contactors and fuses are to be placed in separate boxes.

7.2 Type of installation, accessibility

To ensure that the most economical design can always be selected, the main features of low voltage switchgear should be weighed against each other and a decision be made before defining the structural measures.

Such features are:

- ✓ Open or closed design (kind of operating site)
- ✓ Self-supporting installation: stand-alone in the room, at a wall or in a wall recess
- ✓ Not self-supporting installation: for mounting to the wall, to a supporting frame or in a wall recess
- ✓ Kind of accessibility for installation, maintenance, and operation
- ✓ Dimensions (installation height, depth, width)
- ✓ Notes regarding structural measures

7.3 Selection of the electrical equipment

The following has to be considered for the equipment to be installed in switchgear assemblies:

- ✓ The applicable device specifications
- ✓ The suitability with regard to nominal data, in particular short-circuit strength and breaking capacity
- ✓ The installation of current-limiting protective equipment might be necessary

7.4 Protective measures

- ✓ Protection against direct contact in the distribution board when the door is open by means of contact protection covers, degree of protection IP30
- ✓ Protection against indirect contact at all frame and cladding parts by means of Safety class I (protective conductor connection) and Safety class II (protective insulation).

7.5 Space requirements for built-in units, busbars and terminals

When configuring built-in components in encapsulated switchgear and distribution switchboards, sufficient space must be provided beyond the pure space requirements of the units for:

- ✓ The electrical clearance (clearance in air) to the encapsulation

- ✓ The heat dissipation of the individual units
- ✓ A possibly required blow-out room in switching devices
- ✓ The wiring
- ✓ The connection of external incoming and outgoing feeder cables (terminal compartment)
- ✓ The device identification

Meters and measuring instruments should be located at eye level. All devices that are to be operated manually should be within reach (approximately at a height between 0.6 and 1.8 m). Restrictions resulting from the use of a device in an encapsulation might have to be observed, for example, with regard to the rated current and the switching capacity.

WIRE ELECTRICAL FINAL CIRCUITS

Types and Sizes of Electrical Cables and Wiring

Electrical cable is a wire that helps to conduct the current in the circuit. It is also called a conductor. Cable is an important object in the electricity. Copper and Aluminum conductors are the two types of electrical cables used in the electrical wiring. But in the overhead line, we use copper, aluminum, aluminum conductor with steel reinforced (ACSR), galvanized steel and cadmium copper. In the electrical wiring, mostly we use copper conductor.

Copper conductor have a good conducting capacity than others. While comparing copper, aluminum is the cheapest conductor. Conducting capacity of the conductor is based on how much impurity added to the material and how it is segregated by drawn. Current density of the copper conductor is high.

Types of Electrical Cables Based on Voltage Rating

There are six types of cables used in the electrical wiring of based on the voltage rating. They are,

1. Low tension (L.T) up to 1kV
2. High tension (H.T) up to 11kV
3. Super tension (S.T) 22kV to 33kV
4. Extra high tension (E.H.T) 33kV to 66kV
5. Oil Filled cables – 66kV to 132kV
6. Extra super voltage cables beyond 132kV

Low Tension Cables

For the low voltage system, we use low tension cables. Low tension cables are only capable for below 1000V.

High Tension Cables

1000V to 11kV rating used conductors are called high tension cables.

Super Tension Cables

These type of electrical cables are used on 22kV or 33kV distribution line.

Extra high tension cables

Between 33kv to 66kv voltage rating cables are called extra high tension cables.

Extra super voltage

These type of electrical cables are used in the overhead line for power transmission process.

Types of Cables Based on Cores and Applications

There are three types of cables are used in the domestic electrical construction areas. They are,

1. Power Cables
2. Control Cables
3. Instrument Cables

What is Power Cables? Types and Sizes

Which is the conductor used in the power transmitting that is called power cables. Power cables are carrying current to the circuit. The type of electrical cables are mostly used in the construction line. There are single core, two core, three core, three and half core & four core are the five type of power cables.

Cable Sizes: 1, 1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 240, 300, 400, 600 and 1000 sq.mm are the power cable sizes.

Single Core Cable

Single core cables are having only one core conductor itself and big sized and that would be Phase, Neutral or Earth. Single core conductor is only used in the high tension voltage system.

Two Core Cable

Manufactured by dual core conductor is called two core cables and that would be only Phase and Neutral. It is used in the low tension line.

Tri Core Cable

Three core cables are having triple cores and it would be three phases of red, yellow and blue. Tri core conductors are used in the 415V – low voltage system.

Three and Half Core

The type of electrical cables having itself four cores but last one core would be half sizer than others. Red, Yellow and Blue of three phases are used to have first three cores. Last half size core used as neutral. Three and half core is mostly used in the low voltage system.

Four Core Cables

3 Phases and neutral having conductor of the four core cables are would be made by four cores. It is used in the low voltage system.

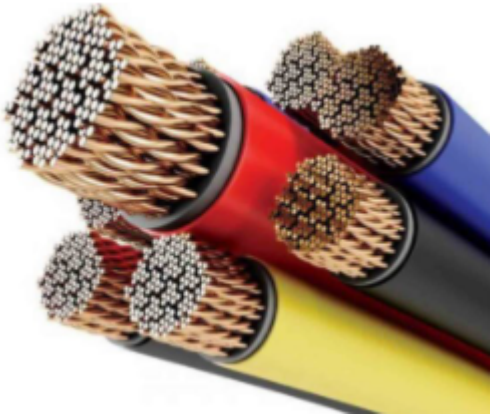
Why We Use Control Cables? Types and Sizes

Control cables are used to control a electrical equipment system. Cable sizes of the control conductors are 0.75 sq.mm to 2.5 sq.mm. Control cables are mostly used on the instrument and electrical panels. 1.5 sq.mm and 2.5 sq.mm cable sizes are mostly used for panel internal wiring.

Cores – 2, 4, 5, 7, 12, 20, 30, 48, 70, 100c
Cable Sizes – 0.75, 1, 1.5, 2.5sq.mm

Instrument Cables Types, Sizes and Uses

The type of cables are used in the instrument equipment such as transmitters, sensors and switches. Only needs direct current supply.



Cores – 2, 4, 6, 10, 12, 19, 27, 37, 40, 50 pair.
Cable Sizes – 0.5, 0.75 and 1sq.mm
Uses – Thermocouples, pressure transmitter, level transmitter, differential pressure transmitter and sensors.
Supply – 12V or 24V (DC)

Rules and Regulations of Cable Installation

For fixed wiring within Premises, PVC, rubber or XLPE (Cross linked Polyethylene) insulated cables with stranded copper conductors must be used, complying with electrical standard. Solid core copper or aluminum conductor cables are not permitted.

For locations subject to a higher than normal risk of interference or damage, armored cables are recommended. For locations with higher than normal fire risk, either cables must be installed in metal conduit or mineral insulated copper clad or enhanced fire-resistance conductors must be used.

In addition, safety circuits such as fire alarms, emergency lighting and control circuits, which are required to remain operational in the event of a fire, must be installed in metal conduits or supplied by MICC conductors.

The location and selection of conductors must take into consideration any special requirements for the prevention of spread of fire. Fire barriers, low smoke insulation or other measures may be required.

General purpose flexible cables and cords for appliances must be PVC insulated, with a PVC over sheath, stranded copper conductors. Conductors for high temperature Appliances (e.g. electric heaters, irons, pendant lighting, connections within luminaires) must be heat resistant rubber or PVC insulated, with over sheath, stranded copper conductors, and comply with standard.

Conductors under repetitive mechanical strain (e.g. lifts, heavy outdoor machinery, etc.) must comply with standard regulation. Where conductors are installed underground, they must be installed so as to protect against mechanical damage and enable future removal. Conductors for meter tails (at 230 V) shall be single-core, PVC insulated with over sheath.

The cross-section of conductors must be selected according to the expected load, voltage drop, ambient temperature and installation. Including appropriate grouping factors. The maximum voltage drop from the connection point to the remote end of any Final Circuit must not exceed 4%, except in special cases where equipment has been designed to operate under a greater voltage drop.

The use of single-core armored conductors should be avoided due to the possibility of induced heating effects. However, such conductors may be used where there is an exceptional need, with the written consent of the distribution company and where adequate precautions are taken to avoid induced heating effects.

Such precautions must include the appropriate configuration of phases to balance induced currents, Earthing at one end only and the use of non-ferromagnetic armoring, cable glands, and switchgear gland plates. All cables that are not armored, or that do not have a metallic sheath or screen, must be installed in plastic or metal conduits or trunking throughout their entire length.

Conductors running through inaccessible areas such as walls, floors and solid ceilings shall be installed, without exception, in conduits or trunking so as to be withdrawable in the future. In such cases, suitable inspection plates and pulling out points must be provided. Non-sheathed conductors must not be installed in concrete ducts.

May be allowed only for insulated and sheathed or flexible conductors which will remain accessible but in locations free from undue risk of damage or interference (e.g. above-head height, or in unoccupied areas). Such conductors must be securely supported by cable clips, cable tray or other fixings at suitable intervals.

All conductors must be installed between purpose-made termination points (switches, junction boxes, distribution boards) and be terminated with purpose-made lugs, crimps, screw or other connectors. Joints between such points are strictly prohibited. Termination points and junction boxes must remain accessible to facilitate future inspection, repair and alteration.

Where conductors are terminated at high-temperature Appliances, their insulation must be suitable for the expected operating temperature or, where necessary, shall be protected by heat-resistant material.

Armored conductors must be terminated using suitable cable glands which incorporate a suitably rated Earth tag or other purpose made connection to the armoring of the conductor and to the metallic sheath if present. Cables must not be installed in lift shafts other than those serving lift functions.

Types of Electrical Wiring

Electrical wiring is a process of conductors connecting to the electrical equipment.
Electrical Wiring: a set of phase and neutral conductors installed as a group to supply power to a location and which originate from one protective device.
There are four types of electrical wiring in the electrical installation work.

1. Ring type wiring
2. Radial type electrical wiring
3. Final type electrical wiring
4. Distribution type electrical wiring

The following are four types of electrical wiring definitions,
Ring Type Electrical Wiring: A ring type electrical wiring which is connected from a single protective device, being run through an area to be supplied (via appropriate socket outlets, switched flex outlets, etc.) and returning back to the same protective device, thus forming an electrically continuous loop.

Ring type electrical wiring should be provided to areas within a premises which can be most economically served by several appliances sharing the same cable feed, arranged in a loop, from one circuit breaker on the final distribution board. This is particularly suitable where appliances are expected to operate at diverse times of the day. Ring wiring would typically be installed in bedrooms, living rooms, kitchens (except major Appliances such as cookers), partitioned office areas, etc.

Radial Electrical Wiring: A wiring which is connected in a ‘parallel’ or ‘branch’ configuration, emanating from a protective device, to the area to be supplied.

Radial electrical wiring should be provided to large appliances, particularly those in continuous or near continuous operation, or those of importance for safety or other priority functions within a premises. Examples include main water pumps, air conditioning units, water heaters, room heating, fire or intruder alarms, cookers and ovens.

Final Electrical Wiring: A wiring system which directly supplies appliances (normally via socket-outlets, switched flex outlets, isolators, ceiling roses, etc.). The sizing of final electrical wiring must be in accordance with the connected load on each circuit.

Distribution Electrical Wiring: A wiring connecting between distribution boards.
The number of Radial wiring and Ring wiring installed in a Premises shall take into consideration future accessibility, maintainability, and safety of the system, whilst limiting the extent of power outage to serviced areas. Circuits supplying a kitchen must not be used to supply any other area.

However, ceiling lighting wiring from a kitchen may be common to other areas. For domestic Premises, all wiring supplying one room must be on the same phase, other than for kitchens and for ceiling lighting.

Electrical Wiring – Circuit Categories

According to the electrical drawings, there are three types of circuit categories in the electrical. They are,
1st Category Circuit: A circuit (other than a fire alarm or emergency lighting Circuit) operating at LV.
2nd Category Circuit: A circuit (other than a fire alarm or emergency lighting Circuit) which supplies telecommunications equipment (such as telephones, intruder alarms, data transmission, call bells, etc.).
3rd Category Circuit: a fire alarm or emergency lighting Circuit.

Color Coding of Cables

Red, yellow and blue color are the three phases of the electrical circuit. Black is the neutral. Green with yellow is the protective earth of the electrical circuit.

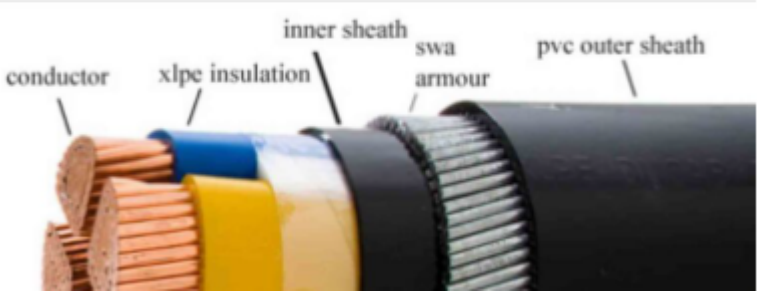
AC – System (Alternating Current System)

3 Phases : **Red** – **Yellow** – **Blue**
Neutral : **Black**
Protective Earth : **Green**
Protective Earth/Neutral : **Green**/**Yellow**

DC – System (Direct Current System)

Positive pole (+) : **Black**
Negative pole (-) : **Blue**(White)

Aluminum and copper conductors are used in electrical cables. But mostly in electrical installation we use copper conductor. Normal cable size is between 1 sq. mm to 400 sq. mm. Insulation selection is depends upon temperature and situation like flammable, explosible or normal. Normally we use two types of insulation for cables. Those are XLPE (Cross linked polyethylene) and PVC (Polyvinyl chloride). In transmission and distribution line we commonly use insulated UG (Under ground) cables.



Insulation: Normal situation we use PVC/XLPE insulated with copper conductor. In flammable or explosive situation we use mineral insulated copper conductor. Also we use Rubber insulation in high temperature area.
Armor: There are two types of armor used in the cable construction.

1. Flat armor
2. Round armor.

In single core conductor we use SWA (Single wire Armored)

INSTALL WIRING FOR STANDBY POWER SUPPLIES

Understanding Emergency & Standby Power for Commercial Facilities and Buildings

Generators have a wide range of options, come in different shapes and sizes, and are used for all kinds of applications in commercial facilities around the world. Almost every large building has one installed or the facility manager is thinking about how to get one. Understanding all these variables and how they factor into your operation can be a major challenge. Generator Source has been working with large generator sales and service for many decades. This article expands on some common generator features and attempts to explain the primary differences in rating types, how to obtain redundancy in your system, and also discusses the typical power configuration most businesses and buildings utilize such as UPS and automatic transfer switches.

Generator Rating Basics

utility interruption

Most generators are manufactured in four basic ratings. These ratings define the amount of time the generator is designed to operate. Ratings are clearly stamped on the generator identification tag. It is important to understand the ratings when understanding the setup of a facility. Cummins generator ratings are featured below:

✓ Emergency Standby Power (ESP) - Used to supply power to a varying electrical load during a

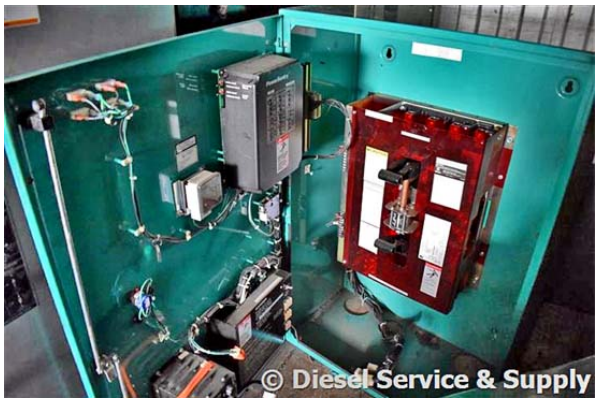
- ✓ Limited-Time Running Power (LTP) - Used to supply power to a constant electrical load for limited operation
- ✓ Prime Power (PRP) - Used to supply power to a varying electrical load for unlimited hours of operation
- ✓ Base Load (Continuous) Power (COP) -Used to supply power to a constant load for unlimited hours of operation

The lion's share of industrial buildings that require emergency or standby power is on the utility power grid. Generators with the ESP ratings are used in these facilities. These generators can be paralleled for multiple generator use. Remote communities in Canada depend totally on diesel generators for power. An ESP generator can be used as a backup when a primary generator is down for maintenance or repairs.

The use of the building or complex determines if it falls under an emergency or standby classification. An ESP rated generator is rated to assume the load when utility power fails. The generator is the main component in both classifications. However, the electrical/electronic equipment is different.

The terms emergency and standby are often switched with one another causing confusion. The National Fire Protection Association (NFPA) maintains standards for all buildings. NFPA 110 is the Standard for Emergency and Standby Power Systems. Go to NFPA 110 to subscribe or purchase complete document. This article will supply some definitions and examples featuring both emergency and standby power.

Emergency Power and Building Redundancy



Both emergency and standby power systems are classified as Emergency Power Supply Systems (EPSS) by the NFPA. They divide the supply systems into two levels. Emergency power is often considered a Level 2 system. "Level 2 systems shall be installed where failure of the EPSS to perform is less critical to human life," and is defined in NFPA 110, 4.4.2.

Local authorities, such as building inspectors and/or fire marshals, should always be consulted to determine if the building is in compliance with all regulations. Level 2 or Emergency Power systems are installed in facilities that require minimal power during utility outages. Systems such as elevators, emergency lighting (egress & design dependent), fire and alarm monitoring are normally powered during outages.

Buildings that employ emergency power systems are considered among the most basic in the equipment line up. However, correct operation is vital to ensure human safety during utility failure. Some of the equipment used in emergency power systems is:

- ✓ Generator (EPS rating) - Generator commonly fueled by diesel or natural gas. Can be indoor or outdoor style.
- ✓ Automatic Transfer Switch (ATS) - Transfers load from utility power to generator power when utility power fails. When utility power is restored, transfers load back.
- ✓ Distribution Panel - Often has switching and circuit protection capabilities. Connected to circuits in the emergency power network. Individual cable routings can be required.

Example

An industrial bearing manufacturer has an automated plant with many pieces of equipment and supporting auxiliary systems. The business plan dictates total plant shutdown during a utility power failure. A basic equipment array supplies power to emergency lighting and safety systems to ensure personal egress. A diesel generator is fueled by natural gas and team main rooms are on emergency lighting for extended utility outages.

When utility power fails, all production equipment and supporting auxiliary systems shut down. Production personnel exit factory. Remote auxiliary spaces have battery backup lighting for personal egress. Main spaces are equipped with egress lighting. Skeleton crew stays in team rooms with emergency lighting. When utility power is restored, skeleton crew starts auxiliary systems and production equipment. The production staff is notified of power restoration.

Standby Power, UPS & Automatic Transfer Switches

Hospitals, Airport Control Towers and Power Plants are examples of buildings that are required to have a standby power system. Standby systems are more advanced and have more equipment to support facility operation. These buildings are considered a Level 1 system. "Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life," and is defined in NFPA 110, 4.4.1.

Any generator requires a short start-up time to assume the load. During this time a brief power loss occurs. Many pieces of advanced life-support and process equipment are sensitive to power loss. A standby power system must supply power to all critical systems without interruption. EPS rated generators are often connected in parallel for to assume the load. Some of the equipment that can be used in these systems is:

- ✓ Uninterruptible Power Supply - This is a battery backup circuit that assumes the load, while the generator starts, during utility power failure. An in-circuit inverter is used to change DC to AC as the UPS assumes the load to critical equipment. UPS switches to charging mode once the generator assumes the load. Multiple UPS systems can be used in a building.
- ✓ Master Paralleling Control Panel - Each generator is equipped with an individual control system. Paralleling control panels parallel multiple generators to assume

the load. Can automatically parallel all generators, including redundant start and stop functions.

- ✓ Distribution and Control Panels - These panels can contain, automatic switching (such as ATS), manual switching, circuit protection, alarm monitoring & systems controls to name just a few. Size and equipment list are only determined by the needs of the building power system.

Example

A remote community in Canada is totally dependent on diesel engines from the local power company. The company operates multiple generators in parallel with a redundant backup design. During high power demand, a generator fails. This causes a temporary power failure while a redundant generator is placed on-line. UPS assumes the load in buildings with critical power requirements. Generators start, parallel, and assume the load from utility power and UPS. When power is returned, generators shut down.

Generators Provide Redundancy & Piece of Mind

For more complex backup power systems, like the ones you often see in data centers and large hospital campuses, there are a wide range of additional details to factor in. A generator is a key cog but many other factors can also be taken into consideration so you essentially build in backups for the backups. One trend being pushed towards hospitals is requiring standby generators for each backup generator they have to protect from failure of the primary backup. This sounds (and is) fairly extreme but there are times when one or more pieces in a system can fail so these high-level operators need to take all this into account and discuss with qualified engineers and planners.

UNIT 11

OPERATE CHEMICAL SEPARATION EQUIPMENT

This unit covers the operation of chemical separation equipment where the feed is usually single phase. It covers the range of separation equipment which rely on a phase change or chemical change to enact the separation and includes crystallizers, ion-exchange filters, absorbers and similar equipment

PREPARE FOR WORK

Hazard Identification and Assessment

One of the "root causes" of workplace injuries, illnesses, and incidents is the failure to identify or recognize hazards that are present, or that could have been anticipated. A critical element of any effective safety and health program is a proactive, ongoing process to identify and assess such hazards.
To identify and assess hazards, employers and workers:

- ✓ Collect and review information about the hazards present or likely to be present in the workplace.
- ✓ Conduct initial and periodic workplace inspections of the workplace to identify new or recurring hazards.
- ✓ Investigate injuries, illnesses, incidents, and close calls/near misses to determine the underlying hazards, their causes, and safety and health program shortcomings.
- ✓ Group similar incidents and identify trends in injuries, illnesses, and hazards reported.
- ✓ Consider hazards associated with emergency or nonroutine situations.
- ✓ Determine the severity and likelihood of incidents that could result for each hazard identified, and use this information to prioritize corrective actions.

Some hazards, such as housekeeping and tripping hazards, can and should be fixed as they are found. Fixing hazards on the spot emphasizes the importance of safety and health and takes advantage of a safety leadership opportunity. To learn more about fixing other hazards identified using the processes described here, see "Hazard Prevention and Control."

Action item 1: Collect existing information about workplace hazards

Information on workplace hazards may already be available to employers and workers, from both internal and external sources.

How to accomplish it

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include:

- ✓ Equipment and machinery operating manuals.
- ✓ Safety Data Sheets (SDS) provided by chemical manufacturers.
- ✓ Self-inspection reports and inspection reports from insurance carriers, government agencies, and consultants.
- ✓ Records of previous injuries and illnesses, such as OSHA 300 and 301 logs and reports of incident investigations.
- ✓ Workers' compensation records and reports.
- ✓ Patterns of frequently-occurring injuries and illnesses.
- ✓ Exposure monitoring results, industrial hygiene assessments, and medical records (appropriately redacted to ensure patient/worker privacy).

- ✓ Existing safety and health programs (lockout/tagout, confined spaces, process safety management, personal protective equipment, etc.).
- ✓ Input from workers, including surveys or minutes from safety and health committee meetings.
- ✓ Results of job hazard analyses, also known as job safety analyses.

Information about hazards may be available from outside sources, such as:

- ✓ OSHA, National Institute for Occupational Safety and Health (NIOSH), and Centers for Disease Control and Prevention (CDC) websites, publications, and alerts.
- ✓ Trade associations.
- ✓ Labor unions, state and local occupational safety and health committees/coalitions ("COSH groups"), and worker advocacy groups.
- ✓ Safety and health consultants.

Action item 2: Inspect the workplace for safety hazards

Hazards can be introduced over time as workstations and processes change, equipment or tools become worn, maintenance is neglected, or housekeeping practices decline. Setting aside time to regularly inspect the workplace for hazards can help identify shortcomings so that they can be addressed before an incident occurs.

How to accomplish it

- ✓ Conduct regular inspections of all operations, equipment, work areas and facilities. Have workers participate on the inspection team and talk to them about hazards that they see or report.
- ✓ Be sure to document inspections so you can later verify that hazardous conditions are corrected. Take photos or video of problem areas to facilitate later discussion and brainstorming about how to control them, and for use as learning aids.
- ✓ Include all areas and activities in these inspections, such as storage and warehousing, facility and equipment maintenance, purchasing and office functions, and the activities of on-site contractors, subcontractors, and temporary employees.
- ✓ Regularly inspect both plant vehicles (e.g., forklifts, powered industrial trucks) and transportation vehicles (e.g., cars, trucks).
- ✓ Use checklists that highlight things to look for. Typical hazards fall into several major categories, such as those listed below; each workplace will have its own list:
    - General housekeeping
    - Slip, trip, and fall hazards
    - Electrical hazards
    - Equipment operation
    - Equipment maintenance
    - Fire protection
    - Work organization and process flow (including staffing and scheduling)
    - Work practices
    - Workplace violence

- Ergonomic problems
- Lack of emergency procedures

✓ Before changing operations, workstations, or workflow; making major organizational changes; or introducing new equipment, materials, or processes, seek the input of workers and evaluate the planned changes for potential hazards and related risks.

Note: Many hazards can be identified using common knowledge and available tools. For example, you can easily identify and correct hazards associated with broken stair rails and frayed electrical cords. Workers can be a very useful internal resource, especially if they are trained in how to identify and assess risks.

Action item 3: Identify health hazards

Identifying workers' exposure to health hazards is typically more complex than identifying physical safety hazards. For example, gases and vapors may be invisible, often have no odor, and may not have an immediately noticeable harmful health effect. Health hazards include chemical hazards (solvents, adhesives, paints, toxic dusts, etc.), physical hazards (noise, radiation, heat, etc.), biological hazards (infectious diseases), and ergonomic risk factors (heavy lifting, repetitive motions, vibration). Reviewing workers' medical records (appropriately redacted to ensure patient/worker privacy) can be useful in identifying health hazards associated with workplace exposures.

How to accomplish it

✓ Identify chemical hazards –review SDS and product labels to identify chemicals in your workplace that have low exposure limits, are highly volatile, or are used in large quantities or in unventilated spaces. Identify activities that may result in skin exposure to chemicals.

✓ Identify physical hazards –identify any exposures to excessive noise (areas where you must raise your voice to be heard by others), elevated heat (indoor and outdoor), or sources of radiation (radioactive materials, X-rays, or radiofrequency radiation).

✓ Identify biological hazards –determine whether workers may be exposed to sources of infectious diseases, molds, toxic or poisonous plants, or animal materials (fur or scat) capable of causing allergic reactions or occupational asthma.

✓ Identify ergonomic risk factors –examine work activities that require heavy lifting, work above shoulder height, repetitive motions, or tasks with significant vibration.

✓ Conduct quantitative exposure assessments –when possible, using air sampling or direct reading instruments.

✓ Review medical records –to identify cases of musculoskeletal injuries, skin irritation or dermatitis, hearing loss, or lung disease that may be related to workplace exposures.

Note: Identifying and assessing health hazards may require specialized knowledge. Small businesses can obtain free and confidential occupational safety and health advice services, including help identifying and assessing workplace hazards, through OSHA's On-site Consultation Program.

Action item 4: Conduct incident investigations

Workplace incidents –including injuries, illnesses, close calls/near misses, and reports of other concerns– provide a clear indication of where hazards exist. By thoroughly investigating incidents and reports, you will identify hazards that are likely to cause future harm. The purpose of an investigation must always be to identify the root causes (and there is often more than one) of the incident or concern, in order to prevent future occurrences.

How to accomplish it

- ✓ Develop a clear plan and procedure for conducting incident investigations, so that an investigation can begin immediately when an incident occurs. The plan should cover items such as:
    - Who will be involved
    - Lines of communication
    - Materials, equipment, and supplies needed
    - Reporting forms and templates
- ✓ Train investigative teams on incident investigation techniques, emphasizing objectivity and open-mindedness throughout the investigation process.
- ✓ Conduct investigations with a trained team that includes representatives of both management and workers.
- ✓ Investigate close calls/near misses.
- ✓ Identify and analyze root causes to address underlying program shortcomings that allowed the incidents to happen.
- ✓ Communicate the results of the investigation to managers, supervisors, and workers to prevent recurrence.

Effective incident investigations do not stop at identifying a single factor that triggered an incident. They ask the questions "Why?" and "What led to the failure?" For example, if a piece of equipment fails, a good investigation asks: "Why did it fail?" "Was it maintained properly?" "Was it beyond its service life?" and "How could this failure have been prevented?" Similarly, a good incident investigation does not stop when it concludes that a worker made an error. It asks such questions as: "Was the worker provided with appropriate tools and time to do the work?" "Was the worker adequately trained?" and "Was the worker properly supervised?"

Note: OSHA has special reporting identifys for work-related incidents that lead to serious injury or a fatality (29 CFR 1904.39). OSHA must be notified within 8 hours of a work-related fatality, and within 24 hours of an amputation, loss of an eye, or inpatient hospitalization.

Action item 5: Identify hazards associated with emergency and nonroutine situations

Emergencies present hazards that need to be recognized and understood. Nonroutine or infrequent tasks, including maintenance and startup/shutdown activities, also present potential hazards. Plans and procedures need to be developed for responding appropriately and safely to hazards associated with foreseeable emergency scenarios and nonroutine situations.

How to accomplish it

- ✓ Identify foreseeable emergency scenarios and nonroutine tasks, taking into account the types of material and equipment in use and the location within the facility. Scenarios such as the following may be foreseeable:
    - Fires and explosions
    - Chemical releases
    - Hazardous material spills
    - Startups after planned or unplanned equipment shutdowns
    - Nonroutine tasks, such as infrequently performed maintenance activities
    - Structural collapse
    - Disease outbreaks
    - Weather emergencies and natural disasters
    - Medical emergencies
    - Workplace violence

Action item 6: Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control

The next step is to assess and understand the hazards identified and the types of incidents that could result from worker exposure to those hazards. This information can be used to develop interim controls and to prioritize hazards for permanent control.

How to accomplish it

- ✓ Evaluate each hazard by considering the severity of potential outcomes, the likelihood that an event or exposure will occur, and the number of workers who might be exposed.
- ✓ Use interim control measures to protect workers until more permanent solutions can be implemented.
- ✓ Prioritize the hazards so that those presenting the greatest risk are addressed first. Note, however, that employers have an ongoing obligation to control all serious recognized hazards and to protect workers.

Note: "Risk" is the product of hazard and exposure. Thus, risk can be reduced by controlling or eliminating the hazard or by reducing workers' exposure to hazards. An assessment of risk helps employers understand hazards in the context of their own workplace and prioritize hazards for permanent control.

IDENTIFY TASK REQUIREMENTS

Task Analysis

A task analysis defines a job in terms of KSA necessary to perform daily tasks. It is a structured framework that dissects a job and arrives at a reliable method of describing it

across time and people by composing a detailed listing of all the tasks. The first product of a task analysis is a task statement for each task on the list.

When writing the task statement, start each task with a verb, indicate how it is performed, and state the objective. For example, "Loads pallets using a forklift." One way of getting a comprehensive list is to have the employees prepare their own list, starting with the most important tasks. Then, compare these lists with yours. Finally, discuss any differences with the employees, and make changes where appropriate. This helps to ensure that you have accounted for all tasks and that they are accurate. It also gets them involved in the analysis activity.

Task or needs analysis should be performed whenever there are new processes or equipment, when job performance is below standards, or when requests for changes to current training or for new training are received. An analysis helps ensure that training is the appropriate solution, rather than another performance solution.
Once the task statement has been defined, the task analysis will then go into further detail by describing the:

- ✓ task frequency
- ✓ difficulty of learning
- ✓ importance to train
- ✓ task criticality
- ✓ task difficulty
- ✓ overall task importance

This in turn provides you with the information for identifying the KSA required for successful task performance. The analysis might also go into further detail by describing the task steps required to perform the task.

There are a wide variety of methods for performing a task analysis, such as observations, interviews, and questionnaires.

Task Statements

As mentioned earlier, a task statement is composed of an action and a result (product). For example, a couple of task statements for a fire person might be:

- ✓ *Determines manual ladder type and size needed at incident scene.* ("Determine" is the action while "identifying the correct ladder" is the result or product.)
- ✓ *Carries manual ladder from apparatus to incident scene.* ("Carries" is the action and the "ladder being placed at the scene" is the result of that action.)

Action can be mental, such as determining, or physical, such as carrying. Some other mental examples would be analyze, calculate, predict, and design. Physical examples might include, paint, dig, move, and operate. Actions can also deal with people such as counsel, mentor, teach, and explain. An example of a fire person doing a people task would be "Calms distressed individuals at emergency scene." Calms is the action being performed, while "producing a less stressed person" is the result or product of that action. It often helps

to sort the task actions into People, Data, and Things for clarity. This helps to identify the main characteristics of the job.

Good task statements are not easy to write. They require some in-depth analysis of the job by observing and interviewing Subject Matter Experts (SME). When observing, you should have them slow down so that you can identify what they are performing. One way to do this is to have them speak out loud as they perform the task, explaining what they are doing and why as they perform the task. This is a must when documenting mental actions as you have no idea what the SME is thinking.

Also, unlike learning objectives, tasks can have more than one action word. For example, "Troubleshoot and repair a carburetor" might be an acceptable task statement where as the two action words would make it unacceptable for a learning objective.

Task Steps

Task steps (also known as performance steps) are the step-by-step instructions for performing the process. They describe each step in sequence. You should ask, " What does the SME do first, second, third, and so on?" Take nothing for granted as experts may do some things so quickly that they are almost invisible. Often, they will not even be aware of the fact that they are performing something because they have done it so many times it just seems second nature to them.

Many task analysis do NOT require the recording of the task steps. Often, just the tasks will be recorded and the required KSA identified. Then, if any of the tasks requires training, rather it be formal, on-the-job, job aids, etc., then a second analysis will be performed to list the task steps. Although identifying and listing the steps can be a big help in defining a job, the cost of performing such a detailed analysis has to be weighed with other factors. Many processes, departments, and organizations are changing rapidly to stay competitive. If the task steps are not going to be used right away, you will need to determine if they will be valid at a later date.

However, the task steps for a learning program are almost always included, as the correct performance procedure needs to be documented. An example of a task for a Buyer with its steps might look like:

Orders manufacturing parts when the system flags a part as being low in stock.

1. Look up usage for the item for the previous 12 month period.
2. Calculate the average monthly use.
3. Add the planned growth rate for the product line.
4. Check parts catalogs or call the source for best buy rates.
5. Check with planned usage tables or the business unit to ensure that the part will not go out of specifications for the best calculated buy period.
6. Place purchase order.

