INSTRUMENTATION AND CONTROL SERVICING

LEVEL-III

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Instruction sheet

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

Obtaining work instructions

Checking received equipment

Identifying, Isolating and reporting faulty equipment

Recording and/or reporting faults and any identified causes

Recommending fault equipment's for replacement or returned to suppliers

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

Obtain work instructions

Check received equipment

Identify , Isolate and report faulty equipment

Record and/or report faults and any identified causes

Recommend fault equipment's for replacement or returned to suppliers

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information Sheet 1- Obtaining work instructions

Obtaining work instructions

work instructions a useful tool: clear (and visual) instructions, interactive to an extent, and aiming for the best possible model through constant collection of data and analysis of it while respecting the individual's privacy. Sounds good to us.

Work instructions are a part of standard work that make for the most efficient and waste-free production system. When you have the proper work instructions in place, your workers get to function as a unit, performing according to best practices while maintaining a safe work environment.

Properly created and utilized work instructions can make a huge difference to where your company is going to be this time next year or even next month. If you want constant improvement (also known as kaizen), you'll surely want to focus on the *how to* which is what work instructions are all about and get the most out of your human workforce.

Standard work is the comprehensive approach (or tool, as it is called in lean production) to achieve kaizen, or continuous and sustained growth.

Standard work instructions is a term that refers to one part of the entire process of standard work. As one of the leading providers of standard work software puts it, standard work is the GPS that shows the driver how to reach the destination, and (standard) work instructions would be the minutiae that deals with how to drive the car and make sense of the GPS.

Choosing a Work Instructions Creation Platform

you can create work instructions that include images, videos, animations, and the best ways to manipulate them for functionality. The level of complexity will depend upon your requirements. There's a way to even collect feedback from your workers much like blogs that leave the commenting feature open.

The difference between work instructions, work guides, SOPs

Work instructions are also called work guides, Standard Operating Procedures (SOPs), job aids or user manuals, depending on the situation. In any case, the purpose of the work instructions is to clearly explain how a particular work task is performed.

What's important is that work instructions should not be confused with processes or process maps. Let's quickly look at where work instructions fit into our overall process documentation levels:

A **process hierarchy** shows your overall process architecture and how it supports your business

A **process** is a chain of activities that transform inputs to outputs.

A **procedure** outlines *how* to perform a process – sequence and who does what. In Gluu we combine process and procedure into a single, simple format (since people confuse them all the time).

A **work instruction** – or work guide, job aid or standard operating procedure – describes in detail how an activity within a process (or procedure) is performed.

Importance of Standard Operating Procedures

They reduce the impact when key people leave

Work instructions, or SOPs, build and preserve the knowledge inside a company. When "how things are done" are passed on verbally, there is room for interpretation and human error. And knowledge about how to most efficiently perform a task is lost when said employee leaves the company and takes the knowledge with them. Good work instructions avoid all this.

Work instructions reduce risk

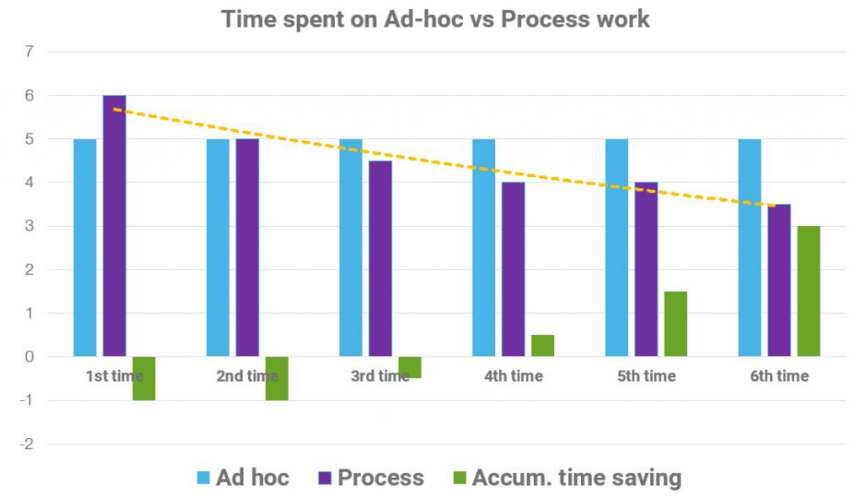
They reduce risk because the safest way of doing a job is clear and known by the people that matter.

Avoid errors and “the blame game”

Clarity avoids errors. Crucially, this avoids the blame game. When things go wrong the tendency is to blame or hold people responsible, which is natural. But if this happens often it can have an impact on staff morale. Having clear work instructions minimises this problem.

Save time

The chart below shows Gluu’s own research on the Return on Investment when writing work instructions. The point is that your initial investment in time is paid back once your work instruction has been used just three times. This only refers to time-saving – we haven’t even mentioned the value of avoiding errors and rework. This is also referred to as “Standard Work” within Lean:



a good instruction look like

Work instructions should make crystal clear how employees perform their tasks. There should be no room for interpretation. They should not be vague. You want to minimise the chance of them confusing your workers. This means your instructions should be as brief and simple as possible.

Work instruction must be

clear

accessible

credible

consistent

short and simple

visual

written by the people that know

Work instructions should follow a single style. Consistency in terms of terminology, layout, media and method makes them easier to follow and digest. Also in terms of consistency, they should adhere to the skill set of the employees.

7 steps to clear work instructions

STEP 1 Write a clear title

What's in an introduction? Well, quite a lot actually. It is crucial to get this part right. To do so make sure you do the following:

Give some context: briefly, explain which process the task is part of.

Identify the owners: briefly, explain who the process owner is an who the task owner is

State the output: briefly, explain what the output or purpose of the task is

The title must refer to the job: A good example might be, "how to disinfect your hands".

STEP 2 Describe the purpose – the why

What's the purpose of your work instruction? Why are you preparing it? Asking why questions help you to step back and think about what you're trying to achieve. The answer to the why isn't simply the output you have already identified. Asking why is about deepening

your understanding before jumping into the details. Read more about the value of the questions why here.

So, a clear purpose to “how to disinfect your hands” would be “Avoid spreading bacteria so that other risk falling ill.”

STEP 3 Describe how to do it

First of all, you need to list the materials required to do the job. For easy reading, it’s best to list these in bullet points and to distinguish between the materials that are provided and not provided. Order your bullet point list logically.

STEP 4 Format for easy reading

Think of your work instruction document as an educational tool. Put yourself in the reader’s shoes and think about what would help him or her digest the document.

Choose how you will format the document and stick with it. If you are practising Lean, then here’s an example format to consider using.

Break down any steps into a number sequence. If there are more than 10 steps, then subdivide the different topics. One step describes one action that takes no more than 15 seconds to complete.

Use images or drawings. Make sure the image fits the text. Refer to the image in the text. Place images on the left side of the paper and keep the text on the right side. Emphasise important information by using upper case, bold or italicised text. Turn any list into a bulleted or numbered list.

STEP 5 Rewrite and simplify

The key rule for good writing is brevity. Short, simple and clear.

Use short and simple sentences. Sentences should be no longer than 15 words and should be without clauses.

Use short and simple words. Multi-syllable words sound brainy but slow the reader down. Make it easy for them and imagine you're writing for a five-year-old.

Avoid acronyms, and if you must use one then spell it out the first time and enclose the acronym in brackets next to it. Use the acronym from then on.

Include a list of abbreviations the reader can refer to.

Decide which word or term you will use to describe something and stick with that. Don't use different words for the same thing. For example, if you use the term "household soap" then only use that throughout the whole document.

.**STEP 6 Add references**

It's always helpful to provide sources and suggestions for further reading and learning. Either add footnotes or have an appendix at the end of the document.

STEP 7 Test with a colleague!

To make sure your work instructions are easy to understand and follow, ask a colleague to perform the task by following it. This will tell you if certain parts or explanations are confusing or need further clarification.

Ask an appropriate colleague to read the draft of your work instruction and to give you feedback on it. Does the work instruction match the way the task is performed in reality? Is it confusing? What could be clearer?

Request the colleague to perform the job by following the draft work instruction. Do NOT help him/her, or give further explanations. Observe.

Make notes of what should be added or changed on your copy of the work instruction.

Your work instruction checklist.

Identified process the task is part of

Identified the purpose of the task

Understood the task's scope

Named people responsible for the task

Stated tools required for the task

Mentioned any safety requirements

Chosen an appropriate and helpful format

Used helpful visual aids

Checked for simple language and short sentences

Removed unnecessary jargon and technical terms

Tested on a colleague.

