



NATIONAL CERTIFICATE IV **PLUMBING**

Student
Learning
Materials

ACKNOWLEDGEMENT

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INSTRUCTION TO TRAINERS

Competency Based Training (CBT) and assessment - An introduction for trainers

Learning Materials presented here can be used to deliver competency based training using the National Competency Standard developed for the respective occupation.

Competency

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

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

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

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

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

Unit of Competency

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

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

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

Element of Competency

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

Performance criteria

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

Learning

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

- Training
- Assessment.

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

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

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

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

Learning Approaches

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

Competency Based Training (CBT)

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

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

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

Competency Based Assessment (CBA)

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

Flexibility in Learning

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

Catering for Participant Diversity

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

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

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

Participant Centered Learning

This involves taking into account structuring training and assessment that:

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

Active Learning

The goal of nurturing independent learning in participants does not imply that they always have to work in isolation or solely in a classroom. On the contrary, the construction of

knowledge in tourism and hospitality studies can often best be carried out in collaboration with others in the field. Sharing experiences, insights and views on issues of common concern, and working together to collect information through conducting investigative studies in the field (active learning) can contribute a lot to their eventual success.

Active learning has an important part to play in fostering a sense of community in the class. First, to operate successfully, a learning community requires an ethos of acceptance and a sense of trust among participants, and between them and their trainers. Trainers can help to foster acceptance and trust through encouragement and personal example, and by allowing participants to take risks as they explore and articulate their views, however immature these may appear to be. Participants also come to realize that their classmates (and their trainers) are partners in learning and solving.

Trainers can also encourage cooperative learning by designing appropriate group learning tasks, which include, for example, collecting background information, conducting small-scale surveys, or producing media presentations on certain issues and themes. Participants need to be reminded that, while they should work towards successful completion of the field tasks, developing positive peer relationships in the process is an important objective of all group work.

Competency Based Training (CBT)

Principle of Competency Based Training

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

Training Strategies

The aims of this curriculum are to enable participants to:

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

Types of Training

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

Lecture/Tutorial

This is a common method of training involving transfer of information from the trainer to the participants. It is an effective approach to introduce new concepts or information to the

learners and also to build upon the existing knowledge. The listener is expected to reflect on the subject and seek clarifications on the doubts.

Demonstration

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

Group Discussions

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

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

Role Play

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

Simulation Games

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

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

Individual /Group Exercises

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

Case Study

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

Field Visit

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

Group Presentation

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

Practice Sessions

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

Games

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

Research

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

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

Competency Based Assessment (CBA)

Principle of Competency Based Assessment

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

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

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

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

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

INSTRUCTIONS TO CANDIDATE

Introduction to trainee manual

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

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

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

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

What is a competency standard?

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

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

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

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

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

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

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

UNIT 01

WRITE TECHNICAL REPORTS

This unit covers the competence to identify and analyse requirements, to plan and conduct research, to evaluate information and findings, and to develop, document and present technical reports

PLAN RESEARCH AND WRITE PROPOSAL

With the planned engineering qualification, it is important that develop the knowledge and skills on undertaking small research projects that could be system of study, or an engineering part and follow the standard process of writing research or project proposal, conducting research and finally writing the report and presenting them.



Purposes of a Proposal

The project or research proposal:

- ✓ Allows the writer to clarify what it is he/she wants to do, why and how he/she wants to do it,
- ✓ Presents what she/he wants to do in the manner and timeframe proposed, and
- ✓ Once approved, provides a written contract between the student and the project supervisor

Components of a Project Proposal

1. Title

The title of the project is very significant. It will go on the spine of the published document when it is bound and becomes accessible in the University of Lethbridge Library. The title is one of the ways that people using the University of Lethbridge electronic search engine will locate the project in the holdings. The title must be clear, appropriate for the topic and less than 45 characters, including spaces and punctuation.

2. Introduction (WHAT is this about?)

The Introduction to the project provides a general introduction to the phenomena or issue of interest, and is usually contained in 2 pages. The issue or problem under investigation is described, and background and/or context for understanding the nature of the issue is provided. In writing this section, students should provide answers to two main questions:



What is the project all about?

Why is the project important or worthwhile?

The Introduction will also typically conclude with a brief description of the structure of the remainder of the document.

3. Research Question (WHAT am I trying to find out? WHY?)

Every project must state a research question or a statement on what is the intent of the project. It is not a "null-hypothesis statement" but rather you are stating the big, overarching question that is guiding your study. Several smaller questions may even be nested in the larger one.

The research question and the title are two required elements of all proposals. The connections between the two must be obvious. (Hopefully, they are obvious to the writer, but they may not be to the audience.)

Where the research question appears in the proposal is something each writer must decide. It could appear in the introduction; it could follow the introduction or the background or the literature review or it could appear within any of the above sections. Just don't leave it until the reference section!

4. Method (HOW? WHO? WHERE?)

(This section must make sense within the context of the document and be linked with the sections preceding it.) In this section provide a clear, explicit and thorough description of how you will complete your project and the timetable for completing each step. For example, what databases will you be using during your literature review? What search terms and exclusion criteria will you be using? When will you be starting your literature review and when will it be finished?

It is the writer's responsibility to ensure that the proposal is clear about what is being proposed, with whom, where and when. (WHY should already have been explained.) Approximately 1-2 paragraphs is suitable for this section.

A project does not involve interviewing people or collecting raw data as this type of collection of data would require ethics approval and a host of other documents would need to be created such as informed consent.



This section needs to include a statement that you will adhere to an approved code of ethics of your selection.

5. Project (What do I do when I'm done doing what I said I would do?)

Describe what the final product will look like. For example, if it is a manual, provide details about the manual's length, formatting style, number of lessons, etc. If the product is to be something creative and other than text, provide examples of what the final product might look like. If the proposal includes writing a series of fictionalized autobiographical accounts, a sample should be included in the proposal. If the proposal includes a website describe it.

Title Page
Acknowledgements Page
Abstract
Table of Contents
Chapter 1: Overview (proposed number of pages:)
Sub headings:
a.
b.
c.
Chapter 2: Review of Literature (proposed number of pages:)
Sub headings:
a.
b.
c.
Chapter 3: Methods (proposed number of pages:)
Chapter 4: Outcome
a.
b.
c.
Chapter 5: Synthesis
a. Strengths
b. Limitations
c. Recommended Future Research
References

6. Timeline Include a draft timeline from start to finish.

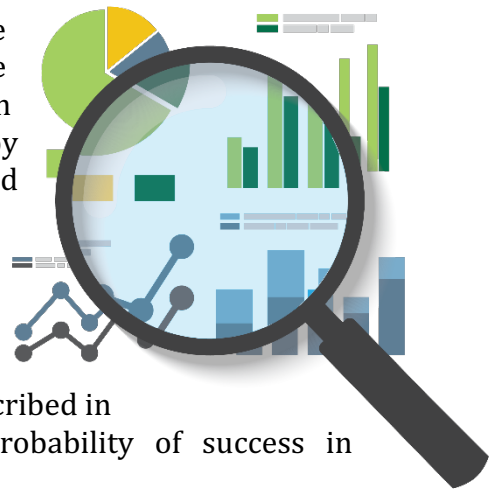
Start with the proposed convocation date and work backwards to revising the final draft of project (expect at least two to three rewrites). Availability of the supervisor is also very important to consider and factor in to your timeline.

7. References

References to anything cited in the text of the proposal must adhere to APA guidelines. (As a matter of fact the entire proposal needs to adhere to APA guidelines). APA formatting requires only those materials cited or referred to in the text be listed in the References. A separate section entitled "Bibliography" lists other materials (books, journal articles, etc.) related to the project but not specifically referred to in the document.

CONDUCT RESEARCH AND ANALYSE THE INFORMATION

The research plan shall detail completely the prosecution of the research, including the submission of an acceptable final report. The plan ultimately becomes a part of the contract by reference of the proposal; therefore, it should describe, in a specific and straightforward manner, the proposed approach to the solution of the problem described in the project statement. It should be concise, yet include sufficient detail to describe completely the approach to the solution of the problem. Research methodology shall be described in sufficient detail to permit evaluation of the probability of success in achieving the objectives.



The research plan shall be subdivided into the following sections:

Introduction

The introduction to the research plan should provide a concise overview of the proposer's approach to conducting research. It should describe the manner in which the expertise and experience of the proposed team will be used in the research, and the application of special data, facilities, contacts or equipment should be presented. The Introduction should highlight the linkages of the proposed team's capabilities to the project tasks and the manner by which the proposed plan will satisfy the objectives.

Research Approach

This section will be used to describe how the objectives will be achieved through a logical, innovative, and rational scientific plan. The plan shall describe each phase or task of the research to be undertaken.

Equipment and Facilities

This section shall include a description of the facilities available to undertake the research and an itemization of the equipment on hand considered necessary to complete the research. In the event that use of the facilities or equipment is conditional, the conditions should be described. In the event that certain facilities or equipment are considered necessary to undertake the research but are not on hand, that fact should be presented. The proposer should identify any arrangements that will be made to borrow or rent necessary equipment. In the case where it is contemplated that additional equipment will be purchased under project funds, be certain that the budget item "capital equipment" indicates this.

Time Requirements

The time required to complete the research project shall be specified. Proposals will not be rejected if the proposed time does not match the time specified in the project statement. However, the agency must justify any difference. In addition, a schedule shall be included that shows each phase or task of the work, when that phase or task will begin, how long it will continue, and when it should end. The timetable should clearly delineate the points in time where project deliverables and reports are planned



Research Work Plan

In the absence of specific requirements for the format and content of the research work plan, the following constitutes a useful outline:

- ✓ Title
- ✓ Introduction
- ✓ Objectives
- ✓ Research Approach
- ✓ Project Team
- ✓ Equipment and Facilities
- ✓ Budget
- ✓ Schedule
- ✓ Anticipated Results
- ✓ Implementation



The introduction provides background information taken from the Problem Statement or the Request for Proposals. It is included because the work plan should be a “stand-alone” document, i.e. the reader should not need to refer to other documents. The objectives also should be a re-statement of the objectives from the earlier documents. The ‘Research Approach’ is the largest section in the work plan. It should present the hypothesis, and describe and justify the strategy, which is being employed to satisfy the objectives. For instance it could be a desk study comprising literature review and analysis, laboratory studies, field studies, or a combination of approaches. It is usual to divide the work into tasks, each of which constitutes a milestone in the completion of the work. For example, if the study involves writing a state-of-the-art report, the tasks might be:

- ✓ Task 1 Literature Survey
- ✓ Task 2 Questionnaire
- ✓ Task 3 Field Visits
- ✓ Task 4 Preparation of First Draft
- ✓ Task 5 Preparation of Second Draft
- ✓ Task 6 Preparation of Final Draft

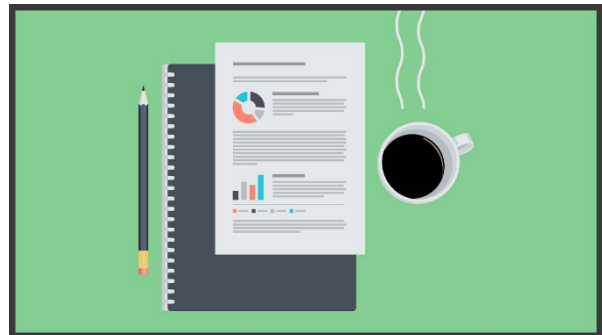
For each task the activities should be described in detail. In Task 1 the search strategy and the databases should be described. In Task 2 the recipients of the questionnaire should be identified. If it is known which agencies will be included in the field visits in Task 3, they should be identified, otherwise it should be made clear how the decision would be made. In Task 4, the scope and intended audience should be identified, and a tentative outline of the report provided. The work plan should also state who would review each of the drafts.

In the case of a project that involves experimental work and developing the plans for subsequent fieldwork, the tasks might be as follows:

- ✓ Task 1 Literature Survey
- ✓ Task 2 Laboratory Studies
- ✓ Task 3 Exposure Plot Studies
- ✓ Task 4 Development of Field Study Design
- ✓ Task 5 Preparation of Final Report

Task 1 would be described as in the previous example. Task 2 will probably consist of sub-tasks, each comprising a series of experiments. The experiments should be described in detail. This allows the principal investigator to ensure that the necessary people, equipment and laboratory facilities will be available to perform the work, and to calculate the cost of the work. This will usually be an iterative process that involves determining how many experiments can be performed within the available budget. It is essential that the principal investigator be confident that the experiments being performed will be sufficient to satisfy the objectives for the task. It

is also good practice to identify a strategy to be followed if the experimental work is not completely successful, e.g. are there other test procedures that could be used? The work plan should describe clearly what would have been accomplished before Task 3 begins, the way in which the work in Task 3 will be influenced by the results obtained in Task 2, and the



manner in which the results will be reported. The activities in Task 3 should be described in the same way as for Task 2, except that they will be more tentative because it is likely that many details cannot be finalized until results from Task 2 become available. Because it is a plan that is being written, it is inevitable that less detail can be provided for the later activities. One of the key roles of the principal investigator is to recognize when changes in the work plan are necessary, and to modify the plan accordingly. The good researcher will maintain flexibility in the work plan to deal with setbacks, and to seize opportunities, while planning in sufficient detail to estimate resources, and to make arrangements for activities which require a long lead time.

In the example given, Task 4 consists of developing a design for a field study to verify the results of Tasks 2 and 3 under real world conditions, not performing the field work itself. The specific details will depend on the results of Tasks 1 to 3, but the plan should contain the following sections:

- ✓ Hypothesis to be tested on field studies
- ✓ Criteria for selection of the study site
- ✓ Potential sites
- ✓ Equipment and other facilities required
- ✓ Data collection and analysis procedures
- ✓ Staffing plan
- ✓ Schedule
- ✓ Budget

The final report prepared in Task 5 should provide full documentation of the problem definition, experimental methods, results, conclusions and future activities, including implementation. Further information on the content and preparation of reports is given in Chapter Five.

In the section describing the project team, the team members should be listed, along with the responsibilities and time commitment for each person. This information is required to ensure that each person will be available to work on the project when required, and to establish costs.

The key members of the team should be identified, but for junior positions where the work could be done by one of a number of technicians, it is sufficient to identify the person by rank, e.g. senior technician @ 200 hours, 3 junior technicians @ 300 hours each. The key members must be identified because if a substitution becomes necessary, management and the sponsor will



need to satisfy themselves that the replacement has the necessary credentials and experience to perform the research. Curriculum vitae are not required in a work plan.

Equipment and facilities are listed for the same reason as personnel, i.e. to ensure that they will be available when needed and that all the costs are captured in the budget. This also forces the researcher to verify that all the equipment necessary to perform the planned experiments is available, or identify equipment and supplies that must be purchased.

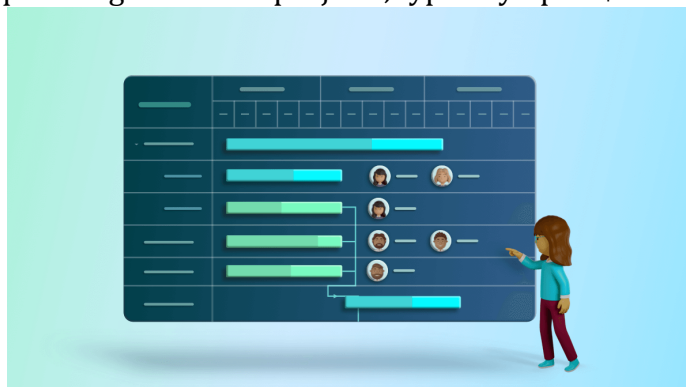
If the research approach, project team, and the equipment are documented in sufficient detail, calculation of the budget for the project is relatively straightforward. Other items such as travel, overhead and profit must, of course, also be included.

A detailed schedule for the work is required to establish a completion date and to provide a mechanism for management to measure the progress of the work. It is also needed to identify when resources will be needed, and to calculate cash flow requirements. For projects that involve no more than about 10 tasks, and about an equal number of sub-tasks, a chart similar to that shown in Figure B-6 is perfectly adequate. Using the second study described above as an example, the chart shows the start and completion dates for each sub-task, and the anticipated progress of each sub-task, as a cumulative percentage. It also shows the interrelationship of the tasks and sub-tasks because it is clear which activities are underway concurrently, and which are sequential. The schedule allows one month for the review of the interim report, and two months to review the final report. The anticipated progress on the overall project can be calculated from a knowledge of the amount of effort required for each task and sub-task. The amount of effort required to complete each sub-task, expressed as a percentage of the effort required to complete the project, is shown in the third column. Taking the end of June 1996 as an example, the anticipated overall completion is:

$$\begin{aligned} & \text{Task 1} + 25\% \text{ of sub-tasks 2a, 2b, and 2c} \\ &= 10\% + 0.25 \times (16\% + 16\% + 16\%) \\ &= 22\% \end{aligned}$$

By plotting the values from the row “Overall Completion” in Figure C-6 against duration of the project, a chart of anticipated progress is developed, as illustrated in Figure B-7. Using the same technique, planned expenditures can be plotted, as shown in Figure B-8, from knowledge of the budget and cash flow projections for each sub-task. Figures C-6 to C-8 are used to measure the progress of the research as described in the section “Execution of the Research”.

The Gantt chart provides a powerful visual representation of the work schedule and quite large research projects, typically up to \$1million budget, can be managed in this



way. Larger projects, especially those involving many semi-autonomous contributors, or requiring access to expensive equipment that is used on many projects, may require a more sophisticated work schedule to be developed. This can be done by preparing a critical path analysis or using computer software designed for project

management.

The final section of the work plan, Implementation, describes how the findings of the research will be implemented. This enables the researchers to involve those who will

be responsible for implementation in the research, and to allow the plans for the implementation activities to be developed while the research is in progress so that there is no delay between completion of the research and implementation of the findings.

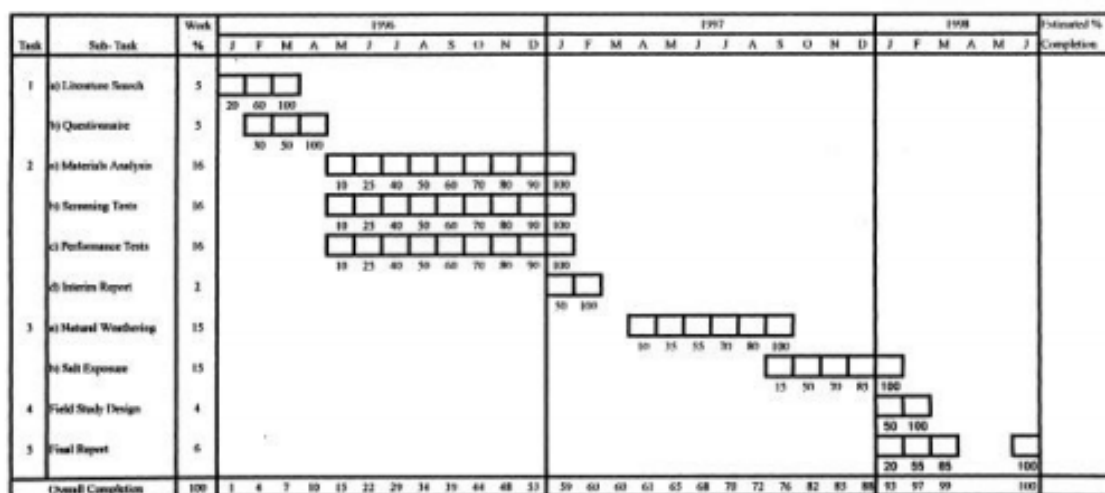


Figure B-6: Example of a Work Schedule Using a Gantt Chart

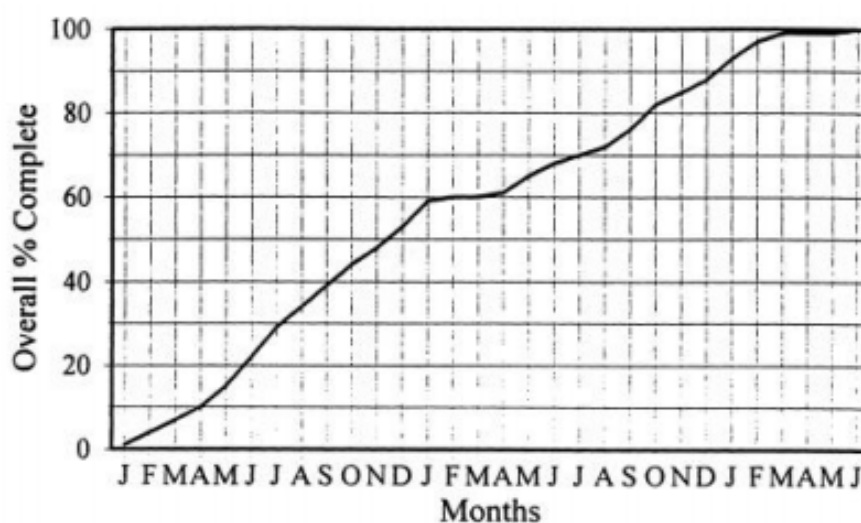


Figure B-7: Planned Progress

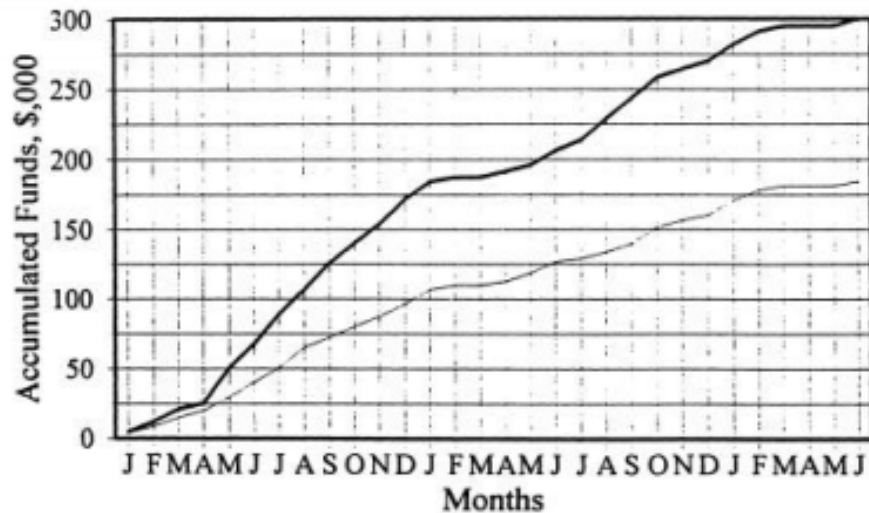


Figure B-8: Anticipated Expenses

Execution of the Research

Technical progress and financial expenditures must be tracked, and monitored, throughout the period of execution of the research. Charts similar to those illustrated in Figures B-6 to B-8 are suitable for this purpose. As an example, Figures B-9 to B-11 illustrate the status of the project described in the previous section as it might have been reported in December 1996. The data indicate that there were delays in beginning Task 2, but, except for work on the performance tests (Task 2c), the project was back on schedule.

Where a greater level of detail is required, as for example, where different budget codes must be reconciled, comparisons between planned and actual expenditures can be made by category, e.g. salaries, travel, and equipment. In this way, variations can be detected early in the process, and steps taken to bring the project under control.

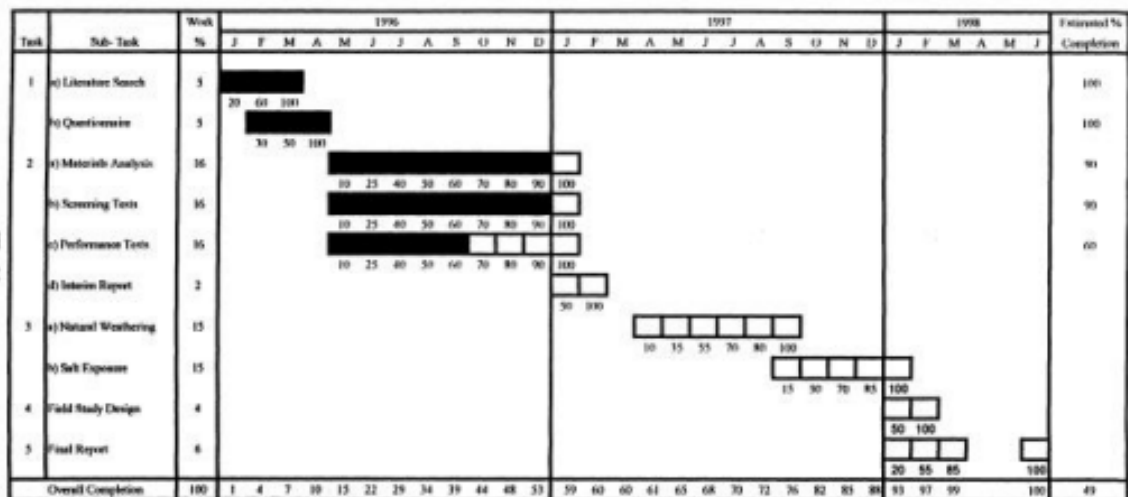


Figure B-9: Completed Progress Schedule for December, 1996

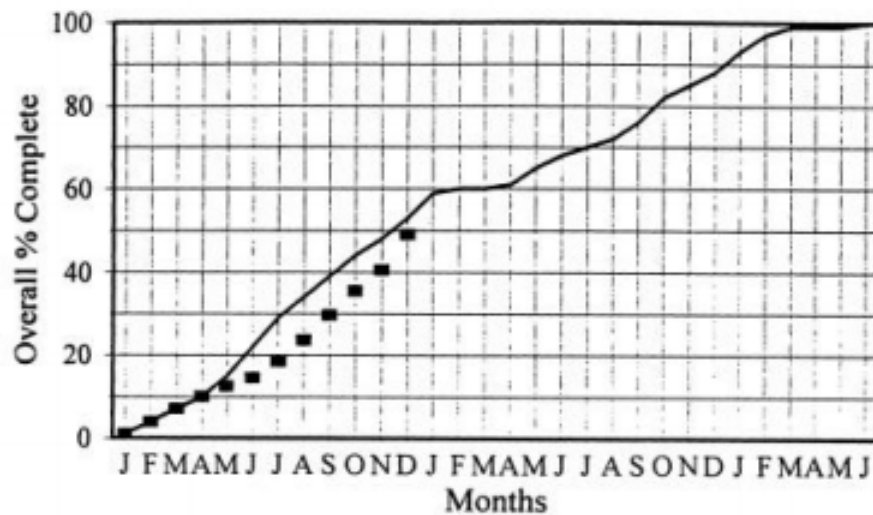


Figure B-10: Overall Progress to December, 1996

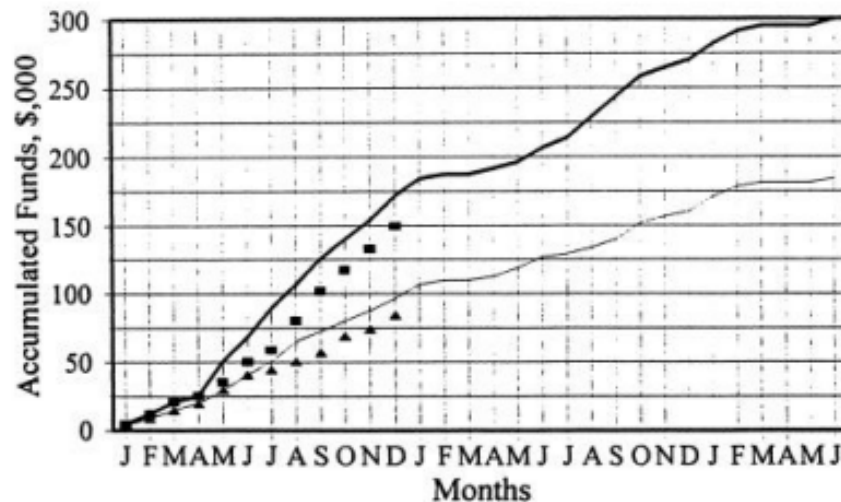


Figure B-11: Expenditures to December, 1996

Implementation and Dissemination of Research Results

An NCHRP study of technology transfer methods and implementation practices included a survey of transportation agencies and an analysis of case studies (10). Much of the information in this section is based on the data collected in the study, and from which the recommendations presented in Chapter Three were developed. Implementation “success” was defined in terms of timeliness, effectiveness, and scope of use. The study examined success from three perspectives:

- ✓ Characteristics of the research results
- ✓ Characteristics of the implementing organization
- ✓ Characteristics of the implementation process

From each perspective, the relative importance of factors that promote implementation, and those which act as barriers to implementation were rated, by participants in a workshop, on a scale of 1 to 5. The results are given in Tables B-1 to B-3 (the data were obtained from figures contained in reference 10). Barriers to implementation have been expressed on a scale of -1 to -5 (-5 being the greatest barrier).

Characteristics of Research Results



Some attributes of the research output can impede implementation. Most obviously, if the research does not meet the needs of potential users, the results will not be put into practice. Also, if users do not see evidence that a new product or process has been adequately tested, they may not want to be guinea pigs.

On the other hand, research results are more likely to be put into practice rapidly and effectively, if the researchers have accounted for real-world situations. In many cases, pilot or demonstration projects are useful steps toward full implementation. Their purpose is to evaluate the new products or processes under operational conditions, and make any necessary improvements, before full implementation on the in-service system. This is important to reduce the risk of failures. Even when full-scale implementation is adopted, the product or process may be designated experimental for a prescribed period to ensure that there is a systematic evaluation of the how well the changes are working.

Site selection for demonstration projects is much more complex than it might appear to be. The objective is to evaluate the new product or process under conditions, which are representative (with respect to site conditions, difficulty of work, contractor expertise, time of year) of the anticipated future applications while



minimizing the risk of delay or failure. Frequently the work must be incorporated in contracts already awarded, or about to be tendered. Each has its disadvantages. Changes to existing contracts are often expensive and the contractor may not have the necessary expertise. Contracts not yet awarded are subject to shifts in award schedules, often resulting in projects being moved from one construction season to another.

Rarely will there be an ideal candidate and the selection must be based on compromises between ideal and available conditions. The longer the time available to plan a demonstration project, the greater are the chances of locating site meeting a larger number of the selection criteria.

Positive Factors	Rating	Barriers	Rating
Pilot projects in real settings	4.2	Mismatch between research and user needs	-4.3
Implementation package with research output	4.0	Research output not sufficiently tested	-3.8
Research adaptable to varied contexts	3.3	Research output does not fit work procedures	-3.6
Research designed for commercialization	2.5	Allocation of patents etc. not settled	-3.1

Table B-1: Factors Pertaining to the Characteristics of Research Results

Positive Factors	Rating	Barriers	Rating
Management commitment	4.8	Risk aversion	-4.2
Long-term innovation champions	4.1	Organizational inertia	-4.2
Capability to sustain innovation	4.0	Inflexible contract specifications	-3.9
Incentives for change	4.0	Discomfort with change	-3.9
In-house expertise	3.9	Legal liability	-3.8
On-the-job recognition	3.7	Inadequate resources	-3.8
Performance-oriented specifications	3.4	Skill obsolescence	-3.2
Job rotation assigned	2.7	Political involvement with managers	-3.2
		No local precedents	-2.8
		Inadequate travel budget	-2.6

Table B-2: Factors Pertaining to the Organization

Positive Factors	Rating	Barriers	Rating
Researcher-user pilot collaboration	4.6	User successes unpublicized	-3.7
Users help design research	4.4	Poor quality/relevance filters	-3.6
Targeted funding	3.6	One-way dissemination	-3.6
Easy access to researchers	3.4	Costliness	-3.6
Effective training	3.2	Unknown information source	-3.2
Mandatory innovation use	2.5	Researchers not market-oriented	-2.5

Table B-3: Factors Pertaining to the Implementation Process

Characteristics of the Organization

The most important institutional barriers to implementation include organizational inertia, risk-averse behavior, management discomfort with change, and inadequacy

of resources. As noted in the section describing the characteristics of research results, new products and processes entail a degree of risk. Some will prove not worth their cost, and some may not function effectively. The organization must be prepared to encourage staff to innovate, and to support them even when new ventures are not successful. This includes a commitment on the part of senior management to provide resources for implementation efforts and the willingness of senior officials to champion innovation.

Characteristics of the Implementation Process

Collaboration between the researchers and the users throughout the research and implementation phases is the key to the successful use of research results. Many agencies involve the researchers, in-house or contract staff, in the implementation efforts and technology transfer. Commonly, this involves giving seminars or training sessions to agency staff. Depending upon the circumstances, it could also involve evaluating the success of demonstration projects or results designated experimental. However, some agencies deliberately limit the involvement of researchers in the implementation process. The main reasons for doing so are that the contractor is not familiar with the internal process of the agency, and not necessarily expert in implementation efforts. It is also recognized that the implementation effort is substantial, and often different disciplines from those needed to conduct the research. In cases where the researchers are not involved directly in the implementation efforts, it is important that they be accessible.



Cost is frequently a major impediment in implementing new products, and procurement rules that prohibit sole-sourcing can be a major obstacle. Targeted funding for implementation, and flexibility to incorporate experimental features in construction contracts are effective ways of dealing with these problems.

Evaluation of Research Projects

Expert Opinion

This method involves obtaining the opinions of people who are knowledgeable about the subject of the research and the impact of the project being evaluated. The experts can be internal or external to the agency.

Expert opinion is often solicited in the project selection phase. The opinion can be provided on an unstructured basis, or structures using performance indicators such as the quality of the research, level of innovation, or economic impact.

User or Client Opinion

This method involves obtaining the opinions of clients, often through technical advisory committees or project panels. Like expert opinion, client opinion is most commonly sought when problem statements or proposals for research projects are reviewed. Surveys are a useful method of obtaining client or user input in situations where there are numerous users, or the users are widely separated geographically.

Cost-Benefit Methods

Cost-benefit analysis seeks to assess the project in terms of the economic and social benefits generated for a particular “referent group” (e.g. an agency, a region or society as a whole) as well as the economic and social costs incurred by the referent group to carry out the research and implement the results. The definition of the referent group is important because it defines the bounds for the analysis. There are a number of general principles associated with conducting cost benefit analyses of transportation-related research projects.

- ✓ There are three main types of costs associated with a research project that must be taken into account in the analysis. These are the costs of generating the research results, the costs of introducing and supplying the results to the end users, and the costs incurred by the end users to implement the results.
- ✓ The benefits of the research project are valued at the price society is willing to pay for them. The assessment of benefits includes not only those for which prices are paid, but also benefits associated with, for example, reduced environmental damage, better air quality and improvements in health and safety, even though such benefits may be difficult to quantify.
- ✓ Once they have been identified, all the benefits and costs associated with the project are compared using a common measuring system of constant dollar values. Allowances can be made for



future changes in relative real prices, but no adjustments are made for the future changes in the general price level as a result of inflation or deflation. All costs and benefits must be discounted to their present values through a social discount rate before they can be compared to determine the net benefit of the project to society. The selection of the discount rate is controversial, and has a major impact on the results of the analysis. The discount rate is intended to be the social discount rate, which represents the present generation's weighting of benefits and costs to be borne by future generations. In the private sector, the discount rate is sometimes taken to be the difference between the prime interest rate and the rate of inflation.

- ✓ The net present value is given by the formula:

$$NPV = \sum_{i=1}^N \frac{(B_i - C_i)}{(1 + r)^i}$$

where B_i = the benefits attributable to the project in year i

C_i = the costs attributable to the project in year i

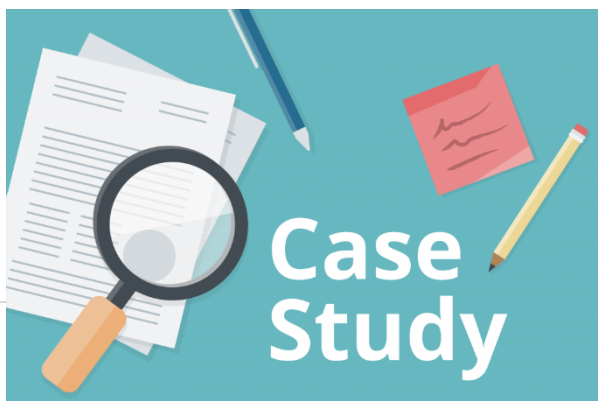
r = the discount rate

N = the number of years over which benefits and costs (compared to the "base case") can be estimated, usually 5 to 10 years.

- ✓ The research project being analyzed must be incremental, and the benefits must be attributable to the results of the research. "Incremental" means that the results would not have been available in the absence of the project. "Attribution" deals with the extent to which the benefits are actually due to the research results. This is extremely important in defining the "base case" which is rarely the situation before the project was undertaken, but more properly it reflects benefits that would have occurred even if the project had not been undertaken. This includes the incorporation of developments made elsewhere, and changes that would have occurred from sound management strategies. Given the uncertainty of research, many evaluators find cost-benefit analysis impractical, except possibly for projects which have been completed for some time, and which have well-defined benefits. On the other hand, cost benefit analysis can be a useful method for deciding which potential projects are most attractive, and for demonstrating the value of investing in research.

Case Studies

Case studies involve a detailed and thorough analysis of research projects, and seek to track and document the evolution of the impacts associated with the research. The



advantage of case studies is that they afford the best opportunity of identifying the relationship between the research study and the impact of the research results. They are particularly useful for evaluating projects that benefit the public good, rather than using cost-benefit

analyses that assign dubious values to some impacts such as the value of a human life. Because the results are usually qualitative, it is difficult to use case studies to compare the value of projects, or to aggregate the results to demonstrate the value of research programs.

Performance Indicators



There are two main categories of performance indicator methods, partial indicators and integrated partial indicators. The first method involves the collection of information items, each of which provides some insight into the project such as cost, time, risk and potential outputs. The method of integrated partial indicators involves the



collection of the same kinds of information, except that it is integrated in some way. The method usually involves summing the partial indicators to arrive at a “bottom line score”. The most common approach is to evaluate each project with reference to a specific set of criteria (e.g. cost, feasibility or risk, likely impact, relevance to the agency mandate), assign a score and a weight to arrive at an overall score for the project. This method is often used to select individual projects, and to evaluate responses to requests for proposals.

PREPARE AND PRESENTING REPORTS

What is a report?

A report is a written presentation of factual information based on an investigation or research. Reports form the basis for solving problems or making decisions, often in the subjects of business and the sciences. The length of reports varies; there are short memorandum (memo) reports and long reports. Most often you will be asked to write a long report.

What makes an effective report?

- ✓ Clear, concise and accurate
- ✓ Easy for the audience to understand
- ✓ Appropriate for the audience
- ✓ Well organized with clear section headings

Report structure:

Reports follow a standardized format. This allows the reader to find the information easily and focus on specific areas. Most reports follow the following structure, but please look at your assignment question and marking guide carefully, as the format and terminology required in your report may vary from this guide. If so, check with your tutor. Please check your marking guide to determine the word limit and how marks are allocated to each section

A report must have:

- ✓ Title Page
- ✓ Table of Contents
- ✓ Abstract or Executive Summary
- ✓ Introduction (or Terms of Reference and Procedure)
- ✓ Findings and/or Discussion
- ✓ Conclusions
- ✓ Recommendations
- ✓ References

A report may also contain:

- ✓ Cover letter
- ✓ Bibliography
- ✓ Glossary
- ✓ Appendices

The table below summarizes the main headings used in reports and outlines the purpose of each section. Please note: Further headings or subheadings may be used depending on the report's content, and are specific to the individual report.

Section	Purpose
Title Page (Not part of the word count)	Gives the title of the report, the student name/number, the name of the person the report is being submitted to, and the completion date.
Table of Contents (Not part of the word count)	Shows the sections of the report. Gives the headings, subheadings and page numbers.
Abstract or Executive Summary	Gives a summary of the whole report. Outlines the report's purpose, methodology, findings, main conclusions and recommendations. Mainly written in past tense, and prepared last.
Terms of Reference	Briefly states the purpose and scope of the report. This includes who requested the report, the main issues or problems to be identified, the reason for undertaking the report and the due date of the report.
Procedure	Outlines the methods used to collect

	information e.g. interviews, questionnaires, observations and/or research.
Introduction (May be used instead of the Terms of Reference and Procedure)	<p>Outlines the context, background and purpose of the report.</p> <p>Defines terms and sets limits of the investigation.</p> <p>The reader/audience can easily identify what the report is about, how information was gathered, and why the report is needed.</p> <p>Mainly uses past tense and can be written last – but is presented first.</p>
Findings and/or Discussion For this section, avoid using the headings “Findings” or “Discussion”. Instead, create headings and sub-headings that identify the main issues or problems.	<p>Findings: What was found during the research or investigation?</p> <p>Gives the facts only – no interpretation by the writer of the report. Tables, graphs or diagrams can be used.</p> <p>Must be relevant to the issues and problems identified in the Terms of Reference.</p> <p>Arranged in a logical order with headings and sub-headings.</p> <p>Discussion: You may also be required to analyses, interpret and evaluate the findings. The discussion draws together different parts of the findings and may refer to findings of other studies and/or theories.</p>
Conclusions	<p>Brief statements of the key findings of the report (full explanation is given in the Findings and/or Discussion).</p> <p>Arranged so the major conclusions come first.</p> <p>Should relate directly to the objectives set out in the Terms of Reference or Introduction.</p> <p>Follow logically from the facts in the Findings and/or Discussion.</p> <p>Must be complete enough for recommendations to be made from them.</p>
Recommendations (note: not all reports give recommendations)	<p>The opinions of the writer of the report about possible changes, or solutions to the problems, including who should take action, what should be done, when and how it should be done.</p>
References (Not part of the word count)	<p>A list of the sources that are used in and referred to in the report.</p> <p>Use APA referencing style.</p>

Bibliography (Not always required)	Lists any sources that were read for the research but were not cited in the report. (Bibliography is not included in the word count).
Appendices (Not always required)	Additional relevant information. May include interview questions, surveys, glossary etc. (Appendices are not included in the word count).

UNIT 02

APPLY AND MAINTAIN OCCUPATIONAL HEALTH AND SAFETY

This unit of competency describes the skills and knowledge to monitor and maintain work health and safety (WHS) within a work area where the person has supervisory responsibility for others

PERFORM ALL WORK SAFELY

Regardless of your job, there are some basic safe work practices that should be observed by everyone working on the job site. The objective of the safety program is to prevent injuries and to allow you to do your job efficiently and safely. It takes an effort on your part to support the safety program but, after all, that's what it's all about.

Right now, let's review some basic safe work practices. All persons must follow these safe practices and render every possible aid to safe operations and be a part of the program by reporting all unsafe conditions or practices to your supervisor or superintendent. The vast majority of work-related injuries are the result of unsafe acts of workers. That means, when you take shortcuts, you violate safety regulations or simply don't take safety seriously, injuries are more likely to occur. Your company has a responsibility and obligation to make sure that all employees observe and obey all applicable company, or national regulations and order as is necessary to the safe conduct of the work and must take such action as necessary to obtain compliance.



If you violate company safety rules, or you work in an unsafe manner, you will be provided a written safety counselling. This counselling will explain what the unsafe behaviour was and how to correct it. If it's a minor violation, then the counselling will serve as a reminder for the proper procedure. If it's a serious violation, or you continue to exhibit unsafe behaviour, disciplinary action may be warranted. The purpose of safety rule enforcement is the protection of all employees. One employee's unsafe behaviour can affect the safety of other employees and safety is too important to allow unsafe behaviour or unsafe conditions.

In the construction industry, frequent accident prevention instructions or training is provided at least every ten days. However, it is each employee's responsibility to work and act safely every day on every job. Training is simply making you more

aware of safety and safety rules and it's your job to work safe and act safely every day.

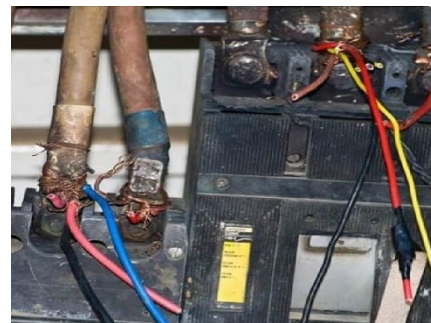
Anyone known to be under the influence of drugs or intoxicating substances which impair the employee's ability to safely perform the assigned duties shall not be allowed on the job while in that condition. If you are taking medication prescribed by a physician or taking over-the-counter medication, be sure to tell your supervisor before you begin work. Some medications may impair your ability to work or operate equipment safely. We discussed unsafe behaviour and how it leads to injuries on the job. Unsafe behaviour includes horseplay. Scuffling, practical jokes and other acts which tend to have an adverse influence on the safety or wellbeing of other employees. No one shall knowingly be permitted or required to work while the employee's ability or alertness is so impaired by fatigue, illness, or other causes that they might unnecessarily expose the employee or others to injury.

Work shall be planned and supervised to prevent injuries in the handling of materials and in working together with equipment. Employees shall not enter manholes, underground vaults, chambers, tanks, silos, or other similar places that receive little ventilation unless it has been determined that it is safe to enter. Confined spaces can be quite hazardous from toxic fumes, gas, and other hazards can gather in the spaces creating a dangerous hazard.

Machine guards and other protective devices must be in their proper place before machinery and equipment is used and employees must report any deficiencies or hazards to the supervisor when they are detected. If the equipment is unsafe to operate, do not operate the equipment until it has been replaced or repaired.

Crowding or pushing when boarding or leaving any vehicle or other conveyance is prohibited.

Employees must not handle or tamper with any electrical equipment, machinery, or air or water lines in a manner not within the scope of their duties unless they have received instructions and authorization from their supervisor.



If you are injured on the job, report the injury immediately. Don't wait. Report the injury when it occurs, even if you believe that medical treatment is not necessary. If medical treatment is required, it will be provided.

When lifting anything, use the power of your legs and not your back. If you keep your back in its natural curvature by bending your legs, it's difficult to suffer a back injury.

Inappropriate footwear or shoes with thin or badly worn soles must not be worn. Wear proper footwear



and clothing on the job. Materials, tools, and other objects shall not be thrown from structures until proper precautions are taken to protect others from the falling objects.

Housekeeping is important to everyone's safety so take time to keep your work area clean. If you see a hazard, correct it. If you can't correct the hazard yourself, report it so it can be corrected.

When handling chemicals or hazardous substances be sure to use personal protective equipment as necessary and follow the instructions provided on the chemical label. Never use gasoline for any type of cleaning purposes. Wash your hands and skin after handling chemicals and hazardous materials.



When using ladders, inspect the ladder before using it to make sure it is in good condition and will carry the load. Using the proper ladder on the job is equally important. Never stand on the top two steps of a ladder, and when using straight ladders, make sure the ladder extends at least 3 feet above the landing, or where the ladder is positioned on the structure.

Any damage to scaffolds, false work, or other supporting structures shall be immediately reported to your supervisor and repaired before use.

No source of ignition shall be applied to any enclosed tank or vessel, even if there are some openings, until it has been first determined that no possibility of explosion exists. An authority for the work is obtained from your supervisor. Persons using welding equipment must always be concerned in starting fires from the sparks or flash. Never weld around combustible or flammable material and, if necessary, have someone standing by with a fire extinguisher during welding operations.

When using tools and equipment, maintain these tools and equipment in good serviceable condition. Damaged tools or equipment must be removed from service and tagged

"defective." Pipe or Stilson wrenches must not be used as substitute for other wrenches. Only appropriate tools shall be used for a specific job.



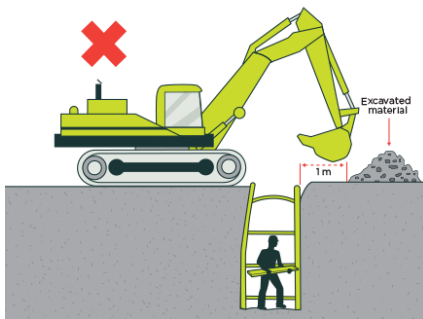
Vices must be equipped with handles and not used to punch or pry. A screwdriver should not be used as a chisel. Portable electric tools shall not be lifted or loaded by means of a power cord. Use ropes, not the power cord for lifting or lowering electrical tools. Before electrical tools are used, they must be inspected to make sure the power cord and plugs are in good condition. Cords with cuts or fray must be replaced. You cannot simply wrap electrical tape over a cut or frayed cord.

Only those persons who are trained and authorized may operate machinery or equipment. Loose or frayed clothing, long hair, dangling ties, finger rings, necklaces, and other potentially hazardous items may not be worn around moving machinery or other areas where they become entangled. Machinery shall not be serviced, repaired or adjusted while in operation, or shall oiling of moving parts be attempted, except when equipment that is designed or fitted with safeguards to protect the person performing the work. Where appropriate, lockout-tagout procedures must be used. If you see a piece of equipment or a machine that is locked out and tagged out, do not attempt to operate this equipment. A lock and tag means that someone is working on that machine and could possibly be injured if the equipment were to be inadvertently started.



Employees shall not work under vehicles or other equipment supported by jacks or chain hoists without protective blocking that will prevent injury if jacks or hoists should fail.

Air hoses shall not be disconnected at compressors until the hose line has been bled and is free of any air pressure.



All excavations must be visually inspected before backfilling to ensure it is safe to backfill. Excavating equipment must not be operated near tops of cuts, banks or cliffs if employees are working below. Tractors, bulldozers, scrapers, and carryalls must not operate where there is a possibility of overturning in dangerous areas, like edges of deep fills, cut banks and steep slopes.

Watch out for moving vehicles and equipment on the job site. Often this equipment is noisy and the operator may not be able to hear or see you. You have the responsibility for watch out for moving equipment.

There are many more safe practices and rules that could be listed, but it's impossible to list them all. Actually, safety is simply using common sense and good judgment. If something appears to have the potential for injury, then that's the time to take steps to make sure the injury doesn't occur.

Teamwork - everyone's cooperation and a special effort can result in a safe and helpful work environment. If you take safety seriously, you'll have a much better



attitude about yourself and your job. Take time for safety, because safety really does make a difference.

The meaning of key terms

Hazard means a situation or thing that has the potential to harm a person. Hazards at work may include: noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, bullying and violence at the workplace.

Risk is the possibility that harm (death, injury or illness) might occur when exposed to a hazard.

Risk control means taking action to eliminate health and safety risks so far as is reasonably practicable, and if that is not possible, minimising the risks so far as is reasonably practicable. Eliminating a hazard will also eliminate any risks associated with that hazard.

ENSURE OTHERS TO OBSERVE AND PRACTICE SAFE WORK PRACTICES

What is involved in managing risks?

Management Commitment

Effective risk management starts with a commitment to health and safety from those who operate and manage the business or undertaking. You also need the involvement and cooperation of your workers, and if you show your workers that you are serious about health and safety they are more likely to follow your lead.

To demonstrate your commitment, you should:

- ✓ Get involved in health and safety issues
- ✓ Invest time and money in health and safety
- ✓ Ensure health and safety responsibilities are clearly understood.

A Step-By-Step Process

A safe and healthy workplace does not happen by chance or guesswork. You have to think about what could go wrong at your workplace and what the consequences could be. Then you must do whatever you can (in other words, whatever is 'reasonably practicable') to eliminate or minimise health and safety risks arising from your business or undertaking.

This process is known as risk management and involves the four steps set out in this Code (see Figure 1 to the right):

- ✓ Identify hazards – find out what could cause harm
- ✓ 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
- ✓ Control risks – implement the most effective control measure that is reasonably practicable in the circumstances

- ✓ Review control measures to ensure they are working as planned.

Many hazards and their associated risks are well known and have well established and accepted control measures. In these situations, the second step to formally assess the risk is unnecessary. If, after identifying a hazard, you already know the risk and how to control it effectively, you may simply implement the controls.

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.

How to find hazards

INSPECT THE WORKPLACE

Regularly walking around the workplace and observing how things are done can help you predict what could or might go wrong. Look at how people actually work, how plant and equipment is used, what chemicals are around and what they are used for, what safe or unsafe work practices exist as well as the general state of housekeeping.



Things to look out for include the following:

- ✓ Does the work environment enable workers to carry out work without risks to health and safety (for example, space for unobstructed movement, adequate ventilation, lighting)?
- ✓ How suitable are the tools and equipment for the task and how well are they maintained?
- ✓ Have any changes occurred in the workplace which may affect health and safety?

Hazards are not always obvious. Some hazards can affect health over a long period of time or may result in stress (such as bullying) or fatigue (such as shiftwork). Also think about hazards that you may bring into your workplace as new, used or hired goods (for example, worn insulation on a hired welding set).

As you walk around, you may spot straightforward problems and action should be taken on these immediately, for example cleaning up a spill. If you find a situation where there is immediate or significant danger to people, move those persons to a safer location first and attend to the hazard urgently.

Make a list of all the hazards you can find, including the ones you know are already being dealt with, to ensure that nothing is missed. You may use a checklist designed to suit your workplace to help you find and make a note of hazards.

RISK ASSESSMENT

A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening. A risk assessment can help you determine:

- ✓ How severe a risk is
- ✓ Whether any existing control measures are effective
- ✓ What action you should take to control the risk
- ✓ How urgently the action needs to be taken.



A risk assessment can be undertaken with varying degrees of detail depending on the type of hazards and the information, data and resources that you have available. It can be as simple as a discussion with your workers or involve specific risk analysis tools and techniques recommended by safety professionals.

When should a risk assessment be carried out?

A risk assessment should be done when:

- ✓ There is uncertainty about how a hazard may result in injury or illness
- ✓ The work activity involves a number of different hazards and there is a lack of understanding about how the hazards may interact with each other to produce new or greater risks
- ✓ Changes at the workplace occur that may impact on the effectiveness of control measures.

A risk assessment is mandatory under the WHS Regulations for high risk activities such as entry into confined spaces, diving work and live electrical work. Some hazards that have exposure standards, such as noise and airborne contaminants, may require scientific testing or measurement by a competent person to accurately assess the risk and to check that the relevant exposure standard is not being exceeded (for example, by using noise meters to measure noise levels and using gas detectors to analyse oxygen levels in confined spaces). A risk assessment is not necessary in the following situations:

- ✓ Legislation requires some hazards or risks to be controlled in a specific way – these requirements must be complied with.
- ✓ A code of practice or other guidance sets out a way of controlling a hazard or risk that is applicable to your situation and you choose to use the recommended controls. In these instances, the guidance can be followed.

- ✓ There are well-known and effective controls that are in use in the particular industry, that are suited to the circumstances in your workplace. These controls can simply be implemented.

MONITOR OBSERVANCE OF SAFE WORK PRACTICES

How to do a risk assessment

All hazards have the potential to cause different types and severities of harm, ranging from minor discomfort to a serious injury or death.

For example, heavy liquefied petroleum gas (LPG) cylinders can cause muscular strain when they are handled manually. However, if the cylinder is damaged causing gas to leak which is then ignited, a fire could result in serious burns. If that leak occurs in a store room or similar enclosed space, it could result in an explosion that could destroy the building and kill or injure anyone nearby. Each of the outcomes involves a different type of harm with a range of severities, and each has a different likelihood of occurrence.



PARTICIPATE IN RISK MANAGEMENT PROCESSES

To estimate the severity of harm that could result from each hazard you should consider the following questions:

- ✓ What type of harm could occur (e.g. muscular strain, fatigue, burns, laceration)? How severe is the harm? Could the hazard cause death, serious injuries, illness or only minor injuries requiring first aid?
- ✓ What factors could influence the severity of harm that occurs? For example, the distance someone might fall or the concentration of a particular substance will determine the level of harm that is possible. The harm may occur immediately something goes wrong (e.g. injury from a fall) or it may take time for it to become apparent (e.g. illness from long-term exposure to a substance).
- ✓ How many people are exposed to the hazard and how many could be harmed in and outside your workplace? For example, a mobile crane collapse on a busy construction site has the potential to kill or injure a large number of people.
- ✓ Could one failure lead to other failures? For example, could the failure of your electrical supply make any control measures that rely on electricity ineffective? „ Could a small event escalate to a much larger event with more serious consequences? For example, a minor fire can get out of control quickly in the presence of large amounts of combustible materials.

SUPPORT IMPLEMENTATION OF EMERGENCY PROCEDURES

In most cases, incidents occur as a result of a chain of events and a failure of one or more links in that chain. If one or more of the events can be stopped or changed, the risk may be eliminated or reduced.

One way of working out the chain of events is to determine the starting point where things begin to go wrong and then consider: 'If this happens, what may happen next?' This will provide a list of events that sooner or later cause harm. See the case study in Appendix A.



In thinking about how each hazard may cause harm, you should consider:

- ✓ The effectiveness of existing control measures and whether they control all types of harm,
- ✓ How work is actually done, rather than relying on written manuals and procedures
- ✓ Infrequent or abnormal situations, as well as how things are normally meant to occur.

Consider maintenance and cleaning, as well as breakdowns of equipment and failures of health and safety controls.

Work Out the Likelihood of Harm Occurring

The likelihood that someone will be harmed can be estimated by considering the following:

- ✓ How often is the task done? Does this make the harm more or less likely?
- ✓ How often are people near the hazard? How close do people get to it?
- ✓ Has it ever happened before, either in your workplace or somewhere else? How often?

You can rate the likelihood as one of the following:

- ✓ Certain to occur - expected to occur in most circumstances
- ✓ Very likely - will probably occur in most circumstances
- ✓ Possible - might occur occasionally
- ✓ Unlikely - could happen at some time
- ✓ Rare - may happen only in exceptional circumstances

Table 1: Risk matrix

Probability	High			
	Med.			
	Low			
		Low	Med.	High
		Severity		

The level of risk will increase as the likelihood of harm and its severity increases.

UNIT 03

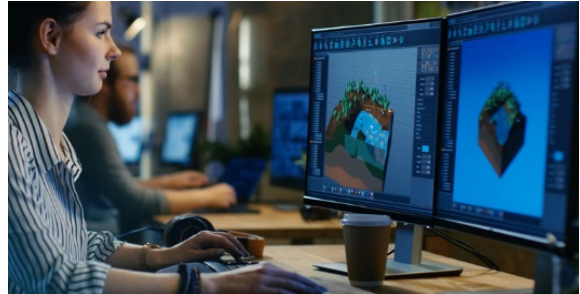
CARRY OUT DATA ENTRY AND RETRIEVAL PROCEDURES

This unit deals with the skills and knowledge required to operate computer to enter, manipulate, and retrieve and to access data and communicate via the Internet

INITIATE COMPUTER SYSTEM

Introduction to computers

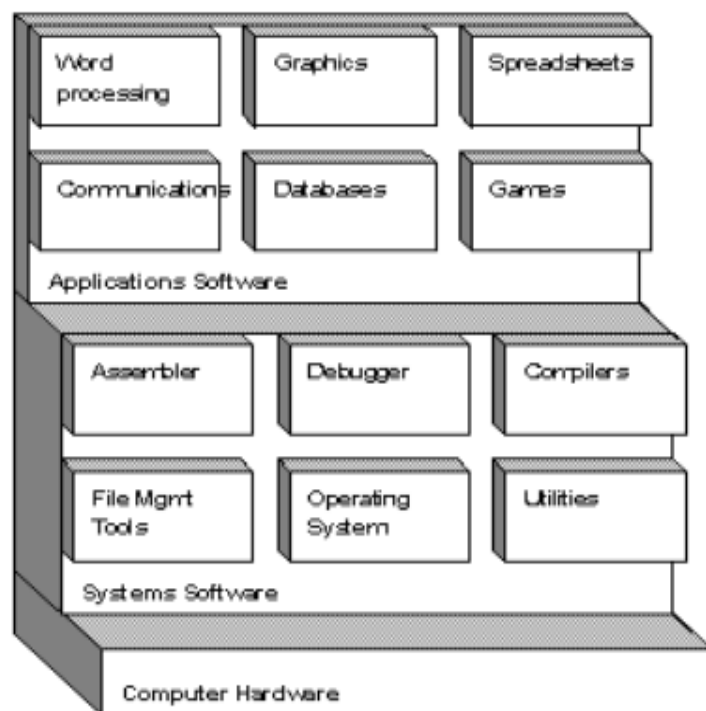
While the computer has been with us for only about half a century, its use dates all the way back to the fourth Century B.C. The first known apparatus was a simple counting aid called the abacus, and may have been invented in Babylonia (now Iraq). Throughout the centuries, computers have changed the way we act, think and view the world. In short, it has revolutionized the world. Today's personal computer, which has been around for only fifteen years, has surpassed its earlier predecessor.



Although computers are used to schedule airlines, predict the weather, play music, control space stations and keep the wheels of the world economy turning; essentially computers do only four things:

- ✓ Receive input
- ✓ Process information
- ✓ Produce output
- ✓ Store information

These four basic functions are responsible for everything computers do.
Computer System:



There are three ingredients of any computer system:

essential

- ✓ Hardware
- ✓ Peripherals
- ✓ Software

Hardware - Consists of the microprocessor (the computer's brain), the memory and the input or output connections which get data in and out of the microprocessor.

Peripherals - Are the devices that allow us to communicate with the computer. . Peripheral devices can be external -- such as a mouse, keyboard, printer, external zip drive or scanner -- or internal, such as a CD-Rom, CD-R or internal modem. Internal peripheral devices are often referred to as integrated peripherals

Software – Also called computer program, is essential to make the system work. Without software a computer can do nothing

Software is often divided into two categories:

- ✓ Systems software: Includes the operating system and all the utilities that enable the computer to function.
- ✓ Applications software: Includes programs that do real work for users. For example, word processors, spreadsheets and database management systems.

NOTE: It is very important to distinguish between the Operating System and Application Software.