There are four main methods for determining the steps in a task analysis:

- ✓ Hierarchical Task Analysis - arranging by order of actions
- ✓ IF and THEN Analysis - If and then relationship
- ✓ Model Based Analysis - possible actions listed
- ✓ Cognitive Task Analysis - critical decision based

Hierarchical Task Analysis

Most task analyses follow this method. Steps are arranged in the order they are performed. For example, a production worker might have the following task steps:
Package products as they come off the production line.

1. Place product in shrink-wrap.
2. Run product through heat-shrink.
3. Place product in package.
4. Glue ends of package together.
5. Place label on front of package.
6. Place on finished line.

It is not always easy to identify what a task step is as experts often group several steps into a larger one. For example, they might list "open the daily receiving spreadsheet file," instead of 1) start computer, 2) open spreadsheet program, 3) etc. If you are going to use the task steps for training purposes, then you are going to have to identify your target population. This will tell you how detailed the steps need to be. For example, if your target population is computer literate, then the expert's combined step might be appropriate, otherwise, you might have to break it into several smaller steps. There is no one right way to list steps as each circumstance will differ. This is why the first part of an analysis is crucial — to determine what type of information is needed and who your target population is.

If possible, steps should include the signs of success. This is how experts know when they've done something right. Carpenters look for edges to be aligned, while plumbers ensure there are no leaks. When you know this kind of event, you can help the learners ensure that they are doing things correctly.

If/Then Analysis

Often, the task performer's action depends upon a condition being satisfied. For example, think of using the delete function on a word processing program:

- ✓ IF text is a word THEN:
  - move cursor to middle of word
  - double-click mouse button
- ✓ IF text is a section of words or letters THEN:
  - move cursor to beginning of text
  - press mouse button down
  - move cursor to end of text
  - release mouse button
- ✓ THEN press [Ctrl-C], press delete button, or click on the cut icon.

An example for a supervisor's coaching task steps with certain conditions being met might look like this:

Coach employees to gain greater competence and to improve job performance.

- ✓ IF the employee is a beginner (cannot perform) THEN:
    - Give lots of clear instructions (training) because the task is new.
    - Give just a little bit of support (motivation) to calm the stress of change.
- ✓ IF the employee has had a little experience (can only perform with some guidance) THEN:
    - Allow the learner to experiment so that learning takes place from mistakes being made, but keep the level of guidance high so that these mistakes do not become learned.
    - Do NOT motivate too much as the employee needs to concentrate on mastering the new task (our brains can only take so many inputs. See Arousal).
- ✓ IF the employee can perform, but makes occasional mistakes or is slow (capable performer) THEN:
    - Drop instructional level to just a few pointers so that the learner can experiment with new skill.
    - Increase the amount of emotional support (motivation) to help increase the level of confidence.
- ✓ IF the employee performs correctly THEN:
    - Provide little coaching and support so that the employee can take ownership of job.
    - Delegate and encourage employee to take on new responsibilities and new assignments.
    - Start using mentoring on employee to help him or her grow.

Model Based Analysis

This method is often used for professional tasks as the steps for performing certain tasks can be extremely vague to define. Although performance is based on methodologies, there might not be any clear and cut guidelines for performing the task. For example, in going back to the task that has the supervisor coaching an employee, we might have this task and steps: Uses one or more accelerated learning techniques to promote learning. Acceptable techniques include, but are not limited to:

- ✓ use examples of others
- ✓ have them form a picture in their minds of what they are trying to learn
- ✓ help them gain and understand necessary information
- ✓ apply the task to their job
- ✓ present information using visual, auditory, and kinesthetic methods
- ✓ practice the task

This method relies upon the task performer to determine what task steps are needed and then sequence those steps in order to accomplish the task in an efficient and effective manner.

Cognitive Task Analysis

Due to the rapid changes that are the major workings of many of today's organizations, a number of organizations are changing from task-based work to process-based. That is, they are becoming more knowledge-based. These jobs are no longer defined by a number of tasks, but by focusing on troubleshooting activities. In these cases, a cognitive task analysis may be more appropriate for identifying strategies involved in effective performance.

A Cognitive Task Analysis is directed at the psychological processes underlying the performance and the subtle cues that may depend on context and experience. The main goal of a cognitive task analysis is to define the actual decision requirements of the task by:

- ✓ Mapping out the task using task analysis (traditional task analysis).
- ✓ Identifying the critical decision points.
- ✓ Clustering and linking the decision points.
- ✓ Prioritizing the decision points.
- ✓ Diagnosing and characterizing the decisions as to the strategies used, cues signaling the decision points, and the inferences made regarding cues and decision points.

There is a key difference between a task analysis and cognitive task analysis. Task analysis focuses mainly on observable behavior and does not offer information on overall organization of knowledge. A cognitive task analysis is directed at the psychological processes underlying the behavior. Cognitive task analysis concentrates on the critical decisions and cognitive processes that separate the expert from the novice.

An example for an instructional designer might be (this example does not go into great detail due to space limitations):
Uses one or more accelerated learning techniques to promote learning.

- ✓ Map out the task using task analysis (traditional task analysis):
    - o use examples of others
    - o have them form a picture in their minds of what they are trying to learn
    - o help them gain and understand necessary information
    - o apply the task to their job
    - o present information with several examples to provide context
    - o practice the task
- ✓ Identify the critical decision points (what do experts ask themselves when deciding on what learning technique to use):
    - o What is the experience level of the learners?
    - o What do I need to ask them to show me they understand
- ✓ Cluster and link the decision points (Note: only the first decision point, “What is the experience level of the learners?” is shown):
    - o Ask learners for their experience level to gain a background.
    - o Ask questions that provide clues.
    - o Observe how they react to new and difficult information.
- ✓ Prioritize the decision points:

- Main decision point is asking for their experience level. Asking questions is then used to ensure that the trainer and the learner both understand each other and know where each other is coming from.

✓ Diagnose and characterize the decisions as to the strategies used, cues signaling the decision points, and the inferences made regarding cues and decision points.

- Asking the learners for their experience level builds a level of trust and rapport between them and the trainer. But, to prevent any form of misunderstanding, questioning techniques are used to verify their answers. With experience learners, the trainer can get right to the point. While less experienced learners need the material presented in a variety of formats.

Duties

Duties are a combination of related or like tasks. For example, an inventory control specialist might have two duties:

✓ Perform shipping duties:
- Pull items using a letdown. (task)
- Prepare items for shipment. (task)

✓ Perform receiving duties:
- Unload trailers using a forklift. (task)
- Receive the items into the computer database. (task)

As mentioned earlier, tasks should have a definite beginning and end and explain a process. This is the main clue for separating tasks from duties. For example, is the following a task or duty for a Fire person?

Stands watch to receive incoming alarms and information, answers phones, and monitors access to the station house.

This would be a duty as it would be extremely hard for someone to identify the process and note when it has started and when it has stopped. Clues that give this off as a duty are the multiple action verbs: stands, receive answer, and monitor. Also, if this was a task, then you would have to see all the actions performed when observing the task, e.g. when an alarm is received then the phone would have to be answered. Remember, a task stands alone as it has a definite start and an end.

The tasks performed while carrying out this duty might include:

✓ Receives notification of multiple alarms, downtown alarms, and other significant emergencies through the Fire Alarm Office. (“Receives” is the action while “being notified of the various alarms” is the result.)

✓ Notifies station personnel over public address system of incoming alarms and required response (e.g., everybody goes, truck only, engine only, etc.). (“Notifying” is the action while “the other fire persons being made aware of the required response” is the result.)

Knowledge, Skills, and Attitudes (KSA)

Knowing the tasks that have to be performed helps you to identify the KSA that the jobholder must possess in order to perform to standards. In some cases you will train some of the required KSA. But even then, you must determine the required entry behaviors (KSA required to be able to learn the new tasks). Some prerequisite skills may be difficult to recognize because they are too obscure, others may be too obvious.
For example, forklift operators need hand and eye coordination before they can be trained. A shipping and receiving specialist might need keyboarding skills, while a planner needs good math and organization skills. On the other end of the scale, you would expect an accountant to have math skills and receptionists to know that a ringing phone needs to be answered.

To help you extract the KSA from a task, you should be familiar with Bloom's Taxonomy or Learning Domains. The three learning domains used in Bloom's Taxonomy - cognitive, psychomotor, and affective; correspond to knowledge, skills, and attitude respectively.

For example, the task *"Create web pages"* has the action word "create. The chart showing the three learning domains has the word create as one of the key words in the *cognitive* domain. This is the next to highest category, so it tells you that it is high on the scale of knowledge skills. Some of the KSA required are "Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure." Using this information, and with the input of SMEs, you might come up with something similar to:

"Create pages for the e-commerce web site."

- ✓ task frequency - performed daily as it is main job task.
- ✓ difficulty of learning - entry behavior requires computer, web, and design skills.
- ✓ importance to train - low as a qualified person can probably be hired
- ✓ task criticality - 5 on a scale of 1 to 5
- ✓ task difficulty - 4 on a scale of 1 to 5
- ✓ overall task importance - 5 on a scale of 1 to 5
- ✓ KSA required:
    - Program in HTML (HyperText Markup Language).
    - Design and build on-screen layout and messages using company templates.
    - Use Dreamweaver or similar remote publishing tool.
    - Works with others (teamwork) by interacting with the Merchandising department group.
    - Constructs pictures using digital cameras and photo editing software.
    - Communicates using both written and verbal skills.

Team Task Analysis

A team task analysis includes teamwork and individual task-work. This is often called a collective task. Teamwork consists of individuals interacting or coordinating tasks that are important to the team's goals, while task-work consists of individuals performing tasks. Like a job analysis, a team task analysis is important because it forms the foundation for team design, team performance measurement, and team training. The purpose of the team task analysis will dictate if the focus is to be upon team tasks, team processes, individual task-work, or some combination of the three.

A team can be defined as a group of individuals working together toward a common goal, product, or solution that requires the sharing of expertise, knowledge, and ideas in a cooperative and interdependent fashion. Some of the goals that they might be trying to achieve are:

- ✓ solving a problem
- ✓ designing a plan
- ✓ defining a process
- ✓ building a product
- ✓ executing a process

Individual tasks, are analyzed using the same methods as discussed earlier. They should, however, be reviewed by the other team-members in order to gauge their full impact. Teamwork, on the other hand, requires a slightly different approach. For example, some of the tasks that might be in teamwork are:

- ✓ Participate and share in the team's leadership.
- ✓ Achieve team roles and norms (focus is on the underlying team mechanics and operating rules).
- ✓ Participate by contributing data and knowledge.
- ✓ Coordinate task responsibilities.
- ✓ Share in the decision making process with the goal of reaching consensus.
- ✓ Communicate, provide feedback, and interact among the team members (openness in critiquing and trusting others).
- ✓ Accomplish goals (the team's ability to meet its milestones and time deadlines).
- ✓ Produce a quality product that will be accepted by the customer (either external or internal).
- ✓ Work efficiently and effectively as a team unit.

Teamwork becomes more difficult to analyze as it is performed collectively by the team. For example, how do you determine the amount of participation of the individuals in accomplishing a goal? Also, most of the team tasks include soft skills. A hard skill can easily be measured, such as *"Paint a door,"* while a soft skill is more difficult to measure, such as *"Share in the decision making process."*

Team tasks can best be analyzed by extracting task information from the team as a whole. It is only after getting agreement by the team on the task's frequency, criticality, difficulty, importance, and KSA that the complete significance of the teamwork task can be defined. Just as a team is responsible for achieving its goals, it should also have the major

responsibility of defining the teamwork (team tasks) that empowers it. Although this requires that you become more of a facilitator than a task analyst, the payoff will be a team that has built and therefore will implement its defining structure.

What is 'coordinating with others'?

There is an African proverb that goes "If you want to go quickly, go alone. If you want to go far, go together."

Fundamental to good teamwork and therefore the success of your team is the ability to coordinate successfully with one another.

This is often easier said than done and it can be traced back to the following three elements:

1. Clear communication

How can you coordinate well with others if they can't understand you?
When speaking keep your language simple and jargon free. Speak slowly and clearly and don't be afraid to ask your audience to confirm that they've understood what you mean.
This applies as much to listening as it does to speaking. Learn to listen actively and devote your whole attention to the person speaking.
Again, don't be afraid to ask questions for clarification.

2. Understanding each other's personality types

We are all motivated in slightly different ways.
In order to get the best out of your colleagues, take time to observe the way they prefer to work.
For example, people's approach to time varies considerably. Some like to be given plenty of time up front to complete the task whilst others prefer to work 'under pressure'.
If you work with rather than against their natural tendencies then you will find that your working relationship is smoother.

3. Get organised

You need to be organised.
It's your responsibility to manage your own workload and ensure that it fits with the overall output of the organisation.
This also gives you the flexibility to handle problems as and when they arise.

Why is it important?

- ✓ Poor coordination leads to suboptimal outcomes. You and your organisation will suffer.
- ✓ When things go wrong it enables you to get back on track more quickly.

- ✓ It gives you the ability to foresee potential problems and obstacles before they happen.

How do I become better at it?

Here are 6 ways to improve your ability to coordinate with others:

1. Learn how to be a clear communicator. Check your team have understood you correctly.
2. Learn to be a better listener.
3. Learn how to give feedback.
4. Learn how to receive feedback.
5. Become better at managing deadlines.
6. Check-in regularly with your team to find out how they are progressing with their individual tasks.

The 'O' And The 'M' In Operation And Maintenance Of Water And Wastewater Treatment Plants

According to Sullivan in 2010, “Operations and Maintenance are the decisions and actions regarding the control and upkeep of property and equipment.” Operations are the activities to make sure the plant produces the desired quality and quantity of treated water and meets the current legislation, while maintenance are the activities to make sure the plant equipment continues to work efficiently to achieve the operational objectives.

Water and wastewater treatment plants are no longer traditional plants; monitoring is not just taste, odor, iron and manganese; water treatment facilities are more complex now a days, new technologies have emerged, raw water is more difficult to treat, the treatment requires more innovative solutions, there is an increasing demand for services, diminishing resources, rising service expectations of customers and increasingly stringent regulatory requirements. This all leads to analyzing and enhancing the way we look at operation and maintenance in the water and wastewater industry and the treatment facilities that should be developed and expanded to accommodate these dramatic changes.

Another reason is the growing trend in outsourcing the operation and maintenance of water and wastewater treatment plants. O&M is outsourced for the main following reasons:

- ✓ You are better
- ✓ You are less expensive
- ✓ The client can transfer operational headache (risk) to you, allowing them to focus on their core business

There are many books and articles talking about operation and maintenance and some are talking about the water treatment plant operation, but it seems that we are missing that comprehensive approach between them to successful operation and maintenance. This article will provide a comprehensive approach on the ‘O’ and the ‘M’ in the operation and maintenance of water and wastewater treatment plants.

The operation and maintenance of water and wastewater plants has been generally been broken up in to five main critical elements; operation, maintenance, engineering, training and administration – also known as OMETA .

The new approach is broken down to eight critical elements; WH&S plan, Scope of service, Operation plan, asset and maintenance plan, people, analytical protocols, communication and reporting, and administration.

The main objective of all elements is to support the effectiveness of the fundamental core element; operation and maintenance.

All of these elements should be well defined before starting an implementation process and analyze should be undertaken as to how these elements are linked to form a sound program

structure. However the link is very obvious – O&M work together. These elements are analyzed below.

1. WH&S Plan

This is primarily a communication tool between the company and its employees, customer and contractors, to ensure that relevant site information is regularly updated between all parties and that safety is monitored, recorded and acted upon.
Benefits (why it matters):

- ✓ Protect people and equipment
- ✓ Reduce downtime and absenteeism
- ✓ Legal compliance
- ✓ Increase the skills and awareness of safety to all involved

Suggested components of WH&S plan:

A WH&S plan should include but not be limited to the following:

- ✓ Site Safety Manual;
- ✓ Safety Training;
- ✓ Safety Audits;
- ✓ Housekeeping Audits;
- ✓ Safety Meetings;
- ✓ Safety Reports (Near miss, incidents, observation, etc.);
- ✓ Customer Specific Requirements;
- ✓ Work permits;
- ✓ Safety procedures (Lock-Out Tag-Out "LOTO", confined space, working at heights, etc.);
- ✓ Statement of responsibilities;
- ✓ Incident Management;
- ✓ Site Safety Rules; and
- ✓ Identifying and managing risk.

2. Scope of Service

This primarily defines what, when and where work will happen, supply responsibilities and liability for deliverables.

Benefits (why it matters):

- ✓ Clearly define deliverables to the team
- ✓ Base for O&M planning
- ✓ Inputs and outputs are clearly defined and executed to delight customers

The scope of service is usually extracted from the operation and maintenance contract; it defines the main objectives of the O&M service provided to the internal or external customers.

The scope of service should include the following as a minimum:

- ✓ Take Of Points (TOPs) – these are the points where the scope of service starts and ends;
- ✓ The raw water quality or influent window/s;
- ✓ The treated water quality limits and KPI's;
- ✓ Reporting requirements both internal, external and regulatory;
- ✓ Legislation and regulatory requirements;
- ✓ Services Performed;
- ✓ Maintenance Performed;
- ✓ Overall Key Performance Indicators;
- ✓ Liabilities;
- ✓ HR requirements;
- ✓ Billing details;
- ✓ Contacts list; and
- ✓ Organisational charts & responsibilities.

3. Operations Plan

This is the primary main operational objective which is to make sure the plant is operating in producing the design quality and quantity efficiently and consistently.

Benefits (why it matters):

- ✓ Enhance tracking and decision making and control of KPIs;
- ✓ Provide optimal operating efficiency;
- ✓ Reduce waste;
- ✓ Support proactive operation;
- ✓ Support continuous process improvement and optimization; and
- ✓ Reduce operating errors

The operations plan should include but not be limited to the following:

- ✓ Operating Schedules;
- ✓ Operating KPIs;
- ✓ Data collection and monitoring;
- ✓ Responses with corrective actions;
- ✓ Standard Operating Procedures (SOP);
- ✓ Work Instructions;
- ✓ Checklists / Task Lists;
- ✓ Operator Logs;
- ✓ Product / Process Change Processes;
- ✓ Chemical details (dosage, preparation, storage and inventory);
- ✓ Process balance sheets;
- ✓ Operation Sequence Charts (OSC); and
- ✓ System settings & alarms list.

Once operating quantifiable parameters such as pressure, pressure drop, flow, temperature, pH level, turbidity and visual checks are properly defined, they are considered indicators that a control device is functioning as designed in accordance with the Operation Plan.

Operating limits for each parameter may initially be suggested by the equipment manufacturer but may later be modified by the facility based on experience or operation during a performance test and operation of the plant.

Data collection is only one part of plant and equipment operational monitoring. Cumulative data collected should be used to produce beneficial information, represent key performance indicators and further enhance the defined operating parameters.

Proactive operation schedules include seasonal changes, shutdown periods, peak demand, low consumption periods, water quality changes and public holidays are all important factors to monitor and manage to increase overall plant efficiency. A response plan should be developed to deal with such different occasions and adjust the plant until the team gains more experience with such future proactive operation instances.

Important factors about data logging:

- ✓ When and what data is collected;
- ✓ How often it is collected depends on the criticality of the process;
- ✓ Using online or manually collected data;
- ✓ Transferring data into information summarized by KPIs;
- ✓ Using the information to control and correct deviations; and
- ✓ Consult with the equipment manufacturer.

4. **Asset & Maintenance Plan**

The asset and maintenance plan is primarily the processes and structure to ensure that equipment continues to deliver maximum value throughout its expected life and at the lowest cost.

Benefits (why it matters):

- ✓ Protect asset value;
- ✓ Reduce down times;
- ✓ Reduce breakdowns;
- ✓ Increase operational performances;
- ✓ Increase resource utilisation; and
- ✓ Improve profit and profitability

Maintenance items can include; inspections, cleanings, lubrications, adjustments, replacements and calibrations. Maintenance procedures may initially be suggested by the equipment manufacturer but may later be modified by the facility based upon experience.

Other important elements in the maintenance plan are:

- ✓ Asset list which includes; asset name, description, asset number, location, criticality, condition, usefulness and value. The asset list will give the operator an understanding of the physical asset capability to meet the stakeholder's expectations and regulatory requirements;

- ✓ Implementing maintenance best practices such as; 5S, Failure Mode Effect Analysis (FMEA) or Root Cause Analysis (RCA);
- ✓ Proactive maintenance programs, especially for critical equipment;
- ✓ Preventive maintenance programs which can include; cleaning, calibration, oil change, greasing and replacing consumables;
- ✓ Critical spare parts list included items such as; correct quality, correct quantity, correct time, correct cost and correct supplier;
- ✓ Tracked Work Orders;
- ✓ Useful maintenance software such as 'CMMS' or even a similar style maintenance spreadsheet;
- ✓ Tools list and the inclusion of some tools for proactive maintenance; and
- ✓ Spare parts inventory.

5. **People**

This primarily includes managing employees and contractors.

Benefits (why it matters)

- ✓ Right person, in the right place;
- ✓ Continuous people development based on requirement; and
- ✓ Increase employee's satisfaction

Important items to address in managing people include:

- ✓ Training based on skills matrix and training matrix;
- ✓ On Job Training (OJT);
- ✓ On Boarding and induction;
- ✓ Communication;
- ✓ Selection Process;
- ✓ Performance reviews;
- ✓ Job Description and responsibilities; and
- ✓ Recognition and motivation.

6. **Analytical Protocols**

This is primarily defined as the quality monitoring of process efficiency.

Benefits (why it matters)

- ✓ Optimizes processes and chemical dosing
- ✓ Supporting decision making to control KPI's
- ✓ Proactive actions
- ✓ Regulatory requirements
- ✓ Reporting basis

In addition to the quality monitoring, the analytical protocol should also include the response plan to any deviation from control limit/s.

7. **Communication and Reporting**

This is primarily addressed as the communication of KPIs to the stakeholders and regulators.

Benefits (why it matters)

- ✓ Forms basis for measurable business value
- ✓ Provides mutual agreement of value delivered
- ✓ Allows tracking and implementation of Best Standard Operation procedures
- ✓ Fulfilling regulatory requirements
- ✓ Identifies opportunities for improvement and expansion

Reporting may include:

- ✓ KPI Communication;
- ✓ Operational Activities;
- ✓ Maintenance Activities;
- ✓ Safety Compliance;
- ✓ Non-Conformance Actions;
- ✓ Profit and Loss "P&L"; and
- ✓ Improvement of projects capital output.

8. **Administration**

Administration are all the supporting activities to main structure of O&M, this include:

- ✓ Procurement
- ✓ Contracts management
- ✓ Budgeting
- ✓ Book keeping
- ✓ Public communication

Benefits (why it matters)

- ✓ Effective management
- ✓ Control of KPIs
- ✓ Support meting regulatory and contractual requirement
- ✓ Better public awareness
- ✓ Provide a documents repository

Key Success Factors to the 'O' and the 'M' in Operation and Maintenance

1. The size and complexity of the plan should match the size and complexity of the plan;
2. Know your team skills and capabilities for effective resource utilization and understanding of training needs;
3. Develop clear key performance indicators and metrics to measure cost and progress;
4. Obtain senior management support and engagement;
5. Program sponsor with authority to change;

6. People, process, then equipment;
7. Balance quick wins with continuous improvement;
8. Focus on the trouble areas;
9. Engage people with trust and respect; and
10. Update stakeholders continuously on the progress

Operating in Shifts

Good communication between teams working on plants is an important contributor to safety.

When a team hands over responsibility to another (as takes place during shift handover) there is always the possibility of an important detail being overlooked.
The handover process relies on good communication to ensure continuity. Any weakness in this communication can introduce safety risk. The result might be a serious accident that could have been avoided.

Shift handover

Changing shifts is a requirement in any continuous process. While plants can operate 24X7, people need to take breaks. Shift handover should be regarded as a high-risk process because it cannot be automated and relies on human behavior. The goal of the handover process is to maintain continuity and the formal transfer of responsibility and accountability between the respective parties.

Work that takes place across shifts

A shift roster is typically set up in advance to accommodate the need for people to work to a schedule. Shift changeover times are planned in advance. The reality of day to day operations is that certain tasks like critical repairs, or unloading bulk raw materials happen on their own time scale. These tasks, sometimes involving different teams can take place during two or more shifts. Other, bigger tasks such as a major repair might take place over days, weeks or even months.

Shift handover procedure

To ensure continuity and minimize errors, a standard procedure is implemented for shift handover. Each company will develop their own procedure in line with their operational requirements. In practice we have observed that there is little standardization of these handover procedures between companies, and while some follow a very rigorous and defined process, others merely rely on individuals to communicate effectively.

Risks associated with shift handover

Considering that a typical shift is either 8 or 12 hours long, changeover happens 1095 or 730 times during the year, in other words there are 730 or 1095 high risk opportunities for

miscommunication leading to safety incidents. Making sure that the changeover process itself is defined and managed properly is a priority area to focus on when looking for ways to improve safety on the plant.

Several studies into shift handover have been done to better understand ways to improve the procedures. One such HSE study analysed a number of incidents involving planned maintenance work and found that the following shift handover related risks were contributing factors to accidents and fatalities:

- ✓ In some of the incidents, planned maintenance work continued over a shift change.
- ✓ Thorough [coordination and] communication of such work should be afforded a very high priority.
- ✓ Operator support [logs] were not designed to capture key information reliably and unambiguously.
- ✓ A lack of procedures which specified how to conduct an effective shift handover was evident.
- ✓ Inaccurate and unreliable carry-forward of written information from shift to shift was evident. For example, reference to a temporary safety system over-ride was not carried forward.

The permit to work and shift handover

In typical industrial environments the permit to work makes sure that communication takes place between all people involved in dangerous, non-routine tasks on the plant.

So, what should happen to these permits at shift handover?

Two approaches are possible:

- ✓ The permit is closed off and a new permit issued by the incoming shift for the work to continue.
- ✓ A shift handover procedure is implemented that ensures that responsibility is transferred from the outgoing to the incoming persons on the permit document itself.

The first approach takes more time but forces a fresh review of the job and helps ensure that communication takes place. The second approach is more streamlined but runs the risk that something important has changed that is not adequately interrogated by the responsible persons at changeover.

In practice there is often confusion as to which of the two approaches is best within a single company, and the procedures also differ between industries. Unsurprisingly for example, in the nuclear industry a much more structured handover process is followed than for example in chemicals manufacturing.

The HSE study [1] also found an interesting disconnect. In a survey of chemicals plant personnel, the majority of fitters and superintendents were of the view that a new permit

should be issued at changeover, while the majority of managers believed that the work should carry on using the same permit. This lack of alignment should be of concern as it seems as there is scope for confusion.

What constitutes a good shift handover procedure?

A good shift changeover procedure should be based on the following design principles:

- ✓ Formal written communication around each handover should be documented in a simple, secure, structured logbook, ideally electronic.
- ✓ Information between shifts should also communicate the "why" and not just the "what".
- ✓ Information between shifts should be communicated between experienced competent persons who understand the process and work being done.
- ✓ Relevant information should be highly visible to all affected – e.g. displays around the plant, mobile devices, etc.

- ✓ Relevant focused shift and safety information should be easily shared.
- ✓ The handover process should always be aligned to the short and medium-term production goals and targets and these need to be visible.
- ✓ Coordination and linking of all the other relevant processes underway – such as any open permits, isolations and so on. The information should ideally be in a common system or database.
- ✓ Face to face communication between role-players.
- ✓ Catering for regular handover and / or production meetings that result in tasks being assigned, followed up and shared in a management system.
- ✓ Support for continuous training and audit of the processes.

Where to start?

During a review or implementation of a new shift handover process it is suggested that you first analyse the existing procedures to see what steps can be improved, and not necessarily just transcribe "what has always been done" into a new computer-based system. These procedures might include:

- ✓ Permit to work
- ✓ Isolation management
- ✓ Shift handover
- ✓ Production meetings
- ✓ Maintenance
- ✓ Routine and non-routine operations that take place over shifts
- ✓ Shift roster management
- ✓ And so on…

In this early phase of the project you would work closely with the supplier of the software to understand the capabilities of the system and help you map your existing processes to the new system. This process mapping exercise will often identify gaps and opportunities which will greatly enhance operational effectiveness and safety.

Machinery, plant and equipment

This section covers the different safety aspects of using machinery and maintaining plant and equipment in the workplace. Employers should consider how their workers use machinery, and have adequate maintenance arrangements in place to ensure it remains safe to use.

There is also specific advice on lifting equipment and carrying out vehicle repairs.

Case study

A company were prosecuted after a worker was killed when he was crushed in the rollers of a rubber and cloth inspection machine.

Other workers heard him cry out and he was found with his left arm, shoulder, head and torso trapped between the rubberised blanket and the roller. He was pronounced dead at the scene.

What caused the accident?

The company had not assessed the risks associated with using the machine. They had not checked that it was safe to use following modifications when the nip guards were removed and an unguarded roller was inserted.

Why is machinery safety important?

Moving machinery can cause injuries in many ways:

- ✓ People can be struck and injured by moving parts of machinery or ejected material. Parts of the body can also be drawn in or trapped between rollers, belts and pulley drives.
- ✓ Sharp edges can cause cuts and severing injuries, sharp-pointed parts can cause stabbing or puncture the skin, and rough surface parts can cause friction or abrasion.
- ✓ People can be crushed, both between parts moving together or towards a fixed part of the machine, wall or other object, and two parts moving past one another can cause shearing.
- ✓ Parts of the machine, materials and emissions (such as steam or water) can be hot or cold enough to cause burns or scalds, and electricity can cause electrical shock and burns.
- ✓ Injuries can also occur due to machinery becoming unreliable and developing faults or when machines are used improperly through inexperience or lack of training.

What should employers do?

Before they start

Before they start using any machine they need to think about what risks may occur and how these can be managed. They should therefore do the following:

- ✓ Check that the machine is complete, with all safeguards fitted, and free from defects. The term 'safeguarding' includes guards, interlocks, two-hand controls, light guards, pressure-sensitive mats etc. National legislation often requires the supplier to provide the right safeguards and inform buyers of any risks ('residual risks') that users need to be aware of and manage because they could not be designed out.
- ✓ Produce a safe system of work for using and maintaining the machine. Maintenance may require the inspection of critical features where deterioration would cause a risk. They should also look at the residual risks identified by the manufacturer in the information/instructions provided with the machine and make sure they are included in the safe system of work.
- ✓ Ensure every static machine has been installed properly and is stable (usually fixed down).
- ✓ Choose the right machine for the job and do not put machines where customers or visitors may be exposed to risk.

Make sure the machine is:

- ✓ Safe for any work that has to be done when setting up, during normal use, when clearing blockages, when carrying out repairs for breakdowns, and during planned maintenance;
- ✓ Properly switched off, isolated or locked off before taking any action to remove blockages, clean or adjust the machine;

Also, make sure they identify and deal with the risks from:

- ✓ Electrical, hydraulic or pneumatic power supplies;
- ✓ Badly designed safeguards. These may be inconvenient to use or easily overridden, which could encourage their workers to risk injury and break the law. If this is happening employers should find out why workers are doing it and take appropriate action to deal with the reasons/causes.

Preventing access to dangerous parts

Employers should think about how they can make a machine safe. The measures they use to prevent access to dangerous parts should be in the following order. In some cases it may be necessary to use a combination of these measures:

- ✓ Use fixed guards (e.g. secured with screws or nuts and bolts) to enclose the dangerous parts, whenever practical. Use the best material for these guards – plastic may be easy to see through but may easily be damaged. Where you use wire mesh or similar materials, make sure the holes are not large enough to allow access to moving parts.
- ✓ If fixed guards are not practical, they should use other methods, e.g. interlock the guard so that the machine cannot start before the guard is closed and cannot be opened while the machine is still moving. In some cases, trip systems such as photoelectric devices, pressure-sensitive mats or automatic guards may be used if other guards are not practical.
- ✓ Where guards cannot give full protection, use jigs, holders, push sticks etc. if it is practical to do so.
- ✓ Employers should control any remaining risk by providing the worker/operator with the necessary information, instruction, training, supervision and appropriate safety equipment.

Other things employers should also consider

- ✓ If machines are controlled by programmable electronic systems, changes to any programmes should be carried out by a competent person (someone who has the necessary skills, knowledge and experience to carry out the work safely). It is good practice if employers' keep a record of such changes and check to ensure they have been made properly.
- ✓ Ensure control switches are clearly marked to show what they do.
- ✓ Have emergency stop controls where necessary, e.g. mushroom-head push buttons within easy reach.
- ✓ Make sure operating controls are designed and placed to avoid accidental operation and injury, use two-hand controls where necessary and shroud start buttons and pedals.
- ✓ Don't let unauthorized, unqualified or untrained people use machinery – never allow children to operate or help at machines. Some workers, e.g. new starters, young people or those with disabilities, may be particularly at risk and need instruction, training and supervision.
- ✓ Adequate training should ensure that those who use the machine are competent to use it safely. This includes ensuring they have the correct skills, knowledge and experience – sometimes formal qualifications may be needed.
- ✓ Supervisors must also be properly trained and competent to be effective. They may need extra specific training and there are recognized courses for supervisors.
- ✓ Ensure the work area around the machine is kept clean and tidy, free from obstructions or slips and trips hazards, and well lit.

Dos and don'ts of machinery safety for workers

Do...

- ✓ check the machine is well maintained and fit to be used, i.e. appropriate for the job and working properly and that all the safety measures are in place – guards, isolators, locking mechanisms, emergency off switches etc.;
- ✓ use the machine properly and in accordance with the manufacturer's instructions;
- ✓ make sure operators are wearing the appropriate protective clothing and equipment required for that machine, such as safety glasses, hearing protection and safety shoes.

Don't...

- ✓ use a machine or appliance that has a danger sign or tag attached to it. Danger signs should only be removed by an authorised person who is
- ✓ satisfied that the machine or process is now safe;
- ✓ wear dangling chains, loose clothing, rings or have loose, long hair that could get caught up in moving parts;
- ✓ distract people who are using machines;
- ✓ remove any safeguards, even if their presence seems to make the job more difficult.

Case study

A company were prosecuted after a worker received horrific injuries, almost severing his left arm when using a cross-cut saw.

What the employer did

The nose guard had not been set correctly because training was inadequate. The worker had no previous experience and had only five minutes' training on the saw. This did not include any instruction about the saw guards and how to adjust them properly. In addition, the saw was unsuitable for training purposes.