From Goal to Work Instructions (and Beyond)

Let's look at **production** as a whole, lean or not:

i. Goal

This is where it begins, of course. Without a goal, where would you go, what would you do?

ii. Policies

While it is important to plan how to achieve your goals, you should also bear in mind the ambit within which you will work. For example, whether or not you will employ cheap labor from third world countries to reduce cost could be a policy. Policies also determine the quality you are aiming for and the minimum standards of perfection you want to achieve.

Policies set boundaries and make it easy for you to take the next steps without worrying about whether you should or should not do this or that—and what might happen as a consequence. All those questions are already answered in your policies, and unless there is a serious issue that calls for a policy revision, all you'll need is to refer to the specific policy that addresses your query.

iii. Process

This is the overview of how you are going to function to achieve your goal. This is the broadest, and the highest-level element of your plan. It states, for example, how many workers will be required and how much raw material, during which time of the year (if relevant) the work will be carried out, which personnel are going to be roped in and how to keep everyone apprised and accountable. It also outlines the sequence in which the work will flow.

iv. Procedure

This is where standard work comes in, although not every single procedure needs to be standard work. Remember also that standard work refers to a very specific tool to achieve zero-defect production and kaizen. You may or may not have the set up or the motivation for standard work for procedure.

However, *all* procedures, whether or not they measure up to the high level of standard work, will outline the exact manner in which a certain job will be done. Considering there is usually more than one job in a production chain, it is normal to have several procedures in place.

v. Work Instructions

This is the part where the “how” is detailed step by step. We have explained this in theory. We will show you the exact steps in Chapter 2, which covers how to create work instructions.

vi. Record Keeping

This is the final stage of production. Without this, there can be no improvement or quality assessment. Do you need a policy revision? Were the processes well-defined and realistic? Did the procedures prove efficient? How effective were the SOPs? Do you need clearer work instructions?

With this concluding part of the workflow, you end your current operations and equip yourself for future evaluations and references. This is also an essential step for meeting the ISO 9000 quality management criteria, but that is a separate topic altogether.

And finally, we’re in a position to explain how work instructions eliminate waste in waiting, defect, over-processing, and skills.

Types of Waste That Work Instructions Eliminate

Waiting

Defects

Over-Processing

Skills

. **Creating Work Instructions**

Here’s a detailed list of things to consider when drafting out a set of work instructions:

1. **The exact purpose of the work instructions**

Some of the questions you’ll want to ask could be:

Are the work instructions for new recruits learning to use a piece of machinery or for veterans being taught a more efficient way of doing things?

Is how to do something the main purpose, or are the instructions primarily to ensure safety, as in what *not* to do, perhaps?

Speaking of safety, how much risk are we even talking about?

Should you also add a section on what to do, who to contact in case something goes wrong?

2. How well the user is likely to understand the language the instructions come in

This is pretty much self-explanatory, and, in any case, instructions must be written in simple, easy-to-follow language.

3. How informed the users already are of the process/machinery/environment

This is very important for two reasons: you need to avoid superfluous introductions, backgrounds, and summaries, and you definitely need to include things that only an experienced user/worker would know.

Regarding the superfluous bit, no one likes to read a long-winded intro when they are looking for instructions to get the job done. If your write-up is annoying, the user will lose focus and possibly make less than optimal use of it.

4. Is background information necessary?

This is where you may need that long-winded intro after all.

Imagine you're writing instructions which the worker needs to view before they enter the

5**. Anticipating problems**

Work instructions can only be written by someone who is aware of how a certain work is performed with optimum efficiency. Problem is, if someone is really good at it, they could easily overlook some of the problems they may have faced as a beginner, like how to retrieve a really thin and delicate machine part without damaging it if it accidentally falls on the floor.

6**. Are visual instructions required?**

One common scenario where a worker could do with clear visual instructions is where they have to assemble various parts of a machine to make it work. Another is when you're writing about a complicated process.

7**. How to draft a troubleshooting guide**

No matter how clear your instructions are and how closely they are followed, there could always be trouble. The PC refuses to boot. The piece of furniture is creaking for no apparent reason. The user finds it hurts their back to work on the woodworking bench. It could be anything. How do you get around to thinking of things that you may have never encountered?

Talk to the manufacturing department personnel. Talk to people who have previously worked on what you're writing about.

To clarify further using our examples, a PC refusing to boot could very well be due to a loose plug—or a loose RAM; optimal tightening of the nuts and bolts (with a bit of trial and error) could stop the creaking; and adjusting the height of a woodworking bench usually takes care of an aching back. But you *will* need to dig around quite a bit to know about both the problems and solutions. The last one, for example, might not affect the majority of users but only the ones taller than average.

8**. Appearance and structure of your instructions**

Someone trying to figure something out for the first time needs *clear* instructions in every sense of the word. This is easily achieved with:

short sentences (in simple language),

bullet points where necessary,

clear and readable font, and a well-thought out page design with lots of white space.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided

Answer the following question as directed below

1. _____ shows your overall process architecture and how it supports your business
2. _____ is a chain of activities that transform inputs to outputs.
3. _____ outlines *how* to perform a process – sequence and who does what.
4. Define work instruction **work instruction**

Answer the following question!

Note: Satisfactory rating - 5and 8points **Unsatisfactory - below 5and 8points**

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

Answer Sheet

Name: _____ Date: _____

Score = _____
Rating: _____

Information Sheet 2 Checking received equipment

Checking received equipment

Received equipment include these but not limited Weighing scale, Infant/Adult

Clinical weighing scale Gooseneck lamp/Examining light Oxygen gauge Sphygmomanometer Suction apparatus Autoclave OR/DR light OR table Nebulizer Rotator/Shaker Electro muscular stimulator Spectrophotometer/Spectroscopy(assorted) Uninterruptible power supply Bag valve mask (Pedia and Adult) Anesthesia bag Clinical oven

Medical equipment management

Healthcare Technology Management (sometimes referred to as clinical engineering, clinical engineering management, clinical technology management, healthcare technology management, medical equipment management, biomedical maintenance, biomedical equipment management, and biomedical engineering) is a term for the professionals who manage operations, analyze and improve utilization and safety, and support servicing healthcare technology. These healthcare technology managers are, much like other healthcare professionals referred to by various specialty or organizational hierarchy names.

Some of the titles of healthcare technology management professionals are biomed, biomedical equipment technician, biomedical engineering technician, biomedical engineer, BMET, biomedical equipment management, biomedical equipment services, imaging service engineer, imaging specialist, clinical engineer technician, clinical engineering equipment technician, field service engineer, field clinical engineer, clinical engineer, and medical equipment repair person. Regardless of the various titles, these professionals offer services within and outside of healthcare settings to enhance the safety, utilization, and performance on medical devices, applications, and systems.

They are a fundamental part of managing, maintaining, and/or designing medical devices, applications, and systems for use in various healthcare settings, from the home and the field to the doctor's office and the hospital.

HTM includes the business processes used in interaction and oversight of the technology involved in the diagnosis, treatment, and monitoring of patients. The related policies and procedures govern activities such as the selection, planning, and acquisition of medical devices, and the inspection, acceptance, maintenance, and eventual retirement and disposal of medical equipment.

Responsibilities of the Healthcare Technology Management Professional

The healthcare technology management professional's purpose is to ensure that equipment and systems used in patient care are operational, safe, and properly configured to meet the mission of the healthcare; that the equipment is used in an effective way consistent with the highest standards of care by educating the healthcare provider, equipment user, and patient; that the equipment is designed to limit the potential for loss, harm, or damage to the patient, provider, visitor, and facilities through various means of analysis prior to and during acquisition, monitoring and foreseeing problems during the lifecycle of the equipment, and collaborating with the parties who manufacture, design, regulate, or recommend safe medical devices and systems.

Some but not all of the healthcare technology management professional's functions are:

Equipment control and asset management

Every medical treatment facility should have policies and processes on equipment control and asset management. Equipment control and asset management involves the management of medical devices within a facility and may be supported by automated information systems (e.g., enterprise resource planning (ERP) systems are often found in U.S. hospitals, and the U.S. military health system uses an advanced automated system known as the Defense Medical Logistics Standard Support (DMLSS) suite of applications) or may use a dedicated equipment management and maintenance software (e.g., BME Assistor). Equipment control begins with the receipt of a newly acquired equipment item and

continues through the item's entire lifecycle. Newly acquired devices should be inspected by in-house or contracted biomedical equipment technicians (BMETs), who will receive an established equipment control/asset number from the facilities equipment/property manager. This control number is used to track and record maintenance actions in their database. This is similar to creating a new chart for a new patient who will be seen at the medical facility. Once an equipment control number is established, the device is safety inspected and readied for delivery to clinical and treatment areas in the facility.