Check Equipment and work Environment for Readiness

Checking your equipment and work environment for readiness to perform scheduled tasks involves checking that your computer and its peripherals are installed and functional. Your check must also include ensuring that the layout of your work space minimizes potential hazards. You should note the following:



- ✓ The lighting must be sufficient for the task and there should be sufficient contrast between the screen and the background
- ✓ Distracting noises should be minimized
- ✓ There should be sufficient leg room for you to change positions easily
- ✓ Windows should have blinds or curtains
- ✓ The software should be appropriate for the task
- ✓ The screen must have a stable image, without glitter, glare or reflections
- ✓ The keyboard must be usable, adjustable, detachable and legible
- ✓ The work surface must allow a flexible arrangement of objects, with sufficient space for documents, keyboard, etc
- ✓ The chair should be adjustable in height and have an adjustable backrest in both height and tilt

- ✓ Cables should be properly installed that is, they should be kept as short as possible and be fastened in place or routed through cable ducts. Check to make sure the system is safe before you turn it on
- ✓ The power supply must be adequate. Is there Uninterrupted Power Supply (U.P.S.)?

TIP: Advise the computer technician or another responsible person if you find faults with your system. Do not poke around inside the system as this may cause serious damage to both you and your computer.

When working with computers, seating is particularly important. Your seat must provide the following posture requirements:

- ✓ Adjustable back support
- ✓ Good lumbar support
- ✓ Adjustable seat height
- ✓ No excess pressure under the thighs or back of the knees
- ✓ Space to change position when needed
- ✓ Adjustable screen position in height and angle to allow a comfortable head position
- ✓ Spaces in front of the keyboard to support the hands and wrists during pauses in work

Identify Hardware Components and their Functions

Every computer system contains hardware components that specialize in each of these four functions:

Input devices - feed data into the computer. The keyboard is the most common input device. Other input devices include pointing devices like the mouse and trackball.

Output devices - produce output through two main types of devices: monitor screens for immediate visual output and printers for permanent paper output.

A processor or central processing unit (CPU) - processes information, performs all the necessary arithmetic calculations and make decisions based on information values. The CPU is, in essence, the computer's "brain."

Memory and storage devices - used to store information, but they serve different purposes. The computer's memory (sometimes called primary storage) is used to store programmes and data that need to be instantly accessible to the CPU. Storage devices (sometimes called secondary storage), including disks and tape drives, serve as long-term repositories for data. A storage device such as disk drive can be considered as a combination of input and output device because the computer sends information out to the storage device (output), and later retrieves that information from it (input). These four components, when combined make up the hardware of the computer system.



Power up the computer system

To power up the computer simply means to turn it on. You may also see the word 'initialize' which refers to the process of starting up a program or system. The key word is process. Computers first need time to warm up before they are put to use. Once the power switch has been activated, the computer will automatically go through a series of "self-checks". These are critical before the system is booted so that the computer operates efficiently. Once the checks are complete, you may be prompted for login details. After this, the next screen you will see, featuring a number of icons, is called the desktop

TIP: Ensure that you use the correct start up and shut down procedures that are recommended by your computer manufacturer.

Apply access code

If you are connected to a network, you are likely to need a password which allows you access when you type it in using the keyboard. If this is the case, ensure that you log on using the correct username and password.

Examine system information

When a computer is switched on, one of the first things it does is to read instructions from one of its disks. These instructions tell it how to operate and are known as the Operating System (OS). This process happens quite quickly and is called booting up. Information about your computer system (processor speed and amount of installed memory), are available on the system itself. Ask your learning facilitator to show you how to access this information.

Customize Desktop Configuration

Simply put, your desktop is what you are looking at when your computer is on and no programs are open. You can arrange the icons on this electronic desktop just as you can arrange real objects on a real desktop. You can:

- ✓ Move them around
- ✓ Put one on top of another
- ✓ Reshuffle them
- ✓ Throw them away

This flexibility allows you to customize your desktop to suit your individual requirements and/or special needs in accordance with organisational guidelines.

The advantages of customizing your desktop configuration is that the most used programs are easily accessible in one area, and if you plan to run more than one program at a time, it is better to have them in the same group window.

Each Programme, such as word processor, spreadsheet or database appears as an icon with its name under it, and many computers already come with some of these icons already loaded.

Use help function

Many programs come with the instruction manual, or a portion of the manual, integrated into the program. Should you encounter a problem or forget a command while running the program, you can bring up the documentation by pressing the Help key or entering a HELP command. In Windows, the Help key is the function key labelled F1.

Once you summon the Help system the program often displays a menu of Help topics. Choose the appropriate topic for the problem you are experiencing. The program will then display a help screen that contains the desired documentation.

Some programs are more sophisticated, displaying different Help messages depending on where you are in the program. Such systems are said to be context sensitive.

ENTER AND RETRIEVE DATA

For processing of data, it is vital that we entry data in the form of the computer requirements for effective and speedy analysis.

Types of data

Data Types are an important concept of statistics, which needs to be understood, to correctly apply statistical measurements to your data and therefore to correctly conclude certain assumptions about it. This blog post will introduce you to the different data types you need to know, to do proper exploratory data analysis (EDA), which is one of the most underestimated parts of a machine learning project.



Introduction to Data Types

Having a good understanding of the different data types, also called measurement scales, is a crucial prerequisite for doing Exploratory Data Analysis (EDA), since you can use certain statistical measurements only for specific data types.

You also need to know which data type you are dealing with to choose the right visualization method. Think of data types as a way to categorize different types of

variables. We will discuss the main types of variables and look at an example for each. We will sometimes refer to them as measurement scales.

Categorical Data

Categorical data represents characteristics. Therefore it can represent things like a person's gender, language etc. Categorical data can also take on numerical values (Example: 1 for female and 0 for male). Note that those numbers don't have mathematical meaning.

Nominal Data

Nominal values represent discrete units and are used to label variables, that have no quantitative value. Just think of them as „labels“. Note that nominal data that has no order. Therefore if you would change the order of its values, the meaning would not change. You can see two examples of nominal features below:

Are you married?

☐ Yes

☐ No

What languages do you speak?

☐ Englisch

☐ French

☐ German

☐ Spanish

The left feature that describes if a person is married would be called “dichotomous”, which is a type of nominal scales that contains only two categories.

Ordinal Data

Ordinal values represent discrete and ordered units. It is therefore nearly the same as nominal data, except that it's ordering matters. You can see an example below:

What Is Your Educational Background?

☐ 1 - Elementary

☐ 2 - High School

☐ 3 - Undegraduate

☐ 4 - Graduate

Note that the difference between Elementary and High School is different than the difference between High School and College. This is the main limitation of ordinal

data, the differences between the values is not really known. Because of that, ordinal scales are usually used to measure non-numeric features like happiness, customer satisfaction and so on.

Numerical Data

Discrete Data

We speak of discrete data if its values are distinct and separate. In other words: We speak of discrete data if the data can only take on certain values. This type of data can't be measured but it can be counted. It basically represents information that can be categorized into a classification. An example is the number of heads in 100 coin flips.

You can check by asking the following two questions whether you are dealing with discrete data or not: Can you count it and can it be divided up into smaller and smaller parts?



Continuous Data

Continuous Data represents measurements and therefore their values **can't be counted but they can be measured**. An example would be the height of a person, which you can describe by using intervals on the real number line.

Interval Data

Interval values represent **ordered units that have the same difference**. Therefore, we speak of interval data when we have a variable that contains numeric values that are ordered and where we know the exact differences between the values. An example would be a feature that contains temperature of a given place like you can see below:

Temperature?

- ☐ - 10
- ☐ -5
- ☐ 0
- ☐ + 5
- ☐ + 10
- ☐ + 15

The problem with interval values data is that they don't have a "true zero". That means in regards to our example, that there is no such thing as no temperature. With interval data, we can add and subtract, but we cannot multiply, divide or calculate ratios. Because there is no true zero, a lot of descriptive and inferential statistics can't be applied.

Ratio Data

Ratio values are also ordered units that have the same difference. Ratio values are the same as interval values, with the difference that they do have an absolute zero. Good examples are height, weight, length etc.

Why Data Types are important?

Datatypes are an important concept because statistical methods can only be used with certain data types. You have to analyze continuous data differently than categorical data otherwise it would result in a wrong analysis. Therefore knowing the types of data you are dealing with, enables you to choose the correct method of analysis.

Statistical Methods

Nominal Data

When you are dealing with nominal data, you collect information through:

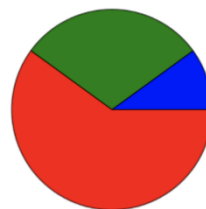
Frequencies: The Frequency is the rate at which something occurs over a period of time or within a dataset.

Proportion: You can easily calculate the proportion by dividing the frequency by the total number of events. (e.g how often something happened divided by how often it could happen)

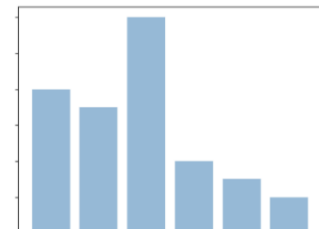
Percentage.

Visualisation Methods: To visualise nominal data you can use a pie chart or a bar chart.

Pie Chart



Bar Chart



Ordinal Data

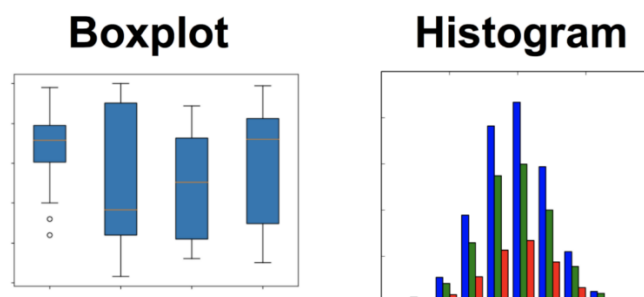
When you are dealing with ordinal data, you can use the same methods like with nominal data, but you also have access to some additional tools. Therefore you can summarise your ordinal data with frequencies, proportions, percentages. And you can visualise it with pie and bar charts. Additionally, you can use percentiles, median, mode and the interquartile range to summarise your data.

Continuous Data

When you are dealing with continuous data, you can use the most methods to describe your data. You can summarise your data using percentiles, median, interquartile range, mean, mode, standard deviation, and range.

Visualisation Methods:

To visualise continuous data, you can use a histogram or a box-plot. With a histogram, you can check the central tendency, variability, modality, and kurtosis of a distribution. Note that a histogram can't show you if you have any outliers. This is why we also use box-plots.



RETRIEVE DATA

Information has become the most significant source of our day-to-day life. Information available on internet may create some confusion among its users because of its diversity. In order to get proper and exact information from internet, users need to know the effective techniques and strategies. This paper focuses on the different information retrieval processes and techniques which help users to get the required information and also to save their valuable time.

Keywords: Information retrieval, Search process, Search strategies, Retrieval techniques.

Introduction:

Data is an observed fact and when any meaning is assign to data or when it is processed, it becomes information. Information reduces uncertainty and it is communicable. Information leads to confirmation but when information is processed and internalized it becomes knowledge. Today, plenty of information available in print and non-print format which leads to information overload. Internet is one of the vital sources of information. Sometimes it becomes impossible for the users to understand the available information or they do not understand where to find it or they are unable to access the right information. These factors leads to their stress, delay in decision making, waste of time etc.

Information Retrieval One of the best examples of information retrieval system (IRS) is library system where information is stored, processed, organized and retrieved on demand of its users.

Different types of information retrieval systems have been developed since 1950's to meet in different kinds of information needs of different users. Information retrieval system offers different search approaches those deals with three basic aspects. These aspects are as follows.

- ✓ Information storage and organization.
- ✓ Information representation.
- ✓ Information access.



Objectives of and Retrieval/Information Retrieval System (ISAR/IRS):

- ✓ To provide information to the user in least time with least efforts.
- ✓ To act as facilitator between information and user.
- ✓ To provide non-ambiguous search results through proper indexing.
- ✓ User friendliness.

Functions of Information Storage and Retrieval/Information Retrieval System (ISAR/IRS):

To identify sources of information relevant to the areas of the target user community,

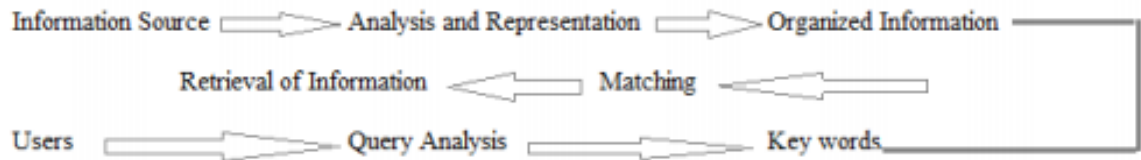
- ✓ To analyze the contents of the sources.
- ✓ Represents contents of analyze sources that will match queries.
- ✓ Analyze user queries that will match with database.
- ✓ Retrieve the information that is relevant.
- ✓ Necessary adjustments in system based on feedback from the user.

Components of Information Storage and Retrieval/Information Retrieval System (ISAR/IRS):

According to Lancaster the major components of an information retrieval system are....

- ✓ Document selection sub-system.
- ✓ Indexing sub-system.
- ✓ Vocabulary sub-system.
- ✓ Searching sub-system.
- ✓ Matching sub-system.

Outline of Information Storage and Retrieval/Information Retrieval System (ISAR/IRS):



Kinds of information retrieval system:

1. Offline Search: In offline search, users can get the required information with or without the help of computer and internet for example: libraries, CD-ROM etc.
- ✓ Online Search: means the search of a remotely located database through interactive communications with the help of computer and communication channel. Online databases can be access through vendor or directly. For example: OPAC, Databases, Internet etc.

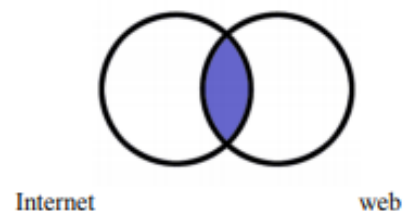
Retrieval Techniques:

Retrieval techniques are designed to help users to locate the information they need effectively and efficiently. These techniques help users to find out the required information easily. There are two types of retrieval techniques.

1. Basic Retrieval Techniques:

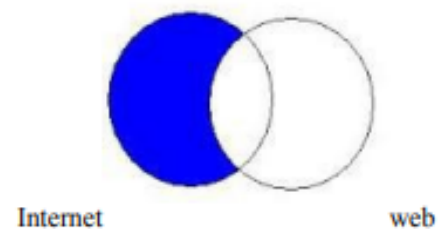
- a. Boolean Searching George Boole (1815-1864) developed AND, OR, NOT Boolean operators. By using these techniques user can narrow down their search to get the required information.

- i. AND: It includes addition of two different concepts for narrowing down the search. It retrieves all those items where all the constituent terms occur.



- ii. NOT: It is separation of complex concepts into individual simpler ones. It allows users to specify those terms that they do not want to occur in the retrieval records. It excludes unwanted results. Search output will decrease with increase in NOT term.

- iii. OR: The inclusion of more concepts to expand their connotation. It is used for broadening a search. It allows users to combine two or more search terms that system will retrieve all those terms that



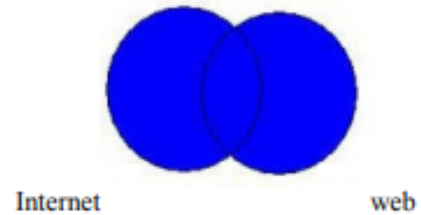
contain either one or all of the constituent terms.

b. Truncation Search :

It is also known as wildcard, stemming, term masking, conflation algorithm etc...

There are three types of truncation.

- i. Right truncation: truncation is on right side of the term. For example...
Lib*
- ii. Left truncation: truncation is on left side of the term. For example...
*rary
- iii. Simultaneous with left and right side. For example...
polymer



c. Proximity search :

This search facility allows users to specify...

- i. Whether two search terms should occur adjacent to each other.
- ii. Whether one or more words occur in between the search terms.
- iii. Whether the search terms should occur in some paragraph irrespective of the intervening words. Proximity search is as good as AND. It searches for the occurrence of two or more search terms but it specifies the distance between the search terms. For example,...

Sun within four words after moon (sun # 2 # after moon)

d. Field Searching:

Document is presented by attributes such as Author, Title, Publication date, Document type, File type etc. these attributes are called as field searching. Search is possible with the help of these fields also.

e. Case Sensitive Searching:

For languages such as English, French, Spanish upper and lower cases makes a difference. Case sensitive searching allows pinpointing exactly how a term is represented in a query and the system. For example,...

Web - World Wide Web.

Web - web woven by spiders.

f. Range Searching:

It is very useful in numerical searching. It is important in selecting records within certain data ranges. For example,...

Greater than (>)

Less than (<)

Equal to (=)

Not equal to (\neq or \neq)

Greater than or equal to (\geq)

Less than or equal to (\leq)

2. Advanced Retrieval Techniques :

g. Fuzzy Search :

It sounds related to truncation search but with a major difference.

Truncation is intended to retrieve different forms of terms when they share some parts in common. Fuzzy searching is designed to find terms that are spelled incorrectly at data entry or query point.

h. **Weighted Search :**

For weighted searching, weights are assigned to terms when a search query is composed to indicate proportionally their significance or the emphasis the user placed upon. For example...internet 3 AND web 5

MONITOR OPERATION OF EQUIPMENT

Preventive maintenance

Preventive maintenance includes measures such as systematic and routine cleaning, adjustment and replacement of equipment parts at scheduled intervals. Manufacturers generally recommend a set of equipment maintenance tasks that should be performed at regular intervals: daily, weekly, monthly or yearly. Following these recommendations will ensure that the equipment performs at maximum efficiency and will increase the lifespan of the equipment. This will also help to prevent:



- ✓ Inaccurate test results due to equipment failure
- ✓ Delays in reporting results
- ✓ Low productivity
- ✓ Large repair costs.

Maintenance plan

A maintenance plan will include preventive maintenance procedures as well as provision for inventory, troubleshooting and repair of equipment. When implementing an equipment maintenance program, some of the initial steps will include:

- ✓ Assigning responsibility for providing oversight;
- ✓ Developing written policies and procedures for maintaining equipment, including routine maintenance plans for each piece of equipment that specify the frequency with which all maintenance tasks should be performed;
- ✓ Developing the format for records, creating logs and forms, and establishing the processes to maintain records;
- ✓ Training staff on the use and maintenance of the equipment, and ensuring that all staff understand their specific responsibilities

Equipment inventory

It is recommended that a label is attached to the instrument indicating when the next maintenance or service should be performed.

The laboratory should keep an inventory log of all equipment in the laboratory. The log should be updated with information on new equipment and include documentation of when old equipment is retired. For each piece of equipment, the equipment inventory log should have a record of:



- ✓ Instrument type, make and model number, and serial number so that any problems can be discussed with the manufacturer;
- ✓ Date the equipment was purchased, and whether it was purchased new, used or reconditioned;
- ✓ Manufacturer/vendor contact information;
- ✓ Presence or absence of documentation, spare parts and maintenance contract;
- ✓ Warranty's expiration date;
- ✓ Specific inventory number indicating the year of acquisition (this is especially useful for larger laboratories); for example, use the style "yy-number" (04-001, 04-002, etc.) Where "yy-number" equals the last two numbers of the year followed by a number attributed in the year.

An inventory process must be conducted if the laboratory does not have an existing inventory system for equipment. This could be conveniently organized following a model grid, room by room; for example, conduct an inventory of equipment in the reception area, then the sample collection area, the serology testing area, and the parasitology testing area. During the inventory, the condition of the equipment should be documented as functional, partially functional or nonfunctional. Equipment that is not functioning needs to be evaluated as to whether or not it can be repaired. Nonrepairable equipment should be retired, and work should be scheduled for equipment needing repair

Inventory of spare parts

To ensure that the laboratory does not run out of spare parts, an inventory record of those used most frequently should be kept for each piece of equipment. The record should include:

- ✓ Part name and number;
- ✓ Average use of the part, and the minimum to keep on hand;
- ✓ Cost;
- ✓ Date when the part is placed into storage and when it is used (in and out stock log);
- ✓ Quantity of each part remaining in inventory.

ACCESS AND TRANSMIT INFORMATION VIA THE INTERNET

In order to work with the Internet we need to know certain related terms like www, web browsers, web pages, websites, etc. We should know how to get connected to the Internet. Once connected – how to use it.

Most of the terms on the Internet are prefixed with the term web. The electronic pages seen on the Internet are known as web pages. A web page can be defined as the document that we see on the Internet. Many web pages linked with each other



combine to form a website. A web page can be written in the language known as HTML (Hyper Text Markup Language). HTML is a very simple language having a number of options to represent text. Many other scripting languages have now been developed which can be embedded into HTML, giving it the power to interact with the users. (These are discussed in detail in the next Unit). These dynamic web

pages can take inputs from users and give information accordingly – taking in the location of the user before displaying the weather forecast. For example, a protocol called Hyper Text Transfer Protocol (HTTP) is used to transmit and receive the web pages.

CONNECTING TO THE INTERNET

In order to activate Internet services on any computer, it requires an Internet connection from an Internet Service Provider. There are several Internet Service Providers (ISPs) in India like VSNL, BSNL, Airtel, Reliance, etc. They charge some nominal fee for installation and connection. Depending on the requirement we can get an Internet connection in any of the following ways:

3. Dial-up connection : We can get connected to the Internet by dialing the ISP's number. This is useful if the network is either confined to small group of computers or for a single PC (Figure 7.4).
- ✓ Leased lines : A dedicated line is laid specifically for the connection. This provides a fairly high speed, but is expensive. This is suitable for an organisation requiring uninterrupted, high speed Internet connection.
- ✓ Broadband : This also provides a good speed. While leased line requires a separate telephone line, broadband can be delivered using an existing telephone line. This is ideal for home and small businesses requiring high speed Internet.

- ✓ WiFi Broadband : These days even wireless connections are available. For this we need to have a Wi Fi card attached to the computer and a wireless modem.
- ✓ When we connect to the Internet we must know its speed parameters. The speed of the Internet is measured in the number of bits transferred per unit time. Generally, the speed of the Internet is measured in kbps (kilo bits per second), but these days some organisations are providing high speed connections in Mbps (Mega bits per second).

In order to have a connection we need a device called the modem. This device converts the digital signal from the computer into an analogue signal that can travel through the telephone line. On the other end, this analogue signal is again converted back to digital form by the modem at the destination end. Some computer systems have internal modems (built-in within the motherboard) while in some systems there might be a need to have an external modem to have an Internet connection.

Another device called a router can be attached to the computer to access the Internet. The router is a device used for connecting two different networks.

Uses of the Internet

The Internet is extensively used for a wide variety of purposes. Some of these are mentioned below:

Search for Information

A number of programs called search engines are available to search for the information on any topic. Some famous search engines are provided by: www.google.com, wikipedia.com, webopedia.com, MSN.com, Yahoo.com, etc.

E-mail (Electronic Mail) E-MAIL (ELECTRONIC MAIL)

The Internet is commonly used for sending and receiving e-mails. We can send a message electronically to any person on the globe, provided that person has an e-mail-id. This service is fast and economical.



Chatting

Chatting involves textual exchange of message in real time. Chat servers provide facility to create virtual chat rooms and only the members associated with these rooms are allowed to share messages. Chat works best if the time is scheduled by both the parties who are willing to chat – as both the parties must be connected to the Internet while chatting. Some common chat engines are : Yahoo Messenger, Google Talk, Rediff Bol, etc.

Instant Messenger Service

These tools can be used to send messages instantly. It also allows us to talk to anyone anywhere in the world. This is a cheaper and quicker method compared to other services. Unlike chatting, it is not necessary to have an account with the same provider. Additionally, both the users need not be connected while sending messages. We can easily download the messenger software from Internet e.g. MSN Messenger, Yahoo Messenger, etc.

Newsgroup

Newsgroup is an e-service hosted by many newsgroup organisations. One can become a member of a newsgroup and read and share current affairs and messages. Newsgroups cover a broad domain of interests including education, science and technology, medicine, arts, sports, etc. USENET is one such example.

Teleconferencing

People can have a conference or meeting sitting at different locations with a microphone attached to their computers.

Video conferencing

In teleconferencing we are able to talk to each other sitting at different places but in video-conferencing we can also see what is happening at the other side. We have observed that the anchor, panelists and experts sitting at different locations across the globe communicate and share their views in many news channels. For this, we need a web-camera and a microphone connected to the computer system, high bandwidth connection, and video-conferencing software.



E-Commerce

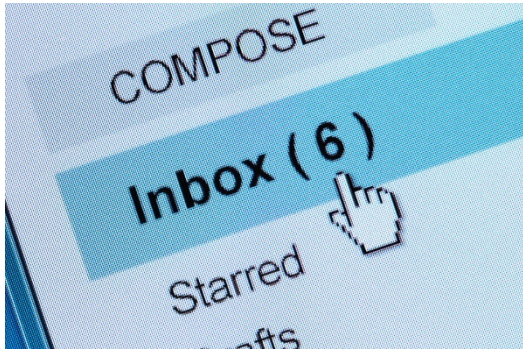
E-commerce or Electronic-Commerce means online transactions of business. In this, the vendor and customer conduct a transaction sitting at different geographical locations, connected through the Internet. The customer need not strain himself by visiting a number of shops outside in scorching heat or heavy rains. He can do shopping by sitting at home, visiting the desired e-commerce site and placing an

order online. E.g. <http://shopping.indiatimes.com>, <http://ebay.com>, <http://shopping.rediff.com>, etc.

M-Commerce

It is an acronym for mobile commerce. It is an upcoming technology after e-commerce. It involves buying and selling of goods and services electronically through wireless handheld devices at any place. We can do transactions through our mobile phones also.

E-MAIL ACCOUNTS



To see the mails received, click on Inbox. A number against the Inbox indicates the number of unread mails. Once the Inbox is open, we shall see all the mails listed there. To read a mail, we need to just click on the mail that we wish to read.

After going through the mails we can either let them remain in our account for future reference or we can also delete the same. There are options for deleting or transferring them to trash. Trash is a folder where we keep the mails to be deleted.

To send an e-mail, both the sender and receiver must have an e-mail account. To send an e-mail, follow the steps listed below:

1. Click on the 'Compose' option.
2. Enter the e-mail address of the receiver against any of the three options - To , CC and BCC.
 - To: Address(es) mentioned in this box are visible to every receiver.
 - CC: stands for Carbon Copy. The mail will be sent to the To address as well as CC address. The addresses typed in To as well as in CC are visible to all other receivers.
 - BCC: Stands for Blind Carbon Copy. Each user whose addresses are typed in BCC is unaware of the fact that the same message has also been sent to others.

Instead of typing in the address, we can also insert the same from the address book

- a. Click Insert Address or Address Book.
 - b. Select the addresses by Checking (ticking) them.
 - c. Click OK or Insert option to insert the address in the recipient mailbox.
3. Write in the message in the text box as indicated in the figure
 4. After typing in the message click on send option as indicated in the figure 7.10.

In order to close the e-mail session, we can click on options like logout or sign out.

CLOSE DOWN COMPUTER SYSTEM

Shutting down a computer safely closes all the programs that are open and exits the Operation System in order to keep the hardware from damage and to prevent the computer from corrupted systems.

Shutting down a computer using Windows 7:

5. Click the Windows Icon at the lower left side of the screen.
6. Click the Shutdown button.

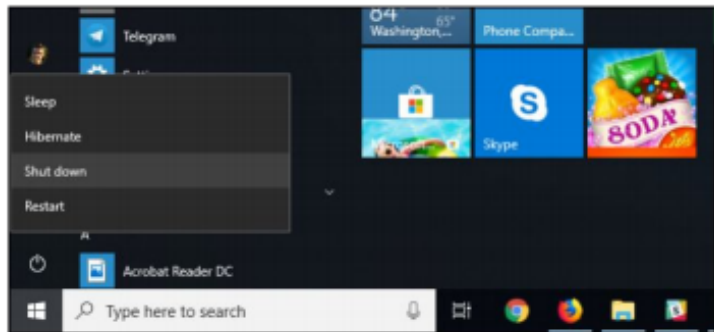
or Press Ctrl+Alt+Del and click the power button in the bottom-right corner of the screen.

From the Windows desktop, press Alt+F4 to get the Shut down Windows screen and select Shut down.



Shutting down a computer using Windows 10:

7. Click the Windows Icon at the lower left side of the screen.
8. Click the Shutdown button to properly shutdown a computer or Press Ctrl+Alt+Del and click the power button in the bottom-right corner of the screen.
9. From the Windows desktop, press Alt+F4 to get the Shut down Windows screen and select Shut down.



4.APPLY MATHEMATICS FOR WATER OPERATIONS

PERFORM SIMPLE MATHEMATIC CALCULATIONS

Definition of Fractions

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

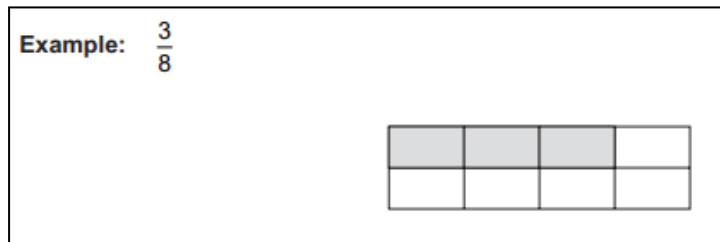
1. Common fractions (fractions)
2. Decimal fractions (decimals)

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

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

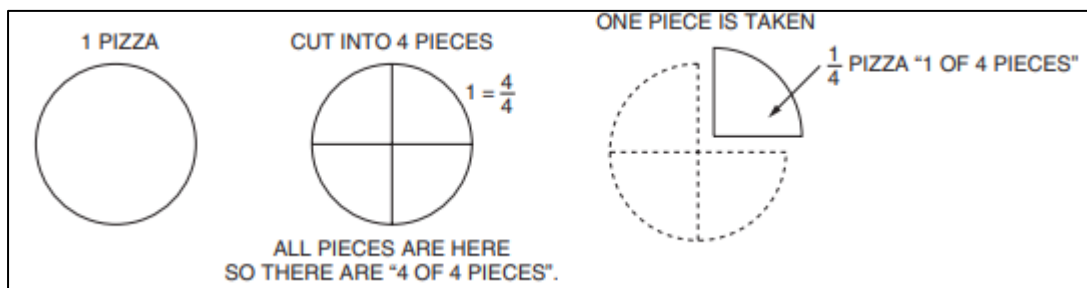
Basic principles

The bottom number (the denominator) of every fraction shows the number of pieces any one whole object is divided into; all pieces are of equal size. The top number (the numerator) shows information about that divided object.

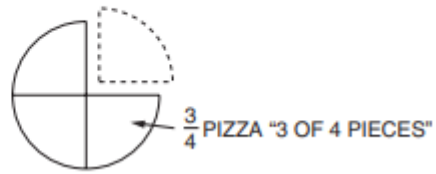


3 is the numerator, and 8 is the denominator. This fraction shows that an object has been divided into 8 equal pieces, and that 3 of those 8 pieces are shaded.

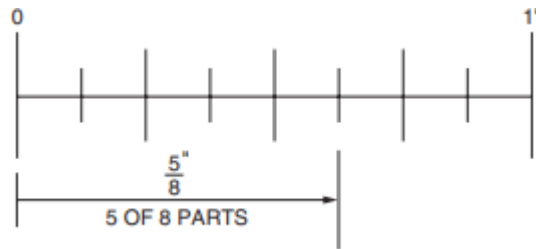
Let's work with other simple examples. If we have one whole unsliced pizza, we can divide it into pieces, and then make fractions about the pizza. This example is cut into 4 pieces (quarters). Fractions concerning this pizza will have the bottom number 4. To describe 1 of those pieces, the fraction is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



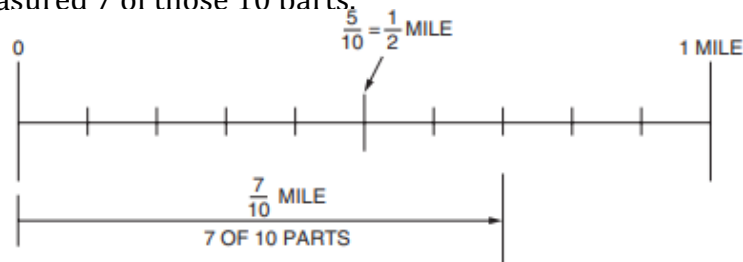
$\frac{3}{4}$ indicates that "3 of 4 pieces" are still available.



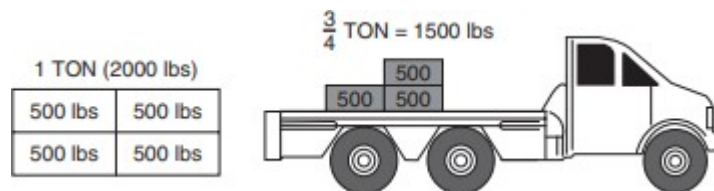
1. $\frac{5}{8}$ " (five-eighths inch) shows that an inch is divided into 8 parts and that 5 of those 8 parts have been measured.



2. $\frac{7}{10}$ 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. $\frac{3}{4}$ 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 $\frac{5}{8}$, $\frac{7}{10}$, and $\frac{3}{4}$ 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:

	<i>Tenths</i>	<i>Hundredths</i>	<i>Thousandths</i>
.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

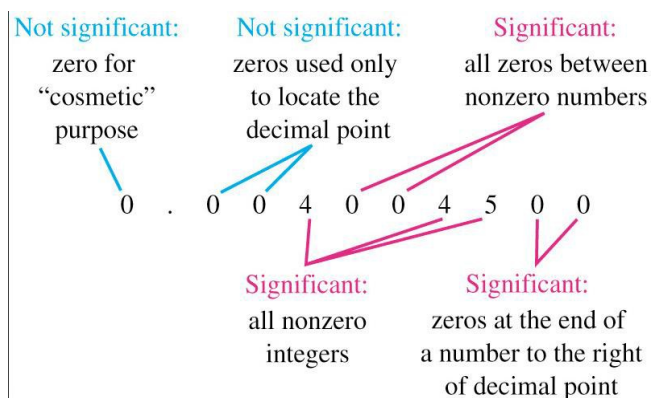
0s placed in front of the decimal point have no effect on the value, as long as there are no whole numbers.

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 you are approximate

One significant figure		Two significant figures	
0.08 N	70 m	1.1 s	0.026 mm
Three significant figures			
23.7 m		0.310 L	

t answer. In other words,

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

Some	Physical Quantity	Name of Unit	Abbreviation	prefixes
	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	
	Prefix	Abbreviation	Meaning	Example
	Giga	G	10^9	1 gigameter (Gm) = 1×10^9 m
	Mega	M	10^6	1 megameter (Mm) = 1×10^6 m
	Kilo	k	10^3	1 kilometer (km) = 1×10^3 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 (μ m) = 1×10^{-6} m
	Nano	n	10^{-9}	1 nanometer (nm) = 1×10^{-9} m
	Pico	p	10^{-12}	1 picometer (pm) = 1×10^{-12} m
	Femto	f	10^{-15}	1 femtometer (fm) = 1×10^{-15} m

Table 1.2 Derived quantities and their units

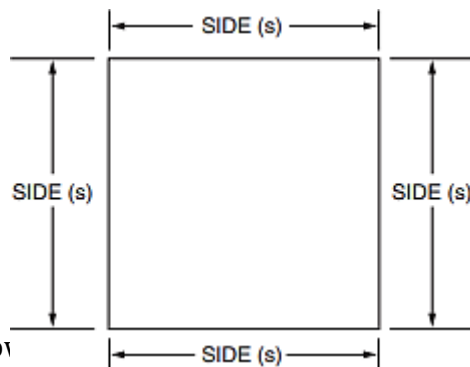
Physic Quantity	Expression	Unit
Area	length \times breadth	m^2
Volume	area \times height	m^3
Velocity	displacement / time	m s^{-1}
Acceleration	velocity / time	m s^{-2}
Density	mass / volume	kg m^{-3}
Pressure	force / area	N m^{-2} or Pa

Perform calculations on: Perimeter and Area

The distance around a figure is called the “perimeter.”

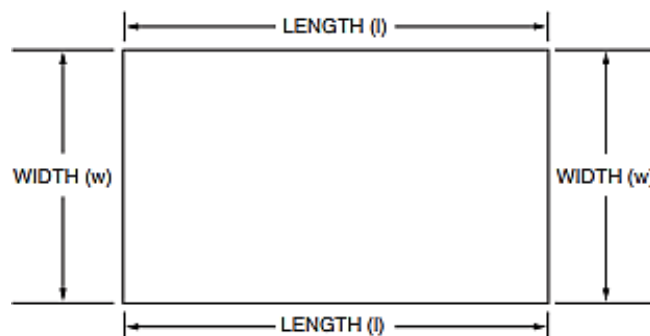
Square

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° .

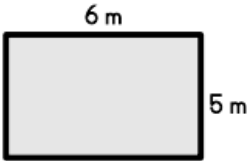
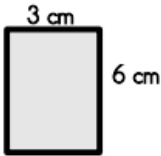
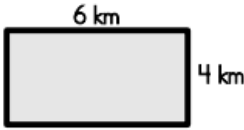


Area of Square

Formula: $A = \text{Side} \times \text{Side}$

Area of Rectangle Formula: $A = L \times H$

Find the area of each rectangle by multiplying.



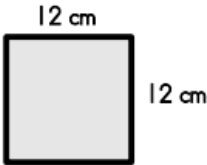
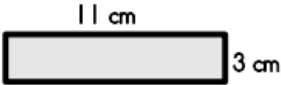
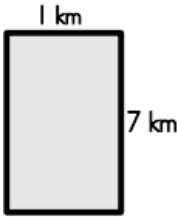
Form

Exam

(a) area = _____

area = _____

area = _____

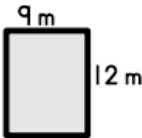
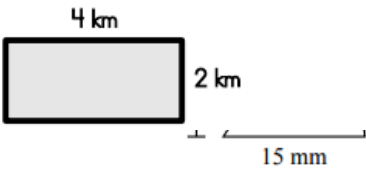
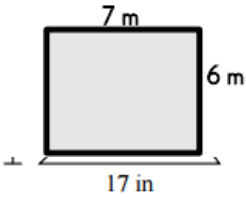


Find area = _____

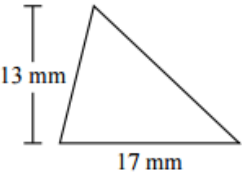
area = _____

area = _____

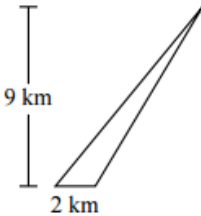
1)



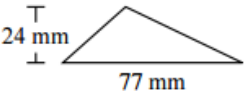
3)



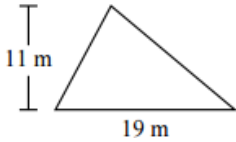
4)



5)

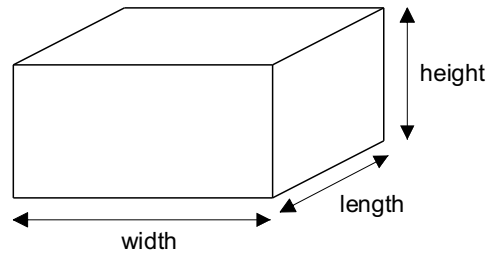


6)

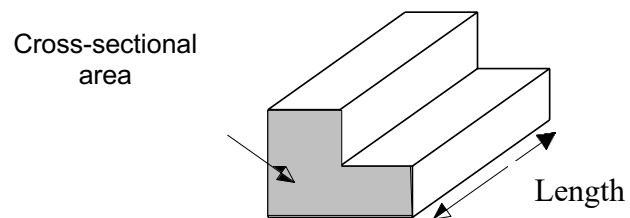


Volume and Surface Area

- ✓ Volume of **cuboid** = length \times width \times height

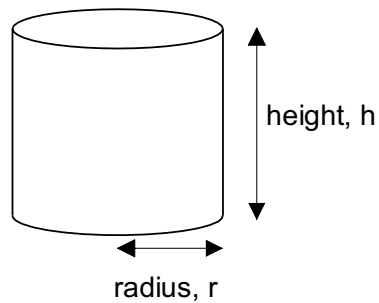


- ✓ Volume of **prism** = cross-sectional area \times length



- ✓ 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:

$$\text{Volume} = 15 \times 12 \times 8 = 1440 \text{ cm}^3.$$

As 1 litre = 1000 cm³, the capacity of the cuboid = 1.44 litres.

Example: 2

A cylinder has a volume of 965 cm³. 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:

$$\text{Volume of cylinder} = \pi r^2 h$$

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

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

$$965 = 50.26548 \times r^2$$

$$19.198 = r^2$$

$$4.38156 = r$$

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.

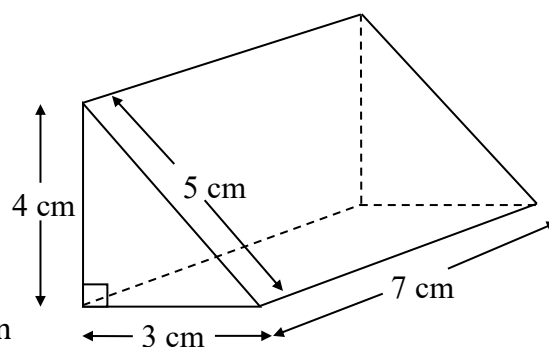
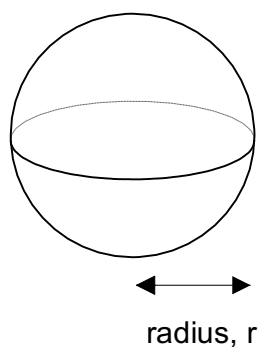


Diagram **NOT** accurately drawn

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:

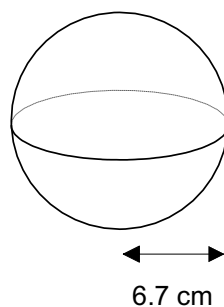
Substitute $r = 6.7 \text{ cm}$ into the formula

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

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

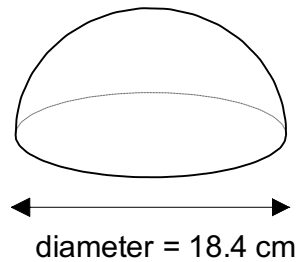
$$V = 1259.833 \text{ (remember to use the cube button on your calculator)}$$

$$V = 1260 \text{ cm}^3 \text{ (to 3 SF)}$$



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 = $\frac{1}{2} \times \text{volume of sphere}$

$$\begin{aligned}
 &= \frac{1}{2} \times \frac{4}{3} \pi r^3 \\
 &= \frac{1}{2} \times \frac{4}{3} \times \pi \times 9.2^3 \\
 &= \frac{1}{2} \times 3261.76 \\
 &= 1630 \text{ cm}^3 \quad (\text{to 3 SF})
 \end{aligned}$$

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

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

$$\text{So } 86.5 = 4.18879 r^3$$

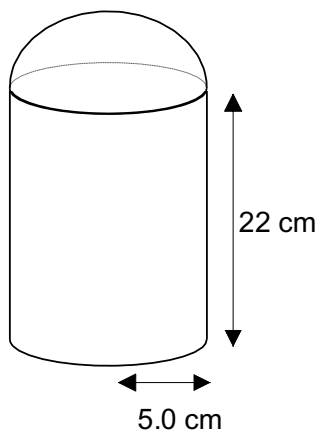
$$\text{i.e. } 20.65035 = r^3$$

$$\text{So } r = 2.74 \text{ cm (to 3 SF) (cube rooting)}$$

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:**

$$\begin{aligned}\text{Volume of cylinder} &= \pi r^2 h \\ &= \pi \times 5^2 \times 22 \\ &= 1728 \text{ cm}^3 \text{ (to nearest whole number)}\end{aligned}$$

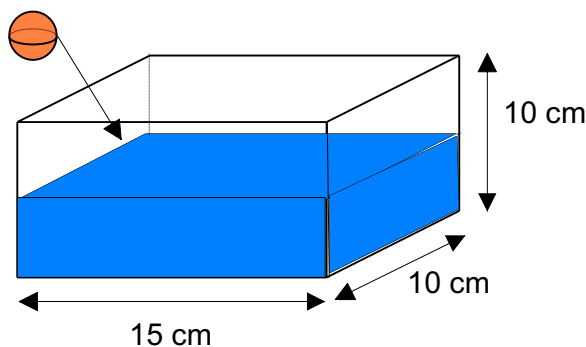
The hemisphere must also have radius 5 cm.

$$\begin{aligned}\text{Volume of the hemisphere} &= \frac{1}{2} \times \text{volume of sphere} \\ &= \frac{1}{2} \times \frac{4}{3} \pi r^3 \\ &= \frac{1}{2} \times \frac{4}{3} \times \pi \times 5^3 \\ &= 262 \text{ cm}^3\end{aligned}$$

Therefore total volume of the object = $1728 + 262 = 1990 \text{ cm}^3$.

Example

A tank measures 15 cm by 10 cm by 10 cm. The tank is half-full of water.



A solid metal sphere with radius 2 cm is placed into the tank.

Assuming that the sphere sinks to the bottom of the tank, calculate the amount by which the water level in the tank rises.

Solution

As the sphere will be completely submerged, it will displace its volume of water.

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

Therefore, the water displaced is 33.51 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.

$$\text{So } 15 \times 10 \times h = 33.51$$

$$\text{i.e. } h = 0.22 \text{ cm}$$

The water rises by 0.22 cm.

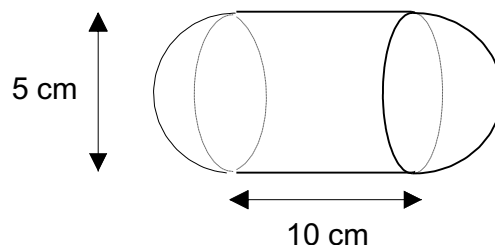
Examination question

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.

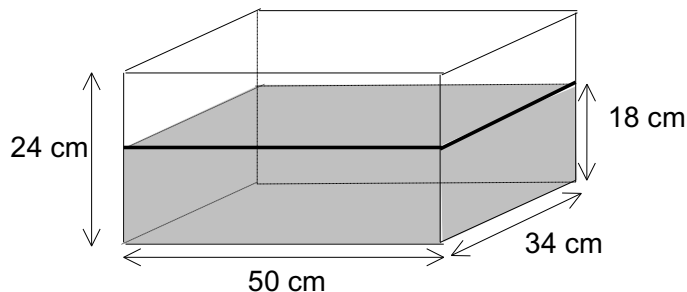
The length of the cylindrical part of the toy is 10 cm.

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



Examination question

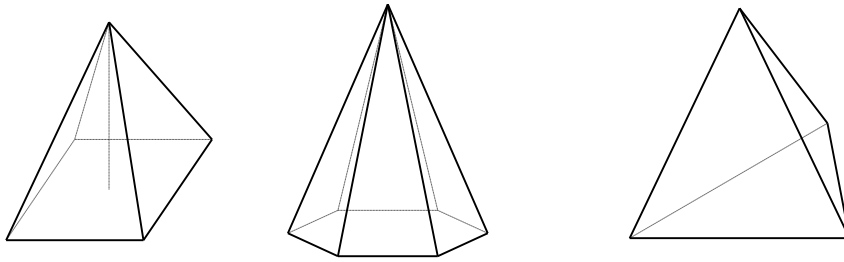
A water tank is 50 cm long, 34 cm wide and 24 cm high. It contains water to a depth of 18 cm.



Four identical spheres are placed in the tank and are fully submerged. The water level rises by 4.5 cm. 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:

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

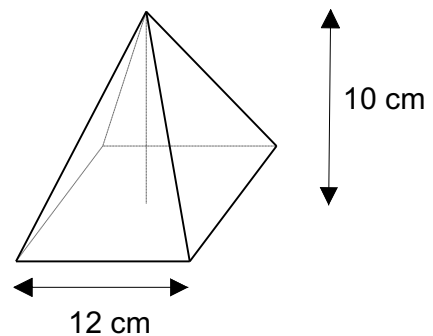
Example:

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 $12 \times 12 = 144 \text{ cm}^2$
So, the volume of the pyramid is:

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

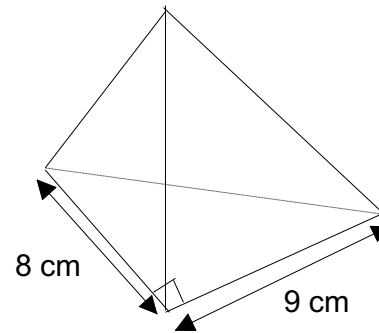
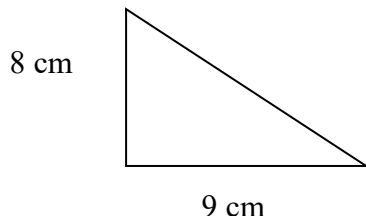


Example: 2

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 $\frac{1}{2} \times 9 \times 8 = 36$ cm².
 Substitute information into the formula for the volume of a pyramid.

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

$$325 = \frac{1}{3} \times 36 \times \text{height}$$

$$325 = 12 \times \text{height.}$$

So, $\text{height} = 325 \div 12 = 27.08 \text{ cm (to 4 SF).}$

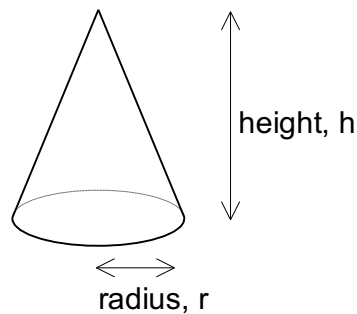
Volume of a cone

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:

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

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.

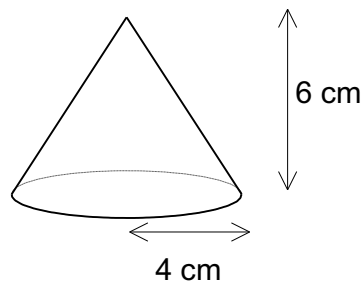
Example 1

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:

$$\begin{aligned}
 \text{Volume of cone} &= \frac{1}{3}\pi r^2 h \\
 &= \frac{1}{3} \times \pi \times 4^2 \times 6 \\
 &= 2 \times \pi \times 16 \quad (\text{start by finding } 1/3 \text{ of } 6) \\
 \text{volume} &= 32\pi \text{ cm}^3.
 \end{aligned}$$

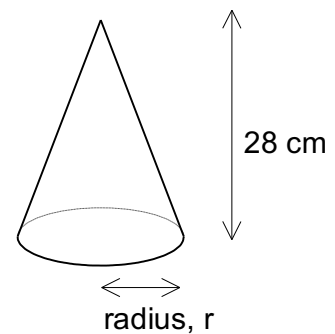
**Example 2:**

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:

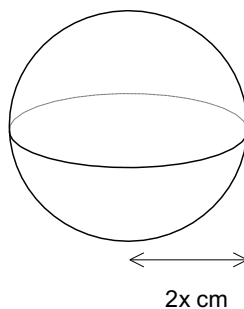
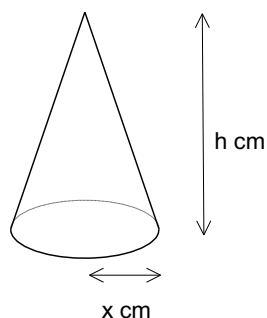
$$\begin{aligned}
 \text{Volume of cone} &= \frac{1}{3}\pi r^2 h \\
 1650 &= \frac{1}{3} \times \pi \times r^2 \times 28 \\
 1650 &= 29.32153r^2 \quad (\text{evaluating } \frac{1}{3} \times \pi \times 28) \\
 r^2 &= 56.2726 \\
 \text{i.e. } r &= 7.5 \text{ cm (to 2 SF)}
 \end{aligned}$$



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 $\frac{1}{3}\pi x^2 h = \frac{1}{3}\pi x^2 h$

The volume of the sphere is $\frac{4}{3}\pi^3 = \frac{4}{3}\pi(2x)^3$ (note: the brackets around $2x$ are important)

$$= \frac{4}{3}\pi \times 8x^3 \quad (\text{cubing both 2 and } x)$$

$$= \frac{32}{3}\pi x^3$$

As the sphere and the cone have the same volume, we can form an equation:

$$\frac{1}{3}\pi x^2 h = \frac{32}{3}\pi x^3$$

$$\pi x^2 h = 32\pi x^3$$

$$x^2 h = 32x^3$$

$$h = 32x$$

(Multiplying both sides by 3)

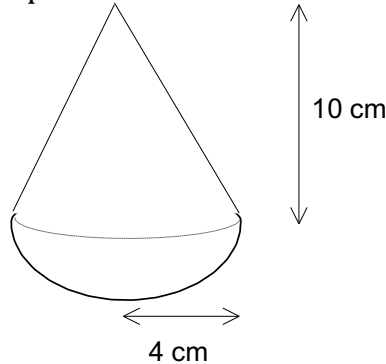
(Dividing both sides by π)

(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

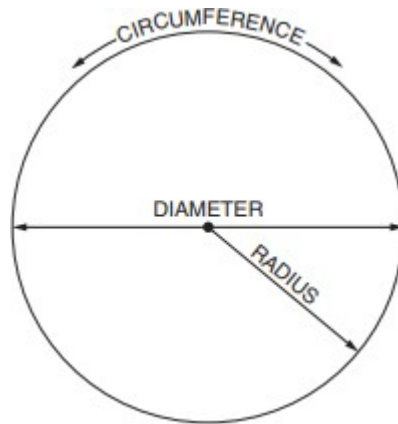
Geometry is essential to welding. Several welding projects require you to understand, calculate and measure welds at different angles accurately. Moderate knowledge of geometrical measurements will make it easier for you to connect metals together while advanced knowledge will make it possible to work 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).

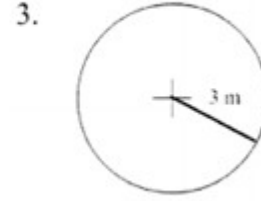
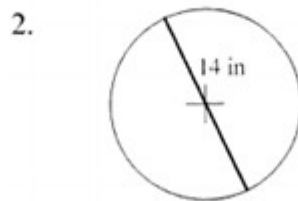
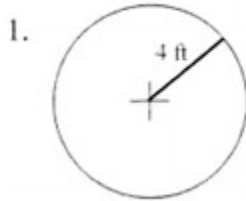
Diameter is designated on blueprints with the symbol Ø.

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.

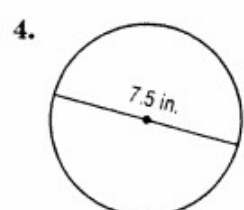
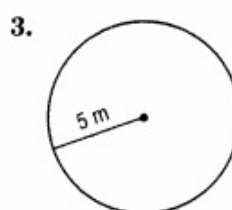
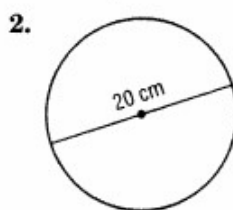
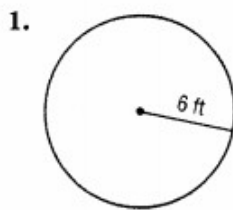
The formula for calculating the circumference of a circle is:

$$\text{Area} = \pi r^2$$

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



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



5. diameter = 15 km

6. radius = 21 mi

7. radius = 50 m

8. diameter = 600 ft

9. radius = 62 mm

10. diameter = 7 km

Trigonometry

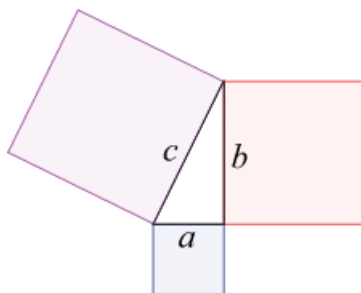
Speaking of angles, welders must also possess a good understanding of trigonometry for creating angled structures. Trigonometry helps welders determine the area of the weld and the angle it should be created at for handling pressure under various environmental conditions.

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.

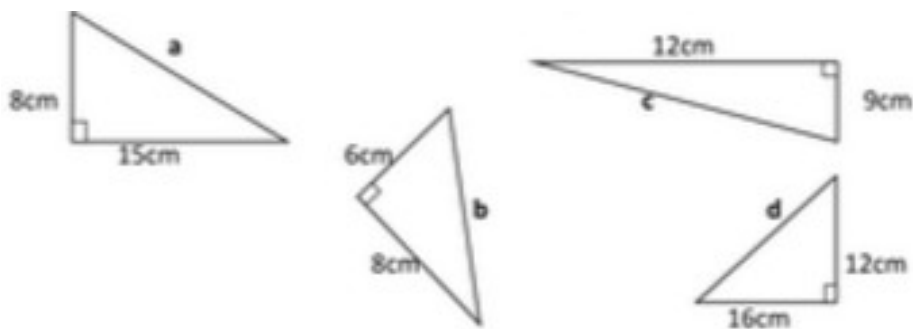
Pythagoras' Theorem

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.

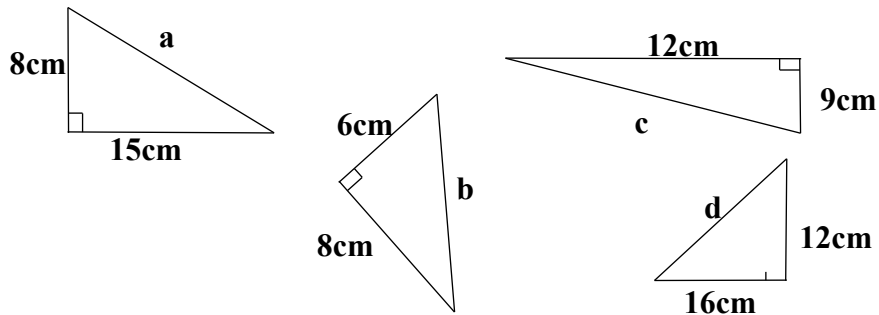


$$a^2 + b^2 = c^2$$

Find hypotenuse of following



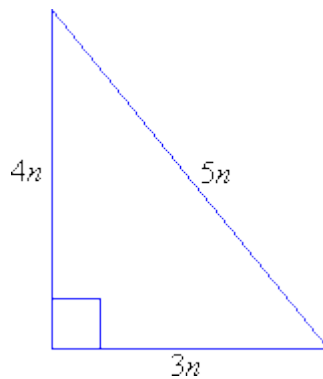
Using Pythagoras, find the length of the side labeled with letters.



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. $6 : 8 : ? = 3(2) : 4(2) : ?$

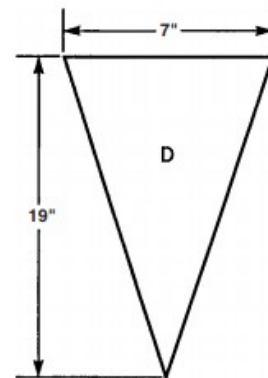
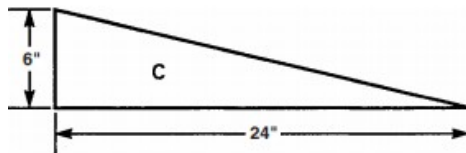
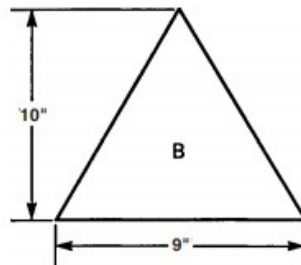
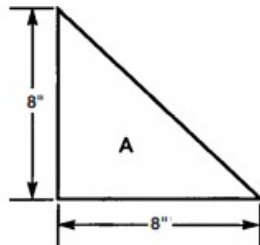
Step 2: Yes, it is a 3-4-5 triangle for $n = 2$.

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

Answer:

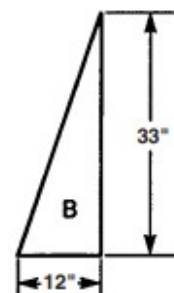
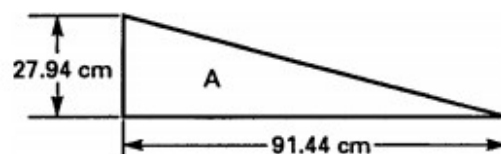
The length of the hypotenuse is 10 inches.

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:

$$\text{Decimal degrees} = \text{Degrees} + (\text{Minutes}/60) + (\text{Seconds}/3600)$$

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

1. First, convert minutes and seconds to their degree equivalents and add the results
 $25'/60=0.4167^\circ$
 $30''/3600=.0083^\circ$
2. and $0.4167^\circ + 0.0083^\circ = 0.425^\circ$
3. Then, add this number to the number of degrees. $39^\circ + 0.425^\circ = 39.425^\circ$
So, the final result is: $39^\circ 25' 30'' = 39.425^\circ$

APPLY KNOWLEDGE OF MATHEMATICS IN WATER OPERATIONS

Water Measurement Units

There are two conditions under which water is measured—water at rest and water in motion. Water at rest is measured in units of volume. Water in motion is measured in units of flow— unit of volume for a convenient time unit. It is important that the difference between a unit of volume and a unit of flow be kept in mind.

Volume Units

Water at rest; i.e., ponds, lakes, reservoirs, and in the soil, is measured in units of volume — gallon, cubic foot, acre-inch, and acre-foot.

Cubic Foot – The volume of water that would be held in a container one foot wide by one foot long by one foot deep.

Acre-Inch – The volume of water that would cover one acre (43,560 square feet) one inch deep.

Acre-Foot – The volume of water that would cover one acre one foot deep.