Plant and equipment maintenance

Maintenance on plant and equipment is carried out to prevent problems arising, to put faults right, and to ensure equipment is working effectively.

Maintenance may be part of a planned programme or may have to be carried out at short notice after a breakdown. It always involves non-routine activities and can expose those involved (and others) to a range of risks.

Why is maintenance of plant and equipment important?

An effective maintenance programme will make plant and equipment more reliable. Fewer breakdowns will mean less dangerous contact with machinery is required, as well as having

the cost benefits of better productivity and efficiency.

Additional hazards can occur when machinery becomes unreliable and develops faults. Maintenance allows these faults to be diagnosed early to manage any risks. However, maintenance needs to be correctly planned and carried out. Unsafe maintenance has caused many fatalities and serious injuries, either during the maintenance or to those using the badly maintained or wrongly maintained/repaired equipment.

What should employers do?

Employers who provide equipment for use, from hand tools and ladders to electrical power tools and larger plant, need to ensure that, so far as is reasonably practicable that the machinery and equipment under their control is safe and without risk to health. One way to achieve this is for employers to have arrangements in place to make sure machinery and equipment is maintained in a safe condition.

They should think about what hazards can occur if:

- ✓ tools break during use;
- ✓ machinery starts up unexpectedly;
- ✓ there is contact with materials that are normally enclosed within the machine, i.e. caused by leaks/breakage/ejection etc.

Failing to correctly plan and communicate clear instructions and information before starting maintenance can lead to confusion and can cause accidents. This can be a particular problem if maintenance is during normal production work or where there are contractors who are unfamiliar with the site.

Case study

A worker received crush injuries to his head and neck while he was undertaking maintenance work, when the hoist he was working on started up.

What caused the accident?

The power supply to the hoist had not been isolated before work started. This was because workers had not been given adequate training or instruction on safe isolation procedures. It was also found that isolation by the interlocked gates could be bypassed.

Extra care is also required if maintenance involves:

- ✓ working at height or when doing work that requires access to unusual parts of the building;
- ✓ when entering vessels or confined spaces where there may be toxic materials or a lack of air.

How can employers do it?

Establishing a planned maintenance programme is a useful step towards reducing risk, as well as having a reporting procedure for workers who may notice problems while working on machinery.

Some items of plant and equipment may have safety-critical features where deterioration would cause a risk. Employers must have arrangements in place to make sure the necessary inspections take place.

But there are other steps to consider:

Before employers instruct workers to start maintenance

- ✓ Decide if the work should be done by specialist contractors. Never take on work for which workers are not prepared or competent.
- ✓ Plan the work carefully before it starts, ideally using the manufacturer's maintenance instructions, and produce a safe system of work. This will avoid unforeseen delays and reduce the risks.
- ✓ Make sure maintenance staff are competent and have appropriate clothing and equipment.
- ✓ Try and use downtime for maintenance. This can avoid the difficulties in co-ordinating maintenance and production work if maintenance work is performed before start-up or during shutdown periods.

Safe working areas

- ✓ Employers must provide safe access and a safe place of work.
- ✓ They must not just focus on the safety of maintenance workers – they must take the necessary precautions to ensure the safety of others who may be affected by the maintenance work, e.g. other workers or contractors working nearby.
- ✓ Employers and the maintenance personnel should set up signs and barriers and position people at key points if they are needed to keep other people out.

Case study

Maintenance staff removed a section of grating to gain access to plant located below a walkway. A worker fell through a gap in the walkway, seriously injuring his shoulder.

What caused the accident?

The fall happened because there was nothing to make workers aware of the dangers caused by machinery maintenance. Barriers, guards and signs should have been used to indicate that maintenance was taking place.

Safe plant and equipment

Employers should ensure plant and equipment is made safe before maintenance starts, through:

Safe isolation

- ✓ Ensuring moving plant has stopped and isolate electrical and other power supplies. Most maintenance should be carried out with the power off. If the work is near uninsulated, overhead electrical conductors, e.g. close to overhead travelling cranes, cut the power off first.
- ✓ Locking off machines if there is a chance the power could be accidentally switched back on.
- ✓ Isolating plant and pipelines containing pressured fluid, gas, steam or hazardous material. Locking off isolating valves.

Other factors needing to be considered

- ✓ Releasing any stored energy, such as compressed air or hydraulic pressure that could cause the machine to move or cycle.
- ✓ Supporting parts of plant that could fall, e.g. support the blades of down-stroking bale cutters and guillotines with blocks.
- ✓ Allowing components that operate at high temperatures time to cool.
- ✓ Place mobile plant in neutral gear, apply the brake and chock the wheels.
- ✓ Safely cleaning out vessels containing flammable solids, liquids, gases or dusts, and check them before hot work is carried out to prevent explosions. Specialist help and advice may be needed to do this safely.
- ✓ Avoiding entering tanks and vessels where possible. This can be very high-risk work. If required, get specialist help to ensure adequate precautions are taken.
- ✓ Cleaning and checking vessels containing toxic materials before work starts.

Dos and don’ts of plant and equipment maintenance

Do...

- ✓ ensure maintenance is carried out by a competent person (someone who has the necessary skills, knowledge and experience to do the work safely);
- ✓ maintain plant and equipment regularly – use the manufacturer’s maintenance instructions as a guide, particularly if there are safety-critical features;
- ✓ have a procedure that allows workers to report damaged or faulty equipment;
- ✓ provide the proper tools for the maintenance person;
- ✓ schedule maintenance to minimise the risk to other workers and the maintenance person wherever possible;
- ✓ make sure maintenance is done safely, that machines and moving parts are isolated or locked and that flammable/explosive/toxic materials are dealt with properly.

Don't...

- ✓ ignore maintenance;
- ✓ ignore reports of damaged or unsafe equipment;
- ✓ use faulty or damaged equipment.

Safe lifting by machine

If the employer provides lifting equipment for use at work, or if they have control of the use of lifting equipment, they must make sure it is safe.

Employers should think about what risks there may be and how they can be managed, for example:

- ✓ damage or deterioration of the equipment caused by wet, abrasive or corrosive environments;
- ✓ trying to move weights that are too heavy and exceed the load limit of the machine;
- ✓ equipment failure;
- ✓ untrained workers planning the lift or using the equipment;
- ✓ people being struck by moving parts of the machinery or by things falling.

Safe lifting needs to be properly planned by a competent person, appropriately supervised and carried out safely. Any equipment used must have been properly designed, manufactured and tested. Not forgetting the need to maintain it properly.

Factors that should be considered

- ✓ What is being lifted?
- ✓ How heavy is it?
- ✓ Where is its centre of gravity?
- ✓ How will it be attached to the lifting machinery?
- ✓ Who is in control of the lift?
- ✓ What are the safe limits of the equipment?
- ✓ Could the lift be rehearsed if necessary?

Dos and don'ts when using lifting machinery

Do...

- ✓ use only certified lifting equipment, marked with its safe working load, which has been regularly examined to ensure it is fit for purpose;
- ✓ keep the reports of any examinations as well as any declarations of conformity or test certificates;
- ✓ make sure the load is properly attached to the lifting equipment. If necessary, securely bind the load to prevent it slipping or falling off;
- ✓ before lifting an unbalanced load, find out its centre of gravity. Raise it a few inches off the ground and pause – there should be little harm if it drops;

- ✓ use packaging to prevent sharp edges of the load from damaging slings and do not allow tackle to be damaged by being dropped, dragged from under loads or subjected to sudden loads;
- ✓ when using jib cranes, make sure any indicators for safe loads are working properly and set correctly for the job and the way the machine is configured;
- ✓ use outriggers where necessary;
- ✓ when using multi-slings, make sure the sling angle is taken into account;
- ✓ have a responsible slinger or banksman and use a recognized signalling system.

Don't...

- ✓ use unsuitable equipment, e.g. makeshift, damaged, badly worn chains shortened with knots, kinked or twisted wire ropes, frayed or rotted fibre ropes;
- ✓ exceed the safe working load of machinery or accessories like chains, slings and grabs. Remember that the load in the legs of a sling increases as the angle between the legs increases;
- ✓ lift a load if you doubt its weight or the adequacy of the equipment.

ISOLATE AND DE-ISOLATE PLANT

The risks associated with any plant or equipment undergoing inspection, maintenance, cleaning, repair or construction should be assessed and appropriate control measures put in place.

Before work commences the plant should be stopped, appropriately isolated/locked and danger tagged, and any stored energy should be dissipated.

Examples of energy sources include electricity, hydraulic pressure, compressed air or gas, gravity, kinetic spring tension and moving parts.

Separate controls away from the plant operator or immediate work area must also be isolated or locked and danger tagged.

Isolation Procedures

An isolation procedure is a set of predetermined steps that should be followed when workers are required to perform tasks such as inspection, maintenance, cleaning, repair and construction.

The aim of an isolation procedure is to:

- ✓ isolate all forms of potentially hazardous energy to ensure that an accidental release of hazardous energy does not occur
- ✓ control all other hazards to those doing the work
- ✓ ensure that entry to a restricted area is tightly controlled.

The following lock-out process is the most effective isolation procedure:

- ✓ shut down the machinery and equipment
- ✓ identify all energy sources and other hazards
- ✓ identify all isolation points
- ✓ isolate all energy sources
  - ✓ in the case of electrical equipment ‘whole current isolation’, such as the main isolator, should be used instead of ‘control isolation’ by way of the stop button on a control panel
- ✓ control or de-energise all stored energy
- ✓ lock-out all isolation points, using padlocks, multi- padlock hasps and danger tags
- ✓ 'danger tag' machinery controls, energy sources and other hazards.

Test that the isolation is effective by 'trying' to reactivate the plant without exposing the tester or others to risk. Failure to reactivate the plant means that the isolation procedure is effective and that all stored energies have dissipated.

This may require further measures to safely release these energies e.g. hydraulic or pneumatic pressure, suspended weight or compressed springs.

Locks and danger tags

Every person working on isolated equipment should fit their own lock and/or danger tag. Alternatively, another management approved system that achieves an equivalent level of safety may be used.

When using locks or danger tags, consider the following:

- ✓ tags should be dated and signed
- ✓ locks should be accompanied by a corresponding tag to identify who has locked out the plant
- ✓ tags and locks should only be removed by the person who applied them or by the supervisor after consultation with the signatory of the danger tag. In the event
- ✓ that the person who applied the danger tag is unavailable, their tag or lock may only be removed in accordance with a management approved procedure
- ✓ danger Tags and/or locks should be fitted to all isolation points.

Out-of-service tags

Out-of-service tags are used to identify equipment or machinery that has been taken out of service due to a fault, damage malfunction.

or

The out-of-service tag is to be securely fixed to the operating control power isolator with the appropriate details completed on the tag (explaining the reason for the machine being 'out of service').

The out-of-service tag should not be removed until the equipment is safe to be returned to service, or the reason for the out-of-service tag no longer exists.
The out-of-service tag may be removed by:

- ✓ the person who attached it
- ✓ the supervisor responsible for the operation or repair of the equipment
- ✓ the maintenance person who carried out the repairs.

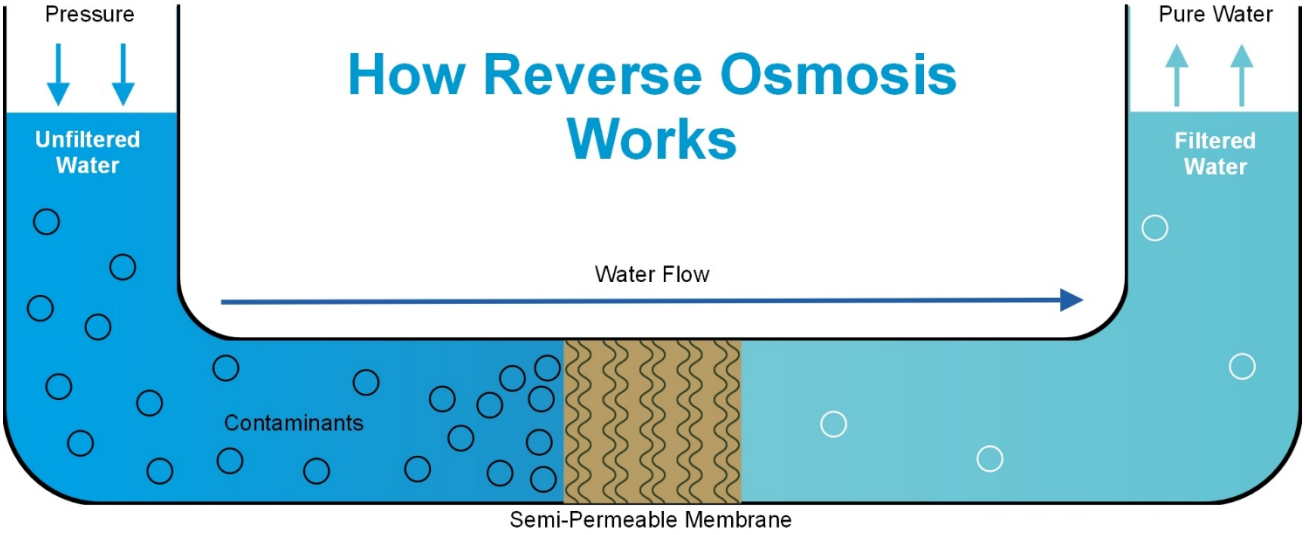
UNIT 12

OPERATE AND MAINTAIN WATER TREATMENT PLANT

This unit of competency covers the skills and knowledge required to operate Water Treatment Plant and distribution system. This unit of competency applies to operators who are required to start up and shut down the equipment, monitor and adjust process parameters, and identify operational problems and take appropriate action.

Reverse Osmosis Plants/RO Plants

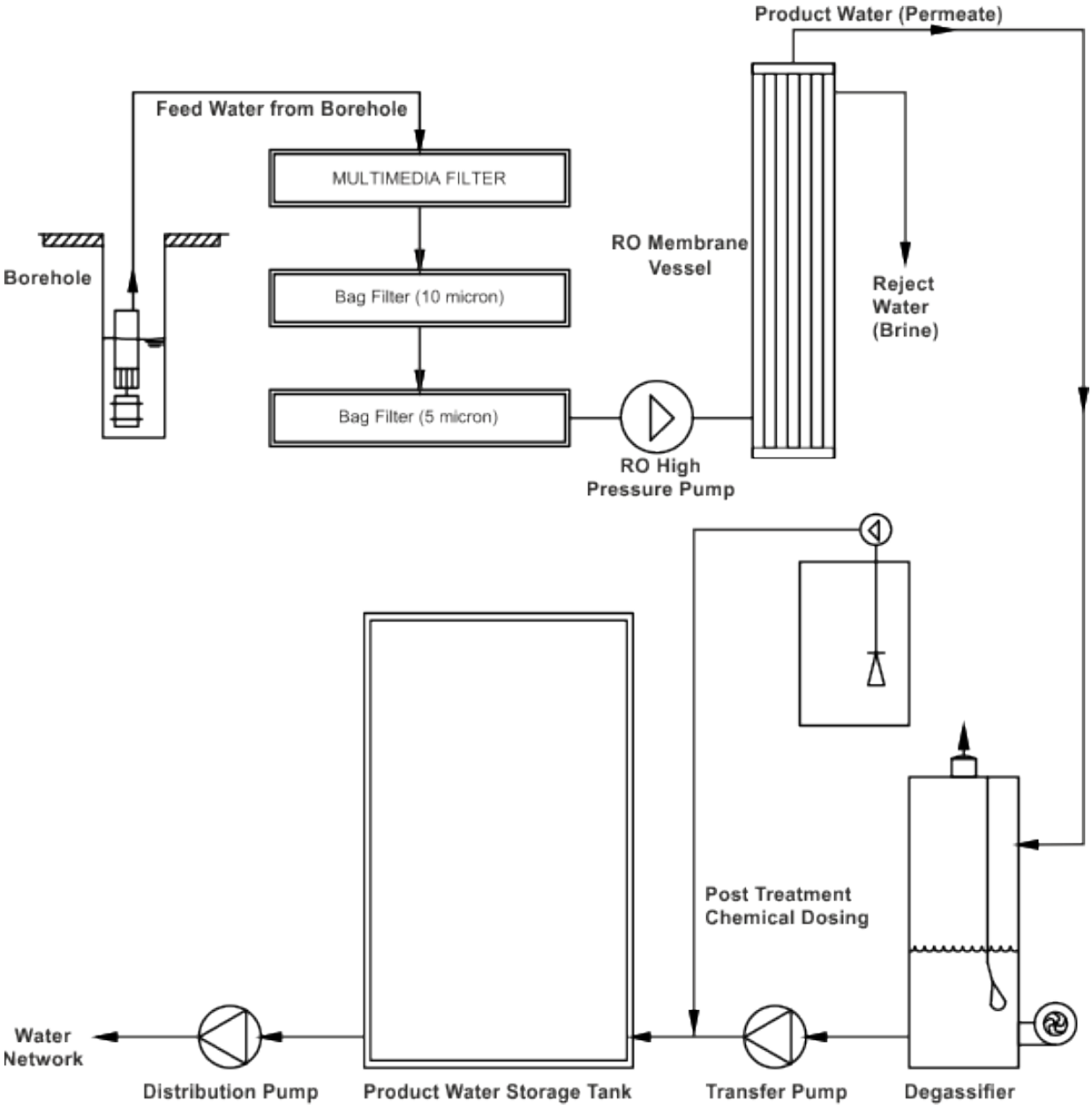
Reverse osmosis is the process of forcing a solvent from a region of high solute concentration through a membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure. This is the reverse of the normal osmosis process, which is the natural movement of solvent from an area of low solute concentration, through a membrane, to an area of high solute concentration when no external pressure is applied. The membrane here is semipermeable, meaning it allows the passage of solvent but not of solute.



To illustrate, imagine a semi permeable membrane with fresh water on one side and a concentrated aqueous solution on the other side. If normal osmosis takes place, the fresh water will cross the membrane to dilute the concentrated solution. In reverse osmosis, pressure is exerted on the side with the concentrated solution to force the water molecules across the membrane to the fresh water side.

The membranes used for reverse osmosis systems have a dense polymer barrier layer in which separation takes place. Since Reverse Osmosis does not occur naturally, it must be created by applying pressure to the high solids water in order to force it through the membrane, with pressures from 8 - 14 bar for fresh and brackish water, and 40 - 70 bar for seawater, which has around 24 bar (350 psi) natural osmotic pressure which must be overcome.

Design Considerations for RO Plant



Fluid Systems RO Plants work on the Crossflow Filtration method, which takes the feed water and uses a percentage of it as a wash or reject stream, removing the solids during the filtration process.

The product flow of an RO Plant is mainly a function of temperature and pressure. System recovery (product divided by feed) is limited by the characteristics of the feed water and can be controlled through the use of recycle stream. Product quality is based on a percentage of dissolved solids fed to the membrane. There should be an economic balance between product quality and system recovery. High recoveries increase concentration of dissolved solids in the system which degrades quality, but high recoveries make the system work more efficiently and decrease waste.

Reverse Osmosis Plants do not deliver to service all of the water that is fed to them. During

operation, some of the incoming water is used to wash down the membrane, and only part becomes finished product water. Purified water is referred to as product and wastewater is referred to as concentrate, or reject. The percent of water delivered as product is called the recovery, and depends upon the membrane and on total RO Plant design considerations.

Pretreatment – Reverse Osmosis Plants

The feed water, depending on its source, may contain various concentrations of suspended solids and dissolved matter. Suspended solids may consist of inorganic particles, colloidal particles and biological impurities such as microorganisms and algae. Dissolved matter may consist of highly soluble salts, such as chlorides, and sparingly soluble salts, such as carbonates, sulfates, and silica.

During the Reverse Osmosis process, the volume of feed water decreases, and the concentration of suspended particles and dissolved ions increases. Suspended particles may settle on the membrane surface, thus blocking feed channels and increasing pressure drop across the system. Sparingly soluble salts may precipitate from the concentrate stream, create scale on the membrane surface, and result in lower water permeability through the RO membranes. This process of formation of a deposited layer on a membrane surface is called membrane fouling and results in performance decline of the RO system. The objective of the feed water pretreatment process is to improve the quality of the feed water to the level which would result in reliable operation of the RO membranes. Based on the raw water quality, the pretreatment process for RO Plants may consist of all or some of the following treatment steps:

- ✓ Clarification followed by Sand Filtration for Turbidity removal
- ✓ Water disinfection with chlorine
- ✓ Hardness reduction by Softening
- ✓ Addition of scale inhibitor
- ✓ Reduction of free chlorine using sodium bisulfite/ Activated carbon filters
- ✓ Final removal of suspended particles using cartridge filters

Industrial Reverse Osmosis Plants/ Industrial RO Systems

Industrial Reverse Osmosis Plants are carefully customized and configured to suit the individual requirement of the output water, which varies from normal drinking application to the specific usage, such as food processing, pharmaceuticals and boiler feeding requirement.

These systems are custom built based on the following components; come standard with pre-filters, chemical dosing and Antiscalant dosing. Customization is available on all our units based on individual water application and customer needs.

- ✓ Pre-filtration
- ✓ Chemical dosing
- ✓ Anti scalant dosing
- ✓ 4" & 8" TFC spiral wound membranes

- ✓ FRP membrane housings
- ✓ Epoxy painted steel frame
- ✓ SS High Pressure Piping
- ✓ Stainless steel High Pressure Multi-stage pumps
- ✓ 20- & 5-micron cartridge filter
- ✓ Low- & High-pressure switches
- ✓ Glycerin filled pressure gauges
- ✓ Permeate & concentrate flow meters
- ✓ PLC/Microprocessor based Controllers
- ✓ Outlet Conductivity meter
- ✓ Product water flow rates (1m^3/hour to 100m^3/hour and above)

Commercial RO Systems / Institutional RO Systems

Commercial RO usually comes in standard models. Commercial RO Systems can be customized to add Multimedia Filters & Activated carbon Filters, Water softeners, Antiscalant Dosing Systems, and UV sterilizers.

These systems are used to purify water and remove salts and other impurities. It is also capable of rejecting bacteria. The Main features of these RO Plants are

- ✓ Powder coated frame
- ✓ 20 & 5 micron sediment pre-filter
- ✓ Stainless Steel Multistage High pressure pump
- ✓ FRP pressure vessel
- ✓ Product and Reject Flow Meters
- ✓ Low- & High-pressure switch
- ✓ High rejection TFC membranes
- ✓ Heavy-duty high-pressure tubing

Commercial/Institutional RO Systems are available in following Flow Ranges:

- ✓ 50 LPH RO Plants
- ✓ 100 LPH RO Plants
- ✓ 200 LPH RO Plants
- ✓ 500 LPH RO Plants
- ✓ 750 LPH RO Plants

Containerized RO Plants

Containerized Reverse Osmosis Plants / Containerized Desalination

Plants/Containerized Ultra Filtration Plants Fluid Systems supplies a host of water treatment in a containerized version. From ultra-filtration to brackish water plants to Desalination Plants. Fluid Systems provides an affordable, plug-and-play desalination solution that can be commissioned in a short period..

The Plant is housed in a standard 20 or 40 ft container. The Plant comes with pre-piped and pre-cabled connections [plug and play]. Remote Monitoring Option also available with GSM connectivity Benefits of Fluid Systems Containerized Plants

- ✓ Plug and Play Unit
- ✓ Minimum civil construction required
- ✓ Small footprint
- ✓ High quality components
- ✓ High recovery
- ✓ High TDS Rejection
- ✓ Easy Spare parts availability as standard Components are used
- ✓ Modular in design
- ✓ Low energy and chemical consumption
- ✓ Quick Installation
- ✓ -

Mineral Water Plants/Packaged Drinking Water Plants

As people become more health conscious, the demand for bottled water is increasing at a rapid rate. Bottled water provides easy transportability and assured water quality.

Typically a Packaged Drinking water Plant may consist of:

- ✓ Water Treatment Plant
- ✓ Packaging Plant

Pressure Sand Filter

Raw Water is first filtered by filtration unit in series prior to feeding the RO Plant. Pressure Sand Filter unit is provided for removal of Suspended Matters & Turbidity from raw water.

Activated Carbon Filter

Basic Natural water may contain Colour, Odour, Chlorine & Organics in different proportion, which is undesirable for potable application, and hence, it is necessary to remove the same from water. The Activated Carbon Filter removes Chlorine, Odour, & Colour, Pesticides, Organics and In organics Impurities while passing the water through Carbon Bed.

Smbs Dosing System

The Chlorinated water may oxidize the membrane and to avoid the same precautionary we provide Sodium Meta BiSulphite dosing system

Antiscalant Dosing

The hardness salts of Calcium & Magnesium are likely to be precipitated if concentration exceeds its solubility limit & it may faults the membranes resulting into scaling which ultimately leads to poor treated water quality from RO System. To prevent this Antiscalant dosing (scale inhibitor) dosing system is provided.

Micron Cartridge Filter / Bag Filter

These filters range from 20 Micron, 10 Micron, 5 Micron, 1 Micron, 0.45 Micron & 0.2 Micron Cartridge. These are consumables and should be replaced after a given period of operation. This for Extra Safety of Product water as it comes through series of filtration and there are some chances of slippages of particles, which can be arrested through the Cartridges

High Pressure Pump

For Reverse Osmosis Process to take place feed pressure of water need to be raised. For this purpose a Vertical Multistage Centrifugal High Pressure Pump in S.S construction is provided R.O. System requires operating pressure of about 14-16 kg/cm^2 . High-pressure pump is fitted with S.S. discharge pipe work with necessary control valves. Necessary instruments like a High Pressure Switch, Pressure Gauge and re-circulation valves are provided for safer operation of system.

Reverse Osmosis System

Reverse Osmosis System rejects 97 – 99 % of total dissolved solids by the principle of `Osmosis'. This system consists of a R.O. Module assembly mounted on Structural Skid. High pressure rating FRP Pressure Vessel (Pressure Tubes) are fitted on the skid which houses spirally wound membrane elements in series.

In RO System feed soften water is divided into two streams viz Product & Reject water. Product water is treated water having lesser TDS. Reject water is highly concentrated water, which is not to be used for any purpose but drained. Followed Filtered water at elevated pressure is first feed to Pressure Vessel; treated water is collected in center core tube. Treated water from each membrane is collected jointly in a common product water storage tank and reject is drained.

For safe operation of system following instruments are provided on the Panel.

- ✓ Feed & Reject Pressure Gauge: to indicate respective pressure of R.O.System.
- ✓ Feed & Reject Flow Indicator: to indicate respective flow of R.O.System.
- ✓ T.D.S Meter: to measure TDS of Raw & Treated water.
- ✓ High Pressure Switch: for tripping HPP in case of excessive feed pressure
- ✓ Time Totaliser: for counting working hours of H.P Pump/ R.O.System.

Product Water Storage Tank

Treated water from R.O. System are collected in S.S. constructed storage tank of appropriate capacity. The tank is fitted with S.S. pipe work & isolation valves and suitable type of level indicator.

Absolute Micron Cartridge Filters: (Mcf) - Removing the Micro Biological Growth

During storage, atmospheric or any other contamination may take place in treated water. Hence, after passing water from R.O. System & after Storage, water is once again passed through a micron cartridge filters. This is a S.S.316 Vessel, internally Electro polished fitted

with internally with P.P Pleated micron cartridge elements having absolute ratings of 1.0 micron & 0.2 microns which removes all bacterial impurities present in the water and make the water free of particulates.

Ultra Violet Sterilizer

With follow treatments treated water is free from all the micro-biological impurities like Bacteria, Virus, etc. it may redevelop again in water during prolonged storage. For dis-infection of water is essential for Reverse Osmosis Application before Filling & Sealing in bottle. Hence, a online Ultra Violet Sterilizer is require for disinfections of Treated water before filling in pre-cleaned PET Bottles. The water to be disinfected, is passed through U.V.System, which consists of U.V.Tubes which radiates high intensity Ultra Violet Rays, which in turn kills the micro organisms. This systems consists of a S.S finished surface housing with Ultraviolet Lamps fitted in it. The water to be treated is surroundings this tubes during treatment. An electrical system is provided for production of high voltage required for U.V.Rays generation and Operating Life of U.V.Lamps.

Operate system according to procedure

According to Sullivan in 2010, "Operations and Maintenance are the decisions and actions regarding the control and upkeep of property and equipment." Operations are the activities to make sure the plant produces the desired quality and quantity of treated water and meets the current legislation, while maintenance are the activities to make sure the plant equipment continues to work efficiently to achieve the operational objectives.

Water and wastewater treatment plants are no longer traditional plants; monitoring is not just taste, odor, iron and manganese; water treatment facilities are more complex now a days, new technologies have emerged, raw water is more difficult to treat, the treatment requires more innovative solutions, there is an increasing demand for services, diminishing resources, rising service expectations of customers and increasingly stringent regulatory requirements. This all leads to analyzing and enhancing the way we look at operation and maintenance in the water and wastewater industry and the treatment facilities that should be developed and expanded to accommodate these dramatic changes.

Another reason is the growing trend in outsourcing the operation and maintenance of water and wastewater treatment plants. O&M is outsourced for the main following reasons:

- ✓ You are better
- ✓ You are less expensive
- ✓ The client can transfer operational headache (risk) to you, allowing them to focus on their core business

There are many books and articles talking about operation and maintenance and some are talking about the water treatment plant operation, but it seems that we are missing that

comprehensive approach between them to successful operation and maintenance. This article will provide a comprehensive approach on the 'O' and the 'M' in the operation and maintenance of water and wastewater treatment plants.

The operation and maintenance of water and wastewater plants has been generally been broken up in to five main critical elements; operation, maintenance, engineering, training and administration – also known as OMETA .

The new approach is broken down to eight critical elements; WH&S plan, Scope of service, Operation plan, asset and maintenance plan, people, analytical protocols, communication and reporting, and administration.

The main objective of all elements is to support the effectiveness of the fundamental core element; operation and maintenance.

All of these elements should be well defined before starting an implementation process and analyze should be undertaken as to how these elements are linked to form a sound program structure. However the link is very obvious – O&M work together. These elements are analyzed below.

1. WH&S Plan

This is primarily a communication tool between the company and its employees, customer and contractors, to ensure that relevant site information is regularly updated between all parties and that safety is monitored, recorded and acted upon.

Benefits (why it matters):

- ✓ Protect people and equipment
- ✓ Reduce downtime and absenteeism
- ✓ Legal compliance
- ✓ Increase the skills and awareness of safety to all involved

Suggested components of WH&S plan:

A WH&S plan should include but not be limited to the following:

- ✓ Site Safety Manual;
- ✓ Safety Training;
- ✓ Safety Audits;
- ✓ Housekeeping Audits;
- ✓ Safety Meetings;
- ✓ Safety Reports (Near miss, incidents, observation, etc.);
- ✓ Customer Specific Requirements;
- ✓ Work permits;
- ✓ Safety procedures (Lock-Out Tag-Out "LOTO", confined space, working at heights, etc.);
- ✓ Statement of responsibilities;

- ✓ Incident Management;
- ✓ Site Safety Rules; and
- ✓ Identifying and managing risk.

2. Scope of Service

This primarily defines what, when and where work will happen, supply responsibilities and liability for deliverables.

Benefits (why it matters):

- ✓ Clearly define deliverables to the team
- ✓ Base for O&M planning
- ✓ Inputs and outputs are clearly defined and executed to delight customers

The scope of service is usually extracted from the operation and maintenance contract; it defines the main objectives of the O&M service provided to the internal or external customers.

The scope of service should include the following as a minimum:

- ✓ Take Of Points (TOPs) – these are the points where the scope of service starts and ends;
- ✓ The raw water quality or influent window/s;
- ✓ The treated water quality limits and KPI's;
- ✓ Reporting requirements both internal, external and regulatory;
- ✓ Legislation and regulatory requirements;
- ✓ Services Performed;
- ✓ Maintenance Performed;
- ✓ Overall Key Performance Indicators;
- ✓ Liabilities;
- ✓ HR requirements;
- ✓ Billing details;
- ✓ Contacts list; and
- ✓ Organisational charts & responsibilities.

3. Operations Plan

This is the primary main operational objective which is to make sure the plant is operating in producing the design quality and quantity efficiently and consistently.

Benefits (why it matters):

- ✓ Enhance tracking and decision making and control of KPIs;
- ✓ Provide optimal operating efficiency;
- ✓ Reduce waste;
- ✓ Support proactive operation;
- ✓ Support continuous process improvement and optimization; and
- ✓ Reduce operating errors

The operations plan should include but not be limited to the following:

- ✓ Operating Schedules;
- ✓ Operating KPIs;
- ✓ Data collection and monitoring;
- ✓ Responses with corrective actions;
- ✓ Standard Operating Procedures (SOP);
- ✓ Work Instructions;
- ✓ Checklists / Task Lists;
- ✓ Operator Logs;
- ✓ Product / Process Change Processes;
- ✓ Chemical details (dosage, preparation, storage and inventory);
- ✓ Process balance sheets;
- ✓ Operation Sequence Charts (OSC); and
- ✓ System settings & alarms list.

Once operating quantifiable parameters such as pressure, pressure drop, flow, temperature, pH level, turbidity and visual checks are properly defined, they are considered indicators that a control device is functioning as designed in accordance with the Operation Plan. Operating limits for each parameter may initially be suggested by the equipment manufacturer but may later be modified by the facility based on experience or operation during a performance test and operation of the plant.

Data collection is only one part of plant and equipment operational monitoring. Cumulative data collected should be used to produce beneficial information, represent key performance indicators and further enhance the defined operating parameters.

Proactive operation schedules include seasonal changes, shutdown periods, peak demand, low consumption periods, water quality changes and public holidays are all important factors to monitor and manage to increase overall plant efficiency. A response plan should be developed to deal with such different occasions and adjust the plant until the team gains more experience with such future proactive operation instances.

Important factors about data logging:

- ✓ When and what data is collected;
- ✓ How often it is collected depends on the criticality of the process;
- ✓ Using online or manually collected data;
- ✓ Transferring data into information summarized by KPIs;
- ✓ Using the information to control and correct deviations; and
- ✓ Consult with the equipment manufacturer.

4. Asset & Maintenance Plan

The asset and maintenance plan is primarily the processes and structure to ensure that equipment continues to deliver maximum value throughout its expected life and at the lowest cost.

Benefits (why it matters):

- ✓ Protect asset value;
- ✓ Reduce down times;
- ✓ Reduce breakdowns;
- ✓ Increase operational performances;
- ✓ Increase resource utilisation; and
- ✓ Improve profit and profitability

Maintenance items can include; inspections, cleanings, lubrications, adjustments, replacements and calibrations. Maintenance procedures may initially be suggested by the equipment manufacturer but may later be modified by the facility based upon experience.