Facilities or healthcare delivery networks may rely on a combination of equipment service providers such as manufacturers, third-party services, in-house technicians, and remote support. Equipment managers are responsible for continuous oversight and responsibility for ensuring safe and effective equipment performance through full-service maintenance. Medical equipment managers are also responsible for technology assessment, planning and management in all areas within a medical treatment facility (e.g. developing policies and procedures for the medical equipment management plan, identifying trends and the need for staff education, resolution of defective biomedical equipment issues).

Work order management

Work order management involves systematic, measurable, and traceable methods to all acceptance/initial inspections, preventive maintenance, and calibrations, or repairs by generating scheduled and unscheduled work orders. Work order management may be paper-based or computer-base and includes the maintenance of active (open or uncompleted) and completed work orders which provide a comprehensive maintenance history of all medical equipment devices used in the diagnosis, treatment, and management of patients. Work order management includes all safety, preventive, calibration, test, and repair services performed on all such medical devices. A comprehensive work order management system can also be used as a resource and workload management tool by managers responsible for personnel time, total number of hour's technician spent working on equipment, maximum repair dollar for one time repair, or total dollar allowed to spend repairing equipment versus replacement.

Post-work order quality checks involve one of two methods: 100% audit of all work orders or statistical sampling of randomly selected work orders. Randomly selected work orders should place more stringent statistical controls based on the clinical criticality of the device involved. For example, 100% of items critical to patient treatment but only 50% of ancillary items may be selected for sampling. In an ideal setting, all work orders are checked, but available resources may dictate a less comprehensive approach. Work orders must be tracked regularly and all discrepancies must be corrected. Managers are responsible to identify equipment location

Data quality management

Accurate, comprehensive data are needed in any automated medical equipment management system. Data quality initiatives can help to insure the accuracy of clinical/biomedical engineering data. The data needed to establish basic, accurate, maintainable automated records for medical equipment management includes: nomenclature, manufacturer, nameplate model, serial number, acquisition cost, condition code, and maintenance assessment. Other useful data could include: warranty, location, other contractor agencies, scheduled maintenance due dates, and intervals. These fields are vital to ensure appropriate maintenance is performed, equipment is accounted for, and devices are safe for use in patient care.

Nomenclature: It defines what the device is, how, and the type of maintenance is to be performed. Common nomenclature systems are taken directly from the ECRI Institute Universal Medical Device Nomenclature System.

Manufacturer: This is the name of the company that received approval from the FDA to sell the device, also known as the Original Equipment Manufacturer (OEM).

Nameplate model: The model number is typically located on the front/behind of the equipment or on the cover of the service manual and is provided by the OEM. E.g. Medtronic PhysioControl's Lifepak 10 Defibrillator can actually be any one of the following correct model numbers listed: 10-41, 10-43, 10 -47, 10-51, and 10-57.

Serial number: This is usually found on the data plate as well, is a serialized number (could contain alpha characters) provided by the manufacturer. This number is crucial to device alerts and recalls.

Acquisition cost: The total purchased price for an individual item or system. This cost should include installation, shipping, and other associated costs. These numbers are crucial for budgeting, maintenance expenditures, and depreciation reporting.

Condition code: This code is mainly used when an item is turned in and should be changed when there are major changes to the device that could affect whether or not an item should be salvaged, destroyed, or used by another Medical Treatment Facility.

Maintenance assessment: This assessment must be validated every time a BMET performs any kind of maintenance on a device.

Several other management tools, such as equipment replacement planning and budgeting, depreciation calculations, and at the local level literature, repair parts, and supplies are directly related to one or more of these fundamental basics. Data Quality must be tracked monthly and all discrepancies must be corrected.

Quality Assurance is a way of identifying an item of supply or equipment as being defective. A good quality control/engineering program improves quality of work and lessens the risk of staff/patient injuries/death.

Biomedical engineers may work primarily in one or a combination of the following fields:

• **bioinformatics –** developing and using computer tools to collect and analyze data.

• **bioinstrumentation** – applying electronic and measurement techniques.

• biomaterials – developing durable materials that are compatible with a biological environment.

• **biomechanics -** applying knowledge of mechanics to biological or medical problems.

• **bio-nano-engineering** – developing novel structures of nanometer dimensions for application to biology, drug delivery, molecular diagnostics, microsystems and nanosystems.

• **biophotonics** – applying and manipulating light, usually laser light, for sensing or imaging properties of biological tissue.

• **cellular and tissue engineering** – studying the anatomy, biochemistry and mechanics of cellular and sub-cellular structures, developing technology to repair, replace or regenerate living tissues and developing methods for controlling cell and tissue growth in the laboratory.

• **clinical engineering** – applying the latest technology to health care and health care systems in hospitals.

• **genomics and genetic engineering –** mapping, sequencing and analyzing genomes (DNA), and applying molecular biology methods to manipulate the genetic material of cells, viruses and organisms.

• medical or biological imaging – combining knowledge of a physical phenomenon (for example, sound, radiation or magnetism) with electronic processing, analysis and display.

• molecular bioengineering – designing molecules for biomedical purposes and applying computational methods for simulating biomolecular interactions.

• **systems physiology** - studying how systems function in living organisms.

• **therapeutic engineering** – developing and discovering drugs and advanced materials and techniques for delivering drugs to local tissues with minimized side effects.

Equipment Used with Compressed Gases

Records, Inspection, and Testing

Carry out high-pressure operations only with equipment specifically designed and built for this use and only by those personnel trained especially to use this equipment. Never carry out reactions in, or apply heat to, an apparatus that is a closed system unless it has been designed and tested to withstand pressure. To ensure that the equipment has been properly

designed, each pressure vessel should have stamped on it, or on an attached plate, its maximum allowable working pressure, the allowable temperature at this pressure, and the material of construction. Similarly, the relief pressure—the pressure at which the safety system (e.g., rupture disk or safety vent) will be triggered—and setting data should be stamped on a metal tag attached to installed pressure-relief devices, and the setting mechanisms should be sealed. Relief devices used on pressure regulators do not require these seals or numbers.

Test or inspect all pressure equipment periodically. The frequency of tests and inspections varies, depending on the type of equipment, how often it is used, and the nature of its usage. Corrosive or otherwise hazardous service requires more frequent tests and inspections. Stamp inspection data on or attach it to the equipment. Testing the entire assembled apparatus with soap solution and air or nitrogen pressure to the maximum operating pressure of the weakest section of the assembled apparatus usually detects leaks at threaded joints, packings, and valves. Alternatively, the apparatus may be pressurized and monitored for pressure drop over time.

Before any pressure equipment is altered, repaired, stored, or shipped, vent it and completely remove all toxic, flammable, or other hazardous material so it can be handled safely. Especially hazardous materials may require special cleaning techniques, which should be solicited from the distributor.

Assembly and Operation

During the assembly of pressure equipment and piping, use only appropriate components, and take care to avoid strains and concealed fractures from the use of improper tools or excessive force. Do not support any significant weight with the tubing in place in a pressure apparatus.

Do not force threads that do not fit smoothly. Do not overtighten fittings. Thread connections must match; tapered pipe threads cannot be joined with parallel machine threads. Use Teflon tape or a suitable thread lubricant on appropriate fittings, (e.g., Teflon tape on pipe fittings only) when assembling the apparatus However, never use oil or lubricant on any equipment that will be used with oxygen. Reject parts having damaged or partly stripped threads

In assembling copper-tubing installations, avoid sharp bends and allow considerable flexibility. Copper tubing hardens and cracks on repeated bending. Many

A technician tried to remove the cap from a 2,000-psig 42-L hydrogen cylinder. Unable to unscrew the cap by hand, the technician attempted to use a wrench to loosen it. While doing this, the cylinder valve opened causing hydrogen to begin leaking from the cylinder. Unable to close the valve because the cap was still jammed in place, the technician pulled the fire alarm and the building was evacuated. Fire personnel were not successful in removing the cylinder cap. The cylinder was placed in an area with adequate ventilation and allowed to empty.

Subsequent investigation showed that the cylinder valve plug had not been properly replaced in the valve by a previous user. Valve caps must be in place for the storage of flammable, toxic, and corrosive gas cylinders. The loose valve plug was responsible for jamming the cylinder cap. Further, the wrench used in the attempt to remove the cap was not the correct tool; a strap or other nonsparking wrench should have been used.

metals can become brittle in hydrogen or corrosive gas service. In carbon monoxide atmospheres, some alloys containing nickel or iron can generate carbonyls [e.g., $Ni(CO)_4$] which are toxic when absorbed through the skin or inhaled. Inspect all tubing frequently and replace when necessary.