Flow Units

Water in motion; i.e., flowing in streams, canals, pipelines, and ditches, is measured in units of volume per unit of time—gallons per minute (gpm), cubic feet per second (cfs), acre-inches per hour and acre feet per day. Cubic feet per second, sometimes written second-feet (sec. ft. or cusec) is most commonly used for measuring flow of irrigation water moving by gravity from streams and reservoirs. Gallons per minute is most commonly used for measuring flow from pumps.

Cubic foot per second – The quantity of water equivalent to a stream one foot wide by one foot deep flowing with a velocity of one foot per second.

Gallon per minute – The quantity of water equivalent to a stream which will fill a gallon measure once each minute.

A flow of one cfs is approximately equal to either 450 gpm, one acre-inch per hour, or two acre-feet per day (24 hours).

Conversion Factors

The following equivalents are useful for converting from one unit to another and for calculating volumes from flow units.

Volume Units

One gallon

= 231 cubic inches

= 0.13368 cubic foot weighs approximately 8.33 pounds

One cubic foot

= 1,728 cubic inches

= 7.481 gallons (7.5 for ordinary calculations) weighs 62.4 pounds (62.5 for ordinary calculations)

One acre-inch

= 3,630 cubic feet

= 27,154 gallons (27,200 for ordinary calculations)

= 1/12 acre-foot weighs approximately 113.1 tons

One acre-foot

= 43,560 cubic feet

= 325,851 gallons

= 12 acre-inches weighs approximately 1,357 tons

Flow Units

One gallon per minute

= 0.00223 (approximately 1/450) cubic foot per second
= 0.00221 acre-inch per hour
= 0.00442 acre-foot per (24 hour) day
= 1 acre-inch in 452.6 hours (450 for ordinary calculations)
= 1 acre-foot in 226.3 days

One cubic foot per second

= 448.83 gallons per minute (450 for ordinary calculations)
= 1 acre-inch in 1 hour and 30 seconds (1 hour for ordinary calculations)
= 1 acre-foot in 12 hours and 6 minutes (12 hours for ordinary calculations)
= 1.984 acre-feet per (24 hours) day (2 acre-feet for ordinary calculations)

Million gallons per day (mgd)

= 694.4 gallons per minute (695 for ordinary calculations)
= 1.547 cubic feet per second (1.5 for ordinary calculations)

Conversion Table

To convert from: To: Multiply by:

Cubic-ft Gallons 7.5

Acre-in Cubic-ft 3,630

Acre-ft Cubic-ft 43,560

Acre-ft Acre-in 12 cfs gpm 450

Acre-in per hr cfs 1

Acre-ft per hr cfs 12

Conversion between English and Metric Units

Agricultural producers in many parts of the world use Metric (also called SI) units in their routine water measurements. The most commonly-used volume units in Metric system include liter, cubic meter, and hectare-millimeter, while common flow units are liter per minute (lpm) and cubic meter per second (cms). The following conversion table can be used to convert between English and Metric units.

Irrigation water management does begin with knowing how much water is available and involves some arithmetic. The most common mistake when working with water measurement units is to accidentally substitute one flow unit or volume unit for another without proper conversion. Usually the final answer appears obviously wrong; however, this is not always true. When checking your arithmetic, also check the measurement unit to see they are correct.

English/Metric Conversion Table

To convert from: To: Multiply by:

Gallons Liters 3.8

Cubic-meter Cubic-ft 35.3

Cubic-ft Liters 28.3

Acre-in Hectare-mm 10.3

gpm lpm 3.8

cfs lpm 1700

cms cfs 35.3

Conversion Formulas

The following formulas are handy for computing the approximate depth of water applied to a field.

$$\frac{\text{Cubic feet per second} \times \text{hours}}{\text{acres}} = \text{acre-inches per acre, or average depth in inches.}$$
$$\frac{\text{Gallons per minute} \times \text{hours}}{450 \times \text{acres}} = \text{acre-inches per acre, or average depth in inches.}$$

Calculating the Weight of Water

The challenge of calculating the weight of water really comes down to exactly what it means to find the *weight* of water, and whether the use of the term is for a specific reason or is simply a colloquial way of asking for the *mass* of water. In any case, you can easily find the result using the general formula for density and the value of the density of water.

Mass vs. Weight

The most important thing to understand before you try to calculate the weight of water is the difference between mass and weight. The mass of a substance is a measure of how much matter is present, and it's measured in kilograms or pounds. Most of the time, this is the most useful measure when you want to see how much of a substance is present.

The weight of a substance or an object is the *force* that gravity exerts on it due to its mass. For this reason, weight is technically measured in newtons or pounds-force. When most people say "weight" in real life, they are actually referring to the mass of the substance, because in colloquial language the words are basically interchangeable. However, in physics they have very specific meanings, and as such, you have to be careful to ensure you're using the right words and calculating the right quantities.

Water Measurement Calculator – mL to g

The metric system has a lot of advantages when it comes to converting between masses and volumes of water. This really comes down to the convenient value for the density of water, but if you just want to calculate the weight or mass of water without going into much detail, this is the simplest approach to use.

In short, 1 mL (milliliter) of water has a mass of 1 g, so 1 liter has a mass of 1 kg. You can use this fact to work out the mass of water from any volume: for example, 450 mL is 450 g, and 1.35 liters is 1.35 kg.

Volume to Mass in General

You should learn the general formula for density to convert the mass of anything to the volume, or vice-versa, and of course you can also use this for water. Density ρ is defined as the mass m divided by the volume V , or (equivalently) the mass per unit volume of a substance. The formula is:

$$\rho = \frac{m}{V}$$

However, if you're looking to calculate the mass or weight of water (or another substance) you can re-arrange the formula to:

$$m = \rho V$$

Then all you need to find is the volume of water you're trying to measure and the density of water. Make sure that the units match before making the calculation. For example, if you have the density of water in kg/m^3 , you need to measure the volume in m^3 , and if you've measured the volume in ft^3 , you'll need the density in lb/ft^3 . The density of water in kg/m^3 is 1,000 kg/m^3 , and in lb/ft^3 it is 62.4 lb/ft^3 .

So if you have 0.01 m^3 of water, this is:

$$\begin{aligned} m &= \rho V \\ &= 1000 \text{ kg/m}^3 \times 0.01 \text{ m}^3 \\ &= 10 \text{ kg} \end{aligned}$$

Mass to Weight of Water

Finally, you can convert between mass and weight (if you really do need the weight rather than the mass) using the formula:

$$W = mg$$

Where W is the weight, m is the mass and $g = 9.81 \text{ m/s}^2 = 32.17 \text{ ft/s}^2$, the acceleration due to gravity. So continuing from the previous example gives:

$$\begin{aligned} W &= mg \\ &= 10 \text{ kg} \times 9.81 \text{ m/s}^2 \\ &= 98.1 \text{ N} \end{aligned}$$

Again, you need to make sure the units match up, so if you have the mass in lb, you'll need the acceleration due to gravity in ft/s^2 to ensure the answer makes sense.

Wastewater Conversion Table

$$\text{Alkalinity, as mg CaCO}_3\text{/L} = \frac{(\text{Titrant Volume, mL})(\text{Acid Normality})(50,000)}{\text{Sample Volume, mL}}$$

$$\text{Amps} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Area of Circle} = (0.785) (\text{Diameter}^2) \text{ or } (\pi) (\text{Radius}^2)$$

$$\text{Area of Cone (lateral area)} = (\pi) (\text{Radius}) \sqrt{\text{Radius}^2 + \text{Height}^2}$$

$$\text{Area of Cone (total surface area)} = (\pi) (\text{Radius}) (\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$$

$$\text{Area of Cylinder (total outside surface area)} = [\text{Surface Area of End \#1}] + [\text{Surface Area of End \#2}] + [(\pi) (\text{Diameter}) (\text{Height or Depth})]$$

$$\text{Area of Rectangle} = (\text{Length}) (\text{Width})$$

$$\text{Area of a Right Triangle} = \frac{(\text{Base})(\text{Height})}{2}$$

$$\text{Average (arithmetic mean)} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

$$\text{Average (geometric mean)} = [(X_1) (X_2) (X_3) (X_4) (X_n)]^{1/n} \text{ The } n\text{th root of the product of } n \text{ numbers}$$

$$\text{Biochemical Oxygen Demand (unseeded), in mg/L} = \frac{(\text{Initial DO, mg/L}) - (\text{Final DO, mg/L})}{\frac{\text{Sample Volume, mL}}{\text{Final Diluted Volume, mL}}}$$

$$\text{Chemical Feed Pump Setting, \% Stroke} = \frac{(\text{Desired Flow})(100\%)}{\text{Maximum Flow}}$$

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD})(\text{Dose, mg/L})(3.785 \text{ L/gal})(1,000,000 \text{ gal/MG})}{(\text{Liquid, mg/mL})(24 \text{ hr/day})(60 \text{ min/hr})}$$

Circumference of Circle = (π) (Diameter)

Composite Sample Single Portion = $\frac{(\text{Instantaneous Flow})(\text{Total Sample Volume})}{(\text{Number of Portions})(\text{Average Flow})}$

Cycle Time, min. = $\frac{\text{Storage Volume, gal}}{\text{Pump Capacity, gpm} - \text{Wet Well Inflow, gpm}}$

Degrees Celsius = (Degrees Fahrenheit - 32) $(\frac{5}{9})$ or $\frac{(F - 32)}{1.8}$

Degrees Fahrenheit = [(Degrees Celsius) $(\frac{9}{5})$ + 32] or [(Degrees Celsius) (1.8) + 32]

Detention Time = $\frac{\text{Volume}}{\text{Flow}}$ Note: Units must be compatible.

Electromotive Force (E.M.F), volts = (Current, amps) (Resistance, ohms) or $E = IR$

Feed Rate, lbs/day = $\frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34 \text{ lbs/gal})}{(\text{Purity, decimal percentage})}$

Filter Backwash Rate, gpm/sq ft = $\frac{\text{Flow, gpm}}{\text{Filter Area, sq ft}}$

Filter Backwash Rise Rate, in/minute = $\frac{(\text{Backwash Rate, GPM/sq ft})(12 \text{ in/ft})}{(7.48 \text{ gal/cu ft})}$

Filter Yield, lbs/hr/sq ft = $\frac{(\text{Solids Loading, lbs/day})(\text{Recovery, \%} / 100\%)}{(\text{Filter Operation, hr/day})(\text{Area, sq ft})}$

Flow Rate, cfs = (Area, sq ft) (Velocity, ft/sec) or $Q = AV$ where: Q = flow rate, A = area, V = velocity

Food/Microorganism Ratio = $\frac{\text{BOD}_5, \text{ lbs/day}}{\text{MLVSS, lbs}}$

Force, pounds = (Pressure, psi) (Area, sq in)

Gallons/Capita/Day = $\frac{\text{Volume of Wastewater Produced, gpd}}{\text{Population}}$

Hardness, as mg CaCO_3/L = $\frac{(\text{Titrant Volume, mL})(1,000)}{\text{Sample Volume, mL}}$ Only when the titration factor is 1.00 of EDTA

Horsepower, Brake (bhp) = $\frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Decimal Pump Efficiency})}$

Horsepower, Motor (mhp) = $\frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Decimal Pump Efficiency})(\text{Decimal Motor Efficiency})}$

$$\text{Horsepower, Water (whp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{3,960}$$

$$\text{Hydraulic Loading Rate, gpd/sq ft} = \frac{\text{Total Flow Applied, gpd}}{\text{Area, sq ft}}$$

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

$$\text{Mass, lbs} = (\text{Volume, MG})(\text{Concentration, mg/L})(8.34 \text{ lbs/gal})$$

$$\text{Mass Flux, lbs/day} = (\text{Flow, MGD})(\text{Concentration, mg/L})(8.34 \text{ lbs/gal})$$

$$\begin{aligned} \text{Mean Cell Residence Time (MCRT)} \\ \text{or Solids Retention Time (SRT), days} \end{aligned} = \frac{\text{Aeration Tank TSS, lbs} + \text{Clarifier TSS, lbs}}{\text{TSS Wasted, lbs/day} + \text{Effluent TSS, lb/day}}$$

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

$$\text{Organic Loading Rate} = \frac{\text{Organic Load, lbs BOD}_5/\text{day}}{\text{Volume}}$$

$$\text{Organic Loading Rate-RBC, lbs BOD}_5/\text{day/1,000 sq ft} = \frac{\text{Organic Load, lbs BOD}_5/\text{day}}{\text{Surface Area of Media, 1,000 sq ft}}$$

$$\text{Organic Loading Rate-Trickling Filter, lbs BOD}_5/\text{day/1,000 cu ft} = \frac{\text{Organic Load, lbs BOD}_5/\text{day}}{\text{Volume, 1,000 cu ft}}$$

$$\text{Oxygen Uptake Rate/Oxygen Consumption Rate, mg/L/minute} = \frac{\text{Oxygen Usage, mg/L}}{\text{Time, minute}}$$

$$\text{Population Equivalent, Organic} = \frac{(\text{Flow, MGD})(\text{BOD, mg/L})(8.34 \text{ lbs/gal})}{\text{lbs BOD/day/person}}$$

$$\text{Recirculation Ratio-Trickling Filter} = \frac{\text{Recirculated Flow}}{\text{Primary Effluent Flow}}$$

$$\text{Reduction in Flow, \%} = \frac{(\text{Original Flow} - \text{Reduced Flow})(100\%)}{\text{Original Flow}}$$

$$\text{Reduction of Volatile Solids, \%} = \frac{(\text{In} - \text{Out})(100\%)}{\text{In} - (\text{In} \times \text{Out})} \quad \text{All information (In and Out) must be in decimal form}$$

$$\text{Removal, \%} = \frac{(\text{In} - \text{Out}) (100)}{\text{In}}$$

$$\text{Return Rate, \%} = \frac{(\text{Return Flow Rate}) (100\%)}{\text{Influent Flow Rate}}$$

$$\text{Return Sludge Rate-Solids Balance} = \frac{(\text{MLSS}) (\text{Flow Rate})}{\text{Return Activated Sludge Suspended Solids} - \text{MLSS}}$$

$$\text{Slope, \%} = \frac{\text{Drop or Rise}}{\text{Distance}} \times 100$$

$$\text{Sludge Density Index} = \frac{100}{\text{SVI}}$$

$$\text{Sludge Volume Index, mL/g} = \frac{(\text{SSV}_{30}, \text{mL/L}) (1,000 \text{ mg/g})}{\text{MLSS, mg/L}}$$

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, grams}) (1,000,000)}{\text{Sample Volume, mL}}$$

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

$$\text{Solids Loading Rate, lbs/day/sq ft} = \frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, sq ft}}$$

Solids Retention Time (SRT): *see* Mean Cell Residence Time (MCRT)

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

$$\text{Specific Oxygen Uptake Rate/Respiration Rate, (mg/g)/hr} = \frac{\text{OUR, mg/L/min (60 min)}}{\text{MLVSS, g/L (1 hr)}}$$

$$\text{Surface Loading Rate or Surface Overflow Rate, gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Area, sq ft}}$$

Three Normal Equation = $(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$, where $V_1 + V_2 = V_3$

Two Normal Equation = $N_1 \times V_1 = N_2 \times V_2$, where N = concentration (normality), V = volume or flow

$$\text{Velocity, ft/second} = \frac{\text{Flow Rate, cu ft / sec}}{\text{Area, sq ft}} \text{ or } \frac{\text{Distance, ft}}{\text{Time, second}}$$

$$\text{Volatile Solids, \%} = \frac{(\text{Dry Solids, g} - \text{Fixed Solids, g}) (100)}{\text{Dry Solids, g}}$$

$$\text{Volume of Cone} = (1/3) (0.785) (\text{Diameter}^2) (\text{Height})$$

$$\text{Volume of Cylinder} = (0.785) (\text{Diameter}^2) (\text{Height})$$

$$\text{Volume of Rectangular Tank} = (\text{Length}) (\text{Width}) (\text{Height})$$

$$\text{Waste Milliequivalent} = (\text{mL}) (\text{Normality})$$

$$\text{Watts (DC circuit)} = (\text{Volts}) (\text{Amps})$$

$$\text{Watts (AC circuit)} = (\text{Volts}) (\text{Amps}) (\text{Power Factor})$$

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water Horsepower, HP}}{\text{Power Input, HP or Motor HP}} \times 100$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{Flow, gpm}) (\text{Total Dynamic Head, ft}) (0.746 \text{ kw/hp}) (100)}{(3,960) (\text{Electrical Demand, kilowatts})}$$

Temperature Conversion

The three common temperature scales are Celsius, Fahrenheit, and Kelvin. Each scale has its uses, so it's likely you'll encounter them and need to convert between them. Fortunately, the conversion formulas are simple:

Celsius to Fahrenheit	$^{\circ}\text{F} = 9/5 (^{\circ}\text{C}) + 32$
Kelvin to Fahrenheit	$^{\circ}\text{F} = 9/5 (\text{K} - 273) + 32$
Fahrenheit to Celsius	$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$
Celsius to Kelvin	$\text{K} = ^{\circ}\text{C} + 273$
Kelvin to Celsius	$^{\circ}\text{C} = \text{K} - 273$
Fahrenheit to Kelvin	$\text{K} = 5/9 (^{\circ}\text{F} - 32) + 273$

Population Equivalent

A means of expressing the strength of organic material in wastewater. In a domestic wastewater system, microorganisms use up about 0.2 pound (90 grams) of oxygen per day for each person using the system (as measured by the standard BOD test). May also be expressed as flow (100 gallons/person/day or 378 liters/person/day) or suspended solids (0.2 lb SS/person/day or 90 grams SS/person/day).

Density and Specific Gravity

Density and specific gravity have very similar, but not quite identical definitions.

Density is the mass of material per unit volume.

Specific gravity is a ratio of the mass of a material to the mass of an equal volume of water at 4 °C. Because specific gravity is a ratio, it is a unitless quantity. For example, the specific gravity of water at 4°C is 1.0 while its density is 1.0 gcm⁻³.

Detention Time

Detention time is the length of time water is retained in a vessel or basin or the period from the time the water enters a settling basin until it flows out the other end. When calculating unit process detention times, we are calculating the length of time it takes the water to flow through that unit process. Detention times are normally calculated for the following basins or tanks:

- ✓ Flash mix chambers (seconds)
- ✓ Flocculation basins (minutes)
- ✓ Sedimentation tanks or clarifiers (hours)
- ✓ Wastewater ponds (days)
- ✓ Oxidation ditches (hours)

To calculate the detention period of a basin, the volume of the basin must first be obtained with the formula: $V = L \times W \times D$

Detention time is calculated in units of time. The most common are seconds, minutes, hours and days. If detention time is desired in minutes, then the flow rate used in the calculation should have the same time frame (cfm or gpm, depending on whether tank volume is expressed as cubic feet or gallons). If detention time is desired in hours, then the flow rate used in the calculation should be cfh or gph.

The simplest way to calculate detention time is to divide the volume of the container by the flow rate into the container. The theoretical detention time of a container is the same as the amount of time it would take to fill the container if it were empty. For volume, the most common units used are gallons; however, on occasion, cubic feet may also be used. Time units will be in whatever units are used to express the flow. For example, if the flow is in gpm, the detention time will be in days. If, in the final result, the detention time is in the wrong time unit, simply convert to the appropriate units.

Detention time can be determined using the following formula:

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad * \text{Units must be compatible}$$

UNDERTAKE WATER/WASTEWATER CALCULATIONS

This section covers water/wastewater calculations.

Service Line Flushing Time

General Service Connection Flushing Procedures

1. Flushing a service connection should not be started until after the water main serving the service connection has been thoroughly flushed by the public water supply system's operating staff.
2. Once the waterline/water main has been thoroughly flushed, begin the process of flushing the service connection by locating the outside spigot/faucet that is closest to the water main.
3. Run the water with the outside spigot/faucet open for at least 10-15 minutes to flush the service line. Lengthy or complex service lines may require flushing for more than 10-15 minutes.
4. A hose may be attached to the outside spigot/faucet to redirect the water to avoid ponding. In doing so, make sure the flow is high and nothing is attached to the end of the hose. Additional flushing time may be necessary to compensate for any restrictions imposed by the attached hose.
5. Wait 30 – 60 minutes without using any water, if possible, to allow the water in the water main to settle.
6. Open the outside spigot/faucet again and check water clarity.
7. If necessary, flush the service line through the outside spigot/faucet for another 10-15 minutes. Depending on the flushing of the water main, it may be necessary to repeat the flushing of the service line checking water clarity each time.
8. After the water from the outside spigot/faucet appears clear, begin the general process of flushing the service connection's interior pipes and faucets.
9. If possible, begin flushing at a cold water faucet that is both on the lowest level of the service connection's structure and closest to its water meter.
10. Fully open each cold water faucet one at a time and run for at least five minutes. Prior to flushing remove all faucet attachments such as aerators, screens, etc. to maximum flow.
11. Flush remaining cold water faucets moving upwardly in the service connection's structure and away from its water meter. Be sure to include tubs and showers.
12. Individually open each remaining outside spigot/faucet and similarly flush as above.
13. Flush hot water heaters according to the manufacturer's instructions for flushing. Disconnect power to the hot water heater at the circuit breaker box and allow the hot water heater to sufficiently cool before flushing to avoid being burned. Begin flushing hot water taps on the lowest level of the service connection's structure. Individually open the hot water faucets and run until the warm water turns to cold water. Restore power to the hot water heater once all hot water faucets have been thoroughly flushed.

14. Flush items such as in-line filters, treatment systems, water softeners, refrigerator water dispensers (direct or tanked) with enough water to replace at least 1-2 volumes of all connecting lines and tanks. To avoid contamination, consider replacing all filters, especially if they are at the end of their useful service life.
15. Refer to owner's manuals for flushing water softening systems, reverse osmosis systems, and other types of filtering systems. To avoid contamination, consider replacing all filters, especially if they are at the end of their useful service life.
16. Other items that utilize water such as coffee makers, pitcher type water filters, and dental cleaning appliances should be cleaned and their filters replaced.
17. If water from taps is not clear, repeat steps 2 through 16.
18. Once flushing has been completed, verify that all spigots and faucets are closed.

Composite Sampling

Wastewater sampling is generally performed by one of two methods, grab sampling or composite sampling. Grab sampling is just what it sounds like; all of the test material is collected at one time. As such, a grab sample reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected. Composite sampling consists of a collection of numerous individual discrete samples taken at regular intervals over a period of time, usually 24 hours. The material being sampled is collected in a common container over the sampling period. The analysis of this material, collected over a period of time, will therefore represent the average performance of a wastewater treatment plant during the collection period.

Numerous industry references list various parameters for wastewater testing and whether samples should be collected using grab sampling or composite sampling methods. For example, grab sampling allows the analysis of specific types of unstable parameters such as pH, dissolved oxygen, chlorine residual, nitrites and temperature. However, the most widely used indicators of treatment plant performance, including CBOD5 (five day carbonaceous biochemical oxygen demand), TSS (total suspended solids) and TN (total nitrogen) require the use of composite sampling techniques. STANDARD METHODS (20th Edition, Section 1060 § B, "Collection and Sampling") states "A sample can represent only the composition of its source at the time and place of collection." Grab samples may be used to represent "some well-mixed surface waters, but rarely, wastewater streams" for water quality evaluation. The widely varying flow patterns of residential treatment plants make it impossible to evaluate performance by analyzing a single grab sample of effluent. Residential treatment plants receive a frequent number of short hydraulic surges throughout the day followed by intermittent periods of no flow whatsoever.

Routine variations in the volume and strength characteristics of incoming wastewater create fluctuations in the quality of treatment plant effluent. Therefore, an effluent grab sample taken at one specific time throughout the daily flow pattern will not be representative of system performance over the entire day.

While the limitations of determining system performance by grab sampling are apparent, the use of grab samples for the evaluation of a residential treatment unit is further compromised if the sample is collected from a location where the effluent does not have sufficient velocity to keep the effluent solids in suspension.

While the limitations of determining system performance by grab sampling are apparent, the use of grab samples for the evaluation of a residential treatment unit is further compromised if the sample is collected from a location where the effluent does not have sufficient velocity to keep the effluent solids in suspension. WASTEWATER SAMPLING FOR PROCESS AND QUALITY CONTROL

(Manual of Practice No. OM-1, § “Representative Sampling”) directs that samples be collected “at points where the sample stream or tank is well mixed.” The manual goes on to say “avoid taking samples at points where solids settling occurs or floating debris is present. These situations occur normally in quiescent areas, where the velocity of the flow has decreased.” For this reason, plant performance can never be evaluated by a sample of effluent taken from a pump chamber, distribution box, sump, roadside ditch or any device that contains effluent below the flow line. The intermittent flow pattern of an individual residence intensifies this problem by allowing effluent solids to settle out within a sump during low flow periods. Even the few solids present in a high quality effluent will settle out when retained within a sump. If only a very few solids settle within a sump during a low flow period today, they remain and accumulate with additional solids settling out over successive days. Any sample drawn from a sump will contain effluent suspended solids combined with days, weeks, months or years worth of accumulated solids. A sample of liquid from such a sump cannot be analyzed for overall system performance, as it is scientifically impossible to determine what portion of the solids were suspended in the effluent and what portion of the solids had accumulated in the sump over a period of time. Using any sample drawn from a sump to evaluate the performance of a residential wastewater treatment plant is simply inappropriate. Samples must be taken from a location where the effluent is free-flowing and has sufficient velocity to keep the effluent solids in suspension.

Composite samples of effluent collected, stored, analyzed, tabulated and averaged over an extended period of time provide the only verifiable indication of treatment plant performance. Collecting and analyzing these composite samples is often an expensive and time-consuming process. For these reasons, most regulatory organizations recognize independent third-party certifiers, who use composite sampling methods to conduct performance evaluation and accurately measure system performance in a standardized, reproducible setting. Attempting to evaluate a residential treatment system in the field by analyzing a grab sample taken from a sump or any other containment vessel provides a compound degree of error and will yield erroneous conclusions about system performance.

Biochemical Oxygen Demand

To determine the value of the BOD in mg/L, use the following formula:

$$\text{BOD, mg/L} = [(\text{Initial DO} - \text{Final DO}) \times 300] / \text{mL sample}$$

For example:

$$\text{Initial DO} = 8.2 \text{ mg/L}$$

$$\text{Final DO} = 4.4 \text{ mg/L}$$

$$\text{Sample size} = 5 \text{ mL}$$

$$\text{BOD mg/L} = [(8.2 - 4.4) \times 300] / 5 = (3.8 \times 300) / 5 = 1140 / 5 = 228 \text{ mg/L}$$

Whenever a sample is dechlorinated, it must be seeded. If the sample is seeded, a correction factor must be calculated to determine the effects that the seed material has on the DO depletion. A number of BOD's must be run on the seed material to determine the seed correction factor.

UNIT 05

PREPARE BASIC TECHNICAL DRAWING

This unit covers identifying the drawing requirements, preparing or making changes to engineering drawings, preparing an engineering parts list and issuing the drawings

Introduction

When you take a project management class, you are likely to be told about the three major constraints of a project – Cost, Schedule, and Scope. You will then spend an exuberant amount of time developing, analyzing, calculating, and optimizing the schedule. Likewise you will review budget categories, analyze depreciation, and determine acceptable variances. However, when it comes to the scope section, very often you will get a 15-minute mandatory session on change control and how to avoid scope creep.

Okay, so what's my point? Please bear with me for a bit longer. In one of the classes I teach I do a teambuilding exercise where the students, in teams, brainstorm reasons that projects succeed. The one answer that always makes it up on the list, in some form, is “well defined requirements”, in other words – SCOPE!

So, if defining scope is a critical part of succeeding on a project (and I would argue that it is, by far, the most important of the three constraints!), why don't we focus more time and attention on it? Because it is difficult! Very often, customers don't know exactly what they want, the “I can't describe it, but I'll recognize it when I see it” syndrome, or the language barriers between the customer and the project team makes the communication of the necessary requirements a nightmare.

That's the problem definition (stating that Scope is difficult would have been more to the point, but I'm an instructor so even the obvious takes time to state).

IDENTIFY DRAWING REQUIREMENTS

Selecting an approach to requirements gathering

There are many types of requirements, as there are many approaches to capturing them. Before starting into the actual capturing of requirements, a plan for the requirements gathering process must be developed. Often the first step for that should be to determine what the roles and responsibilities should be during this phase of the project. While the project manager would normally be responsible for the requirements of the project, it should typically be the customer, or an analyst, who is responsible for the requirements of the product. Even though the same person may play both roles, their overall responsibilities are different and it is important to be aware of which role is involved in what steps.

The project scope defines how the product (or service) will be developed while the product scope defines the actual functions and features of that same product. The traditional focus in project management has been on developing a product faster, cheaper, and better. The requirements of that product though are often assumed to be correct. This is changing through the popularity of agile approaches where it is assumed that the customer does not have a clear understanding of what they want up front, but rather that requirements gathering is a discovery process, where the customer gradually discovers the product requirements through iterations, prototyping and modelling.

There are many good techniques to gather requirements, all of them have their time and place and it is good for the project team to spend some time upfront determining the right approach for the specifics of this project. Some of the techniques to consider are:

- ✓ One-on-one interviews. An easy to arrange approach to requirements gathering that works well in a single-user environment where requirements are expected to be non-controversial. However, it is easy to get side tracked in these interviews so the interviewer must have the ability to keep the focus on the topics discussed and to be well prepared.
- ✓ Surveys. Surveys are a good technique to reach a large number of customers. Surveys must be kept simple and it is often difficult to get a significant number of the surveys to be returned. However, if the questions are specific and clear, the survey can serve as a great tool to take the pulse of the customer.
- ✓ Job shadowing or observation. This seems to be a fast growing technique for requirements gathering and it works great when the analyst is not real familiar with the business or when the customer has difficulties verbalizing the requirements. It does tend to primarily focus on the as-is situation of the business so if business processes are changing or a new business is started, this may not give the desired result. It is also noteworthy that observation tends to change the behaviour of the person being observed, so the analyst may not get an accurate picture of the customer's true problem.
- ✓ Facilitated sessions, or as I will refer to them, JAD (Joint Application Development) sessions. These are designed for multi stakeholder situations where there is a need to build consensus between the stakeholders.

JAD sessions

Joint application design was pioneered by IBM in the late 1970's and the early 1980's, and popularized further by James Martin who made it a key technique for RAD (Rapid Application Development) projects.

So, what is it? Well, consider a traditional project (I'll look at an IT project for example, since that is my background). First there will be a customer, often a functional manager, who will meet with you and get started, giving you some level project goals. Then you're sent out on the interview circuit – find out what the purchasing department needs, see if the finance group has any requirements (they usually do!), talk to the material management department, and so on through all necessary departments and divisions.... After that you lock yourself in a room to compare all the requirements, identify the inconsistencies, and try to figure out best way to deal with them.

In the best-case scenario, you make a few more rounds to all your stakeholders and get an agreement – at worst (and unfortunately this happens more often), you decide to “interpret” the requirements or maybe tweak them enough so they fit together. This will invariably result in a product that is less than the customer wanted.

However, by using JAD you would bring the stakeholders together into a number of sessions (normally two or four), where they, with the guidance of a facilitator, will determine and come to an agreement on the requirements. By having the stakeholders actually discuss and come to a consensus on system requirements, you are starting out with a greater level of ownership up front. If you also choose to develop and review prototypes during these sessions, you will greatly help the users visualize what the end product will actually look like.

Since JAD is a techniques largely focused on group dynamics and team synergy, it is important to get the right people involved. The key people for a JAD session are:

1. The Facilitator

The facilitator should be selected based on their ability to work with and lead a group of people in consensus building. They should be neutral to the outcome of the session, meaning that they should not have a vested impact in steering the discussion in a certain direction. This normally means that the project manager or the developers do not make good facilitators. Ideally, it should be a person that has a general understanding of the customer's business areas, who is comfortable with modeling techniques that are to be used in the session and who can deal with a group of disagreeing people and move them along in the decision process.

While the facilitator is not the most important person for the project, they are the one with the most influence on the success of the JAD session itself. They need to be able to sense how the JAD team is functioning, to deal with conflicts, and to make sure that the goals of the session are being met.

2. The Scribe

The scribe, or scribes, will capture the key decisions, and the rational behind those decisions. If a 3-day JAD session is being held and at the end there is no documentation of the outcome, then everyone has just wasted 3 days. Have one scribe focus on conversations and one on models. This will improve the odds of catching everything important. The scribe must have good listening skills and must understand the business that is being discussed. You don't want constant interruptions from the scribe, requesting clarifications of items that are well understood by the rest of the room.

3. The Analyst

The analyst is the person focusing on capturing the right information. Often the analyst will also be the facilitator, but when that happens they are playing two different roles. The facilitator is focusing on getting the group to consensus and to meet the session goals while the analyst is there to make sure that the right questions are asked and that the models correctly identifies the business. The analyst is really more of a subject matter expert on the customer's business.

4. The Customer

Obviously you cannot hold a JAD session without a customer. While it is true that you may not be able to select your customer, there are ways to influence the selection of them. Identify the criteria that you are looking for and meet with management ahead of time and explain the importance of the role and the characteristics of the person that is needed.

There are other people that will be involved in JAD sessions as well. The sponsor should kick off the session and set the tone, Subject Matter Experts may be brought in for portion of the session to explain a process or a technology. The developers should also attend the session, but especially in the beginning it will important that play more of an observer role than an active role.

Having a successful session

Since the goal of a JAD session is to create team synergy and build consensus, the facilitator must create an environment where the stakeholders work well together and can accomplish the session objectives. To start off on the right track, it is important to have the sponsor or a key executive from the organization, attend the meeting and show management support for the project. This will ensure that everyone understands and supports the goals.

There must also be ground rules established for the JAD session. Ideally most of the ground rules are established by the participants themselves. This tends to lead to the team enforcing the rules, rather than the facilitator. Sample ground rules include:

- ✓ Breaks and how to handle late comers
- ✓ Decision process and how consensus is defined
- ✓ What to do when a topic goes longer than the agenda
- ✓ Rules to deal with participants monopolizing the conversation

One of the biggest difficulties during a JAD session is to stay on track and prevent the team from going off on tangents. A great tool for this is the Parking Lot. A parking lot serves two main purposes, first, it allows the team to capture important information that should be addressed, but not by this team at this time. The second benefit is for the facilitator. It allows moving a person off a topic which is not in line with the goals of the session. There may not be intent to ever re-visit the topic again, but by putting it in writing and making it visible, it may allow the team to put the topic aside.

The facilitator must be monitoring the team through-out the session to assess how well they function. All teams will go through a team development cycle such as Forming/Storming/Norming/Performing/

In the forming stage, the team is insecure and need a lot of guidance. Team building and clear assignments are important for this stage. In the storming stage the team is now trying to assess the competency of other team members and figure out where they fit. The facilitator needs to let the team storm, while making sure that the ground rules are being followed. In the norming stage the team is falling in to natural roles and responsibilities and the team starts to find its purposes. When that has been sorted out the team is in the performing stage. In real life the team will move back and forth between these stages and the facilitator should adjust their facilitation style based on that.

Implementing a JAD approach

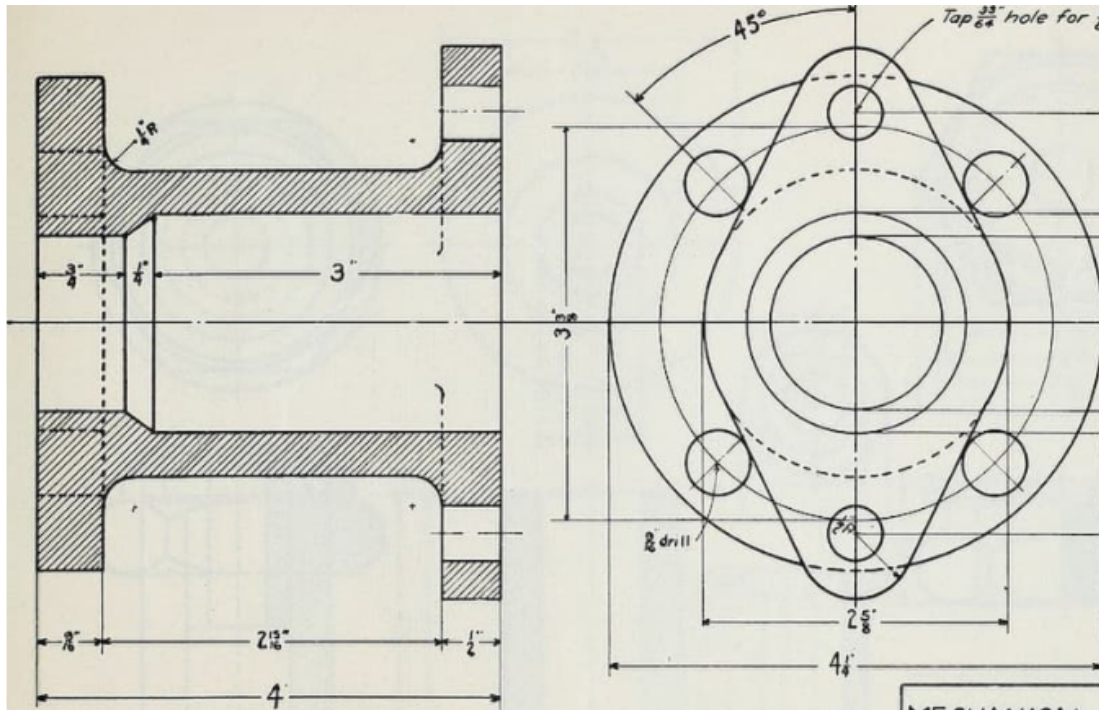
To get started, select a core JAD team within your organization. Have them get up to speed on the various versions of JAD (as many as there are authors), pick one and start the education process, some of the key steps are:

1. Sell it to your management to the customer. If you **don't** get buy-in **this will fail**, so make sure you put together a good sales presentation.
2. Train your core team on the techniques you'll be using (could be Process Modeling, Data Modeling, Prototyping, etc.)
3. Train some facilitators (select people that can lead a discussion, not necessarily the ones that want to do the most talking)
4. Pick a pilot project. Pick something not too large, something that you can afford to learn one and work through.
5. Train all participants (the users in the sessions have to understand the technique)
6. Schedule and run the pilot session.
7. Do an extensive lessons and learned session.

If you plan it right, you should now have a great foundation for many future successes with Joint Application Designs. Good Luck!

DEVELOP KNOWLEDGE AND PROPER TECHNIQUES IN PREPARING DRAWINGS AND SKETCHES

Engineering Drawings Basics



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

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

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

The Purpose of Engineering Drawings

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

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

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

How to Make Drawings?

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

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

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

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

Basic Components of an Engineering Drawing

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

Different Types of Lines

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



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



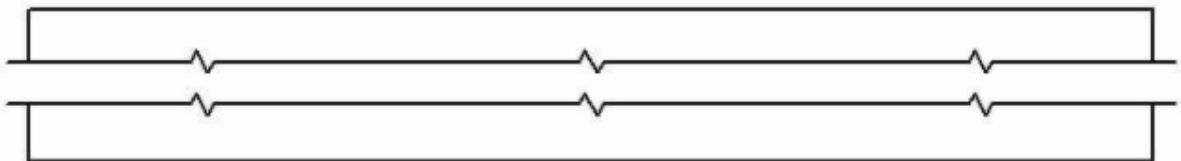
Hidden lines can show something that would not be otherwise visible on the drawings. For example, hidden lines may show the length of an internal step in a turned part without using a section or a cutout view (we explain both later).



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

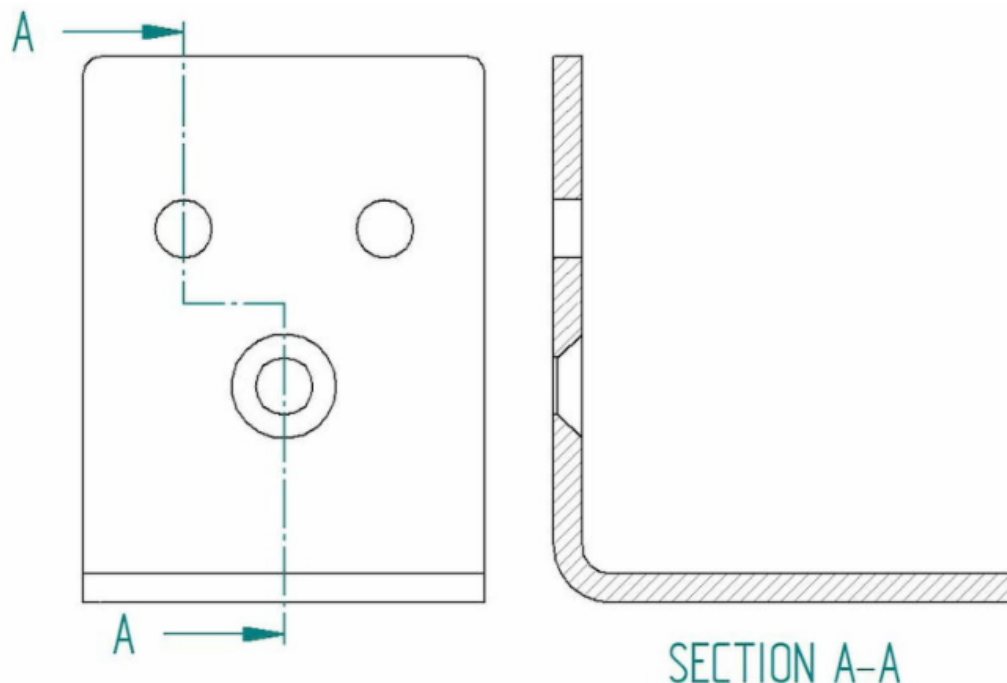


Extension lines annotate what is being measured. The dimension line has two arrowheads between the extension lines and the measurement on top (or inside, like in the image above) the line.



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

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



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

Types of Views

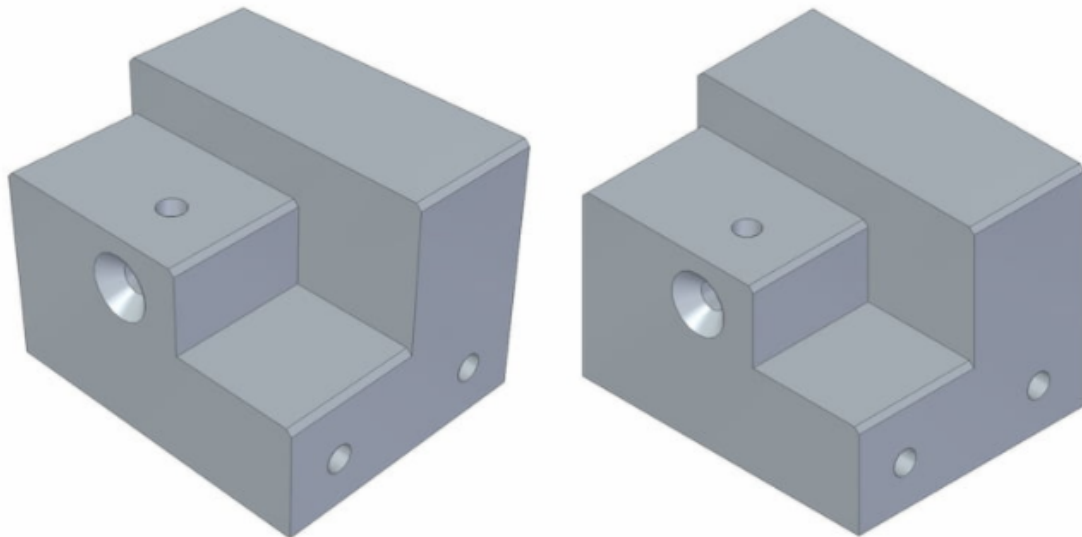
So let's take a closer look at the different types of views that are often present in a manufacturing drawing. Each serves a certain purpose. Bear in mind that adding views should follow the same logic as dimensioning – include as little as possible and as much as necessary.

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

Isometric View

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

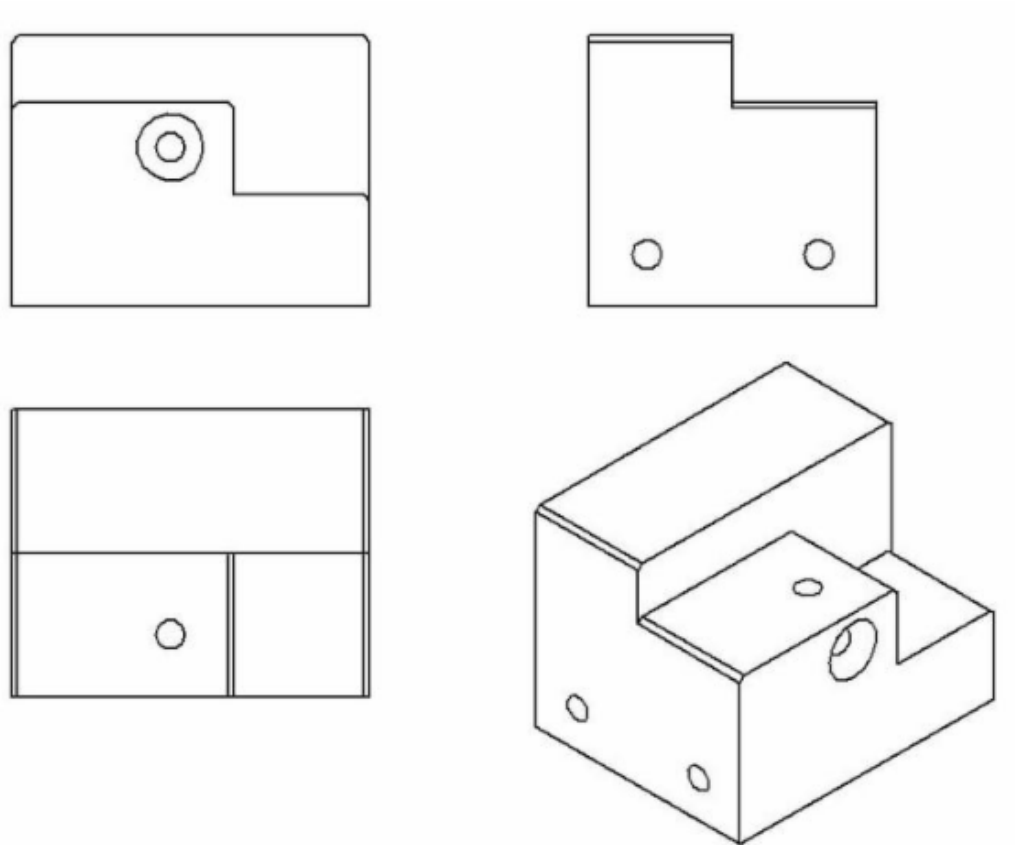
The lines that are vertical and parallel are in their true length. Which means you can use a ruler and the scaling of the drawing to easily measure the length straight from a paper drawing, for example. The same does not apply to angled lines.



Left – perspective; right – isometric

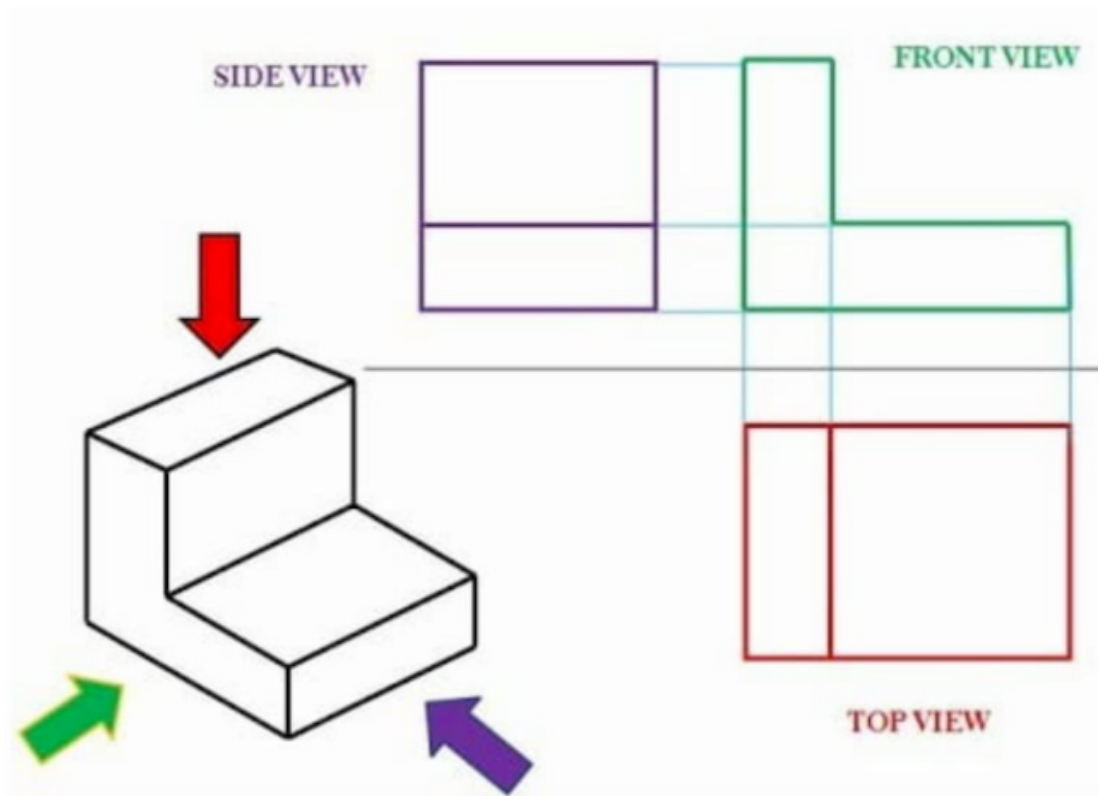
It is important to distinguish the isometric view from a perspective view. A perspective view is an artistic one that represents an object as it seems to the eye. Engineers stay true to the dimensions rather than optical illusions.

Orthographic View



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

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



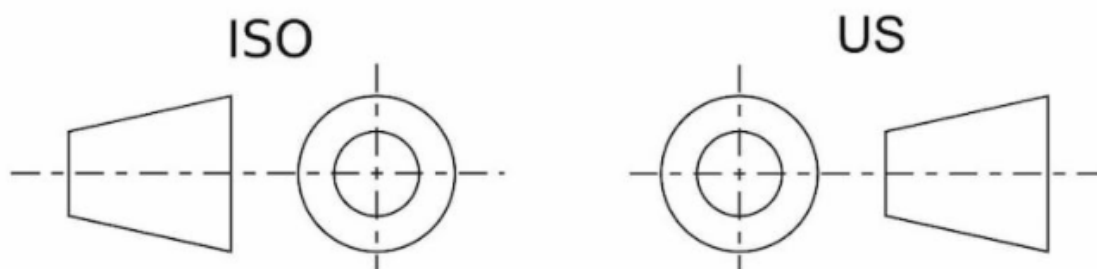
Orthographic projection (ISO standard)

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

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

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

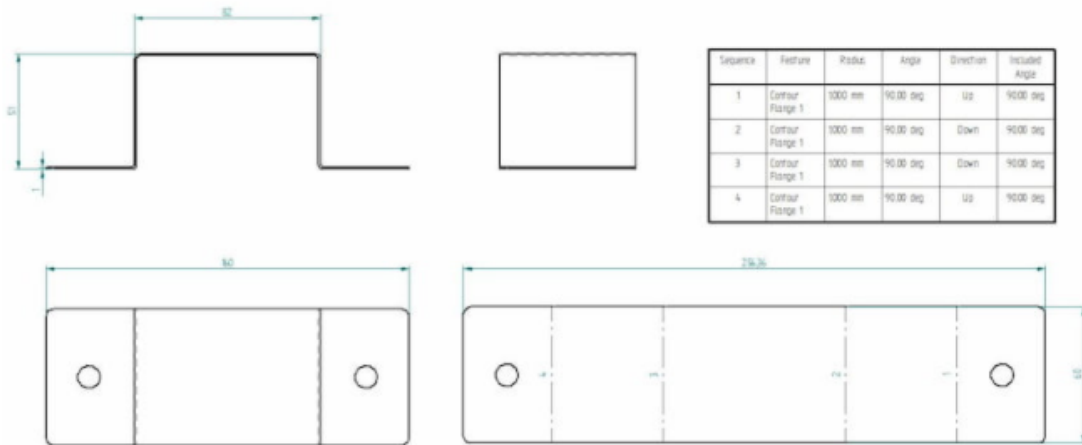
The positioning of the views differs a bit regionally. For example, look at the image below to compare the US and ISO layouts.



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

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

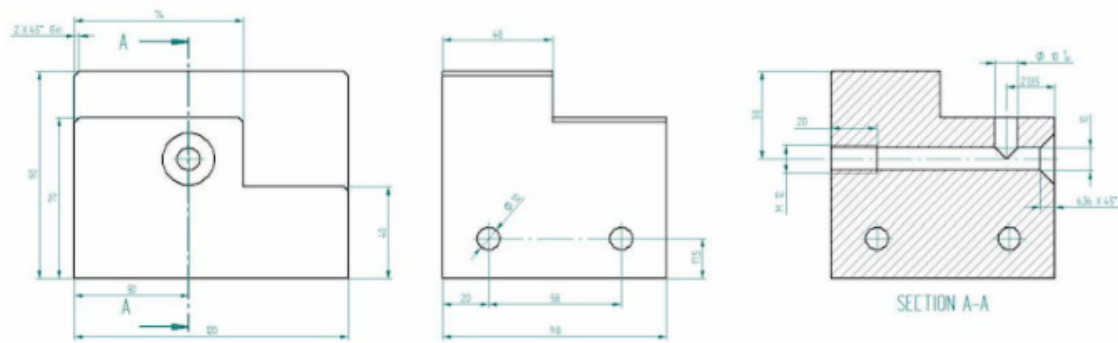
Flat Pattern



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

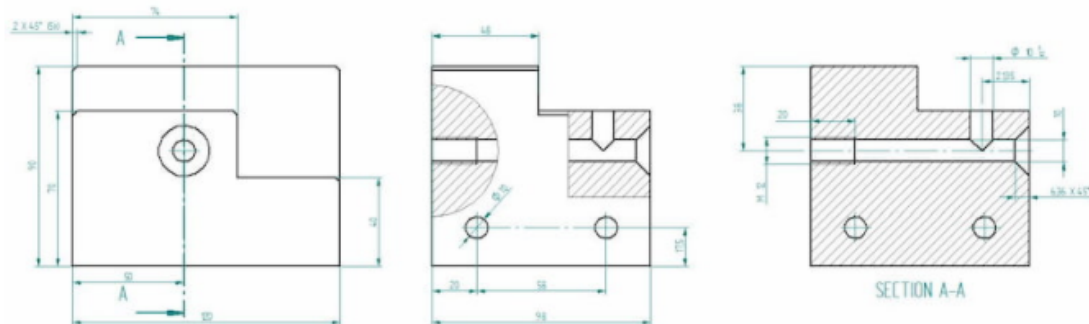
If you are using the standard part environment, the same option is not available. Still, many CAD programs have the possibility to convert a standard part into sheet metal if the part properties correspond to sheet metal (e.g. uniform thickness, inside radius, etc.).

Section View



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

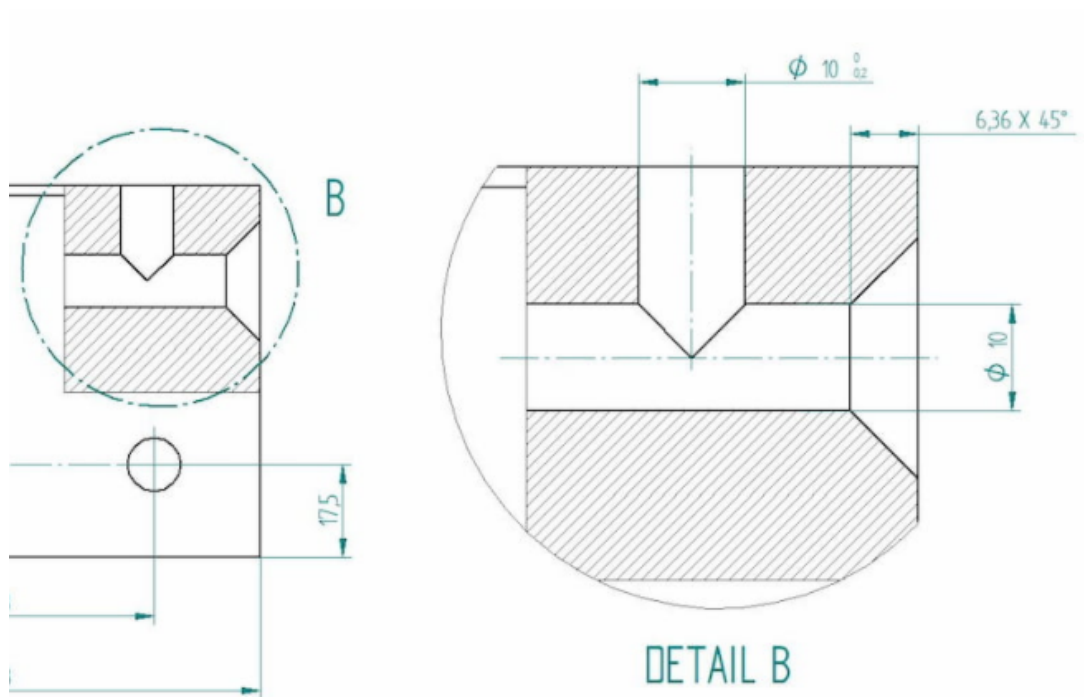
Cutout View



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

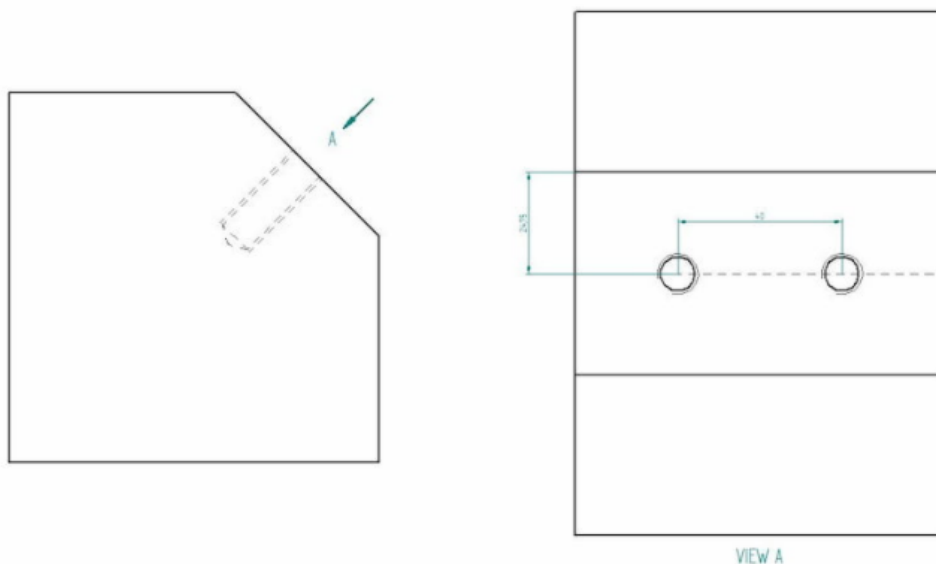
Thus, we could easily delete the section view and add all the necessary dimensions to cutouts.

Detail View



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

Auxiliary View



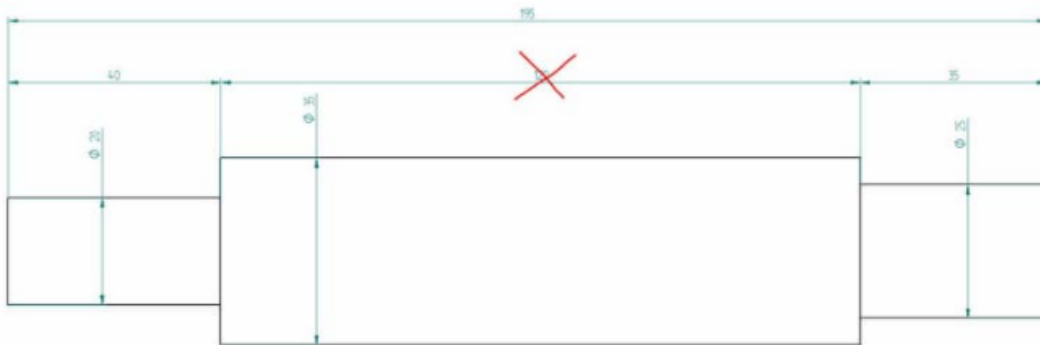
An orthographic view to represent planes that are not horizontal or vertical. It helps to show inclined surfaces without any distortion.