Other important elements in the maintenance plan are:

- ✓ Asset list which includes; asset name, description, asset number, location, criticality, condition, usefulness and value. The asset list will give the operator an understanding of the physical asset capability to meet the stakeholder's expectations and regulatory requirements;
- ✓ Implementing maintenance best practices such as; 5S, Failure Mode Effect Analysis (FMEA) or Root Cause Analysis (RCA);
- ✓ Proactive maintenance programs, especially for critical equipment;
- ✓ Preventive maintenance programs which can include; cleaning, calibration, oil change, greasing and replacing consumables;
- ✓ Critical spare parts list included items such as; correct quality, correct quantity, correct time, correct cost and correct supplier;
- ✓ Tracked Work Orders;
- ✓ Useful maintenance software such as 'CMMS' or even a similar style maintenance spreadsheet;
- ✓ Tools list and the inclusion of some tools for proactive maintenance; and
- ✓ Spare parts inventory

5. People

This primarily includes managing employees and contractors.

Benefits (why it matters)

- ✓ Right person, in the right place;
- ✓ Continuous people development based on requirement; and
- ✓ Increase employee's satisfaction

Important items to address in managing people include:

- ✓ Training based on skills matrix and training matrix;
- ✓ On Job Training (OJT);
- ✓ On Boarding and induction;
- ✓ Communication;
- ✓ Selection Process;
- ✓ Performance reviews;
- ✓ Job Description and responsibilities; and

- ✓ Recognition and motivation.

6. Analytical Protocols

This is primarily defined as the quality monitoring of process efficiency.

Benefits (why it matters)

- ✓ Optimizes processes and chemical dosing
- ✓ Supporting decision making to control KPI's
- ✓ Proactive actions
- ✓ Regulatory requirements
- ✓ Reporting basis

In addition to the quality monitoring, the analytical protocol should also include the response plan to any deviation from control limit/s.

7. Communication and Reporting

This is primarily addressed as the communication of KPIs to the stakeholders and regulators.

Benefits (why it matters)

- ✓ Forms basis for measurable business value
- ✓ Provides mutual agreement of value delivered
- ✓ Allows tracking and implementation of Best Standard Operation procedures
- ✓ Fulfilling regulatory requirements
- ✓ Identifies opportunities for improvement and expansion

Reporting may include:

- ✓ KPI Communication;
- ✓ Operational Activities;
- ✓ Maintenance Activities;
- ✓ Safety Compliance;
- ✓ Non-Conformance Actions;
- ✓ Profit and Loss "P&L"; and
- ✓ Improvement of projects capital output.

8. Administration

Administration are all the supporting activities to main structure of O&M, this include:

- ✓ Procurement
- ✓ Contracts management
- ✓ Budgeting
- ✓ Book keeping
- ✓ Public communication

Benefits (why it matters)

- ✓ Effective management

- ✓ Control of KPIs
- ✓ Support meting regulatory and contractual requirement
- ✓ Better public awareness
- ✓ Provide a documents repository

Key Success Factors to the 'O' and the 'M' in Operation and Maintenance

1. The size and complexity of the plan should match the size and complexity of the plan;
2. Know your team skills and capabilities for effective resource utilization and understanding of training needs;
3. Develop clear key performance indicators and metrics to measure cost and progress;
4. Obtain senior management support and engagement;
5. Program sponsor with authority to change;
6. People, process, then equipment;
7. Balance quick wins with continuous improvement;
8. Focus on the trouble areas;
9. Engage people with trust and respect; and
10. Update stakeholders continuously on the progress

Operating in Shifts

Good communication between teams working on plants is an important contributor to safety.

When a team hands over responsibility to another (as takes place during shift handover) there is always the possibility of an important detail being overlooked.
The handover process relies on good communication to ensure continuity. Any weakness in this communication can introduce safety risk. The result might be a serious accident that could have been avoided.

Shift handover

Changing shifts is a requirement in any continuous process. While plants can operate 24X7, people need to take breaks. Shift handover should be regarded as a high-risk process because it cannot be automated and relies on human behavior. The goal of the handover process is to maintain continuity and the formal transfer of responsibility and accountability between the respective parties.

Work that takes place across shifts

A shift roster is typically set up in advance to accommodate the need for people to work to a schedule. Shift changeover times are planned in advance. The reality of day to day operations is that certain tasks like critical repairs, or unloading bulk raw materials happen on their own time scale. These tasks, sometimes involving different teams can take place during two or more shifts. Other, bigger tasks such as a major repair might take place over days, weeks or even months.

Shift handover procedure

To ensure continuity and minimize errors, a standard procedure is implemented for shift handover. Each company will develop their own procedure in line with their operational requirements. In practice we have observed that there is little standardization of these handover procedures between companies, and while some follow a very rigorous and defined process, others merely rely on individuals to communicate effectively.

Risks associated with shift handover

Considering that a typical shift is either 8 or 12 hours long, changeover happens 1095 or 730 times during the year, in other words there are 730 or 1095 high risk opportunities for miscommunication leading to safety incidents. Making sure that the changeover process itself is defined and managed properly is a priority area to focus on when looking for ways to improve safety on the plant.

Several studies into shift handover have been done to better understand ways to improve the procedures. One such HSE study analysed a number of incidents involving planned maintenance work and found that the following shift handover related risks were contributing factors to accidents and fatalities:

- ✓ In some of the incidents, planned maintenance work continued over a shift change.
- ✓ Thorough [coordination and] communication of such work should be afforded a very high priority.
- ✓ Operator support [logs] were not designed to capture key information reliably and unambiguously.
- ✓ A lack of procedures which specified how to conduct an effective shift handover was evident.
- ✓ Inaccurate and unreliable carry-forward of written information from shift to shift was evident. For example, reference to a temporary safety system over-ride was not carried forward.

The permit to work and shift handover

In typical industrial environments the permit to work makes sure that communication takes place between all people involved in dangerous, non-routine tasks on the plant.

So, what should happen to these permits at shift handover?
Two approaches are possible:

- ✓ The permit is closed off and a new permit issued by the incoming shift for the work to continue.
- ✓ A shift handover procedure is implemented that ensures that responsibility is transferred from the outgoing to the incoming persons on the permit document itself.

The first approach takes more time but forces a fresh review of the job and helps ensure that communication takes place. The second approach is more streamlined but runs the risk that something important has changed that is not adequately interrogated by the responsible persons at changeover.

In practice there is often confusion as to which of the two approaches is best within a single company, and the procedures also differ between industries. Unsurprisingly for example, in the nuclear industry a much more structured handover process is followed than for example in chemicals manufacturing.

The HSE study [1] also found an interesting disconnect. In a survey of chemicals plant personnel, the majority of fitters and superintendents were of the view that a new permit should be issued at changeover, while the majority of managers believed that the work should carry on using the same permit. This lack of alignment should be of concern as it seems as there is scope for confusion.

What constitutes a good shift handover procedure?

A good shift changeover procedure should be based on the following design principles:

- ✓ Formal written communication around each handover should be documented in a simple, secure, structured logbook, ideally electronic.
- ✓ Information between shifts should also communicate the “why” and not just the “what”.
- ✓ Information between shifts should be communicated between experienced competent persons who understand the process and work being done.

- ✓ Relevant information should be highly visible to all affected – e.g. displays around the plant, mobile devices, etc.
- ✓ Relevant focused shift and safety information should be easily shared.
- ✓ The handover process should always be aligned to the short and medium-term production goals and targets and these need to be visible.
- ✓ Coordination and linking of all the other relevant processes underway – such as any open permits, isolations and so on. The information should ideally be in a common system or database.
- ✓ Face to face communication between role-players.
- ✓ Catering for regular handover and / or production meetings that result in tasks being assigned, followed up and shared in a management system.
- ✓ Support for continuous training and audit of the processes.

Where to start?

During a review or implementation of a new shift handover process it is suggested that you first analyse the existing procedures to see what steps can be improved, and not necessarily just transcribe "what has always been done" into a new computer-based system. These procedures might include:

- ✓ Permit to work
- ✓ Isolation management
- ✓ Shift handover
- ✓ Production meetings

- ✓ Maintenance
- ✓ Routine and non-routine operations that take place over shifts
- ✓ Shift roster management
- ✓ And so on…

In this early phase of the project you would work closely with the supplier of the software to understand the capabilities of the system and help you map your existing processes to the new system. This process mapping exercise will often identify gaps and opportunities which will greatly enhance operational effectiveness and safety.

Machinery, plant and equipment

This section covers the different safety aspects of using machinery and maintaining plant and equipment in the workplace. Employers should consider how their workers use machinery, and have adequate maintenance arrangements in place to ensure it remains safe to use.

There is also specific advice on lifting equipment and carrying out vehicle repairs.

Case study

A company were prosecuted after a worker was killed when he was crushed in the rollers of a rubber and cloth inspection machine.

Other workers heard him cry out and he was found with his left arm, shoulder, head and torso trapped between the rubberised blanket and the roller. He was pronounced dead at the scene.

What caused the accident?

The company had not assessed the risks associated with using the machine. They had not checked that it was safe to use following modifications when the nip guards were removed and an unguarded roller was inserted.

Why is machinery safety important?

Moving machinery can cause injuries in many ways:

- ✓ People can be struck and injured by moving parts of machinery or ejected material. Parts of the body can also be drawn in or trapped between rollers, belts and pulley drives.
- ✓ Sharp edges can cause cuts and severing injuries, sharp-pointed parts can cause stabbing or puncture the skin, and rough surface parts can cause friction or abrasion.

- ✓ People can be crushed, both between parts moving together or towards a fixed part of the machine, wall or other object, and two parts moving past one another can cause shearing.
- ✓ Parts of the machine, materials and emissions (such as steam or water) can be hot or cold enough to cause burns or scalds, and electricity can cause electrical shock and burns.
- ✓ Injuries can also occur due to machinery becoming unreliable and developing faults or when machines are used improperly through inexperience or lack of training.

What should employers do?

Before they start

Before they start using any machine they need to think about what risks may occur and how these can be managed. They should therefore do the following:

- ✓ Check that the machine is complete, with all safeguards fitted, and free from defects. The term 'safeguarding' includes guards, interlocks, two-hand controls, light guards, pressure-sensitive mats etc. National legislation often requires the supplier to provide the right safeguards and inform buyers of any risks ('residual risks') that users need to be aware of and manage because they could not be designed out.
- ✓ Produce a safe system of work for using and maintaining the machine. Maintenance may require the inspection of critical features where deterioration would cause a risk. They should also look at the residual risks identified by the manufacturer in the information/instructions provided with the machine and make sure they are included in the safe system of work.
- ✓ Ensure every static machine has been installed properly and is stable (usually fixed down).
- ✓ Choose the right machine for the job and do not put machines where customers or visitors may be exposed to risk.

Make sure the machine is:

- ✓ Safe for any work that has to be done when setting up, during normal use, when clearing blockages, when carrying out repairs for breakdowns, and during planned maintenance;
- ✓ Properly switched off, isolated or locked off before taking any action to remove blockages, clean or adjust the machine;

Also, make sure they identify and deal with the risks from:

- ✓ Electrical, hydraulic or pneumatic power supplies;
- ✓ Badly designed safeguards. These may be inconvenient to use or easily overridden, which could encourage their workers to risk injury and break the law. If this is happening employers should find out why workers are doing it and take appropriate action to deal with the reasons/causes.

Preventing access to dangerous parts

Employers should think about how they can make a machine safe. The measures they use to prevent access to dangerous parts should be in the following order. In some cases it may be necessary to use a combination of these measures:

- ✓ Use fixed guards (e.g. secured with screws or nuts and bolts) to enclose the dangerous parts, whenever practical. Use the best material for these guards – plastic may be easy to see through but may easily be damaged. Where you use wire mesh or similar materials, make sure the holes are not large enough to allow access to moving parts.
- ✓ If fixed guards are not practical, they should use other methods, e.g. interlock the guard so that the machine cannot start before the guard is closed and cannot be opened while the machine is still moving. In some cases, trip systems such as photoelectric devices, pressure-sensitive mats or automatic guards may be used if other guards are not practical.
- ✓ Where guards cannot give full protection, use jigs, holders, push sticks etc. if it is practical to do so.
- ✓ Employers should control any remaining risk by providing the worker/operator with the necessary information, instruction, training, supervision and appropriate safety equipment.

Other things employers should also consider

- ✓ If machines are controlled by programmable electronic systems, changes to any programmes should be carried out by a competent person (someone who has the necessary skills, knowledge and experience to carry out the work safely). It is good practice if employers' keep a record of such changes and check to ensure they have been made properly.
- ✓ Ensure control switches are clearly marked to show what they do.
- ✓ Have emergency stop controls where necessary, e.g. mushroom-head push buttons within easy reach.
- ✓ Make sure operating controls are designed and placed to avoid accidental operation and injury, use two-hand controls where necessary and shroud start buttons and pedals.
- ✓ Don't let unauthorized, unqualified or untrained people use machinery – never allow children to operate or help at machines. Some workers, e.g. new starters, young people or those with disabilities, may be particularly at risk and need instruction, training and supervision.
- ✓ Adequate training should ensure that those who use the machine are competent to use it safely. This includes ensuring they have the correct skills, knowledge and experience – sometimes formal qualifications may be needed.
- ✓ Supervisors must also be properly trained and competent to be effective. They may need extra specific training and there are recognized courses for supervisors.
- ✓ Ensure the work area around the machine is kept clean and tidy, free from obstructions or slips and trips hazards, and well lit.

Dos and don’ts of machinery safety for workers

Do...

- ✓ check the machine is well maintained and fit to be used, i.e. appropriate for the job and working properly and that all the safety measures are in place – guards, isolators, locking mechanisms, emergency off switches etc.;
- ✓ use the machine properly and in accordance with the manufacturer’s instructions;
- ✓ make sure operators are wearing the appropriate protective clothing and equipment required for that machine, such as safety glasses, hearing protection and safety shoes.

Don’t...

- ✓ use a machine or appliance that has a danger sign or tag attached to it. Danger signs should only be removed by an authorised person who is
- ✓ satisfied that the machine or process is now safe;
- ✓ wear dangling chains, loose clothing, rings or have loose, long hair that could get caught up in moving parts;
- ✓ distract people who are using machines;
- ✓ remove any safeguards, even if their presence seems to make the job more difficult.

Case study

A company were prosecuted after a worker received horrific injuries, almost severing his left arm when using a cross-cut saw.

What the employer did

The nose guard had not been set correctly because training was inadequate. The worker had no previous experience and had only five minutes’ training on the saw. This did not include any instruction about the saw guards and how to adjust them properly. In addition, the saw was unsuitable for training purposes.

Plant and equipment maintenance

Maintenance on plant and equipment is carried out to prevent problems arising, to put faults right, and to ensure equipment is working effectively.

Maintenance may be part of a planned programme or may have to be carried out at short notice after a breakdown. It always involves non-routine activities and can expose those involved (and others) to a range of risks.

Why is maintenance of plant and equipment important?

An effective maintenance programme will make plant and equipment more reliable. Fewer breakdowns will mean less dangerous contact with machinery is required, as well as having the cost benefits of better productivity and efficiency.

Additional hazards can occur when machinery becomes unreliable and develops faults. Maintenance allows these faults to be diagnosed early to manage any risks. However, maintenance needs to be correctly planned and carried out. Unsafe maintenance has caused many fatalities and serious injuries, either during the maintenance or to those using the badly maintained or wrongly maintained/repaired equipment.

What should employers do?

Employers who provide equipment for use, from hand tools and ladders to electrical power tools and larger plant, need to ensure that, so far as is reasonably practicable that the machinery and equipment under their control is safe and without risk to health. One way to achieve this is for employers to have arrangements in place to make sure machinery and equipment is maintained in a safe condition.

They should think about what hazards can occur if:

- ✓ tools break during use;
- ✓ machinery starts up unexpectedly;
- ✓ there is contact with materials that are normally enclosed within the machine, i.e. caused by leaks/breakage/ejection etc.

Failing to correctly plan and communicate clear instructions and information before starting maintenance can lead to confusion and can cause accidents. This can be a particular problem if maintenance is during normal production work or where there are contractors who are unfamiliar with the site.

Case study

A worker received crush injuries to his head and neck while he was undertaking maintenance work, when the hoist he was working on started up.

What caused the accident?

The power supply to the hoist had not been isolated before work started. This was because workers had not been given adequate training or instruction on safe isolation procedures. It was also found that isolation by the interlocked gates could be bypassed.

Extra care is also required if maintenance involves:

- ✓ working at height or when doing work that requires access to unusual parts of the building;
- ✓ when entering vessels or confined spaces where there may be toxic materials or a lack of air.

How can employers do it?

Establishing a planned maintenance programme is a useful step towards reducing risk, as well as having a reporting procedure for workers who may notice problems while working on machinery.

Some items of plant and equipment may have safety-critical features where deterioration would cause a risk. Employers must have arrangements in place to make sure the necessary inspections take place.

But there are other steps to consider:

Before employers instruct workers to start maintenance

- ✓ Decide if the work should be done by specialist contractors. Never take on work for which workers are not prepared or competent.
- ✓ Plan the work carefully before it starts, ideally using the manufacturer's maintenance instructions, and produce a safe system of work. This will avoid unforeseen delays and reduce the risks.
- ✓ Make sure maintenance staff are competent and have appropriate clothing and equipment.
- ✓ Try and use downtime for maintenance. This can avoid the difficulties in co-ordinating maintenance and production work if maintenance work is performed before start-up or during shutdown periods.

Safe working areas

- ✓ Employers must provide safe access and a safe place of work.
- ✓ They must not just focus on the safety of maintenance workers – they must take the necessary precautions to ensure the safety of others who may be affected by the maintenance work, e.g. other workers or contractors working nearby.
- ✓ Employers and the maintenance personnel should set up signs and barriers and position people at key points if they are needed to keep other people out.

Case study

Maintenance staff removed a section of grating to gain access to plant located below a walkway. A worker fell through a gap in the walkway, seriously injuring his shoulder.

What caused the accident?

The fall happened because there was nothing to make workers aware of the dangers caused by

machinery maintenance. Barriers, guards and signs should have been used to indicate that maintenance was taking place.

Safe plant and equipment

Employers should ensure plant and equipment is made safe before maintenance starts, through:

Safe isolation

- ✓ Ensuring moving plant has stopped and isolate electrical and other power supplies. Most maintenance should be carried out with the power off. If the work is near uninsulated, overhead electrical conductors, e.g. close to overhead travelling cranes, cut the power off first.
- ✓ Locking off machines if there is a chance the power could be accidentally switched back on.
- ✓ Isolating plant and pipelines containing pressured fluid, gas, steam or hazardous material. Locking off isolating valves.

Other factors needing to be considered

- ✓ Releasing any stored energy, such as compressed air or hydraulic pressure that could cause the machine to move or cycle.
- ✓ Supporting parts of plant that could fall, e.g. support the blades of down-stroking bale cutters and guillotines with blocks.
- ✓ Allowing components that operate at high temperatures time to cool.
- ✓ Place mobile plant in neutral gear, apply the brake and chock the wheels.
- ✓ Safely cleaning out vessels containing flammable solids, liquids, gases or dusts, and check them before hot work is carried out to prevent explosions. Specialist help and advice may be needed to do this safely.
- ✓ Avoiding entering tanks and vessels where possible. This can be very high-risk work. If required, get specialist help to ensure adequate precautions are taken.
- ✓ Cleaning and checking vessels containing toxic materials before work starts.

Dos and don’ts of plant and equipment maintenance

Do...

- ✓ ensure maintenance is carried out by a competent person (someone who has the necessary skills, knowledge and experience to do the work safely);
- ✓ maintain plant and equipment regularly – use the manufacturer’s maintenance instructions as a guide, particularly if there are safety-critical features;
- ✓ have a procedure that allows workers to report damaged or faulty equipment;
- ✓ provide the proper tools for the maintenance person;

- ✓ schedule maintenance to minimise the risk to other workers and the maintenance person wherever possible;
- ✓ make sure maintenance is done safely, that machines and moving parts are isolated or locked and that flammable/explosive/toxic materials are dealt with properly.

Don't...

- ✓ ignore maintenance;
- ✓ ignore reports of damaged or unsafe equipment;
- ✓ use faulty or damaged equipment.

Safe lifting by machine

If the employer provides lifting equipment for use at work, or if they have control of the use of lifting equipment, they must make sure it is safe.

Employers should think about what risks there may be and how they can be managed, for example:

- ✓ damage or deterioration of the equipment caused by wet, abrasive or corrosive environments;
- ✓ trying to move weights that are too heavy and exceed the load limit of the machine;
- ✓ equipment failure;
- ✓ untrained workers planning the lift or using the equipment;
- ✓ people being struck by moving parts of the machinery or by things falling.

Safe lifting needs to be properly planned by a competent person, appropriately supervised and carried out safely. Any equipment used must have been properly designed, manufactured and tested. Not forgetting the need to maintain it properly.

Factors that should be considered

- ✓ What is being lifted?
- ✓ How heavy is it?
- ✓ Where is its centre of gravity?
- ✓ How will it be attached to the lifting machinery?
- ✓ Who is in control of the lift?
- ✓ What are the safe limits of the equipment?
- ✓ Could the lift be rehearsed if necessary?

Dos and don'ts when using lifting machinery

Do...

- ✓ use only certified lifting equipment, marked with its safe working load, which has been regularly examined to ensure it is fit for purpose;
- ✓ keep the reports of any examinations as well as any declarations of conformity or test certificates;

- ✓ make sure the load is properly attached to the lifting equipment. If necessary, securely bind the load to prevent it slipping or falling off;
- ✓ before lifting an unbalanced load, find out its centre of gravity. Raise it a few inches off the ground and pause – there should be little harm if it drops;
- ✓ use packaging to prevent sharp edges of the load from damaging slings and do not allow tackle to be damaged by being dropped, dragged from under loads or subjected to sudden loads;
- ✓ when using jib cranes, make sure any indicators for safe loads are working properly and set correctly for the job and the way the machine is configured;
- ✓ use outriggers where necessary;
- ✓ when using multi-slings, make sure the sling angle is taken into account;
- ✓ have a responsible slinger or banksman and use a recognized signalling system.

Don't...

- ✓ use unsuitable equipment, e.g. makeshift, damaged, badly worn chains shortened with knots, kinked or twisted wire ropes, frayed or rotted fibre ropes;
- ✓ exceed the safe working load of machinery or accessories like chains, slings and grabs. Remember that the load in the legs of a sling increases as the angle between the legs increases;
- ✓ lift a load if you doubt its weight or the adequacy of the equipment.

OPERATE DISTRIBUTION SYSTEMS

Distribution Systems & Their Maintenance

Introduction

Even if the water source for your small water system is of pristine quality, if the distribution system is not maintained or is in a state of disrepair, the quality of water may deteriorate before it reaches the customer.

The focus on this section is on the safe delivery of water. We will discuss the following:

- ✓ delivery of water
- ✓ some common issues and hazards that must be avoided
- ✓ sampling and monitoring
- ✓ operations and maintenance
- ✓ easements
- ✓ leak detection and water loss
- ✓ water metering
- ✓ the importance of a cross connection control program

Delivery of Water

The primary function of any water distribution system is the transportation of drinking water safely to the consumer. The water source may originate from a well, river, lake or spring. In order to ensure the water is safe to drink (potable), it is usually treated to remove bacteria, viruses or parasites, and dissolved minerals that may cause illness in humans.

As the water flows through the distribution system, there are a number of components that keep the system operational. These include reservoirs, pumping stations, fire hydrants, air valves, gate valves and piping networks, each of which is described below.

The reservoir stores water for higher demand flows, such as for fire emergencies, and peak domestic flows, such as when people are getting ready for work in the morning and returning home later in the day. The reservoir also acts as a buffer in maintaining constant flow and pressure of water in the distribution system. For small water systems, pneumatic tanks are typically used instead of large reservoirs, as they, too, are capable of supplying and keeping up with the water demand. The tanks are generally not sized to provide fire flow. The minimum storage should be equal to the average daily consumption or the storage calculated to meet CT disinfection requirements, whichever is greater. A pressure switch regulates the amount of water to be stored in order to maintain a constant pressure in the distribution system.

Pumping stations are added to the distribution system to maintain pressure and delivery of water to uphill areas and reservoirs.
Air valves are devices that allow air to be introduced into the distribution pipe when a vacuum may be created. A vacuum can potentially damage the pipe or stop the water and is to be avoided. The air valves are located at high points in the distribution system.

Gate valves are added throughout the distribution system, so sections can be isolated for water main work and the water flow can be throttled for pipeline repair. They are a type of valve that uses a flow control element shaped like a sliding gate to block flow, often used as isolation valves.

Pipe networks' efficiency is effected by both the materials used and the layout. Pipe material is crucial for the efficient delivering of water. The smoother the interior of the pipe, such as with PVC pipes and ductile iron, the less friction there is. Also, the less twists and turns in the pipe, the more efficient the delivery of water.

Common Issues & Hazards

The greatest concerns for the safe delivery of water are loss of pressure, loss of chlorine residual and cross contamination.

Loss of pressure may result from a water main break, fire flow or inoperable pumping stations, due to power failure.

Loss of chlorine residual can be caused by a number of factors:

- ✓ Source water quality: Water that is high in organic or inorganic matter will use up the chlorine residual faster than water that is lower in organic matter.
- ✓ Residency time: The more time the water spends in storage and distribution, the more chlorine residual is used up. Long residency time can result from low water usage, dead ends in the distribution system and poor turnover in the reservoir.
- ✓ Reaction with pipe materials: Some pipe materials (e.g., iron) can react with chlorine, resulting in loss of the residual.
- ✓ Biofilm growth: Biofilm is a large colony of microorganisms that grown on pipe walls within the distribution system that will use up the chlorine residual.

If low chlorine residual is detected, you should flush the system until the residual is re-established. If chlorine levels continue to drop below an acceptable level, the cause should be investigated. Operators may consider increasing the disinfectant dose if that is not effective.

Cross contamination from the exterior environment into the water main may occur if there is a leak or opening in the pipe. Standard practice is to maintain a minimum water pressure of 1.4 bar (20 psi) to prevent the potential of cross contamination.

Bacteriological contamination and microbiological growth is also a concern. It may be introduced through a cross connection (more on cross connections at the bottom of this section) or failure to adequately treat the water at source.

Sampling & Monitoring

In order to ensure drinking water is safe for consumption, routine sampling and testing is required under Supply Water Quality Standard set by the Environmental Protection Agency of the Maldives.

Environmental Protection Agency EPA

SUPPLY WATER QUALITY STANDARD

The water produced for municipal purpose shall have the following parameters in the given ranges. The following parameters need to be tested and reported to Environmental protection Agency according to the timeframe given below.

Table 1: Daily Tests

The following parameters must be tested daily.

Parameter	Reference range
Free Chlorine	0.04 - 0.2 mg/l
pH	6.5 - 8.5
Physical Appearance	Clear & Colorless
Electrical Conductivity	<1000 µs/cm
Total Coliform	0/100ml CFU
Fecal Coliform	0/100ml CFU
Turbidity	<1 NTU
Total Dissolved Solids	<500 mg/L

Table 2: Monthly Tests

The following parameters must be tested every month along with those given in Table 1.

Parameter	Reference range
Chlorides	<200 mg/l
Nitrates	<50 mg/l
Ammonia	<0.02 – 2.50 mg/l
Iron	<0.3 mg/l
Hydrogen Sulphide	0.05 mg/l
Total Hardness	<75 mg/l
Suspended Solids	5-750 mg/L

Table 3: Bi-Annual Tests

The following parameter must be tested twice a year along with those given in Table 1 and Table 2.

Parameter	Reference range
Total viable count at 22°C	100/1ml CFU
Total viable count at 37°C	20/1ml CFU

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Environmental Protection Agency EPA

Table 4: Annual Tests

The following parameters must be tested once every year along with those given in Table 1, Table 2 and Table 3.

Parameter	Reference range
Anionic detergents	0.002 - 0.275 mg/l
Arsenic	<0.01 mg/l
Boron	<0.3 mg/l
Bromine	0.05 – 4.50 mg/l
Cadmium	<0.003 mg/l
Calcium hardness	<60 mg/l
Chromium	<0.05 mg/l
Copper	<2 mg/l
Cyanide	<0.07 mg/l
Enterococci	0/100ml CFU
Fluoride	<1.5 mg/l
Lead	<0.01 mg/l
Manganese	0.1 mg/l
Mercury	<0.001 mg/l
Phenolic compounds	0.002 - 0.2 mg/l
Phosphate	<5mg/l
Potassium	0 – 50 mg/l
Salmonella Typhi	0/100ml CFU
Shigella spp.	0/100ml CFU
Sodium	<200 mg/l
Sulphate	<250 mg/l
Total petroleum hydrocarbon	0 mg/l
Vibrio Cholerae	0/100ml CFU

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Additional testing required will be highlighted in the Operating License issued by the Utility Regulatory Authority,

Operations & Maintenance

It is essential that all equipment for operating and maintaining the distribution system is exercised (i.e., tested or used) on a regular basis. This ensures the water flow is minimally disrupted in the event of an emergency or during regular repair work. For example, in the event of a water main leak, valves can be easily operated if they were previously located and exercised. If a valve is not exercised, it may seize up or become difficult to turn, making the repair work much more difficult. Other challenges that may occur if the equipment is not regularly maintained include the failure of a backup generator to start in the event of a power failure or of a hydrant to deliver adequate water flow in an emergency.

Timing of Maintenance

Hydrants and valves should be evaluated and exercised at a minimum once per year. If a hydrant is used, it should be evaluated afterwards.

Backup generators should be tested each month.

Pumps should undergo maintenance as per the manufacturer's recommendation.
Dead end mains should be flushed on a routine basis to maintain water quality.

Water reservoirs should be evaluated annually and cleaned every 3 to 5 years, based on sediment collection on the bottom.

Easements

An Easement or Right of Way (ROW) is a strip of land on private property that acts as a corridor for water mains, sanitary sewers and/or storm mains. With an easement, a legal agreement exists between the landowner and the utility to provide 24/7 access for operating, maintaining or repairing any component that requires attention. The minimum widths of these ROWs are generally 3 metres. Typically, the width is determined by 2 X depth of pipe + width of trench excavated. For example, if the top of the pipe is 1 m from the ground surface and the trench width is 1 m, the result is 2 X 1m depth of pipe + 1 m excavation trench = 3 m ROW width.

Leak Detection & Water Loss

Most water systems experience approximately 10% leakages and/or unaccounted water use. This may be from water main leaks, unaccounted water use from a property (running toilet or hoses), or illegal use of a fire hydrant.

Leaks may have originated from weakened joints or fitting connections or from a damaged or corroded part of the pipe. If unresolved, leaks may undermine pavement or other structures, resulting in damage. Perhaps the greatest concern is that the leak will soak the ground surrounding the pipe and, in the event that pressure is lost in the pipe, the water, combined now with dirt and other contaminates, may backflow into the pipe.

If a water system is metered, leak detection is easier to detect. Operators should try to isolate parts of the distribution system and pressure test. Once an area for the water loss is determined, specially trained personal use leak detection equipment to pinpoint the area. They typically use sound-intensifying equipment in a systematic fashion to locate leaks. Preliminary methods of locating leaks include damp spots or water seepage in the vicinity of mains or services.

Reference: Water Distribution System Operation & Maintenance, 5th Edition, A Field Study Training Program, California State University, Sacramento California, 2005, p.211.

Water Metering

Water metering establishes a user pay system, which ensures equity and fairness for water consumers. If a water system is unmetered and users pay a flat rate, there may be inequity if a neighbour uses more water for their green house and swimming pool and another one uses only water within the home.

The cost/benefit for establishing a metering program may be more beneficial for a large municipal system versus a smaller system, due to the lower dollar cost averaging for installation and maintenance of the meters. For smaller systems, it may be more beneficial to maintain a flat rate system (unmetered) and ensure users use water responsibly.

Cross Connections

In order to ensure the safe delivery of water to users, any potential cross connections with contaminated sources need to be addressed. This includes simple threats, such as leaving the garden hose in a pool or hot tub or leaving it connected to a pesticide dispenser. Any loss of pressure (negative pressure) from water delivery may turn the hose into a vacuum and draw the contaminated water into the plumbing system. More complex threat include a direct connection of an irrigation system to a water supply without the barrier of a backflow preventer, or the direct connection of the water to a chemical supply. The backflow preventer contains a spring-loaded valve that closes if the water flows in reverse, hence isolating the contaminated source from the water supply. In order to protect drinking water from all potentially contaminated sources, a cross connection control program should be instituted. The acceptable backflow preventer devices (BPDs) should be testable and meet the relevant CSA standards (i.e., CSA B64) or equivalent. Operation and maintenance of the water pipeline should include regular testing and maintenance of testable BPDs.

RECOGNIZE AND TAKE ACTION ON ABNORMAL SITUATION IN ACCORDANCE WITH PROCEDURES

Do You Have the Tools to Analyze Abnormal Operating Conditions (AOCs)?

As we approach 2020, you may be viewing the New Year as a fresh opportunity to address your Alarm Management program in the pipeline control room. Specifically, how to address Abnormal Operating Conditions (AOCs).

We have heard from control room managers on several issues related to AOCs, including:

- Lack of a clear definition of AOCs
- Same AOCs occurring repeatedly
- Controllers unable to respond to AOCs in a timely manner
- AOCs not recorded properly in the SCADA system
- Lack of tools to review and analyze AOCs

Set a Goal to Address Specific AOC Issues

Each pipeline control room is different. Take time to identify the most prevalent AOC-related issue that you need to address in 2020. Then, prioritize the next most important issues you need to address to support your Alarm Management program.
Consider these common situations and what steps you can take to elevate your control room response to AOCs to support safety, compliance, and operational objectives.

1. Lack of Clear Definitions

A root issue for how your control room handles AOCs could be a lack of understanding of the actual definition of an AOC.

Create clarity in the control room by relaying the definition that an Abnormal Operating Conditions is an operating condition of the pipeline outside the normal operating parameters, but not yet an emergency.

Additionally, an abnormal operating condition may indicate a malfunction of a component or deviation from normal operations that may (a) indicate a condition exceeding design limits or (b) result in a hazard(s) to persons, property, or the environment.

2. Repeated AOCs

For many control rooms, the same AOCs occur repeatedly on a regular basis. Controllers become desensitized to this example of alarm flood and cannot separate actual alarms from the bad actors.