Stuffing boxes and gland joints are a likely source of trouble in pressure installations. Give particular attention to the proper installation and maintenance of these parts, including the proper choice of lubricant and packing material.

Shield all reactions under pressure and carry them out as remotely as possible, for example, with valve extensions and behind a heavy shield or with closed-circuit TV monitoring if needed.

Do not fill autoclaves and other pressure-reaction vessels more than half full to ensure that space remains for expansion of the liquid when it is heated. Do not make leak corrections or adjustments to the apparatus while it is pressurized; rather, depressurize the system before mechanical adjustments are made.

A regulator or step-down pressure valve should be used to pressurize low-pressure equipment from a high-pressure source. After pressurizing equipment with a high-pressure source, the equipment should either be disconnected or the connecting piping/tubing should be vented to atmospheric pressure. This will prevent the accidental buildup of excessive pressure in the low-pressure equipment due to leakage from the high-pressure source. For example, after completing the pressurization of an autoclave with a compressed gas cylinder, the cylinder valve should be closed, the delivery regulator backed off to 0 psig, and the lines between the cylinder and the autoclave vented.

Do not use vessels or equipment made partly or entirely of silver or copper or alloys containing more than 50% copper in contact with acetylene or ammonia. Do not let those vessels or equipment made of metals susceptible to amalgamation (e.g., copper, brass, zinc, tin, silver, lead, and gold) come into contact with mercury. This warning includes equipment that has soldered and brazed joints.

Place prominent warning signs in any area where a pressure reaction is in progress so that personnel entering the area will be aware of the potential risk.

Pressure-Relief Devices

Protect all pressure or vacuum systems and all vessels that may be subjected to pressure or vacuum by properly designed, installed, and tested pressure-relief devices. Experiments involving highly reactive materials that might explode or undergo rapid decomposition with gas evolution (tetrafluoroethylene and hydrogen cyanide are two examples) may also require the use of special pressure-relief devices and may need to be operated at a fraction of the permissible working pressure of the system.

Examples of pressure-relief devices include the rupture-disk type used with closed-system vessels and the spring-loaded safety valves used with vessels for transferring liquefied gases. The following precautions are advisable in the use of pressure-relief devices:

- In addition to the pressure setting, pressure-relief device and associated fittings (tubing, connectors, etc.) must be properly sized and configured to provide a sufficient rate of pressure relief while preventing overpressurization. The diameter of the relief device

and fittings and the presence of bends and angles are important considerations that should be addressed by a qualified and trained person or persons.

- The materials of construction must be considered, taking into account the compatibility of the chemicals being handled with the relief components.
- The temperature rating of the relief device must be sufficient. Heat conduction via tubing and fittings can cause the relief device to reach high temperatures, depending on the apparatus design.
- Orient pressure-relief devices with the vent side of the device directed away from the operator or

  other personnel. Also vent the relief device into an appropriate trap to catch flammable solvent, reaction solids, etc., avoiding spray into the workspace in the event of a release and minimizing the potential of a fire and aiding clean up. The relief device and trap must be supported so that they are not dislodged or thrown due the thrust resulting from sudden venting.
- The maximum setting of a pressure-relief device is the rated maximum allowable working pressure (MAWP) established for the vessel or for the weakest member of the pressure system at the operating temperature. The operating pressure should be less than the system MAWP. In the case of a system protected by a spring-loaded relief device, the maximum operating pressure should be from 5 to 25% lower than the rated working pressure, depending on the type of safety valve and the importance of leak-free operation. In a system protected by a rupture-disk device, the maximum operating pressure should be approximately two-thirds of the rated MAWP; the exact figure is governed by the fatigue life of the disk used, the temperature, and load pulsations.
- Vent pressure-relief devices that may discharge toxic, corrosive, flammable, or otherwise hazardous or noxious materials in a safe and environmentally acceptable manner such as scrubbing or diluting with nonflammable streams.
- Do not install valves or other shutoff devices between pressure-relief devices and the equipment they are to protect. Similarly, do not install shutoff valves downstream of the relief device and take care to ensure that the relief vent is not blocked or restricted. Tubing and piping downstream of such devices must be at least the same diameter as the fitting on the vent side of the relief device.

- Only qualified persons should perform maintenance work on pressure-relief devices.
- Inspect and replace pressure-relief devices periodically.
- Gas manifolds, compressors, and other sources of high-pressure gas used to supply an apparatus, and which can be isolated from the apparatus by valving, should also be protected by a properly designed pressure-relief device.

Pressure Gauges

The proper choice and use of a pressure gauge involve several factors, including the flammability, compressibility, corrosivity, toxicity, temperature, and pressure range of the fluid with which it is to be used. Generally, select a gauge with a range that is double the working pressure of the system.

A pressure gauge is normally a weak point in any pressure system because its measuring element must operate in the elastic zone of the metal involved. The resulting limited factor of safety makes careful gauge selection and use mandatory and often dictates the use of accessory protective equipment. The primary element of the most commonly used gauges is a Bourdon tube, which is usually made of brass or bronze and has soft-soldered connections. More expensive gauges are available that have Bourdon tubes made of steel, stainless steel, or other special metals and welded or silver-soldered connections. Accuracies vary from ±2% for less expensive pressure gauges to ±0.1% for higher quality gauges. Use a diaphragm gauge with corrosive gases or liquids or with viscous fluids that would destroy a steel or bronze Bourdon tube.

Consider alternative methods of pressure measurement that may provide greater safety than the direct use of pressure gauges. Such methods include the use of seals or other isolating devices in pressure tap lines, indirect observation devices, and remote measurement by strain-gauge transducers with digital readouts.

Mount pressure gauges so that they are easily read during operation.

Pressure gauges often have built-in pressure-relief devices. Care must be taken to ensure that, in the event of failure, this relief device is oriented away from personnel.

Piping, Tubing, and Fittings

The proper selection and assembly of components in a pressure system are critical safety factors. Considerations include the materials used in manufacturing the components, compatibility with the materials to be under pressure, the tools used for assembly, and the reliability of the finished connections. Use no oil or lubricant of any kind in a tubing system with oxygen because the combination produces an explosion hazard. Use all-brass and stainless steel fittings with copper or brass and steel or stainless steel tubings, respectively. Fitting of this type must be installed correctly. Do not mix different brands of tube fittings in the same apparatus assembly because construction parts are often not interchangeable.

Glass Equipment

Avoid glassware for work at high pressure whenever possible. Glass is a brittle material, subject to unexpected failures due to factors such as mechanical impact and assembly and tightening stresses. Poor annealing after glassblowing can leave severe strains. Glass equipment, such as rotameters and liquid-level gauges, incorporated in metallic pressure systems should be installed with shutoff valves at both ends to control the discharge of liquid or gaseous materials in

the event of breakage. Mass flowmeters are available that can replace rotameters in desired applications.

Plastic Equipment

Except as noted below, avoid the use of plastic equipment for pressure or vacuum work unless no suitable substitute is available. These materials can fail under pressure or thermal stress. Only use materials that are appropriately rated or recommended for that particular service.

Tygon and similar plastic tubing have quite limited applications in pressure work. These materials can be used for hydrocarbons and most aqueous solutions at room temperature and moderate pressure. Reinforced plastic tubing that can withstand higher pressures is also available. However, loose tubing under pressure can cause physical damage by its own whipping action. Details of permissible operating conditions must be obtained from the manufacturer. Because of their very large coefficients of thermal expansion, some polymers

have a tendency to expand greatly on heating and to contract on cooling. This behavior can create a hazard in equipment subjected to very low temperatures or to alternating low and high temperatures. Plastic tubing may also disrupt electrical grounding and thus present a static electricity hazard. The use of plastic tubing with flammable gases or liquids is not recommended if grounding is an issue.

Valves

Valves come in a wide range of materials of construction, pressure and temperature ratings, and type. The materials of construction (metal, elastomer, and plastic components) must be compatible with the gases and solvents being used. The valves must be rated for the intended pressure and temperature. Ball valves are preferred over needle valves because their status (on/off) can be determined by quick visual inspection. Use metering or needle valves only when careful flow control is important to the operation. Micrometers can sometimes be used with needle valves to allow quick determination of the status.

Gas Monitors

Electronic monitors and alarms are available to prevent hazards due to asphyxiant, flammable, and many toxic gases. Consider their use especially if large quantities or large cylinders of these gases are in use. Make sure the monitor is properly rated for the intended purpose as some detectors are subject to interference by other gases.

Teflon Tape Applications

Use teflon tape on tapered pipe thread where the seal is formed in the thread area. Tapered pipe thread is commonly found in applications where fittings are not routinely taken apart (e.g., general building piping applications).