Dimensions

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

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

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



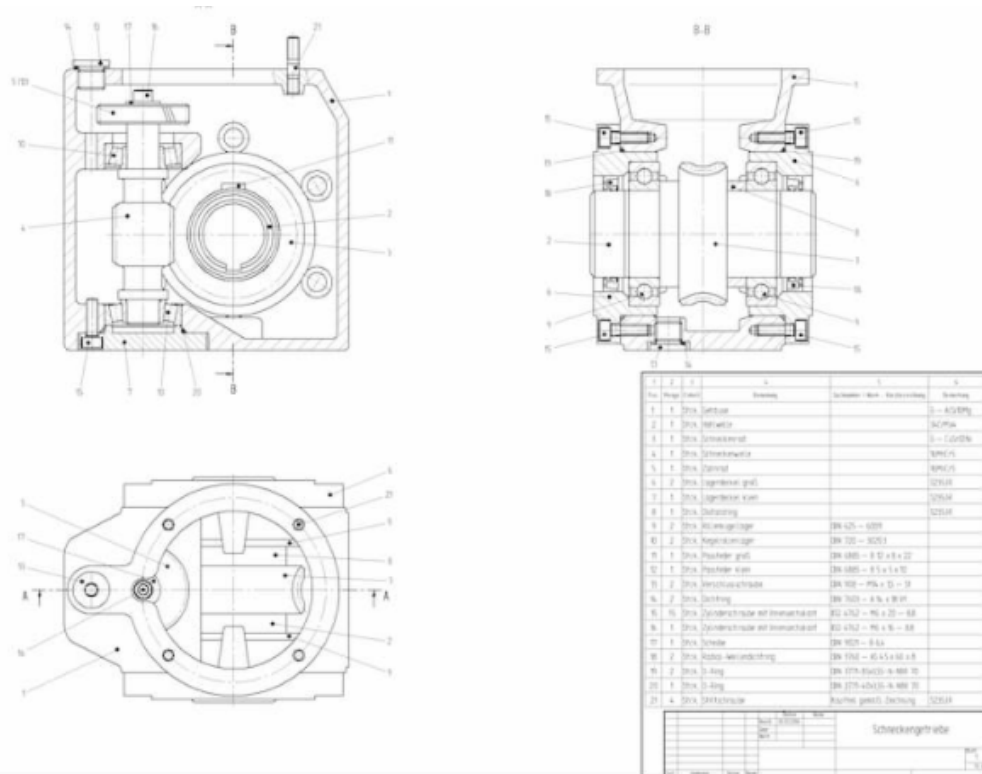
The image above shows a shaft with all the measurements. In reality, it creates a closed system whereby the manufacturer cannot guarantee all these dimensions 100%. Therefore, you have to determine the most important ones. In our case, we chose the end steps to be more important than the length of the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

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

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

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

Information Blocks



BOM and title block in the lower right corner

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

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

Assembly Drawings

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

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

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

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

How to create Technical Drawings

I am optimistic about technology, someday, giving us the power to imagine things and directly build an exact physical replica of what we have in our minds.

Unfortunately, we are not quite there yet, and to go from idea to a physical product we need to first “translate” what we have in our mind into a format that other humans and machines can interpret and use to build a product.



For most creative processes, machines still need humans to instruct them what to do. This is what designers and engineers do, they evaluate your idea and your requirements and produce the formats that will allow anyone to visualize the idea and then help machines build the final product.

We call them the product Technical Drawings. I will go through the most common formats that are generated to help define your physical product idea based on which stage the product is or the level of detail needed.

Design Sketches

One of the most basic and relatively simple formats to start with are design sketches. But these are not simply rough hand-drawings made on a piece of paper.

In order for design sketches to be useful in the development and fabrication process, they must have a certain level of accuracy and information included on them. These design sketches are commonly produced by an Industrial Designer and they often create them by hand although nowadays most use computer software. This is the first level of detail about your idea and it should include the following main elements:

- ✓ **Visual aesthetics** that show the main design intent and give a clear understanding of the product look. Materials & Finishes of the product and different components.
- ✓ **General dimensions** of the product to have a reference (with low accuracy) when fabricating a mock-up or prototype.
- ✓ **Description of the main functionalities** that help to understand how parts are fixed together, how they move or how they are supposed to function.

With this information, a professional (or even yourself if you have certain skills) can fabricate mock-ups of the product and explore different designs and material alternatives.

2D Drawings

In the past, 2D drawings or blueprints were common in any product development and they were literally laying around any office or workshop. Today they are mostly used in their digital format but they are still commonly used.

The two-dimensional world is not dead yet

Depending on which product you are developing 2D drawings are the main technical drawings used. That's the case with most soft-goods for example, where parts and layers of the product can be produced from 2D patterns.

Despite the rise of 3D modeling which has made these "flat" versions less relevant, they are still widely used as support documentation since they provide certain information that is critical in the development.

These technical 2D drawings are mainly created by Mechanical Engineers and are highly accurate and precise. This is what you would expect to see in a 2D drawing:

- ✓ **Product views.** Different types of views such as front, rear, side, top, bottom, sections, and isometric views are defined to have access to every single area of the product.
- ✓ **Materials.** The exact material and grade (this is the commercial name from material manufacturers) are specified. Also, the color and any additional finish or post-process such as protective coating or paint are included in the drawing.
- ✓ **Detailed dimensions.** Most of the dimensions of the product and features are defined in the drawing as a reference.
- ✓ **Critical dimensions.** There are certain dimensions that are important for the design since they may affect the fit between components, mechanical movements or function of your product.
- ✓ **Tolerances.** All dimensions should have a range of tolerances, especially those defined as critical above. The manufacturing process usually drives the tolerance range achievable, but the geometry of the product affects as well.

Sometimes 2D drawings are used as a full product specification and may include other relevant information to help define assembly or inspection instructions among other useful data.

CAD Models

Computer-Aided Design (CAD) models are probably the most commonly used type of format nowadays and the one that is usually required to be able to fabricate the product and its components using machines.

CAD software allows designing the 3D digital representations of a product

In fact, the 2D Drawings described above are usually created after the 3D models. CAD software can quickly create those 2D digital versions from the 3D model and create a link between them so when you modify the 3D it will automatically update the 2D drawing.

These, again, are mostly created by Mechanical Engineers and will define volumes for the product and components. This is the main information that you can get from CAD models:

- ✓ **3D view.** Using a CAD software (or any available viewer) you can visualize the product in every orientation and in real-time. From 3D models, you can also get Renders which are photorealistic visualizations of your 3D model.
- ✓ **Dimensions.** While dimensions are not explicitly indicated in the model, you are able to measure any dimension that you want in the model with exact precision.
- ✓ **Assembly.** Most products are made of different parts, so CAD models let you visualize where components are located and how they fit with each other.
- ✓ **Simulations.** A very useful and powerful aspect of CAD models is the possibility to perform virtual simulations. You can check the performance of a component when loads are applied, the effects of temperature or check the dynamics of fluids and gases among many others.

CAD models are the main technical files used to fabricate prototypes and mass production. With these files, manufacturers can 3D print, design their own tools (also in CAD) and perform analysis to confirm that the product is ready for manufacturing.

Electronics Schematics

This is only relevant if your product has electronic boards on it, commonly known as Printed Circuit Boards Assembly (PCBA). In terms of dimensions and materials, as seen earlier, a 2D drawing of the boards will be used as well.

However, there are specific electronic files that will be produced to illustrate with a diagram the logic of how the electronic components interact with each other to achieve a particular function.

These files are created by an Electronic Engineer and they represent a less visual aspect of the product and instead explain how the product should function. An electronics schematics include the following elements:

- ✓ **Components.** The diagram uses symbols to represent the different electronic components such as resistors, capacitors, switches, transistors or Integrated Circuits among others.
- ✓ **Connections.** The schematics diagram indicates how components are wired together in a circuit by the means of lines and nodes.
- ✓ **Voltage.** It assigns each component to a specific voltage level.

This information will later help to build the physical board by knowing how each component will connect to each other. Also, it will help to define the actual location for each component on the board based on the diagram's logic and taking into account each component's size and other specific rules and regulations that need to be met.

PERFORM DRAWING AND SKETCHES TO WORKPLACE REQUIREMENTS

While most engineers enjoy the process of getting to the first working model, few employers view that as sufficient. Instead, engineers' efforts are useful only when the design has been captured in engineering drawings and supporting engineering data because:

- ✓ Engineering drawings describe how to consistently reproduce the design. Consistent reproduction is essential, since it forms the basis for product improvements and production efficiency.
- ✓ Engineering data proves that the product conforms to the original design goals. Proof of conformance is important to both internal stakeholders (marketing, accounting, production) and external groups (distributors, customers, service providers, regulatory agencies).

But simply creating engineering drawings and recording engineering data is insufficient. To be useful, engineering drawings and engineering data must be stored, reviewed and approved, published and maintained. In other words, engineering drawings and data require engineering document control.

Document control for engineering drawings

Document control for engineering drawings is comprised of both document attributes and a defined control process.

Engineering drawings, including technical documents such as specifications, procedures, will usually have these attributes:

- ✓ Owning organization, which is ultimately responsible for the document content.
- ✓ Document identification through the use of a document numbering system
- ✓ Title or description
- ✓ Document revision or other indication of a specific design iteration
- ✓ Author(s), reviewer(s) and/or others who created the information
- ✓ And, of course, the appropriate technical information necessary to fulfill their purpose

A document control process consists of a set of procedures for creating and maintaining the attributes of engineering drawings. Engineering drawing management processes include business rules that define:

- ✓ Which engineering drawing types are supported, and the contents and format of each type
- ✓ How engineering drawings are identified (e.g., owner, number, revision, title)
- ✓ Who is responsible for creating, reviewing and approving engineering drawings
- ✓ When engineering drawings may be released to interested parties
- ✓ The conditions under which existing engineering drawings are revised, replaced or canceled
- ✓ How obsolete engineering drawings are controlled, recalled or destroyed

Engineering drawings that reflect a consistent set of attributes, and are controlled using a documented set of procedures, significantly reduce product costs by simplifying design, sourcing, production, customer adoption and field service. PDXpert PLM software offers these precise advantages.

Engineering data management policies

In addition to managing the formal engineering drawings, a complete engineering document control system will manage the "background" information that is the basis for the engineering drawings. This engineering data may include a wide variety of electronic files which are saved in a file library (or "vault"):

- ✓ Product capabilities & functional requirements
- ✓ Budget estimates, production volume assumptions, and development schedules
- ✓ Suppliers' component datasheets
- ✓ Product performance tests and qualification results
- ✓ Alternative design data
- ✓ Notes, calculations and other written communications

A complete engineering drawing management environment encourages archiving as much "organizational knowledge" as possible. The ideal system captures all the data that would allow performance analysis, field diagnostics, and incremental design improvements over the entire product life cycle.

UNIT 06

PLAN TO UNDERTAKE A ROUTINE TASK

This unit covers a person planning their own work where tasks involve one or more steps or functions and are carried out routinely on a regular basis. It includes the concepts of following routine instructions, specifications and requirements

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 whereas 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
- ✓ 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):
 - 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 with several examples to provide context
 - Practice the task

- ✓ Identify the critical decision points (what do experts ask themselves when deciding on what learning technique to use):
 - What is the experience level of the learners?
 - 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):
 - Ask learners for their experience level to gain a background.
 - Ask questions that provide clues.
 - 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.
 - Prepare items for shipment.
- ✓ Perform receiving duties:
 - Unload trailers using a forklift.
 - Receive the items into the computer database.

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.

PLAN STEPS REQUIRED TO COMPLETE TASK

Task management plans: the best way to stay organized at work

Getting and staying organized at work is really just a matter of making essential task management mechanisms a part of your work day environment.

In other words, the answer to how to organize tasks at work better is with a plan for accomplishing your goals that incorporates these basic criteria:

- ✓ Time management,
- ✓ Scheduling efficiency,
- ✓ Data consolidation, and
- ✓ Fluid communication

Whether you're working alone or as part of a bigger team project, you're far more likely to meet your deadlines – and help others meet theirs – with a personal task management plan in place.

Team task management plans, meanwhile, are ideal for helping project organizers and managers prioritize, assign, and track shared tasks and outcomes.

The bottom line is that arming yourself with a strategy for breaking large goals into bite-sized objectives will make your tasks easier to manage, measure, execute, and share. And a few fundamental planning components are all it takes to get a strategy like that working for you.

How to organize tasks at work from the foundation up.

Advice on how to manage tasks in the workplace is everywhere. But like most cases of information overload, too much of a good thing can quickly become overwhelming. So we're going to stick with the basics.

Before we move forward, however, it's important to recognize that there's no true one-size-fits-all solution when it comes to task management. In most cases, the specific project in play – and your personal work style – will determine what works and what doesn't.

That said, the best ways to stay organized at work share four basic planning components:

- ✓ They help restructure big picture goals into smaller picture objectives.
- ✓ They break those objectives into individual tasks and subtasks.
- ✓ They lay out start dates, end dates, milestones, and timelines in a way that's easy to see and coordinate.
- ✓ They make use of efficiency and productivity tools.

Both personal and team task management plans can be built using this core foundation. So work through the components below and find out how you can construct a plan that will keep you on top of your daily and project objectives.

1. Rework big goals into small objectives

Restructuring large-scale goals into smaller, more actionable steps is the only way to map out a viable plan for organizing work and measuring progress.

By working with a mix of short-term and long-term objectives, you can:

- ✓ Prioritize and arrange steps that will need to be taken, and
- ✓ See how each action fits into the whole

Let the complexity of your single, overriding goal determine whether you use pen and paper, text documents, spreadsheets, or diagramming software to sketch out a framework for breaking it into multiple mini-objectives.

Then flesh out and schedule or assign those objectives as individual, stepping-stone tasks.

2. Clarify objectives by converting them into a series of tasks

Organizing mini-objectives into tasks and subtasks lets you create a series of daily and weekly to-do's for yourself or team members. One advantage of knowing exactly what needs to get done and when that is you won't feel so overwhelmed by the bigger endgame.

As the breakdown of tasks, subtasks, and timelines grows more complicated, however, it's very possible that a simple "grocery list" of to-do's won't be enough to keep your work organized. So to stay on point, give your process a boost with flowcharts, planning templates, or task management software.

3. Lay out and manage task timelines visually

Managing multiple jobs – whether they're daily, weekly, or group project one-offs – is much less of a burden when you have a crystal-clear view of:

- ✓ the start date and end date for each task, and
- ✓ the various milestones along the way (these often take the form of subtasks)

You can achieve this clarity by using a visual timeline to plot key dates and targets.

Not only does visualizing your plan make it easier to review your own progress, it lets you see the status of shared tasks and amend or update pre-planned steps as needed. Consider using visual planning software and flexible project templates to organize, schedule, and oversee tasks.

4. Take advantage of visual task management tools

There's a very good reason why brightly colored sticky notes are so popular: visual task reminders work. And when you have specific goals to accomplish – and jobs you need to manage and organize – visual tools:

- ✓ Help steer you through the most pressing objectives first,
- ✓ Make it easy to see where you've been and where you're going, and
- ✓ Shine a spotlight on potential roadblocks or bottlenecks so workaround routes can be planned

From online calendars to Gantt charts, visual and interactive task management tools encourage efficiency and promote productivity. They're also your best defense against procrastination at one end of the work duty spectrum – and temptations to multitask at the other.

You've discovered how to manage tasks better – now what?

Now that you have a firm grasp on how to manage tasks for better performance at work, how do you bring these basic components together?

It's not uncommon in our attempts to stay organized to introduce so many scheduling, time management, data, and communication aids into our work environment that they compete with each other for our limited attention.

Having determined that the best way to stay organized at work is with a personal or team task management plan, it should also be clear that the best way to create and implement that plan is with the help of one centralized system.

When you take advantage of a mind mapping platform like MindManager, for example, you can consolidate all your planning components in one place. Pre-built map templates make it easy to visually break goals into tasks, organize tasks into timelines, and keep an eye on the status of each action step – all in one fluid interface.

Whichever task management solution you choose, make sure the plan you create – and the tools you use to bring it to life – function *with* you, not *against* you, to keep you organized at work.

REVIEW PLAN

1. Reviewing your plans helps limit decision fatigue

A well-done plan helps you limit decision fatigue because a plan is a set of pre-made decisions. Thus, it's both a product of the most taxing thing we have to do and it helps us not have to do it all over again.

For instance, planning at broader levels of perspective enables us to not have to do so much decision-work at more narrow levels of perspective. If you set three big goals for the year, you already know that sometime during the quarters to follow, you need to be working towards those goals. You also know that during the months, you need to be working towards those quarterly goals. And so on and so forth, until you know that today's actions are moving you toward those three big goals. (Yes, this is baked right into our Digital Momentum Planner Pack. The Yearly Momentum Planner and Quarterly Momentum Planner that come with the premium set help you work down from the year.)

Many people don't think of it this way, but scheduling appointments is also a planning activity. An appointment at 3pm removes the decision about what you're going to do at 3pm, unless, of course, it's you telling yourself you're going to do something at 3pm. In those cases, most people start the decision process all over again, whereas when it comes to meeting with other people, we don't start the process all over again. Compare "Hey Pam, I know we had a 3pm today, but I decided that I want to do something else right now" to "I have on my calendar that I'm going to work out right now, but I'd rather process email." (Or maybe that's just me.)

We all are presented with too many decisions every day; there's no sense in doing the decision-work to make a plan and not use it.

2. Reviewing your plans helps reveal assumptions that need to be adjusted

Plans rest upon assumptions, whether you articulate those assumptions or not. Not having a plan rests upon many assumptions, with the most prominent one being that you don't need a plan.

For instance, setting a goal of finishing Project X by the end of the month assumes that finishing Project X by the end of the month is possible. Any plan that you make to accomplish that goal rests upon that goal. One way of looking at plans is that they help us make our assumptions true — we generally *are* capable of doing more than we think we can do but just don't focus our resources effectively. Plans help you do that.

When people talk of unrealistic goals and plans, largely what they mean is that the optimist's or deluded's assumptions about the way the world works don't match reality. The entrepreneur who starts a business with the goal of making a million dollars in their first year *usually* hasn't done sufficient research or doesn't have the experience to know that it takes a while to build up a market and production force to do that. There are outliers, of course, and it is *possible*; this goal rests upon a host of assumptions, though, any one of which can make that goal unachievable.

The more your projects involve other people, the more your assumptions are likely to be off. They can be off favorably, too; the right people bringing the right resources can shave months and years off of how long it takes you to do something.

Reviewing your plans, then, allows you to see which assumptions are better than others. The better your assumptions, the more likely you are to achieve your goals.

3. Reviewing your plans helps you proactively problem-solve and coordinate

It happens to the best of us. We assume that we can finish Project A in one day, but it takes two. Unfortunately, we've also assumed that we could start and finish Project B the next day. The miscalculation on Project A starts the project cascade, wherein one project displaces another project, which displaces another project, and so on down the line.

What I've seen most people do when the project cascade starts is just focus on catching up on whatever projects are starting to slip because they assume they'll catch up. A better option is to review your plans to see whom you need to proactively coordinate and communicate with.

If you're looking 15-20 days down the road, you have enough time to pull in additional people to help you finish the project. Or you have enough time to renegotiate some of your other projects so that you *can* double-down on it without losing face. The people you're working with can also adjust their plans to either alter the deadline, help with the project, or add additional resources to it.

In my experience, people are willing to help out if you give them advance notice. It's when you come up with a last-minute situation that frustrations occur. Continually reviewing your plans keeps you out of this last-minute hot water.

4. Reviewing your plans helps you keep momentum on Big Projects

Big Projects — which we call objectives around here — always contain a lot of smaller projects. Objectives can span quarters; rarely do we sustain our motivation that long. It can be challenging to stick with a project that you know isn't going to bear fruit for another three to six months.

Building your body of work is much like building a brick wall. You lay down one brick at a time, but as you're laying down that brick, it doesn't look like you've gotten anywhere. It's tedious and messy, too.

It's only when you take a step back from your work that you can truly appreciate that all those bricks are adding up to something. Yes, having an end in mind is nice and helps speed up your progress *and* I know many people who have built an incredible body of work almost accidentally.

I spent an entire spring building a retaining wall on our first home about six years ago. It was a curved wall on a double slope, so leveling the foundation stones took what seemed like forever for each one and I only had a few hours at a time. Leveling them required lying on the ground to read the level, adjusting a brick or two, reading the level, adjusting a brick or two, and so on. It was tedious and often demotivating to see that I'd spent my afternoon to lay two bricks.

At the end of it, though, we ended up with a bed to plant bushes and roses in. While I'm not in a hurry to do it again, it was worth it when I was done and paid for itself when we sold that home.

Reviewing your plans helps you see that the sum of each brick laid is greater than the brick itself.

5. Reviewing your plans ultimately helps you save time

The items listed above help you save time on their own, but the more you review your plans, the better you get at making plans that work. Whereas most people think effectiveness comes from world-mastery, the truth is that it comes from self-mastery. Systematically reviewing your plans helps you dial in your strengths and weaknesses such that you leverage your strengths and mitigate your weaknesses.

Successful people don't just know that they can accomplish something; they also know *why* they'll be able to accomplish it. Sometimes this is just an unconscious knowing, but what I've found is that the most successful people are the ones who intentionally sculpt their environments and conditions to favor their success. They don't just play the current set of games available — they create new ones that favor them.

Doing this requires you to know what works for you and what doesn't. Continually comparing your plans against your results sets up a continuous feedback loop that, done right, is the precursor to an upward spiral of success.

Why You're Not Reviewing Your Plans?

Over the years that I've been having conversations about planning and accomplishment, people have given me a few reasons why they're not reviewing their plans:

1. They don't have a plan to start with
2. They don't understand the value of doing so
3. They forget they've made the plan
4. They lose the plans they've made
5. They don't have time to do so

I'll be addressing each of these in future posts since, obviously, there's a lot to cover judging by the length of this post. I started here because it was easier to finish and it gives the "Why" of reviewing plans at the same time that it helps me address why your plans aren't working. Also, if you know something's valuable, you're less likely to forget it or lose it.

I'll address the time piece briefly now: if you don't have time to review your plan, you don't have time to *not* review your plan. If you don't have time to make a plan, you don't have time to *not* make a plan.

To be clear, plans can be fleshed out to different degrees of specificity. Simple goals and strategies can have simple plans; complex goals and strategies often need detailed plans.

While the planning process is itself more important than the plans that come from the process, it's also true that reviewing a well-made plan can enhance your success. Dust off those plans, adjust them, and move forward more intelligently!

UNIT 07

APPLY SCIENCE FOR WATER OPERATIONS

This unit of competency covers the ability to relate fundamental laws of science with routine tasks and work environment

APPLY PRINCIPALS AND THEORIES OF PHYSICS IN REAL WORLD

Scalars & vectors

Scalars: Scalars are mathematical entities which have only a magnitude- (and no direction). Physical examples include mass and energy.

Vectors: Vectors are mathematical entities which have both a magnitude and a direction. Note that the location of the vector (for example, on which point a specific vector force is acting, or where a car with a given vector velocity is located) is not part of the vector itself. Physical examples include forces, velocities, momenta and locations. Note that as we show below, not all entities having a magnitude and direction are necessarily vectors (as is elaborated below).

We can also define the following:

Scalar functions: The scalar function (aka a scalar field) is a function which returns a scalar at each location of space. Examples include the pressure field (i.e., the pressure at each point in your room), the energy density in an electric field, etc.

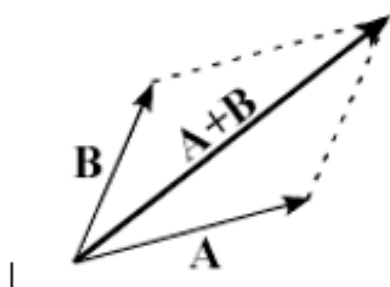
Vector functions: The vector function (aka a vector field) is a function which returns a vector at each location of space. Examples include the gravitational field (at each location we have a different vector defining the local acceleration of gravity), the electric field, the velocity field of a flow (e.g., the speed of the water in your bathtub, which depends on its location relative to the sinkhole, etc.)

Notation:

- **Scalar:** Plain (or often italicized) letters: a, k , etc.
- **Vectors:** Either bold letters: \mathbf{x}, \mathbf{v} (often used in books), or a small vector sign: \vec{x} , or a small underline: \underline{x} . The latter two are the two standard handwritten notation (how does one write bold letters with a pencil?). Some prefer the small arrow mark, while others prefer the underline. Do whatever you like, but be consistent!
- **Magnitude of a vector:** $A \equiv |\mathbf{A}|$.
- **Unit vector in the direction of \mathbf{A}** (a vector which has a unit magnitude and the direction of \mathbf{A}): $\hat{\mathbf{A}}$. Clearly, one has that $|\hat{\mathbf{A}}| = 1$ and $\mathbf{A} = \hat{\mathbf{A}} |\mathbf{A}|$.
- **Position vector** (aka radius vector or location vector): The vector \mathbf{r} is the vector connecting the origin (usually denoted as O) to the location P of a given point.

Vector addition:

The sum of two vectors is defined as the diagonal of the parallelogram formed when the two vectors **A** and **B** are placed at the same point, as is described in the diagram. Evidently, we see that the addition is commutative, that is, the order is not important: $\mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}$.



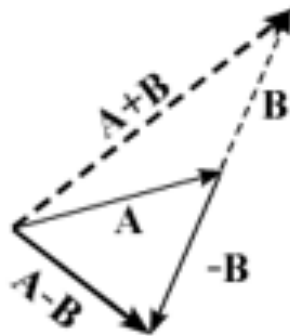
The negative of a vector:

The vector $-\mathbf{A}$ is defined to be the same as vector **A**, but with the opposite direction. Thus, when we add a vector and its negative we obtained that $\mathbf{A} + (-\mathbf{A}) = \mathbf{0}$, as evident from the diagram.



Vector subtraction:

Vector subtraction $\mathbf{A} - \mathbf{B}$ is defined as: $\mathbf{A} + (-\mathbf{B})$, that is, adding the negative of the subtracted vector \mathbf{B} , as is apparent in the figure.



Vector distributivity:

The graphical definition of vector addition also implies a very important characteristic: Vector addition is distributive, that is $\mathbf{A} + (\mathbf{B} + \mathbf{C}) =$

$(\mathbf{A} + \mathbf{B}) + \mathbf{C}$. In other words, when we add three vectors, it does not matter whether we add the first pair first, or the second pair first. This is demonstrated in the following figure.



Multiplication by a scalar:

Multiplying a vector by a scalar gives a new vector with the same direction but with a magnitude which is multiplied by the scalar. A negative scalar would yield a vector in the opposite direction as the original vector. For example: $(-1)\mathbf{A} = -\mathbf{A}$.



Examples of Vectors:

The following are examples of vectors, that is, entities which have both a magnitude and a direction, and which can be added following the parallelogram rule:

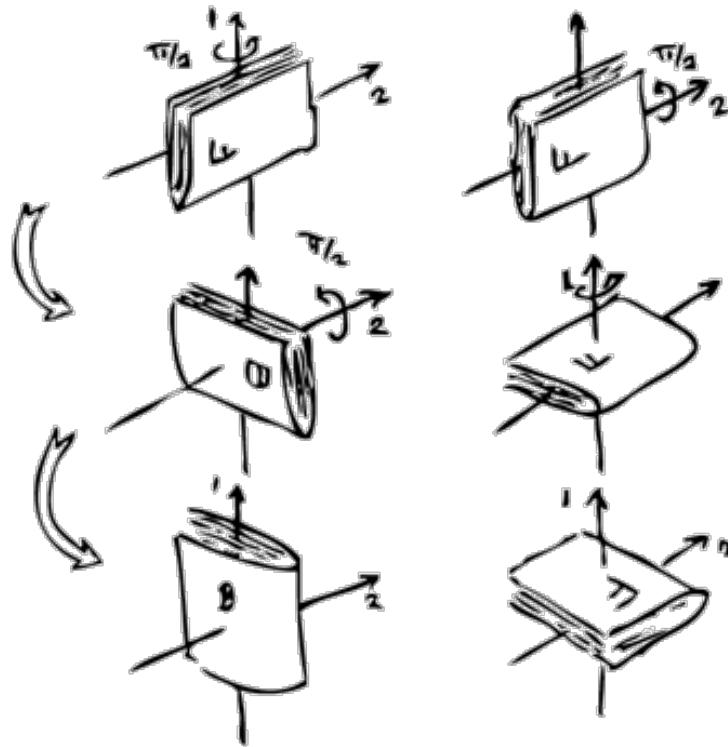
1. Displacement vector (e.g., by how much a certain object moved) - the total displacement of an object satisfies the parallelogram definition of addition. If you first walk 1 mile east and then 1 mile north, you will end up at the same point as you would if you would first walk 1 mile north and then 1 mile east (assuming of course a flat earth!).
2. Forces are vectors (e.g., opposite forces cancel each other, two perpendicular forces add up to a force $\sqrt{2}$ larger and so forth).

Examples of non-vectors:

Just as a precaution, it is worth noting that not every mathematical entity which has a magnitude and a direction is necessarily a vector. Two interesting examples include:

- ✓ The polarization of light - As first glance, one may think that the polarization of light can be described by a vector, that is, a direction and a magnitude. However, this is not the case. Polarization (and therefore polarizers) have the characteristic that if you rotate them by 180° , they return to their original state (have you ever tried rotating polarizer sunglasses by 90° and 180° ? If you didn't look for such glasses and try it). This is in contrast to vectors which become their negative when rotated by 180° , and it is only after a 360° rotation that they return to their original state. Hence, polarization cannot be described by a vector (for the curious: you actually can, though not in real space but in the Poincaré sphere instead. More about it here).
- ✓ Finite angle rotations - Rotations are another example of a mathematical entity which seems to be describable as a vector. The direction is the axis of the rotation while the magnitude is the angle of rotation. However, it turns out (literally) that rotations are not commutative. That is, if you rotate by one rotation, and then by another, you do

not end up in the same state as you would if you interchanged the order of the rotations. This is evident from the drawing below.



Rotations are not commutative and therefore cannot be described by vectors: Rotating around axis 1 by $\pi/2$ (i.e., 90°) and then around axis 2, is not the same as the net rotation obtained when first rotating around axis 2 and then around axis 1.

Kinetics

Distance and Displacement

Distance and displacement are two quantities that may seem to mean the same thing yet have distinctly different definitions and meanings.

Distance is a scalar quantity that refers to "how much ground an object has covered" during its motion.

Displacement is a vector quantity that refers to "how far out of place an object is"; it is the object's overall change in position.

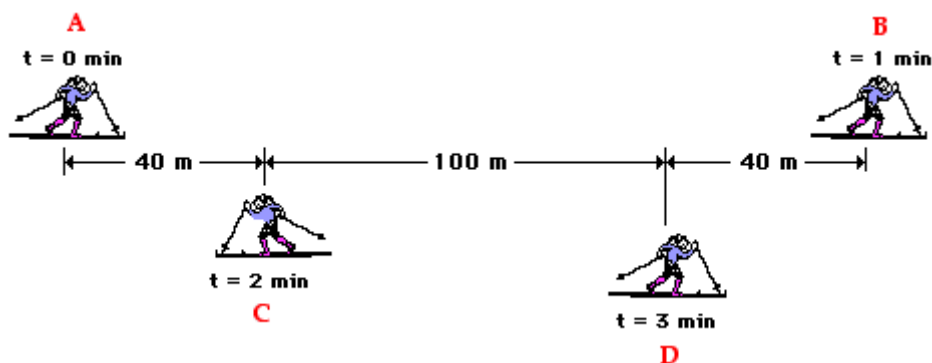
To test your understanding of this distinction, consider the motion depicted in the diagram below. A physics teacher walks 4 meters east, 2 meters south, 4 meters west, and finally 2 meters north.



Even though the physics teacher has walked a total distance of 12 meters, her displacement is 0 meters. During the course of her motion, she has "covered 12 meters of ground" (distance = 12 m). Yet when she is finished walking, she is not "out of place" - i.e., there is no displacement for her motion (displacement = 0 m). Displacement, being a vector quantity, must give attention to direction. The 4 meters east cancels the 4 meters west; and the 2 meters south cancels the 2 meters north. Vector quantities such as displacement are direction aware. Scalar quantities such as distance are ignorant of direction. In determining the overall distance traveled by the physics teachers, the various directions of motion can be ignored.

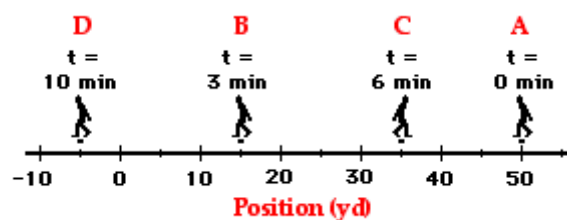
Now consider another example. The diagram below shows the position of a cross-country skier at various times. At each of the indicated times, the skier turns around and reverses the direction of travel. In other words, the skier moves from A to B to C to D.

Use the diagram to determine the resulting displacement and the distance traveled by the skier during these three minutes. Then click the button to see the answer.



As a final example, consider a football coach pacing back and forth along the sidelines. The diagram below shows several of coach's positions at various times. At each marked position, the coach makes a "U-turn" and moves in the opposite direction. In other words, the coach moves from position A to B to C to D.

What is the coach's resulting displacement and distance of travel? Click the button to see the answer.



To understand the distinction between distance and displacement, you must know the definitions. You must also know that a vector quantity such as displacement is *direction-aware* and a scalar quantity such as distance is *ignorant of direction*. When an object changes its direction of motion, displacement takes this direction change into account; heading the opposite direction effectively begins to *cancel* whatever displacement there once was.

Circular motion

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

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

where R represents radius
T represents period

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

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

where v represents speed
R represents radius
T represents period

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

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

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

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

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

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

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

Equations as a Guide to Thinking

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

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

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


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

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

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

This equation shows that the net force required for an object to move in a circle is directly proportional to the square of the speed of the object. For a constant mass and radius, the F_{net} is proportional to the **speed²**.

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



for a constant mass (m)
and constant radius (R)

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

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

Laws of forces

The Meaning of Force

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

Contact versus Action-at-a-Distance Forces

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

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

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

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

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

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

The Newton

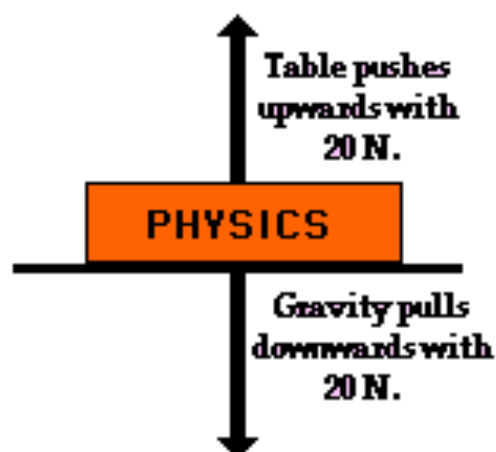
Force is a quantity that is measured using the standard metric unit known as the Newton. A Newton is abbreviated by an "N." To say "10.0 N" means 10.0 Newton of force. One Newton is the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Thus, the following unit equivalency can be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

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

Force is a Vector Quantity

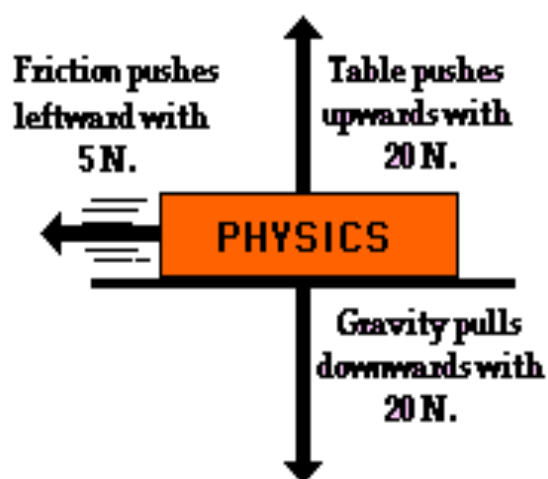
A force is a vector quantity. As learned in an earlier unit, a vector quantity is a quantity that has both magnitude and direction. To fully describe the force acting upon an object, you must describe both the magnitude (size or numerical value) and the direction. Thus, 10 Newton is not a full description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

Because a force is a vector that has a direction, it is common to represent forces using diagrams in which a force is represented by an arrow. Such vector diagrams were introduced in an earlier unit and are used throughout the study of physics. The size of the



arrow is reflective of the magnitude of the force and the direction of the arrow reveals the direction that the force is acting. (Such diagrams are known as free-body diagrams and are discussed later in this lesson.) Furthermore, because forces are vectors, the effect of an individual force upon an object is often canceled by the effect of another force. For example, the effect of a 20-Newton upward force acting upon a book is *canceled* by the effect of a 20-Newton downward force acting upon the book. In such instances, it is said that the two individual forces *balance each other*; there would be no unbalanced force acting upon the book.

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



Types of Forces

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

Type of Force (and Symbol)	Description of Force
Applied Force F_{app}	An applied force is a force that is applied to an object by a person or another object. If a person is pushing a desk across the room, then there is an applied force acting upon the object. The applied force is the force exerted on the desk by the person.
Gravity Force (also known as Weight) F_{grav}	the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object. All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: $F_{\text{grav}} = m * g$ where $g = 9.8 \text{ N/kg}$ (on Earth) and $m = \text{mass (in kg)}$
Normal Force F_{norm}	The normal force is the support force exerted upon an object that is in contact with another stable object. For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book. On occasions, a normal force is exerted horizontally between two objects that are in contact with each other. For instance, if a person leans against a wall, the wall pushes horizontally on the person.
Friction Force F_{frict}	The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - sliding and static friction. Though it is not always the case, the friction force often opposes the motion of an object. For

	<p>example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula below:</p> $F_{\text{frict}} = \mu \cdot F_{\text{norm}}$
<p>Air Resistance Force</p> F_{air}	<p>The air resistance is a special type of frictional force that acts upon objects as they travel through the air. The force of air resistance is often observed to oppose the motion of an object. This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value). It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas.</p>
<p>Tension Force</p> F_{tens}	<p>The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.</p>
<p>Spring Force</p> F_{spring}	<p>The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it. An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position. For most springs (specifically, for those that are said to obey "<u>Hooke's Law</u>"), the magnitude of the force is directly proportional to the amount of stretch or compression of the spring.</p>

Confusion of Mass and Weight

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

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

Sliding versus Static Friction

As mentioned above, the friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. For the purpose of our study of physics at The Physics Classroom, there are two types of friction force - static friction and sliding friction. Sliding friction results when an object slides across a surface. As an example, consider pushing a box across a floor. The floor surface offers resistance to the movement of the box. We often say that the floor exerts a friction force upon the box. This is an example of a sliding friction force since it results from the sliding motion of the box. If a car slams on its brakes and skids to a stop (without antilock brakes), there is a sliding friction force exerted upon the car tires by the roadway surface. This friction force is also a sliding friction force because the car is sliding across the road surface. Sliding friction forces can be calculated from knowledge of the coefficient of friction and the normal force exerted upon the object by the surface it is sliding across. The formula is:

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

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

of the relative amount of adhesion or attraction of the two surfaces for each other. The more that surface molecules tend to adhere to each other, the greater the coefficient values and the greater the friction force.

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

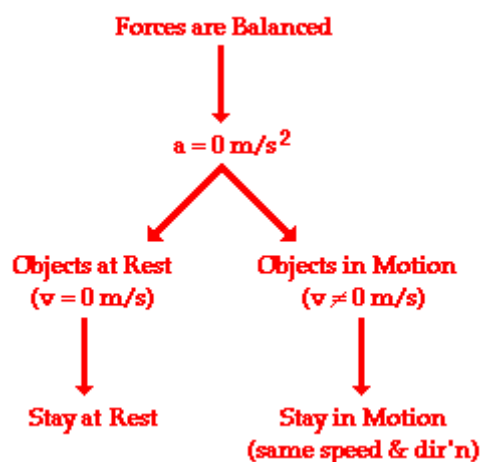
$$F_{\text{frict-static}} \leq \mu_{\text{frict-static}} \cdot F_{\text{norm}}$$

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

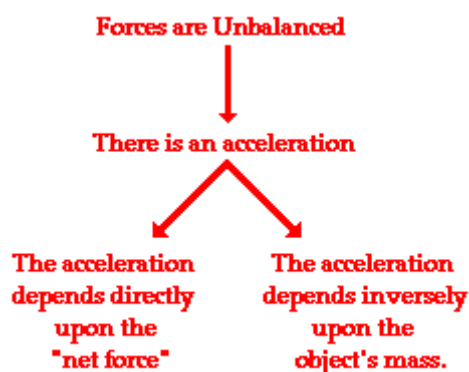
The meaning of each of these forces listed in the table above will have to be thoroughly understood to be successful during this unit. Ultimately, you must be able to read a verbal description of a physical situation and know enough about these forces to recognize their presence (or absence) and to construct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

Newton's Second Law

Newton's first law of motion predicts the behavior of objects for which all existing forces are balanced. The first law - sometimes referred to as the law of inertia - states that if the forces acting upon an object are balanced, then the acceleration of that object will be 0 m/s^2 . Objects at **equilibrium** (the condition in which all forces balance) will not accelerate. According to Newton, an object will only accelerate if there is a net or unbalanced force acting upon it. The presence of an unbalanced force will accelerate an object - changing its speed, its direction, or both its speed and direction.



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



The BIG Equation

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

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

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

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

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

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

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

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

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

Acceleration

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

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

Newton's Third Law

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

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

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

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on

the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Examples of Interaction Force Pairs

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

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

Conservation of energy

Energy is required for the evolution of life forms on earth. In physics, it is defined as the capacity to do work. We know that energy exists in different forms in nature. You have learned about various forms of energy – heat, electrical, chemical, nuclear, etc. In this section, we will learn about the laws and principles that govern energy. This law is known as the law of conservation of energy.

What is the Law of Conservation of Energy?

The law of conservation of energy states that ***energy can neither be created nor be destroyed. Although, it may be transformed from one form to another.*** If you take all forms of energy into account, the total energy of an isolated system always remains constant. All the forms of energy follow the law of conservation of energy. In brief, the law of conservation of energy states that

In a closed system, i.e., a system that is isolated from its surroundings, the total energy of the system is conserved.

So in an isolated system such as the universe, if there is a loss of energy in some part of it, there must be a gain of an equal amount of energy in some other part of the universe. Although this principle cannot be proved, there is no known example of a violation of the law of conservation of energy.

The amount of energy in any system is determined by the following equation:

$$U_T = U_i + W + Q$$

- ✓ U_T is the total energy of a system
- ✓ U_i is the initial energy of a system
- ✓ Q is the heat added or removed from the system
- ✓ W is the work done by or on the system

The change in the internal energy of the system is determined using the equation

$$\Delta U = W + Q$$

Law of Conservation of Energy Examples:

In Physics, most of the inventions rely on the fact that energy is conserved when it is transferred from one form to another. A number of electrical and mechanical devices operate solely on the law of conservation of energy. We will discuss a few examples here.

- ✓ In a torch, the chemical energy of the batteries is converted into electrical energy, which is converted into light and heat energy.
- ✓ In hydroelectric power plants, waterfalls on the turbines from a height. This, in turn, rotates the turbines and generates electricity. Hence, the potential energy of water is converted into the kinetic energy of the turbine, which is further converted into electrical energy.
- ✓ In a loudspeaker, electrical energy is converted into sound energy.
- ✓ In a microphone, sound energy is converted into electrical energy.
- ✓ In a generator, mechanical energy is converted into electrical energy.
- ✓ When fuels are burnt, chemical energy is converted into heat and light energy.
- ✓ Chemical energy from food is converted to thermal energy when it is broken down in the body and is used to keep it warm.

Momentum & impulse

Momentum can be defined as "mass in motion." All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion. The amount of momentum that an object has is dependent upon two variables: how much *stuff* is moving and how fast the *stuff* is moving. Momentum depends upon the variables mass and velocity. In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object.

$$\text{Momentum} = \text{mass} \bullet \text{velocity}$$

In physics, the symbol for the quantity momentum is the lower case **p**. Thus, the above equation can be rewritten as

$$p = m \bullet v$$

where **m** is the mass and **v** is the velocity. The equation illustrates that momentum is directly proportional to an object's mass and directly proportional to the object's velocity.

The units for momentum would be mass units times velocity units. The standard metric unit of momentum is the kg•m/s. While the kg•m/s is the standard metric unit of momentum, there are a variety of other units that are acceptable (though not conventional) units of momentum. Examples include kg•mi/hr, kg•km/hr, and g•cm/s. In each of these examples, a mass unit is multiplied by a velocity unit to provide a momentum unit. This is consistent with the equation for momentum.

Impulse

These concepts are merely an outgrowth of Newton's second law as discussed in an earlier unit. Newton's second law ($F_{\text{net}} = m \cdot a$) stated that the acceleration of an object is directly proportional to the net force acting upon the object and inversely proportional to the mass of the object. When combined with the definition of acceleration ($a = \text{change in velocity} / \text{time}$), the following equalities result.

$$F = m \cdot a$$

or

$$F = m \cdot \Delta v / t$$

If both sides of the above equation are multiplied by the quantity t , a new equation results.

$$F \cdot t = m \cdot \Delta v$$

This equation represents one of two primary principles to be used in the analysis of collisions during this unit. To truly understand the equation, it is important to understand its meaning in words. In words, it could be said that the force times the time equals the mass times the change in velocity. In physics, the quantity Force • time is known as **impulse**. And since the quantity $m \cdot v$ is the momentum, the quantity $m \cdot \Delta v$ must be the **change in momentum**. The equation really says that the

$$\text{Impulse} = \text{Change in momentum}$$

One focus of this unit is to understand the physics of collisions. The physics of collisions are governed by the laws of momentum; and the first law that we discuss in this unit is expressed in the above equation. The equation is known as the **impulse-momentum change equation**. The law can be expressed this way:

In a collision, an object experiences a force for a specific amount of time that results in a change in momentum. The result of the force acting for the given amount of time is that the object's mass either speeds up or slows down (or changes direction).

The impulse experienced by the object equals the change in momentum of the object. In equation form, $F \cdot t = m \cdot \Delta v$.

Waves

A wave can be described as a disturbance that travels through a medium from one location to another location. Consider a slinky wave as an example of a wave. When the slinky is stretched from end to end and is held at rest, it assumes a natural position known as the **equilibrium or rest position**. The coils of the slinky naturally assume this position, spaced equally far apart. To introduce a wave into the slinky, the first particle is displaced or moved from its equilibrium or rest position. The particle might be moved upwards or downwards, forwards or backwards; but once moved, it is returned to its original equilibrium or rest position. The act of moving the first coil of the slinky in a given direction and then returning it to its equilibrium position creates a **disturbance** in the slinky. We can then observe this disturbance moving through the slinky from one end to the other. If the first coil of the slinky is given a single back-and-forth vibration, then we call the observed motion of the disturbance through the slinky a *slinky pulse*. A **pulse** is a single disturbance moving through a medium from one location to another location. However, if the first coil of the slinky is continuously and periodically vibrated in a back-and-forth manner, we would observe a repeating disturbance moving within the slinky that endures over some prolonged period of time. The repeating and periodic disturbance that moves through a medium from one location to another is referred to as a **wave**.

A Wave Transports Energy and Not Matter

When a wave is present in a medium (that is, when there is a disturbance moving through a medium), the individual particles of the medium are only temporarily displaced from their rest position. There is always a force acting upon the particles that restores them to their original position. In a slinky wave, each coil of the slinky ultimately returns to its original position. In a water wave, each molecule of the water ultimately returns to its original position. And in a stadium wave, each fan in the bleacher ultimately returns to its original position. It is for this reason, that a wave is said to involve the movement of a disturbance without the movement of matter. The particles of the medium (water molecules, slinky coils, stadium fans) simply vibrate about a fixed position as the pattern of the disturbance moves from one location to another location.

Waves are said to be an **energy transport phenomenon**. As a disturbance moves through a medium from one particle to its adjacent particle, energy is being transported from one end of the medium to the other. In a slinky wave, a person imparts energy to the first coil by doing work upon it. The first coil receives a large amount of energy that it subsequently transfers to the second coil. When the first coil returns to its original position, it possesses the same amount of energy as it had before it was displaced. The first coil transferred its energy to the second coil. The second coil then has a large amount of energy that it subsequently transfers to the third coil. When the second coil returns to its original position, it possesses the same amount of energy as it had before it was displaced. The third coil has received the energy of the second coil. This process of energy transfer continues as each coil interacts with its neighbor. In this manner, energy is transported from one end of the slinky to the other, from its source to another location.

Categories of Waves

Waves come in many shapes and forms. While all waves share some basic characteristic properties and behaviors, some waves can be distinguished from others based on some observable (and some non-observable) characteristics. It is common to categorize waves based on these distinguishing characteristics.

Longitudinal versus Transverse Waves versus Surface Waves

One way to categorize waves is on the basis of the direction of movement of the individual particles of the medium relative to the direction that the waves travel. Categorizing waves on this basis leads to three notable categories: transverse waves, longitudinal waves, and surface waves.

A **transverse wave** is a wave in which particles of the medium move in a direction perpendicular to the direction that the wave moves. Suppose that a slinky is stretched out in a horizontal direction across the classroom and that a pulse is introduced into the slinky on the left end by vibrating the first coil up and down. Energy will begin to be transported through the slinky from left to right. As the energy is transported from left to right, the individual coils of the medium will be displaced upwards and downwards. In this case, the particles of the medium move perpendicular to the direction that the pulse moves. This type of wave is a transverse wave. Transverse waves are always characterized by particle motion being perpendicular to wave motion.

A **longitudinal wave** is a wave in which particles of the medium move in a direction parallel to the direction that the wave moves. Suppose that a slinky is stretched out in a horizontal direction across the classroom and that a pulse is introduced into the slinky on the left end by vibrating the first coil left and right. Energy will begin to be transported through the slinky from left to right. As the energy is transported from left to right, the individual coils of the medium will be displaced leftwards and rightwards. In this case, the particles of the medium move parallel to the direction that the pulse moves. This type of wave is a longitudinal wave. Longitudinal waves are always characterized by particle motion being parallel to wave motion.

A sound wave traveling through air is a classic example of a longitudinal wave. As a sound wave moves from the lips of a speaker to the ear of a listener, particles of air vibrate back and forth in the same direction and the opposite direction of energy transport. Each individual particle pushes on its neighboring particle so as to push it forward. The *collision* of particle #1 with its neighbor serves to restore particle #1 to its original position and displace particle #2 in a forward direction. This back and forth motion of particles in the direction of energy transport creates regions within the medium where the particles are pressed together and other regions where the particles are spread apart. Longitudinal waves can always be quickly identified by the presence of such regions. This process continues along the *chain* of particles until the sound wave reaches the ear of the listener.

While waves that travel within the depths of the ocean are longitudinal waves, the waves that travel along the surface of the oceans are referred to as surface waves. A **surface**

wave is a wave in which particles of the medium undergo a circular motion. Surface waves are neither longitudinal nor transverse. In longitudinal and transverse waves, all the particles in the entire bulk of the medium move in a parallel and a perpendicular direction (respectively) relative to the direction of energy transport. In a surface wave, it is only the particles at the surface of the medium that undergo the circular motion. The motion of particles tends to decrease as one proceeds further from the surface.

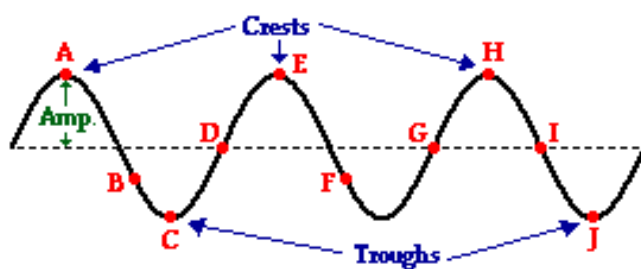
Electromagnetic versus Mechanical Waves

An **electromagnetic wave** is a wave that is capable of transmitting its energy through a vacuum (i.e., empty space). Electromagnetic waves are produced by the vibration of charged particles. Electromagnetic waves that are produced on the sun subsequently travel to Earth through the vacuum of outer space. Were it not for the ability of electromagnetic waves to travel through a vacuum, there would undoubtedly be no life on Earth. All light waves are examples of electromagnetic waves.

A **mechanical wave** is a wave that is not capable of transmitting its energy through a vacuum. Mechanical waves require a medium in order to transport their energy from one location to another. A sound wave is an example of a mechanical wave. Sound waves are incapable of traveling through a vacuum. Slinky waves, water waves, stadium waves, and jump rope waves are other examples of mechanical waves; each requires some medium in order to exist. A slinky wave requires the coils of the slinky; a water wave requires water; a stadium wave requires fans in a stadium; and a jump rope wave requires a jump rope.

The Anatomy of a Wave

A transverse wave is a wave in which the particles of the medium are displaced in a direction perpendicular to the direction of energy transport. A transverse wave can be created in a rope if the rope is stretched out horizontally and the end is vibrated back-and-forth in a vertical direction. If a snapshot of such a transverse wave could be taken so as to *freeze* the shape of the rope in time, then it would look like the following diagram.



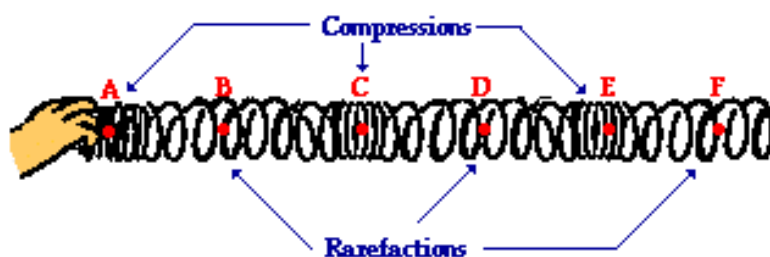
The dashed line drawn through the center of the diagram represents the equilibrium or rest position of the string. This is the position that the string would assume if there were no disturbance moving through it. Once a disturbance is introduced into the string, the particles of the string begin to vibrate upwards and downwards. At any given moment in time, a particle on the medium could be above or below the rest position. Points A, E and H on the diagram represent the crests of this wave. The **crest** of a wave is the point on the medium that exhibits the maximum amount of positive or upward displacement from the rest position. Points C and J on the diagram represent the troughs of this wave. The **trough** of a

wave is the point on the medium that exhibits the maximum amount of negative or downward displacement from the rest position.

The wave shown above can be described by a variety of properties. One such property is amplitude. The **amplitude** of a wave refers to the maximum amount of displacement of a particle on the medium from its rest position. In a sense, the amplitude is the distance *from rest to crest*. Similarly, the amplitude can be measured from the rest position to the trough position. In the diagram above, the amplitude could be measured as the distance of a line segment that is perpendicular to the rest position and extends vertically upward from the rest position to point A.

The wavelength is another property of a wave that is portrayed in the diagram above. The **wavelength** of a wave is simply the length of one complete wave cycle. If you were to trace your finger across the wave in the diagram above, you would notice that your finger repeats its path. A wave is a repeating pattern. It repeats itself in a periodic and regular fashion over both time and space. And the length of one such spatial repetition (known as a *wave cycle*) is the wavelength. The wavelength can be measured as the distance from crest to crest or from trough to trough. In fact, the wavelength of a wave can be measured as the distance from a point on a wave to the corresponding point on the next cycle of the wave. In the diagram above, the wavelength is the horizontal distance from A to E, or the horizontal distance from B to F, or the horizontal distance from D to G, or the horizontal distance from E to H. Any one of these distance measurements would suffice in determining the wavelength of this wave.

A longitudinal wave is a wave in which the particles of the medium are displaced in a direction parallel to the direction of energy transport. A longitudinal wave can be created in a slinky if the slinky is stretched out horizontally and the end coil is vibrated back-and-forth in a horizontal direction. If a snapshot of such a longitudinal wave could be taken so as to *freeze* the shape of the slinky in time, then it would look like the following diagram.



Because the coils of the slinky are vibrating longitudinally, there are regions where they become pressed together and other regions where they are spread apart. A region where the coils are pressed together in a small amount of space is known as a compression. A **compression** is a point on a medium through which a longitudinal wave is traveling that has the maximum density. A region where the coils are spread apart, thus maximizing the distance between coils, is known as a rarefaction. A **rarefaction** is a point on a medium through which a longitudinal wave is traveling that has the minimum density. Points A, C and E on the diagram above represent compressions and points B, D, and F represent rarefactions. While a transverse wave has an alternating pattern of crests and troughs, a longitudinal wave has an alternating pattern of compressions and rarefactions.

As discussed above, the wavelength of a wave is the length of one complete cycle of a wave. For a transverse wave, the wavelength is determined by measuring from crest to crest. A longitudinal wave does not have crest; so how can its wavelength be determined? The wavelength can always be determined by measuring the distance between any two corresponding points on adjacent waves. In the case of a longitudinal wave, a wavelength measurement is made by measuring the distance from a compression to the next compression or from a rarefaction to the next rarefaction. On the diagram above, the distance from point A to point C or from point B to point D would be representative of the wavelength.

Frequency

The **frequency** of a wave refers to how often the particles of the medium vibrate when a wave passes through the medium. Frequency is a part of our common, everyday language. For example, it is not uncommon to hear a question like "How *frequently* do you mow the lawn during the summer months?" Of course the question is an inquiry about *how often* the lawn is mowed and the answer is usually given in the form of "1 time per week." In mathematical terms, the frequency is the number of complete vibrational cycles of a medium per a given amount of time. Given this definition, it is reasonable that the quantity *frequency* would have units of cycles/second, waves/second, vibrations/second, or something/second. Another unit for frequency is the **Hertz** (abbreviated Hz) where 1 Hz is equivalent to 1 cycle/second. If a coil of slinky makes 2 vibrational cycles in one second, then the frequency is 2 Hz. If a coil of slinky makes 3 vibrational cycles in one second, then the frequency is 3 Hz. And if a coil makes 8 vibrational cycles in 4 seconds, then the frequency is 2 Hz ($8 \text{ cycles} / 4 \text{ s} = 2 \text{ cycles/s}$).

The quantity frequency is often confused with the quantity period. Period refers to the time that it takes to do something. When an event occurs repeatedly, then we say that the event is **periodic** and refer to the time for the event to repeat itself as the period. The **period** of a wave is the time for a particle on a medium to make one complete vibrational cycle. Period, being a time, is measured in units of time such as seconds, hours, days or years. The period of orbit for the Earth around the Sun is approximately 365 days; it takes 365 days for the Earth to complete a cycle. The period of a typical class at a high school might be 55 minutes; every 55 minutes a class cycle begins (50 minutes for class and 5 minutes for passing time means that a class begins every 55 minutes). The period for the minute hand on a clock is 3600 seconds (60 minutes); it takes the minute hand 3600 seconds to complete one cycle around the clock.

$$\text{period} = \frac{1}{\text{frequency}} \qquad \text{frequency} = \frac{1}{\text{period}}$$

The speed of an object refers to how fast an object is moving and is usually expressed as the distance traveled per time of travel. For a wave, the speed is the distance traveled by a given point on the wave (such as a crest) in a given period of time. So while wave frequency refers to the number of cycles occurring per second, wave speed refers to the meters traveled per second. A wave can vibrate back and forth very frequently, yet have a small speed; and a wave can vibrate back and forth with a low frequency, yet have a high speed.

The Speed of a Wave

A wave is a disturbance that moves along a medium from one end to the other. If one watches an ocean wave moving along the medium (the ocean water), one can observe that the crest of the wave is moving from one location to another over a given interval of time. The crest is observed to *cover* distance. The speed of an object refers to how fast an object is moving and is usually expressed as the distance traveled per time of travel. In the case of a wave, the speed is the distance traveled by a given point on the wave (such as a crest) in a given interval of time. In equation form,

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

If the crest of an ocean wave moves a distance of 20 meters in 10 seconds, then the speed of the ocean wave is 2.0 m/s. On the other hand, if the crest of an ocean wave moves a distance of 25 meters in 10 seconds (the same amount of time), then the speed of this ocean wave is 2.5 m/s. The faster wave travels a greater distance in the same amount of time.

APPLY PRINCIPALS AND THEORIES OF CHEMISTRY IN REAL WORLD EXAMPLES

States of Matter

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

Note that particles in a:

- ✓ gas are well separated with no regular arrangement.
- ✓ liquid are close together with no regular arrangement.
- ✓ solid are tightly packed, usually in a regular pattern.
- ✓ Particles in a:
 - ✓ gas vibrate and move freely at high speeds.
 - ✓ liquid vibrate, move about, and slide past each other.
 - ✓ solid vibrate (jiggle) but generally do not move from place to place.

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

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

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

Pure Substances

Pure substances are substances that are made up of ***only one kind of particles*** and has a fixed or constant structure.

Pure substances are further classified as elements and compounds.

An element is a substance that consists of only one type or kind of atom. An element is a pure substance as it cannot be broken down or transformed into a new substance even by using some physical or chemical means. Elements are mostly metals, non-metals or metalloids.

Compounds, on the other hand, are also pure substances when two or more elements are combined chemically in a fixed ratio. However, these substances can be broken down into separate elements by chemical methods.

Characteristics and Properties Of Pure Substances

- ✓ Pure substances are mostly homogeneous in nature containing only one type of atoms or molecules.
- ✓ These substances mainly have a constant or uniform composition throughout.
- ✓ The substances have fixed boiling and melting points.
- ✓ A pure substance usually participates in a chemical reaction to form predictable products.

Examples of Pure Substances

All elements are mostly pure substances. A few of them include gold, copper, oxygen, chlorine, diamond, etc. Compounds such as water, salt or crystals, baking soda amongst others are also grouped as pure substances.

Mixtures

A substance, on the other hand, is impure if it consists of different kinds of elements combined together physically and not chemically. Impure substances are also called mixtures. Mixtures are further divided into a homogenous or heterogeneous mixture.

- ✓ A homogeneous mixture occasionally called a solution, is comparatively unvarying in configuration or constant. Every unit of the mixture is like every other unit. For instance, if you liquefy sugar in water and blend it really well, your concoction is essentially the same, no matter where you sample it. This mixture contains two or more chemical substances.
- ✓ A heterogeneous mixture is a concoction whose configuration varies from spot to spot within the sample. For example, if you put a little amount of sugar in a vessel, add some sand, and then shake the jar a couple of times, your concoction doesn't have the same configuration all throughout the jar. As the sand is heavier, there's possibly more amount of sand at the bottom of the jar and more sugar at the top part. These mixtures can be identified visually and separated easily by physical means.