Your goal should be to remove unnecessary triggers that generate a high number of alarms in the SCADA system. By removing these bad actors from the system, controllers can maintain focus on actual alarms associated with an AOC.

3. Lack of Timely Response

A byproduct of alarm flood in the control room is slow response time to important AOCs.

Your controllers may be slowed down in either identifying AOCs or responding to AOCs because of the bad actors. Ensure that controllers can achieve situational awareness in a timely manner by evaluating response time to actual alarms.

4. Inconsistent Recording of AOCs

Proper recording of AOCs in the SCADA system is critical to support analysis, compliance, and safety.

However, if control room personnel do not have a clear definition of AOCs, they may be challenged to understand how to record the alarms they are seeing.

Or, if you lack clear policies and procedures for identifying and responding to AOCs, there may be inconsistencies in how AOCs are recorded in the SCADA system.

Ensure that your team has a clear understanding of the importance of accurate recording to support your objectives for analysis, compliance, and safety.

5. Lack of Tools to Analyze AOCs

The quality of your recordkeeping feeds into your ability to analyze the AOCs. Control room managers need to be able to review and analyze AOCs to identify issues surrounding alarm flood, bad actors, controller response time, and recordkeeping.

This ties into the importance of alarm rationalization, which is the process of documenting the alarm-specific process to verify, diagnose, determine causes, and take the appropriate course of action to respond to an alarm. Ideally, the alarm rationalization defines the AOCs that can be associated with the alarm.

Take a step forward by assessing the quality of the alarm rationalization within your Alarm Management program. Look at the alarm response for each controller to see whether the controller is following a specified course of action when presented an alarm through the SCADA system on their HMI display. Ideally, the controller will follow the rationalized procedure each time.

If you lack tools to perform this analysis, talk to our company about implementing or updating software to support your control room. Our POEMS Control Room Management Suite (CRM Suite) includes a module to manage the pipeline alarm rationalization process so that you can perform informed analysis of the AOCs.

ISOLATE AND DE-ISOLATE PLANT

The risks associated with any plant or equipment undergoing inspection, maintenance, cleaning, repair or construction should be assessed and appropriate control measures put in place.

Before work commences the plant should be stopped, appropriately isolated/locked and danger tagged, and any stored energy should be dissipated.

Examples of energy sources include electricity, hydraulic pressure, compressed air or gas, gravity, kinetic spring tension and moving parts.

Separate controls away from the plant operator or immediate work area must also be isolated or locked and danger tagged.

Isolation Procedures

An isolation procedure is a set of predetermined steps that should be followed when workers are required to perform tasks such as inspection, maintenance, cleaning, repair and construction.

The aim of an isolation procedure is to:

- ✓ isolate all forms of potentially hazardous energy to ensure that an accidental release of hazardous energy does not occur
- ✓ control all other hazards to those doing the work
- ✓ ensure that entry to a restricted area is tightly controlled.

The following lock-out process is the most effective isolation procedure:

- ✓ shut down the machinery and equipment
- ✓ identify all energy sources and other hazards
- ✓ identify all isolation points
- ✓ isolate all energy sources
  - ✓ in the case of electrical equipment ‘whole current isolation’, such as the main isolator, should be used instead of ‘control isolation’ by way of the stop button on a control panel
- ✓ control or de-energise all stored energy
- ✓ lock-out all isolation points, using padlocks, multi- padlock hasps and danger tags
- ✓ 'danger tag' machinery controls, energy sources and other hazards.

Test that the isolation is effective by 'trying' to reactivate the plant without exposing the tester or others to risk. Failure to reactivate the plant means that the isolation procedure is effective and that all stored energies have dissipated.

This may require further measures to safely release these energies e.g. hydraulic or pneumatic pressure, suspended weight or compressed springs.

Locks and danger tags

Every person working on isolated equipment should fit their own lock and/or danger tag. Alternatively, another management approved system that achieves an equivalent level of safety may be used.
When using locks or danger tags, consider the following:

- ✓ tags should be dated and signed
- ✓ locks should be accompanied by a corresponding tag to identify who has locked out the plant
- ✓ tags and locks should only be removed by the person who applied them or by the supervisor after consultation with the signatory of the danger tag. In the event
- ✓ that the person who applied the danger tag is unavailable, their tag or lock may only be removed in accordance with a management approved procedure
- ✓ danger Tags and/or locks should be fitted to all isolation points.

Out-of-service tags

Out-of-service tags are used to identify equipment or machinery that has been taken out of service due to a fault, damage or malfunction.

The out-of-service tag is to be securely fixed to the operating control power isolator with the appropriate details completed on the tag (explaining the reason for the machine being 'out of service').

The out-of-service tag should not be removed until the equipment is safe to be returned to service, or the reason for the out-of-service tag no longer exists.
The out-of-service tag may be removed by:

- ✓ the person who attached it
- ✓ the supervisor responsible for the operation or repair of the equipment
- ✓ the maintenance person who carried out the repairs.

PERFORM LOG TAKING AND DOCUMENT MANAGEMENT

Importance of Control Room Log Book

Plant operators communicate vital information verbally among themselves in the field via radio communication, and within the control room. The spoken word is the predominant form of communication. It's fast, handy and recognizable.

There are, however, problems with verbal communication alone. As the audience is confined to those hearing what is being said at the time, the message may subsequently change. Additionally, verbal communication lends itself to subjective information and often suffers from understatement or exaggeration. For instance, what appears as a "little leak" to some may, in fact, be significant to others.

A written record is a must in documenting prominent events. In addition to equipment rounds and automated data records, operators should also maintain narrative information in the form of a control room logbook. This chronological account should record the important events occurring throughout each and every work shift. Considered to have the force of a legal record, the language, correctness, impartiality and detail should reflect such consideration. The control room logbook is valuable to others who must later chronicle important event sequences and verify past performance.

Let's look at some significant incidents regarding logbook utilization (or the lack thereof):

- ✓ Sverdlovsk Anthrax Leak (1979): A technician working in the plant removed a clogged filter in a drying machine. He left a written notice, but did not add the information in the logbook. The supervisor of the next shift found nothing unusual and turned the machines on.
- ✓ Texas City Refinery Explosion (2005): When the control room shift turnover occurred, little was said regarding the state of the unit. The day and night operators spoke to each other, but because the night operator was not the one who filled the tower, he provided few details about the night shift's activities other than what was written in the logbook. The day shift operator read the logbook and interpreted the entry to mean that liquid was added only to the tower. The day operator, in post-incident testimony, said he was unaware that the heat exchangers, piping and associated equipment had also been filled during the previous shift.
- ✓ Nine Mile Point Nuclear Power Plant (2008): A plastic hose fouled a cooling water intake pump. The subsequent Nuclear Regulatory Commission investigation indicated the plant's day shift operators knew the two pumps had sucked in hose

pieces, but “for unclear reasons” operators did not record the pumps as inoperable in the control room log, which would have elevated awareness of the incident.

- ✓ Bruce Nuclear Power Plant (2009): Nearly half a ton of steel fell 20 meters to the ground from a plant crane. A day before the fall, a crane operator noted a problem with the equipment in a logbook. But the crane was never inspected or put out of service, according to internal reports.

Log entries should be unambiguous, concise and legible written statements with their corresponding dates and times made unmistakable. When possible, log entries should be recorded as the event occurs since delayed entries are often incomplete. Major routine events should be logged along with abnormal events affecting equipment status. Any accident or emergency should also be logged, taking care to document the initial indication, remedy actions, the cause and subsequent status. Log books should be maintained and stored after their use for future reference.

A recent trend uses software for plant operators to maintain an electronic record of pertinent events. These systems have the advantage of remote accessibility. The entire plant staff has the ability to access the control room logbook in real time from the convenience of their workstations. Additional information can be incorporated into this common window to include operating data, operating plans equipment lockout status, inhibited alarms and a list of onsite personnel.

One question to consider is how many operational incidents could have been prevented if a control room logbook was better utilized and updated. Has in-market availability been impacted by ineffective and insufficient communication among operators? As managers, we are ultimately responsible for the quality of communication and documentation specific to our plants. Do we have policies for effective logbook utilization and shift turnover? And if policies exist, do we enforce them?

UNIT 13

MONITOR SYSTEMS AND EQUIPMENT

This unit covers the operation and monitoring of a complex compressor system and associated equipment. Moreover, maintenance of an effective plant

PREPARE FOR WORK

Hazard Identification and Assessment

One of the "root causes" of workplace injuries, illnesses, and incidents is the failure to identify or recognize hazards that are present, or that could have been anticipated. A critical element of any effective safety and health program is a proactive, ongoing process to identify and assess such hazards.

To identify and assess hazards, employers and workers:

- ✓ Collect and review information about the hazards present or likely to be present in the workplace.
- ✓ Conduct initial and periodic workplace inspections of the workplace to identify new or recurring hazards.
- ✓ Investigate injuries, illnesses, incidents, and close calls/near misses to determine the underlying hazards, their causes, and safety and health program shortcomings.
- ✓ Group similar incidents and identify trends in injuries, illnesses, and hazards reported.
- ✓ Consider hazards associated with emergency or nonroutine situations.
- ✓ Determine the severity and likelihood of incidents that could result for each hazard identified, and use this information to prioritize corrective actions.

Some hazards, such as housekeeping and tripping hazards, can and should be fixed as they are found. Fixing hazards on the spot emphasizes the importance of safety and health and takes advantage of a safety leadership opportunity. To learn more about fixing other hazards identified using the processes described here, see "Hazard Prevention and Control."

Action item 1: Collect existing information about workplace hazards

Information on workplace hazards may already be available to employers and workers, from both internal and external sources.

How to accomplish it

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include:

- ✓ Equipment and machinery operating manuals.
- ✓ Safety Data Sheets (SDS) provided by chemical manufacturers.
- ✓ Self-inspection reports and inspection reports from insurance carriers, government agencies, and consultants.
- ✓ Records of previous injuries and illnesses, such as OSHA 300 and 301 logs and reports of incident investigations.
- ✓ Workers' compensation records and reports.
- ✓ Patterns of frequently-occurring injuries and illnesses.
- ✓ Exposure monitoring results, industrial hygiene assessments, and medical records (appropriately redacted to ensure patient/worker privacy).

- ✓ Existing safety and health programs (lockout/tagout, confined spaces, process safety management, personal protective equipment, etc.).
- ✓ Input from workers, including surveys or minutes from safety and health committee meetings.
- ✓ Results of job hazard analyses, also known as job safety analyses.

Information about hazards may be available from outside sources, such as:

- ✓ OSHA, National Institute for Occupational Safety and Health (NIOSH), and Centers for Disease Control and Prevention (CDC) websites, publications, and alerts.
- ✓ Trade associations.
- ✓ Labor unions, state and local occupational safety and health committees/coalitions ("COSH groups"), and worker advocacy groups.
- ✓ Safety and health consultants.

Action item 2: Inspect the workplace for safety hazards

Hazards can be introduced over time as workstations and processes change, equipment or tools become worn, maintenance is neglected, or housekeeping practices decline. Setting aside time to regularly inspect the workplace for hazards can help identify shortcomings so that they can be addressed before an incident occurs.

How to accomplish it

- ✓ Conduct regular inspections of all operations, equipment, work areas and facilities. Have workers participate on the inspection team and talk to them about hazards that they see or report.
- ✓ Be sure to document inspections so you can later verify that hazardous conditions are corrected. Take photos or video of problem areas to facilitate later discussion and brainstorming about how to control them, and for use as learning aids.
- ✓ Include all areas and activities in these inspections, such as storage and warehousing, facility and equipment maintenance, purchasing and office functions, and the activities of on-site contractors, subcontractors, and temporary employees.
- ✓ Regularly inspect both plant vehicles (e.g., forklifts, powered industrial trucks) and transportation vehicles (e.g., cars, trucks).
- ✓ Use checklists that highlight things to look for. Typical hazards fall into several major categories, such as those listed below; each workplace will have its own list:
    - o General housekeeping
    - o Slip, trip, and fall hazards
    - o Electrical hazards
    - o Equipment operation
    - o Equipment maintenance
    - o Fire protection
    - o Work organization and process flow (including staffing and scheduling)
    - o Work practices
    - o Workplace violence
    - o Ergonomic problems
    - o Lack of emergency procedures

- ✓ Before changing operations, workstations, or workflow; making major organizational changes; or introducing new equipment, materials, or processes, seek the input of workers and evaluate the planned changes for potential hazards and related risks.

Note: Many hazards can be identified using common knowledge and available tools. For example, you can easily identify and correct hazards associated with broken stair rails and frayed electrical cords. Workers can be a very useful internal resource, especially if they are trained in how to identify and assess risks.

Action item 3: Identify health hazards

Identifying workers' exposure to health hazards is typically more complex than identifying physical safety hazards. For example, gases and vapors may be invisible, often have no odor, and may not have an immediately noticeable harmful health effect. Health hazards include chemical hazards (solvents, adhesives, paints, toxic dusts, etc.), physical hazards (noise, radiation, heat, etc.), biological hazards (infectious diseases), and ergonomic risk factors (heavy lifting, repetitive motions, vibration). Reviewing workers' medical records (appropriately redacted to ensure patient/worker privacy) can be useful in identifying health hazards associated with workplace exposures.

How to accomplish it

- ✓ Identify chemical hazards –review SDS and product labels to identify chemicals in your workplace that have low exposure limits, are highly volatile, or are used in large quantities or in unventilated spaces. Identify activities that may result in skin exposure to chemicals.
- ✓ Identify physical hazards –identify any exposures to excessive noise (areas where you must raise your voice to be heard by others), elevated heat (indoor and outdoor), or sources of radiation (radioactive materials, X-rays, or radiofrequency radiation).
- ✓ Identify biological hazards –determine whether workers may be exposed to sources of infectious diseases, molds, toxic or poisonous plants, or animal materials (fur or scat) capable of causing allergic reactions or occupational asthma.
- ✓ Identify ergonomic risk factors –examine work activities that require heavy lifting, work above shoulder height, repetitive motions, or tasks with significant vibration.
- ✓ Conduct quantitative exposure assessments –when possible, using air sampling or direct reading instruments.
- ✓ Review medical records –to identify cases of musculoskeletal injuries, skin irritation or dermatitis, hearing loss, or lung disease that may be related to workplace exposures.

Note: Identifying and assessing health hazards may require specialized knowledge. Small businesses can obtain free and confidential occupational safety and health advice services, including help identifying and assessing workplace hazards, through OSHA's On-site Consultation Program.

Action item 4: Conduct incident investigations

Workplace incidents –including injuries, illnesses, close calls/near misses, and reports of other concerns– provide a clear indication of where hazards exist. By thoroughly investigating incidents and reports, you will identify hazards that are likely to cause future harm. The purpose of an investigation must always be to identify the root causes (and there is often more than one) of the incident or concern, in order to prevent future occurrences.

How to accomplish it

- ✓ Develop a clear plan and procedure for conducting incident investigations, so that an investigation can begin immediately when an incident occurs. The plan should cover items such as:
  - Who will be involved
  - Lines of communication
  - Materials, equipment, and supplies needed
  - Reporting forms and templates
- ✓ Train investigative teams on incident investigation techniques, emphasizing objectivity and open-mindedness throughout the investigation process.
- ✓ Conduct investigations with a trained team that includes representatives of both management and workers.
- ✓ Investigate close calls/near misses.
- ✓ Identify and analyze root causes to address underlying program shortcomings that allowed the incidents to happen.
- ✓ Communicate the results of the investigation to managers, supervisors, and workers to prevent recurrence.

Effective incident investigations do not stop at identifying a single factor that triggered an incident. They ask the questions "Why?" and "What led to the failure?" For example, if a piece of equipment fails, a good investigation asks: "Why did it fail?" "Was it maintained properly?" "Was it beyond its service life?" and "How could this failure have been prevented?" Similarly, a good incident investigation does not stop when it concludes that a worker made an error. It asks such questions as: "Was the worker provided with appropriate tools and time to do the work?" "Was the worker adequately trained?" and "Was the worker properly supervised?"

Note: OSHA has special reporting identifys for work-related incidents that lead to serious injury or a fatality (29 CFR 1904.39). OSHA must be notified within 8 hours of a work-related fatality, and within 24 hours of an amputation, loss of an eye, or inpatient hospitalization.

Action item 5: Identify hazards associated with emergency and nonroutine situations

Emergencies present hazards that need to be recognized and understood. Nonroutine or infrequent tasks, including maintenance and startup/shutdown activities, also present potential hazards. Plans and procedures need to be developed for responding appropriately and safely to hazards associated with foreseeable emergency scenarios and nonroutine situations.

How to accomplish it

- ✓ Identify foreseeable emergency scenarios and nonroutine tasks, taking into account the types of material and equipment in use and the location within the facility. Scenarios such as the following may be foreseeable:
  - Fires and explosions
  - Chemical releases
  - Hazardous material spills
  - Startups after planned or unplanned equipment shutdowns
  - Nonroutine tasks, such as infrequently performed maintenance activities
  - Structural collapse
  - Disease outbreaks
  - Weather emergencies and natural disasters
  - Medical emergencies
  - Workplace violence

Action item 6: Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control

The next step is to assess and understand the hazards identified and the types of incidents that could result from worker exposure to those hazards. This information can be used to develop interim controls and to prioritize hazards for permanent control.

How to accomplish it

- ✓ Evaluate each hazard by considering the severity of potential outcomes, the likelihood that an event or exposure will occur, and the number of workers who might be exposed.
- ✓ Use interim control measures to protect workers until more permanent solutions can be implemented.
- ✓ Prioritize the hazards so that those presenting the greatest risk are addressed first. Note, however, that employers have an ongoing obligation to control all serious recognized hazards and to protect workers.

Note: "Risk" is the product of hazard and exposure. Thus, risk can be reduced by controlling or eliminating the hazard or by reducing workers' exposure to hazards. An assessment of risk helps employers understand hazards in the context of their own workplace and prioritize hazards for permanent control.

STARTUP SYSTEMS/EQUIPMENT

Plant & Machinery Pre-Start Checklist

As a responsible operator, running a pre-start check on your plant or machinery before you start the day is the best way to ensure the job gets done safely and without delay.
Undertaking a pre-start check on your machine before you start a days work, happens in three stages.

Step 1 - Visual inspections of important features prior to starting the machine
Step 2 - Visual & function tests while the machine is turned on but stationary
Step 3 - Testing the machine's functions during a short drive

Within each of these steps there are activities that are common to all pre-start checks. We itemised them below and we then go into a few examples of extra items that are unique to those machine classes.

The following items are on all pre-start checklists for plant and machinery and are universal whether they are done on paper or electronically. We then review the slight tweaks you need to make in three pertinent examples - Pre-Start Checks for Excavators, Pre-Start Checks for Forklifts and Pre-Start Checks for Mobile Cranes.

Step 1 - Before turning the machine on:

The following checks need to be made while the engine is off and we recommend that they are done in the following order.

Important Features

- ✓ Inspect Hydraulic Lifts & Tilt Rams (if applicable) - are these lubricated and carry no damage?
- ✓ Battery - are the bracket terminals secure and clean?
- ✓ Are the battery electrolyte levels correct and caps in place?
- ✓ Is the battery charge sufficient for a day's work?

After these steps there are then a bunch of machine specific steps that are unique to each class of machine that you will need to visually inspect prior to turning the machine on. This involves things like the tracks, booms, arms and ground engaging tools.

Safety Fittings and Features

- ✓ Seat and Seatbelt - working and no damage?
- ✓ Data Plate - is it readable?
- ✓ Warning Decals - are they readable?
- ✓ FOPS & ROPS - are they secure and in good condition?

Coolant, Oil & Fuel Levels

- ✓ Engine Oil Level - correct?
- ✓ Fuel - enough for the day?
- ✓ Transmission Oil Level - correct?
- ✓ Hydraulic Oil Level - correct?
- ✓ Coolant Level Correct for temperature?
- ✓ Fluid Leaks - ensure there are no fluid leaks under the machine

Attachment Security

- ✓ Attachments like Buckets, Brooms, Spreader Bars etc - are they secure and the pins secure?
- ✓ Is there any damage to attachments that is visible? Make a note
- ✓ Ground Engaging Tools and surface (such as tracks, buckets etc) - is the cutting edge loose or worn?

At the end of these basic checks, plus the visual inspections you make that are specific to the machine you are checking, then it's time to turn the key. Make note of how smoothly it started and whether it's running well at the point of start.

Step 2 - After turning the machine on:

Now, it's time to get that machine purring and run through the final safety inspections.

General Functions (common to all machines)

Horn - does it work? And is there any issue with its volume?
Hand Controls - do they operate correctly?

- ✓ Foot Pedals - are they clean and do they operate correctly?
- ✓ Control Panel - are there any issues with warning indicators, lights and gauges?
- ✓ Reversing Beeper - does the machine operate in reverse? And do the beepers work?
- ✓ Lights - do they work? Can they operate on spot or drive mode?
- ✓ Rotating Warning Light - is it operational?
- ✓ Park Break - does it hold the machine on an incline?

After these general checks, we are going to run through a bunch of unique features with your machine - like operating the boom, bucket, rippers or GPS if these are fitted to the machine. We'll discuss these below.

Step 3 - While driving the machine now:

To complete the final checks you need to drive the machine a small distance.

- ✓ Is the steering working well with no undue noise/stress?
- ✓ Steering clutches - is there no excessive play?
- ✓ Creep - the machine doesn't creep when controls are neutralised

5 Simple Steps to Maximize Safety at Your Plant

When considering what an organization must have for consistent production, more often than not a facility's safety is not the first thing to come to mind. But dig a little deeper and you'll find that the safety of a facility comes from the very aspects that make for efficient production. What are these key factors? From the technical know-how of operating machines through training to maintaining machines that operate at high levels, every aspect of safety leans toward efficiency. Below are five necessary steps to improve the safety of a standard production facility.

1. Ongoing Safety-Focused Training

All new machine operators and maintenance technicians should have a mandatory training process so they can be eased into using and maintaining complex assets. This requires each employee to go through the same safety training exercises using each machine at the facility. Even if one has been working at the plant for a long time, machines are constantly changing as technology evolves. Schedule a few days each year with your employees and conduct the necessary training to ensure everyone stays up to date with the safest way to use the equipment.

In addition, having a safety test administered at the end of the training helps to confirm that personnel understand their own experience level. It might seem like wasted time from normal production, but it's not. Unfortunate accidents cause huge declines in output through long delays. This alone should give you enough reason to dedicate time to safety awareness training.

2. A High-Performing Asset Is a Safe Asset

As the saying goes, "You can hurt yourself far worse with a dull knife than a sharp one." This applies to heavy machines, too. New machines work with ease and can get the job done fast. However, after enough wear and tear, every machine comes to a breaking point. If you are running the equipment past its recommended limits and don't pay close attention to its performance and condition, you are asking for trouble. This situation can result in an endless list of problems that create hazards for both the user and those around the machine as well.

Using proper lubricants will help keep machines functioning at their highest level for longer periods of time. On the contrary, one of the quickest ways to run down a machine is to not oil it or grease it regularly. This not only leads to a machine that functions in unpredictable

ways but also one that can break down unexpectedly and even put an operator in danger in the process.

Maintenance strategies such as predictive maintenance are very useful in increasing the reliability and availability of critical assets. By better understanding your equipment and identifying when it will begin to wear down, you will know what you can do to prevent a machine breakdown. Ultimately, machines that are operated in the optimum condition by people who know how to interact with them are highly unlikely to cause safety problems.

3. Keep Your Facility Tidy and Organized

It is common to race the clock throughout the day. In a plant where many people are operating large machines and each individual is trying to work at the quickest possible speed to make progress on the busy schedule, accidents can occur that otherwise could have been prevented. This might involve empty boxes obstructing a lane, spilled liquid that will be cleaned later, wires and tape that will be put away as soon as the next order is filled, etc. During the pressure of the day, it's understandable that organizing and cleaning tasks may get pushed back to whenever one has time. In the end, though, this can be a big safety concern.

Keep in mind that a facility's safety is increased tenfold the moment an operation makes cleanliness and order the main focus. By acting on spills and accidents as soon as they happen, the hazard is almost removed completely. When each team member does his or her part, everyone can have more peace of mind. Waiting for someone to get seriously injured before introducing necessary changes is simply bad practice.

4. Review Your Facility's Layout for Possible Dangers

You may have worked at your facility for years and know where everything is, but that doesn't mean everyone else does, too. Verify that there is quality lighting in every area of your facility, especially around signs. Also, the message behind each sign must be fully understood by all employees to ensure everyone knows what safety precautions to take.

If your facility has piping systems, take great care in labeling each of the pipe's contents. When there is a damaged pipe, repair or replace it before the damage increases. Always expect the worst and prepare accordingly.

If there are chemicals in your facility, each worker must have sufficient understanding of the hazards and risks involved in the unfortunate event of a chemical leak. This would include what steps must occur, how to deal with an accident and what to do if you have been exposed to the chemical.

Floor markings provide another great way to stay on top of possible dangers. These types of markings are used to alert facility personnel of dangerous chemicals. They can notify anyone in the area about which places are not safe to walk and can alert personnel of hazardous zones in a facility that are normally safe.

Routine Machinery and Building Safety Checks

Scheduled safety checks are key. Set a date at the beginning or end of the month and devote a large portion of the day to evaluate the following:

- ✓ Employees are using protective equipment at all times.
- ✓ Daily proactive maintenance checks are being performed.
- ✓ Walkways and stairwells are free of debris.
- ✓ Emergency exits are unlocked and easily accessible.
- ✓ Stray cords are put away.
- ✓ Liquids are dried and cleaned from all surfaces.
- ✓ All chipped concrete or holes have been covered or smoothed out.

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Lessons Learned

Safety is the backbone of all plants. Without safety, you have accidents and machine failures, which lead to delays and people getting hurt. However, with safety, you have efficient and consistent output, which is the goal of all organizations. By keeping safety at the heart of every decision you make in your facility, there's no question you will lead a successful operation.

SHUT DOWN SYSTEMS/ EQUIPMENT

HOW TO PLAN FOR PLANT MAINTENANCE SHUT-DOWN

Some factories temporarily shut down each year for scheduled plant maintenance shut-down. Within that period of time, the plant floor is cleaned, equipment is inspected or replaced, processes are improved, and/or production lines are added. The "off-line" time can be detrimental, or advantageous, to your bottom line depending if a plan is properly prepared and executed through these 5 phases.

Phase I: Define and Implement Strategies for Plant Maintenance Shut-Down

- ✓ Provides a foundation for the goals of your plant maintenance shut-down.
- ✓ Analyzes how frequently plant maintenance must be performed to allow the production process to function optimally.
- ✓ Estimates how long plant maintenance shut-down must occur, and assesses the best time for plant maintenance shut-down to occur, in relation to manufacturing forecasts. Plant maintenance shut-down is a long-term business strategy – not a "week of" decision.
- ✓ Key drivers of plant maintenance shut-down:
    - Improve equipment to reduce waste in manufacturing resources, thus reducing operating costs.
    - Improve overall equipment effectiveness (OEE).
    - Maintenance equipment to sustain its equipment life cycle.
    - Maintenance equipment to improve mean time between failure (MTBF).
    - Equipment inspection.
    - Equipment repair.
    - Replacement of worn equipment.
    - Replacement of broken equipment.
    - Replace depreciated equipment (ie: Equipment that has reached the end of its useful life).
    - Ensure compliance with health & safety codes.
- ✓ Be mindful of and create a budgetary buffer for the fact that unexpected issues will be found internal to the system, once maintenance inspections have begun.
- ✓ Appoint a steering committee to lead the plant maintenance shut-down. That committee should host meetings with executive management to assess how the maintenance shut-down will impact the greater good of the company, and to assess what Key Performance Indicators (KPIs) are most important to the company's long-term business goals. Typical KPIs include safety, cost, production scheduling, labor hours, overtime hours, lead times, and more. By assessing KPIs, a business can prioritize its investments in system components, based on level of importance to the business' common, overarching goals. (Example: If the goal is to increase capabilities at bulk bag loading stations, a wise investment would be in a flap diverter to double the loading capacity capabilities. A less appropriate investment would be in a new silo of equal size above the loading station, if that silo was still capable of efficiently holding materials.)

- ✓ Make a list of all equipment parts that should be up for debate. Categorize those list items based on what items are required for maintenance to remain compliant with agency guidelines, and which improvements are "a la carte" to benefit the system's goals, ranking in level of importance. Use data analysis to determine what equipment areas are "bottlenecks" and more degrading to efficiency, in comparison to the rest of the system. Upon analysis of improvement priorities, finalize what improvements will be made during the curing system shut-down by adding them to the CMMS (Computerized Maintenance Management System). Those improvements that were opted against for this shut-down should be noted, so that they can be re-considered for the next system shut-down.
- ✓ Be sure the improvements being made during plant maintenance shut-down can only be done during full shut-down. If a task can be performed while the system remains active, the company is not best utilizing their shut-down resources.
- ✓ Document the estimated costs, down-time schedule, list of jobs, and estimated resources needed to complete the shut-down project. This allows the company to anticipate the full scope of the project. Have this agreement approved by the shut-down steering team and the company executive team before the project is to begin. Once approved, disseminate the information throughout the organization, so that there is project transparency across company sectors.

Phase II: Plant Maintenance Shut-Down Preparation

- ✓ Develop plans for how the maintenance will be performed, prior to project execution. To reinforce the improvements being made, consider adjusting the company's environmental, health and safety plans. Analyze the different manufacturing departments to determine if they can be optimized or otherwise improved in any way. Determine the logistics on what materials are needed for the shut-down project, when they will arrive on-site, how they will arrive on-site, and who will be working on this equipment during the shut-down. Make sure equipment and materials are ordered early, so that the shut-down is not delayed. Consider how the equipment and materials will be stored until they are called upon during shut-down.
- ✓ Develop plans for quality assurance. This provides standard procedures for quality control techs, so that they can inspect new equipment after system shut-down has concluded, to be sure the equipment is running safely and efficiently.
- ✓ Using information from Phase I, develop the work package. A work package details the job scope, the number of laborers assigned to the shut-down project, the estimated number of labor hours needed for project execution, and scheduling of task completion. This includes a detailed, step-by-step instruction plan on how the project will be complete. Include safety steps and precautions to be taken, drawings of the project at-hand, and photos to support how each sub-project will be completed most effectively.
- ✓ Determine what steps of the shut-down will be completed using internal resources, and which project stages will external resources be necessary. For those jobs demanding external resources, begin fielding bids from contractors for such jobs. (Example: Contracting a crane company to remove valves from line.)

- ✓ Create contingency plans, to account for any risks or problems that may occur during plant maintenance shut-down.
- ✓ Determine any necessity work that must be done pre-shut-down. Complete those jobs, so that they are ready to accommodate the shut-down improvements, when called upon. (Example: If adding a production line, prepare new piping to run toward the inlet and outlet of new equipment.)
- ✓ If Phase II is done correctly, a full, detailed schedule of the plant maintenance shut-down will be complete, and cost figures will be estimated within approximately 10 percent of budget allocations.
- ✓ Have plans approved by both the shut-down steering committee and the company executive team. Once approved, communicate Phase II to each of the company's departmental sectors, to create project transparency.
- ✓ It is also important to consider the effects the shut-down may have on your customers and constituents. If the shut-down will have a direct impact on the customer, frequent and effective communication is crucial. Update your customers regularly throughout the process to reduce the risk of dissatisfaction and future loss of business.

Phase III: Execution of the Project

- ✓ As previously discussed, once the project begins, it is the inevitable that undetected and unpredictable findings will arise during inspection. On the fly, it is important to assess these issues to determine the necessity of their repair, the costliness of their repair, and how they will affect the overall scope of completion for the original project. Be sure to stay true to the work package, to avoid working over-budget, and to be sure the important projects are brought to fruition during the allotted project time schedule.
- ✓ Be sure the internal and external resources on the project are well-managed, so that the project is being executed efficiently.
- ✓ Update the work package schedule daily, so that resources who finish their tasks early can be re-delegated to assist on tasks that are understaffed, not begun, incomplete, or otherwise behind schedule. Prioritize which projects are more pertinent to the project's overall success, as well as which projects are more or less time-consuming. This creates a planned sequence for job tasks. Continuously update the package, so that communication across the project team is transparent for what projects have or have not been completed, and which projects are currently in progress.
- ✓ Track data to compare with the pre-determined KPIs – ie: actual vs. estimated labor hours, actual vs. estimated overtime hours, actual costs vs. budgeted costs, etc. This data is critical to project progression, in order to maximize costs and labor utilization. For example, if the project is developing too slowly and the staff is at maximum utilization plus ample overtime, it may be necessary to contract more resources to assist on the project. Oppositely, as the project comes to an end, often times, only a few tasks remain. In many instances, the crew becomes overstaffed for completing these minor tasks. KPI analysis allows the project supervisor to

determine when resources are not being fully utilized, so that they can make the decision to cut resources for project cost efficiency.

- ✓ Once improvements and repairs have been complete, the system must be tested to be sure all improvements are running as predicted.

Phase IV: Start Up & Turn Over

Part I: Handoff

- ✓ Once testing has been complete by the shut-down team, the operations team is introduced to the new system. Then, the operations team runs testing on the full asset base to be sure the process was actually improved. The shut-down team stands by as tests are performed, to provide technical support, if necessary.

Part II: Ramp Up

- ✓ Once testing has been complete by the operations team, trials runs are performed by the system, so that the equipment can be observed in-operations and adjustments can be made accordingly. This stage is arguably the most important aspect of plant maintenance shut-down, as it is the time when errors are most likely to occur, and it is the most important aspect of the project because it determines how the system as a whole will operate and stabilize, moving forward.

Part III: the Punch List

- ✓ Once the shut-down team and the operations team are satisfied with the results of the shut-down, the shut-down team does a final walk-through to assess what tasks on the project list were completed, and which ones were not. Because of budgetary issues and un-predictable issues, it's nearly impossible to finish all items on the punch list. However, by determine what items were not complete during this shut-down, it creates a starting point when planning the next system shut-down.

Phase V: Evaluation

- ✓ Demobilize the work site: Plan the logistics for returning any external resources or equipment. Determine how unused resources will be disposed. Clean the work site to prepare it for operations. Get rid of the equipment removed from the system. Tear down any trailers/offices constructed for the purpose of the maintenance shut-down (ie: Those assembled to house external work teams).
- ✓ Host a post-mortem meeting to summarize the success/failures of the shut-down project. Detail the work that was complete, what remains to be complete, and lessons learned on the project. Assess the KPIs and determine the efficiency of the project's completion, to learn from the data to better shut-down practices for next time. The premise is that if best practices can be determined, fewer problems and unforeseen complications will arise during upcoming projects, making the project streamlined of error or ambiguity.
- ✓ Finally, tie up the loose ends of the project. For bookkeeping purposes, close purchase orders, work orders, external resource contracts, or any other financial paperwork that must be processed for project completion. Keep records of how

much material was used versus quantities returned upon project completion, so that more accurate material quantities can be ordered when they are needed for the next shut-down project.