Do not use Teflon tape on straight thread (e.g., Swagelok) where the seal is formed through gaskets or by other metal-to-metal contacts that are forced together when the fitting is tightened [e.g., Compressed Gas Association (CGA) gas cylinder fittings or compression fittings]. Metal-to-metal seals are machined to tolerances that seal without the need of Teflon tape or other gasketing materials. If used where not needed, as on CGA fittings, Teflon tape

only spreads and weakens the threaded connections and can plug up lines that it enters accidentally.

Handling and Use of Gas Cylinders

Gas cylinders must be handled carefully to prevent accidents or damage to the cylinder. Leave the valve protection cap in place until the cylinder is secured and ready for use. Do not drag, roll, slide, or allow gas cylinders to strike each other forcefully. Always transport them on approved wheeled cylinder carts with retaining straps or chains. The plastic mesh sleeves sometimes installed by vendors are intended only to protect the paint on the cylinder and do not serve as a safety device.

Secure compressed gas cylinders firmly at all times. A clamp and belt or chain, holding the cylinder between waist and shoulder to a wall, are generally suitable for this purpose. In areas of seismic activity, secure gas cylinders both toward the top and toward the bottom. Individually secure cylinders; using a single restraint strap or chain around a number of cylinders is often not effective. Locate cylinders in well-ventilated areas. Although inert gases are not exposure hazards, they can produce conditions of oxygen depletion that could lead to asphyxiation. Vent pressure-relief devices protecting equipment that is attached to cylinders of flammable, toxic, or otherwise hazardous gases to a safe place

Standard cylinder-valve outlet connections have been devised by CGA to prevent the mixing of incompatible gases due to an interchange of connections. Outlet threads used vary in diameter; some are male and some are female, some are right-handed and some are left-handed. In general, right-handed threads are used for nonfuel and water-pumped gases, and left-handed threads are used for fuel and oil-pumped gases. Information on the standard equipment assemblies for use with specific compressed gases is available from the supplier. To minimize undesirable connections that may result in a hazard, use only CGA standard combinations of valves and fittings in compressed gas installations. Avoid the assembly of miscellaneous

parts (even of standard approved types). Do not use an adapter or cross-thread a valve fitting. Examine the threads on cylinder valves, regulators, and other fittings to ensure that they correspond to one another and are undamaged.

Place cylinders so that the rotary cylinder valve handle at the top is accessible at all times. Open cylinder valves slowly, and only when a proper regulator is firmly in place and the attachment has been shown to be leakproof by an appropriate test. Close the cylinder valve as soon as the necessary amount of gas has been released. Valves should be either completely open or completely closed. Install flow restrictors on gas cylinders to minimize the chance of excessive flows. Never leave the cylinder valve open when the equipment is not in use. This precaution is necessary not only for safety when the cylinder is under pressure but also to prevent the corrosion and contamination that would result from diffusion of air and moisture into the cylinder when it is emptied.

Most cylinders are equipped with hand-wheel valves. Those that are not should have a spindle key on the valve spindle or stem while the cylinder is in service. Use only wrenches or other tools provided by the cylinder supplier to remove a cylinder cap or to open a valve. Never use a screwdriver to pry off a stuck cap or pliers to open a cylinder valve. If valve fittings require washers or gaskets, check the materials of construction before the regulator is fitted.

If the valve on a cylinder containing an irritating or toxic gas is being opened outside, the worker should stand upwind of the cylinder with the valve pointed downwind, away from personnel, and warn those working nearby in case of a possible leak. If the work is being done inside, open the cylinder only in a laboratory chemical hood or specially designed cylinder cabinet. Install a differential pressure switch with an audible alarm in any chemical hood dedicated for use with toxic gases. In the event of chemical hood failure, the pressure switch should activate an audible alarm warning personnel.

Preventing and Controlling Leaks

Check cylinders, connections, and hoses regularly for leaks. Convenient ways to check for leaks include a flammable gas leak detector (for flammable gases only) or looking for bubbles after application of soapy water or a 50% glycerin–water solution. At or below freezing temperatures, use the glycerin solution instead of soapy water. Bubble-forming solutions designed for leak testing are commercially available. When the gas to be used in the procedure is a flammable, oxidizing, or highly toxic gas, check the system first for leaks with an inert gas (helium or nitrogen) before introducing the hazardous gas. Only leak-test

solutions Specifically designed for oxygen compatibility may be used to test for oxygen leaks; do not use soap solutions because they may contain oils that can react violently with the oxygen.

If a leak at the cylinder valve handle cannot be remedied by tightening a valve gland or a packing nut, take emergency action and notify the supplier. Never attempt to repair a leak at the junction of the cylinder valve and the cylinder or at the safety device; consult with the supplier for instructions.

When the nature of the leaking gas or the size of the leak constitutes a more serious hazard, an approved SCBA and protective apparel may be required, and personnel may need to be evacuated If toxic gas is leaking from a cylinder, donning of protective equipment and evacuation of personnel are required. Cylinder coffins are also available to encapsulate leaking cylinders

Pressure Regulators

Pressure regulators are required to reduce a high-pressure supplied gas to a desirable lower pressure and to maintain a satisfactory delivery pressure and flow level for the required operating conditions. They are available to fit many operating conditions over a range of supply and delivery pressures, flow capacities, and construction materials. All regulators are typically of a diaphragm type and are spring-loaded or gas-loaded, depending on pressure requirements. They can be single-stage or two-stage. Under no circumstances should oil or grease be used on regulator valves or cylinder valves because these substances may react with some gases (e.g., oxygen).

Each regulator is supplied with a specific CGA standard inlet connection to fit the outlet connection on the cylinder valve for the particular gas. Never tamper with or adapt regulators for use with gases for which they are not designed. Likewise, never substitute the fittings that are on either the cylinder side or downstream (low-pressure) side of a vendor-supplied regulator. Instead, purchase a regulator designed for

use with the specific cylinder, and use adapters only on the downstream side of the regulator. Unqualified persons must never attempt to repair or modify regulators.

Check regulators before use to verify they are free of foreign objects and to correct for the particular gas. Regulators for use with noncorrosive gases are usually made of brass. Special regulators made of corrosion-resistant materials are available for use with such gases as ammonia, boron trifluoride, chlorine, hydrogen chloride, hydrogen sulfide, and sulfur dioxide. Because of freeze-up and corrosion problems, regulators used with carbon dioxide gas must have special internal design features and be made of special materials. Regulators used with oxidizing agents must be cleaned specially to avoid the possibility of an explosion on contact of the gas with any reducing agent or oil left from the cleaning process.

All pressure regulators should be equipped with spring-loaded pressure-relief valves for further information on pressure-relief devices) to protect the low-pressure side. When used on cylinders of flammable, toxic, or otherwise hazardous gases, vent the relief valve to a laboratory chemical hood or other safe location. Avoid the use of internal-bleed-type regulators. When working with hazardous gases, installing flow-limiting devices after the regulator is recommended in order to add a level of control on the system. Remove regulators from corrosive gases immediately after use and flush with dry air or nitrogen. Bubblers of any type (e.g., mercury, oil) are not suitable for use as pressure regulators and should not be used.

Flammable Gases

Keep all sources of ignition away from cylinders of flammable gases and ensure that these cylinders will not leak. Always keep connections to piping, regulators, and other appliances tight to prevent leakage, and keep the tubing or hoses used in good condition. Perform leak checks periodically. Flash arrestors are recommended for flammable gases. Do not interchange regulators, hoses, and other appliances used with cylinders of flammable gases with similar equipment intended for use with other gases. Ground cylinders properly to prevent static electricity buildup, especially in very cold or dry environments. Separate cylinders containing flammable gases from cylinders of oxidizing gases by at least 20 ft or by a 5-ft-high fire-resistant partition with a minimum 30-minute fire rating. Store all cylinders containing flammable gases in a well-ventilated place. Never store reserve stocks of such cylinders in the vicinity of cylinders containing oxidizing gases including oxygen, fluorine, and chlorine. Never store oxidizing gases near flammable liquids.

Working with high or low pressures and temperatures

Work with hazardous chemicals at high or low pressures and high or low temperatures requires planning and special precautions. For many experiments, extremes of both pressure and temperature, such as reactions at elevated temperatures and pressures and work with cryogenic liquids and high vacuum, must be managed simultaneously. Carry out procedures at high or low pressures with protection against explosion or implosion by appropriate equipment selection and the use of safety shields. Provide appropriate temperature control and interlocks so that heating or cooling baths cannot exceed the desired limits even if the equipment fails. Take care to select and use glass apparatuses that can safely withstand thermal expansion or contraction at the designated pressure and temperature extremes.