Characteristics And Properties Of Mixtures Or Impure Substance

- ✓ It does not have any specific properties, the properties of the mixture are a result of the average properties of all the constituents.
- ✓ It is formed as a result of a physical change.
- ✓ They have a variable composition.
- ✓ Their melting and boiling points differ.

Example Of Mixtures

- ✓ Some common examples of mixtures include;
- ✓ Gas and gas like nitrogen and oxygen in the atmosphere.
- ✓ A solution like water and oil.
- ✓ Gas and liquid such as water.
- ✓ Solid and liquid such as sand and water

Atoms, elements and compounds

Atoms

Everyday experience should convince you that matter is found in myriad forms, yet all the matter you have ever seen is made of atoms, or atoms stuck together in configurations of dizzying complexity. A chemical element is a substance that cannot be made into a simpler form by ordinary chemical means. The smallest unit of a chemical element is an atom, and all atoms of a particular element are identical.

Molecules

In the previous section we said that many atoms are more stable when they have a net charge: they are more stable as ions. When a cation gets close to an anion, they link up because of their different net charges — positive charges attract negative charges and vice versa. When two or more atoms link up, they create a molecule. A molecule of water is made of two atoms of hydrogen (H) and one atom of oxygen (O). The molecular mass is the sum of the masses of all the atoms in the molecule. A collection of molecules is called a compound.

Elements

A chemical element is a pure substance that consists of one type of atom. Each atom has an atomic number, which represents the number of protons that are in the nucleus of a single atom of that element. The periodic table of elements is ordered by ascending atomic number.

The chemical elements are divided into the metals, the metalloids, and the non-metals. Metals, typically found on the left side of the periodic table, are:

- ✓ Often conductive to electricity
- ✓ Malleable
- ✓ Shiny
- ✓ Sometimes magnetic.

Aluminum, iron, copper, gold, mercury and lead are metals.

In contrast, non-metals, found on the right side of the periodic table (to the right of the staircase), are:

- ✓ Typically not conductive
- ✓ Not malleable
- ✓ Dull (not shiny)
- ✓ Not magnetic.

Examples of elemental non-metals include carbon and oxygen.

- ✓ Metalloids have some characteristics of metals and some characteristics of non-metals. Silicon and arsenic are metalloids.

As of November, 2011, 118 elements have been identified (the most recently identified was unseptium, in 2010). Of these 118 known elements, only the first 98 are known to occur naturally on Earth. The elements that do not occur naturally on Earth are the synthetic products of man-made nuclear reactions. 80 of the 98 naturally-occurring elements are stable; the rest are radioactive, which means they decay into lighter elements over timescales ranging from fractions of a second to billions of years.

Compounds

Pure samples of isolated elements are uncommon in nature. While the 98 naturally occurring elements have all been identified in mineral samples from the Earth's crust, only a small minority of them can be found as recognizable, relatively pure minerals. Among the more common of such "native elements" are copper, silver, gold, and sulfur. Carbon is also commonly found in the form of coal, graphite, and diamonds. The noble gases (e.g., neon) and noble metals (e.g., mercury) can also be found in their pure, non-bonded forms in nature. Still, most of these elements are found in mixtures.

When two distinct elements are chemically combined—i.e., chemical bonds form between their atoms—the result is called a chemical compound. Most elements on Earth bond with other elements to form chemical compounds, such as sodium (Na) and Chloride (Cl), which combine to form table salt (NaCl). Water is another example of a chemical compound. The two or more component elements of a compound can be separated through chemical reactions.

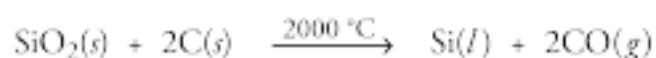
Chemical compounds have a unique and defined structure, which consists of a fixed ratio of atoms held together in a defined spatial arrangement by chemical bonds. Chemical compounds can be:

- ✓ Molecular compounds held together by covalent bonds
- ✓ Salts held together by ionic bonds
- ✓ Intermetallic compounds held together by metallic bonds
- ✓ Complexes held together by coordinate covalent bonds.

Pure chemical elements are not considered chemical compounds, even if they consist of diatomic or polyatomic molecules (molecules that contain only multiple atoms of a single element, such as H₂ or S₈).

Chemical reactions

A chemical change or chemical reaction is a process in which one or more pure substances are converted into one or more different pure substances. Chemical changes lead to the formation of substances that help grow our food, make our lives more productive, cure our heartburn, and much, much more. For example, nitric acid, HNO_3 , which is used to make fertilizers and explosives, is formed in the chemical reaction of the gases ammonia, NH_3 , and oxygen, O_2 . Silicon dioxide, SiO_2 , reacts with carbon, C , at high temperature to yield silicon, Si —which can be used to make computers—and carbon monoxide, CO . An antacid tablet might contain calcium carbonate, CaCO_3 , which combines with the hydrochloric acid in your stomach to yield calcium chloride, CaCl_2 , water, and carbon dioxide. The chemical equations for these three chemical reactions are below.



Solutes and solvent

When one substance dissolves into another, a **solution** is formed. A solution is a homogeneous mixture consisting of a **solute** dissolved into a **solvent**. The solute is the substance that is being dissolved, while the solvent is the dissolving medium. Solutions can be formed with many different types and forms of solutes and solvents.

Types of Solutions

Type	Solvent	Solute	Example
gas/gas	nitrogen	oxygen	air
gas/liquid	water	carbon dioxide	soda pop
liquid/liquid	water	ethylene glycol	antifreeze
solid/liquid	water	salts	seawater

In order to be a true solution, a mixture must be stable. When sugar is fully dissolved into water, it can stand for an indefinite amount of time and the sugar will not settle out of the solution. Further, if the sugar-water solution is passed through a filter it will be unchanged. The dissolved sugar particles will pass through the filter along with the water. This is because the dissolved particles in a solution are very small, usually less than 1

nm in diameter. Solute particles can be atoms, ions, or molecules, depending on the type of substance that has been dissolved.

Solute, solvent, solution definition with examples

A **solution** in chemistry is a **homogenous mixture** of two or more substances.

- ✓ The substance which is dissolved is called a **solute**.
- ✓ The substance in which the solute is dissolved is called a **solvent**.

Main characteristics of a solution

Solution is homogenous

That the solution is a homogenous mixture means that it forms a single phase. You cannot differentiate one substance from another within the solution. Characteristics of a solution are identically distributed through it. For an easy example, if you dissolve sugar in water but some of the sugar is still visibly laying on the bottom of the container (or even floating moved by movement of water) then this not part of a solution - only the dissolved "invisible" sugar is.

You cannot see a solute inside a solvent, nor can you mechanically take one out of another (eg. taking dissolved sugar from water is impossible with a sifter or another mechanical method).

Solution is stable

A solution is stable in given conditions. Eg. in a particular temperature and pressure it does not require stirring or other methods to remain homogenous.

Solution is in one phase

That the whole solution is on one phase means that the whole of it is either gaseous, liquid or solid.

Which is the solute and which is the solvent?

Usually it is easy to determine which substance is a solute and which is a solvent. The **solute** when dissolved takes on the characteristics of the **solvent**. A solution is composed in majority of a solvent (there is more of it than the solute). A sugar dissolved in water seems to take on its characteristics and there is more water than sugar in the solution.

Examples of solutions

Common example of a solution in everyday life is salt or sugar (solute) dissolved in water (solvent). Below you can find links to further examples of various types of solutions with a more detailed explanation.

Solubility Basics - What is solubility?

In General

In general, **SOLUBILITY** is an ability of a substance to dissolve. In the process of dissolving, the substance which is being dissolved is called a **solute** and the substance in which the solute is dissolved is called a **solvent**. A mixture of solute and solvent is called a **solution**.

To put it in simple words:

When we insert sugar into water it will dissolve. In this process:

- ✓ Sugar is the **solute**
- ✓ Water is the **solvent**

One of the characteristics of table sugar is its **solubility in water**.

That was a definition of solubility as it is used in a common language. Now let's see **solubility as chemists understand it**.

Chemist's understanding of Solubility

A chemist understands solubility as a measure. A chemist would say that:

SOLUBILITY is understood as a maximum amount of solute that dissolves in a solvent at so called **equilibrium**. In chemistry an equilibrium is a state where reactants and products reach a balance - no more solute can be dissolved in the solvent in the set conditions (temperature, pressure). Such a solution is called a **saturated solution**.

To put it in simple words: If you take one litre of water and you start dissolving table salt in it (chemical formula of salt is **NaCl**) and:

- ✓ Temperature of water is 25°C
- ✓ Pressure is 1 ATM (Atmosphere - standard pressure in the open air on Earth)

You should be able to dissolve exactly 357.00 grams and not a gram more. The rest of the salt will stay on the bottom as residue and will not dissolve. **Solubility of salt in water is therefore 357.00g/L**. When this amount of salt is dissolved the solution reaches its equilibrium. Every chemical substance which dissolves in water has a fixed solubility. If it does not dissolve - its solubility is zero. Many of these solubilities have been measured and special charts are produced displaying solubility of many substances at once.

To complete our introduction to solubility, we will describe two groups of substances in case of which solubility measure cannot be applied. These are **miscible and immiscible substances**.

Miscible and immiscible substances

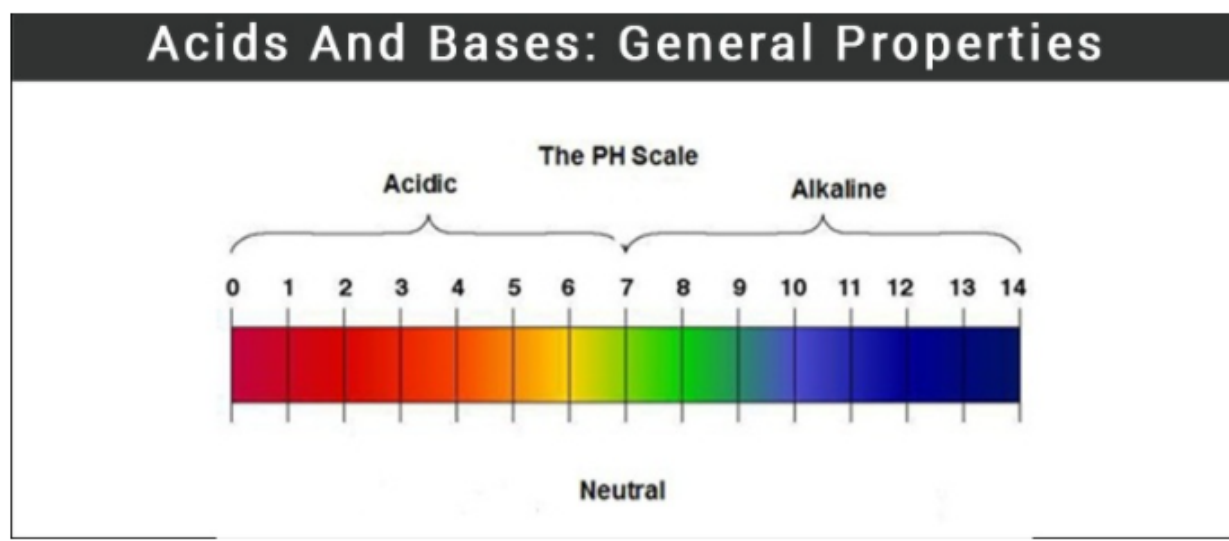
Some substances, like water and alcohol, can be mixed together and create a homogenous phase in any proportion. A solubility measure cannot be applied to such two substances. Such substances are called **miscible**. On the other hand if two substances cannot be mixed together (like water and oil), they are called **immiscible**.

Now, when you know what solubility really is, you can check out 'why do things dissolve', where we explain in detail why some things dissolve and some do not.

Acids and bases

Acids are chemical substances which are characterized by a sour taste in an aqueous medium. They have the tendency to turn blue litmus red. On the other hand, ***bases are chemical substances which are characterized by a bitter taste and are slippery to the touch.*** Some bases are soluble in water while others are not.

Water soluble bases are known as alkalis. They have the tendency to turn red litmus blue. Acids and bases react with a wide range of chemical compounds to form salts. Some chemical reactions of acids and bases are:



Physical Properties of Acids and Bases

Properties	Acids	Bases
Colour	Mineral acids are colourless liquids but sometimes sulphuric acid becomes yellow due to impurities. Some organic acids are white coloured solids. Examples: benzoic acid	Bases are colourless except the hydroxides of iron and copper.
Taste	Sour	Bitter
Touch	–	Slippery
Solubility	Soluble in water	Some bases are soluble in water.

UNIT 08

PERFORM INDUSTRIAL WELDING SKILLS

This unit covers performing welding/fabrication inspection by selecting, conducting or verifying appropriate non-destructive tests, establishing and validating welding procedures, ensuring quality assurance is carried out, and monitoring procedures

PREPARE AND UNDERTAKE BASIC WELDING

Polymer Pipes

Where there are limitations to hot work, cold repair materials are an alternative. Polymer materials are essentially epoxy or polyurethane products with additions of metal or ceramic filler. They are cold curing materials consisting of a base and activator that are mixed together. During solidification and curing it does not develop any heat. Polymer materials form a surface bonding and it is absolutely essential that the base materials surface be cleaned in order to give good addition.

Therefore:

1. Surfaces must be cleaned and ruffed up in order to give a good bonding.
2. Measure out base and activator according to instructions
3. Mix base and activator thoroughly together. Any unmixed material will not solidify.
4. At first only apply a small amount of product and make sure to press it hard into the prepared surface securing good bonding. Afterwards add more product and build up to required height. If needed, a reinforcement bandage can be added to the product in order to increase strength.

NB. In order for curing to take place the ambient temperature for polymers must at least be + 5°C. Polymer products are organic material that will start to carbonise at 150°C. This will make a natural limitation to polymer when it comes to high temperature application and in cases where there are specific demand for fire retardant properties. One must also check that the polymer product to be used is resistant to the cargo the part is handling.

Repair case 1.



In some repair situations the cast iron is so corroded and oxidized that welding cannot be done. In this kind of situations cold repairs might be the solution.



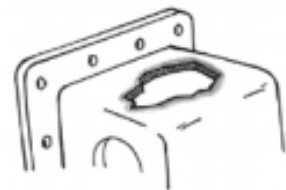
Clean surface to remove grease and accumulated dirt. Remove as much of the loose metal and oxides as possible. Thoroughly abrade the edge and the surrounding surface of the hole.



If the hole is large, a metal mesh formed to the shape of the hole should be made. Measure up and mix a small quantity of Metalgrade Express and apply it along the edge of the hole. Remember to squeeze the product hard into the surface to secure good bonding. The first thin covering acts as a "wetting layer" to improve adhesion.



Place the pre cut mesh down in the hole so that it makes contact with the polymer along the edge. If needed secure it with additional polymer.



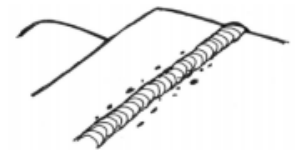
Allow drying for 6 minutes (at 20°C). With the mesh securely fastened measure up and mix a sufficient quantity of Metalgrade Rebuild. Apply the product on to the mesh spreading it out evenly. Apply the product to totally encapsulate the mesh and blend it in with the Metalgrade Express already on the cast-iron edge.

If the mesh size is too big, and the polymer falls through, apply reinforcement bandage on the mesh to prevent it happening.

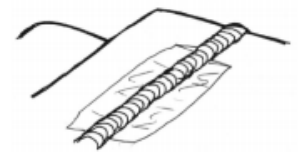
If necessary, support the mesh by placing steel wires across the hole. The wires can be fastened to the edge by a small tack weld or by drilling a hole with slightly bigger diameter.

Repair case 2.

After welding has successfully been employed to weld a crack, it sometimes turns out that there is liquid penetrating through porosity in the weld or heat affected zone.



The porosity is often caused by residue oil in the cast iron structure. Instead of risking cracking by further welding, polymer can be used to seal the surface area. The surface must be thoroughly degreased and abraded. In some cases grind or drill out the porosity to half its depth. Remember that grinding has a tendency to polish the surface and require abrading afterwards.



Safety in welding

Welding Hazards

1. Electric shock can kill.

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

- ✓ Do not touch live electrical parts.
- ✓ Wear dry, hole-free insulating gloves and body protection.
- ✓ Insulate yourself from work and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground.
- ✓ Do not use AC weld output in damp, wet, or confined spaces, or if there is a danger of falling.
- ✓ Use AC output ONLY if required for the welding process.
- ✓ If AC output is required, use remote output control if present on unit.
- ✓ Additional safety precautions are required when any of the following electrically hazardous conditions are present: in damp locations or while wearing wet clothing; on metal structures such as floors, gratings, or scaffolds; when in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or

accidental contact with the workpiece or ground. For these conditions, use the following equipment in order presented: 1) a semiautomatic DC constant voltage (wire) welder, 2) a DC manual (stick) welder, or 3) an AC welder with reduced open-circuit voltage. In most situations, use of a DC, constant voltage wire welder is recommended. And, do not work alone!

- ✓ Disconnect input power or stop engine before installing or servicing this equipment.
- ✓ Properly install, ground, and operate this equipment according to its Owner's Manual and national, state, and local codes.
- ✓ Always verify the supply ground – check and be sure that input power cord ground wire is properly connected to ground terminal in disconnect box or that cord plug is connected to a properly grounded receptacle outlet.
- ✓ When making input connections, attach proper grounding conductor first – double-check connections.
- ✓ Keep cords dry, free of oil and grease, and protected from hot metal and sparks.
- ✓ Frequently inspect input power cord and ground conductor for damage or bare wiring – replace immediately if damaged – bare wiring can kill.
- ✓ Turn off all equipment when not in use.
- ✓ Do not use worn, damaged, undersized, or repaired cables.
- ✓ Do not drape cables over your body.
- ✓ If earth grounding of the workpiece is required, ground it directly with a separate cable.
- ✓ Do not touch electrode if you are in contact with the work, ground, or another electrode from a different machine.
- ✓ Do not touch electrode holders connected to two welding machines at the same time since double open-circuit voltage will be present.
- ✓ Use only well-maintained equipment. Repair or replace damaged parts at once. Maintain unit according to manual.
- ✓ Wear a safety harness if working above floor level.
- ✓ Keep all panels and covers securely in place.
- ✓ Clamp work cable with good metal-to-metal contact to workpiece or worktable as near the weld as practical.
- ✓ Insulate work clamp when not connected to workpiece to prevent contact with any metal object.
- ✓ Do not connect more than one electrode or work cable to any single weld output terminal. Disconnect cable for process not in use.
- ✓ Use GFCI protection when operating auxiliary equipment in damp or wet locations.

2. Hot parts can burn.

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

3. Fumes and gases can be hazardous.

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

- ✓ Keep your head out of the fumes. Do not breathe the fumes.

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

4. Arc rays can burn eyes and skin.

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

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

5. Welding can cause fire or explosion.

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

- ✓ Remove all flammables within 35 ft (10.7 m) of the welding arc. If this is not possible, tightly cover them with approved covers.
- ✓ Do not weld where flying sparks can strike flammable material.
- ✓ Protect yourself and others from flying sparks and hot metal.
- ✓ Be alert that welding sparks and hot materials from welding can easily go through small cracks and openings to adjacent areas.
- ✓ Watch for fire, and keep a fire extinguisher nearby.
- ✓ Be aware that welding on a ceiling, floor, bulkhead, or partition can cause fire on the hidden side.
- ✓ Do not cut or weld on tire rims or wheels. Tires can explode if heated. Repaired rims and wheels can fail.

- ✓ Do not weld on containers that have held combustibles, or on closed containers such as tanks, drums, or pipes unless they are properly prepared.
- ✓ Do not weld where the atmosphere can contain flammable dust, gas, or liquid vapors (such as gasoline).
- ✓ Connect work cable to the work as close to the welding area as practical to prevent welding current from traveling long, possibly unknown paths and causing electric shock, sparks, and fire hazards.
- ✓ Do not use welder to thaw frozen pipes.
- ✓ Remove stick electrode from holder or cut off welding wire at contact tip when not in use.
- ✓ Wear body protection made from durable, flame-resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.
- ✓ Remove any combustibles, such as a butane lighter or matches, from your person before doing any welding. After completion of work, inspect area to ensure it is free of sparks, glowing embers, and flames.
- ✓ Use only correct fuses or circuit breakers. Do not oversize or bypass them.

6. *Flying metal or dirt can injure eyes.*

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

7. *Buildup of gas can injure or kill.*

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

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

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

9. *Noise can damage hearing.*

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

10. Cylinders can explode if damaged.

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

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

Welding tools and their uses

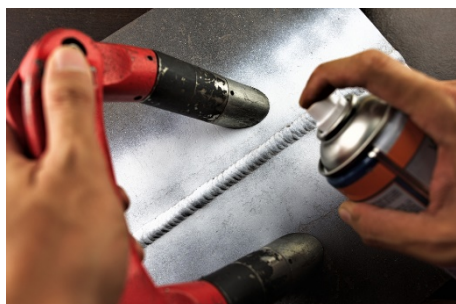
To get started with your welding, you must have a set of at least basic equipment and safety gear. However, before getting to welding, we'd also recommend completing training, so you can learn how to properly weld and would know all the safety requirements. But here's a list of the basic welding tools and their uses.

Measuring

The success of a project greatly depends on making proper prior measurements, so invest in measuring and marking devices. You will need a tape measure, calipers, metal T-squares and some sort of marking tool.

Welding Clamps

This is an absolute must have welding tool. Welding clamps allow you to firmly set up your work piece, so the welding will produce a tight joint. Clamps come in many different sizes. It's best to have at least 10 clamps, so you'll always have one ready for the project at hand. Without metal clamps, the metal warpage produced by welding will throw your project out of square and create welding defects.



Welding Magnets

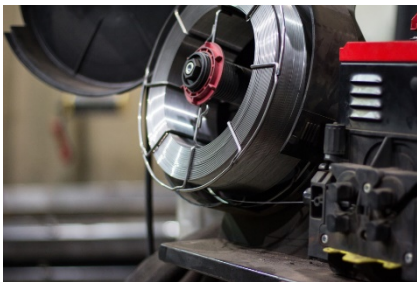
Another essential for welding projects is the magnet. Using them, you can set up your metal pieces to hold at a variety of angles, such as 45, 90 and other. They also come in different sizes, so you can get a few of them to always be available for different project needs.

Sheet Metal Gauge

This tool is very useful for those times when you're not sure of your metal thickness. You can't eyeball the thickness, so that's where this gauge comes in. It's not an absolute necessary welding tool, but it will definitely come in handy around the workshop.

Electrode

An electrode is a tip that is installed on the end of the tool and through which the electric current is passed from the welder to the material. For different applications, you'll need a certain type of electrode. Also, electrodes used for MIG and stick welding differ from those used for TIG welding. The electrodes for TIG welding are made from non-consumable tungsten. This means that unlike with MIG and stick welding, TIG electrodes don't need regular replacement.

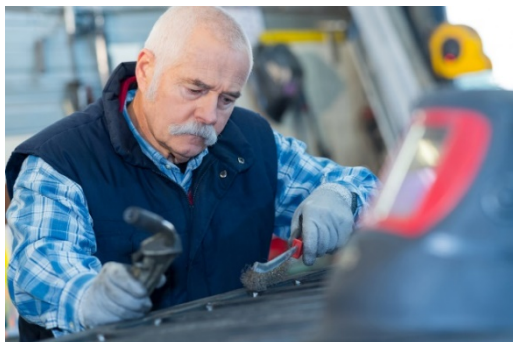


Wire and Electrode Feed

Depending on the type of welding you'll be doing, you'll be using either a wire or electrode feed. TIG welding uses the wire feed since the electrode is non-consumable. MIG welding, even though it uses a consumable electrode, also uses the wire feed. Stick welding, however, uses the electrode.

Angle Grinder

An angle grinder is a useful tool to have for prepping and finishing welds. Before you start welding, you can use the angle grinder to remove rust, paint or dirt from the work piece. You can also use the welding tool after you finish welding to remove the slag that has built up. You can even cut metal with an angle grinder as it can easily chop through thin metal.



Metal Brush

If your welding process creates a lot of slag, you'll also need a metal brush. For example, if you're stick or flux-cored welding, there'll be a lot of slag left behind after the weld is completed. To reveal the final weld, you'll need to use the metal brush to scrape off that slag coating.

Personal protective equipment (ppe)

Arc welding, like most welding processes, requires operators to protect themselves from the radiated heat and rays associated with the process.

Perhaps the most efficient way of doing this is by the wearing of protective clothing. The use of all protective clothing is dictated by the nature of the work and the comfort of the operator.

Ideally, clothing for the operator should consist of:

- ✓ long-sleeved cotton shirt
- ✓ sleeves rolled down and buttoned
- ✓ strong trousers without cuffs
- ✓ strong leather shoes or work boots
- ✓ aprons
- ✓ gloves
- ✓ spats (leather)
- ✓ caps
- ✓ leather capes or jackets.



Always take care to check clothing for frayed edges, torn areas and open pockets where sparks can lodge and start burning. Work clothes should also be free of oil or grease. This may be difficult in some workshops, but a spare pair of clean overalls could be left at work specifically for welding operations

IDENTIFY WELDING REQUIREMENTS

Create a materials list and collect

Auto-Darkening Welding Helmet

An auto-darkening welding helmet is the most important part of the welding safety gear. The purpose of the helmet, first of all, is to protect your eyes from the flash of the arc. However, when the arc of the torch is not active, the helmet's lens maintains a light shade, so you can still see your work. This eliminates the need to take the helmet on and off each time before welds. Another purpose of the welding helmet is to protect your face and neck from welding radiation and sparks.

Jacket Or a Welding Apron With a Long Sleeve Shirt

Welding usually involves sparks and molten metal shooting in all different directions. So it's important to protect from them not only your face but also the rest of the body. So you should wear either a heat-resistant leather jacket or if you find wearing one of them, you can opt for a welding apron and a long sleeve cotton shirt. It's important to remember, that the protective clothing should be made from natural fiber and not synthetic materials. You don't want it to burn and damage your skin.

Welding Shoes

You'll also need a good pair of work shoes to protect your feet during the welding process. Again, make sure that they are not made from synthetic materials, which can burn. The leather is the best choice.

Gloves

While welding, your hands will be in the closest proximity of the arc. So it's important to protect them as well. For example, you can get MIG gloves, which will comfortably sit on your hands.

Safety Glasses

You can also wear safety glasses under the helmet for extra protection. Make sure to wear them also when grinding metal. Choose glasses that will also give you some UV protection.

Ear Plugs

The welding process produces a lot of noise. If you'll be working long hours, this exposure can cause pain. so protect your ears by wearing earmuffs or earplugs.

A Mask Or a Respirator

As welding produces a lot of fumes that can have dangerous outcomes if you breathe them in, also get a mask or a respirator.

Welding Tools

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WELD AND INSPECT PIPE JOINTS

Materials and Jointing Methods for Pipe and Tube Systems

Joint Methods Used for Pipe and Tube

Pipes are commonly joined by welding, by using pipe threads, or by using a mechanical coupling. Process piping is usually joined by welding using a TIG or MIG process. The most common process pipe joint is the butt weld. The ends of pipe to be welded must have a certain weld preparation called an End Weld Prep (EWP) which is typically at an angle of 37.5 degrees to accommodate the filler weld metal. Another form of jointing for heavy wall pipe is threading of which the most common form in Europe is the British standard pipe thread (BSP).

Copper pipes are typically joined by soldering, brazing, compression fittings, flaring, or crimping. Plastic pipes may be joined by solvent welding, heat fusion, or elastomeric sealing.

If frequent disconnection will be required, gasketed pipe flanges or union fittings provide better reliability than threads. Some thin-walled pipes of ductile material, such as the smaller copper or flexible plastic water pipes found in homes for example, may be joined with compression fittings.

Underground pipe typically uses a "push-on" gasket style of pipe that compresses a gasket into a space formed between the two adjoining pieces. Push-on joints are available on most types of pipe. Under buried conditions, gasket-joint pipes allow for lateral movement due to soil shifting as well as expansion/contraction due to temperature differentials.

Large above ground pipe typically uses a flanged joint, which is generally available in ductile iron pipe and some others. It is a gasket style where the flanges of the adjoining pipes are bolted together, compressing the gasket into a space between the pipes.

Mechanical grooved couplings or Victaulic joints are also frequently used for frequent disassembly & assembly. Developed in the 1920s, these mechanical grooved couplings can operate up to 1,200psi working pressures and available in materials to match the pipe grade. Another type of mechanical coupling is a Swagelok brand fitting; this type of compression fitting is typically used on small tubing under $\frac{3}{4}$ " in diameter.

Other jointing methods such as welding and threading and have been dealt with in earlier units and therefore this unit will only concentrate on the following jointing techniques:

- ✓ Soldering
- ✓ Bronze Welding
- ✓ Compression joints
- ✓ Flange joints

Materials Used for Pipe and Tube

For the purpose of this unit we will be dealing with the following materials:

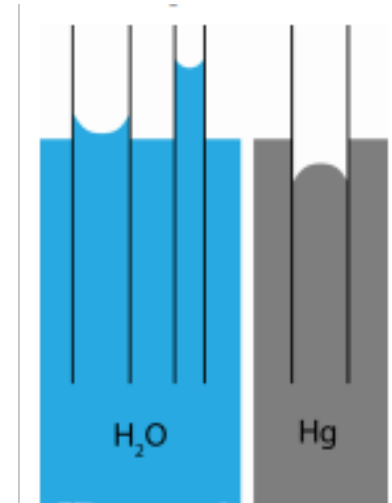
- ✓ Carbon Steel
- ✓ Stainless steel
- ✓ Copper
- ✓ Plastic piping
- ✓ Glass and ceramic piping

Thermal Joining Process for Copper Tube and Fittings

Capillary Action Applied to Soldering

A well-known phenomenon, which many people find hard to believe, in which liquids can rise upwards between two surfaces. To demonstrate this phenomenon put a clear drinking straw into a glass of water; if the straw is squeezed together the water will rise even higher.

Capillary attraction is caused by the liquid adhering to the side walls of the straw and then, due to cohesion of the water molecules (the need to hold together), pulling itself up to the level of adherence, the water then adheres again to the sides of the straw and again the water pulls itself up to the level of adherence. This process continues until the weight of the water molecules is too great and pulling itself up the level of adhesion proves too much.



Capillary action of water in tubes. (Note how the water rises higher in the narrower tube.)

Thus it can be stated that capillary attraction is caused by the adhesion and cohesion qualities of liquids. The closer two surfaces are together, the higher the liquid will rise (see illustration below). Also should the surface be greasy or oily liquid will not readily adhere. But it can also cause problems and damage such as water passing between the laps in sheet weathering material.

Soldering and Capillary Action for Soldered Joints

Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, the filler metal having a relatively low melting point. The filler metal used in the process is called solder. Soldering is distinguished from brazing by use of a lower melting temperature filler metal; it is distinguished from welding by the base metals not being melted during the joining process. In the soldering process, heat is applied to the parts to be joined, causing the solder to melt and be drawn into the joint by capillary action and to bond to the materials to be joined by wetting action. After the metal cools, the resulting joints are not as strong as the base metal, but have adequate strength and water-tightness for many uses. Because soldering relies on capillary action to draw the solder into the joint the surfaces need to be clean to get good adhesion. If capillary joints are used on mains water supply the solder used must be lead free. There are 2 types of soldering joints:

- ✓ Hard Soldering
- ✓ Soft Soldering

Hard Soldering

Hard Soldering is also known as silver soldering or cupro-techtic welding. This is because the rod used has a small amount of silver added to it to lower its melting point and to allow the molten metal to flow more easily.

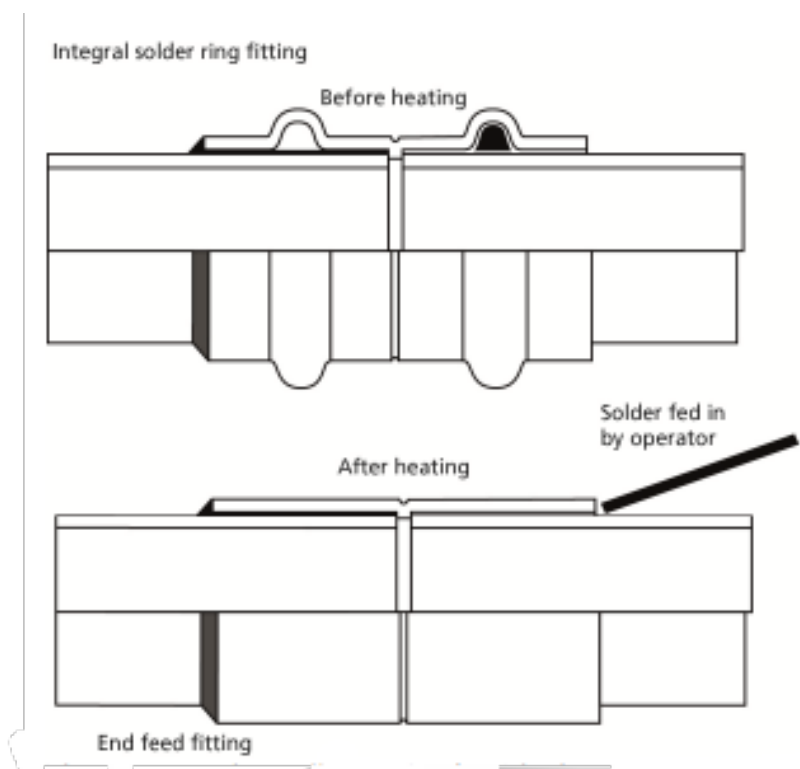
A special kit of tools has been designed by the Rothenberger company for use with this type of hard soldering. This kit allows the plumber to make straight joints, branches and reduces without the use of any fitting. This has a number of advantages for the plumber. Since less fittings are required there are considerable cost savings.

Silver Soldering requires a lot of heat and special torches are available for this. One is the air-acetylene torch which gives a mixture of air and propane. Both of these flames are hot enough to melt the silver solder rod but not the copper pipe. Oxyacetylene equipment may also be used but care must be taken not to melt the copper. No flux is required for this joint due to the high temperature (600° - 500°).

The silver solder joint is one of the most reliable ways of jointing copper. The joint itself has almost the same characteristics as copper and it seldom leaks.

Soft Soldering

Soft soldering is a means of jointing pipe using traditional plumbers solder which is a mixture of tin and lead. A comprehensive range of fittings are available and the solder is usually incorporated into each one in the form of an integral ring. Fitting without this ring of solder are also available but are not as popular as the first type.



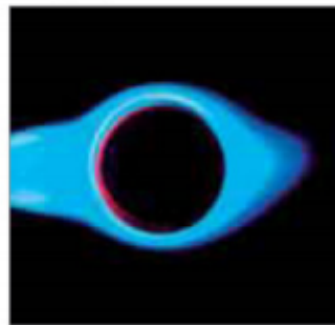
Soldered joints demonstrating capillary action (top joint integral solder ring, bottom joint solder fed by operator)

Soft soldering is characterized by the melting point of the filler metal, which is below 400 C and so a standard butane plumber's blowtorch or blowlamp is used. In fact too much heat is almost as bad as too little where soft soldering is concerned.

Because of the low temperature being used great care must be taken when preparing the joint. Both the outside of the pipe and the inside of the fitting must be thoroughly cleaned with steel wool or emery paper. Flux is then applied to both surfaces and the joint is then pushed together. All parts of the fitting must be prepared and jointed at the same time. Always try and do the lower joint first. When the heat is applied look for a small ring of solder which will appear at the face of the fitting. This is an indication that the solder is melting. Most plumbers like to add a small amount of solder to the joint to make sure the joint is sound. If too much solder is used the excess can be wiped off with a piece of rag or brown paper smeared with a small amount of flux.

Flux is applied to help clean the joint and should never be applied with the fingers or allowed come into contact with the skin as it is very corrosive. It should always be applied with a brush. When soft solder jointing is used in plumbing and heating systems always ensure the system is flushed out thoroughly to remove any excess or residue flux.

Soft soldering is a lot cheaper than using compression fittings but care must be taken when using this method to ensure that there are no leaking joints.



Soft Soldering central heating pipe Flame heating action on joint

Bronze Welding

A third common thermal process to join copper pipe is a method known as bronze welding. Although it is referred to as "welding", no melting of the parent metal takes place. However, the bond produced is equal in strength and comparable to a fusion weld.

Oxy-acetylene equipment is most satisfactory for this process as it is able to produce and intensely hot flame that gives controlled local heating.

A special brass rod is used to make the joint. This rod consists of approximately 60% copper and 40% zinc. It is necessary to add flux to the joint to enable the rod to adhere to the copper and to prevent oxidation. The flux may be used in powder form by dipping the heated end of the brass rod into it. An alternative method is to mix the flux with clean water to form a smooth paste which can be applied to the weld area and the filler rod with a small brush. Some brass rods have flux impregnated into them by the manufacturers.

The melting point of copper is 1,080°C while the melting point of the brass filler rod is 850°-950°C. A slightly oxidising flame should be used.

The main types of bronze welding joints used on copper pipe are:

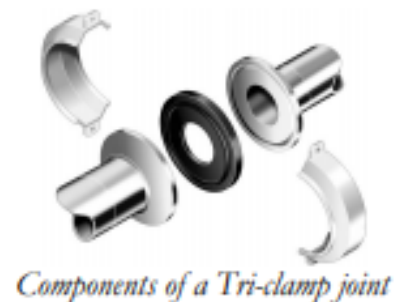
- ✓ Bell Joint: Used on pipes in the vertical position. The lower pipe end is belled out to receive the top pipe.
- ✓ Butt Joint: Used to join pipes in the horizontal position.
- ✓ Branch Joint: Used for branch welds. The branch hole may be filled, cut or burned out.
- ✓ Reducing Joint: Used where it is necessary to join pipes of different sizes.
- ✓ Blank Welds Used to blank pipe ends.

Note: Many people refer to bronze welding as “brazing”. While the materials and joint process are the same, the technique is slightly different. Brazing uses the principal of capillary attraction in the jointing.

Tri-clamp and Compression Joints for Tube Systems

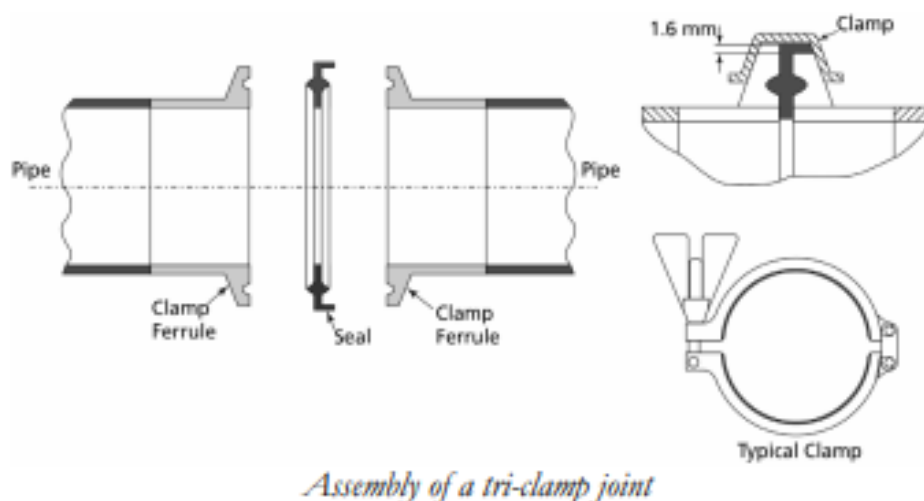
Tri-Clamp Joint for Hygienic Tube

Clamp fittings provide a crevice free joint and, depending on the clamp design, requires no tools for assembly or dismantling for cleaning. Provides quick method of regularly opening up a system and often has some kind of closure device such as a 'Triclover' clamp. Used where corrosion and contamination are particular hazards, as in the pharmaceutical industry. Also used in systems carrying warm semi-solids and viscous liquids, such as chocolate and tomato sauce, which must not cool in the line but tend to cause regular blockages.



Components of a Tri-clamp joint

Clamp fittings comprise four parts – two welding ferrules, a seal ring (gasket) and a clamp. The ends of the tubes and/or fittings to be joined have a welding ferrule fitted by welding. The joint is made by positioning the welding ferrules together, with a seal inserted between the faces, and then clamping the ferrules together. The clamp is not in contact with the contents of the pipe and may be made of any suitable material.



Assembly of a tri-clamp joint

Standards for Tri-Clamp Joints

There are a wide range of different standards for the tri-clamp fitting and it is important to ensure you have the correct one. There are subtle differences between the overall ferrule dimensions which can cause consternation when trying to seal a joint with the wrong seal or clamp. Some of the different standards for tri-clamp joints are as follows:

- ✓ ASME BPE 2004
- ✓ BS4825 Part 3
- ✓ BS Sch 5 and Sch 10
- ✓ DN32676 Series 2 (Standard and Non-standard)
- ✓ DN32676 Series 1 & 3
- ✓ ISO1127
- ✓ ISO2037
- ✓ Mini series ultra bore

Introduction to Compression Joints

A quicker alternative to soldering a joint for tubing systems is to use compression fittings. Soldering light tubing requires a special skill while making a compression fitting requires only a wrench. If the segments of piping or tubing are of dissimilar metals or materials--if a segment of copper pipe to be joined to a segment of PVC pipe, for example--the compression fitting is

the optimum choice to make the joint. The fittings will also be made of one or more compatible materials appropriate for the connection.



Compression fitting showing compression nut and olive

Compression joints are frequently used for small gauge, thin-walled piping such as fuel lines, gas lines or potable water systems, (to avoid the use of lead solder). Compression fittings are also used extensively for hot and cold water faucets (taps) and toilet stop valves. These valves generally control water to one fixture, such as a toilet, to allow it to be serviced without turning off the water to the entire house. Compression fittings are well suited to this application, as these valves are usually located in confined spaces where copper pipe would be difficult to solder without creating a fire hazard.

How Compression Joints Work

As the name implies, compression fittings form a tight seal by applying a compressive force to the pipes and pipe fitting. The fitting is compressed against the pipe with a force sufficient to eliminate all space remaining in the joint, thus preventing fluid from leaking.

The compression fitting is composed of an outer compression nut and an inner ring called a compression ring. This brass ring is referred to as a ferrule or olive. This is usually made of brass or copper. When the nut is tightened, it clamps down on the ferrule, causing it to conform to the circumference of the pipe. Ferrules vary in shape and material but are most commonly in the shape of a beveled ring and are most commonly made out of brass or according to the pipe material. To work properly, the ferrule must be oriented correctly. Typically the ferrule is fitted such that the longest sloping face of the ferrule faces away from the nut.



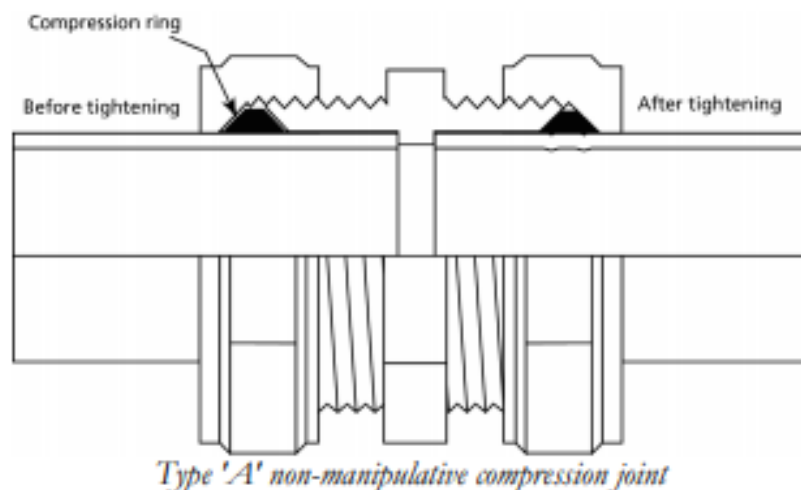
Component parts of a compression joint

Types of Compression Joints

There are two common types of compression fitting, the standard (British, type-A/non-manipulative) and flare fittings (British, type-B/manipulative) compression joints. Standard fittings are generally used for water and compressed air connections, while the flare fittings are used for gas and high pressure lines.

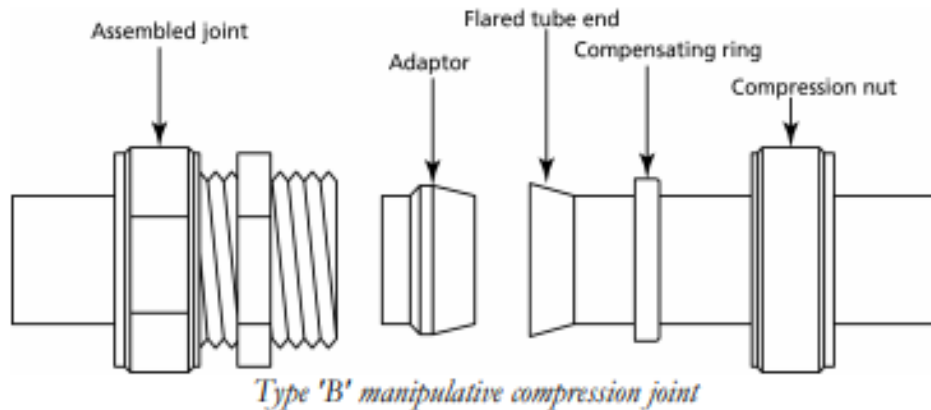
Non-Manipulative Compression Joint

The jointing method for the standard compression joint, illustrated below, simply consists of selecting the correct sized fitting for the tube, cutting the tube to the correct length, removing any burrs and checking that the tube end is clean and free from deep scores or other imperfections. If the tube end is oval it should be re-rounded with a suitable tool. Now the tube can be fully inserted into the fitting until it makes contact with the tube stop. Next tighten in accordance with the manufacturers instructions. For example:- tighten the compression nut by hand and a spanner until the compression ring grips the tube, so that it cannot be rotated by hand in the fitting. Now further tighten the nut one third to two thirds of a turn using two spanners, this is to cause the compression ring to bite into and slightly deform the tube.



Manipulative Compression Joint

The manipulative compression joint, as shown below, is designed to grip both the inner and outer surfaces of the tube, this results in a joint which can both support and tightly grip the soft condition tube for which it is designed. The jointing method consists of ensuring that the tube is of the correct specification and that the correct size of fitting is being used, next the tube is cut to length using a fine toothed hacksaw and the burrs moved inside and out. Slip the compression nut and compensating ring over the tube end and hammer the correct sized flaring tool or drift into the end of the tube to open out the end. Next check that the adaptor fits correctly into the end of the tube and the fitting body and tighten the compression nut first by hand and then with a spanner for about one full turn to produce a strong and leak-proof joint. The well known Swagelok brand of compression fittings are an example of this type of joint.



Standard fittings require no modifications to the tubing. Flare fittings require modification of the tubing with a special tool.

Sealing a Compression Joints

The most important component in a compression seal is the compression ring itself. The ring is a thin piece of brass and is extremely prone to damage; therefore care should be used when installing them. It is important to the integrity of a compression fitting that excessive force is avoided in tightening the nut. If the fitting is over-tightened, the ferrule frequently deforms and the compression fitting fails. Over-tightening is the most common cause of leaks in compression fittings. Generally, compression fittings are tightened to "finger tight" and then tightened a half-turn more with a wrench. The actual amount varies with the size of the fitting; a larger one requiring less. The fitting is then tested. If slight weeping is observed, the fitting is slowly tightened until the weeping stops.

Joint compound or thread seal tape is not applied to a compression fitting's threads. Joint compound and Teflon tape act to seal the threads from the water pressure in normal threaded connections, but serve little purpose in compression seals and may actually serve to weaken them. The compression is the means of sealing the joint, not the sealing of the threads themselves. Pipe compound or PTFE tape frequently leads to leaks in the fitting; in the case of Teflon tape, it allows a gap to form between the compression ring and nut. Joint compound is sometimes applied to the ferrule or olive to seal imperfections in the fitting, but really serves no purpose as the sealing is enacted through the compression ring itself. Rarely does joint compound or Teflon tape compensate for the loss of an air/watertight seal if the compression ring becomes "ovalled" (due to over-tightening while in a misoriented position, in relation to the compression nut), or if there is some factory defect in the product. In these instances, the compression fittings are simply replaced.

Advantages and Disadvantages of Compression Joints

Compression fittings are popular because they do not require soldering, so they are comparatively quick and easy to use. They require no special tools or skills to operate. They work at higher pressures and with toxic gases. Compression fittings are especially useful in installations that may require occasional disassembly or partial removal for maintenance etc, since these joints can be broken and remade without affecting the integrity of the joint. They are also used in situations where a heat source, in particular a soldering torch, is prohibited.

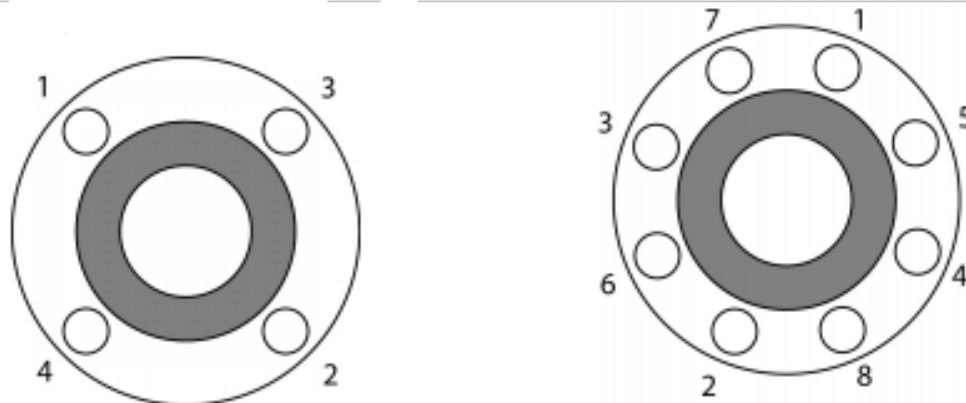
Compression fittings are not as robust as soldered fittings. They should be used in applications where the fitting will not be disturbed and not subjected to flexing or bending. A soldered joint is highly tolerant of flexing and bending (such as when pipes knock or shake from sudden pressure changes). Compression fittings are much more sensitive to these types of dynamic stresses. They are also bulkier, and may be considered less aesthetically pleasing than a neatly soldered joint.

Flanged Pipe Joints

Assembling a Flange Joint

When assembling a flanged joint, always use a full complement of clean, new high strength bolts ensure that the new bolting material strength properties exceed the calculated bolt stress values to be generated in making the piping connection.

5. Always use flat washers on both sides of the connection.
6. Tighten all bolts until finger tight and ensure that joint and gasket are correctly aligned.
7. Tighten the flange bolts with a calibrated torque wrench to the specified bolt torques. Note: For anti-seize compounds, the torque values will be different.
8. Tighten the flange bolts with a torque wrench; using a "crisscross" pattern that alternately tightens the bolts located 180 degrees apart. (see illustration below for 4 hole and 8 hole flanges.)
9. Using this pattern, tighten the bolts in 20% increments of the final bolt torque until 80% of final bolt torque has been achieved.
10. For tightening to the final torque values, tighten bolts sequentially clockwise once around the flange. This will help ensure that the bolts are evenly stressed.
11. Care should be taken to avoid over-torqueing, which can cause damage to the gasket and the sealing surfaces.



Torquing sequence for 4 bolt and 8 bolt flanges.

Note: When bolting together dissimilar materials, always tighten to the lowest recommended torque of the components in the joint. Using higher torques may cause excessive deformation of the "softer" material in the joint.

Pressure Testing Systems with Flanged Joints

Normally, after initial torque and re torque, a hydro test should be performed following ANSI requirements. Experience has shown that if the above procedure has been followed very few, if any, of the flange joints may fail the hydro test. If a flange joint does leak, first check the torque values, and then tighten in 10% increments over the specified bolt torques until sealed. However, if 150% of the specified torque value is reached and the flange joint still leaks, stop and disassemble the flange joint. Something else is probably wrong such as a damaged flange face, damaged gasket or a misaligned joint. Only after the pressure test has been successfully completed and any leaks corrected, can the pipeline can be signed off and commissioned.

Re-Torquing Flanged Joints

Torque loss is inherent in any bolted joint. The combined effects of bolt relaxation, (approximately 10% during the first 24 hours after installation), gasket creep, vibration in the system, thermal expansion and elastic interaction during bolt tightening contribute to torque loss. When torque loss reaches an extreme, the internal pressure exceeds the compressive force holding the gasket in place and a leak or blow-out occurs. A re-torque should be applied a minimum of 24 hours after the initial torque or after the first thermal cycle. This allows for seating of the flanged joints and for relaxation of the bolts. If the system is to perform at elevated temperatures, it is recommended that hot water be circulated at the maximum operating temperature of the process (if possible) for a minimum of 24 hours. This allows for the pipe system to experience one thermal cycle. After cool down, re-torquing of the system should be done. Torqueing should only be done on the system in the ambient, cooled state, never while the process is at elevated temperature, or excessive force could be applied to the flanged joints. Never disassemble a flange joint in a hot system. Wait until the system has cooled to ambient temperature.

Annual Re-Torquing Flanged Joints

Re-torquing should be done at least annually thereafter, especially if the process line experiences elevated temperatures or extreme ambient temperature situations. Torqueing should only be done on the system in the ambient, cooled state, never while the process is at an elevated temperature, as an excessive force will likely be applied to the flanged joints.

Gasket Selection for a Flanged Joints

It is important to select the correct gasket for the flanged joint. Properties such as system temperatures, pressures and chemical resistance of the gasket should all be considered. Proper gasket thickness is also important. The thicker the gasket, the higher the gasket creep which in turn can result in torque loss. On standard ANSI raised face flanges a 1.5mm thick gasket is normally recommended. Thinner gasket materials can take a higher gasket load and therefore higher internal pressures.

CLEAN UP

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally. Periodic "panic" cleanups are costly and ineffective in reducing incidents.

What is the purpose of workplace housekeeping?

Poor housekeeping can be a cause of incidents, such as:

- ✓ tripping over loose objects on floors, stairs and platforms
- ✓ being hit by falling objects
- ✓ slipping on greasy, wet or dirty surfaces
- ✓ striking against projecting, poorly stacked items or misplaced material
- ✓ cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

What are some benefits of good housekeeping practices?

Effective housekeeping results in:

- ✓ reduced handling to ease the flow of materials

- ✓ fewer tripping and slipping incidents in clutter-free and spill-free work areas
- ✓ decreased fire hazards
- ✓ lower worker exposures to hazardous products (e.g. dusts, vapours)
- ✓ better control of tools and materials, including inventory and supplies
- ✓ more efficient equipment cleanup and maintenance
- ✓ better hygienic conditions leading to improved health
- ✓ more effective use of space
- ✓ reduced property damage by improving preventive maintenance
- ✓ less janitorial work
- ✓ improved morale
- ✓ improved productivity (tools and materials will be easy to find)

How do I plan a good housekeeping program?

A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling. The plan also makes sure that work areas are not used as storage areas by having workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organization must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this is done. A good housekeeping program identifies and assigns responsibilities for the following:

- ✓ clean up during the shift
- ✓ day-to-day cleanup
- ✓ waste disposal
- ✓ removal of unused materials
- ✓ inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

What are the elements of an effective housekeeping program?

Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. So it is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep and repair of tools, equipment, machines and processes.

Dust and Dirt Removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibreglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

Employee Facilities

Employee facilities need to be adequate, clean and well maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed.

If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home.

Smoking, eating or drinking in the work area should be prohibited where hazardous products are handled. The eating area should be separate from the work area and should be cleaned properly each shift.

Surfaces

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

Walls: Light-coloured walls reflect light while dirty or dark-coloured walls absorb light. Contrasting colours warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colours.

Maintain Light Fixtures

Dirty light fixtures reduce essential light levels. Clean light fixtures can improve lighting efficiency significantly.

Aisles and Stairways

Aisles should be wide enough to accommodate people and vehicles comfortably and safely. Aisle space allows for the movement of people, products and materials. Warning signs and mirrors can improve sight-lines in blind corners. Arranging aisles properly encourages people to use them so that they do not take shortcuts through hazardous areas.

Keeping aisles and stairways clear is important. They should not be used for temporary "overflow" or "bottleneck" storage. Stairways and aisles also require adequate lighting.

Spill Control

The best way to control spills is to stop them before they happen. Regularly cleaning and maintaining machines and equipment is one way. Another is to use drip pans and guards where possible spills might occur. When spills do occur, it is important to clean them up immediately. Absorbent materials are useful for wiping up greasy, oily or other liquid spills. Used absorbents must be disposed of properly and safely.

Tools and Equipment

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

Waste Disposal

The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities.

Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier. All waste receptacles should be clearly labelled (e.g., recyclable glass, plastic, scrap metal, etc.).

Storage

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one metre (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. All storage areas should be clearly marked.

Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction.

UNIT 09

INSTALL WASTE WATER PIPE LINE

This competency unit covers the process of installing surface and/or subsurface drainage systems. It requires the ability to interpret site specifications and drainage system plans, set out drainage system works, measure materials, and level and align earthworks, and use relevant equipment, tools and machinery

PREPARE FOR DRAINAGE SYSTEM INSTALLATION ACTIVITIES

The installation of a drainage system has as its main objective the removal of excess water from the soil resulting in an improvement in trafficability and the development of a favourable root zone for plant growth. The excess water may occur either on the surface or within the soil and the drainage system must be designed to cope with the prevailing conditions. It should be emphasized, however, that the installation of even a very intensive system of drains is no guarantee of success. To ensure the maximum potential production is attainable, each scheme must be scientifically designed and properly installed. If either of these requirements is not fully implemented maximum returns will not be achieved on the drainage investment

Construction quality requirements for water supply and drainage construction

The construction units should make clear the relevant requirements of the construction quality of the construction and drainage, and take this as the basis to rationally select the construction methods. The details are as follows: First, we should ensure that it can meet people's basic living needs, provide enough water for people, and meet the needs of building heating system, and achieve effective discharge of kitchen sewage, air conditioning sewage and rainwater, etc., to ensure that it can meet the function of building works, provide high quality services for people. Secondly, it should be ensured that to meet the needs of the safety performance of the construction project. This is mainly to ensure that the quality of the water supply and drainage works can provide adequate water resources to the fire control system, the fire treatment system and the automatic sprinkler system, etc. And then it can also reduce the probability of building fire, reduce the impact of building fire on the building safety, and can also meet the safety requirements of the construction project. Thirdly, it is necessary to ensure that the water supply and drainage works meet the economic requirements. This mainly means that after the water supply and drainage system is put into use, its subsequent operation cost control is also very important. And through the rational design of water supply and drainage engineering, we can effectively improve the feasibility and economy of engineering design, and help construction enterprises control the operation cost of water supply and drainage system.

Putting together a drainage plan

Before a trench is excavated, site surveys and drainage design works will combine to create an overall plan of sustainable drainage features that are part of gaining planning permission. Establishing facts such as soil type and water table level not only help in the design of the drainage plan, they also help the groundworks or drainage contractor to plan the practical aspects of the works.

Eliminating potential problems

Part of preparing for the drainage works can include planning and scheduling testing and survey activities for when the works are complete, before construction of the superstructure begins.

While the temptation is to get on with developing the site above ground as quickly as possible, taking the time to test the system and record it 'as-built' before covering it over could save time and money later on, should a problem be discovered.

Ultimately, the potential for many problems to occur can be reduced or removed entirely by working with an experienced, trusted drainage contractor. If they also provide the groundworks as part of a complete package, there is greater flexibility in scheduling across the site and more 'joined-up thinking' towards implementing the drainage plan as a whole.

Where the services are provided separately, a groundworks contractor might unintentionally damage drainage works already installed, then leave that work to be redone by the drainage contractor. A single contractor hopefully knows where they have already carried out drainage work – but can take responsibility and rectify things quickly if an unfortunate mistake occurs.

Drainage design considerations A drainage system should be designed to remove excess gravitational water and lower the water table far enough from the ground surface so it does not interfere with plant growth. The system designer must determine:

- ✓ The desired depth to which the water table should be lowered (Fig. 6)
- ✓ The amount of rainfall received and the amount of irrigation to be applied
- ✓ The proper depth and spacing of the relief and collector lines
- ✓ The maximum length of laterals
- ✓ The material and diameter of the pipe
- ✓ The slope grade at which the lines should be installed

The design should take into consideration critical soil properties (permeability, hydraulic conductivity, drainage coefficient) that will determine the drainage water relief outflow rate, the drain depth, and spacing.

Permeability and hydraulic conductivity

Permeability is the capacity of the soil to transmit water. Soil can have low, moderate or high permeability (Table 2). The hydraulic conductivity is a numerical value of a soil's permeability. It represents the speed that water seeps through the soil; this speed is determined by several properties such as pore size, structure of the soil, and soil chemistry. Sandy soils have higher permeability and higher hydraulic conductivities than do clay soils (Table 2). A designer needs to know the soil texture and conductivity to determine the size of the drains.

Drainage coefficient or water relief outflow rate

The drainage coefficient is the rate of water removal needed to obtain the desired protection of the crop from excess water. It is based on local field experience and is generally expressed in flow rate per unit of area. Most drainage systems are designed to remove 0.005 to 0.01 inch of water per hour. The designer determines the drainage coefficient according to the deep percolation expected, rainfall received, and irrigation depths applied. The designer then uses the drainage coefficients and the amount of area to be drained to determine the diameter of the lateral and collector drains needed.