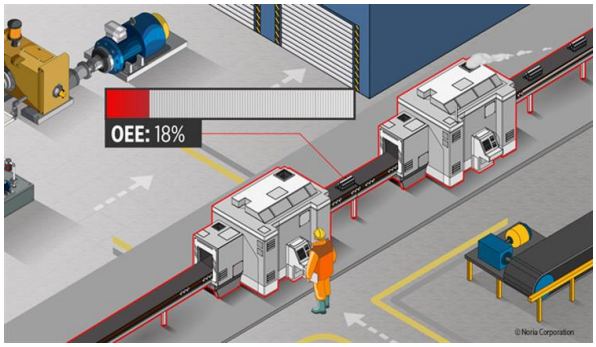
- ✓ Make a cost analysis document to directly compare estimated/budgeted costs versus actual costs. Based upon this analysis, draw conclusions on how the numbers can be more accurately aligned on future projects.
- ✓ Over time, until the next shut-down is to occur, continuously monitor the equipment that was improved during the previous shut-down. This helps to justify the effectiveness of decision making in previous shut-down(s), and gives insight on major equipment categories that are most impactful for improving the asset base.

Because career changes occur, it is unlikely that the same shut-down team will work on multiple projects – especially consecutively. This is why thorough and formal documentation is necessary throughout each phase of shut-down, as it serves as an "instruction manual" for the team(s) to follow. The key factors to successful plant maintenance shut-down are simple: Outstanding management, repeatability, and consistency. If the best practices are streamlined, understandable and attainable for any team, regardless of ever-changing resources, shut-down projects themselves will also be well-oiled machines.

MAINTAIN PLANT EFFECTIVENESS

What is Overall Equipment Effectiveness (OEE)?

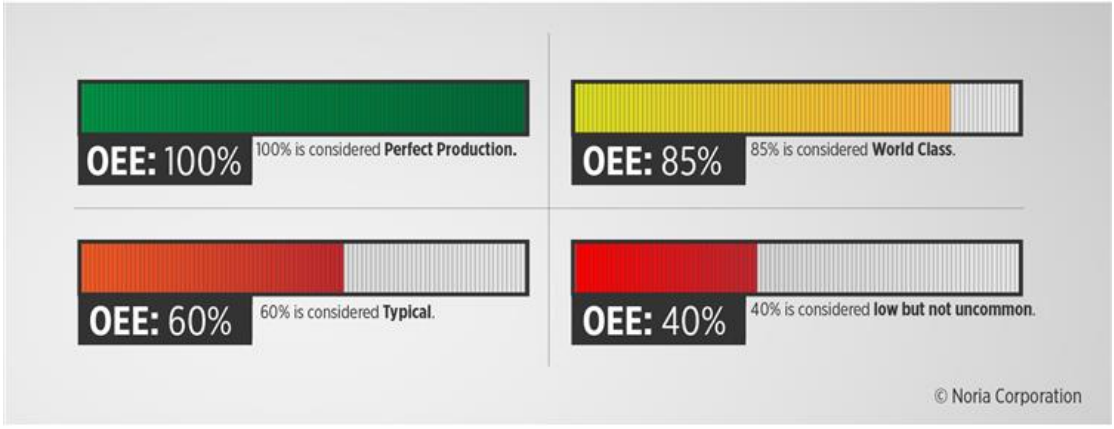
Overall equipment effectiveness (OEE) is a term used to evaluate how efficiently a manufacturer's operation is being used. In other words, overall equipment effectiveness helps you notice a problem in your operations, identify which percentage of manufacturing time is actually productive and fix it while giving you a standardized gauge for tracking progress. The goal for measuring your OEE is continuous improvement.



How to Use Overall Equipment Effectiveness (OEE) to Measure Manufacturing Productivity

Overall equipment effectiveness is a powerful figure. It provides a lot of information in one number, so there are multiple ways OEE is used to measure manufacturing productivity. When calculated and interpreted correctly, it can significantly maximize your production. Overall equipment effectiveness is used as a benchmark to compare any given production to industry standards, in-house equipment or other shifts working on the same piece of equipment. Standard OEE benchmarks are as follows:

- ✓ An OEE score of 100 percent is considered perfect production, meaning you're only manufacturing quality parts as quickly as possible with no downtime.
- ✓ An OEE score of 85 percent is considered world class for discrete manufacturers and is a sought-after long-term goal.
- ✓ An OEE score of 60 percent is typical for discrete manufacturers and shows there is considerable room for improvement.
- ✓ An OEE score of 40 percent is considered low but not uncommon for manufacturers just starting to track and improve performance. In most cases, a low score can easily be improved through easy-to-apply measures.



Overall Equipment Effectiveness is not only a great tool for managers but can have a significant impact on employees working the plant floor. Plant floor metrics can include:

- ✓ Target - A real-time production target

- ✓ Actual - The actual production count
- ✓ Efficiency - The ratio of target to actual; the percentage of how far ahead or behind production is
- ✓ Downtime - This includes all unplanned stoppage time for each shift and is updated in real-time.

Overall Equipment Effectiveness: Terms to Know

Before we discuss overall equipment effectiveness further, there are some important terms to be aware of.

- ✓ Fully Productive Time - Production time after all losses are subtracted
- ✓ Planned Production Time - The total time your equipment or system is expected to produce
- ✓ Ideal Cycle Time - The time it takes to manufacture one part
- ✓ Run Time - The time your system is scheduled for production and is running
- ✓ Total Count - The total of all parts produced including those with defects
- ✓ Good Count - Parts produced that meet quality-control standards
- ✓ Good Parts - Parts produced that meet standards and don't need to be redone
- ✓ Quality - This refers to manufactured parts that don't meet quality-control standards, including ones that need to be reworked. It is calculated as Quality = Good Count / Total Count.
- ✓ Performance - This takes into account the number of times there are slowdowns or brief stops in production. A perfect performance score in OEE terms means your operation is running as quickly as possible. It is calculated as Performance = (Ideal Cycle Time x Total Count) / Run Time.
- ✓ Availability - This takes into account planned and unplanned stoppage time. A perfect availability score means your operation is constantly running during planned production times. It is calculated as Availability = Run Time / Planned Production Time.

How to Calculate Overall Equipment Effectiveness (OEE)

Before calculating overall equipment effectiveness, it's important to denote the difference between the terms effectiveness and efficiency when discussing OEE.
Effectiveness is the relationship between what could technically be produced and what is actually produced at the end of a production period. For example, if your machinery is capable of making 100 products an hour and it only makes 80, then it is 80 percent effective.

However, this doesn't tell us how efficient the machinery is because we didn't consider things like the number of operators, energy and the materials needed to reach 80 percent effectiveness. For example, if your machinery runs 60 percent effective with one employee and becomes 75 percent effective with two employees, the effectiveness increases by 25 percent, but efficiency decreases to 50 percent based on labor.

There are two main ways to calculate OEE:

- ✓ Simple Calculation: The easiest way to calculate OEE is the ratio of fully productive time to planned production time. It looks like this: OEE = (Good Count x Ideal Cycle Time) / Planned Production Time.
- ✓ Preferred Calculation: This type of OEE calculation is based on the three OEE factors discussed earlier – availability, performance and quality (good count). It looks like this: Availability x Performance x Quality = OEE. This is the preferred calculation method because not only do you get your OEE score showing how well you're doing, but you get three numbers (availability, performance and quality) showing what caused your losses.

What Are the Six Big Losses When It Comes to Overall Equipment Effectiveness (OEE)?

Perhaps the biggest goal of implementing an OEE program is to reduce or eliminate the most common causes of machine- or equipment-based productivity loss, known as the six big losses. These six losses are broken down into the three main OEE categories (availability, performance and quality).

Availability Loss	**Equipment Failure**
	Setup and Adjustments
Performance Loss	Idling and Minor Stops
	Reduce Speeds
Quality Loss	Process Defects
	Reduced Yield

Available Losses

- ✓ Equipment Failure: This is equipment that is not running when it is scheduled for production, causing unplanned downtime. Machine breakdowns, unplanned maintenance stops and tooling failure are common examples.
- ✓ Setup and Adjustments: This is production downtime due to changeovers, machine and tooling adjustments, planned maintenance, inspections and setup/warmup time.

Performance Losses

- ✓ Idling and Minor Stops: Sometimes called small stops, idling and minor stops are when equipment stops for a short period of time. This can be caused by jams, flow obstructions, wrong settings or cleaning. These issues are usually resolved by the operator.
- ✓ Reduced Speed: Sometimes referred to as slow cycles, reduced speed is when equipment runs at speeds slower than the ideal cycle time (the fastest possible time). Worn out or poorly maintained equipment due to poor lubrication practices, substandard materials and bad environmental conditions are common causes of reduced speed.

Quality Losses

- ✓ Process Defects: This refers to any defective part manufactured during stable production, including scrapped parts and parts that can be reworked. Incorrect machine settings and operator or equipment errors are common reasons for process defects.
- ✓ Reduced Yield: Reduced yield refers to defective parts made from startup until stable production is achieved. Like process defects, this can mean scrapped parts and parts that can be reworked. Reduced yield most commonly occurs after changeovers, incorrect settings and during machine warmups.

Five Benefits of Using Overall Equipment Effectiveness (OEE) to Improve Production

Implementing an overall equipment effectiveness strategy is a powerful advantage in achieving your production targets. It allows you to take a proactive approach by tweaking manufacturing processes in real time, reducing downtime, increasing capacity, reducing costs, improving quality and increasing efficiency. Let's take a look at 10 benefits of OEE.

- ✓ Return of Investment (ROI) for Equipment: Companies invest heavily in machinery, so it's important to maximize the return on this investment. If you can use an OEE strategy to produce 15 percent more product on the same equipment in the same amount of time, it can greatly impact your bottom line.
- ✓ Increase Competitiveness: Manufacturers always strive to reduce losses during production to achieve maximum competitiveness. Using data from an OEE report helps you identify bottlenecks or weaknesses in production, allowing you to take immediate action.
- ✓ Quality and competitiveness go hand-in-hand, and OEE's quality metric can help you identify problems in production causing scrap or rework parts.
- ✓ Cutting Machinery Costs: An OEE strategy helps you understand your equipment's actual performance so you know whether it is working efficiently. It also alerts you to issues that may lead to future breakdowns and repairs. Overall equipment effectiveness lets you anticipate potential machine failure, reducing maintenance costs and downtime.
- ✓ Maximize Workforce Productivity: Use OEE to see why you experience operator downtime, reveal productivity data and pinpoint long changeovers or setup times.

Information like this helps you appropriately allot resources, identify where excess capacity is occurring and determine where you need new hires.

- ✓ Easily Visualize Performance: Overall equipment effectiveness emphasizes visibility, letting you visualize production problems instead of having to rely on your best guess. By highlighting the biggest sources of productivity losses into one single percentage, everyone can see what's working and where improvement is needed.

Overall Equipment Effectiveness (OEE): A Case Study

Based out of Fort Collins, Colorado, New Belgium Brewing company started as a small-batch hobby brewery and quickly became the nation's third biggest craft brewery (eighth overall) by 2012. Making popular beers such as Fat Tire amber ale, New Belgium quickly found itself struggling to keep up with demand, especially when it came to bottling. With their brewing operations quickly reaching capacity, New Belgium was struggling to identify efficiencies and inefficiencies in their bottling lines. Their goals quickly shifted toward improving OEE. The goals were as follows:

- ✓ Increase the brewery's ability take advantage of more manufacturing capabilities.
- ✓ Improve Overall Equipment Effectiveness (OEE) so quality products are being produced, production efficiency is managed and make sure the production line is available during scheduled downtimes, package changes and maintenance procedures.
- ✓ Operate the brewery at full capacity and double case production.

New Belgium faced a few challenges when it came to meeting their OEE goals. It didn't have any way to view real-time information during unscheduled downtimes on various equipment, causing slowdowns; The production team were constantly reacting to unscheduled downtime on certain assets; and the bottling operation didn't have the ability to predict capabilities, which would allow them to effectively place brewery staff in certain areas to help meet specific production goals.

Over a five-year span, the brewery implemented a series of manufacturing automation initiatives, including an upgrade to their manufacturing automation software system to help streamline its bottling production and figure out its maximum potential. After an audit, the brewery quickly realized its existing lines are capable of producing 294,000 cases a week, but were only producing 150,000 cases a week due to scheduled and unscheduled downtime.

This issue, coupled with its still archaic manual data recording process, which involved managing paper production logs and spreadsheets, wasn't cutting it when it came to keeping up with the level of production the brewery was facing. They realized using a software-based system for production greatly helped in managing the various beer mixes and packaging options, as well as accurately managing scheduled and unscheduled downtime.

Upgrading their automation system also allowed for the massive amounts of data that was being collected to be put into context, making it easier to analyze and be turned int

actionable information. This greater visibility of the overall production picture led to a real understanding of the actual production capacity, which helped predictable order fulfillment.

Finally, New Belgium needed a way to react more quickly to unscheduled downtime. Thanks to the data from the upgraded software, the brewery realized it need to increase its maintenance team by 60 percent. They added a process improvement and analysis team, educated key staff in Kaizen processes and trained other team members in Six Sigma to react to issues more quickly.

New Belgium needed an effective way to gather, processes and analyze data to better benefit its overall business production. It had a significant impact on the brewery's OEE:

- ✓ OEE increased from 45 to 65 percent in a little over two years.
- ✓ Downtime was decreased by over 50 percent.
- ✓ Scheduled run time efficiency increased by 25 to 30 percent.
- ✓ Production weeks broke records by producing 190,000 to 200,000 cases consistently.
- ✓ Packaging area capacity was extended to around 1.3 million barrels a year.
- ✓ The brewery maintained lower operating costs by delaying capital investments.

UNIT 14

COLLECT SAMPLES AND PERFORM BASIC WATER TESTS

This unit of competency covers the ability to collect samples at field or production sites using specified equipment and standard or routine procedures

PREPARE FOR SAMPLING

Fundamental to water-quality sampling is the fact that the analytical results can be no better than the sample on which the analysis was performed. Thus, the sample collector must accept primary responsibility for the quality and integrity of the sample up to the time that it is delivered to the analysing laboratory or office. Communication and collaboration between field and laboratory personnel is essential to producing valid data from the sampling effort.

Field Personnel Responsibilities

Before sample collection begins, field personnel must take steps to ensure that the samples collected will be representative of the aqueous system being investigated. A representative water sample is a sample that typifies ("represents") in time and space that part of the aqueous system to be studied and is delineated by the objectives and scope of the study. Take a whole-system approach, meaning that data-collection methods ensure representation of an entire stream reach or aquifer volume. A modified approach is needed for studies in which samples are representative of a specific part or aspect of an aqueous system instead of the entire system; for example, a study of aquatic ecology may establish nearshore boundaries on the system, and an oil-spill study may target only the surface of a water-table aquifer.

- ✓ Be alert to sample representativeness. The data are no better than the confidence that can be placed in how well the sample represents the aqueous system (Feltz and Culbertson, 1972; Horowitz and others, 1994).
- ✓ Plan to collect quality-control samples. Quality-control checks applied during laboratory analyses of the samples cannot compensate for data that are biased because samples were not representative of the aqueous system or because samples were improperly collected and processed.

Field personnel also are responsible for providing the necessary information to establish USGS National Water Information System (NWIS) site files for each sampling site and for checking to see that the site file is functional, that the information it contains is correct, and that updates are made promptly. NWIS is the hydrologic data base for the U.S. Geological Survey. Updated versions are released periodically.

Update files promptly:

- ✓ The Ground-Water Site Inventory (GWSI) file contains site information.
- ✓ The Quality-of-Water Data (QWDATA) file contains field and laboratory data.
- ✓ The Automatic Data Processing System (ADAPS) file contains time-series information.

Field-Trip Preparations

All details of a field trip need to be planned well in advance. Adequate time must be scheduled in the work plan to review data requirements and make field-trip preparations; a common mistake is to put off these activities until the last minute.
Before selecting sites or making other preparations:

- ✓ Understand the purpose for which the various types of data will be collected and the aqueous system that each sample should represent.
- ✓ Review the study workplan, especially types of measurements and samples needed.
- ✓ Make field reconnaissance trips before selecting sampling sites, if possible.
    - Note conditions that could affect sampling operations (such as the seasonal high or low streamflow, flowing wells, or siteaccess peculiarities).
    - Evaluate potential sources of contamination at the site, based on target analytes1 to be collected.
- ✓ Review site files and field folders. (Note site location, description and access, and review any previously collected physical, chemical, and biological data.)
- ✓ X Obtain and keep current with training and the laboratory requirements associated with your data-collection activities.

Checklists Of Equipment, Supplies, And Activities

Each study needs to establish and follow a protocol for data-collection activities. Checklists help ensure that equipment and supplies will be ordered on time, that data-collection activities will be completed appropriately, and that data-quality requirements will be met. Most checklists are generic to all projects and sites (for example, vehicle and equipment maintenance checklists), but may need to be customized (for example, items listed, quantities of equipment and supplies, number of batteries, and types of sample bottles and other equipment).

Perform pre-use and safety checks in accordance with workplace procedures and manufacturer instructions

pH meters are calibrated (set to a correct reading) with purchased solutions that have specific pH values. They are called buffers, and are composed of phosphates, acetates, etc., depending upon the pH of the buffer. These are the standards with which the meter is set to work correctly. The pH is listed on each buffer bottle, and it is dependable, but shelf life is limited. Buffers can also be purchased in dry capsule form (long shelf life) and prepared as solutions when needed. Follow the
instructions carefully on the meter for calibration. Instructions are somewhat different for each meter. Use the buffers indicated for calibration with that meter.

Always calibrate a pH meter with two buffers. A pH meter, near the end of calibration, will usually give a reading of “slope.” This has to do with the efficiency of the electrode. It is the change in millivolts per decade of concentration. In pH terms, a decade of concentration is

the difference between pH units, since the concentration multiplies by 10 from 1 pH unit to another. The instrument divides this change in mv/decade concentration by the ideal change in mv/decade concentration and obtains a percentage (of probe efficiency). The reading should be over 90% slope; some meters will adjust for the slight amount off 100% accuracy. If the slope reading is under 90%, repeat the calibration. If it is still off, recondition or change the electrode.

If you are using an older meter and there are no directions for calibration, choose two buffers that straddle the expected pH of the sample. Immerse the electrode in one of them and set the calibration knob to read that pH. Do the same with the other buffer, then set the meter to "read pH" and read the sample.

The buffer solution is really a "buffer." It neutralizes any possible acid or alkaline influences present in the water in which it is dissolved, and the pH should reside very stably at its designated value. When the pH electrode is immersed in the buffer, the reading should not drift. If it does, recondition or change the probe. A pH meter operates in millivolts, and it will give millivolt readings all the way through calibration, making the conversion to pH units at the end.

Identify faulty or unsafe equipment and report to appropriate personnel

pH Troubleshooting Tips

1. Open air port when using. Close when done.
2. Rinse between samples with distilled water.
3. Do not be concerned with odd readings obtained while the electrode is rinsing in distilled water. Although distilled water should have a pH of 7 at 25°C, the electrode has difficulty reading anything at all in distilled water, which does not conduct electricity.
4. Handle the pH electrode carefully. Glass membranes break easily.
5. Wait for the sample reading to settle down before recording it. Wait 5 to 6 min before taking a reading with any electrode method (cleaner waters often have low ionic strength and a slow response time).
6. If an automatic temperature adjustment probe is included with the meter, this must be immersed in the solution with the pH electrode in order to sense the temperature and read the correct pH.
7. Needle drift is frequently caused by the sample changing. Check for drift when immersed in pH 7 buffer. If there is drift when in the buffer, change the filling solution.Recondition or replace the electrode.
8. Don't stir the solution with the pH electrode. It may cause the needle to swing. However,
9. if the sample is not stirred at all, a polarity may build up around the electrode. It is
10. best to stir the sample very slowly with a stir bar.
11. Don't immerse the electrode in very high or low pH solutions. This shocks the electrode

12. and it may have difficulty recovering.
13. Don't immerse the electrode in sample deeper than level of the electrolyte. Sample
14. will flow in rather than electrolyte flowing out.
15. Electrode contamination from electrolyte crystallization can be rinsed off with distilled
16. water. See conditioning instructions in manufacturer's pamphlet.
17. If readings are poor, it is more likely the electrode than the meter that is at fault.
18. Troubleshoot the obvious first:
    - ✓ Is it plugged in?
    - ✓ Is there electrolyte in the electrode?
    - ✓ Is the meter switched to "pH"?
    - ✓ Is the glass membrane broken?
    - ✓ Is the sleeve on the filling port open?
19. After use, store electrode immersed in pH 7 buffer. Never let a pH electrode dry out.
20. Keep electrode clean between uses. pH 7 buffer is phosphate and it stimulates algae
21. and bacterial growth. Change it frequently.

Check calibration status of equipment and report any out-of-calibration items to appropriate personnel

It is important to calibrate equipment according to the manufacturer's specifications to get results. Most electronic equipment will require some sort of calibration. Commonly used water quality testing equipment that requires calibration include incubators, pH meters, turbidimeters, colorimeters and photometers. Manufacturers should give the instructions for calibration when you buy a piece of equipment.

COLLECT SAMPLING

Sampling Surface Water

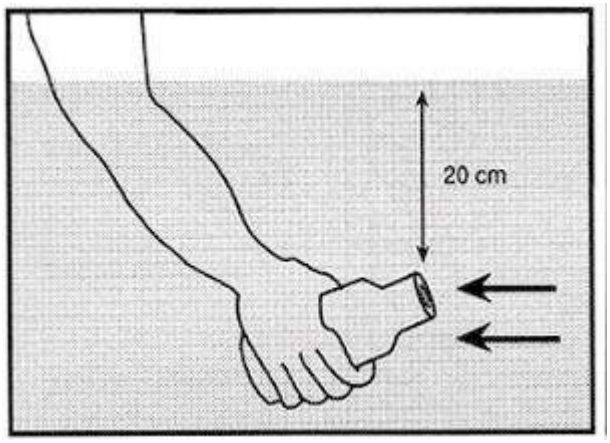
Lakes and reservoirs can be subject to several influences that cause water quality to vary from place to place and from time to time. Where feeder streams or effluents enter lakes or reservoirs there may be local areas where the incoming water is concentrated, because it has not yet mixed with the main water body. Isolated bays and narrow inlets of lakes are frequently poorly mixed and may contain water of a different quality from that of the rest of the lake (UNEP/WHO,
1996).

For rivers or other moving water, you should try to obtain samples from a point where the water is well mixed and representative of the drinking water supply. Do not take samples that are too near the bank, too far from the point of where the drinking water is taken, or at a depth above/below the point of where the drinking water is taken.

Surface water quality can also change depending on the time of day or season. It is important to sample at the same time of the day and record the weather conditions when you are taking your sample.

It may be possible to take the sample by hand if it is easy to get to the water. In many cases it may be inconvenient or dangerous to enter the water. In these cases, you may need to tie your container to a piece of wire or rope and throw it into the water. A bridge is an excellent place at which to take a sample, but only if it is close to where people get their drinking water.

To sample a surface water source:

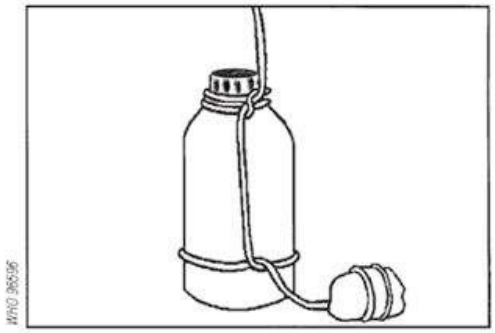


1. Carefully remove the cap from the container and put it facing up in a clean place or ask somebody to hold it. Take care to prevent dust from entering the container or anything else that may contaminate the sample.
2. Hold the sample container firmly and dip the open mouth of the container into the water.

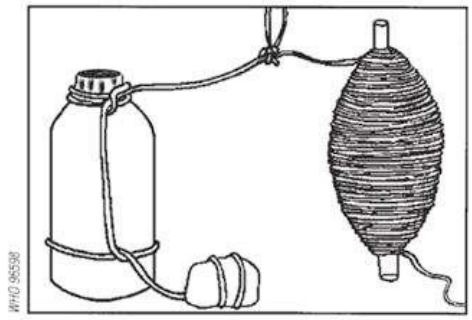
3. Lower the container about 20 cm below the surface of the water and scoop up the water sample. This scooping action ensures that no external contamination enters the sample container. In areas where the water is moving (e.g., rivers), the sample should be taken against the direction of the flow of water.
4. Lift the sample container carefully and place on a clean surface where it cannot be knocked over. If the container is completely full, pour out a little water to leave an air space in the container. This allows space for mixing the water sample before analysis. Put the cap back on the container.

Sampling an Open Well or Tank

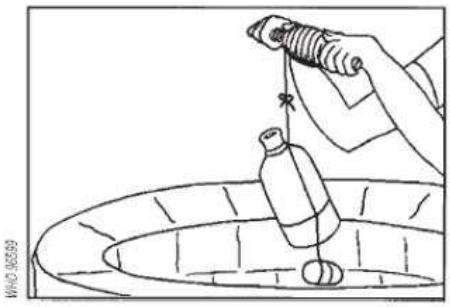
1. Prepare the sample container. Use string, rope or cable to attach a weight (e.g., small rock) to the container.



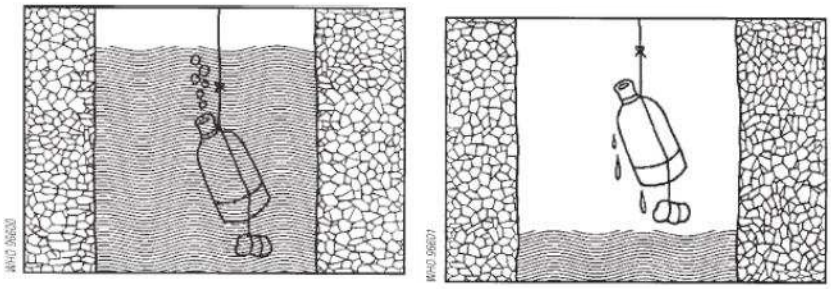
2. Take a 20 m length of string, rolled around a stick, and tie it to the container Open the container as described above.



3. Carefully remove the cap from the container and put it facing up in a clean place or ask somebody to hold it. Take care to prevent dust from entering the container or anything else that may contaminate the sample.
4. Lower the weighted sample container into the well or tank, unwinding the string slowly. Do not allow the container to touch the sides of the well or tank because it may pick up dirt and contaminate the sample.

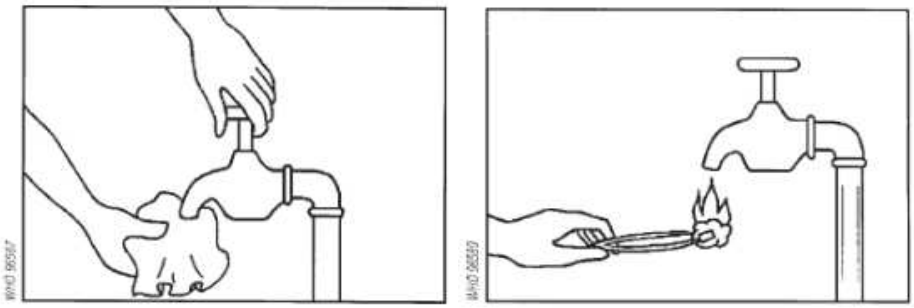


5. Immerse the container completely in the water and continue to lower it below the surface of the water (about 20 cm although this can be difficult to judge). Do not allow the container to touch the bottom of the well or disturb any sediment.
6. Once the container is full, bring it up by rewinding the string around the stick. Lift the container carefully and place on a clean surface where it cannot be knocked over. If the container is completely full, pour out a little water to leave an air space in the container. This allows space for mixing the water sample before analysis. Put the cap back on the container.

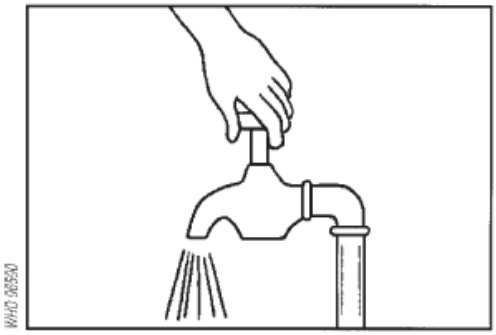


Sampling a Tap

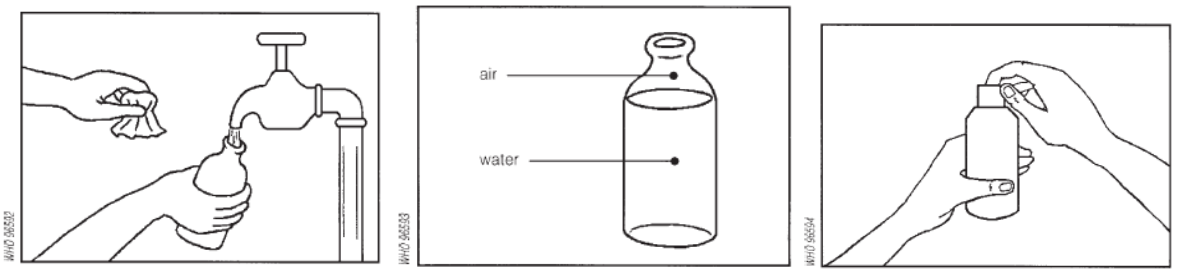
1. Remove any attachments (e.g., nozzles, pipes, screens) from the tap. These attachments are a frequent source of contamination.
2. Optional - Use a clean cloth to wipe the tap and to remove any dirt. Sterilize the inside and outside of the tap for 1 minute. Pour alcohol on the outlet and flame it with a lighter or use tweezers to hold an alcohol-soaked cotton swab that is lit on fire. If the tap is made of plastic, then use an alcohol-soaked cotton swab that is NOT lit on fire, or else the plastic will melt! Sterilizing the tap will tell you the actual water quality. Not sterilizing the tap will tell you the water quality that people are drinking.



3. Open the tap before sampling. Carefully turn on the tap and allow water to flow at a moderate rate for 2-3 minutes to clear out any deposits in the pipes.



4. Carefully remove the cap from the container and put it facing up in a clean place or ask somebody to hold it. Take care to prevent dust from entering the container or anything else that may contaminate the sample. Hold the sample container under the water flow to fill it.
5. Leave an air space in the container. This allows space for mixing the water sample before analysis. Put the cap back on the container.



PERFORM BASIC WATER TEST

In general, water testing can be classified as bacteriological, mineral/inorganic and organic chemicals tests.

- ✓ Bacteriological tests generally check for indicator bacteria (for example, total coliform, fecal coliform or Escherichia coli) and can indicate the presence or absence of disease-causing bacteria. However, there are many types of bacteriological tests that cover a variety of bacteria. These tests are costly and are conducted only if they are absolutely essential.
- ✓ Mineral tests can determine if the mineral content of your water is high enough to affect either health or the aesthetic and cleaning capacities of your water. A mineral test may include calcium, magnesium, manganese, iron, copper, zinc and some others. An abundance of these minerals can cause hard water, plumbing and laundry stains, or bad odours.
- ✓ Organic chemicals tests are generally performed only if there is reason to believe a specific contaminant has infiltrated the water system (such as pesticides entering

the water supply). Industrial and petroleum contamination can also be found through organic chemical testing.

- ✓ Other tests may be conducted on radiological contaminants (radium and radon) or heavy metals (such as arsenic, mercury, lead or cadmium) based on the suspected natural and anthropogenic (man-made) sources of such contaminants

UPDATE DOCUMENTATION

A log sheet or register should be used to record the results of every test performed. The keeping of complete and accurate records is a professional activity and can be used to demonstrate competency in operations. Log books containing all of the log sheets should be maintained in a register for assessment of any technical issues and problems that may arise. Log sheets tend to be designed specifically for each premises and location.

Where automated in-line tests are recorded electronically, these should be downloaded monthly and kept with any other records. It is also possible to represent the data graphically which may add further meaning to the results.

The testing log should be shared with all relevant stakeholders in order to keep everyone informed if there needs to be any actions taken.
The test can be documented as the following log:

Water Testing Log

Save any document providing information on test methods and test results from your laboratory.

Date	Water source (surface, well, etc.)	Laboratory	Results	Corrective actions if necessary	Initials

UNIT 15

MONITOR AND OPERATE POWER GENERATION SYSTEM

This unit of competency describes the outcomes required to operate, monitor and maintain power generation systems and record and report operating data. The unit applies to production support operators who monitor and control power generation facilities

This unit of competency describes the outcomes required to operate, monitor and maintain power generation systems and record and report operating data. The unit applies to production support operators who monitor and control power generation facilities. This typically involves working in a facility with complex integrated equipment and continuous operations.

As a powerhouse operator, it is important that you are familiarized with the equipment and godets used in the engine and control rooms and be familiar with power generation plant operations and maintenance with clear understanding of functions for various shift work and their importance for smooth operation of the powerplants.

CONFIRM OPERATIONAL STATUS

Check production requirements at start of shift and plan daily work activities

Water treatment plants are operated using electrical power and the referred power is often produced through the power plants that are often established together with the water treatment plants. This unit mandates that those working in the powerplants are adequately trained and empowered to ensure they are aware of the power generation process, requirements of associated functions and planning of work within each shift and their operational details.

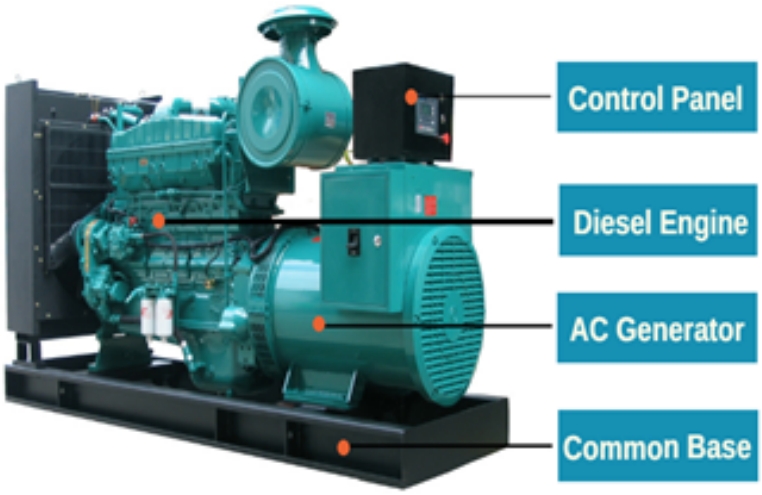
First and foremost, your work schedule needs to ensure that each shift is staffed appropriately for each position and it is important that each staff is made aware of the various shifts tasks that need to be maintained while the powerplants need to be operated round the day for uninterpreted power the water treatment plants.