Pressure Vessels

Perform high-pressure operations only in special chambers equipped for this purpose. Trained laboratory personnel should ensure that equipment and pressure vessels are appropriately selected, properly labeled and installed, and protected by pressure-relief and necessary control devices. Vessels must be strong enough to withstand the stresses encountered at the intended operating pressures and temperatures. The vessel material must not corrode when it is in contact with its contents. The material should not react with the process being studied, and the vessel must be of the proper size and configuration. Never carry out reactions in, or apply heat to, an apparatus that is a closed system unless it has been designed and tested to withstand the generated pressure.

Pressure-containing systems designed for use at elevated temperatures should have a positive-feedback temperature controller. Manual control using a simple variable autotransformer, such as a variac, is not good practice. The use of a backup temperature controller capable of both recording temperatures and shutting down an unattended system is strongly recommended.

Records, Inspection, and Testing

In some localities, adherence to national codes such as the American Society of Mechanical Engineers

(ASME) Boiler and Pressure Vessel Code (ASME, 1992) is mandatory. Selection of containers, tubing, fittings, and other process equipment, along with the operational techniques and procedures, must conform to the constraints necessary for high-pressure service. The proper selection and assembly of components in a pressure system are critical safety factors. Compatibility of materials, tools used for assembly, and the reliability of connections are all key considerations.

Each pressure vessel in a laboratory should have a stamped number or fixed label plate that uniquely identifies it. Information such as the maximum allowable working pressure, allowable temperature at this pressure, material of construction, and burst diagram should be readily available. Information regarding the vessel's history should include temperature extremes it has experienced, any modifications and repairs made to the original vessel, and all inspections or test actions it has undergone. Similarly, the relieving pressure and setting data should be stamped on a metal tag attached to installed pressure-relief devices. Relief devices used on pressure regulators do not require these seals or numbers.

Test or inspect all pressure equipment periodically. The interval between tests or inspections is determined by the severity of the usage the equipment has received. Corrosive or otherwise hazardous service requires more frequent tests and inspections. Stamp inspection data on or attach it to the equipment. Pressure vessels may be subjected to nondestructive inspections such as visual inspection, penetrant inspection, acoustic emissions recording, and radiography. However, hydrostatic proof tests are necessary for final acceptance. They should be performed as infrequently as possible but before the vessel is placed into initial service, every 10 years thereafter, after a significant repair or modification, and if the vessel experiences overpressure or overtemperature.

Testing the entire apparatus with soap solution and air or nitrogen pressure to the maximum allowable working pressure of the weakest section of the assembled apparatus usually detects leaks at threaded joints, packings, and valves.

Pressure-test and leak-test final assemblies to ensure their integrity. Trained laboratory personnel are strongly advised to consult an expert on high-pressure work as they design, build, and operate a high-pressure process. Finally, exercise extreme care when disassembling pressure equipment for repair, modification, or decommissioning. Personnel should be familiar with the safe procedures for depressurizing the system, including the order

in which to open valves or fittings. Wear protective equipment in case a line or vessel that is opened contains material under pressure. Good practice is to cover the vessel or fitting being opened with a cloth or paper towel to contain any spray should the contents be unknowingly pressurized.

Pressure Reactions in Glass Equipment

Run reactions under pressure in metal equipment, not glass, if at all possible. For any reaction run on a large scale (>10 g total weight of reactants) or at a maximum pressure in excess of 690 kPa (100 psi), use only procedures involving a suitable high-pressure autoclave or shaker vessel. If glass is required because of material-of-construction concerns, use a metal reactor with a glass or Teflon liner instead of a glass vessel under pressure. Glass pressure reaction vessels are available from several vendors and are designed for use in the 0- to 200-psig range. However, it is sometimes convenient to run very small scale reactions at low pressures in a small sealed glass tube or in a thick-walled pressure bottle of the type used for catalytic hydrogenation. For any such reaction, laboratory personnel should be fully prepared for the significant possibility that the sealed vessel will burst. Gases must be vented properly and adequate precautions taken for ventilation. When using glass under pressure, assume that the glass will fail. Take every precaution to prevent injury from flying glass or from corrosive

or toxic reactants by using suitable shielding. Often a mesh is provided around the glassware to catch pieces should the vessel rupture. Seal centrifuge bottles with rubber stoppers clamped in place, wrapped with friction tape and shielded with a metal screen or wrapped with friction tape and surrounded by multiple layers of loose cloth toweling, and clamped behind a good safety shield. Some bottles are typically equipped with a head-containing inlet and exhaust gas valves, a pressure gauge, and a pressure-relief valve. If a pressure gauge is not used, estimate the maximum internal pressure by calculation prior to beginning the experiment to ensure that the maximum allowable pressure is not exceeded. When corrosive materials are used, use a Teflon pressure-relief valve. The preferred source of heat for such vessels is steam, because an explosion in the vicinity of an electrical heater could start a fire and an explosion in a liquid heating bath would scatter hot liquid around the area. Carry out

any reaction of this type in a chemical hood, labeled with signs that indicate the contents of the reaction vessel and the explosion risk.

Fill glass tubes under pressure no more than three-quarters full. Appropriate precautions using the proper shielding must be taken for condensing materials and sealing tubes. Vacuum work can be carried out on a Schlenk line, an apparatus used for work with air-sensitive compounds, as long as proper technique is used. The sealed glass tubes can be placed either inside pieces of brass or iron pipe capped at one end with a pipe cap or in an autoclave containing some of the reaction solvent (to equalize the pressure inside and outside the glass tube). The tubes can be heated with steam or in a specially constructed, electrically heated sealed-tube furnace that is controlled thermostatically and located to direct the force of an explosion into a safe area. When the required heating has been completed, allow the sealed tube or bottle to cool to room temperature. Wrap sealed bottles and tubes of flammable materials with cloth toweling, place behind a safety shield, and cool slowly, first in an ice bath and then in dry ice. After cooling, the clamps and rubber stoppers can be removed from the bottles prior to opening. Use PPE and apparel, including shields, masks, coats, and gloves, during tube-opening operations. Note that NMR tubes are often thin-walled and should only be used for pressure reactions in a special high-pressure probe or in capillary devices.

Examine newly fabricated or repaired glass equipment for flaws and strains under polarized light. Never rely on corks, rubber stoppers, and rubber or plastic tubing as relief devices to protect glassware against excess pressure; use a liquid seal, Bunsen tube, or equivalent positive-relief device. With glass pipe, use only proper metal.

Liquefied Gases and Cryogenic Liquids

Cryogenic liquids are materials with boiling points of less than –73 °C (–100 °F). Liquid nitrogen, helium, argon, and slush mixtures of dry ice with isopropyl alcohol are the materials most commonly used in cold traps to condense volatile vapors from a gas or vapor stream. In addition, oxygen, hydrogen, and helium are often used in the liquid state.

The primary hazards of cryogenic liquids are frostbite, asphyxiation, fire or explosion, pressure buildup (either slowly or due to rapid conversion of the liquid to the gaseous state), and embrittlement of structural materials. The extreme cold of cryogenic liquids requires

special care in their use. The vapor that boils off from a liquid can cause the same problems as the liquid itself.

The fire or explosion hazard is obvious when gases such as oxygen, hydrogen, methane, and acetylene are used. Air enriched with oxygen can greatly increase the flammability of ordinary combustible materials and may even cause some noncombustible materials to burn readily. Oxygen-saturated wood and asphalt have been known to explode when subjected to shock. Because oxygen has a higher boiling point (–183 °C) than nitrogen (–195 °C), helium (–269 °C), or hydrogen (–252.7 °C), it can be condensed out of the atmosphere during the use of these lower boiling-point cryogenic liquids. With the use of liquid hydrogen particularly, explosive conditions may develop

Furnish all cylinders and equipment containing flammable or toxic liquefied gases (not vendor-owned) with a spring-loaded pressure-relief device (not a rupture disk) because of the magnitude of the potential risk that can result from activation of a non resetting relief device. Commercial cylinders of liquefied gases are normally supplied only with a fusible-plug type of relief device, as permitted by DOT regulations. Protect pressurized containers that contain cryogenic material with multiple pressure-relief devices.

Cryogenic liquids must be stored, shipped, and handled in containers that are designed for the pressures and temperatures to which they may be subjected. Materials that are pliable under normal conditions can become brittle at low temperatures. Dewar flasks, which are used for relatively small amounts of cryogenic material, should have a dust cap over the outlet to prevent atmospheric moisture from condensing and plugging the neck of the tube. Special cylinders that are insulated and vacuum-jacketed with pressure-relief valves and rupture devices to protect the cylinder from pressure buildup are available in capacities of 100 to 200 L.