Drain depth and spacing

The spacing between drain lines may vary from 50 to 175 feet, depending on the soil type, the drain depth, and the crop grown (Table 2). In soils with moderate permeability, the drains can be spaced between 100 and 150 feet apart. They must be spaced more closely in soils with low permeability. A closer spacing reduces the amount of time to drain a certain volume of water but increases the cost of the system. The spacing will also be influenced by the pipe diameter of the interceptor lines. The depth of installation of the laterals is affected by the drain spacing, the crop and soil texture, and the desired drop of the water table. The drains are usually placed at a minimum depth of 6.5 feet (minimum of 5 feet at the upper end) in arid areas and at 5 feet in humid areas.

Hazards related to this job

Accident hazards

- ✓ Falls from height, esp. when standing/working on ladders
- ✓ Slips, trips and falls (esp. while carrying heavy or bulky loads)
- ✓ Slips, trips and falls (esp. while carrying heavy or bulky loads)
- ✓ Cuts and injuries caused by sharp instruments and tools
- ✓ Hazard of suffocation from asphyxiant gases released in sewerage systems, or from oxygen deficiency, during maintenance and cleaning operations
- ✓ Burns caused by hot parts of equipment, steam lines, etc., or by release of hot water or steam
- ✓ Electric traumas, caused by defective installations and equipment (esp. portable)
- ✓ Musculoskeletal injury (esp. of back), resulting from lifting and moving of heavy loads

Physical hazards

- ✓ Exposure to cold and/or heat stress, as a result of rapid movement between cold and hot areas
- ✓ Exposure to UV radiation during welding operations

Chemical hazards

- ✓ Exposure to various chemicals, such as: adhesives, caulking compounds, fluxes (solder), hydrochloric acid, zinc chloride, tar and solvents, various greases, and inorganic lead

Biological hazards

- ✓ Exposure to parasites, such as hookworm, ascaris, and various mites, chiggers, and ticks

Ergonomic, psychosocial and organizational factors

- ✓ Repetitive strain injury (RSI) and other musculoskeletal problems as a result of continuous repetitive movements (e.g., screwing), overexertion during lifting and moving of heavy loads, work in awkward (bent, etc.) postures
- ✓ Psychological stress due to dissatisfaction at work as a result of boredom, monotony, low salary, problematic personal relations with peers and/or superiors General ill feeling as a result of work in confined spaces and development of "sick building syndrome"

Preventive measures

- ✓ Inspect ladder before climbing. Never climb on a shaky ladder or a ladder with slippery rungs
- ✓ Wear safety shoes with non-skid soles
- ✓ Observe all recommended safety precautions for entering a confined space
- ✓ Use heat-insulating gloves to handle hot parts. Wear heat-protective gloves and face and eye protection against hot gases or splashes of hot liquids
- ✓ Learn and use safe lifting and moving techniques for heavy or awkward loads; use mechanical aids to assist in lifting
- ✓ Wear welding helmet with UV protection during welding

Minimising the risk using Personal Protective Equipment (PPE)

PPE is the lowest order control measure in the hierarchy of controls. PPE should also only be considered when other higher order control measures are not reasonably practicable or to increase protection from the hazard.

PPE relies on the proper fit and use of the PPE and does nothing to change the hazard itself. It therefore requires thorough training and effective supervision to ensure compliance and effectiveness. Examples of PPE include:

- ✓ Wide brimmed hats that shade face, head, neck and ears (where hard hats are required then it should be a hard hat brim or neck flap), sunglasses and broad spectrum SPF 30 or higher sunscreen to minimise the exposure to ultraviolet (UV) radiation.
- ✓ High visibility reflective clothing or vests.
- ✓ Ear plugs or ear muffs to minimise the risk of exposure to excessive noise when operating noisy machinery and power tools

COORDINATING INSTALLATION WORK

As you can see, placing an exterior drainage system is a challenging task to tackle on your own. On top of that, if done incorrectly, your insurance company may not cover any damages, and you could be in violation of local laws and regulations.

Secure the safety of your home and landscaping by using a professional team that can get the job done right the first time. Superior's team of experts can make sure your home or building is protected from foundation drainage.

Consulting, cooperating and coordinating activities with other duty holders

Consultation is a legal requirement and an essential part of managing health and safety when carrying out construction work.

A safe workplace is more easily achieved when everyone involved in the work communicates with each other to identify hazards and risks, talks about any health and safety concerns, and works together to find solutions. This includes cooperation between the people who manage or control the work and those who carry out the work or who are affected by the work.

Since various contractors and sub-contractors work on the same construction site, their activities are likely to overlap and interact with each other. They each have a duty to protect the health and safety of workers and other persons at the workplace and must therefore consult, cooperate and coordinate activities to ensure each person is made aware of what the others are doing, to identify the hazards and risks and decide who is best placed to take action to control the risks.

Principal contractors for a construction project have specific duties under the WHS Regulations to include arrangements in their WHS management plan that outline how persons conducting a business or undertaking at the workplace will consult, cooperate and coordinate activities between each other.

One of the ways in which PCBU's should do this is by discussing WHS arrangements with other duty holders, including other subcontractors, prior to commencing work (e.g. by visiting the site or by phone, fax or email).

Sub-contractors working on the same site should also discuss their activities with each other directly.

Trenchless Drainage Machines

Trenchless drainage machines have been used since about 1965, after flexible corrugated plastic pipe appeared on the market. Two main types of trenchless devices are: vertical plough (Fig. 10.5) and V-plough (Fig. 10.6).

A **vertical plough** acts as a subsoiler: the soil is lifted and large fissures and cracks are formed. If these extend down to the drain depth, the increased permeability leads to a low entrance resistance and an enhanced inflow of water into the pipe. Beyond a certain critical depth, however, the soil is pushed aside by the plough blade, instead of being lifted and fissured. This results in smearing, compaction and a destruction of macropores, so that the permeability is reduced and the entrance resistance is increased. The critical depth depends mainly on the soil texture and on the water content during pipe installation.

The **V-plough**, which lifts a triangular 'beam' of soil while the drain pipe is being installed, has a hazard of deforming the corrugated pipe under the weight of the soil beam. The problem was found to occur in heavy alluvial clay soil in The Netherlands, but it can be solved by simple adjustments to the plough.

PREPARE SITE FOR INSTALLATION OF DRAINAGE SYSTEM

Drainage is one part of the groundworks carried out on site prior to starting the above-ground construction. Whether a single building plot or a substantial housing development, once foul and storm drainage runs have been laid, they are soon built over – leaving any potential issues to be discovered when it is least convenient to rectify them.

Putting together drainage plan

Before a trench is excavated, site surveys and drainage design works will combine to create an overall plan of sustainable drainage features that are part of gaining planning permission.

Establishing facts such as soil type and water table level not only help in the design of the drainage plan, they also help the groundworks or drainage contractor to plan the practical aspects of the works.

Drainage construction-design versus reality

As with many areas of construction above ground, being careful to ensure the agreed specification for below ground works like drainage is followed is an important part of making sure design intent is achieved in reality.

A contractor may think they can save money, perhaps by omitting a rodding point or manhole, and thinking it won't be an issue, but falling into that trap can cause real problems later if there is no adequate maintenance access. On large developments particularly, drainage systems are carefully engineered and even an apparently small problem could impact on many properties at once.

Similarly, preparing trenches to receive the correct pipe sizes, and achieve the correct levels to provide the right falls and connect into the existing drainage system, is an important part of site



preparation. Understanding what needs to be achieved before starting work, and how best to achieve it once work has started, is key to a smooth-running project.

Drainage flows are also affected by the pipe material – installing a corrugated plastic pipe rather than a specified smooth-sided pipe can dramatically impact on the drainage flows achieved and on the success of the system. Having an appreciation of what has been specified in order to be able to achieve it on site is an important aspect of preparation.

Eliminating potential problems

Part of preparing for the drainage works can include planning and scheduling testing and survey activities for when the works are complete, before construction of the superstructure begins.

While the temptation is to get on with developing the site above ground as quickly as possible, taking the time to test the system and record it ‘as-built’ before covering it over could save time and money later on, should a problem be discovered.

Ultimately, the potential for many problems to occur can be reduced or removed entirely by working with an experienced, trusted drainage contractor. If they also provide the groundworks as part of a complete package, there is greater flexibility in scheduling across the site and more ‘joined-up thinking’ towards implementing the drainage plan as a whole.

Where the services are provided separately, a groundworks contractor might unintentionally damage drainage works already installed, then leave that work to be redone by the drainage contractor. A single contractor hopefully knows where they have already carried out drainage work – but can take responsibility and rectify things quickly if an unfortunate mistake occurs.

UNDERTAKE INSTALLATION OF DRAINAGE SYSTEM

Step 1: Dig the trench

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

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

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

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

Step 2: Create a proper slope

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

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

Step 3: Level the soil

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

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

Step 4: Add geotextile and gravel

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

Step 5: Place the pipe

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

Step 6: Finish

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

Finish filling the trench and replacing any affected landscaping.



APPENDIX VII - STANDARD SYMBOLS FOR USE ON THE DRAWINGS

(Consistent with NWC/DoE Standing Technical Committee on Sewers and Water Mains, Report No. 25 Sewer and Water Main Records)

150 mm 1/83 	FW Sewer	Pipe diameter and gradient
225 mm 1/156 	SW Sewer	Pipe diameter and gradient
300 mm 1/150 	Combined Sewer	Pipe diameter and gradient
 F1(22.23)	Adoptable Foul Manhole	Reference and invert level
 S1(23.67)	Adoptable Surface Water Manhole	Reference and invert level
 C1(21.56)	Adoptable Combined Manhole	Reference and invert level
 (22.0) I F3(20.26)	Backdrop Manhole	Reference and invert level
 (19.65)	Pumping Station with invert level of inlet	
 100 mm	Rising Main - Foul	Diameter of pipe and direction of flow
 150 mm	Rising Main - Surface Water	Diameter of pipe and direction of flow
 150 mm	Rising Main - Combined	Diameter of pipe and direction of flow
	Air Release Valve	Use of colour
 HB	Hatch Box	If it is required to use colour to enhance the presentation of the Drawings the following colours shall be used:
 EM	Emptying Valve	Foul - Brown
For lateral drains the same symbols and colours shall be used but with a finer line.		Surface Water - Dark Blue
		Combined - Red
		Water courses - Light Blue
		Building over/basements - Orange
		Property not connected - Yellow

Identifying Soil Type

Before selecting a specific recessed in-grade luminaire, best practices recommend first identifying the type of soil present at the project site. Soils have been classified into two distinct groups, Type I and Type II, as it relates to a soil's ability to drain.

Type I describes a soil that is an easy or free draining soil. In general, this type of soil has very little or no clays and may have a sandy feel or appearance. Type II describes a soil that has more difficulty draining. In many cases, even small amounts of water will pool and can take hours or days to drain away from the surface. Typically, this type of soil consists of a varied amount of clay or hardpan, which inhibits subsurface drainage.

The Soil Type Test

Determining whether the soil on a project is Type I or Type II is a fairly straightforward process. There is a simple test that will reveal the soil type in two hours. First, dig a hole at least 18 inches in diameter and 18 to 24 inches deep. Then fill half of the hole with water and track how long it takes for the water to drain into the soil. If complete drainage occurs in less than two hours, the soil is Type I. If complete drainage takes more than two hours, the soil is considered Type II.

Matching Installation Practices and Soil Type

The type of soil available on a project heavily influences how the recessed in-grade luminaire should be installed in order to reduce the fixture's exposure to standing water. While it is generally understood that the contractor will need to provide some type of drainage during installation, there are different ways to create drainage and these different approaches can deliver very different results. A technique that provides adequate drainage on one project may provide terribly insufficient drainage in another, ultimately creating a problematic installation. It is critical to match the site-specific drainage needs with the installation technique that will provide the necessary degree of drainage.

Other Installation Considerations

The presence of concrete, walkways, buildings, and other landscape and architectural features can materially affect how water travels through an environment, regardless of soil type. Some elements, like concrete, for example, may offer the installation area additional protection against super-saturation, while the presence of other items, such as a building's downpipe, irrigation systems, or the rain-heavy climate of the location may warrant additional drainage as a prudent precaution.

Concrete. If the lighting fixtures are being installed in concrete and there is a minimum of 5 feet between the lighting fixtures and nearby soil, Type I installation practices are recommended, because concrete protects the nearby soil from saturation and the presence of standing water may not be an environmental factor.

Planter areas and walkway. If the lighting fixtures will be installed between a walkway and another structure, such as a building or sidewalk, Type II installation practices are recommended to better manage the water that will run off of the pavement and onto the dirt where the fixtures are installed.

Areas subject to heavy rainfall. In areas that receive heavy rainfall, such as Seattle, Advanced or Premium Type II installation practices are recommended unless the existing soil demonstrates good Type I characteristics.

A word about clean gaskets. While poor drainage is the predominant cause of water ingress that leads to the failure of an in-grade fixture, poorly sealed gaskets are the next most common cause of water-related damage. To avoid leaky gaskets, it is critically important that the gaskets and the surface areas they are attempting to seal are clean. The presence of any grit, dust, or grime can interfere with the formation of a watertight seal, compromising the integrity of the gasket. Contractors should clean the gaskets and adhering surfaces before installation to ensure a tight and effective fit

Excavation

On some projects, such as construction of an excavated pond or a cropland waterway, excavation is the primary item of work. On other projects, excavation is only a part of the work to accomplish items such as preparing the foundation or obtaining material (borrow) to be used for earthfill.

(1) Excavation safety

The qualifications of equipment operators and the conditions of the excavating equipment must comply with safety regulations. In addition to concerns about safe excavating equipment and equipment operation, there are specific items of safety associated with excavation that must be addressed. See chapter 4 of this handbook for guidance concerning excavation safety.

(2) Trench excavation

Trench excavation refers to any excavation with vertical or near vertical walls and is a major safety concern in any earthwork construction operation due to the potential for sloughing and poor air quality in confined working conditions. Trench excavation must comply with Occupational Safety and Health Administration (OSHA) regulations, and the contractor's plan to comply with these regulations should be reviewed and discussed with all employees. Trenching operations should be supervised by a competent person. Material removed from the trench should be placed a safe distance from the excavation (a minimum distance of 2 ft is recommended) to prevent excessive loading on the trench walls (fig. 7-7). To reduce excavation hazard potential, limit the amount of excavation to no more than can be maintained.

(3) Buried utilities

NRCS policy states that employees are to check with the landowner, operator, or sponsoring organization to determine if there are underground utilities in the work area and to check records of known utilities on file in the field office. Particular attention should be given to utility markers set in fence lines or elsewhere. These checks should be made during the design phase and again prior to beginning excavation. Excavation should not begin until all buried utilities in the area to be excavated have been marked or otherwise identified

(4) Materials to be excavated

Various types of excavation are required to install conservation measures. These include foundation, borrow, and auxiliary spillway excavation to name a few. The inspector must be able to identify: the type of excavation, the class of excavation, and the various classes of soils being excavated. Additionally, payment for excavation will likely be based on type and class of excavation making it necessary for the inspector to monitor changes in excavation limits for the various types and class of excavations.

COMPLETE INSTALLATION OF DRAINAGE SYSTEM

Whatever the design and purpose be, it is important that following steps are followed while completing the drainage system.

Inspection after installation

The drainage, waste system, venting system, water distribution system, fixtures and appliances are inspected to ensure that they operate properly and provide the occupants with a healthy living environment and safe drinking water. Inspection of the completed drainage system requires the system be monitored through operation of the drainage system for reasonable time frame to ensure the system operates without leakage and function appropriately. It is advised that an external party is involved with the inspection to ensure the laid down drainage system is safe and effective in delivering its designated services.

Backfilling trench dug for the installation of drainage system

Backfilling is the process of putting the soil back into a trench or foundation once excavation, and the related work has been completed. The backfill process requires skills and heavy equipment as well as knowledge of the specifications, contract requirements, and soil conditions. Every area of soil has unique characteristics, requiring different construction techniques to ensure optimum performance. Also, backfill crews must take care to prevent impact loading of any pipeline, shaft, structure, cabling, or other buried elements when placing and compacting backfill. There are a few common methods of backfilling and compacting backfill. Filling and compacting trenches for utility lines involves special considerations.



UNIT 10

INSTALL TRENCH SUPPORT

This unit describes a participant's skills and knowledge required to install trench support in Civil construction

PREPARING FOR INSTALLING TRENCH SUPPORT

Techniques Available

1. Trenchless ("No-dig" solutions)
2. Sloped or stepped excavations
3. Trench shields (or trench boxes)
4. Drag shields
5. Trench shoring systems (including sheet piling)

At the outset it must be stated that there are trenchless techniques being employed in Christchurch for pipe installation that remove the requirement for trenches and therefore trench support, e.g. directional drilling. A Designer may also consider rehabilitation of the pipe which again mitigates the need for a trench altogether. This guide does not cover trenchless techniques, however consideration should always be given to their use, especially for deep installations and/or in poor ground conditions, where pipe laying in an open trench is likely to be expensive and /or hazardous.

Sloped or Stepped Excavations

These methods are usually only viable on greenfield sites. However, there will be occasions when these 'open-cut' solutions are viable e.g. where pipes are laid across reserves.

If these methods are to be used then the safe angle of repose (and step height where applicable) must be determined by a qualified person, e.g. a Chartered Civil or Geotechnical Engineer.

Note that moisture affects slope stability and a safe slope in dry conditions may become unsafe after exposure to water from any source such as rainfall, groundwater ingress, broken water mains, run off etc. The excavation must therefore be inspected daily by a competent person prior to permitting man entry.

Advantages:

- ✓ No shoring or trench support required

Disadvantages:

- ✓ Additional volume of excavation and backfill are required.
- ✓ In poor soils in Christchurch, the safe angle of repose can be so shallow as to render this methodology impractical.
- ✓ Temporary works may be required to protect adjacent and crossing utilities.

Trench Shields



Figure 2-1 Sloped Excavation



Source: OSHA Excavation Standard Handbook

Figure 2-2 Stepped Excavation

The function of trench shields (also known as trench boxes) is to protect workers in case of a trench collapse. Trench shields should not be confused with trench shores. Shields are not usually intended to shore up or otherwise provide positive support to the walls of the trench.

Trench shields must be inspected and certified by an Authorised Person as safe for use and fit for purpose.

Advantages:

- ✓ Readily available and commonly used
- ✓ Protect workers effectively, without additional cost of supporting the trench walls

Disadvantages:

- ✓ In general, trench walls are not positively supported, which can lead to collapse / slumping / subsidence of native soil, especially if the trench is left open for an extended period
- ✓ The trench shield must be lifted progressively to ensure full-width compaction of backfill layers



In cohesionless soils, such as silty sands, the trench walls will not be self-supporting. Although workers within the shield will be protected, collapsing trench sides will undermine any adjacent services as well as the road pavement above. In the case of trench 'cave-ins' in the public road, reinstatement costs can be very expensive. At ECI and planning stage, the risks should be assessed and it may be prudent to budget for a proper shoring system, perhaps a sheet piled solution.

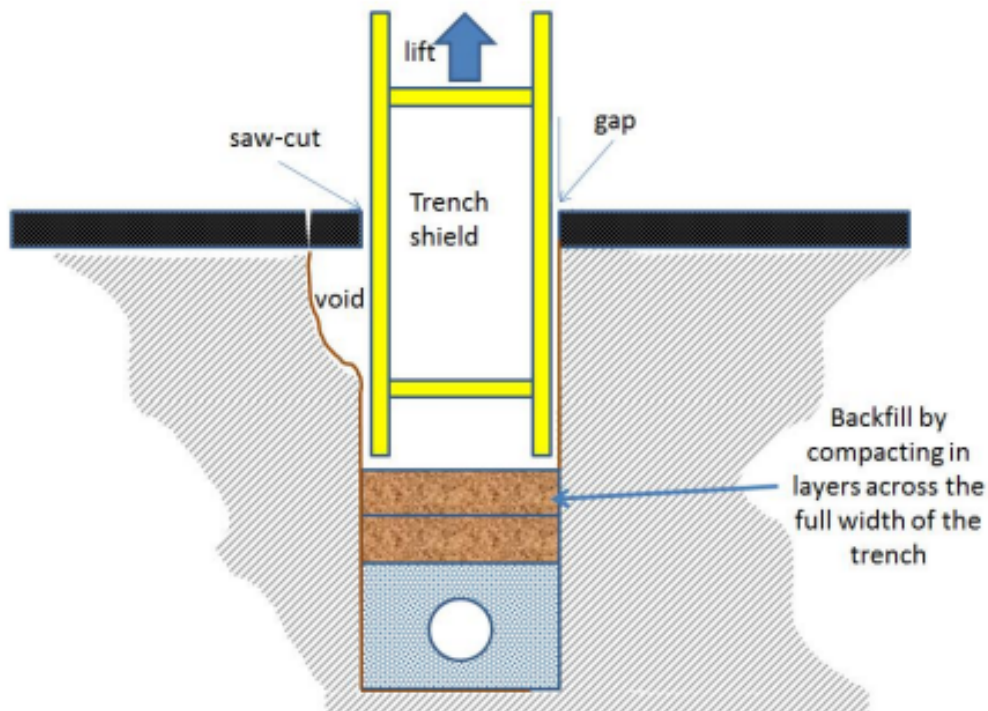


Figure 2-4 The shield must be withdrawn progressively to allow full width compaction

When using trench shields, a methodology must be devised for backfilling the full width of the trench. Backfilling in compacted layers within the shield is pointless if the shield is pulled out afterwards causing the material to relax (see Figure 2-6 below). Instead, the shield must be withdrawn progressively as backfill progresses. The shield may have to be propped or otherwise safely supported to allow for removal in stages.

Drag Shields

A drag shield is a type of trench shield that is dragged horizontally by an excavator, often by means of certified chains attached to the shield and secured to the dipper arm of the excavator.



Drag shields (like all trench shields) must be inspected and certified by an Authorised Person as safe for use.

Advantages:

- ✓ Drag shields, in appropriate ground conditions, can facilitate quicker progress than ordinary trench shields, which must be lifted vertically in and out of the trench.
- ✓ A drag shield can provide positive support to the native soil when used in a trench that has been deliberately excavated to be slightly narrower than the shield itself.



Disadvantages:

- ✓ Cannot be used where existing services cross the path of the trench
- ✓ In many soils, the amount of force required to overcome friction on the shield walls makes this method impractical, i.e. the shield cannot cut through the native soil and larger equipment is generally required to overcome the frictional forces exerted between shield and the trench sides.
- ✓ There is a temptation to excavate the trench somewhat wider than the shield so that dragging the shield is not difficult, however this method is not recommended. Due to the voids outside the shield wall it becomes impossible to backfill the full width of the trench in compacted layers (refer to Figure 2-6).
- ✓ As the shield moves forward the positive support of the native soil is removed and trench collapse could follow the rear of the box.

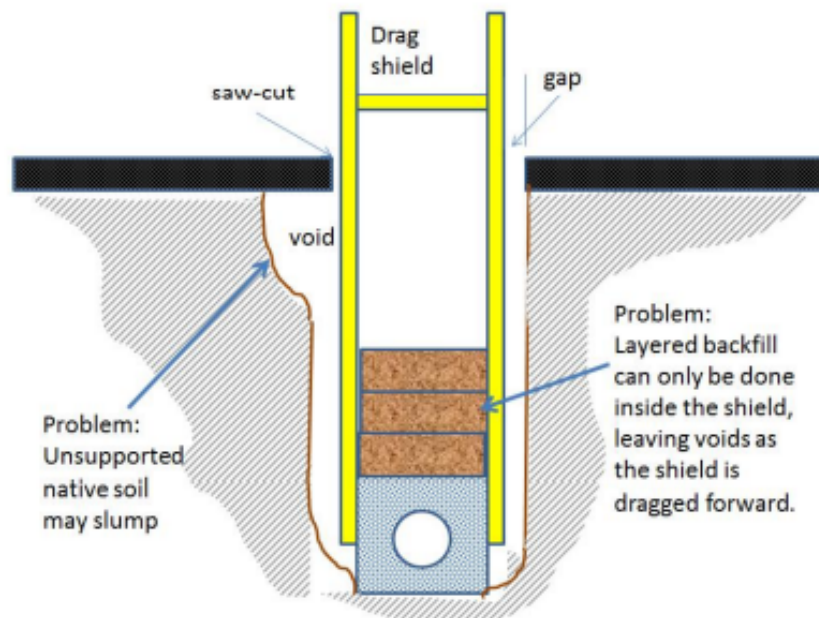


Figure 2-6 Do not use a drag shield in a trench that is wider than shield

INSTALL AND REMOVE TRENCH SHORING

Categories

By definition, shoring systems support the trench walls. Shoring systems can be categorised as follows:

- ✓ Sheeting, waling and strutting
- ✓ Traditional methods
- ✓ Systems incorporating hydraulic struts
- ✓ Proprietary shoring systems
- ✓ Sheet Piling

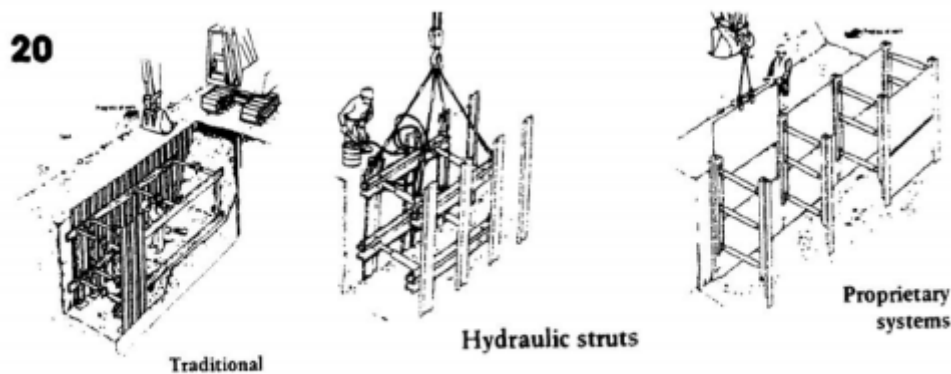


Figure 2-7 Trench Shoring Systems

Source: CIRIA R97

All shoring methods require a temporary works design by a competent Engineer.

Sheeting, Waling and Strutting

Sheeting: Nowadays, steel trench sheets are used but traditionally, timber boards were common. In poorer soils, sheeting needs to be continuous in the trench ('full sheeting'), and should be toed in especially where ground water was an issue. In good ground however, intermittent sheeting or 'half sheeting' may be considered.

Walings: Generally stout timbers or steel sections are used. They act as beams, transferring the horizontal loads from the soil/sheeting to the struts.

Struts: Traditionally timber but nowadays adjustable steel props (e.g. 'Acrow props') or hydraulic props are often used.

Advantages: Adaptable, particularly when working around existing services. Actively support the native soil. Quick to install especially in shallow excavations. **Disadvantages:** Traditional 'timbering' system requires considerable experience and skill to install. Each arrangement requires a bespoke design. Deeper excavations require Temporary Work design calculations.

Traditional shoring methods should not be used unless the persons at the workface are highly competent and experienced in the installation, inspection and maintenance



Source: Ischebeck

Figure 2-8 Traditional Shoring

of such systems. Instead the use of standard proprietary shoring systems and sheet piles should be considered.

Proprietary Shoring Systems

There are many different proprietary shoring systems available. These include modular trench box systems and hydraulic frames.

Advantages: Standard components and uniform installation methodologies can reduce risks inherent with bespoke shoring arrangements. Design service available from supplier.

Disadvantages: Some systems may lack flexibility e.g. to accommodate existing utilities crossing the trench.

Sheet Piling

A sheet piled shoring system is often used in poor ground for deep drainage and is considered by many as the best and safest solution for installing structures or pipes below ground.

Advantages:

- ✓ Interlocking sheets prevent water ingress · Native soils and adjacent utilities and/or structures can be adequately supported
- ✓ One advantage of Christchurch's relatively poor soils is that sheet piles can often be driven with relatively little effort by excavator mounted equipment e.g. Movax (Figure 2-9). Rarely is installation impeded by boulders or bed rock. These ground conditions can allow relatively lightweight sheets to be driven.
- ✓ Can add dewatering systems by preventing water migration under the toe of the excavation



Figure 2-9 Installing Sheet Piles

Disadvantages:

- ✓ Expensive – but should be viewed in overall context of mitigation of risks to the road pavement and adjacent utilities and properties
- ✓ Vibrations during installation (and removal) may liquefy native soil and lead to settlement
- ✓ May be difficult when coping with crossing services



Figure 2-10 Sheet Piled Trench

Selection of Appropriate Method

Developing the Concept Design

Early Contractor Involvement (ECI) should commence during the Concept Design stage of any pipeline project in poor ground or high risk areas e.g. adjacent to the river etc. This should help Designers focus on any issues his or her design may cause for the contractor.

Things to be considered could be:

- ✓ Trenchless alternatives, both for pipe replacement or rehabilitation of existing infrastructure
- ✓ Alignment changes to help with installation, access, traffic management etc.
- ✓ Appropriate trench support systems required given ground conditions anticipated

The following non-exhaustive list should be used to guide decisions regarding the design of both the temporary and the permanent works:

- ✓ Depth of dig
- ✓ Underlying geology
- ✓ Water table (and likely fluctuation, artesian pressure, etc.)
- ✓ Location (adjacent to water courses, buildings, structures, existing utilities, etc.) ·
Likely traffic loading and road hierarchy adjacent to trench
- ✓ Historical evidence (EQ damage experienced)
- ✓ Likely timing of works (seasonal / daily variations)
- ✓ Strategic importance (e.g. for overall network stability, priority CBD works, etc.)

Detailed Design Stage

At this stage of the process the Designer should have made use of the variety of information that is available from other disciplines, e.g. geotechnical and maintenance providers. Roading engineers should have access to borehole information detailing carriageway makeup and underlying ground conditions adjacent to any proposed trench excavation. This type of information may help the contractor tailor their install methodology during ECI and design development, which then develops a more robust Risk Register. Having a fuller understanding of any issues helps to manage or mitigate risks earlier in the process leading to more certainty when the estimate is finalised.

Delivery

Development of a clear understanding of the ground conditions and constraints facing the contractor in carrying out any restorative works to the piped system can only culminate in a more robust solution. By tailoring and managing risk together, the Designer and contractor learn from each other and develop well managed outcomes. Trench support is only one part of the overall Delivery phase of installing new pipes in the ground. Other considerations will be:

- ✓ Dewatering requirements
- ✓ Bedding material types
- ✓ Proximity of adjacent infrastructure
- ✓ Availability of suitably qualified and experienced subcontractors

CONDUCT HOUSEKEEPING ACTIVITIES

Introduction

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally. Periodic "panic" cleanups are costly and ineffective in reducing incidents.

Clear work area and dispose of or recycle materials

Dust and Dirt Removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibreglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

Surfaces

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

Walls: Light-coloured walls reflect light while dirty or dark-coloured walls absorb light. Contrasting colours warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colours.

Waste Disposal

The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities.

Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier. All waste receptacles should be clearly labelled (e.g., recyclable glass, plastic, scrap metal, etc.).

Clean and maintain condition of equipment, ensure suitability for use, and address/report issues

Tools and Equipment

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

Manage/report hazards, and maintain a safe working environment

Identify and control hazards

Before you can control hazards you need to know what the hazards are. Here are some ways to identify safety and health hazards:

- ✓ Review records of accidents, injuries, illnesses, and close calls
- ✓ review OSHA logs, first aid logs, workers' compensation reports, complaints, and close calls
- ✓ look for trends or common factors in
 - kinds of injuries or illnesses
 - parts of body
 - time of day/shift
 - location
 - equipment
 - protective equipment
 - department
- ✓ Survey employees
- ✓ Review inspection reports from enforcement inspections, insurance surveys, or consultations.

Once you know the hazards, you can decide how to control them.

- ✓ Prioritize the hazards you found
 - Which are most likely to cause serious injury or illness?
 - Which can you fix immediately?
 - Do you have to make long term plans to correct some of the hazards?
- ✓ Make a plan for correcting the hazards
 - Conduct job hazard analysis to identify how best to correct the hazards
 - Find out best practices from companies in your industry
- ✓ Correct the hazards
 - Engineering controls eliminate the hazards through safe tools, facilities, and equipment. These are the best controls.
 - Administrative controls don't remove the hazards; they reduce exposure by changing the work practices. For instance, rotating workers, rest breaks, training programs.
 - Personal protective equipment puts a barrier between the employee and the hazard, using, for example, gloves or safety shoes. If you use personal protective equipment, you have to assess the hazard beforehand and train employees the right way to use the equipment.

- ✓ Evaluate the changes to make sure they have corrected the problem and not created other hazards. And periodically re-survey the work environment and work practices.

Process written records

It is important for students to present carefully prepared written work. Written presentation in industry must be professional in appearance and accurate in content. If students develop good writing skills whilst studying, they are able to easily transfer those skills to the workplace.

Why have a procedure for record keeping?

It is good practice to have an effective method of record keeping on-site. Not only does it assist with successful health and safety management, it is also useful when undertaking audits both internally and externally and when external organisations

There are two main objectives of this procedure:

- ✓ To formalise how documents are held on a site, and
- ✓ To show the retention period for each record.
- ✓ Formalising how documents are held

There should be one area in which records are located; this will usually be in the responsible manager's office and it could be a filing cabinet. It is suggested that a suspension file is utilised for each separate topic/heading. Within the suspension file, the records should either be present or there should be a clear indication of where the records can be found.

Note: It is at the discretion of the responsible manager to decide if plant inspection records are retained within his office or within the workshop environment.

Reports

The reports are useful to study past records of occupancy, cleaning schedules, and predict the future status of the rooms. Let us see the reports generated for housekeeping department:

1. Housekeeping Report

This can be generated at the end of each shift to report the housekeeping status of each room.

2. Housekeeping Occupancy Report

This report shows the list of guests who have checked-in the hotel with details such as number of adults and children, number of nights, and housekeeping status. This report is generated for scheduling rooms for cleaning the work area or maintenance works.

Documents/records that are two-years old or less

Don't bother cleaning out files less than two years old. These are relatively current, and you have a high likelihood of needing to regularly access these files, whether they are senate resolutions, master plan proposals, or board minutes. The multiple copies you keep may also come in handy as you have extras that you can pull and give away as necessary. This also applies to all electronic communications such as emails and attachments. Set up folders in your email program and on your hard disk that parallel your filing system. This will make it easier to find these electronic records.

Documentation needs to be completed in accordance with protocols and procedures.

Your workplace has a legal requirement to complete documentation related to regulations, standards and codes of practice, such as dangerous goods and freight regulations. These may include load limits, health and safety legislation, equal employment legislation and environmental protection regulations. Protocols and procedures are implemented to ensure documentation is legally binding. These procedures must be easy to access in the workplace.

Maintain privacy

If documentation contains personal information, such as names and addresses, you must ensure this information remains private.

Be concise

Complete transport memos, daily diaries and logs efficiently, but accurately. Some workplaces use shorthand or abbreviations. Ensure you know when and how to use these. Unless required, avoid wasting time recording events in excessive detail. Just ensure the relevant information is correctly recorded

Be accurate

Accuracy is important when completing documentation. Names and dates must be spelt and recorded correctly. If you are documenting where and how goods are located or stored, ensure the product is correctly recorded. Inaccuracies can lead to workplace errors, which can cause safety issues, damage to goods and loss of productivity.

Check for quality

Quality assurance checking should be completed each time documentation is completed. This not only provides consistency but also a monitoring system to correct any process issues. Ask your supervisor or a colleague to check for discrepancies.

How to organise information to complete documentation?

Whether documents are one-off incident reports, or regular records of daily activities, it is necessary to ensure information is interpreted correctly and that the right person receives the right information. For example, all staff should know when and how to complete daily activity diaries and when to review them. Transport operators should know when and how to complete transport logs and how to review them. It is also essential to know how to read and respond to a transport memo, SDS or WHS incident report. Important documentation requiring immediate action needs to be readily accessible and the appropriate personnel should be alerted.

Documentation requirements

Workplace documentation requirements

- ✓ Follow privacy protocols.
- ✓ Be accurate and precise.
- ✓ Pay attention to detail.
- ✓ Alert appropriate personnel if required.
- ✓ Store documentation appropriately.

Standard forms

- ✓ Ensure details are accurate.
- ✓ Include relevant details, such as date, time and place of incident.
- ✓ Fill in all required fields.
- ✓ Follow the instructions on the form.
- ✓ Store forms in the appropriate place.

Logs and diaries

- ✓ Complete entries regularly.
- ✓ Keep copies of receipts, such as fuel dockets.
- ✓ Alert supervisor if non-compliance is noted.

UNIT 11

INSTALL CONTROL VALVE ASSEMBLIES, ACTUATING DEVICES AND LOCAL ALARMS

This unit of competency specifies the outcomes required to install control valve assemblies, actuating devices and local alarms for fire protection systems in commercial, industrial, residential and domestic situations

PREPARE FOR WORK

Introduction

Before starting any job, it is important to prepare your project plan. This plan should include all the stakeholders related to the project or the task. Make sure to identify those stakeholders including customers, designers and other relevant authorities. Their interest should be kept in mind when creating a project plan.

Meet the key stakeholders to discuss their need and project expectations, and establish baselines for project scope, budget and timeline. Before starting the plumbing job, architectural drawings and plumbing plans need to be compared to see if there are any discrepancies.

Material purchase plan and project timeline is formulated with reference to drawings and plans. These plans and drawings shall show all valves, controls, instruments and other devices.

Quality of Work

In order to achieve quality work, a quality plan is required. A quality plan is a document, or several documents, that together specify quality standards, practices, resources, specifications, and the sequence of activities relevant to a particular product, service, project, or contract. Quality plans should define:

- ✓ Objectives to be attained (for example, characteristics or specifications, uniformity, effectiveness, aesthetics, cycle time, cost, natural resources, utilization, yield, dependability, and so on).
- ✓ Steps in the processes that constitute the operating practice or procedures of the organization.
- ✓ Allocation of responsibilities, authority, and resources during the different phases of the process or project.
- ✓ Specific documented standards, practices, procedures, and instructions to be applied.
- ✓ Suitable testing, inspection, examination, and audit programs at appropriate stages.
- ✓ A documented procedure for changes and modifications to a quality plan as a process is improved.
- ✓ A method for measuring the achievement of the quality objectives.
- ✓ Other actions necessary to meet the objectives.

Work Plan

Before you begin installation of control valve assemblies, actuating devices and local alarm, you need to check that the design has been submitted to the appropriate authority and approved. The system design may be obtained from your job supervisor. The drawings and specification should be signed and dated and marked as approved for construction, in accordance with the quality assurance procedures.

Gathering information about the job will help you to make informed decisions about the nature of the job and how to plan and sequence the entire process.

Planning your work may include the following steps.

- ✓ Read the drawings and the specification to familiarise yourself with the work.
- ✓ Check the work site against the drawings to confirm orientation and work space.
- ✓ Check for normal work hazards.
- ✓ Check for special hazards, such as working over machinery, high temperatures or working at height.
- ✓ Identify entry and exit points and storage areas.
- ✓ Confirm location of other services, such as air conditioning ducts, that may effect your work.
- ✓ Plan with your supervisor, the builder or other contractors, a cooperative work strategy that avoids conflict.
- ✓ Organise test equipment, compressor and pump.
- ✓ Organise your equipment, such as ladders, scaffolds or scissor lifts and personal safety equipment for safe working.
- ✓ Confirm test timing with builder or representative.

Working with others is an essential part of good work practice. Others may include your supervisor, the builder, other tradespersons, suppliers, union representatives and others.

Tools and Equipment

Installation work can be dangerous if the correct precautions are not taken. Personal protective equipment (PPE) is recommended and is compulsory under most site conditions. Using PPE will help you do your job safely with minimal risk of injury.

It is in your best interest to wear the PPE supplied as appropriate for the task in hand, and to keep the PPE in good order. PPE is designed to protect you from falling objects, crushing toes, noise, dust and grit, sun and rain. Normal PPE supplied and used for installing control valve assemblies and associated work is listed below.

- ✓ Overalls.
- ✓ Boots.
- ✓ Shirts.
- ✓ Hard hat.
- ✓ Safety glasses.
- ✓ Ear muffs or plugs.
- ✓ Safety vests.
- ✓ Bluey (coat).
- ✓ Gloves.
- ✓ Sunscreen.

To work safely and effectively it is important to have the correct tools for the job and to maintain them in good working order. A typical list of tools required for installation work is shown below. You may be required to purchase your own tools, or they may be supplied by your employer. In either case you are responsible for the ongoing maintenance and replacement as required.

- ✓ Tool box.
- ✓ Mash hammer.
- ✓ Claw hammer.
- ✓ Stillsons pipe wrench.
- ✓ shifter adjustable spanner.
- ✓ Hacksaw.
- ✓ Chalk line.
- ✓ Pump bob.
- ✓ Straight tin snips.
- ✓ Ratchet spanner.
- ✓ round/flat file.
- ✓ Flat screw driver.
- ✓ Phillips head screw driver.
- ✓ Cole chisels
- ✓ Deep sockets
- ✓ Tape.
- ✓ Key saw.
- ✓ String line.
- ✓ Pliers.

You will also need to use power tools, cutting, threading or grooving machines. You will be trained to use each item of equipment as required. Do not use any equipment unless you have been instructed in its correct use.

IDENTIFY INSTALLATION REQUIREMENTS

Procurement of material is an important element in project planning and quality control. Material represent a major expense in construction, so minimizing procurement or purchase costs presents important opportunities for reducing costs. Poor materials management can also result in large and avoidable costs during construction.

Materials management is not just a concern during the monitoring stage in which construction is taking place. Decisions about material procurement may also be required during the initial planning and scheduling stages. For example, activities can be inserted in the project schedule to represent purchasing of major items such as elevators for buildings. The availability of materials may greatly influence the schedule in projects with a fast track or very tight time schedule: sufficient time for obtaining the necessary materials must be allowed. In some case, more expensive suppliers or shippers may be employed to save time.

Materials and tools needed for particular task will be selected according to the work plan prepared. Works are planned in sequence, therefore delay or incomplete one task will affect all other tasks.

Control Valves Assembly

The control valve assembly consists of the actuator that opens and closes the valve, positioner that converts electric signals to pneumatic signals, and valve that partially obstructs flow to control a process parameter.

The positioner has a lot of moving parts, but it's typically a box mounted directly to the valve; it hooks up to the instrument air supply; supplies the actuator with air to control valve position; and often provides diagnostic information for the valve.

Meanwhile, the actuator receives a pneumatic signal from the positioner; amplifies the signal to overcome process pressure; and provides a safe failure direction in the event of signal loss, such as "open, closed, last." The two main types of actuators are:

- ✓ **Diaphragm actuators**, in which air pressure acts on a diaphragm with high surface area, and it's opposed by a spring that dictates fail direction. They're low-friction; provide a fast response to small changes (which account for most changes in a process); and have a longer response time for larger changes. They're the process industry standard.
- ✓ **Piston actuators**, which are selected when more thrust or greater stroke length is needed. They can be single-acting or double-acting. While double-acting provides better thrust and is more precise, it also requires a volume tank that needs maintenance, as well as a locking mechanism to fail in any position other than last.

The valve body's primary features include the process connections, such as flange, NPT or wafer, which join it to the pipe; stem that moves the final element to partially obstruct process flow; which is the point where the stream has the lowest surface area. The two main design families are:

- ✓ **Rotary** valves are modulated by a rotating stem, and are generally classified by the design of the closing member. They're full port and free draining, have high capacity

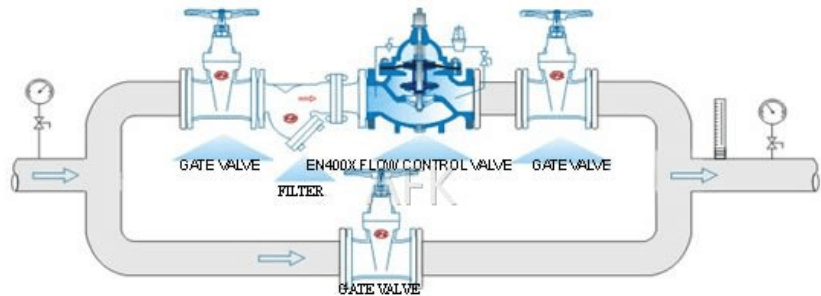
for a given line size, and have a narrower optimal control range. They include butterfly, v-notch ball and eccentric plug valves.

- ✓ **Sliding stem** valves are modulated by moving the stem in a linear fashion. They have lower capacity for a given line size, and a wide control range. Their two varieties are balanced and unbalanced. Unbalanced moves against process pressure, and is easier to seal. Balanced uses holes to transfer pressure, and doesn't require as much force from the actuator, but requires a seal between the plug and the cage.

INSTALL AND TEST SYSTEM COMPONENTS

In case of installing a valve we must know its functions, we must know if it is able to prevent backflow, start the flow, stop the flow, regulate flow, or regulate pressure. Most of the details will be stamped

on the valve body by the manufacturer, like the type of system, operating pressure direction of flow, etc. The operating characteristics of the valve must be known. We must be aware of metal it is made of and the type of end connection it has. Operating characteristics and the material of the valve could affect the service a valve can provide. By checking the end connection we could know if the valve is suited or not for the installation in the system.



The installation of the valve should be done at accessible places and with a proper headroom for better operation. The stem position must be kept upwards whenever it is possible. It is ok if the stem position is horizontal or straight up but the inverted position or the stem pointing downward must be avoided. Before installation, the system should be checked so that we could know if the pressure is on the wrong side of the disk if so it could damage the valve.

Maintenance must be done periodically for valves so that the service life will be better. If a leak is seen then it must be taken care, sometimes it can be done by tightening a packing gland nut. Loose hangers could allow sections of a line to sag. Valves that are used for a long time and subjected to constant service must need gland tightening, replacing or a complete overhaul.

The valve can be checked visually to know if the seat and disk make good contact with each other and this known as spotting valves. Grinding valves grinding can be done manually to remove irregularities by grinding together the contact surfaces of the seat and disk.

Inspection before Starting Operation

Before starting operating of the control valve, check & confirm the following to ensure all conditions are correct and secure.

- ✓ Confirm that the flow direction marked on the control valve conforms with the process fluid flow direction.
- ✓ Confirm that the bolts and nuts of the diaphragm are securely tightened.

- ✓ Confirm that bonnet clamp bolts are securely tightened.
- ✓ Confirm that the yoke clamp bolt is securely tightened.
- ✓ Confirm that the clamp bolts of any accessory devices (positioner, regulator valve, etc.) are securely tightened.
- ✓ Confirm that the air connection to the actuator is securely tightened and there is no air leak.
- ✓ Confirm that the bolts of the stem connector that connect the actuator stem to the valve stem are securely tightened.
- ✓ Confirm that the actuator stem and valve stem are not warped or show any other sign of defect.
- ✓ Confirm that the control valve smoothly operates within its full lift scale range.
- ✓ Confirm that the actuator spring is correctly compressed.
- ✓ Confirm that gland packing bolts are sufficiently tightened.
- ✓ If the control valve employs asbestos packing, it is recommended to lubricate it with the lubricator.
- ✓ If the control valve has a manual handwheel, check that the pointer of the operation nut is at AUTO position and the handwheel is locked.

CLEAN UP

The work site must be cleared of debris.

Cleaning up the work site is not just a matter of appearance, it also concerns safety and health issues. It is good work practice to clean up as you go. Building sites are always short of space and build up of debris will only add to storage, health and safety issues.

- ✓ Most sites will have a site safety committee policy on cleaning up the work site.
- ✓ The disposal areas for site debris should be identified at the site induction, if not find out from your supervisor.
- ✓ Clean up as you go if possible, but at least on a daily and weekly basis and on completion of an installation.
- ✓ Food and drink waste, wrappers and containers should be disposed of in the correct bin, immediately after use as build up attracts vermin and associated health risks.
- ✓ Packaging debris should not be allowed to become a tripping or other hazard. Dispose of it in the correct bin as soon as practicable.
- ✓ Off cuts and surplus material that may be used later in the job should be held in a safe storage area until required.
- ✓ Off cuts and surplus material that are not suitable for re-use should be disposed of in the correct bin at the end of each day's work or sooner if practicable.
- ✓ Do not use cupboards, empty rooms or corners to store rubbish and debris.
- ✓ On completion of an installation check the whole of the work area. Remove materials to the store, tools and equipment to the correct location and rubbish and debris to the correct bins.
- ✓ Sweep the completed work area clean and correctly dispose of sweepings.
- ✓ Tools and equipment must be cleaned, maintained and stored.

UNIT 12

INSTALL AND COMMISSION WATER HEATING SYSTEMS

This unit of competency specifies the outcomes required to install and commission water heaters for domestic and commercial applications

PREPARING FOR WORK

Tools and Supplies

- ✓ Voltage Tester
- ✓ Tubing (pipe) cutter
- ✓ Flexible hoses
- ✓ Pipe Dope or Plumbers Tape
- ✓ Wrench and Screwdriver
- ✓ Sandpaper cloth
- ✓ Soldering Flux with torch & solder wire
- ✓ Dielectric Connectors

IDENTIFY INSTALLATION REQUIREMENTS

The requirements are only for new or replacement water heaters. Working water heaters don't need to be replaced.

For most homes, it means installing:

- ✓ a low emission water heater, such as a high efficiency gas, solar or electric heat pump system
- ✓ water efficient shower heads or flow restrictors.

These requirements don't apply if the water heater installation is:

- ✓ non-residential, eg for a commercial building, shop, school, or office
- ✓ an electric or gas gravity-fed water heater of up to 250 litres installed in a roof space
- ✓ a like-for-like replacement under warranty
- ✓ only supplying a shed, garage or swimming pool
- ✓ a temporary electric water heater of up to 55 litres that is providing water heating for up to 60 days while waiting for a new, compliant water heater to be installed
- ✓ a secondary electric water heater of up to 55 litres that isn't supplying a shower or bath
- ✓ shared between multiple units, flats or apartments in a multi-storey building
- ✓ repairing or replacing a single major component of a solar or electric heat pump.

These requirements only apply to the installation of new water heaters or the replacement of old water heaters. Under no circumstances do working water heaters need to be replaced.

In many situations, these requirements will require:

- ✓ low greenhouse gas emission (low emission) water heaters to be installed, such as high-efficiency gas, solar or electric heat pump water heaters
- ✓ the shower outlets connected to the installed water heater to have a water efficient showerhead or flow restrictor.

What type of building will the water heater supply?

Building classifications

Class 1A: Single detached dwelling or two or more attached dwellings separated by a fire-resistant wall, including a maisonette, row house, townhouse, and single-storey flats or units.

Class 1B: Boarding/guest house or hostel not exceeding 300m² with no more than 12 residents.

Class 2: Multi-storey building containing two or more sole-occupancy units, where each is a separate dwelling.

Water Heating Equipment

There are several different types of equipment used for producing domestic hot water. Any water heater type used for compliance must be recognized under the appliance regulations. The most commonly used water heater for single family homes is either small storage gas or instantaneous (tankless) gas units.

1. Small Storage Gas Water Heaters

Storage water heater means a water heater that heats and stores water within the appliance at a thermostatically-controlled temperature for delivery on demand, and that has an input less than 4,000 Btu per hour per gallon of stored water.

Small Storage Water Heater is defined as a water heater that is a gas storage water heater with an input of 75,000 Btu per hour or less, an oil storage water heater with an input of 105,000 Btu per hour or less, an electric storage water heater with an input of 12 kW or less. All small storage water heaters are rated using an Energy Factor. This value represents the combination of the units firing efficiency and standby loss over a 24 hour period.

2. Large Storage Gas

Large Storage Gas is a storage gas water heater with input capacity greater than 75,000 Btu/h. They are rated with an AFUE and either a total standby loss numeric value or a percent standby loss.

3. Small Storage Electric

A Storage Electric water heater is an electric water heater designed to heat and store water at less than 180°F. Water temperature is controlled with a thermostat. Storage electric water heaters have a manufacturer's specified storage capacity of at least two gallons.

4. *Storage Heat Pump*

A Storage Heat Pump is an electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps or controls

5. *Instantaneous (Tankless) Gas*

Instantaneous gas water heaters are defined as a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water. These units, commonly referred to as gas tankless water heaters, operate their burner in response to water flow heating the water flowing through the heat exchanger (typical volumes around 0.5 gallons). The main efficiency benefit associated with these units is the elimination of standby losses common to storage water heaters. Virtually all of these units require an electrical connection for controls and combustion air blower.

6. *Instantaneous (Tankless) Electric*

An Instantaneous Electric water heater is an electric water heater controlled automatically by a thermostat, with a manufacturer's specified storage capacity of less than 2 gallons.

7. *Hot Water Supply Boiler*

A hot water supply boiler is industrial water heating equipment with a heat input rate from 300 kBtu/hr to 12,500 kBtu/hr and at least 4,000 Btu/hr per gallon of stored water. A hot water boiler should have either the temperature and pressure control necessary for heating potable water for purposes other than space heating, or the boiler manufacturer's literature should indicate that the boilers' intended uses include heating potable water for purposes other than space heating. A hot water boiler could be fueled by oil or gas, and it must adhere to the minimum thermal efficiency and maximum standby loss as described in California's Title 20 Appliance Standards in effect.

Mandatory Requirements for Water Heaters

1. Equipment Certification

Manufacturers must certify that their products comply with the Appliance Efficiency Regulations that are practices across Europe and other developed nations.

Type	Size	Energy Factor (EF) (Effective date January 1, 2014)	Energy Factor (EF) (Effective date April 16, 2015)
Gas Storage (≤ 55 gallons)	≤ 75 Btu/hr	0.67-(0.0019*V)	0.675-(0.0015*V)
Gas Storage (> 55 gallons)	≤ 75 kBtu/hr	0.67-(0.0019*V)	0.8012 – (0.00078*V)
Gas Instantaneous	≤ 200 kBtu/hr	0.62	0.82
Oil Storage	≤ 105 kBtu/hr	0.59-(0.0019*V)	0.68-(0.0019*V)
Oil Instantaneous	≤ 210 kBtu/hr	0.59-(0.0019*V)	--
Electric Storage (≤ 55 gallons, exc. table top)	≤ 12 kW	0.97-(0.00132*V)	0.96-(0.0003*V)
Electric Storage (> 55 gallons, exc. table top)	≤ 12 kW	0.97-(0.00132*V)	2.057 – (0.0013 *V)
Electric Table Top	≤ 12 kW	0.93-(0.00132*V)	No change
Electric Instantaneous (exc. table top)	≤ 12 kW	0.93-(0.00132*V)	No change
Heat pump Water Heater	≤ 24 Amps	0.97-(0.00132*V)	See Electric Storage >55 gallons

2. Equipment Efficiency

Many countries have established standards for equipment efficiency although it's not the same in the Maldives. The efficiency requirements for such equipment are given in the below table. Across Europe and other developed nations, classifying storage water heaters are divided into two categories: ≤ 55 gallons volume, and > 55 gallons. The larger volume units will require higher performance. For gas water heaters with > 55 gallon storage volume, the efficiency levels dictate condensing performance, while for electric storage water heaters > 55 gallons, the efficiency level suggest performance comparable to a heat pump water heater.

The energy efficiency of equipment can be visualized from the table below

Appliance	Input to Volume Ratio	Size (Volume)	Minimum Thermal Efficiency (%)	Maximum Standby Loss ^{1,2}
Gas storage water heaters	$< 4,000 \text{ Btu/hr/gal}$	any	80	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Gas instantaneous water heaters	$\geq 4,000 \text{ Btu/hr/gal}$	$< 10 \text{ gal}$	80	–
		$\geq 10 \text{ gal}$	80	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Gas hot water supply boilers	$\geq 4,000 \text{ Btu/hr/gal}$	$< 10 \text{ gal}$	80	–
		$\geq 10 \text{ gal}$	80	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Oil storage water heaters	$< 4,000 \text{ Btu/hr/gal}$	any	78	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Oil instantaneous water heaters	$\geq 4,000 \text{ Btu/hr/gal}$	$< 10 \text{ gal}$	80	–
		$\geq 10 \text{ gal}$	78	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Oil hot water supply boilers	$\geq 4,000 \text{ Btu/hr/gal}$	$< 10 \text{ gal}$	80	–
		$\geq 10 \text{ gal}$	78	$Q/800 + 110(V_r)1/2 \text{ Btu/hr}$
Electric storage water heaters	$< 4,000 \text{ Btu/hr/gal}$	any	–	$0.3 + 27/V_m \%/\text{hr}$
<p>1. Standby loss is based on a 70° F temperature difference between stored water and ambient requirements. In the standby loss equations, V_r is the rated volume in gallons, V_m is the measured volume in gallons, and Q is the nameplate input rate in Btu/hr.</p> <p>2. Water heaters and hot water supply boilers having more than 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R-12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.</p>				

3. Storage Tank Insulation

Any unfired tanks (used as a back-up for solar water heating or as storage for a boiler) must either be insulated externally with a label indicating the tank is internally insulated with. Alternatively, a tank can comply with this mandatory measure if calculations are provided that show that the average heat loss is less than 6.5 Btu/hr-ft^2 when there is a temperature difference of 80°F between the water in the tank and the ambient air.

4. High Efficiency Water Heater Ready

In order to facilitate future installations of high efficiency equipment, the Standards has implemented the following requirements for systems using gas or propane water heaters to serve individual dwelling units:

1. A 120 V electrical receptacle that is within three feet of the water heater and accessible to the water heater with no obstructions; and,
2. A Category III or IV vent, or a Type B vent with straight pipe between the outside termination and the space where the water heater is installed; and,
3. A condensate drain that is no more than 2 inches higher than the base of the installed water heater, and allows natural draining without pump assistance, and,
4. A gas supply line with a capacity of to provide at least 200,000 Btu/hr to the water heater.

These requirements make it easier for someone to retrofit high efficiency gas water heaters in the future. Virtually all high efficiency gas water heaters require an electrical connection and wiring during initial construction stage is much less costly than trying to retrofit it later. Table below summarizes venting requirements for different types of water heaters.

Appliance Venting Category	Vent Pressure	Condensing or Non-Condensing	Common Vent Pipe Material
Category I: An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Non-positive; atmospheric vented; gravity vented; most common category of gas-fired water heaters.	Non condensing (typically less than 82% efficiency)	Metal double wall "B" vent
Category II: An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent	Non-positive	Condensing	Special venting material per the product manufacturer
Category III: An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Positive (usually created by a blower motor); generally cannot be adjoined to gravity-vented water heater.	Non condensing (typically less than 82% efficiency)	Stainless Steel; these usually require 3" clearance to combustibles and the joints must be sealed air tight.
Category IV: An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Positive (usually created by a blower motor); generally cannot be adjoined to gravity-vented water heater.	Condensing	Plastic pipe (PVC, CPVC, ABS, etc.)

INSTALL, COMMISSION AND MAINTAIN SYSTEM

Step 1

Turn OFF the electricity to your water heater at the circuit breaker panel.

Check the water heater wiring with a voltage tester to make sure that the unit is off. *This is not covered in the video below, but you should always check that the water heater is not receiving any electricity after shutting it off at the circuit breaker before working on it.*

Step 2

Open a hot water faucet and allow the water to run until it is cold. *This step is not covered in the video, however, it will ensure that you'll be able to safely drain the tank without being scalded.*

Shut off the cold water supply to the water heater (located at the top of the unit).

Connect a hose to the water heater's drain valve. Open the valve and drain the tank outside (or to a floor drain, or even into buckets).

If you closed the hot water faucet in Step 1, you should open it again. You can also open the T&P valve. This will help the water drain faster by allowing air into the tank.

Step 3

Disconnect the electrical wires on the top of the water heater. Be sure that you turned off the circuit breaker at the breaker box first. Then, before starting, check the wires with a voltage tester.

Cap the wires off and label (or take a picture) of them to avoid any future confusion when you are hooking your new water heater up.

Step 4

Disconnect the hot and cold water supply lines. If your water heater was plumbed with copper piping, you may need to cut the pipes. If you need to cut the pipes, use a tubing (pipe) cutter and leave as much of the pipe as possible.

If the T&P discharge pipe is in good repair you can remove it from the T&P valve and reuse it on your new water heater.

Step 5

Once the tank is empty, remove the old water heater with a dolly.

Move the new tank into place.

Check that your electrical supply will adequately reach the tank. Double check that you can access the panels and the drain valve for maintenance.

Step 6

If your old water heater used copper piping, and it was necessary to cut the pipes, you'll need to prepare the pipes using sandpaper cloth. Rub the sandpaper cloth on the ends of the pipes until they shine brightly.

Step 7

Remove the junction box cover to access the electrical wires.

Attach the ground wire to the green ground screw. Connect the other wires together by twisting them with wire connectors. Use the previous wire connections as a guide and connect the wires in the same way you removed them. Follow your label tags, or the picture you took, from Step 3. Then replace the junction box cover.

Step 8

Connect the hot and cold water supply lines. Be sure to connect the cold water pipe to the cold water inlet on the water heater (it's easy to make the mistake of connecting the cold to the hot).

If your old water heater used copper piping, you may choose to plumb it with copper piping again. However, we highly recommend using flexible hoses to make the connections. Not only is it easier, but it's a recommended safety feature for earthquakes. *Your plumbing will vary depending on your original configuration and your preference.*

Attach the flexible hoses to the nipples on the water heater. In most cases, you'll need to line the threads with plumbers tape. We recommend using dielectric connectors to attach the flexible hoses to the hot and cold water pipes. These fittings will help reduce the corrosion between the two different metals.