For a smoother shift, production requirements are determined and each sift personnel is given the work requirements of the shift for effective operation of the power plant and continued production of electrical power necessary to operate water plants and other electrical equipment.

Carefully planned shift and timely attendance of work will ensure the power plant operation is kept smooth and effective implementation of each shift duties and responsibilities.

Confirm power generation processes are within operational specifications

Powerhouse or powerplants established across the Maldives are primarily comprised of diesel generators and the demand for power at the respective location determines required capacity of the powerhouse which influences types and number of generators being installed.



A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

They require less maintenance due to their durability, reliability and the sturdiness characteristic and also, they are considered cheaper to operate due to the low fuels costs as compared to the other types of fuels such as gasoline and propane.

They can withstand heavy load for long hours and start off the power supply on full load within minutes and must be regularly maintained to ensure they provide quality power throughout their service life. The best generator maintenance practice is following the maintenance schedule provided by the manufacturer of the generator to ensure maximum service time for the generator and proper operation when it is called upon to provide power.

The preventive maintenance tips for the diesel generator that guarantees uninterrupted power supply that is innocuous and consistent for all the needs intended for. They include the following aspects:

Routine General Inspection

During the running of the diesel generator, the exhaust system, fuel system, DC electrical system and engine require close monitoring for any leaks that can cause hazardous occurrences. As with any internal combustion engine, proper maintenance is essential. Diesels are no exception, and the most important maintenance is oil changes at every 100 hours of operation for a long and trouble-free life assurance.

Lubrication Service

The engine oil must be checked while shutting down the generator at regular intervals using a dipstick. Allow the oil in the upper portions of the engine to drain back into the crankcase and follow the engine manufacturer's recommendations for API oil classification and oil viscosity. Keep the oil level as near as possible to the full mark on the dipstick by adding the same quality and brand of oil.

The oil and filter must also be changed at acclaimed time intervals. Check with the engine manufacturer for procedures for draining the oil and replacing the oil filter and their disposal is to be done appropriately to avoid environmental damage or liability.

Cooling System

Check the coolant level during shutdown periods at the specified interval. Remove the radiator cap after allowing the engine to cool, and, if necessary, add coolant until the level is about 3/4 in. Heavy-duty diesel engines require a balanced coolant mixture of water, antifreeze, and coolant additives. Inspect the exterior of the radiator for obstructions, and remove all dirt or foreign material with a soft brush or cloth with caution to avoid damaging the fins. If available, use low-pressure compressed air or a stream of water in the opposite direction of normal air flow to clean the radiator.

Fuel System

Diesel is subject to contamination and corrosion within a period of one year, and therefore regular generator set exercise is highly recommended to use up stored fuel before it degrades. The fuel filters should be drained at the designated intervals due to the water vapor that accumulates and condenses in the fuel tank. Regular testing and fuel polishing may be required if the fuel is not used and replaced in three to six months. Preventive maintenance should include a regular general inspection that includes checking the coolant level, oil level, fuel system, and starting system. The charge-air cooler piping and hoses should be inspected regularly for leaks, holes, cracks, dirt and debris that may be blocking the fins or loose connections.

Testing Batteries

Weak or undercharged starting batteries are a common cause of standby power system failures. The battery must be kept fully charged and well-maintained to avoid dwindling by regular testing and inspection to know the current status of the battery and avoid any start-up hitches of the generator. They must also be cleaned; and the specific gravity and electrolyte levels of the battery checked frequently.

Routine Engine Exercise

Regular exercising keeps the engine parts lubricated and thwart oxidation of electrical contacts, uses up fuel before it deteriorates, and helps to provide reliable engine starting. Engine exercise is recommended to be executed at least once a month for a minimum of 30 min. loaded to no less than one-third of the nameplate rating.

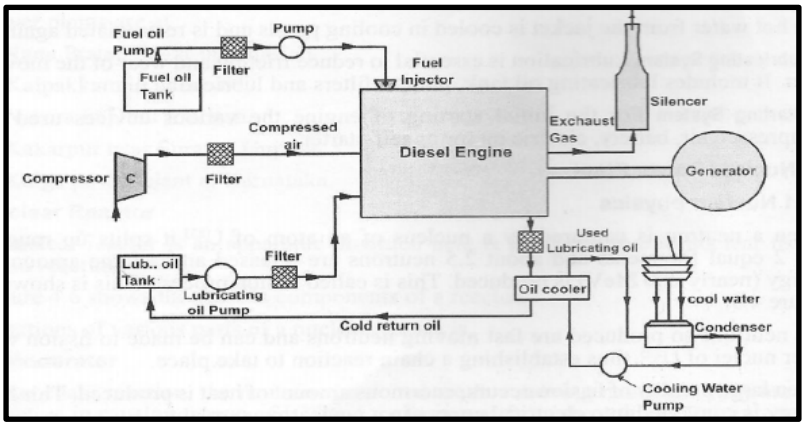
Keep your Generator Clean

Oil drips and other issues are easy to spot and take care of when the engine is nice and clean. Visual inspection can guarantee that hoses and belts are in good condition. Frequent checks can keep wasps and other nuisances from nesting in your equipment.

The more a generator is used and relied on, the more it needs to be taken care of. However, a generator set that is rarely used might not need a lot of care.

Maintain process supplies to meet production requirements.

Demand for electrical power needs to be uninterrupted to ensure power supply system is reliable and consistent throughout.

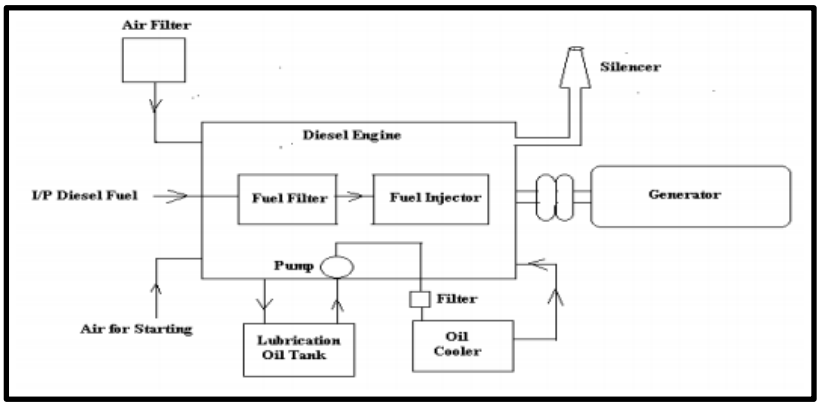


The essential components of a diesel electric power plant are as follow:

1. Diesel Engine
2. Engine Fuel Supply System
3. Engine Air Intake System
4. Engine Exhaust System
5. Engine Cooling System
6. Engine Lubrication System.
7. Engine Starting System.

Diesel Engine:

It is the main components used in diesel electric power plant for developing mechanical power.

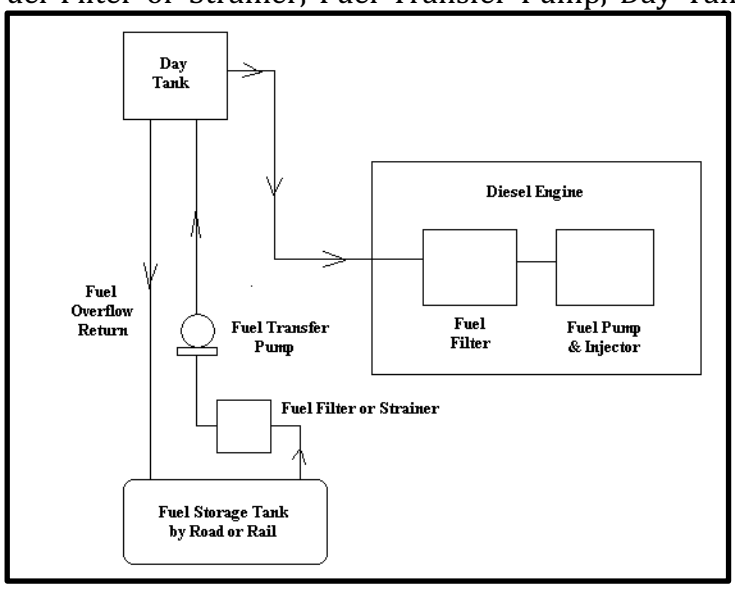


This mechanical power we use to run the generator & produce electrical energy. For producing the electrical energy the diesel engine is mechanically coupled to generator.

When the diesel fuel burning inside the engine, its start to produce a mechanical power. The combustion of diesel fuel produces increased temperature & pressure inside the engine. Due to this pressure gases are formed, this gas pushes the piston inside the diesel engine, and then mechanical power is produced. With the use of this mechanical power the shaft of diesel engine starts rotating.

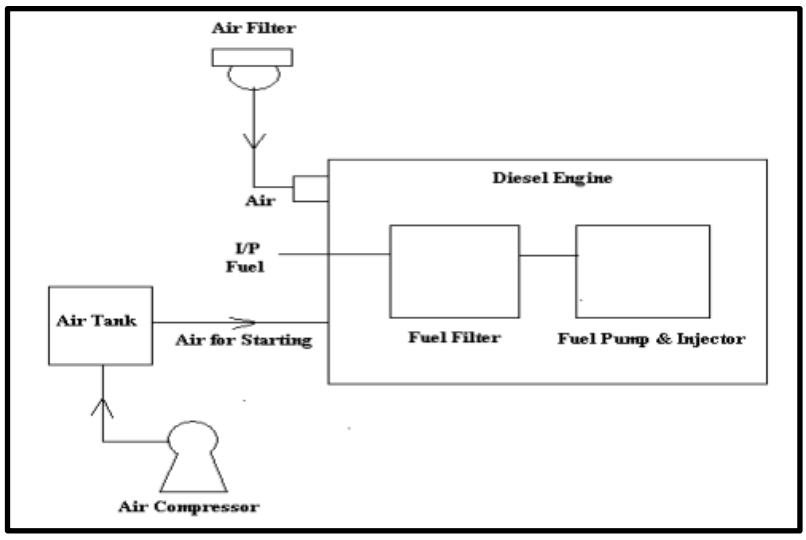
Engine Fuel Supply System:

It consists of Fuel Storage Tank, Fuel Filter or Strainer, Fuel Transfer Pump, Day Tank, Heaters & Connecting Pipes.



First up all with the help of transportation facility available (road, rail etc.) the diesel fuel stored in storage tank. Then this diesel fuel transfer to day tank, the function of day tank is how much quantity of diesel required for 24 hours is store. If the day tank is full or overflow occurs, then excessive diesel returned to storage tank. The filter or strainer is used to purify diesel. With the help of fuel transfer pump the diesel is transfer to day tank.

Engine Air-Intake System



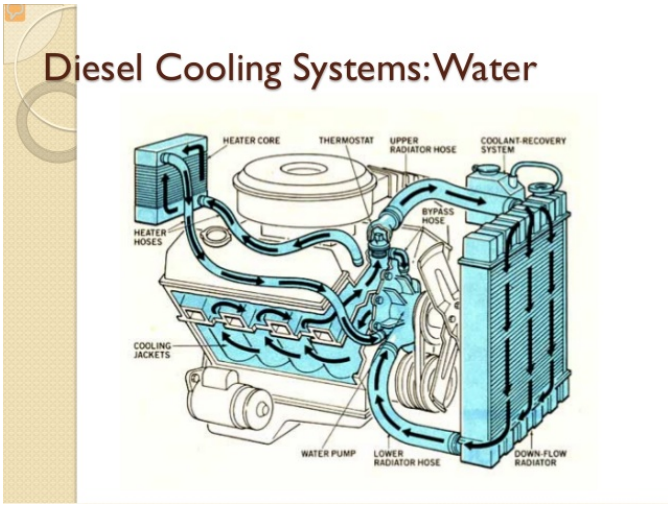
This System includes air filters, air tank, compressor & connecting pipes. The air filters are used to supply the fresh air to diesel engine for the purpose of combustion. Engine required fresh air because, if dust particles in the air entered into the engine will cause disastrous effect to valve, cylinder & pistons. The compressor or Supercharger is used to increase pressure of the air supplied to the engine. This will helps to increase the output power.

Engine Exhaust System:

These systems consist of silencers & connecting ducts. As the temperature of the exhaust gases is sufficiently high, it is used for heating the fuel oil or air supplied to the diesel engine. The exhaust gas is removed from engine, to the atmosphere by means of an exhaust system. A silencer is normally used in this system to reduce noise level of the engine.

Engine Cooling System

The Diesel Engine Cooling System Consist of coolant pumps, water cooling towers or spray pond, water treatment or filtration plant & Connecting Pipe Works.



The heat produced due to internal combustion, drives the engine. But some parts of this heat raise the temperature of different parts of the engine. High temperature may cause permanent damage to the machine. Hence, it is essential to maintain the overall temperature of the engine to a tolerable level. Cooling system of diesel power station does exactly so.

The cooling system is required to carry heat from diesel engine to keep its temperature within safe limits. The water pump circulates water to cylinder of diesel engine to carry away the heat.

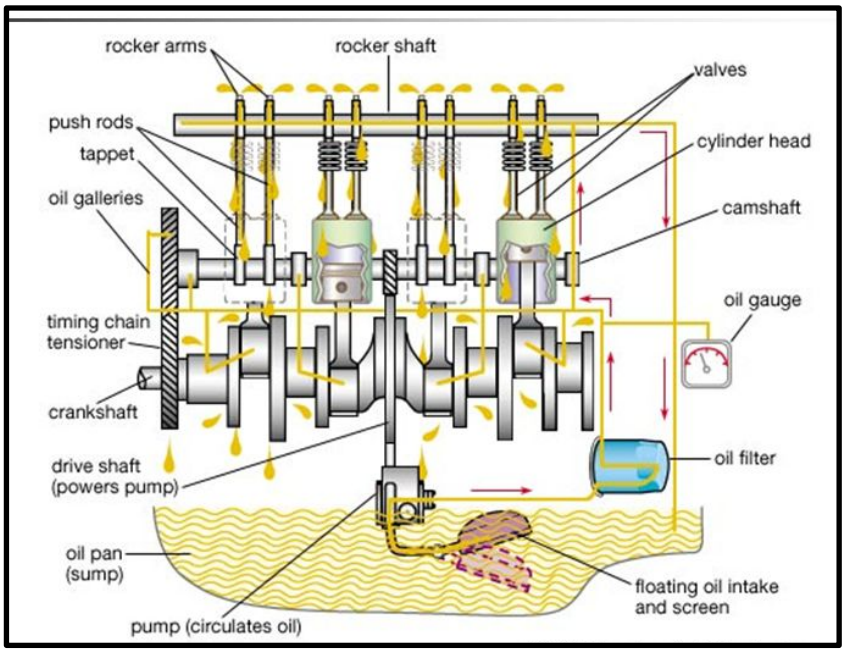
<u>The cooling tower is used for the same water reused.</u>
The cooling system requires a water source, water pump and cooling towers. The pump circulates water through cylinder and head jacket. The water takes away heat from the engine and it becomes hot. The hot water is cooled by cooling towers and is re-circulated for cooling.

The cooling system can be classified into two types:

- ✓ <u>Open Cooling System</u>***:*** A Plant near the river may utilize the river water for cooling & discharging again the hot water into river. This type of cooling system is known as open cooling system.
- ✓ <u>Closed Cooling System</u>***:*** The Cooling Water is circulated again & again and only water lost due to leakage, evaporation etc. is made up by taking make up water from supply source.

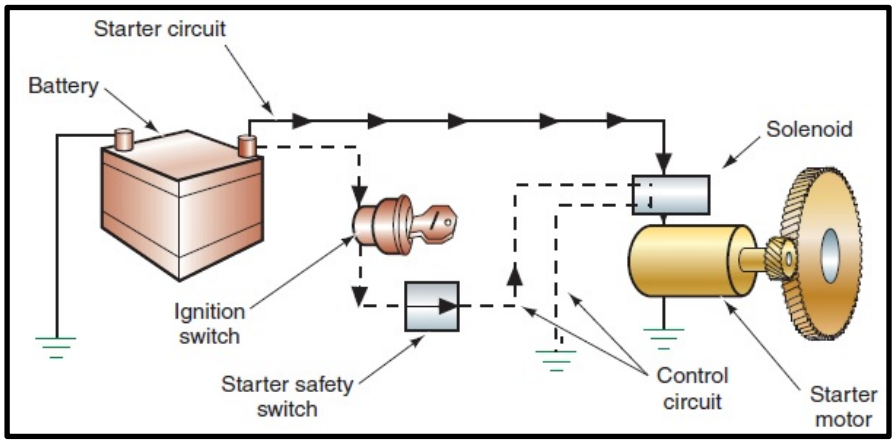
Engine Lubrication System:

Engine lubrication system consists of lubricating oil pump, oil tanks, filters, coolers, purifiers & connecting pipes. This system provides lubricating oil to moving parts of the system to reduce the friction between them wear & tear of the engine parts.



This system minimizes the water of rubbing surface of the engine. Here lubricating oil is stored in main lubricating oil tank. This lubricating oil is drawn from the tank by means of oil pump. Then the oil is passed through the oil filter for removing impurities. From the filtering point, this clean lubricating oil is delivered to the different points of the machine where lubrication is required the oil cooler is provided in the system to keep the temperature of the lubricating oil as low as possible. It is then cooled through heat exchanger by means of cold water and then it is fed to the engine.

Engine Starting System:



The function of starting system is to start the engine form stand still or cold conditions by supplying compressed air. For starting a diesel engine, initial rotation of the engine shaft is required. Until the firing start and the unit runs with its own power. For small DG sets, the initial rotation of the shaft is provided by battery operated starting motors.

To start the electrical motor batteries are used, the motor is geared with diesel engine, it will start rotating with the motor & will start in few seconds & as it picks up the speed the motor gets disengaged automatically. In some cases, the motor works as a generator, this will further help to charge the batteries.

Communicate operational status to relevant personnel

Reporting is the process of communicating an identified issue by notifying the relevant information to the supervisory level and to the appropriate internal and external organizations.

Purpose of the referred communication is to provide detailed procedures, recommendations, suggestions and good practices in managing and implementing reporting activities to ensure that equipment, human performance, procedural and organizational issues are being reported at an appropriate threshold, to the adequate level of supervision, with the adequate level of detail and entered into the reporting process. The issues reporting process includes distribution as appropriate within the plant, to regulatory body or to external organizations according to the corresponding procedures and criteria.

MONITOR AND CONTROL POWER GENERATION PLANT OPERATION

Confirm operational status by inspection and routine observation.

Over the plant's operating lifetime, the operating organization should examine for possible deterioration so as to determine whether they are acceptable for continued safe operation or whether remedial measures should be taken. This can be done through confirmation of operational status by inspection and routine observations.

Maintaining a generator is a relatively similar process among the three major types of engines. First, it is vital to follow the maintenance schedule of the manufacturer with each type of generator. A routine maintenance practice is that of general inspection. Inspections consist of checking for leaks, assessing oil and coolant levels, glancing at the belts and hoses and checking the battery terminals and cables. It is important to inspect the oil as well, as it must be changed regularly. Oil change frequency depends on the manufacturer, how often the generator is used and your work environment. Typically, it is recommended you change the oil after 100 hours of operation, especially if the generator uses diesel.

Generator maintenance requires:

- ✓ Annual fuel cleaning and filtering, as diesel fuel degrades quickly. After a few weeks of operation, diesel fuel degrades via contamination of water and microbes, resulting

in clogged fuel lines and filters. Fuel cleaning involves using biocides annually in all generators except for the standby generator, in which it will attract moisture.

- ✓ The cooling system to be maintained, which requires checking the coolant level at existing intervals. This must be done during shutdown periods.
- ✓ Checking for battery power; this is especially true for standby generators, as battery issues are their primary cause of failure. Make sure the batteries are robust and charged enough to last long so as to not incur any start-up hitches for the generator.
- ✓ Regular testing to inform of the battery's current status. Testing involves checking the electrolyte levels and specific gravity of the batteries. The batteries themselves also must be clean.

Monitor and maintain continuing process supplies to meet production requirements.

Besides the above best practices, it is also important to exorcise the generator on a weekly basis for 30 minutes under load. This will charge the battery, remove excess wetness, lubricate the engine and filter the fuel and foil. Any loose pieces found anywhere on the generator must be placed securely in.

You should also keep records of inspections and tests for future inspections and scrutiny. These records will allow you to stay in the know of your generator's state.

Baseline data should be collected for future reference. These data are normally collected in the pre-service inspection carried out before the start of plant operation; they give information on initial conditions which supplements manufacturing and construction data in providing a basis for comparison with the data from subsequent examinations. In the pre-service inspection the same methods, techniques and types of equipment should be used as those which are planned to be used for in-service inspections. Whenever an SSC has been repaired or replaced, a pre-service inspection should be performed before putting it into operation.

In establishing the extent of the in-service inspection programme, consideration should be given to the following systems and components in accordance with their importance to safety:

a) Pressure retaining parts of components in the reactor coolant system;
b) Components of or connected to the primary reactor coolant system that are essential for ensuring the shutdown of the reactor and cooling of the nuclear fuel in relevant operational states and in postulated accident conditions;
c) Other components, such as main steam lines or feedwater lines, whose dislodgement or failure might put in jeopardy the systems mentioned in items (1) and (2) above.
d) When new inspection methods are introduced, a comparison with the previous methods should be made. Such a comparison will provide a revised baseline for future inspections.

Maintenance requirement for oil circuit breakers:

Every circuit-breaker should be thoroughly inspected at regular intervals of three or six months, depending upon usage, during which all the points referred to under above should be checked. In addition, check the level and condition of oil. Clean the insulators examine the arcing contacts and attended if necessary, check auxiliary contacts for cleanliness and contact making. Finally, check all bolts and nuts for tightness, particularly those securing heavy current carrying parts, check operating mechanism, adding a few drops of oil where required. The indicating devices and lamps should also be checked, as well as safety shutters, etc..

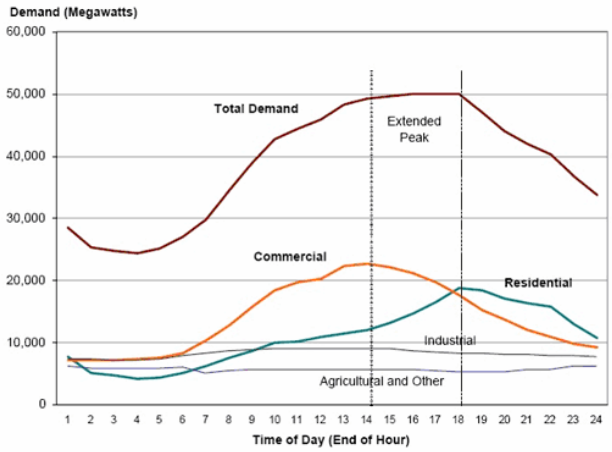
In addition , a circuit-breaker which has operated on a heavy fault should be examined as soon as possible, although every breaker should be capable of being closed after the operating duty cycle consisting of B-3'-MB-3'-MB, standing for "break, 3 minutes interval, make-break, 3 minutes interval, and again make-break", on full fault current, without inspection or change of oil. The points to be checked during periodical maintenance are:

1. Check all current carrying parts and attend to the arcing contacts
2. Examine the oil and change it if it is badly discolored, test breakdown voltage if in doubt. Good oil should withstand 30KV for one minute, in a standard oil testing cup with 0.15 inch gap between electrodes. Renew oil if bad, after removing all sludge.
3. Inspect the insulation for possible damage. Clean the surface and remove deposits of carbon. In cleaning circuit-breakers never use loose cotton waste, but only strong, firm and dry fabric, which will not deposit loose fibers.
4. Check closing, tripping and interlock mechanisms.
5. Ensure, before closing the tank that no tools have been left behind, that the tank lining and barriers are in position and secure, and that the tank gasket is in good condition.

Monitor power output demand to meet production requirements.

It is important to properly document performance of the generators as the referred documentations will assist in monitoring and maintaining power output demand and distribution system to meet production requirements.

A written record of generator inspections, tests, exercising, operation and repairs must be maintained on the premises and be available for review by the fire inspector on request. This record must, at a minimum, include: the date of the report, name(s) of the person(s) providing the service, identification of unsatisfactory conditions and corrective action taken (including parts replaced), and any testing of repairs recommended by the manufacturer.



It is important that at least two people in your facility know where your logs are kept to increase the likelihood that they can be readily provided if requested during an inspection. It is recommended that these logs be maintained for at least three years

RECORD AND REPORT POWER GENERATION PERFORMANCE

Record pressures, temperatures and flows.

Performance of diesel engine used within the diesel generators, will include pressure and temperature points, together with difference in flow that impact performance of the engine. These points need to be constantly monitored and recorded as they impact performance of the diesel generators.

Record power generation processes and data in operating log

Monitoring and observations are vital to entry into a log and it is vital that the operators in power houses using diesel engines, need to perform eh following tasks and record the parameters into a log sheet.

Temperature Monitoring

Generally, temperatures which are too high are detrimental to engine operation. High temperature can weaken the engine internal components, reduce clearances, and cause a chemical breakdown of the lubricating oil. Monitors or sensors are installed at various locations in the engine to detect excessive temperature and respond with an alarm. If allowed to go unchecked, these temperatures would eventually lead to damage or engine failure.

1. ***Jacket Water Temperature***

A key monitoring point is the temperature of the jacket cooling water as it leaves the engine. The engine manufacturer has set a recommended maximum temperature, generally less than 200degree F for low pressure systems. Jacket water temperatures which climb above the recommended operational point for the engine are normally an indication of a problem developing. In some instances, the water or air sink temperature to which the unit rejects its excess heat may be too high to remove enough heat from the cooling system. Under such conditions, reductions in engine load are recommended to reduce the heat load on the engine and hence continuous monitoring of water temperature in jackets are mandatory.

2. ***Lubrication Oil Temperature***

As with the jacket cooling water, excessive temperature of the lubricating oil will lead to engine damage and failure. The lubrication system not only provides lubrication for the engine components, it also serves a cooling function by removing excess heat from various

points in the engine not cooled by the jacket water system. In addition, chemical failure, or break-down, of the lubricating oil will occur if it is not adequately cooled. This leads to reduced oil viscosity. Reduced oil viscosity will ultimately result in metal-to-metal contact, friction, excessive wear, component damage, and possible engine failure. Temperature sensors are normally located in the lubrication oil sump or in the exit piping from the sump and it is vital to continuously monitor and record changes.

3. ***Main Bearing Temperature***

On some large engines, it is desirable to monitor directly the temperature of the engine main bearings. Direct measurement here will indicate to plant operators the potential failure of an engine main bearing. A temperature probes are used to undertake monitoring and they are placed in close proximity to all or selected engine main bearing shells. Output circuitry provides for indication alarm and trip.

Pressure Monitoring

Depending on the specific pressure being monitored, an alarm or trip may be initiated by a pressure either too high or too low.

1. ***Lubricating Oil Pressure***

During engine operation, it is important to maintain the proper lubricating oil pressure. Loss of sufficient pressure could lead to an insufficient flow of oil to key engine components. A severe loss of lubricating oil pressure will quickly result in engine failure. A lubricating oil pressure sensor or switch is normally connected to the main lube oil header. It monitors the lube oil pressure being supplied to the majority of the engine components. It may be desirable to monitor lubricating oil pressure at selected locations other than the main oil header. For example, oil pressure is often monitored at the inlet to the engine turbocharger. A decrease in pressure at this location may not be indicated by a sensor at the main oil header. A low-pressure indication at the turbocharger inlet would generally initiate alarm and not necessarily engine trip.

2. ***Engine Crankcase Pressure***

The general rule for large diesel engines is to maintain the crankcase at a slight vacuum. This reduces the chance for crankcase explosions by preventing the buildup of potentially explosive hot oil vapors. Crankcase pressure is monitored by a diaphragm actuated pressure switch, similar to the one shown in Figure 5-16 (Chapter 5). In the event of high crankcase pressure (explosion), the pressure sensitive diaphragm pops open the crankcase relief covers to relieve this pressure. Then, they pop closed immediately to prevent the entrance of air, which would cause a crankcase fire.

Engine Over-speed

Most diesel engines are equipped with some type of over-speed sensing device which sends a signal to the control system to cause the unit to be shut down should an over-speed occur.

Engine Alarms

Diesel generators will produce alarms if any of the following happens

- ✓ Fuel Oil Level-Day Tank-Low
- ✓ Starting Air Pressure-Low
- ✓ Start Failure
- ✓ Intercooler Water Temperature-High
- ✓ Jacket Water Keep Warm Temp-Low
- ✓ Jacket Water Pressure-Low
- ✓ Jacket Water Level-Low
- ✓ Lube Oil Keep Warm Temp-Low
- ✓ Lube Oil Strainer Differential-High
- ✓ Lube Oil Filter Differential-High
- ✓ Lube Oil Level-Crankcase/Sump-Low
- ✓ Rocker Arm LO Pressure-Low
- ✓ Rocker Arm LO Lever-Abnormal
- ✓ Engine Vibration-High
- ✓ Loss of Control Power
- ✓ Switch not in Auto
- ✓ Engine Lockout Tripped (86DG)
- ✓ Engine Ready to Load

It is crucial that the powerplant operators undertake the above recording of power generation processes and data and effectively y keep updating on the operating log.

Record and report maintenance requirements.

The implementation of an effective data collection and record keeping system at a power plant is a major task which requires significant resources. However, the attendant benefits and the decreasing cost and increasing capability of computation are expected to make the proposed improvements feasible and economic. The general data needs and the attributes of a data collection and record keeping system for the management of ageing degradation and the service life of components.

Specifications for a data collection and record keeping system for a given power plant should be derived from the plant specific conditions, such as the stage in a plant life cycle (i.e. the design, construction, commissioning or operating stage), the existing data collection and record keeping system, and available resources. It may be appropriate to meet these needs by introducing the proposed data collection and record keeping system in phases. Identifies factors that may be used to prioritize the data requirements and to provide a basis for phased implementation of the system.

A basic diesel generator maintenance checklist is used to ensure diesel generators provide good power quality. Engineers and operators can follow this template as a guide when performing the following during inspections:

a. Perform physical and visual inspection of diesel generator
b. Take photo evidence of leakage, damage, and defects
c. Check the battery, oil, and fuel condition
d. Provide overall condition assessment of diesel generator
e. Conclude the inspection with signature and clear recommendations

UNIT 16

TROUBLE SHOOTING OF CONTROL SYSTEMS

This unit covers finding and rectifying faults in process control apparatus and systems. The unit encompasses safe working practices, interpreting process and circuit diagrams, applying knowledge of process controls to logical fault-finding procedures, conducting repairs, safety and functional testing and completing the necessary service documentation

PREPARE TO FIND AND RECTIFY FAULTS

OHS procedures for a given work area are identified, obtained and understood

What is an occupational health and safety (OH&S) program?

A health and safety program is a definite plan of action designed to prevent accidents and occupational diseases. Some form of a program is required under occupational health and safety legislation in most Canadian jurisdictions. A health and safety program must include the elements required by the health and safety legislation as a minimum.

Because organizations differ, a program developed for one organization cannot necessarily be expected to meet the needs of another. This document summarizes the general elements of a health and safety program. This approach should help smaller organizations to develop programs to deal with their specific needs.

What are individual OH&S responsibilities?

Health and safety is the joint responsibility of management and workers. Management is accountable for non-compliance to health and safety legislation.

Responsibility may be defined as an individual's obligation to carry out assigned duties. Authority implies the right to make decisions and the power to direct others. Responsibility and authority can be delegated to subordinates, giving them the right to act for superiors. It is important to note that, while some responsibilities can be delegated, the superior remains accountable for seeing that they are carried out.

Individual responsibilities apply to every employee in the workplace, including the Chief Executive Officer. All employees will then know exactly what is expected of each individual in health and safety terms.

To fulfill their individual responsibilities, the people must:

- ✓ Know what these responsibilities are (communication required).
- ✓ Have sufficient authority to carry them out (organizational issue).
- ✓ Have the required ability and competence (training or certification required).

Once all these criteria have been met, safety performance can be assessed by each individual's supervisor on an equal basis with other key job elements. Health and safety is not just an extra part of an employee's job: it is an integral, full-time component of each individual's responsibilities.

How do you establish correct work procedures?

Correct work procedures are the safest way of doing a job, job instruction, monitoring performance, and accident investigation.

Job safety analysis (JSA), also known as "job hazard analysis", is the first step in developing the correct procedure. In this analysis, each task of a specific job is examined to identify hazards and to determine the safest way to do the job. Job safety analysis involves the following steps:

1. Select the job.
2. Break down the job into a sequence of steps.
3. Identify the hazards.
4. Define preventive measures.

The analysis should be conducted on all critical tasks or jobs as a first priority. Critical jobs include:

- ✓ Those where frequent accidents and injuries occur.
- ✓ Those where severe accidents and injuries occur.
- ✓ Those with a potential for severe injuries.
- ✓ New or modified jobs.
- ✓ Infrequently performed jobs, such as maintenance.

Job safety analysis is generally carried out by observing a worker doing the job. Members of the joint health and safety committee should participate in this process. The reason for the exercise must be clearly explained to the worker, emphasizing that the job, not the individual, is being studied. Another approach, useful in the analysis of infrequently-performed or new jobs, is group discussion.

A work procedure may consist of more than one specific task. In such cases, each separate task should be analyzed to complete a job safety analysis for that procedure. The final version of the correct work procedure should be presented in a narrative style format that outlines the correct way to do the job in a step-by-step outline. The steps are described in positive terms, pointing out the reasons why they are to be done in this way. Reference may be made to applicable rules and regulations and to the personal protective equipment required, if any. Employees who carry out the tasks should be consulted in developing the procedure.

Example
Job Safety Analysis (JSA) Worksheet

Industry: Construction
Operation: Road repair
Job: Pavement repair

Task	Who does it	Hazards	How to prevent injury/accident
Operating jack-hammer	Joe Doe	- noise - vibration	- ear protectors - vibration absorbing gloves

Applicable Legislation:

OH&S Act and Regulations: _____
(refer to the act and regulations in your jurisdiction)

Date: _____

Developed by: _____

What are workplace inspections?