A special risk to personnel is skin or eye contact with the cryogenic liquid. Because these liquids are prone to splash owing to the large volume expansion ratio when the liquid warms up, wear eye protection, preferably chemical splash goggles and a face shield, when handling liquefied gases and other cryogenic fluids. Do not transfer liquefied gases from one container to another for the first time without the direct supervision and instruction of someone who is experienced in this operation. Transfer very slowly to minimize boiling and splashing.

Do not allow unprotected parts of the body to come in contact with uninsulated vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation or withdrawal is attempted. Even very brief skin contact with a cryogenic liquid can cause tissue damage similar to that of frostbite or thermal burns, and prolonged contact may result in blood clots that have potentially very serious consequences. Gloves must be insulated, impervious to the fluid being handled, and loose enough to be tossed off easily in case the cryogenic liquid becomes trapped close to the skin. Never wear tight gloves when working with cryogenic liquids. Trained laboratory personnel are also encouraged to wear long sleeves when handling cryogenic fluids. Handle objects that are in contact with cryogenic liquids with tongs or potholders. Ventilate the work area well. Virtually all liquid gases present the threat of poisoning, explosion, or, at a minimum, asphyxiation in a confined space. Major harmful consequences of the use of cryogenic inert gases, including asphyxiation, are due to boiling off of the liquid and pressure buildup, which can lead to violent rupture of the container or piping.

Take special care when handling liquid hydrogen. In general, do not transfer liquid hydrogen in an air atmosphere because oxygen from the air can condense in the liquid hydrogen, presenting a possible explosion risk. Take all precautions to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.

Although nitrogen is inert, its liquefied form can be hazardous because of its cryogenic properties and because displacement of air oxygen in the vicinity can lead to asphyxiation followed by death with little warning. Fit rooms that contain appreciable quantities of liquid nitrogen (N_2) with oxygen meters and alarms. Do not store liquid nitrogen in a closed room because the oxygen content of the room can drop to unsafe levels.

Do not fill cylinders and other pressure vessels that are used for the storage and handling of liquefied gases to more than 80% capacity, to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature outside of the cylinder may increase to greater than 30°C, a lower percentage (e.g., 60%) of capacity should be the limit.

Cold Traps and Cold Baths

Choose cold traps that are large enough and cold enough to collect the condensable vapors. Check cold traps frequently to make sure they do not become plugged with frozen material. After completion of an operation in which a cold trap has been used, isolate the trap from the source, remove from the coolant, and vent to atmospheric pressure in a safe and environmentally acceptable way. Otherwise, pressure could build up, creating a possible explosion or sucking pump oil into a vacuum system. Cold traps under continuous use, such as those used to protect inert atmosphere dryboxes, should be electrically cooled, and their temperature should be monitored with low-temperature probes.

Use appropriate gloves and a face shield to avoid contact with the skin when using cold baths. Wear dry gloves when handling dry ice. Do not lower the head into a dry ice chest because carbon dioxide is heavier than air and asphyxiation can result. The preferred liquids for dry-ice cooling baths are isopropyl alcohol or glycols; add dry ice slowly to the liquid portion of the cooling bath to avoid foaming. Avoid the common practice of using acetone–dry ice as a coolant; the alternatives are less flammable, less prone to foaming and splattering with dry ice, and less likely to damage some trap components (O-rings, plastic). Dry ice and liquefied gases used in refrigerant baths should always be open to the atmosphere. Never use them in closed systems, where they may develop uncontrolled and dangerously high pressures.

Selection of Low-Temperature Equipment

Select equipment used at low temperatures carefully because temperature can dramatically change characteristics of materials. For example, the impact strength of ordinary carbon steel is greatly reduced at low temperatures, and failure can occur at points of weakness, such as notches or abrupt changes in the material of construction. When combinations of materials are required, consider the temperature dependence of their volumes so that leaks, ruptures, and glass fractures are avoided. For example, O-rings that provide a good seal at room temperature may lose resilience and fail to function on chilled equipment.

Stainless steels containing 18% chromium and 8% nickel retain their impact resistance down to approximately -240 °C; the exact value depends heavily on special design considerations. The impact resistance of aluminum, copper, nickel, and many other nonferrous metals and alloys increases with decreasing temperatures. Use special alloy

steels for liquids or gases containing hydrogen at temperatures greater than 200 °C or at pressures greater than 34.5 MPa (500 psi) because of the danger of weakening carbon steel equipment by hydrogen embrittlement.

Cryogenic Lines and Supercritical Fluids

Design liquid cryogen transfer lines so that liquid cannot be trapped in any nonvented part of the system. Experiments in supercritical fluids include high pressure and should be carried out with appropriate protective systems.

Vacuum Work and Apparatus

Vacuum work can result in an implosion and the possible hazards of flying glass, spattering chemicals, and fire. Set up and operate all vacuum operations with careful consideration of the potential risks. Although a vacuum distillation apparatus may appear to provide some of its own protection in the form of heating mantles and column insulation, this is not sufficient because an implosion could scatter hot flammable liquid. Use an explosion shield and a full-face shield to protect laboratory personnel, and carry the procedure out in a laboratory chemical hood. Glassware under vacuum should be kept behind a shield or hood sash, taped, or resin (plastic) coated.

Equipment at reduced pressure is especially prone to rapid pressure changes, which can create large pressure differences within the apparatus. Such conditions can push liquids into unwanted locations, sometimes with undesirable consequences.

Do not allow water, solvents, and corrosive gases to be drawn into a building vacuum system. When the potential for such a problem exists, use a cold trap. Water aspirators are not recommended.

Protect mechanical vacuum pumps by cold traps, and vent their exhausts to an exhaust hood or to the outside of the building. If solvents or corrosive substances are inadvertently drawn into the pump, change the oil before any further use. (Oil contaminated with solvents, mercury, and corrosive substances must be handled as hazardous waste.) It may be desirable to maintain a log of pump usage as a guide to length of use and potential contaminants in the pump oil. Cover the belts and pulleys on vacuum pumps with guards.

Glass Vessels

Although glass vessels are frequently used in low-vacuum operations, evacuated glass vessels may collapse violently, either spontaneously from strain or from an accidental blow. Therefore, conduct pressure and vacuum operations in glass vessels behind adequate shielding. Check for flaws such as star cracks, scratches, and etching marks each time a vacuum apparatus is used. These flaws can often be noticed if the vessel is help up to a light. Use only round-bottom or thick-walled (e.g., Pyrex) evacuated reaction vessels specifically designed for operations at reduced pressure. Do not use glass vessels with angled or squared edges in vacuum applications unless specifically designed for the purpose (e.g., extra thick glass). Repaired glassware must be properly annealed and inspected with a cross-polarizer before vacuum or thermal stress is applied. Never evacuate thin-walled, Erlenmeyer, or round-bottom flasks larger than 1 L.

Dewar Flasks

Dewar flasks are under high vacuum and can collapse as a result of thermal shock or a very slight mechanical shock. Shield them, either by a layer of fiber-reinforced friction tape or by enclosure in a wooden or metal container, to reduce the risk of flying glass in case of collapse. Use metal Dewar flasks whenever there is a possibility of breakage.

Styrofoam buckets with lids can be a safer form of short-term storage and conveyance of cryogenic liquids than glass vacuum Dewar flasks. Although they do not insulate as well as Dewar flasks, they eliminate the danger of implosion.

Desiccators

If a glass vacuum desiccator is used, it should be made of Pyrex or similar glass, completely enclosed in a shield or wrapped with friction tape in a grid pattern that leaves the contents visible and at the same time guards against flying glass if the vessel implodes. Plastic (e.g., polycarbonate) desiccators reduce the risk of implosion and may be preferable but should also be shielded while evacuated. Solid desiccants are preferred. Never carry or move an evacuated desiccator. Take care opening the valve to avoid spraying the desiccator contents from the sudden inrush of gas.

Rotary Evaporators

Glass components of the rotary evaporator should be made of Pyrex or similar glass. Completely enclose in a shield to guard against flying glass should the components implode. Gradually increase rotation speed and application of vacuum to the flask whose solvent is to be evaporated.

Assembly of Vacuum Apparatus

Assemble vacuum apparatus to avoid strain. Joints must allow various sections of the apparatus to be moved if necessary without transmitting strain to the necks of the flasks. Support heavy apparatus from below as well as by the neck. Protect vacuum and Schlenk lines from overpressurization with a bubbler. Gas regulators and metal pressure-relief devices must not be relied on to protect vacuum and Schlenk lines from overpressurization. If a slight positive pressure of gas on these lines is desired, the recommended pressure range is not in excess of 1 to 2 psi. This pressure range is easily obtained by proper bubbler design (depth of the exit tubing in the bubbler liquid).