Check the flexible hose connections for leaks by turning on the hot water tap at the nearest faucet. Then turn on the cold water supply to your water heater. *This step is not covered in the video, but we recommend double-checking your plumbing **before** moving forward.* If there are no leaks, continue to fill your water heater tank with water.

Once the tank is full, water will begin to flow out of the hot water tap.

Step 9

Install the discharge pipe to the T&P valve. The end of the pipe needs to be within 6 inches of the floor.

- ✓ Use a 3/4" male copper fitting.
- ✓ Paint pipe dope onto the outside of the fitting and the inside of the valve fitting.
- ✓ Attach the fitting to the T&P valve fitting and tighten.
- ✓ Clean the fitting the end of the pipe.
- ✓ Paint soldering flux on the inside of the male fitting and the outside of the pipe.
- ✓ Attach the pipe to the fitting.
- ✓ Use solder and a torch to connect the pipe.

Step 10

After your water heater tank has filled with water, turn on the circuit breaker at the main power box. CAUTION: Turning on the power *before* the tank has completely filled can cause the electric elements to dry fire if they are not fully submerged. This can ruin your electric heating elements.

If your water heater isn't getting power, be sure to turn off the circuit breaker BEFORE checking the electrical connections on the water heater.

Step 11

To eliminate the air in the tank and plumbing, allow the hot water tap to run for a few minutes until it stops "sputtering".

It may take a few hours before the water within the tank to become fully heated.

The recommended temperature setting is 120° Fahrenheit.

Wait a couple of hours and check the T&P discharge pipe. If the pipe is dripping, the pressure may be too high.

CLEAN UP

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally. Periodic "panic" cleanups are costly and ineffective in reducing incidents.

What is the purpose of workplace housekeeping?

Poor housekeeping can be a cause of incidents, such as:

- ✓ tripping over loose objects on floors, stairs and platforms
- ✓ being hit by falling objects
- ✓ slipping on greasy, wet or dirty surfaces
- ✓ striking against projecting, poorly stacked items or misplaced material
- ✓ cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

What are some benefits of good housekeeping practices?

Effective housekeeping results in:

- ✓ reduced handling to ease the flow of materials
- ✓ fewer tripping and slipping incidents in clutter-free and spill-free work areas
- ✓ decreased fire hazards
- ✓ lower worker exposures to hazardous products (e.g. dusts, vapours)
- ✓ better control of tools and materials, including inventory and supplies
- ✓ more efficient equipment cleanup and maintenance
- ✓ better hygienic conditions leading to improved health
- ✓ more effective use of space
- ✓ reduced property damage by improving preventive maintenance
- ✓ less janitorial work
- ✓ improved morale
- ✓ improved productivity (tools and materials will be easy to find)

How do I plan a good housekeeping program?

A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling. The plan also makes sure that work areas are not used as storage areas by having workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organization must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this is done. A good housekeeping program identifies and assigns responsibilities for the following:

- ✓ clean up during the shift
- ✓ day-to-day cleanup
- ✓ waste disposal
- ✓ removal of unused materials
- ✓ inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

What are the elements of an effective housekeeping program?

Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. So it is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep and repair of tools, equipment, machines and processes.

Dust and Dirt Removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibreglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

Employee Facilities

Employee facilities need to be adequate, clean and well maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed.

If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home.

Smoking, eating or drinking in the work area should be prohibited where hazardous products are handled. The eating area should be separate from the work area and should be cleaned properly each shift.

Surfaces

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

Walls: Light-coloured walls reflect light while dirty or dark-coloured walls absorb light. Contrasting colours warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colours.

Maintain Light Fixtures

Dirty light fixtures reduce essential light levels. Clean light fixtures can improve lighting efficiency significantly.

Aisles and Stairways

Aisles should be wide enough to accommodate people and vehicles comfortably and safely. Aisle space allows for the movement of people, products and materials. Warning signs and mirrors can improve sight-lines in blind corners. Arranging aisles properly encourages people to use them so that they do not take shortcuts through hazardous areas.

Keeping aisles and stairways clear is important. They should not be used for temporary "overflow" or "bottleneck" storage. Stairways and aisles also require adequate lighting.

Spill Control

The best way to control spills is to stop them before they happen. Regularly cleaning and maintaining machines and equipment is one way. Another is to use drip pans and guards where possible spills might occur. When spills do occur, it is important to clean them up immediately. Absorbent materials are useful for wiping up greasy, oily or other liquid spills. Used absorbents must be disposed of properly and safely.

Tools and Equipment

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

Waste Disposal

The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities.

Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier. All waste receptacles should be clearly labelled (e.g., recyclable glass, plastic, scrap metal, etc.).

Storage

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one metre (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. All storage areas should be clearly marked.

Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction.

Documentation needs to be completed in accordance with protocols and procedures.

Your workplace has a legal requirement to complete documentation related to regulations, standards and codes of practice, such as dangerous goods and freight regulations. These

may include load limits, health and safety legislation, equal employment legislation and environmental protection regulations. Protocols and procedures are implemented to ensure documentation is legally binding. These procedures must be easy to access in the workplace.

Maintain privacy

If documentation contains personal information, such as names and addresses, you must ensure this information remains private.

Be concise

Complete transport memos, daily diaries and logs efficiently, but accurately. Some workplaces use shorthand or abbreviations. Ensure you know when and how to use these. Unless required, avoid wasting time recording events in excessive detail. Just ensure the relevant information is correctly recorded.

Be accurate

Accuracy is important when completing documentation. Names and dates must be spelt and recorded correctly. If you are documenting where and how goods are located or stored, ensure the product is correctly recorded. Inaccuracies can lead to workplace errors, which can cause safety issues, damage to goods and loss of productivity.

Check for quality

Quality assurance checking should be completed each time documentation is completed. This not only provides consistency but also a monitoring system to correct any process issues. Ask your supervisor or a colleague to check for discrepancies.

How to organise information to complete documentation?

Whether documents are one-off incident reports, or regular records of daily activities, it is necessary to ensure information is interpreted correctly and that the right person receives the right information. For example, all staff should know when and how to complete daily activity diaries and when to review them. Transport operators should know when and how to complete transport logs and how to review them. It is also essential to know how to read and respond to a transport memo, SDS or WHS incident report. Important documentation requiring immediate action needs to be readily accessible and the appropriate personnel should be alerted.

Documentation requirements

Workplace documentation requirements

- ✓ Follow privacy protocols.
- ✓ Be accurate and precise.
- ✓ Pay attention to detail.

- ✓ Alert appropriate personnel if required.
- ✓ Store documentation appropriately.

Standard forms

- ✓ Ensure details are accurate.
- ✓ Include relevant details, such as date, time and place of incident.
- ✓ Fill in all required fields.
- ✓ Follow the instructions on the form.
- ✓ Store forms in the appropriate place.

Logs and diaries

- ✓ Complete entries regularly.
- ✓ Keep copies of receipts, such as fuel dockets.
- ✓ Alert supervisor if non-compliance is noted.

UNIT 13

TEST AND MAINTAIN FIRE HYDRANT AND HOSE REEL INSTALLATIONS

This unit of competency specifies the outcomes required to test and maintain fire hydrant and hose reel installations in commercial and domestic situations. The unit requires the conduct of routine testing and maintenance of fire hydrant and hose reel installations in the full range of domestic and commercial situations

Introduction

The fire hydrant is one of the most important parts of a water distribution system but is often one of the most ignored. Hydrants stand idle for long periods of time and are subject to the effects of weather and the elements and are vulnerable to damage, but they are expected to work well in emergencies. To ensure that hydrants will operate correctly when they are needed, the proper procedures must be followed when they are inspected, installed, tested, and maintained.

PREPARE FOR WORK

Hydrants should be inspected at the time of delivery to verify compliance with specifications and to check for damage during shipment. Specifications to be checked during the initial inspection include the size and shape of the operating nut and its direction to open, depth of bury, size and type of inlet connection, size of the main valve (for a dry-barrel hydrant) or valve washer (for a wet-barrel hydrant), outlet nozzle sizes and configuration, and thread style. The hydrant should be cycled to full open and full closed positions to ensure that no internal damage or breakage has occurred during shipment and handling. All external bolts should be checked for tightness. Shortly after delivery, hydrants should be pressure and leak tested on a statistically sampled basis. It is not uncommon for outlet nozzles and pressure bolting to loosen as a result of handling during shipping and storage. Loose nozzles or pressure bolting may cause leakage during a pressure test. Tightening the flange bolting, the caulking of leaded-in nozzles, and the tightening of threaded-in nozzles will prevent or eliminate minor leaks. In most cases, tightening is all that is needed to achieve a satisfactory pressure test.

After inspection, the hydrant valve should be closed and the outlet-nozzle caps replaced to prevent the entry of foreign matter. Hydrants should be stored with the inlets facing down. Whenever possible, hydrants in storage should be protected from the effects of weather and the elements.

Hydrants should be re-inspected just before installation.

PERFORM ROUTINE MAINTENANCE

Fire hose reels have become less common in recent years and Fire Authorities are recommending that they be removed and replaced with alternative means of firefighting such as portable fire extinguishers, however in some situations fire hose reels remain the only option. Where this is the case, they still must be maintained to ensure that they remain in an operable condition and can be relied upon in the event of fire.

Routine Maintenance

Servicing of fire hose reels is depend on the manufacture guidelines and this requires that during the service ,a flow rate test and a pressure test is conducted and recorded on a service label attached to the reel. In addition, the hose itself must be pressure tested every five years. We are happy to service all types of fire hose reels and can obtain spares from most manufacturers that are still producing them. M-Fire can service, maintain, repair, replace and install fire hose reels. It can even be done at the same time as other fire safety systems such as fire alarms and fire extinguishers saving you money.

REPAIR AND REPLACE FAULTY COMPONENTS AND TEST JOB

Any condition that cannot be repaired easily during routine inspection should be recorded in the inspection report. The problem should be reported to repair crews for action. Leakage, broken parts, bad operation, corrosion, and other major defects should be repaired as soon as possible after the defect is reported. If repairs are to be performed in the field, the repair crew should take a full complement of repair parts to the job site.

NOTE: Before any repair takes place, the fire department must be notified of the outage.

To obtain the exact procedure for disassembly and repair of a specific hydrant, refer to the manufacturer's maintenance manual. The following information is to be used as a general guideline. If it appears to conflict with the manufacturer's recommendations, the manufacturer's recommendations should be followed.

1. Close the auxiliary valve ahead of the hydrant or use another means to cut off flow and pressure to the hydrant. CAUTION: Before proceeding, open the hydrant main valve a few turns to make certain pressure to the hydrant has been cut off.
2. Disassemble the hydrant in accordance with the manufacturer's recommendations.
3. Replace damaged parts and parts that show wear, corrosion, or signs of incipient failure. Always replace all gaskets, packing, and seals.
4. Reassemble the hydrant and open the auxiliary valve (or otherwise pressurize the hydrant). Test the main valve for leakage.
5. Vent the air from the hydrant and put the entire hydrant under pressure. Check for leakage, ease of operation, and drainage.
6. Always record the repair and operating condition of the hydrant after completion of the repairs. Notify the fire department after completion of the repair.

Fault finding

1. No Water: During your service procedure, and you have checked the arrow direction on the Control Valve. You hear water entering the system but little or none is coming out of the Nozzle. Remove nozzle: Water flows: Unblock or Replace Nozzle.
2. Missing or broken mounting bolts: Fit missing bolt or remove frame and remove broken bolt. If there is a joint under the Control Valve you should be able to swing the reel assembly forward (remove hose to reduce weight) without switching off at the mains. If there is no joint you will have to report to the Responsible Person
3. Control Valve fitted with the arrow direction facing the wrong way: As this is a one-way valve remove all service labels and mark no water. Report to the responsible person.
4. Leaking Reel after service: In this case you may not pick up a problem during the service, and it may only appear a few days, weeks later. If you have serviced unit correctly, and the seal is not broken the problem is the Control Valve washer. This is not part of the service (Inspection only during service) Report to the responsible person. If you do intend to repair it you will have to have the water switched off at the mains. It is very important that everybody that is going to be effect with the water being switched off is informed. You should ensure that the Responsible

person takes this responsibility, and not yourself or your company. Once water is off on the modern Control Valves it's as simple as changing a tap washer, and on the older type the whole unit will have to be replaced.

5. Waterway Leaks: You have two types of water ways "O"Ring and Gland Packing.

O" Ring Type: Ensure as much water has been drained

1. Remove Hose.
2. Remove drum and waterway assembly
3. Remove the three screw from the front plate behind the instruction label
4. Remove the waterway from the drum
5. Remove the circlip from the recess, and pull out the shaft
6. Remove the old "O" rings, and clean the shaft / body
7. Refit new "O" rings, lubricate, and refit shaft
8. Refit the circlip ensuring correctly site in the grove. (failure to do this, and the drum will fly off under pressure)
9. Refit waterway to the drum with the three screws
10. Use thread tape for the threaded part of the shaft, and refit to the header bracket
11. Refit hose, and slowly open the Control Valve.

At this stage there will be a slight leak until the waterway has bedded in. Once leak has stopped close the Control Valve and release the water pressure. Repeat, and ensure leaks have stopped. Carry on and complete the service

Some buildings have their fire circuits connected to the fire department, and or the warning alarm go off once you release water from the fire protection arrangement. Also especially high rise building parts or all of the system is supplied from tank usually situated on the top of the building. Once you open a valve and release the water during testing. The pump kicks in and keeps the tank topped up. If this pump doesn't kick in you will only be getting static water pressure, and may get the readings required throughout the building. You will assume the service work is to the standards required. But in fact you have depleted the water in the tank, and should there be an incident the equipment will not work.

Before you start you must pose all the above questions to the client. If you find the pump switched off or the tank inlet valve in the closed position. Ask the question why. If the answer is they do not know why – Then tell them to find out before you perform any work. There might be a leak or other fault for the protection system to be switched off. If the client tells you to just turn the equipment on – Refuse, and tell them they must perform this task of switching on. (You flood the place – They will hold you and your company responsible for any damage caused). Also if the alarms go off and there is a feed back to the Fire Department – You and your company will be responsible for the call out fees.

If at any time you switch the water supply to any fire protection equipment

1. The fire department should be informed
2. The client needs to inform the insurance company and anybody who is going to be affected by the switch off.

CLEAN UP

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally. Periodic "panic" cleanups are costly and ineffective in reducing incidents.

What is the purpose of workplace housekeeping?

Poor housekeeping can be a cause of incidents, such as:

- ✓ tripping over loose objects on floors, stairs and platforms
- ✓ being hit by falling objects
- ✓ slipping on greasy, wet or dirty surfaces
- ✓ striking against projecting, poorly stacked items or misplaced material
- ✓ cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

What are some benefits of good housekeeping practices?

Effective housekeeping results in:

- ✓ reduced handling to ease the flow of materials
- ✓ fewer tripping and slipping incidents in clutter-free and spill-free work areas
- ✓ decreased fire hazards
- ✓ lower worker exposures to hazardous products (e.g. dusts, vapours)
- ✓ better control of tools and materials, including inventory and supplies
- ✓ more efficient equipment cleanup and maintenance
- ✓ better hygienic conditions leading to improved health
- ✓ more effective use of space
- ✓ reduced property damage by improving preventive maintenance
- ✓ less janitorial work
- ✓ improved morale
- ✓ improved productivity (tools and materials will be easy to find)

How do I plan a good housekeeping program?

A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling. The plan also makes sure that work areas are not used as storage areas by having workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organization must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this is done. A good housekeeping program identifies and assigns responsibilities for the following:

- ✓ clean up during the shift
- ✓ day-to-day cleanup
- ✓ waste disposal
- ✓ removal of unused materials
- ✓ inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

What are the elements of an effective housekeeping program?

Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. So it is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep and repair of tools, equipment, machines and processes.

Dust and Dirt Removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibreglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

Employee Facilities

Employee facilities need to be adequate, clean and well maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed.

If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home.

Smoking, eating or drinking in the work area should be prohibited where hazardous products are handled. The eating area should be separate from the work area and should be cleaned properly each shift.

Surfaces

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

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UNIT 14

APPLY INDUSTRIAL ELECTRICAL SKILLS

This unit covers installing and testing electrical wiring and circuits and conduct workplace tasks required to undertake inspection, diagnosis and repair of electrically operated equipment and systems

PLAN AND PREPARE FOR INSTALLATION

If your career in the electrical industry is to be a long, happy and safe one, you must always wear appropriate PPE such as footwear and head protection and behave responsibly and sensibly in order to maintain a safe working environment. Before starting work, make a safety assessment; what is going to be hazardous, will you require PPE, do you need any special access equipment?

Construction sites can be hazardous because of the temporary nature of the construction process. The surroundings and systems are always changing as the construction process moves to its completion date when everything is finally in place.

Safe methods of working must be demonstrated by everyone at every stage. 'Employees have a duty of care to protect their own health and safety and that of others who might be affected by their work activities.'

To make the work area safe before starting work and during work activities, it may be necessary to:

- ✓ use barriers or tapes to screen off potential hazards;
- ✓ place warning signs as appropriate;
- ✓ inform those who may be affected by any potential hazard;
- ✓ use a safe isolation procedure before working on live equipment or circuits;
- ✓ obtain any necessary 'permits to work' before work begins. Get into the habit of always working safely and being aware of the potential hazards around you when you are working.

Having chosen an appropriate wiring system which meets the intended use and structure of the building and satisfies the environmental conditions of the installation, you must install the system conductors, accessories and equipment in a safe and competent manner.

The structure of the building must be made good if it is damaged during the installation of the wiring system. For example, where conduits and trunking pass through walls and floors. All connections in the wiring system must be both electrically and mechanically sound and accessible for testing and inspection (IET Regulations 131.14 and 526.3). All conductors must be chosen so that they will carry the design current under the installed conditions.

If the wiring system is damaged during installation it must be made good to prevent future corrosion. For example, where galvanized conduit trunking or tray is cut or damaged by pipe vices, it must be made good to prevent localized corrosion.

All tools must be used safely and sensibly. Cutting tools should be sharpened and screwdrivers ground to a sharp, square end on a grindstone.

It is particularly important to check that the plug top and cables of handheld electrically powered tools and extension leads are in good condition. Damaged plug tops and cables must be repaired before you use them. All electrical power tools of 110 and 230 V must be tested with a portable appliance tester (PAT) in accordance with the company's health and safety procedures, but probably at least once each year.

Tools and equipment that are left lying about in the workplace can become damaged or stolen and may also be the cause of people slipping, tripping or falling. Tidy up regularly and put power tools back in their boxes (called 'good housekeeping'). You personally may have no control over the condition of the workplace in general, but keeping your own work area clean and tidy is the mark of a skilled and conscientious craftsman.

You have a responsibility to comply with health and safety regulations to:

- ✓ learn how to work safely and to follow company procedures of work;
- ✓ obey all safety rules, notices and signs;
- ✓ not interfere with or misuse anything provided for safety;
- ✓ report anything that seems damaged, faulty or dangerous;
- ✓ behave sensibly, not play practical jokes and not distract other people at work;
- ✓ walk sensibly and not run around the workplace;
- ✓ use the prescribed walkways;
- ✓ drive only those vehicles for which you have been properly trained and passed the necessary test;
- ✓ not wear jewelry which could become caught in moving parts if you are using machinery at work;
- ✓ always wear appropriate clothing and PPE if necessary.

Marking Out the Work On-Site

When the electrician arrives on-site to begin the work, that is, installing the trunking, conduit or cables and boxes to the final fixing positions in the building, they will need to know what is being installed and exactly where it is being installed.

On a larger job they will probably be given a site plan or layout drawing. This is a scale drawing based upon the architect's site plan of the building and will show the position of the electrical equipment to be installed.

The electrical equipment will be identified by graphical symbols on the plan. The drawing will be to scale, and if we say the scale was 1:100, then 10 mm or 1cm on the site plan will represent 1m in the building. The electrician can take measurements from the drawing and transfer these to the building, probably using a retractable steel rule. They can then mark on the walls of the building with a piece of chalk or a marker the final positions of the electrical equipment which is to be installed.

If the job is a small one the electrician's supervisor or foreman may walk them around the site showing them what is to be installed and where. On a very small job it might be the customer who describes what is to be done by the electrician. When the electrician knows what is required, they can begin to plan out cable routes and mark out where they will install their trunking and conduits, cables or tray.

Trunking, conduits, cables and tray must be installed securely, but most of all they must be installed horizontally or vertically for a professional finish. A long spirit-level is very useful in determining what is horizontal and vertical, although a plumb-line can also be used to determine the vertical. A plumb-line is a piece of string with a steel weight attached to the bottom. Holding the string up against a wall, the steel weight at the bottom will initially swing like a pendulum, but quickly come to rest in a true vertical line. If a little chalk is first rubbed onto the line, it becomes a chalk line. If an assistant holds the steel weight in its rest position so that the line presses against the wall, and then plucks the string so that it bounces against the wall, the chalk will transfer to the wall, leaving a true vertical line on the wall.

When the measuring and marking out is completed, the electrician can begin the process of installing the trunking, conduits, cables or tray, using the hand tools and power tools described previously in this chapter.

Selection of Power Cables

Selection of Power cables for given purpose depends on a number of factors. Hence selection of it is never a simple task. Selection is also made difficult as there is such a large variety of cables available in the market.

Through this article we will see some of the important factors that determine selection of Power Cables.

Rated Voltage

It is necessary to select a power cable capable of supporting a particular system voltage.

In case of AC system, the rated voltage of power cable should always be equal to or greater than the system voltage.

To determine rated voltage consider following formula:

If V_0 is the rated cable voltage between each conductor and earth,
Then, V is the cable rated voltage between phase conductors, expressed as:
$$V = \sqrt{3} V_0$$

The exact rated voltage selection of power cable depends on earth fault withstand limits and specifications considerations that are made by the power system designers.

As per IEC standards following three classifications exist:

- ✓ Category A: The earth fault must be cleared within 1 second
- ✓ Category B: Earth fault cleared within 1 hour for IEC-183 type cables, and cleared within 8 hours for IEC-502 type cables
- ✓ Category C: All systems not covered under A and B

For categories A and B – cables with same rated voltage as system voltage can be chosen.

However, for Category C, the rated voltage of cable should be higher than system voltage. e.g. for 3.3 kV system voltage, a 6.6 kV rated voltage cable should be selected.

Current Carrying Capacity

Each power cable is designed to operate under certain temperature conditions.

Current carrying capacity of power cable is also dependent on conductor material (Copper / Aluminium) and insulation type.

Thus, Copper conductor cable has greater current carrying capacity than Aluminium.

XLPE insulation is better than PVC, hence the current carrying capacity of XLPE cable is more than that of PVC insulated cable.

Operating a cable continuously beyond its rated current carrying capacity shortens the lifespan of the cable, as the insulation becomes prone to failure.

The current carrying capacity is also dependent on operating temperature. Higher the temperature, lower is the current carrying capacity of the cable and vice versa.

Derating Factor

A power cable designed with standard operating conditions may not operate so in practical. Therefore, the current carrying capacity may get impacted due to this.

Some examples of this: Cables installed deep under the ground will have reduced current carrying capacity than cables installed in air. This is impacted due to multiple factors like soil temperature, soil thermal resistivity etc.

In order to deal with this, a Derating Factor is associated with cables to arrive at actual value of current carrying capacity.

Actual Current Carrying Capacity = Derating Factor x Cable current carrying capacity under std. conditions.

Thus for a 100 A cable with a derating factor of 0.8 the actual current carrying capacity would be: $0.8 \times 100 = 80 \text{ A}$

Voltage Drop

A power cable manufacturer provides this as part of their data sheet. A voltage drop across the length of the power cable is very important. It is expressed as: mV / A-m.

The voltage drop per unit length of cable should as minimum as possible so as to get voltage at delivery end approximately same as supply side.

Short circuit Withstand

A power cable in case of short circuit event should be able to withstand the high current values without any damage to the cable and insulation.

The selection of short circuit current withstand capacity of a power cable is directly dependent on the specification of connected protection device.

E.g. if a breaker connected to a power cable is set to trip at 1000 A in 1 second then we need to select appropriate cable that can withstand the high current of 1000 A for a period of 1 second.

INSTALL THE WIRING/ENCLOSURES OR SUPPORT SYSTEMS

The final choice of a wiring system must rest with those designing the installation and those ordering the work, but whatever system is employed, good workmanship by electrically skilled or instructed persons and the use of proper materials is essential for compliance with the wiring regulations. When installing wiring systems and enclosures the safe working practices and procedures discussed earlier in this chapter must be followed. The necessary skills can be acquired by an electrical trainee who has the correct attitude and dedication to his or her craft.

Different types of wiring enclosures or support systems are dependent the applications of the respective building and nature of how such installation needs to be carried out. Following are some of the different types of arrangements that can be kept in place while installation of electrical cables.

1. Installation of Conduit Piping

Conduit Pipe are the two types of electrical conduit pipes. In the electrical installation, conduit pipes are used for the electrical cable protection. It is an enclosure type and most commonly used conduit pipes can be of hard and flexible conduits. They come in three sizes and are known to be of 20mm, 25mm and 32mm.

2. Concealed Installation



Concealed installation is used in interior spaces. With concealed electrical installation/cable laying requires the use of an electrical conduit in a number of European countries. Of course, you should not only consider mechanical characteristics but also bear in mind the replaceability of installed wires and cables.



Conduits with light compressive strength are of a particular advantage here.

3. *Exposed installations*

For the sake of installation simplicity, cables, wires and conduits in exposed installations are installed directly on the plaster or above the plaster with spacing brackets. The installation takes place in an exposed manner with nail clamps, in cable channels or rigid installation conduits.



Classic exposed installation work using straight length conduits (plastic or metal conduit) must be done with

non-flame propagating materials. The plastic straight length conduits are available in halogen-free and UV-stabilised design. The conduits are used for renovation, modernisation and reconstruction, as well as for installation on the wall.

4. *Installations in concrete*

In commercial buildings, highspeed corrugated conduit is a safe and reliable solution for installations in concrete.

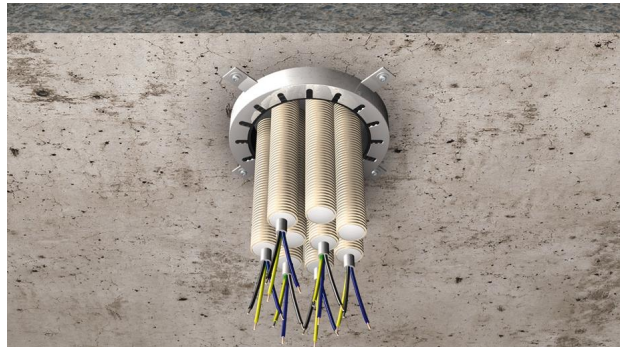
Our corrugated plastic conduit not only fulfils all requirements but also combines additional advantages in one product: The low-friction inner surface of our conduit allows easy cable insertion even over longer distances up to 50 metres, while the specially designed jacket provides additional safety and protection against damage at the construction site or in concrete.



5. *Fire Protection*

Electrical conduits as well as cables and wires running through several fire sections must be secured using fire stops.

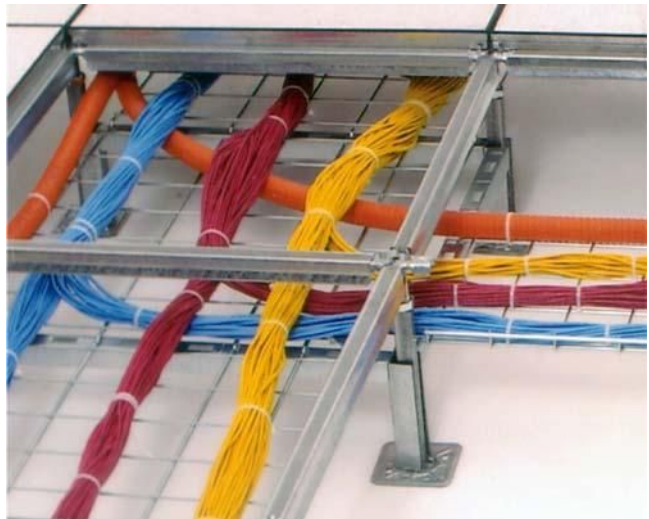
Fire stop includes all protective measures preventing propagation of fire and smoke allowing the rescue of humans and animals and effective fire-fighting operations in case of fire.



6. *Electrical Cable Trays*

Cable trays are used for providing mechanical protection in an environment where large quantities of power control cables are at work. Besides providing mechanical protection, these cables are also designed to facilitate a perfect routing path for power or control cables. These cables could be both overhead and under-ground.

There are a variety of cable trays available in different materials. Cable tray manufacturers make cable trays with galvanized steel, aluminium, stainless steel and glass-fibre reinforced plastic. Making a decision about which cable tray to choose completely depends on the usage and installation environment. Here the installation environment refers to taking into account electrical considerations as well as corrosion. Besides, cost is also an important decisive factor to be taken into account while picking cable trays.



Installation of electrical cables need to carried out based on the design provided to the building service engineer eand it is vital that proper clarification and information is obtained prior to the commencement of the work.

COMMISSION AND TEST THE INSTALLED WIRING SYSTEM

Completion of the electrical installation involve connection of fitting as per the regulations provided by the Maldives Regulatory Authority. Once the electrical fittings are installed, the system is now ready to be energized and tested for compliance with certification.

Inspection and testing an electrical installation

The testing of an installation implies the use of instruments to obtain readings. However, a test is unlikely to identify a cracked socket outlet, a chipped or loose switch plate or a

missing conduit-box lid or saddle, so it is also necessary to make a visual inspection of the installation.

All new installations must be inspected and tested during erection and upon completion before being put into service. All existing installations should be periodically inspected and tested to ensure that they are safe and meet the MEA regulations.

The method used to test an installation may inject a current into the system. This current must not cause danger to any person or equipment in contact with the installation, even if the circuit being tested is faulty. The test results must be compared with any relevant data, including the tables in the IET Regulations, and the test procedures must be followed carefully and in the correct sequence, as indicated by IET Regulation 612.1. This ensures that the protective conductors are correctly connected and secure before the circuit is energized.



Visual inspection

The installation must be visually inspected before testing begins. The aim of the visual inspection is to confirm that all equipment and accessories are undamaged and comply with the relevant standards, and also that the installation has been securely and correctly erected.

Following provide a schedule or checklist of examples of items requiring inspection during the initial verification of the installation, including:

- ✓ electrical intake equipment;
- ✓ parallel or switched alternative sources of supply;
- ✓ automatic disconnection of supply;
- ✓ other methods of protection;
- ✓ basic protection;
- ✓ fault protection;
- ✓ additional protection such as RCD and bonding;
- ✓ specific inspection examples as appropriate to the installation;
- ✓ distribution equipment;
- ✓ circuits;
- ✓ isolation and switching;
- ✓ current using equipment (permanently connected);
- ✓ Part 7 Special installations and locations.

Each of the headings above can be broken down into specific items which are to be inspected and the relevant IET Regulation number is also specified. So, for example, the heading circuits above is further subdivided as follows:

- ✓ identification of conductors
- ✓ cables correctly supported throughout
- ✓ examination of cables for damage during installation
- ✓ concealed cables adequately protected against damage
- ✓ provision of fire barriers and sealing arrangements to reduce spread of fire
- ✓ termination of cables at enclosures
- ✓ suitability of circuit accessories for external influences
- ✓ single-pole switching devices in line conductor
- ✓ circuit accessories not damaged during erection.
- ✓ the quality or adequacy of connections within accessories and equipment

UNIT 15

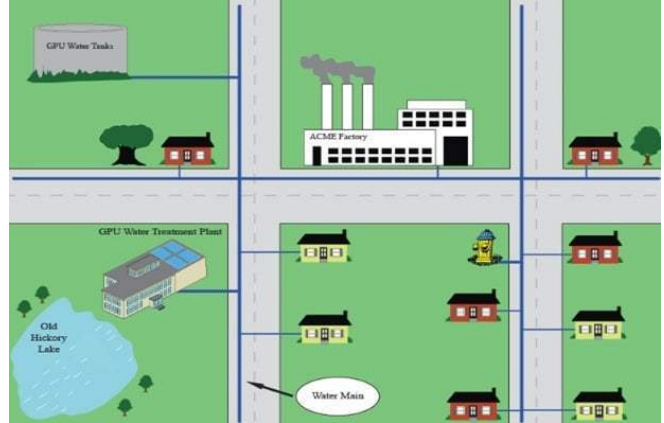
INSTALL INDUSTRIAL WATER PIPE SYSTEMS

This unit of competency specifies the outcomes required to install and test water pipes larger than DN65, or large water services

PLAN AND PREPARE

Obtain work instructions, plans, specifications, quality requirements

The plans for water mains and appurtenances should show all appropriate physical features adjacent to the proposed water mains along with horizontal and vertical controls and hydrant coverages. Other utilities, such as sanitary and storm sewers, manholes, etc., should be shown on the plans with horizontal and vertical separation distances. Design details for other utilities that do not affect the water main may not be shown on water main plans.



Prior to the commencement of the work, all the information needs to be worked out, and it is expected that the plan will provide details on the following.

- ✓ Stream crossings, providing profiles with elevations of the stream bed and the normal and extreme high and low water levels
- ✓ Profiles having a horizontal scale of no more than 100 feet to the inch and a vertical scale of no more than 10 feet to the inch, with both scales clearly indicated
- ✓ Location of all existing and potential sources of pollution that may affect the water source or underground treated water storage facilities
- ✓ Size, length, and materials of proposed water mains
- ✓ Location of existing or proposed streets; water sources, ponds, lakes, and drains; storm, sanitary, combined, and house sewers; septic tanks, disposal fields, and cesspools
- ✓ All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and/or water works structures
- ✓ Locations of all sampling taps
- ✓ Adequate description of any features not otherwise covered by the specifications

Besides the above, Complete, detailed, technical specifications should be supplied for the proposed project, including:

1. A program for keeping existing water works facilities in operation during construction of additional facilities to minimize interruption of service
2. Procedures for flushing, disinfection, and testing, as needed, prior to placing the project in service
3. Materials or other facilities including any necessary backflow or back-siphon protection

Assess and evaluate traffic management plan and possible signage requirements

Prospective digging may involve excavation and excavation work generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity, using excavators or other digging equipment.

For this reason, digging may need to be carried out on public areas such as parks, pavements or even roads.

To implement safety of all involved, it is important to manage traffic, including all road users while the work takes place with a temporary traffic management plan. All work on a road or work that affects the normal operating condition of a road must have an approval from local authorities and need to be informed to all the relevant stakeholders.

Besides that, proper signage or boards need to be displayed on the site of digging



to ensure traffic is properly diverted to ensure ongoing work is smoothly carried out without disturbing the traffic.

Plant, tools and equipment selected for the job are identified and selected

It is important that proper tools planning is undertaken to ensure the planned work is carried out smoothly and effectively. For this purpose, tasks need to be reviewed for the purpose of identifying tools and the referred tools and equipment need to be kept handy prior to the commencement of the work.



SET OUT AND EXCAVATE

To a home or business, the water main is the main artery connecting the building to the primary water supply. This important system components function is conveying water. Working with water mains can be a very lengthy and complex process for inexperienced plumbing contractors. However, the plumbers at Local Plumbing And Sewer are experts in all aspects of water main integration, installation and repair.

Working with water mains consists of several steps, including digging a trench, bedding and so on. Below we break down the main steps that we may encounter when working on a water main project.

Excavation

First and foremost, the initial step in Water Main Installation is excavation. It is a process where we dig a passage for installing the pipe. A number of factors which we keep in mind before initiating this process are:

- ✓ Ground frost conditions
- ✓ Ground water conditions
- ✓ Traffic load that will be over the pipe
- ✓ Soil type
- ✓ Size of pipe to be installed
- ✓ Surface restoration requirement and
- ✓ Depth of other utility lines that must be crossed or paralleled by the water main.

Trench depth

The depth of a trench depends upon the climate, the size of the pipe, traffic and several other factors.

- ✓ In colder regions, severe winter frost can penetrate twice the average winter frost depth. Closed cell Styrofoam insulated board, 2 in. (50mm) thick and 2 to 4 ft (0.6 to 1.2 m) wide is considered fit, if adequate depth is not possible.
- ✓ In warmer regions, minimum depth of cover to protect it from any danger is usually 2.5 ft (0.8m) for water main.

Trench width

The width of trench necessary for Water Main Installation is generally governed by the following conditions:

- ✓ Minimum depth to allow for proper joint assembly and compaction of soil around the pipe
- ✓ Safety considerations
- ✓ The need to minimize the external loading on the pipe

Trench width below the top of the pipe should generally be not more than 1 to 2ft (0.3 to 0.6 m) greater than the outside diameter of the pipe. The width provides enough space to

workers for installing. Wide trenches should be avoided in small diameter pipes, especially in hard clay soils.

Bedding

Bedding means preparing a platform for placing the pipes (PVC). Few things while bedding should be kept in mind.

- ✓ Bottom of the trench must be properly leveled and compacted so that the barrel of the pipe will have continuous, firm support along its full length.
- ✓ Leveling board should be used to ensure that there are no voids and high spots and that the grade is correct.
- ✓ In adverse soil situations (damp soil or solid rocks), special pipe bedding may be specified by the engineers. A clean, well graded granular material upto 1 in (25mm) in size. It should contain no lumps or frozen ground and have no more than 12% of clay and silt that can be sensitive to water.
- ✓ When natural trench bedding is unable to support the pipe, it is necessary to dig another 12 to 24 in (300 to 600 mm) deeper.
- ✓ Haunching is a process of placing bedding material around the haunch of a pipe. It is necessary for increasing the load bearing capacity of the pipe.

INSTALL MAINS PIPELINE

Mobilization and Locate Existing Utilities

Equipment/supplies are mobilized. Underground lines and utilities such as fiber, cable, gas, water/wastewater, and traffic signal communication lines are located and marked on the ground; see what the different colors represent.

Installation of New Water Main

The asphalt is milled to dig a trench. The new and inactive water main is placed and connections are made to existing system.

The trench is backfilled to the surface of the road or existing grade if located outside of the road.

Laying pipe

Once the trench is ready, the pipe may be placed into position. There are several general directions for laying pipe.

1. Inspection- A pipe should be inspected for damage. Any unsatisfactory section should be removed.
2. Cleaning- Dirt, oil, grease, animals or any other foreign material should be removed before installation. The hypo chloride solution is recommended for quick and proper cleaning
3. Placement- The pipe should not be rolled, it should be lowered into the trench by hand or mechanical equipment
 - a. While placing, pipe is usually supported by a sling in the middle

- b. Installers should make a conscious effort to keep the inside of pipe clean during lying.

Joining pipe

This is a sensitive part of the Water Main Installation process. It must be done correctly to minimize leakage and ensure proper functionality and longevity for the water main service. Methods of joining, depends upon the type of pipe material and type of the joints. Bell holes must be dug by hand where pipes will be jointed. This will allow room for the joint to be installed. The size of the bell hole will vary with the type of pipe and joint used. Too large bell holes can create stress on the pipe.

Push on joints

1. The four general steps in making up ductile iron or PVC pipes push on joints are:
2. Clean the groove and bell socket of the pipe.
3. Apply lubricant to the gasket and plain end of the pipe.
4. Plain end should be beveled, sharp edges may damage or dislodge the gasket.
5. Small pipe can be pushed into bell socket with a long bar. A timber header should be used between the pipe and backhoe bucket to avoid damage to the pipe.

Connecting to existing mains

There are two possible ways to connect with existing mains. Installer can connect either by a new tee or by making a pressure tap.

Tee connections

A tee fitting is inserted in existing mains. Existing mains must be out of connection for several hours. A piece of main is to make a cut or snap at the outside edges of the section to be removed. Then a third cut is made midway between them. When the pipe is hit with a sledge in the center, it will easily break out.

Pressure taps

Pressure taps are highly recommended and used because of their advantages. Few of the advantages are following-

- ✓ Customers are not inconvenienced by having their water turned off
- ✓ Lower probability of contaminating the water system
- ✓ Fire protection in the area remains in service
- ✓ No water loss
- ✓ Based on the time required to close valves and notify customers before inserting a tee is taken into account making a pressure tap is much faster.

Once the excavation has been prepared, a pressure tap is completed in following steps:

1. The surface of the existing main is cleaned. The tapping sleeve is installed on the main, with the face of the flange vertical.

2. The special tapping valve is attached to the sleeve's projecting flange.
3. The tapping machine is installed on the valve, with the shell cutter attached. The machine is supported on contemporary blocks.
4. With the tapping valve open, the cutter is advanced to cut a hole in the main.
5. The cutter is retracted to beyond the valve, and the valve is closed.
6. The tapping machine is removed, and the new main is connected.

This is the basic overview of what we encounter during the process of working with a Water Main Installation project. Due to the complexity of these projects, it is important to utilize a licensed, insured & experienced plumbing contractor for any jobs where there is a water main installation, water main repair or water main integration.

TEST MAINS PIPE SYSTEM

Water Main Testing

During this critical stage you may see little to no construction activity for approximately two weeks.

The water main is put under pressure to ensure it was installed correctly. To confirm the water main is properly disinfected and meets our water quality requirements, we conduct two rounds of testing that are performed by certified labs. Additional testing and flushing continue until passing results are achieved.

Service Lines Connected

A new water service line and meter box to each property is installed and is generally located in close proximity to the existing one. Water service is shut down while the new connections are made.

NOTE: It may take a few days for multiple service lines to be installed along the street before the connections are finalized. Property owner(s) are notified 24 hours in advance of the service line switch over that typically take 2-4 hours to complete, but at times could take longer.

When water is turned back on, each property's outdoor water hose bib will be run to help flush the system and remove any air in the line.

Old Water Main Abandonment

Old water mains are drained, pumped full of a grout and abandoned.

Restoration

All disturbed areas such as grass, concreted sidewalks or curbs are restored to existing conditions or better, and the trenched areas are re-paved. Once these items are completed the project area is swept and cleaned.

CLEAN UP

The work site must be cleared of debris.

Cleaning up the work site is not just a matter of appearance, it also concerns safety and health issues. It is good work practice to clean up as you go. Building sites are always short of space and build up of debris will only add to storage, health and safety issues.

- ✓ Most sites will have a site safety committee policy on cleaning up the work site.
- ✓ The disposal areas for site debris should be identified at the site induction, if not find out from your supervisor.
- ✓ Clean up as you go if possible, but at least on a daily and weekly basis and on completion of an installation.
- ✓ Food and drink waste, wrappers and containers should be disposed of in the correct bin, immediately after use as build up attracts vermin and associated health risks.
- ✓ Packaging debris should not be allowed to become a tripping or other hazard. Dispose of it in the correct bin as soon as practicable.
- ✓ Off cuts and surplus material that may be used later in the job should be held in a safe storage area until required.
- ✓ Off cuts and surplus material that are not suitable for re-use should be disposed of in the correct bin at the end of each day's work or sooner if practicable.
- ✓ Do not use cupboards, empty rooms or corners to store rubbish and debris.
- ✓ On completion of an installation check the whole of the work area. Remove materials to the store, tools and equipment to the correct location and rubbish and debris to the correct bins.
- ✓ Sweep the completed work area clean and correctly dispose of sweepings.
- ✓ Tools and equipment must be cleaned, maintained and stored.

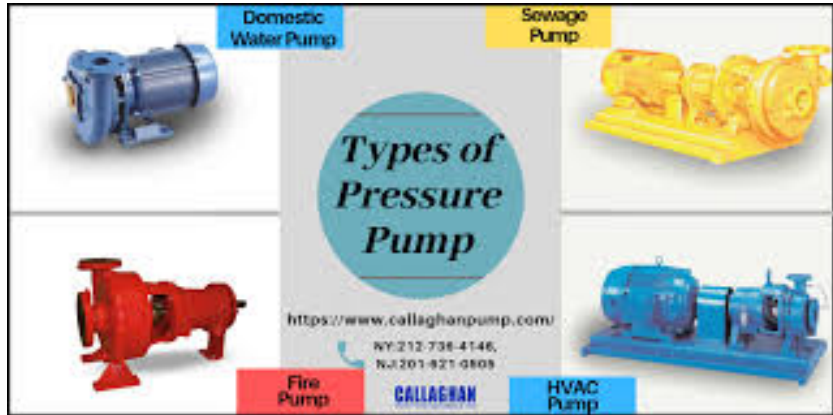
UNIT 16

PERFORM INSTALL, COMMISSION AND REPAIR WATER PUMPS

This unit of competency describes the skills and knowledge required to carry out testing and repair of centrifugal and positive displacement pumping systems for outdoor power equipment

Introduction

Maintenance will never be exciting. But it's necessary work required to ensure that a pumping system operates when you need it. If pump operation was a football team, maintenance would be the offensive linemen who do the grunt work in the trenches of the scrimmage line and make possible the exciting plays and athletic prowess that make the quarterback so famous. But no quarterback, no matter his athletic prowess, would be anything but a defender's tackling dummy without a strong offensive line in front of him. So, let us for once shine the limelight on repair operations and examine their requirements. Let us take a close look at pump maintenance. What are the essentials? What practices are recommended by manufacturers?



PREPARE AND CONDUCT TEST

Two characteristics define a pumping operation and flow rate: the pump's performance and the system's resistance. A pump performance determines the flow rate the pump can produce for a given pressure head. Flow rates are typically measured in gallons per minute (gpm), while pressure heads are measured in equivalent feet of water column. Water at standard pressure and temperature weighs about 62.4 pounds per cubic foot (pcf). At 144 square inches per square foot, the pressure exerted by a 1-foot-high column of water is equal to 0.433 psi. The relationship between a pump's operating head and its generated flow rate is called a pump performance or characteristics curve. This curve is drawn on a grid with the y-axis being head (in feet) and the x-axis representing the flow rate (in gallons per minute). The curve inflects downward from a maximum head at the y-axis (when the flow rate is zero) to maximum flow rate at the x-axis (when the head is zero).



In addition to the pump's performance curve, there are three other curves that define a pump's operating characteristics: the efficiency curve (measured in percent), the brake horsepower (BHP) curve (typically measured in watts), and the pump's Positive Suction Head (NPSH). The first two are roughly parabolic and help to define the pump's recommended operating range (as defined by its flow rate). The efficiency curve starts at 0% at the point of zero flow and zero head (the grid's origin point) and continues to a peak that determines the pump's Best Efficiency Point (BEP). From there it curves down again to 0%. BHP is represented by a shallower parabolic curve that starts at the minimum BHP

associated with maximum head and zero flow of the performance curve, peaks near the BEP, and declines again to the minimum BHP required for maximum flow and zero head. BHP is defined as “the available power of an engine, assessed by measuring the force needed to brake it.” Peak BHP occurs within the pump’s recommended operating range. There are two definitions of NPSH. The first is available head (NPSHa) and the second is what is required (NPSHr) by the pump without being subject to potentially damaging cavitation and resultant reduction in pumping output.

The system resistance curve compares the system’s resistance head, measured in feet, to the allowable flow rate, measured in gallons per minute. Total resistance head is the sum of the elevation head difference between the pump’s outlet and the pipe system’s discharge point (the static head), the friction head lost as a result of water flowing along the surface of the pipe’s interior walls, and the head loss from the water’s flow velocity through the pipe (determined by dividing the pump’s flow rate by the pipe’s cross-sectional area). Since the static elevation head is a constant, the system resistance curve intercepts the y-axis (when the flow rate is zero) at a point equal to the static head. Static head is positive when the discharge point is higher than the pump outlet, zero when the two are at the same elevation, and even negative should the discharge point be physically negative (in this last case, the total system head would require large values for friction and velocity head from a complicated and long plumbing system to even require a pump in the first place). From the y-axis, the system resistance curve inflects upward to a maximum head value associated with the maximum flow rate that can be generated by the pump.

So how do these curves define the pump’s operating state in terms of flow and head? This occurs at the point where the system resistance curve intersects the pump performance curve. To maximize operational efficiency, it is best to choose a pump whose performance curve results in an operating point that coincides with the pump’s recommended operating range (flow rate) as defined by the efficiency curve.

Types of pumps

While pump engineering is based on standard performance characteristics, pump mechanics are highly variable and utilize a wide variety of methods to move water through a pipeline. There are two major types of pumps: centrifugal and positive displacement.

Centrifugal pumps use a set of rapidly spinning impellor blades. As these impellor blades spin around an axis, centrifugal force causes the water to travel along the surface of the blades to the outer rim of the impellor assembly. Water enters the impellor unit through a port in the axis, and in effect, the spinning blades fling the water outward. The force imparted by the rotation

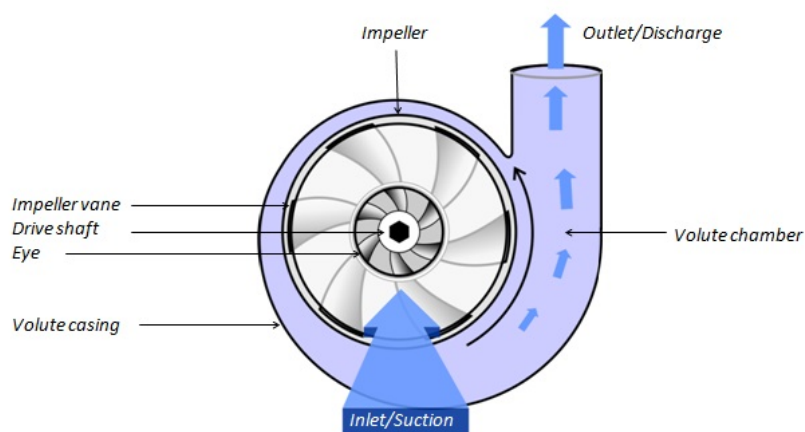
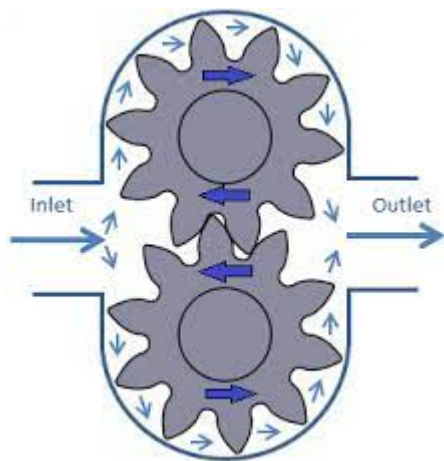


Figure 2. Volute case design

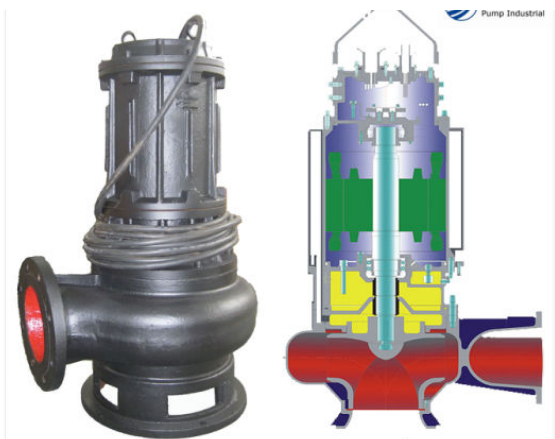
forces the water out of the impellor casing via a discharge port built into the pump's outer housing. In general, centrifugal pumps generate high flow rates with relatively low operating heads. The lower operating heads result in lower operating costs, making centrifugal pumps a cost-effective choice for high volume water removal. There can be many variations of the impellor design. One option is a pump that utilizes flexible impellors instead of stiff, fixed vanes or blades. The centrifugal force of the rotation also distorts these flexible blades, allowing them to trap a larger amount of water and expel it from the pump. Fixed, stiff impellors can use complicated curved lobe shapes or simple flat fan blades, with a tradeoff between cost and performance.

Some centrifugal pumps do not use blades or impellors at all, but instead rely on rapidly spinning enmeshed gears. Similar to a peristaltic pump, the enmeshed gears trap, squeeze,



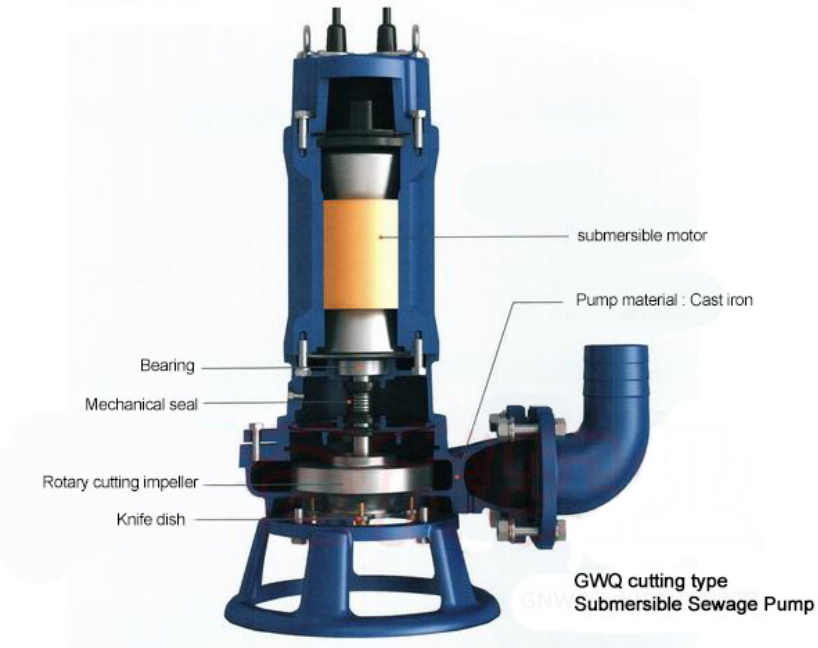
and pinch water to a space between the gear teeth and use the rotary motion and centrifugal force of the spinning gears to expel water from the pump. Centrifugal pumps also come in submersible (designed to be placed below water level) and extraction (which operate from above the level of water being pumped) varieties. Submersible centrifugal pumps get their power from a vibrating drum, which can operate underwater without the need for direct electrical power. While operating underwater is not considered a harsh environment, certain

applications and fluids definitely are. These include water with high turbidity (high amounts of total suspended solids), unfiltered groundwater, water with large suspended objects such as rags or green waste, raw municipal sewage, leachate from solid waste and hazardous waste landfills, industrial water pollution and spillage, and diesel and gasoline, as well as unrefined oil, viscous fluids and oil, heavy slurries, and sludges.



There is a direct correlation between the size of the objects suspended in the water or other liquid being pumped and the amount of energy required by the pump, as well as an inverse relationship between object/particle size and pump head. For suspended objects up to the size of fine gravel (diameter of 0.375 inches) sump pumps are used. For the range between fine gravel and medium gravel (0.5 inches), there are effluent pumps. For objects between medium gravel and cobbles (up to 2.0 inches in diameter), sewage pumps are utilized. Larger than this, specialized grinder pumps are required that will crush these objects down to a finer particle size prior to actual pumping, resulting in a thick slurry. Furthermore, the flow rates decrease with increased size. And as the object sizes increase, the amount of energy needed for pumping increases and the pumping head falls. The final result is the grinder pump, which requires very high horsepower and creates a low flow and low head pumping operation.

Positive displacement pumps “push” instead of “fling.” They utilize a reciprocating mechanical device, such as a piston inside of a cylinder, which pushes water out of a chamber and propels it out through the discharge pipelines. Other types of reciprocating mechanisms include bellow cavity, vibrating diaphragm, or drumhead squeezing a peristaltic with a pair of pinch rollers and syringes. This last type differs from pistons in that they operated at low flow rates but high-pressure heads. In fact, displacement pumps in general are capable of operating at high operating heads while generating low flow rates (the opposite of typical centrifugal pump performance).



No matter the mechanical design, performance characteristics, or operational applications, all pumps have one thing in common: the need for an exterior power source. This power source is either mechanical (from a reciprocating internal combustion engine) or electrical (from a battery or turbine power source). How much power any pump requires is relatively simple to calculate. Power requirements are a function of the pump’s mass flow rate (cubic feet per second or cfs), the density of the fluid (62.4 pounds per cubic foot or pcf, for water at standard temperature and pressure), the differential head (measured in feet), and the acceleration due to gravity (32.17 feet per second squared). Multiplying these values together and a conversion factor and the result is power requirements expressed in horsepower. This is referred to as the pump’s brake horsepower, the power actually used to perform the work. The pump’s rated horsepower is larger than this value depending on the pump’s efficacy rating. For example, a pumping operation requiring 120-brake hp to pump water would require the use of a 150-hp pump operating at 80% efficiency.

PREPARE FOR REPAIR OPERATION

It is easy to get maintenance and repair confused. Even experienced operators can make that mistake. Maintenance is performed so that repairs can be avoided. Anything with moving parts requires maintenance, while repairs are completely avoidable. Maintenance is planned as part of a regular operating schedule; repair events are unwelcomed surprises. Maintenance is a cost of doing business, no different than the cost of labor or fuel needed to operate a pump or other piece of equipment. The costs associated with repair extend far beyond the direct costs of labor and parts involved in the actual repair work. Repair creates opportunity costs in terms of schedule delays, lost production, even safety violations and potential property damage or personal injury. In short, maintenance saves money and

repairs cost money. Any attempt to skimp on maintenance is a classic example of a false economy. Shirking on maintenance makes major repairs almost inevitable.

“An ounce of prevention is worth a pound of cure” goes the old saying. So, the first step in proper maintenance is setting up the pumping operations to prevent damage in the first place. Damage typically results from either cavitation or clogging. Cavitation is defined as “the formation of bubbles or cavities in liquid, developed in areas of relatively low pressure around an impeller. The imploding or collapsing of these bubbles can trigger intense shockwaves inside the pump, causing significant damage to the impeller and/or the pump housing”. These bubbles, as small as they are, can cause a series of micro-explosions and impacts with the pump itself. The shocks and vibration created by cavitation can over time damage the pump housing, impellor blades, seals, bearing packages, and pipeline connections. In the end, the pump loses both flow and pressure until it fails completely.

Cavitation can occur at either the suction or discharge end of the pump. Suction cavitation results when the pump is left to operate in a low-pressure regime (caused by poor pipe system design, not meeting the pump’s NPSHr standards, or partial or complete blockage of the intake and its filters) resulting in the pump not receiving enough water inflow. Air bubbles then form at the impellor inlet and travel along the vanes to the discharge—all the while impacting the blade surface. This can cause pitting and scarring of the impellor blade surface, and even the formation of holes that resemble Swiss cheese. The resultant rough surface further degrades pump performance and leads to increasing damage and further cavitation. Conversely, high pressure at the pump’s discharge point can cause discharge cavitation. Excessively high pressure at the receiving end makes it difficult for water to exit the discharge pipe which in turn makes it difficult for water to exit the pump itself. Bubbles then form along the interior surface of the pump housing walls, creating the same impact and shockwave damage caused by inlet cavitation.

In addition to avoiding those system characteristics and operational settings that make cavitation more likely, active measures can be taken to minimize the potential for cavitation. First and foremost, the filters and strainers at the pump’s intake should be checked and cleaned on a regular basis. Clogging of any kind can create the pressure imbalances that lead to cavitation. In many cases heavy filtration including mounds of filter stones and layers of geotextile are required in the field to prevent suspended solids from entering the pump. The pump’s operation should be monitored to ensure that it is working within the acceptable zone and preferably at the pump’s best efficiency point. Conversely, the piping system receiving discharge from the pump can be modified to eliminate the pressure differential that can lead to cavitation.

In addition to clogged intakes, clogging and biological buildup can affect the operation of a pump’s control switches. This is true of both pressure transducers located in the nose of a submersible pump or a floater switch. Dirt, plant growth, floating objects, mold, and bacterial scum can affect the linkages and connects that turn a pump on and off. Failure to turn a pump on can lead to overflow and flooding. But failure to turn a pump off when the water level has dropped below an acceptable head level can cause the pressure differentials that lead to cavitation. Lastly, there is the problem of ice formation, which can be considered to be a special type of floating debris. Ice clogging, either partial or complete plugging, can damage a pump during operation by preventing discharge and causing cavitation to reduced discharge flow rates.

Monitoring, inspections, and maintenance

In short, there are a half-dozen pump operating parameters that have to be monitored to ensure proper pump operations: intake pressure (feet), outlet pressure (feet), flow rate (cubic feet per second), pump speed (revolutions per minute), pump efficiency (percentage), and power requirements (watts). In addition to direct monitoring of the operating pump, vibration and noise levels should be checked along with any service fluids such as the fuel tank (and fuel consumption rates) and oil reservoir levels. Monitoring of these parameters is the next best thing to performing actual maintenance. It is less costly in terms of labor and time (no need to dismantle, maintain, or clean the pump) and does not require the pump to be temporarily brought offline. Furthermore, the accumulated data from this operational monitoring can be used to better plan the frequency and type of maintenance required to keep the pump functioning.

Pump inspection schedules typically follow routine, quarterly, and annual cycles. Routine inspections (weekly to monthly) should examine oil level and condition, noise and vibration, bearing temperatures, leaks from the pump housing, leaks from pipe connections, cracks in pipes or hoses, discharge pressure, intake pressure, seal integrity, and operating temperature. Quarterly inspections include checking the mechanical seals, changing the oil, and shaft alignment. Annual inspections include checking the pump's capacity, pressure, and power requirements.