Workplace inspections help to identify existing hazards so that appropriate corrective action can be taken. Health and safety legislation requires workplace inspections as a proactive action to ensure workplace health and safety.

Supervisors and workers are responsible for reporting and taking action on unsafe conditions and acts as they are encountered. The frequency of planned formal inspections may be set out in legislation. Records of previous accidents and the potential for serious accidents and injuries are factors to be included when determining if more frequent inspections are needed.

Joint health and safety committee members are obvious choices of personnel to carry out formal inspections, especially if they have received training or certification. Other criteria for selecting the inspection team are:

- ✓ Knowledge of regulations and procedures.
- ✓ Knowledge of the hazards in the workplace.

- ✓ Experience with work processes involved.

Pre-planning any inspection is always worthwhile. Documents, such as previous inspections, accident investigations, maintenance reports, and committee minutes, should be consulted. If a checklist is to be used, it should be reviewed and changed to meet specific needs of the workplace.

Checklists are useful aids in that they help ensure that no items are overlooked in an inspection. One type of checklist is the "critical parts inventory". This inventory itemizes parts and items that may result in a serious accident if they fail. While many ready-made checklists are available in safety literature, it is best to adapt these to local conditions. The joint health and safety committee should participate in the preparation of these tailor-made checklists.

During the actual inspection, both work conditions and procedures should be observed. If a hazard that poses an immediate threat is discovered, preventive action must be taken right away, not after the inspection. Notes are made, specifying details of the hazard, including its exact location. When completing the inspection report, it is a good idea to classify each hazard by degree of possible consequences (for example: A = major, B = serious, C = minor). In this way, priorities for remedial action are established.

Inspections serve a useful purpose only if remedial action is taken to correct shortcomings. Causes, not symptoms alone, must be rectified. Corrective action should be taken immediately, with the emphasis on engineering controls, management failures, or need for worker education, whatever applies.

OHS risk control measures and procedures are followed in preparation for the work

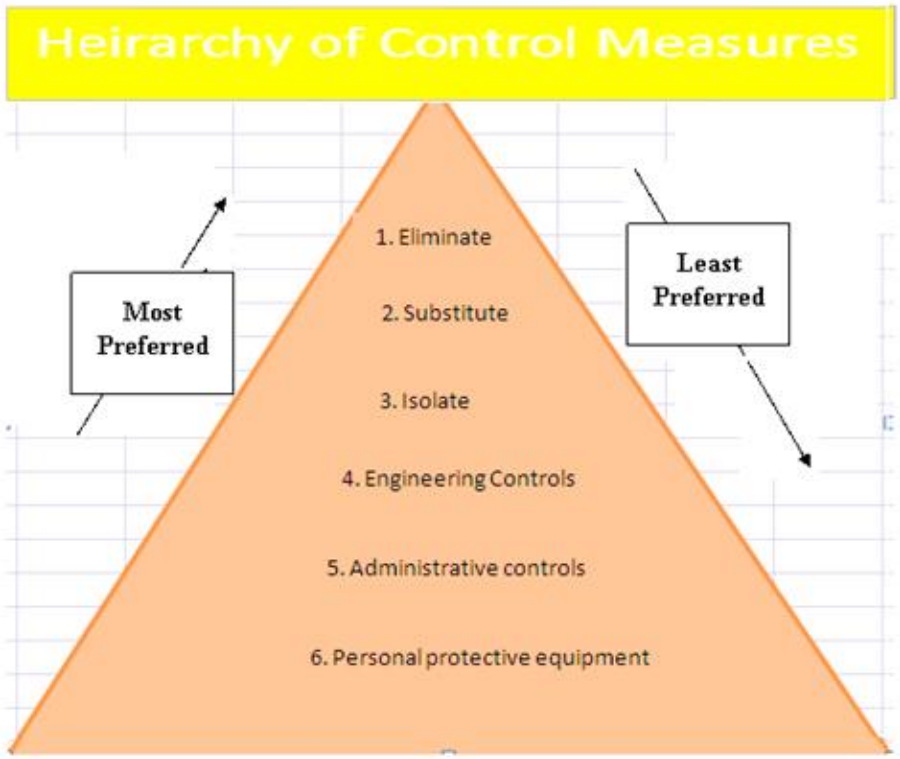
What is Risk?

When we refer to risk in relation to occupational safety and health the most commonly used definition is ‘risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard.’

Categorising Risk

The level of risk is often categorised upon the potential harm or adverse health effect that the hazard may cause, the number of times persons are exposed and the number of persons exposed. For example exposure to airborne asbestos fibres will always be classified as high because a single exposure may cause potentially fatal lung disease, whereas the risk associated with using a display screen for a short period could be considered to be very low as the potential harm or adverse health effects are minimal.

What are Control Measures?



Control measures include actions that can be taken to reduce the potential of exposure to the hazard, or the control measure could be to remove the hazard or to reduce the likelihood of the risk of the exposure to that hazard being realised. A simple control measure would be the secure guarding of moving parts of machinery eliminating the potential for contact. When we look at control measures we often refer to the hierarchy of control measures.

A step-by-step approach to managing WHS risks

Risk management is a proactive process that helps you respond to change and facilitate continuous improvement in your business.

It should be planned, systematic and cover all reasonably foreseeable hazards and associated risks.

The four steps for managing WHS risks are:
Step 1 - Identify hazards
Find out what could cause harm.

Step 2 - Assess risks

If necessary – understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening.

This step may not be necessary if you are dealing with a known risk, with known controls.

Step 3 - Control risks
Implement the most effective control measure that is reasonably practicable in the circumstances and ensure that it remains effective over time.

Step 4 - Review control measures
Review the control measures to ensure they are working as planned.

Consulting workers

Consultation with workers and their health and safety representatives is required at each step of the risk management process. By drawing on the experience, knowledge and ideas of your workers, you are more likely to identify all hazards and choose effective control measures.

Reasonably practicable

Deciding what is reasonably practicable to protect people from harm requires taking into account and considering all the relevant matters, including:

- ✓ the likelihood of the hazard or risk occurring
- ✓ the degree of harm that might result from the hazard or risk
- ✓ knowledge about the hazard or risk, and ways of minimising or eliminating the risk
- ✓ the availability and suitability of ways to eliminate or minimise the risk, and
- ✓ after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Controlling risks using the hierarchy of control measures

The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of control measures.

The hierarchy of control measures can be applied in relation to any risk.

You must always aim to eliminate the risk, which is the most effective control. If this is not reasonably practicable, you must minimise the risk by working through the other alternatives in the hierarchy.

Administrative controls and PPE are the least effective at minimising risk because they do not control the hazard at the source and rely on human behaviour and supervision.

The nature of the fault is obtained from documentation or from work supervisor to establish the scope of work to be undertaken

Accidents happen in every walk of life and often, are down to lack of concentration or simple carelessness but accidents in the workplace can happen because equipment is not safe to use or a risk assessment hasn't taken place.

Clearly, a worker should not use equipment if he or she thinks it isn't safe but employers are bound by a duty of care which means they are ultimately responsible for making sure that both staff and visitors are not put at risk.

So employers must ensure that all equipment and machinery is safe for use. This means that it should be inspected regularly in case it has been damaged or misused.

Ensuring Safety in Your Business

Most obviously, you need to keep the workplace clean and safe for all and ensure that people are protected from falling from heights or being exposed to hazardous substances.

You should also check that all roads, walkways, floors and stairs are safe to use and not blocked by large pieces of equipment or piled up stock.

Although serious accidents can occur with large or specialised machinery, many injuries happen every year when employees are using basic every day equipment such as stepladders, hand saws or mechanical screwdrivers.

Inspections

So it's extremely important to make sure that all equipment is inspected regularly. In most cases, a daily pre-check should be carried out. You can emphasise the importance to your workers through regular toolbox talks.

Show them some examples of accidents which have happened through every day equipment and make sure they know the importance of checking all equipment before they use it.

For example, before using a ladder they should check it visually for any broken or cracked rungs and ensure that the feet are solid.

They need to check that any locking devices on stepladders are working properly and should use any recommended safety equipment at heights, such as a harness.

Other equipment such as machinery should be visually checked and employees must know who is responsible for checking that any safety guards or switches are in good working order and that any moving parts, waste collectors and other gadgets have been oiled regularly.

If machinery has an exhaust system, this needs to be inspected on a regular basis.

Safety Aids

Research by the Health and Safety Executive has shown that experience is no substitute for safety guards or equipment.

It takes only a split second of concentration loss to lose a finger in cutting equipment but often, experienced workers have disabled safety features to make a machine easier to use.

It is easy to become complacent about small equipment such as wood saws or mechanical screwdrivers but they are capable of causing serious injury if not well maintained or used correctly.

Employers should make a list of all equipment in use and decide how and when it should be checked and who will note that an inspection has been undertaken. In the event of an accident, this will at least show that dangers have been taken seriously and that procedures are in place to keep employees safe.

Protective Equipment

Lots of every day equipment has the potential to cause injury unless workers have been given personal protective equipment (PPE) to reduce the chances of harm.

PPE equipment can vary from something as simple as clothing which provides protection against the weather to safety helmets, gloves, eye protection, safety footwear, noise reduction headphones or safety harnesses.

If PPE is needed for a job, it must be provided by the employer and they cannot charge employees for it.

It is important that employers provide the required PPE and ensure that it is fit for purpose. Check gloves for holes or damage, ensure that headphones are not broken and follow guidelines for checking harnesses.

Employees also have a responsibility towards their own safety and can refuse to undertake any job which they consider unsafe.

As an employee you can reduce the risk of accidents by reporting any faulty equipment or machinery as soon as possible. Make sure equipment that you are using is in good condition and well looked after. It should always be cleaned well and correctly stored after use.

If you believe that your employer is not taking safety seriously, you have a few options:

- ✓ Talk to your employer/manager and make them aware of any issues
- ✓ Let your union or safety representative know of any problems

If your employer does not take action over any issue, you can report it to HSE or to your local authority through the environmental health department but it is best if you first give your employer the opportunity to put things right.

Advice is sought from the work supervisor to ensure the work is coordinated effectively with others

Coordinating completion of complex tasks in an organization typically requires planning and organization. With technology advancements, business owners have a variety of freely available software application options to manage their company's projects and operations. Techniques such as effective decision making, process improvement and time management, allow your company to get more done in less time to achieve your strategic goals and objectives.

Establishing Structure

Creating an effective workflow starts by establishing a clear chain of command. Clearly defining job roles and associated responsibilities ensures that everyone knows what to do. Establishing an organizational chart lets everyone know who to contact when things go wrong. This can be distributed by email, newsletter or company website. Each department should produce regular status reports and communicate with other departments to ensure work flows from one part of the organization to another. Process improvement initiatives examine workflow processes to eliminate waste, reduce errors and improve customer satisfaction.

Planning Tasks

Project coordinators usually develop comprehensive plans to describe the work involved with producing a company's products and services. They use the techniques recommended by professional organizations, such as the Project Management Institute. For example, these coordinators use standard templates to complete a stakeholder analysis, develop a project charter, create a work breakdown structure, assign resources and monitor task completion. According to the Project Management Institute, during the planning process, the project manager defines the objectives and gathers stakeholder needs to coordinate the team and direct efforts. Team members can review the details associated with a project so there is no confusion about what needs to be done and when it needs to occur.

Communicating Decisions

Good communication prevents disputes, conflicts and delays. Project coordinators can foster effective communication by conducting regular team meetings, distributing status reports and documenting decisions made. Effective leadership often involves influencing and motivating team members to adhere to established policies and procedures so operations run smoothly. Coordinating the efforts of many different employees, particularly when they are not located in the same place or time zone, typically requires arranging

regular meetings to exchange information and using written communication to document procedures.

Aligning Activities

Developing and marketing a new product takes time and planning. To achieve an aggressive deadline, several teams may be working in parallel. Coordinating the efforts requires an effective liaison, ensuring supplies are ordered and delivered in time to use in production activities. Volunteers may contribute to completing checklists or formal quality control processes can be implemented to coordinate work flow effectively.

Tools, equipment and testing devices needed to carry out the work are obtained in accordance with established procedures and checked for correct operation and safety

Appropriate personal protective equipment such as safety goggles and gloves must be worn to protect against hazards that may be encountered while using hand tools. Workplace floors shall be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

To prevent hazards associated with the use of power tools, OSHA recommends that workers should observe the following general precautions:

- ✓ Never carry a tool by the cord or hose.
- ✓ Never yank the cord or the hose to disconnect it from the receptacle.
- ✓ Keep cords and hoses away from heat, oil, and sharp edges.
- ✓ Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- ✓ Keep all people not involved with the work at a safe distance from the work area.
- ✓ Secure work with clamps or a vise, freeing both hands to operate the tool.
- ✓ Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- ✓ Maintain tools with care; keep them sharp and clean for best performance.
- ✓ Follow instructions in the user's manual for lubricating and changing accessories.
- ✓ Be sure to keep good footing and maintain good balance when operating power tools.
- ✓ Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.
- ✓ Remove all damaged portable electric tools from use and tag them: "Do Not Use."

FIND AND RECTIFY FAULTS

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!

COMPLETION AND REPORT FAULT FINDING RECTIFICATION ACTIVITIES

Introduction to Maintenance:

Machines, buildings and other service facilities are subject to deterioration due to their use and exposure to environmental conditions. If this process of deterioration is not checked, it may render them unserviceable. It is, therefore, necessary to attend to them from time to time, to repair and recondition them so as to enhance their life economically.

Maintenance aspect is more important specially in the case of machines due to their non-uniform pattern of wear and tear which depends on large number of factors.

Every machine is thoroughly tested and inspected by the manufacturers before selling it, and by the purchaser before it is put to use. When it is used, it will be subjected to wear and tear hence proper attention should be given to protect the machine and its components from undue wear and thus protect them from failures.
A proper attention means lubrication, cleaning, timely inspection and systematic maintenance. Maintenance of a machine means efforts directed towards the up-keep and the repair of that machine.

A major part of the expenditure is generally on men, material and maintenance in an industry. Every machine will require repairs even if it is best designed, hence the repair must be done at such a time when it may have least disruptions, i.e. machine may be repaired when it is not being used or its use may be postponed without affecting the production of the whole concern.

Therefore, checking of the machine is generally done when it is not in operation, so that the defect, if any, can be immediately and easily rectified without causing extensive damage to the plant.

In this way, we say that maintenance is responsible for the smooth and efficient working of an industry and helps in improving the productivity. It also helps in keeping the machines in a state of maximum efficiency with economy.

Realising the high importance of maintenance of plants and equipment's. National Productivity Council, undertook the survey of engineering industries, and found that due to failure of the plants, equipment and machineries, non-availability is 28 per cent. Looking to this high percentage of failures, it is essential that the engineering units should improve their maintenance system.

Maintenance can be defined as a combination of actions carried out to replace, repair, service or modify the components in a plant or equipment so that it will continue to operate at a specified "availability" for a specified period of time.

Maintenance management is concerned with the direction and organization of resources in order to control the availability and performance of plant to some specified level.

The maintenance management is therefore a restorative function to ensure availability and efficiency of the existing plant, equipment and buildings at an optimum level.

Plant and equipment maintenance plays an important role in production management because breakdown creates problems such as:

- ✓ Loss of productive time
- ✓ Re-scheduling of production
- ✓ Need for sub-contracting work
- ✓ Temporary work shortage, as during break down workers may not have work for them.

Types of Maintenance

Generally, maintenance can be done in the following two ways:

1. Breakdown maintenance.
2. Preventive maintenance.

In the first case of maintenance, repair can be done after the breakdown occurs while in the second case maintenance is done on the basis of prediction or on the basis of periodical checking.

1. Break Down Maintenance:

Breakdown maintenance is defined as a maintenance activity conducted on a machine which has ceased functioning owing to shear or crushing or buckling or elongation or swelling or any other form of failure of any critical component of the said machine in order to enable the same to function as before by resorting to necessary replacement(s) of the same and/ or more number of components by new ones or usable old ones and/ or re-conditioning of the same within the minimum time period considering scope of work, available facilities and skill.

Breakdown of a machine can occur due to the following two reasons:

- ✓ Due to unpredictable failure of components which cannot be prevented.
- ✓ Due to gradual wear and tear of the parts, which can be eliminated to a large extent by regular inspections, known as preventive maintenance. From experience it can be decided that, when a part should be replaced, so that breakdown can be avoided.

In breakdown maintenance, defects are rectified only when the machine cannot perform its function any longer, and the production department is compelled to call on the maintenance

engineer for repairs. After repairing the defect, the maintenance engineers do not attend the machine again until another failure occurs.

In this type of maintenance, repair shall have to be done on failure, thus it may disrupt the whole production, if it is performing an important work. This method is expensive also due to increase of depreciation cost, payment to idle operators, overtime to the maintenance staff for doing the emergency repairs.

2. Preventive Maintenance:

Preventive Maintenance is defined as a maintenance activity conducted on a machine as per laid down schedule or frequency by making necessary or need-based replacement and/or reconditioning of component(s) within the pre-fixed time period of the said work in order to reduce and avert breakdown(s).

Preventive maintenance is sometimes termed as "planned maintenance" or "scheduled maintenance" or "systematic plant maintenance" etc. It is an extremely important function for the reduction of maintenance cost and to keep the good operational condition of equipment and hence increases the reliability.

Preventive maintenance aims to locate the sources of trouble and to remove them before the breakdown occurs. Thus it is based on the idea "prevention is better than cure". Scheduled maintenance is always economical than unscheduled maintenance, as we all know that, "a stitch in time saves nine."

Best safeguard against costly breakdown is to inspect, lubricate and checkup the equipment as frequently as possible. To take full use of equipment and to maintain it in reliable condition, necessary measures should be taken to prevent overloading, dampness, negligence and misuse of machines.

Frequency of inspection should be decided on the basis of the importance of the machine wear and tear of the machine and its delicacy. This periodic inspection or checking helps to find out the reasons leading to breakdown and to rectify them, when they are in minor stages.

Thus the repair can be done when one wants to do it, i.e. when it has least effect on the production schedule. Further this repair requires lesser time as compared to that of breakdown repair and thus down time is reduced by doing preventive maintenance.

Objectives

- ✓ Preventive maintenance has following main objectives:
- ✓ To obtain maximum availability of the plant by avoiding breakdown and by reducing the shutdown periods to a minimum.
- ✓ To keep the machine in proper condition so as to maintain the quality of the product.
- ✓ By minimising the wear and tear, preserve the value of the plant.

- ✓ To ensure for the safety of the workers.
- ✓ To keep the plant at the maximum production efficiency.
- ✓ To achieve all the above objectives with most economical combination.

Procedure for Maintenance

Maintenance should be done considering all the above mentioned factors. Daily maintenance is done by the operators themselves. Before starting the work of their shift, cleaning, oiling and greasing should be done by the operators. For this purpose manufacturers used to issue maintenance instructions for their machines, which should strictly be followed.

Preventive maintenance of the machine depends largely on the operators. Hence, as far as possible, one operator be allotted for each machine, and when the same machine is used in more than one shift, one operator for each machine for each shift be allotted.

This system has following advantages:

- ✓ An operator gets used to the sound and working of his machine and notices any change immediately, which helps in investigation and rectification of the defect then and there. If operators are changed frequently, immediate check-up and timely repair cannot be possible.
- ✓ It is easy to pin-point operators with bad operating habits. To remove these habits training can be arranged or disciplinary actions can be taken as the case may be.
- ✓ The machine will remain in good conditions.
- ✓ Periodic maintenance is generally conducted by the maintenance crew, specially trained for this purpose. The period should be decided on the basis of past experience. Apart from this, operating instructions should carefully be followed by the operators.

In case any abnormal sound or behaviour is noticed in the machine, he should immediately brought this into the notice of maintenance crew, so that the defect can be rectified immediately. Care must be taken that it may not be left for the latter date.
Inspections and lubrication schedules should be strictly followed. Inspection schedule should include the inspection of tools, accessories and other equipments.

Complete work processes

Equipment Inspections

With regular inspection, you make sure your equipment is in top shape and can handle the toughest jobs. A trained technician can determine if small repairs will make a big difference and can suggest repairs to help your equipment run more efficiently. An equipment inspector may point out details your team might tend to overlook.

Most importantly, regular inspections ensure the safety of your workers. You can get projects done on schedule and with peace of mind, knowing your equipment is in good condition. When it comes down to it, there is no reason not to have regular inspections and get the most out of the investment you made in your heavy equipment. Still not convinced? Keep reading to learn more about inspections and why they are critical to your heavy equipment lifespan.

What is checked during and equipment inspection?

Heavy equipment inspections combine data collection and analysis with hands-on testing and examination for a thorough look at the equipment's condition. A complete inspection is an important preventive way to make sure equipment is safe for use and that all systems are working properly.

The Occupational Safety and Health Administration (OSHA) requires each piece of heavy equipment to pass inspection before use. If any of the safety features are in disrepair, you should not use the equipment. Employers are required to get unsafe equipment repaired to ensure worker safety.

Damaged or broken equipment requires immediate repair to prevent problems. According to OSHA, all heavy equipment must have:

- ✓ A working brake system, including emergency brake and parking brake
- ✓ Working headlights, taillights and brake lights
- ✓ An audible warning device, like a horn

- ✓ A windshield and windshield wipers in good condition

Although heavy equipment owners have the option of maintaining only the minimum to meet OSHA requirements, they shouldn't overlook other details if they want their equipment to last. Heavy equipment can last for years if properly maintained. Considering some heavy machinery costs more than a house, it is a smart move to take utmost care of these powerful tools. Get the most out of your investment by conducting regular inspections on your own or with a trusted technician.

MacAllister Machinery uses cutting-edge technology and hands-on expertise to inspect, collect, analyze, diagnose and monitor equipment. When combined with other information, like machine history and use, we have all the tools we need to suggest repairs and maintenance for optimal safety and performance. It is easy to access and view inspection results, too. Just log in to the Cat Inspect app or VisionLink to take the next step or review results.

What do inspectors look for?

Heavy equipment inspectors check all the components of a piece of equipment, emphasizing safety. A technician can not only test for safety, but can also consider ways to increase equipment productivity and efficiency. Once you're certain of safety, it is up to you what you want to accomplish with your equipment. Our inspections are tailored to meet your specific needs.

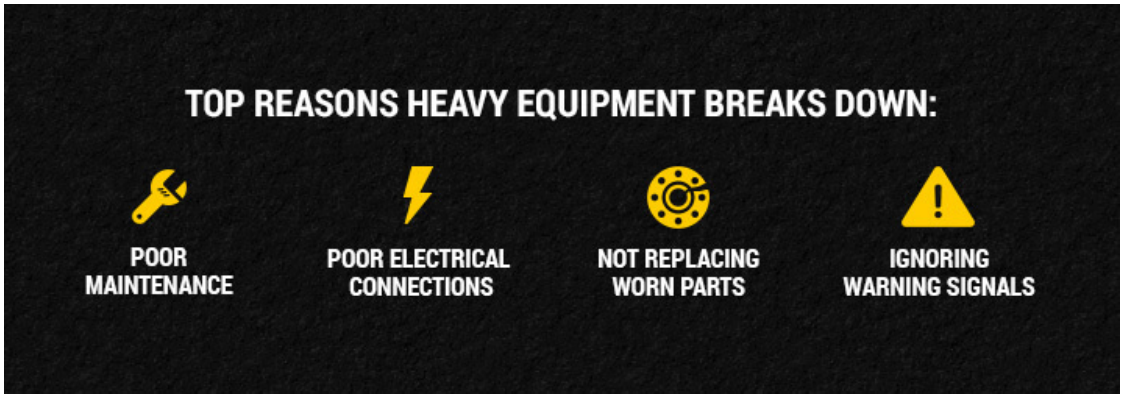
In general, equipment inspectors will check the following components using both diagnostic tools and an expert eye:

- ✓ Roll-over protection structures, including seatbelts
- ✓ Gauges and lights
- ✓ Battery
- ✓ Engine performance
- ✓ Safety features such as deflectors and sweeps
- ✓ Steering components
- ✓ Brake systems
- ✓ Exhaust system
- ✓ Cooling system
- ✓ Fan belts
- ✓ Engine support
- ✓ Radiator guards
- ✓ Transmission function
- ✓ Tracks and rollers
- ✓ Rear hitch
- ✓ Oil level and condition
- ✓ Tires and wheels
- ✓ Glass and mirrors
- ✓ Undercarriage
- ✓ Hydraulic system

Heavy equipment is a significant investment, so it is worth fitting maintenance and inspections into your work schedule. You'll potentially save yourself thousands of dollars in repairs. Get ahead of the game and save yourself the trouble of dealing with failed equipment.

Sometimes, the value of expert advice is priceless. An expert is more likely to notice when parts or systems are damaged beyond what an untrained eye can spot. It is not uncommon for heavy equipment to break down, and the majority of the causes are preventable. Here are some of the top reasons heavy equipment breaks down.

- ✓ Poor maintenance: Failing to replace belts or forgetting to check oil levels, for example.
- ✓ Poor electrical connections: An inspector can detect electrical issues early, before equipment breaks down and causes you to lose work.
- ✓ Not replacing worn parts: By fixing only one broken part, you are only temporarily taking care of the issue. Other worn parts need to be inspected to prevent further damage and future costs.
- ✓ Ignoring warning signals: Always ask a technician to investigate a warning signal. Ignoring a warning signal can lead to major equipment damage or serious injury.



An inspector will run tests, collect diagnostic codes, analyze data and visually inspect the equipment to checks for leaks, broken or loose parts, excessively worn parts or any potential problem areas. With an inspection checklist in hand, either on a device or paper, a technician will make sure they don't miss anything, and they will teach your team what to look out for during daily checks.

What are the benefits of equipment inspections?

Equipment inspection is not something to dread. Inspection is an opportunity to save money, prevent injury and stand out from competitors. Your productivity is only as good as your equipment is, and you can't get very far with broken equipment or out-of-work employees. Regular inspections take productivity and safety to the next level, beyond mandatory inspections.

Heavy equipment is a powerful tool that undergoes a lot of different conditions and completes amazing tasks. With the incredible work a piece of equipment can do, like lifting tons, wear and tear are inevitable. Plus, no matter how great your team is, sometimes packed schedules can lead to equipment abuse and misuse. Worn or damaged components are not always apparent. Regular inspection makes sure equipment is still in great condition, despite being used by multiple workers under difficult conditions.

Considering the costs of heavy equipment repair and replacement, the pros of frequent inspection far outweigh the cons. If you wonder about the condition of your equipment, do not hesitate to contact a qualified technician immediately. Here are the reasons why.

1. **Lower risk of workplace injuries**

Regular inspections lower the chances of one of your workers getting injured. Unfortunately, injuries do happen on the job, and most of the time, they are preventable. Inspections are a preventive safety measure for you and your employees.

Consider that in 2016, there were 4,693 deaths in private industry, according to OSHA. About 21 percent of the deaths occurred in the construction industry. Excluding highway injuries, the leading causes of construction workers' deaths were the "fatal four" — falls, struck by an object, electrocution or caught between two pieces of machinery. Eliminating the fatal four could save 631 lives each year in America.

Now, consider how failing equipment could play a part in these statistics. A failed horn, brakes or any other important component could lead to a crash, or a vehicle driver striking another worker. A collision or failed system could cause a heavy object to fall and lead to injury or death. Or, a worker could become distracted by broken-down equipment and less aware of nearby workers, putting their safety at risk. If brakes fail or if equipment suddenly shuts down, it could easily cause a dangerous chain reaction to occur.

Although your equipment might be in great shape one day, you'll want to have it inspected after a tough job. If it does need a repair, don't wait — make repairs immediately and play it safe.

1. ***Lost Time***

If a worker gets injured as a result of damaged equipment, chances are, they are going to miss some time. Common injuries relating to heavy equipment are often serious, such as amputations, spinal injuries, sprains, fractures and cuts.

Workers who suffer any of these injuries could be out for days. According to a 2015 Bureau of Labor Statistics news release, workers who sustained sprains or strains resulting from a workplace injury required 10 days off work, on average. Workers with fractures needed 31 days, and those who suffered amputations required 22 days or more.

Even less severe injuries could lead to lost time. To stay on schedule, you will have to find someone to make up for the lost worker. If you are not able to find someone, productivity can slow down substantially.

2. ***Restaffing Costs***

If a worker is severely injured, they might need a long time to recover, or they may never return to the jobsite. In such a case, you will need to replace the worker with someone new. Whenever you hire a new employee, you take a chance. Even when the new hire is a good fit for your company, it almost always comes with a price. New workers usually need training and time to adapt. It could also take a while to find a worker who is right for the job.

According to a 2016 survey by the Society for Human Resource Management (SHRM), it takes 42 days to fill a job vacancy with a new employee, which is a lot of time with insufficient staff. New employees cost money, too. On average, it costs companies $4,129 to hire someone new.

Even if you think you've found the perfect worker, there is no guarantee they'll stick around to see a project through. According to the SHRM survey, the average annual turnover rate is 19 percent. Considering an employee who makes $8 an hour could wind up costing a company $3,500 in turnover costs, your best bet is to try to keep the employees you have. Inspecting your equipment regularly is just one aspect of best practices.

3. ***Higher Workers' Compensation Premiums***

Workers' compensation means employers are required by law to pay for workers' compensation benefits if a worker gets hurt on the job. Injuries can be from one event or repeated injuries, such as those caused by regular exposure to chemicals or loud noises. Sometimes, workers' compensation even covers psychological stress.

When an employee files a workers' compensation claim, your workers' compensation premium increases as a result. Injury can also affect health care premiums. However, if your claim costs are lower than average compared to similar companies, your premium may decrease — more incentive to keep your equipment fully intact.

Regular inspection allows you to take care of your equipment and even greater care of your workers.

4. ***Possible Fines***

Avoid fines and serious violations with regular inspections by ensuring safety at all times. Under OSHA law, employers are responsible for maintaining safe workplaces for their employees. If you ignore safety, you break the law.

For example, in 2012, OSHA cited a heavy equipment rental company in Hawaii for serious safety violations after a crane fatally crushed a worker. An OSHA inspector found outriggers meant to stabilize the crane were not extended, allowing the crane to tip. The company failed to inspect and keep a record of vital crane components. The company also allowed a worker to use the crane when it was displaying a warning indicator. Also, other equipment was not properly maintained or guarded to prevent amputation or injury. OSHA set fines totaling $70,000.

Not only did this company have hefty fines to pay, but they lost a worker and impacted their business name — all of which they could have prevented if they had put safety first. Clearly, it is not worth taking a chance when it comes to heavy equipment.

5. ***Could Be Held Liable***

There are plenty of ways you could legally be liable if equipment fails and causes injury. For example, if a worker is injured and sent home, and if you hurriedly hire another worker to help your team finish a project on time, you might be putting yourself and workers at risk if the new employee is unqualified for the job. If the new worker causes harm to another worker, you could be held liable for hiring someone who brought danger to other employees.

Another way you could be liable as an employer is if you are aware your equipment needs repair, even if it had passed a mandatory inspection, but fail to repair it. If someone is injured, you could be liable for negligence.

2. **Increase productivity**

Although safety is a priority, consider how damaged equipment can also affect productivity. When equipment fails, the workflow gets interrupted, and projects come to a halt. It's impossible to complete a job if even one piece of equipment has broken down.

When projects are interrupted, you might not be able to stick to your schedule and meet deadlines. It is important for customers to know they can depend on you, and regular

inspections help make sure your equipment is reliable for you, your workers and your clients. To stay on schedule and meet your goals, you want to have all equipment working optimally.

Also, downtime is costly. According to Farm Industry News, downtime due to equipment breakdowns costs companies around $1,400 a day during planting season. Failure to get equipment inspected before use is the biggest reason the equipment breaks down.

In general, machinery failure is usually due to one of the following.

- ✓ Thermally induced failure: Equipment overheats, or extreme temps cause equipment to break down.
- ✓ Mechanically induced failure: It is easy to prevent this with inspection and replacing parts. Mechanically induced failure often happens due to overexertion, collision and misuse or abuse.
- ✓ Erratic failure: Occurs randomly due to harder-to-detect reasons, such as electrical issues or software malfunction. Erratic failure can be prevented with the help of diagnostic equipment used during inspection.

Equipment failure can be sudden or gradual. Inspections are important because you may not notice the seriousness of an issue until it's too late. By regularly having a professional check your equipment, you prevent disaster and make informed choices. You can replace parts when necessary and not wait until equipment breaks down in the middle of the workday to make repairs. As a result, you decrease unscheduled downtime and improve productivity. Your clients will be impressed when projects are safely finished on time.

3. Lower repair costs

With regular inspections performed by a trained technician, you will be able to make a repair before it leads to a much more expensive problem. Your equipment will run better, and you'll extend its lifespan significantly with inspections and maintenance. The better condition your equipment is in, the less time you'll need to spend on repairs, and the more work you can get done.

Ultimately, you will get a greater return on your investment if you run highly efficient equipment for a longer amount of time. Consider the circumstances in which you use the equipment. What is the environment? What are the weather conditions? You may need more inspections and maintenance than you might think.

Small repairs are often worth the time and cost because heavy equipment is not cheap to replace. Considering a bulldozer can range in price from $30,000 to more than $200,000, it only makes sense to properly maintain something so valuable.

When and why should you do inspections?

Inspections should be carried out daily, and should include a look at the following:

- ✓ Brakes and lights
- ✓ Tire pressure
- ✓ Fluid levels
- ✓ Mirrors and glass
- ✓ Seatbelts
- ✓ Horn
- ✓ Emergency stopping system
- ✓ Safety devices
- ✓ Steering
- ✓ Tire condition
- ✓ Fuel and oil leaks

Every day, team members should focus on making sure the equipment is safe before each use. However, certain conditions require a more thorough inspection, best performed by a trained technician. You should get your equipment professionally inspected when:

- ✓ It has been exposed to conditions that could cause damage and lead to harm
- ✓ Suspected damage has occurred
- ✓ It has experienced severe environmental conditions, such as when it is dusty, wet, muddy or has been in corrosive coastal environments
- ✓ It has been driven on unpaved roads or mountainous terrain
- ✓ It has had several operators
- ✓ There is any sign of needed repair shown through signals, noises or obvious damage
- ✓ You are about to do a tough job
- ✓ Your worksite is located far away from your shop
- ✓ You are about to buy a piece of used equipment or sell your equipment
- ✓ When in doubt, get your equipment inspected by a trusted professional

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