Maintenance regimes require a certain standard set of procedures. These include:

- ✓ Lock-out and tag-out of all power sources, including shutting off of all power switches, removing electrical fuses, shutting down the control panel, closing off all valves, and disconnecting or otherwise shutting off any fuel or oil service lines to the pump. In other words, disconnect anything carrying any kind of electrical, hydraulic, or mechanical power from the pump. Rotating parts (couplings, belt pulleys, external fans, spinning axles, etc.) especially have to be shielded from contact by people or clothing.
- ✓ Examine the pump's foundation and ensure that the anchor bolts are tight and firmly in place.
- ✓ Make sure that pump vibration has not caused it to misalign with its power source, intake piping, or discharge piping.
- ✓ Key lubrication points (such as the ball bearing package) need to be inspected to ensure that they have sufficient lubricant and that their moving parts have not been subject to wear and tear along their contact points. Similarly, shaft seals need to be examined in order to ensure that there has been no leakage or loss of lubricants.
- ✓ Often the pump requires a complete internal examination requiring disassembly and reassembly. This time-consuming process usually requires that the pump be temporarily replaced with a backup pump during the inspection process. Furthermore, a ready supply of spare parts should always be kept on hand to minimize the wait time to get the pump back online. Not having to order parts greatly reduces any delays caused by delivery times.

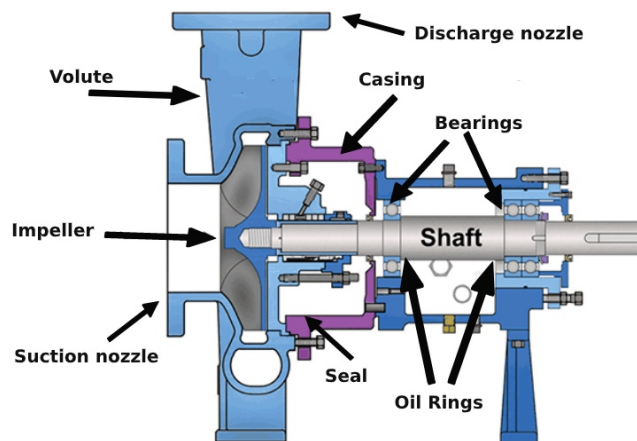
REPAIR PUMPING SYSTEM

This section explain the step by step guide on repairing a centrifugal pump and use this as a general guideline as it is vital to review manufacturer provided manuals prior to engaging with repairing of pumps.

Overhaul a centrifugal pump

Following overhaul or repair of pump given in step-by-step instructions,

- ✓ Check if the suction and discharge valves are closed. If not, close them manually.
- ✓ Switch off the power. Disconnect the pump from the main switch or distribution panel.
- ✓ Disconnect the electrical wire. Ensure that you note the rotation direction of the terminals (if you're using a three face connection). This will help you in connecting the pump the same way after the overhaul.
- ✓ Check if the pump has coupling bolts (beam, bellow, coupling, etc.) If yes, remove all coupling bolts.
- ✓ If the pump is mounted vertically,
 - Connect the chain block and pull the motor up
 - Check if water pressure is locked inside.
 - And then open the pump.
- ✓ If the pump is mounted horizontally,
 - Loosen the motor base bolt and remove the motor
 - Then, follow the same procedures as mentioned above.
- ✓ Loosen the pump impeller joint and pump flanges.
- ✓ Bring out the pump for inspection.

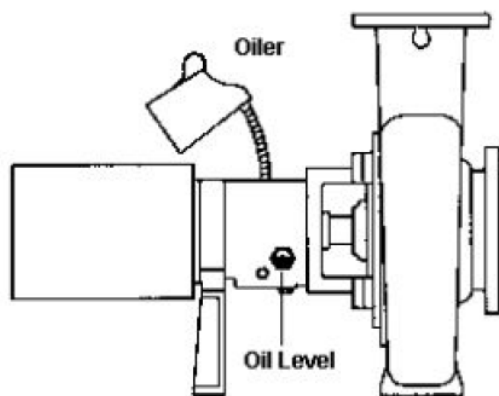


How to dismantle, inspect, and reassemble a centrifugal pump? Step-by-Step Instructions

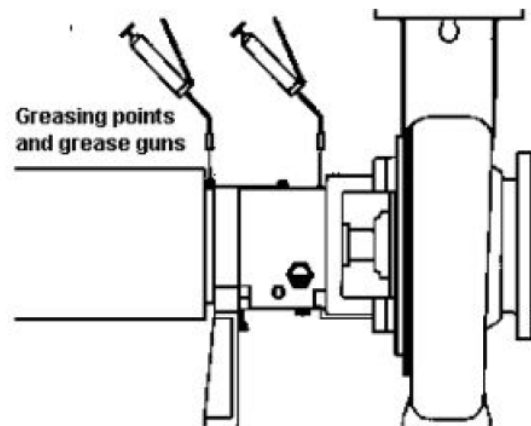
- ✓ Start from the impeller side. Loosen the washer and guide nut.
- ✓ Use a pulley to unscrew the impeller.
- ✓ Next, remove the mechanical seal on the impeller.
- ✓ Remove the lock ring/bearing guide pin behind the impeller.
- ✓ Tap gently on the shaft using a rubber or wooden hammer.
- ✓ Remove the bearings along with the shaft.
- ✓ Inspect if the bearings are in good condition. If they are worn out, replace them with new bearings.

- To change the bearings, first, clean the shaft. Then lubricate it and tap the behind of the bearing groove gently.
- Before you install the new bearings, clean the groove and lubricate it well.
- Install the new bearings at the small end, just like you removed it.
- ✓ Clean the housing of the bearing and grease it adequately.
- ✓ Install the shaft from the impeller's side.
- ✓ Install new mechanical seals, if needed.
- ✓ Install all removed washers.
- ✓ Replace removed nuts and washers and tighten them as needed.
- ✓ Rotate the shaft and check if it can move freely.
- ✓ Check the alignment of the Mount the electric motor and connect the pump.
- ✓ Check for free movement, before starting the pump.

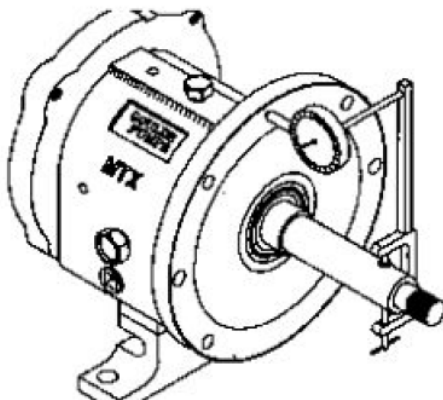
Illustration of Maintenance Checks¹



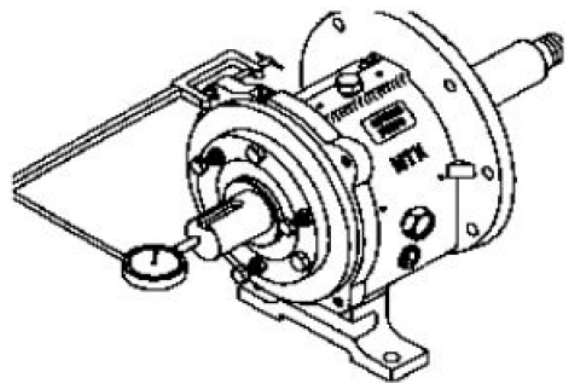
1. Oil level check



2. Re-greasing of bearings



3. Shaft to bearing housing face runout



4. Shaft end play measurement

¹ Pictures courtesy of Goulds Pumps Copyright Elfer, Inc. 1998, Waterford, New York

COMPLETE WORK AND PREPARE RELEVANT DOCUMENTS

With the completion of the pump repair and repair of other equipment, make a habit of filling workplace documents as referred documents will help to maintain repair and maintenance history of the pump being repaired.

If a piece of plant or equipment is well maintained, the risk of accidents occurring due to malfunctioning machinery is reduced. When incidents involving faulty machinery occur, there's a big chance that the operator is the first one to be affected. Having equipment's maintenance history documented will help you keep track of your machinery's health. This enables you to schedule an inspection when needed, at the same time it ensures that your equipment are safe to work with.

UNIT 17

PERFORM PLUMBING WORK TO SUPPORT STORM WATER DRAINAGE SYSTEM

This unit of competency specifies the outcomes required to design systems for the collection, storage, distribution and re-use of rainwater for drinking and nondrinking uses, including irrigation, toilet flushing and other uses approved by relevant authorities

EVALUATE DESIGN PARAMETERS

Scope of work is established for rainwater harvesting systems

This Manual is a guide book for hydrologic & hydraulic design of storm water drainage systems and includes, inter alia, planning, designing, detailed engineering and operation and maintenance of various components of urban storm water drainage systems. The appurtenant socio-environmental aspects, are also an embedded component of the scope.

Design requirements are determined from client brief

Objectives of Planning & Investigation

The objective of planning and investigation is to provide detailed information about the type and topography of the land, details of existing drains, land use pattern, networks of roads, culverts and railway lines etc. which required due consideration in planning / augmentation of drainage system in the city. The following aspects need to be considered while planning & investigating for development of a drainage system:

1. Identification and marking of probable drainage zones, direction of gradients and selection of disposal points
2. Preparation of topographical layout of collection and conveyance.
3. Identification of locations for pumping stations
4. Strategy for rainwater storage and its recharge to ground water
5. Strategy for prevention of solid waste and C & D waste into storm water ways.
6. Strategy for arresting pollutants with urban runoff from entering into water bodies
7. Conserving the aesthetic, public safety and other social concerns of recreational open space and landscape to preserve the ecological nature of water ways;
8. Identification of existing storm water drains / drainage corridors including age-old drainage conduits for rehabilitation;
9. Non-structural measures should be studied and components designed accordingly to provide relief during occurrence of disasters due to flooding.
10. Frame a Road Map for Urban Storm Water Best Management Practices (BMP).
11. Preparation of strategy for protection of urban areas from flooding
12. Strategy for sustainable operation & maintenance of storm water systems
13. Holistic approach to local area planning including aspects of sustainability, consistency and responsive to community values.

Rainfall patterns analyzed and system is reviewed

In storm water drainage system design, estimation of runoff from the tributary catchment reaching various inlets of drain is important. This can be estimated if Intensity Duration Frequency (IDF) curves are available. The IDF curve is drawn based on rainfall data analysis of the project area obtained from the daily rainfall charts of Self-recording Rain Gauge (SRRG) stations of Indian Meteorological Department (IMD).

In this Chapter, the rainfall data obtained from SRRG station of IMD has been analysed and the procedure for construction of IDF curve using Empirical method is explained. Once IDF curve for required return period are constructed, the same can be used for estimation of runoff using rational method. Probabilistic methods for constructing IDF curves have also been explained in brief.

Measurement of Rainfall

Rainfall is measured by two types of gauges:

1. Self-recording type
2. Non-recording type

Self-recording type rain gauges automatically record on a daily basis a continuous plot of rainfall depth against time down to 15 minutes interval or even less, whereas, non-recording rain gauges can only record cumulative rainfall for a day that is measured daily at site. The data collected using non-recording gauges are of limited use for design purpose. Hence, non-recording gauges are being gradually replaced in Indian subcontinent. Therefore, the mechanism of types of self – recording gauges that are in current use has been discussed as follows:

Tipping Bucket Type Rain Gauge

Tipping bucket type rain gauge is a 30 cm sized circular rain gauge adopted for use. It has 30 cm diameter sharp edged receiver and at the end of the receiver a funnel is provided.

Pair of buckets is pivoted under this funnel in such a manner that when one bucket receives 0.25 mm of precipitation (rainfall), it tips discharging its rainfall into the container, bringing the other bucket under the funnel as shown in Fig 3.1.

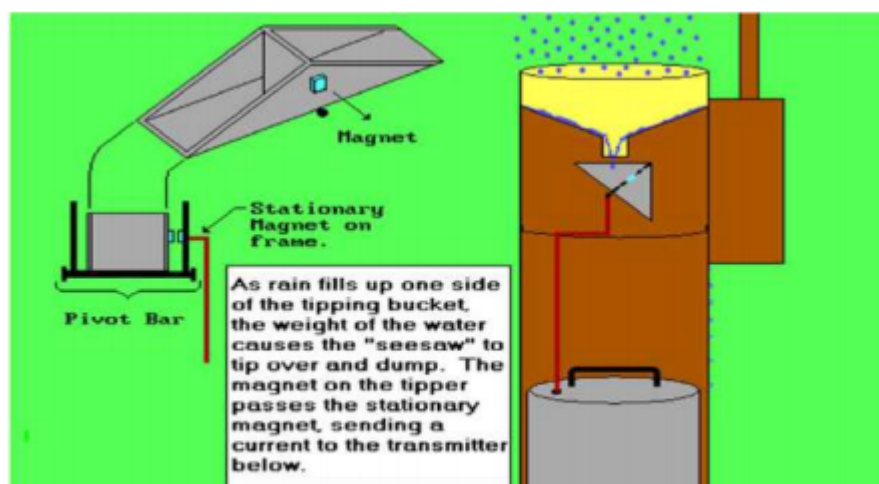


Figure 3.1: Tipping bucket type rain gauge

Tipping of bucket completes an electric circuit causing the movement of pen to mark on clock driven receiving drum which carries a recorded sheet. These electric pulses generated are recorded at the control room far away from the rain gauge station. This instrument is further suited for digitalizing the output signal.

Weighing Bucket Type Rain Gauge

Weighing bucket type rain gauge is most common self-recording rain gauge. It consists of a receiver bucket supported by a spring or lever balance or some other weighing mechanism. The movement of bucket due to its increasing weight is transmitted to a pen which traces record or some marking on a clock driven chart as shown in Fig 3.2.

Weighing bucket type rain gauge instrument gives a plot of the accumulated (increased) rainfall values against the elapsed time and the curve so formed is called the mass curve.

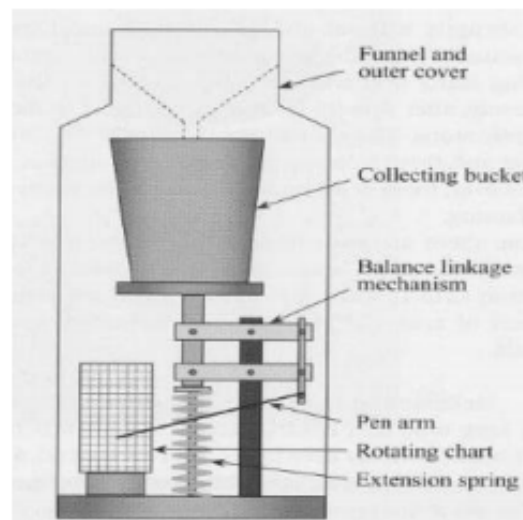


Figure 3.2: Weighing Bucket Type Rain Gauge

Floating or Natural Syphon Type Rain Gauge

The working of this type of rain gauge is similar to weighing bucket rain gauge. A funnel receives the water which is collected in a rectangular container. A float is provided at the bottom of container, and this float rises as the water level rises in the container. Its movement is recorded by a pen moving on a recording drum actuated by a clock work.

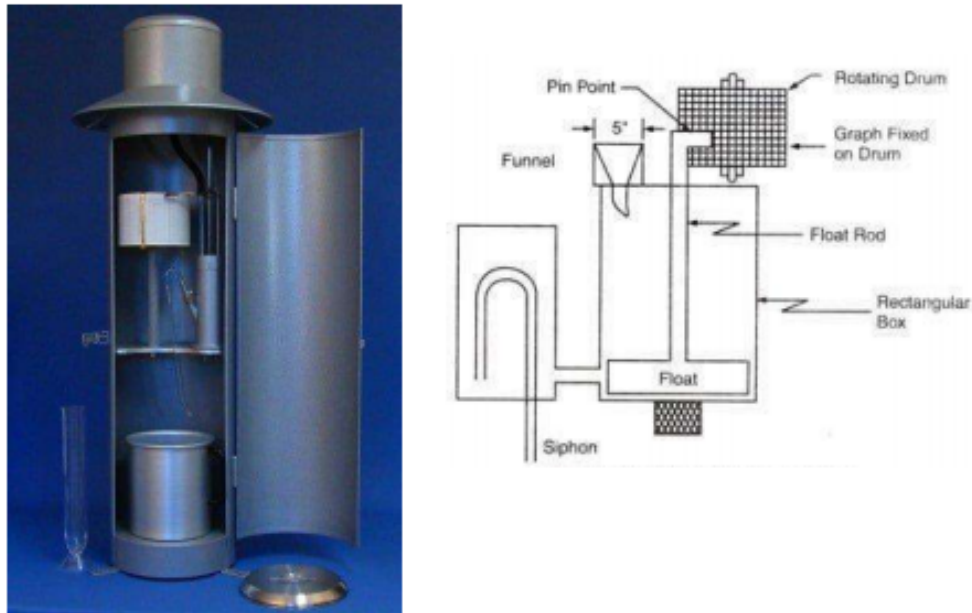


Figure 3.3: Natural Syphon or Float Type Rain Gauge

When water rises, this float reaches to the top, and then syphon comes into operation and releases the water outwards through the connecting pipe, thus all water in box is drained out.

Rainfall Analysis

Rainfall analysis is carried out to identify and sort out various magnitudes (intensities) of rainfall events and their corresponding durations occurring at a station from a continuous series of historic rainfall records taken for a fairly long period viz. last 25 - 30 years or more. IDF curves are not static as they are influenced by change in pattern of rainfall and therefore IDF curve should be prepared at an interval of 5 – 10 years for accurate results. The rainfall analysis helps to establish intensity-duration-frequency relationship for various frequencies which are used in estimation of runoff for design of storm water drains. The frequency or return period of a storm event may be defined as the average recurrence interval between events equal to or exceeding a specified magnitude. For example, if it is stated that a return period of a rainfall of magnitude 70 mm/hour at a station is 10 years that implies that on an average rainfall magnitude equals or exceeds 70 mm/hr once in 10 years.

Manufacturer requirements and trade and technical manuals are interpreted

Numerous standards and certification bodies exist nationally and internationally, so it may not be necessary for a country to develop a unique set of standards. It could decide to adopt one of the existing systems and require that products are certified to meet that system's requirements. In judging a product or material, the regulating authority (or certifier) must consider factors such as the following:

- ✓ Is the product or material under consideration suitable for the application or purpose?
- ✓ Will it be harmful to the health of the community in its normal use?
- ✓ Is there a risk of these materials being released into the environment (e.g. the water) in the first instance or after the working life of the product or material has expired?

All pipes, valves, taps and other fittings used for the supply of drinking-water or the removal of wastewater must not contain harmful substances above the specified amount that could leach into the water. Lead, cadmium and arsenic are examples of many possible contaminants that could be present. The pipes, valves, taps and other fittings must be capable of conveying water at a nominated pressure within a prescribed environment, and must be of sufficient strength to contain anticipated internal pressures. They must also be able to withstand external pressures if they are to be buried. The impact of environmental factors such as heat, cold, expansion, contraction, corrosion, pH and bacteria levels also need to be considered.

WHO and many national authorities have developed guidelines or standards that set out the maximum acceptable levels of metals and chemicals and other contaminants in public drinking-water supplies (WHO 2004a). These are then converted to apply to contaminants that may leach from the fixtures and the associated network of piping systems. For example, a pipe standard might require that the leaching level of a heavy metal must not exceed 10% of the drinking-water standard based upon a standard test that simulates use and exposure conditions. Some authorities also insist that piping systems for soil and waste-water drainage systems comply with the same material criteria. Manufacturers in these areas are obliged to comply or risk losing market share or perhaps face prosecution. The standards set for materials in contact with drinking-water are minimum requirements and are based upon a specified use condition range; for example, a product suitable for a cold water system will, in most cases, not be acceptable for a hot water system. It is common for piping and construction materials, as well as the water being conveyed, to be seriously affected by aggressive environments and local conditions. In summary, it is still very much in the hands of the individual project adviser or installer to ensure that the plumbing products and materials selected for the application are in accordance with official requirements, will not be unduly affected or influenced by local factors and are correct for the application.

As well as deciding what is an acceptable plumbing product or material, the water authority or governing organization must set standards for the level of training attained by the installation personnel, a point that cannot be overemphasized. In some countries, for reasons of economy, transport, proximity to manufacturing plants or restricted access to international markets, the choice of available materials for plumbing products and piping systems is often limited. Socioeconomic reasons may also dictate the quality and standard of plumbing in domestic dwellings.

PLAN AND DETAIL SYSTEM COMPONENTS

A plumbing system is a long-term investment and should be so designed that it does not become outdated and need replacement while its major parts are still serviceable. This requires careful estimation of current and future demand so that the correct capacity can be specified.

The capacity and dimensions of component parts in a plumbing installation should be adequate to meet both immediate needs and anticipated future use. However, perfection in design is frequently compromised by cost, especially in poor and developing communities.

Good design of plumbing systems is an important step in ensuring that the installations are efficient, safe and affordable. It should take into account the special needs and limitations of developing countries and should also ensure that the installations are appropriate for the different situations they serve. An understanding of the technical requirements and regulatory restrictions is vital for the provision of good plumbing services. This chapter includes design recommendations for plumbing installations in single dwellings, multiple dwellings and multi-storey buildings. It deals with special issues related to industrial and other special purposes, hot water and other dual supply systems and storm water drainage. It includes guidelines on capacities of plumbing systems, plumbing materials and products, and the use of protective devices to prevent backsiphonage and backflow.

Drinking-water supply pipes and specifications

Table 11.1 lists the typical unit water demands for the design of plumbing systems for various classes of buildings.

In each case the actual values will depend on local conditions, but no water service pipe should be of less than 20 millimetres (0.75 inch) diameter and all water service pipes should be laid so as to avoid high points where air may become trapped. Usually the water service pipe between the public main and the curb cock (the water authority's main water shut-off valve) at the boundary of the property belongs to the water authority, which assumes responsibility for its future maintenance, and the remainder of the service pipe is the responsibility of the owner of the property (in many cases, the responsibility of the water authority is extended up to the meter).

TABLE 11.1 TYPICAL DEMANDS FOR VARIOUS USES

Class of building	Consumption per day (litres)
Dwelling houses and apartments, per occupant	40–120
Industrial and commercial premises, staff sanitary facilities, per staff member	10–30
Addition per staff member, if showers or baths are provided	10–15
Motels, per occupant plus staff:	
With communal baths	100–200
With private bathrooms for each bedroom	200–400
Luxury hotels in the tropics	400–600
Hospitals, per bed, including catering and laundry	350–500
Nurses' homes and medical quarters, per occupant	115–150
Schools, per occupant plus staff:	
Day schools	15–30
Boarding schools	100–200
Cinemas, theatres, per seat	8–15
Restaurants, per seat plus staff	75–100
Laundries, per kg dry laundry:	
Hand operated	30–40
Mechanized	60–90
Airports, bus or railway terminals, per passenger catered for plus staff	15–45
Addition per passenger catered for, if showers or baths are provided	10–15

Source: Taylor & Wood 1982 (p. 55).

The depth at which the service pipe should be laid will depend on climatic and other circumstances. In areas subject to frost, the depth specified should be sufficient to avoid damage from freezing, and a depth of 1 metre (3 feet) or even more may be required. However, a maximum depth should be specified to facilitate future maintenance and installation procedures and to enable the pipe to be tracked if required. In tropical areas it is desirable that the incoming water should be kept cool, and a depth of 0.5 metres (20 inches) may be suitable. Where the ground is under cultivation, a depth of 0.8 metres (30 inches) should provide adequate protection. Distance requirements from other services such as electric, telecommunications and gas pipes should be specified. Under no circumstances should a service pipe be permitted to pass through a sewer, access chamber or inspection chamber. Table 11.2 shows the minimum diameter of water pipes needed to supply various types of plumbing fixtures.

Drainpipes

Each separately occupied building should have its own drain connection terminating at the public sewer. Such drains should be of adequate size, and laid at a constant gradient that will permit their contents to discharge at a self-cleansing velocity. Drains carrying human wastes need to have a diameter of at least 100 millimetres (4 inches) for a single dwelling and at least 150 millimetres (6 inches) if more than one property is served. Where a number of plumbing systems have a single connection to the sewer, the plumbing authority may require a combined drainage agreement or other documentation to ensure that disputes do not arise over the apportionment of maintenance responsibility.

TABLE 11.2 MINIMUM INTERNAL DIAMETER OF WATER PIPES TO PLUMBING FIXTURES

Plumbing fixture	Minimum internal diameter
Drinking fountain, washbasin, water closet with flush tank	10 mm (0.375 inch)
Bathtub, domestic dishwasher, hose connection, domestic water heater, shower, sink, urinal with flush tank	15 mm (0.5 inch)
Commercial sink, urinal with flush valve	20 mm (0.75 inch)
Water closet with flush valve	25 mm (1 inch)

Source: Taylor & Wood 1982 (p. 60).

Although internal and external drains are often referred to as “horizontal”, they should never be laid level, but at a constant gradient that will ensure satisfactory drainage. A minimum velocity of 0.6 metres (2 feet) per second will prevent solids building up to block the pipe, and if the maximum velocity is limited to 3 metres (10 feet) per second this will prevent scouring and damage to the pipes. Table 11.3 shows the gradients at which these velocities are reached in pipes of various diameters and the approximate quantities that will be carried at such velocities.

TABLE 11.3 GRADIENTS TO PRODUCE MINIMUM AND MAXIMUM VELOCITIES IN DRAINS

Diameter of pipe		Minimum velocity 0.6 metres (2 feet) per second				Maximum velocity 3 metres (10 feet) per second			
		Grade		Carrying capacity per second		Grade		Carrying capacity per second	
		%	Litres	US gallons	UK gallons	%	Litres	US gallons	UK gallons
100	4	0.87	5	1.3	1.1	21.7	24	6.4	5.3
150	6	0.51	11	2.8	2.4	12.6	54	14.2	11.8
250	10	0.26	30	7.9	6.6	6.4	150	39.6	33.0
300	12	0.20	43	11.4	9.5	5.0	216	57.0	47.5

Source: Taylor & Wood 1982 (p. 59).

It may be necessary to use a pipe with a larger diameter if the relative levels of the building and the sewer are such that the appropriate gradient is inadequate to give a self-cleansing velocity for a particular size of pipe. However, a larger pipe will also have a tendency to lower velocity due to the fact that more of the water is in proximity to the frictional bed (contact surface between water and pipe). If the slope of the ground would cause the maximum velocity or gradient to be exceeded, the drain should be stepped, with the base of each vertical riser being adequately supported and the vertical section of the drain securely held in place. Such vertical sections can be more readily secured inside an access chamber.

INSTALL STORM WATER SYSTEM

Unstable Trench Walls

Due to the unstable nature of some native soils, the trench may require over-excavation to prevent collapse. In these cases, the trench width shall be determined based on an evaluation of the in-situ soil and the anticipated loading. Alternatively, a trench box may be used to support the trench walls and provide a safe work area during the pipe laying process. Depending on the trench box design, a sub-trench may need to be constructed to avoid contact between the box and the pipeline. All local, state and national safety guidelines should be followed when using trench boxes and sub-trenches. An example of a sub-trench is shown Figure 4.

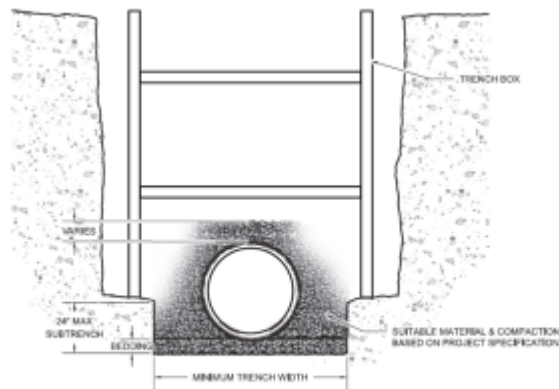


Figure 4: Typical Sub-Trench Installation

When working with trench boxes, it is critical to prevent disruption of the pipe installation while moving the trench box. If the trench box cannot be dragged without disrupting the pipe or initial backfill, it must be lifted in sections.

Water inside of the trench should be controlled before and during the pipe installation. The pipe should only be installed during dry conditions, never with running or standing water in the trench bottom. This may require control of surface and subsurface water sources by the following methods: sump pumps, wells or well points, drainage blankets, water tight sheathing, and/or sheeting. Control of water sources should be maintained until initial backfill has been installed and there is an adequate amount of final backfill to prevent floatation. The use of anti-floatation restraints such as collars or anchors may be used, if deemed necessary. It should be noted that OSHA standards change from time to time. In the event any of these recommendations are in conflict with OSHA, state and local safety requirements or specific site conditions warrant alternative safety precautions, contact a qualified engineer.

Foundations

Just like the trench walls, the soil at the bottom of the trench, referred to as the foundation, is a critical part of the installation. The foundation material must be supportive and stable, to prevent excessive settlement. In many instances the in-situ soil is stable and provides a suitable foundation. Typically, a foundation is considered stable if a person can walk over the soil without sinking in or feeling the soil move beneath them. If unstable soil, such as muck, is encountered, a typical corrective measure is to remove and replace the unstable soil. However, there are several methods of improving the foundation prior to installation depending on the soil conditions present:

- ✓ Reinforce – Soft soils are reinforced by adding dry soil, stabilizing geotextile or geogrid materials, or lime and then compacting for stabilization.
- ✓ Displace – Soupy soils are displaced by placing an overburden material such as large aggregate in the bottom until the foundation is consolidated and stabilized.
- ✓ Restore – Loose soils can be restored by compacting to a greater density.
- ✓ Remove – Existing soils that are unusable should be completely excavated and replaced with a suitable material.

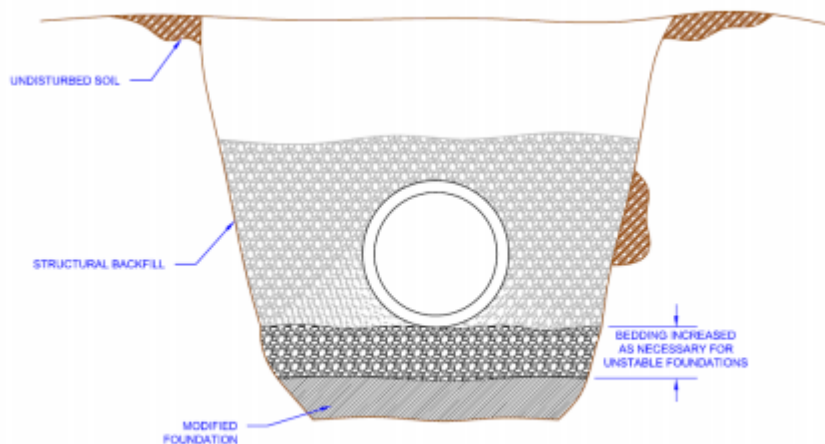


Figure 5: Modified Foundation

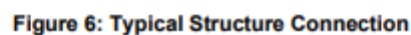
Each project will be unique and the method and material used to construct the foundation should be chosen by a geotechnical engineer.

Unyielding/ Hard Foundations

Unyielding materials, such as rock, in the trench bottom also pose a potential problem. To protect the pipe, bedding depth should be increased to 6"-10" as directed by a geotechnical engineer. Over-excavation of the trench may be required to accommodate the increased bedding while still achieving the desired line and grade.

In a situation where a hard foundation adjoins a soft foundation, there is potential for damage to the pipe. The dissimilar foundations may settle at different rates and result in depressions. To compensate for this, short sections of pipe with joints or couplers could be used at this transition point to better absorb the differential settlement. This is represented as an installation best practice and not a requirement.

Trench construction which involves connecting to structures, such as manholes or catch basins, will typically require over-excavation. The foundation in these cases will need to be built to grade with compacted structural fill or a controlled low strength material (CLSM). Connections to structures can be made in a number of ways dependent on the joint performance requirements and installation practices. As a best practice, a structure adapter should also be used to allow for some differential settling without causing strain on the pipe structure. As a recommended professional procedure, the first joint should be between 18"-36" from the structure connection to account for the concerns stated in this paragraph and the 'Transition from Hard to Soft Foundations' section above. Although not a requirement, this exercise will reduce the risks related with imperfect installation.



Bedding

The bedding material is placed in the bottom of the trench, between the foundation and the bottom of the pipe. The bedding allows for uniform longitudinal support and also distributes the load from the bottom of the pipe. The minimum bedding thickness should be a minimum of four inches for 4"-36" diameter pipe and a minimum of six inches for 42"-60" diameter pipe. Recommended bedding material is a Class I, Class II or Class III material as defined in Table 2 below. It is noted, use of class III bedding material is recommended only in dry trench conditions. Maximum particle size in the bedding material should not exceed 1½ inches. If bedding is to be used as an under drain, use a large, coarse, clean aggregate, not exceeding the maximum particle size.

The outer thirds of the bedding should be compacted and the middle one third portion should be loosely placed as shown in the Figure 7 below. This loosely placed area provides for uniform support at the invert.

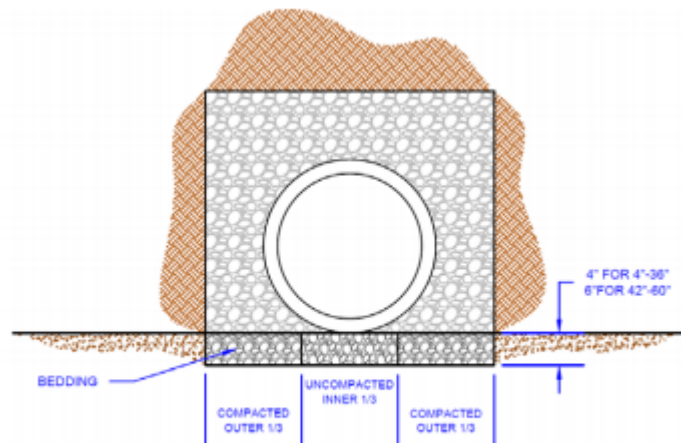


Figure 7: Bedding Placement

The bedding should be placed so that the pipe invert is at the correct grade when backfilled. It is important to note that there may be settlement of the pipe when placed on uncompact or loosely placed soil. A backhoe bucket should not be used to press on the pipe to bring it to grade. Also, blocking or soil mounds should not be used under the pipe, as this will cause point loading.

Laying Pipe

Before pipe is laid into the trench, re-inspect the pipe for any damage and clean any debris that may have accumulated on the inside of the pipe or sealing surfaces.

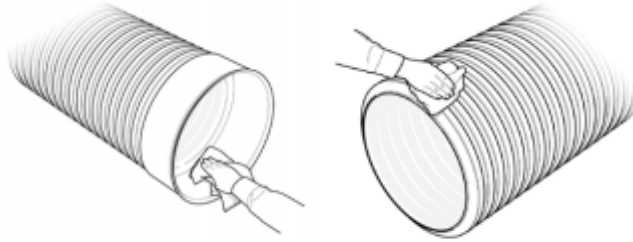


Figure 8: Cleaning Sealing Surfaces of Pipe

Pipe should also be checked to ensure that it is the correct type and size. The pipe should be lowered into the trench using slings placed in a manner that evenly supports the pipe. It is good practice to use a “tag line” when moving the pipe into position; this is a line attached to the end of the pipe, used to prevent uncontrolled pipe movement.

Pipe equipped with integral bell and spigots, such as Prinsco’s GOLDFLO WT®, ECOFLO® 100, or GOLDPRO Storm™, must be installed by inserting the spigot into the bell.

Pushing the bell onto a spigot increases the likelihood of forcing bedding material into the joint, disrupting the gasket and severely undermining water-tight performance. With this in mind, pipe laying should begin at the lowest point of the project with spigots pointed down-grade. With the spigot ready to be inserted into the bell, remove the protective film around the gasket. Use a clean brush, cloth rag, sponge or gloved hand to apply approved pipe lube to both the gasket and the bell. Do not allow lubricated section to contact dirt or backfill. Foreign matter could adhere to the lubricated surface and compromise the joint integrity. Failure to properly lubricate the joint will adversely affect the joint performance and will increase the force needed to push the joint “home”.

Pushing the pipe together may be accomplished in a number of ways: smaller diameter pipe may be pushed together by hand or leveraged together using a spanner block and a lever as shown in Figure 10.



Figure 10: Installing Small Diameter Pipe

Larger diameter pipe typically requires more force to assemble which necessitates the use of machinery, such as a backhoe. One method of using a backhoe for assembly is to use the slinging strap to “pull” the spigot into the bell of a previously installed pipe, as shown in Figure 11.

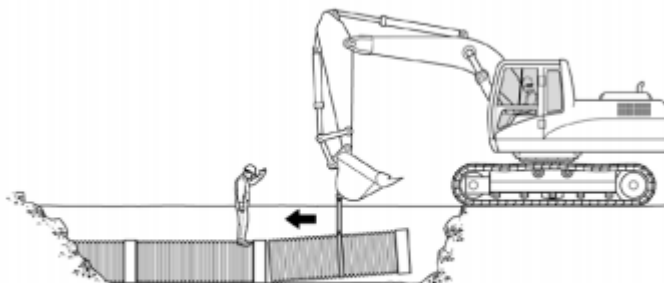


Figure 11: Installing Large Diameter Pipe with Sling

Another method involves pushing the pipe joints together. For this method, a sacrificial spigot or portion of pipe is placed inside the bell of the pipe to be installed, and then the assembly is pushed into the bell of a previously installed pipe, as shown in Figure 12.

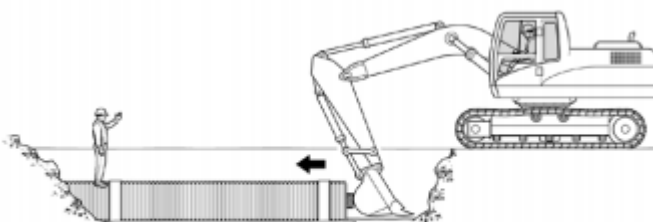


Figure 12: Installing Large Diameter Pipe with Stub

This sacrificial installation stub acts as a bumper to prevent damage to the pipe from the bucket. When using machinery to assemble joints, caution should be used to assure joints do not slam together and that the pipe already installed is not shoved out of alignment. A spotter should observe the spigot insertion to signal the operator when the joint is completely inserted and to prevent “over-homing.”

Note: During pipe joint assembly it is critical to ensure the pipe lengths are aligned both vertically and horizontally. Improper alignment will result in difficult or improper joint assembly and may cause the pipe joint to leak. If the misalignment is necessary for grade or curvilinear alignment a maximum of 1 degree misalignment is recommended.

Backfilling

The backfilling process is critical to ensure long trouble free service. The backfill and pipe function together as a structural system, forming the pipe/soil envelope, to support the soil overburden and live vehicular loads. For this reason, the backfill material and level of compaction directly impacts the performance of the pipe/soil envelope. The backfill material must have a high density as well as a resistance to migration and degradation.

Soil within the pipe/soil envelope should not contain any organic material, stumps, logs or limbs, man-made waste, debris, frozen soil, or any other unsuitable material. During the backfill process there should not be any rocks larger than the maximum particle size of 1½ inches placed in the pipe/soil envelope. Meeting the requirements for the soil in the pipe/soil envelope is absolutely critical to obtaining maximum structural performance and service life. Any changes to the material used should be approved by the specifying organization or engineer of record.

When beginning the backfilling process, the embedment material should be distributed and compacted in lifts evenly on each side of the trench to ensure that the pipe is not pushed out of alignment and help to prevent against elongation. Placing embedment material in the center of the pipe and allowing it to fall evenly on each side of the pipe is a method often used to maintain alignment of the pipe in the trench.

- ✓ Bedding
 - The bedding is placed in the bottom of the trench, between the foundation and the outside diameter of the pipe.
- ✓ Haunch
 - The haunch is the area of initial backfill that extends from the bedding up to the spring line of the pipe. Getting adequate material into the haunch area, and compacting as necessary, is a critical step to ensuring a high performance installation.
- ✓ Initial backfill
 - Depending on the product and the application, the initial backfill extends from the spring line to the crown of the pipe or to 6 inches over top of the pipe.
- ✓ Final backfill
 - The final backfill is placed over the initial backfill and this material is used to build the trench up to final grade.
- ✓ Embedment
 - The embedment refers to the zone of structural backfill around the pipe including the haunch and the initial backfill.

Compaction

The desired compaction level may be achieved using common compaction equipment, which may include, but is not limited to: hand tampers, power tampers, static compactors, vibratory compactors or rammers. A few of the compactors are shown in Figure 14.

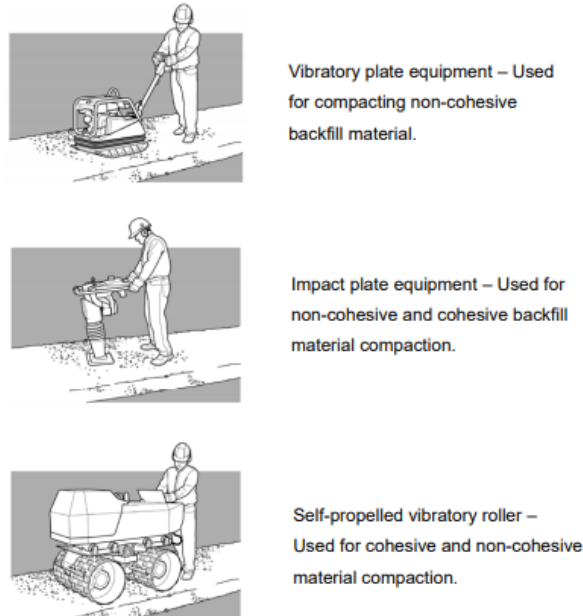


Figure 14: Typical Compaction Equipment

To eliminate the possibility of damaging the pipe, a minimum of three feet of cover should be achieved before large, self-propelled compactors are used on or around the pipe. Hydrohammers or other tractor mounted hydraulic vibratory and impact compaction equipment should not be used until a minimum of 4 feet of cover is over the pipe and then only if the embedment material design has been compacted to a minimum 85% standard proctor density.

Minimum Cover Height

Cover height is one of the determining factors when calculating the load carrying capacity of the installation. Minimum cover heights are dependent on the backfill material used and the expected live loads.

These cover heights assume initial backfill to the crown of the pipe for HP pipe and 6" of structural backfill over the pipe crown for HDPE pipe with an additional layer of compacted subbase material or rigid pavement to achieve the minimum requirements.

If the pipe will experience loading from construction equipment while the project is still being constructed, temporary fill may be placed over the pipe during construction and removed after the heavy construction equipment traffic is rerouted. For heavy construction loads, between 30 and 60 tons, there should be a minimum of 3 feet of cover. For construction equipment exceeding 60 tons the minimum cover depends upon the loading foot print of the equipment. Additional fill may be required. For loads exceeding 60 tons, contact your local Prinsco Representative for minimum cover heights.

Often during the paving process, it is necessary to decrease the minimum cover heights. For temporary construction loads, such as pavers, the minimum allowable cover height is governed by the pressure at the surface of the soil which is a result of the vehicular load distributed over the tire contact patches.

Maximum Cover Height

Increased cover heights allow live load to be dispersed over a greater area of surrounding soil, however it also adds to the weight of the soil column directly above the pipe. Maximum cover heights are dependent on many variables including the pipe type, level of the ground water table, the backfill material used and also the level of compaction. Refer to Prinsco's Structures Section for more information regarding maximum cover heights.

Geotextiles

To prevent the migration of fine soil particles into the pipe/soil envelope, the use of a geotextile may need to be considered. When the groundwater table is at or above the elevation of the pipe, fine particles from the in-situ soil have a tendency to migrate into the course backfill which can result in a loss of pipe support. The geotextile will act as a filter around the bedding, haunch and initial backfill and prevent this migration from occurring. Due to the wide variety of soil and site conditions, the use of a geotextile should be determined by a geotechnical engineer.

Dewatering

As previously stated, the properties of the in-situ soil surrounding the pipe envelope are very important for any pipeline installation. Standing water in an open trench greatly increase the likelihood of reduced structural capacity and make proper pipe placement and backfill compaction impossible. There are many methods to dewater, including: sump pumps, well points, deep wells, underdrains, stone blankets and diversion ditches. Each of these methods has their advantages and disadvantages; the specific project conditions should dictate the most appropriate dewatering method.

Groundwater/Pipe Flotation

Pipe flotation, due to buoyancy, may be a concern for pipe systems installed in areas where seasonal or permanent water tables extend beyond the pipe. This concern is exacerbated for watertight pipe systems and installations in poorly graded non-cohesive soils. In all cases it is important to consider minimum cover heights necessary to prevent flotation. Depending on the site conditions these minimum cover heights may be greater than required for structural considerations. In applications where pipe buoyancy is too great for the soil load present, earth anchors or poured concrete collars may be used to secure the pipe to grade.

Sealing Vent Tubes

Vent tubes are utilized during the manufacturing of HDPE and HP to release hot air from inside of the corrugations in order to properly form the corrugations. These tubes run the length of the pipe and are sealed on the ends during the manufacturing process. However, when field cuts are made, these vent tubes are exposed and present a potential problem for

water tight situations. It is recommended that these vent tubes are sealed to eliminate a potential leak path.

Vertical Installations

Prinsco's dual wall HDPE and HP pipe are sometimes installed in vertical applications for use as catch basins or manholes. Pipe in vertical installations are subjected to different loading conditions than typical installation due to the pipe/soil interaction. Special consideration must to be made for vertical installations. Additionally, vertical installations have a potential for flotation in areas of height ground water.

Parallel Pipe Installation

In some applications, such as underground detention systems or high volume fluid conveyance, it may be desirable to run multiple parallel pipelines in the same trench. In this situation, the trench width is a function of the number of runs, the adequate spacing between the pipes and between the pipe and the trench walls is shown below.

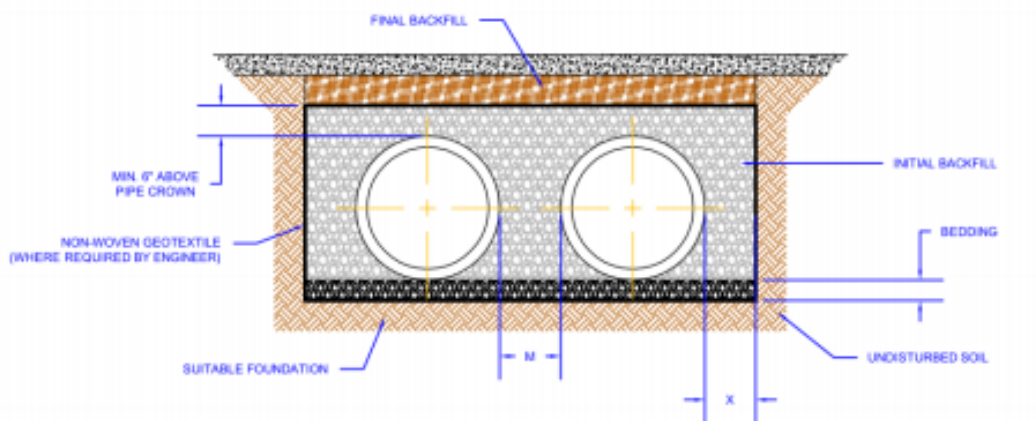


Figure 15: Typical Parallel Pipe Installation

Nominal I.D. (in)	Min. Side Wall "X" (in)	Minimum Spacing "M" (in)
12	8	12
15	8	12
18	9	12
24	10	12
30	18	15
36	18	18
42	18	21
48	18	24
60	18	30

Table 7: Parallel Pipe Installation Spacing

Note: Minimum Spacing "M" measured from outside diameters.

Soil Jetting

Soil jetting is a process by which a long hose or other device is worked down into the soil with a high velocity stream of water and is then pulled out slowly, compacting the soil as it is removed. Due to the relative light weight of HDPE and HP pipe, the soil jetting process could cause pipe floatation as well as disrupting the grade and line of the buried pipe. This process is not recommended for use with corrugated HDPE and HP pipelines.

PREPARE DOCUMENTATION

Visual Inspection

Typically, a visual inspection is all that is necessary to determine the quality of a pipeline installation. If additional testing is necessary, deflection testing and/or low-pressure testing may be used.

Deflection Testing

Deflection testing is generally not required when using proper construction practices associated with initial backfill material selection, placement and compaction. However, if considered necessary, random deflection tests of pipe may be performed within 30 days of installation. Some projects may require post installation deflection testing as a means of installation quality control. This is typically accomplished using a mandrel, laser measurement tools or video inspection. Pulling a mandrel through 10% of the pipe installed provides a reasonable indication of installation quality.

Routine Maintenance

Having a stormwater management system and pollutant reduction system is not enough on its own. Proper and regular maintenance is required to ensure a healthy water source. Depending on the type of system you have, it's important to select a well-seasoned company or stormwater expert who is familiar with your local requirements and a variety of practices such as bioretention, infiltration, green roofs, detention vaults, storm drains, interceptors, and more. This will eliminate the guesswork on your end. Some companies offer maintenance contracts so your system doesn't fall into disrepair.

Below are factors to consider when maintaining your stormwater management system.

Regulations

Federal, state, and local regulations require that stormwater systems be maintained and serviced on a recurring basis and that collected materials (trash, debris, and sediments) be properly disposed of. Some materials found in stormwater systems may contain hazardous wastes that are ignitable, corrosive, or toxic. It's best to let a professional company ensure the waste is disposed of properly and in a manner that follows the guidelines of your local jurisdiction.

Timing/Frequency

Depending on the system, the manufacturer's recommendations, and your location, the timing and frequency at which you need to perform maintenance may differ. A regular "recurring" basis may mean a full clean-out annually or bi-annually, but filters may need to be changed more frequently. The amount of runoff, volume of pollutants, and interference from debris (cans, leaves, paper, etc.) can impact frequency. Also, depending on your locale, it might be necessary to have service completed before the rainy season or heavy rainfall.

Configuration

For underground detention, retention, and infiltration systems, there are configuration attributes that dictate how the system must be maintained. For instance, in units made up of a single detention tank, a long-handled net can be used to retrieve the bulk of trash and debris. In larger, multi-unit systems, there may be passage ways or doorways with corners where a person must enter and vacuuming must be done to remove sediment. Make sure these technicians are trained and certified in confined-space operations to properly work on your systems.

Open bottom storage basins that use gravel and aggregates may have splash guards in place to prevent erosion. Jetting and flushing should be avoided for systems like these so that there is no particle displacement. However, flushing is acceptable in systems with concrete bases. Additionally, there may be time needed for observing the inlet and outlet pipes for blockages and monitoring drain-down time.

Vegetation

Some bioretention/biofiltration systems may require periodic irrigation to establish and maintain trees or vegetation. Vegetation will typically become established about two years after planting. Irrigation requirements are ultimately dependent on climate, rainfall, and the type of vegetation selected. In some units, pollutants such as trash, debris and coarse sediment are retained within a pre-filter chamber for easy removal by hand or with conventional vacuum equipment.

Inspections

Making sure you follow municipal and state regulations is key. Whether you are a municipality-owned facility or a private HOA, a thorough inspection of the system can protect everyone's interests. Plus, it is often a state or local requirement.

It's important to schedule an inspection even if the system is new to establish a baseline that future inspections can be compared to. For all inspections, your system inspector should be OSHA-compliant and certified in confined space operations. While looking for improper discharges, they may use a closed circuit TV (CCTV) to inspect storm drains and sewers. He or she will evaluate the type of facility, where the water enters and exits, and what the age of the material is, among other things.

Indicators that are often identified during an inspection might include:

- ✓ Slow draining outlet pipes
- ✓ Concrete damage
- ✓ Standing water
- ✓ Erosion
- ✓ Invasive vegetation (in bioretention/biofiltration systems)
- ✓ Excessive sediment load
- ✓ A clog

In addition to keeping your system running properly, regular inspections can allow you to budget for future maintenance and possible failure.

18.REFERENCES

REFERENCES

- ✓ <https://images.template.net/wp-content/uploads/2015/08/Writing-a-Project-Proposal-PDF1.pdf>
- ✓ <https://www.fool.com/the-blueprint/project-proposal/>
- ✓ <http://www.distance.vic.edu.au/wp-content/uploads/2015/09/HELPSHEET-The-Research-Process.pdf>
- ✓ <https://www2.hawaii.edu/~halina/ExpDesWk/ResSteps.pdf>
- ✓ <https://samples.jbpub.com/9781449627843/Chapter1.pdf>
- ✓ <https://onlinepubs.trb.org/onlinepubs/nchrp/cd-22/manual/v1appendixb.pdf>
- ✓ <https://www.tpp.ac.nz/assets/Uploads/Report-Writing.pdf>
- ✓ <https://grimsby.ac.uk/documents/highereducation/skills/Structure-of-Reports-Learnhigher.pdf>
- ✓ https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_687610.pdf
- ✓ <https://www.cancerwa.asn.au/resources/2011-12-01-How-to-Manage-Work-Health-and-Safety-Risks.pdf>
- ✓ <https://rambolevy11.files.wordpress.com/2014/11/initiate-computer-system-1.pdf>
- ✓ <https://towardsdatascience.com/data-types-in-statistics-347e152e8bee>
- ✓ <https://www.iimdirect.com/blog/data-entry/7-steps-data-entry-system-implementation/>
- ✓ <https://www.wgtn.ac.nz/lals/research/projects/language-in-the-playground-project/publications/lip5.pdf>
- ✓ [https://publications.jrc.ec.europa.eu/repository/bitstream/JRC88200/kg301514_120p_e3%20\(2\)_01.07.2013.pdf](https://publications.jrc.ec.europa.eu/repository/bitstream/JRC88200/kg301514_120p_e3%20(2)_01.07.2013.pdf)
- ✓ <http://www.ijnlt.com/files/Vol%202%20Issue%201/Kiran%20Prakash.pdf>
- ✓ <https://fitforwork.org/blog/maintenance-of-equipment-in-the-workplace/>
- ✓ <https://extranet.who.int/lqsi/sites/default/files/attachedfiles/LQMS%203-4%20Equipment%20maintenance%20programme.pdf>
- ✓ <https://ncert.nic.in/textbook/pdf/kect107.pdf>
- ✓ <https://hvacr.vn/diendan/resources/so-tay-xu-ly-nuoc-mathematics-manual-for-water-and-wastewater-treatment-plant-operators-2014.67/download?version=71>
- ✓ https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_sketching/
- ✓ http://www.minddecider.com/Articles.Tasks_management.htm
- ✓ <https://www.thespruce.com/how-to-create-a-daily-routine-2648007>
- ✓ <https://www.siteware.co/en/strategic-management/what-is-work-routine-management/>
- ✓ http://www.sciencebits.com/vector_algebra#:~:text=Scalars%3A%20Scalars%20are%20mathematical%20entities,a%20magnitude%20and%20a%20direction.&text=Physical%20examples%20include%20forces%2C%20velocities%2C%20momenta%20and%20locations
- ✓ <https://www.csus.edu/indiv/m/mackj/chem142/kinetics.pdf>
- ✓ <https://www.physicsclassroom.com/class/circles/Lesson-1/Mathematics-of-Circular-Motion>
- ✓ <https://www.physicsclassroom.com/class/newtlaws/Lesson-2/The-Meaning-of-Force>
- ✓ <https://byjus.com/physics/law-of-conservation-of-energy/>
- ✓ <https://www.physicsclassroom.com/class/momentum/Lesson-1/Momentum>

- ✓ <https://www.physicsclassroom.com/class/waves>
- ✓ <https://ncert.nic.in/ncerts/l/kech105.pdf>
- ✓ <https://www.wilhelmsen.com/globalassets/marine-products/welding/documents/wilhelmsen-ships-service---unitor-welding-handbook.pdf>
- ✓ <https://welderportal.com/welding-tools-and-their-uses/>
- ✓ https://local.ecollege.ie/Content/APPRENTICE/liu/pipefitting/pdf/M3_U5_Pipe%20Joining.pdf
- ✓ <https://www.ccohs.ca/oshanswers/hsprograms/house.html>
- ✓ <https://www.marleyplumbinganddrainage.com/media/1190/soil-waste-design-installation-manual.pdf>
- ✓ <https://ccc.govt.nz/assets/Documents/Consents-and-Licences/construction-requirements/approved-contractors/Trench-Support-Best-Practice-Guideline-2-February-2017.pdf>
- ✓ https://www.cedd.gov.hk/filemanager/eng/content_435/trench_excavations.pdf
- ✓ <https://www.emerson.com/documents/automation/control-valve-handbook-en-3661206.pdf>
- ✓ http://www.festo-didactic.com/didactic/Demos/Pneumatik/data/1017/misc/aktoren_und_ausgabegeraete-en.pdf
- ✓ <https://www.meprogram.com.au/wp-content/uploads/2018/03/MFE3004AdditionalPT5.pdf>
- ✓ https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Lot_3i_-ADB-ITB-MZFO-2016-0109_-_Fire_Security_Project_Description_MZFO.pdf
- ✓ https://www.ifsta.org/sites/default/files/Chapter14_FICE8.pdf
- ✓ <https://www.dmme.virginia.gov/de/LinkDocuments/HandbookWaterHeating.pdf>
- ✓ <https://www.nrel.gov/docs/fy01osti/26465.pdf>
- ✓ <https://www.waterheaterleakinginfo.com/electric-water-heater-installation/>
- ✓ https://www.who.int/water_sanitation_health/hygiene/plumbing15.pdf
- ✓ <http://siglercommercial.com/wp-content/uploads/2017/10/02-Chilled-Water-Piping-Pumps.pdf>
- ✓ <https://www.waterworld.com/home/article/14070974/pump-maintenance-101>
- ✓ <https://swab.zlibcdn.com/dtoken/39b0d97d53a66cbbf6d795f561a55322>
- ✓ <https://bunker2.zlibcdn.com/dtoken/1973341ab17354399b72a3d4d9550855>
- ✓ <http://www.fieldandcivilengineering.co.uk/prepare-drainage-construction/>
- ✓ https://www.researchgate.net/publication/325189144_Discussion_on_construction_methods_and_precautions_of_building_water_supply_and_drainage
- ✓ <https://www.teagasc.ie/media/website/animals/dairy/DesignInstallationDrainageSystem.pdf>
- ✓ <http://riograndewater.org/media/1071/b-6229-understanding-and-installing-drainage-systems.pdf>
- ✓ https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_192256.pdf
- ✓ <https://www.legislation.gov.au/Details/F2016L00394>
- ✓ <https://www.superiorgroundcover.com/install-a-foundation-drainage-system/>
- ✓ <https://www.water.org.uk/wp-content/uploads/2019/03/Appendix-C-to-draft-sewerage-Sector-Guidance-Design-and-Construction-Guidance.pdf>

- ✓ <https://continuingeducation.bnpmedia.com/courses/bk-lighting/best-practices-for-site-preparation-and-installation-of-ingrade-fixtures/2/>
- ✓ <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=32418.wba>
- ✓ <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=21>
- ✓ https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_093550.pdf
- ✓ <https://www.hse.gov.uk/managing/delivering/do/implementing/index.htm>
- ✓ <https://doresearch.stanford.edu/policies/research-policy-handbook/environmental-health-and-safety/health-and-safety-principles#anchor-973>
- ✓ https://www.hsa.ie/eng/Topics/Managing_Health_and_Safety/Safety_and_Health_Management_Systems/#training
- ✓ <https://www.education.vic.gov.au/school/students/beyond/Pages/hsresponsibilities.aspx>
- ✓ https://www.academia.edu/37001454/LG_ITICOR0011A_CARRY_OUT_DATA_ENTRY_AND_RETRIEVAL_PROCEDURES_LEARNERS_GUIDE_CARRY_OUT_DATA_ENTRY_AND_RETRIEVAL_PROCEDURES_HEART_TRUST_NATIONAL_TRAINING_AGENCY_2003_LG_ITICOR0011A_CARRY_OUT_DATA_ENTRY_AND_RETRIEVAL_PROCEDURES
- ✓ <https://www.querytool.com/help/toc721223.htm>
- ✓ http://paramjamwal.blogspot.com/2020/03/routine-systems-and-records-of_74.html
- ✓ <https://www.asccc.org/content/housekeeping-records-and-files>
- ✓ <https://www.agg-net.com/documents/health-safety-risk-management-system/safety/s24-record-keeping>
- ✓ https://www.safetyworksmaine.gov/safe_workplace/safety_management/
- ✓ <https://www.ccohs.ca/oshanswers/hsprograms/house.html>
- ✓ <https://aspire-solidus-production.s3-ap-southeast-2.amazonaws.com/assets/TLSE2008/samples/TLSE2008-sample.pdf>
- ✓ <https://energycodeace.com/site/custom/public/reference-ace-2013/index.html#!Documents/52waterheatingequipment.htm>
- ✓ <https://www.sa.gov.au/topics/energy-and-environment/energy-efficient-home-design/water-heater-requirements>
- ✓ <https://www.sa.gov.au/topics/energy-and-environment/electrical-gas-and-plumbing-safety-and-technical-regulation/plumbing-trades/water-heater-installation-requirements>
- ✓ https://www.saqccfire.co.za/images/ToolboxTalk/33HoseReelService_Faults.pdf
- ✓ https://intrans.iastate.edu/app/uploads/sites/15/2019/12/Chapter_04-2019.pdf
- ✓ <http://localplumbingandsewerga.com/water-mains/water-main-installation/>
- ✓ <https://www.townofcary.org/projects-initiatives/project-updates/water-projects/annual-water-main-replacement/water-main-installation-process-2718>
- ✓ [http://mohua.gov.in/upload/uploadfiles/files/Volume%20I%20Engineering\(3\).pdf](http://mohua.gov.in/upload/uploadfiles/files/Volume%20I%20Engineering(3).pdf)
- ✓ https://www.who.int/water_sanitation_health/hygiene/plumbing10.pdf
- ✓ <https://www.prinsco.com/wp-content/uploads/2014/06/Stormwater-Installation-Guide.pdf>
- ✓ <https://www.buildingsolutions.com/industry-insights/stormwater-management-system-maintenance>



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