Place vacuum apparatus well back onto the bench or into the laboratory chemical hood where it will not be inadvertently hit. If the back of the vacuum setup faces the open laboratory, protect it with panels of suitably heavy transparent plastic to prevent injury to nearby personnel from flying glass in case of implosion.

Using personal protective, safety, and emergency equipment

As outlined in previous chapters, trained laboratory personnel must be proactive to ensure that the laboratory is a safe working environment. This attitude begins with wearing appropriate apparel and using proper eye, face, hand, and foot protection when working with hazardous materials. The institution is responsible for providing appropriate safety and emergency equipment for laboratory personnel and emergency personnel

Personal Protective Equipment and Apparel

Protective Clothing

Clothing that leaves large areas of skin exposed is inappropriate in laboratories where hazardous chemicals are in use. Personal clothing should fully cover the body. Appropriate laboratory coats should be worn, buttoned, with the sleeves rolled down. Leave lab coats in

the laboratory to minimize the possibility of spreading chemicals to public assembly, eating, or office areas, and clean them regularly.

Always wear protective apparel if there is a possibility that personal clothing could become contaminated or damaged with chemically hazardous material. Washable or disposable clothing worn for laboratory work with especially hazardous chemicals includes special laboratory coats and aprons, jumpsuits, special boots, shoe covers, and gauntlets, as well as splash suits. Protection from heat, moisture, cold, and radiation may be required in special situations. Among the factors to be considered in choosing protective apparel, in addition to the specific application, are resistance to physical hazards, flexibility and ease of movement, chemical and thermal resistance, and ease of cleaning or disposal.

Foot Protection

Not all types of footwear are appropriate in a laboratory where both chemical and mechanical hazards may exist. Wear substantial shoes in areas where hazardous chemicals are in use or mechanical work is being done. Clogs, perforated shoes, sandals, and cloth shoes do not provide protection against spilled chemicals. In many cases, safety shoes are advisable. Steel toes

are recommended when working with heavy objects such as gas cylinders. Shoe covers may be required for work with especially hazardous materials. Shoes with conductive soles prevent buildup of static charge, and insulated soles can protect against electrical shock.

Eye and Face Protection

Appropriate eye protection is a requirement for working in a chemical laboratory. Requisite eye protection should be provided for laboratory personnel and visitors, and signs should be posted outside the laboratory indicating that eye protection is required where hazardous chemicals are in use. Ordinary prescription glasses with hardened lenses do not serve as eye protection in the laboratory. Appropriate laboratory eye and face protection includes impact goggles with splash protection (chemical splash goggles), full-face shields that also protect the throat, and specialized eye protection (i.e., protection against ultraviolet light or

laser light). The following provides basic information regarding eye protection. (For more information, see Chapter 6, section 6.C.2.2)

- Wear impact protection goggles if there is a danger of flying particles, and full-face shields with safety glasses and side shields for complete face and throat protection.

- Although safety glasses can provide satisfactory protection from flying particles, they do not fit tightly against the face and offer little protection against splashes or sprays of chemicals. Chemical splash goggles that conform to ANSI standard Z87.1-2003 are recommended when working in laboratories and, in particular, when working with hazardous chemicals that present a splash hazard, with vapors or particulates, and with corrosives. Chemical splash goggles have splash-proof sides to fully protect the eyes.

- When there is a possibility of liquid splashes, wear both a face shield and chemical splash goggles; this is especially important for work with highly corrosive liquids.

- Use full-face shields with throat protection and safety glasses with side shields when handling explosive or highly hazardous chemicals.

- Wear specialized eye protection if work in the laboratory could involve exposure to lasers, ultraviolet light, infrared light, or intense visible light.

Hand Protection

Use gloves that are appropriate to the degree and type of hazard. At all times pay special attention to the hands and any skin that is likely to be exposed to hazardous chemicals. Wear proper protective gloves when handling hazardous chemicals, toxic materials, materials of unknown toxicity, corrosive materials, rough or sharp-edged objects, and very hot or very cold objects, for more information about selecting and using gloves to prevent chemical exposure.) The following list highlights some basic information regarding protection of hands.

- Before using gloves, inspect them for integrity and check for discoloration, punctures, or tears.

- The thin latex surgical vinyl and nitrile gloves that are popular in many laboratories may not be appropriate for use with highly toxic chemicals or solvents because of their composition and thin construction.

- Cut-resistant gloves, such as Kevlar® or leather gloves, are appropriate for handling broken glassware, inserting tubing into stoppers, and handling sharp-edged objects if protection from chemicals is not needed.

- Wear insulated gloves when working with very hot or very cold materials. With cryogenic fluids the gloves must be impervious to fluid but loose enough to be tossed off easily. Absorbent gloves could freeze on the hand and intensify any exposure to liquefied gases.

- Wear insulating rubber gloves when working with electrical equipment.

- Wear a double set of gloves when a single glove material does not provide adequate protection for all the hazards encountered in a given operation. For instance, operations involving a chemical hazard and sharp objects may require the combined use of a chemical-resistant glove and a cut-resistant glove.

- Replace gloves immediately if they are contaminated or torn.

- Replace gloves periodically, depending on the frequency of use. Regular inspection of their serviceability is important. If they cannot be cleaned, dispose of contaminated gloves according to institutional procedures.

- Decontaminate or wash gloves appropriately before removing them; leave gloves in the work area, and do not touch any uncontaminated objects in the laboratory or any other area.

Safety and Emergency Equipment

Safety equipment, including spill control kits, safety shields, fire safety equipment, respirators, safety showers and eyewash units, and emergency equipment should be available in well-marked highly visible locations in all chemical laboratories. Fire-alarm pull

stations and telephones with emergency contact numbers must be readily accessible. In addition to the standard items, other safety devices may also be needed. The laboratory

supervisor is responsible for ensuring proper training and providing supplementary equipment as needed.

Spill Control Kits and Cleanup

All personnel who work in a laboratory in which hazardous substances are used should be familiar with their institution's policy regarding spill control. For non-emergency[3] spills, spill control kits may be available. Tailor them to deal with the potential risk associated with the materials being used in the laboratory. These kits are used to confine and limit the spill if such actions can be taken without risk of injury or contamination. If a spill exceeds the on-scene personnel's ability or challenges their safety, they should leave the spill site and call the emergency telephone number for help. Emergency response spill cleanup personnel should be provided with all available information about the spill.

Specific procedures for cleaning up spills vary depending on the location of the accident, the amount and physical properties of the spilled material, the degree and type of toxicity, and the training of the personnel involved. A typical cleanup kit may be a container on wheels that can be moved to the location of the spill and may include such items as instructions; absorbent pads; a spill absorbent mixture for liquid spills; a polyethylene scoop for dispensing spill absorbent, mixing it with the spill, and picking up the mixture; thick polyethylene bags for disposal of the mixture; and tags and ties for labeling the bags. Use any kit in conjunction with the appropriate PPE, and dispose of the material according to institutional requirements.

(Also see Chapter 6, section 6.C.10.5)

Safety Shields

Use safety shields for protection against possible explosions or splash hazards. Shield laboratory equipment on all sides to avoid any line-of-sight exposure of personnel. The front sashes of laboratory chemical hoods provide shielding. Use a portable shield also when manipulations are performed, particularly with chemical hoods that have vertical-rising doors rather than horizontal-sliding sashes.

Use portable shields to protect against hazards of limited severity, such as small splashes, heat, and fires. A portable shield, however, provides no protection at the sides or back of the equipment, and if it is not sufficiently weighted for forward protection, the shield may topple toward personnel during a blast. A fixed shield that completely surrounds the experimental apparatus can afford protection against minor blast damage. Polymethyl methacrylate, polycarbonate, poly(vinyl chloride), and laminated safety plate glass are all satisfactory transparent shielding materials. Where combustion is possible, the shielding material should be nonflammable or slow burning; if it can withstand the working blast pressure, laminated safety plate glass may be the best material for such circumstances. When cost, transparency, high-tensile strength, resistance to bending loads, impact strength, shatter resistance, and burning rate are considered, poly(methyl methacrylate) offers an excellent overall combination of shielding characteristics.

Polycarbonate is much stronger and self-extinguishing after ignition but is readily attacked by organic solvents.

Fire Safety Equipment

Fire Extinguishers

All chemical laboratories should have carbon dioxide and dry chemical fire extinguishers. Other types of extinguishers should be available if required for the work that will be performed in the laboratory. The four types of most commonly used extinguishers are listed below, classified by the type of fire for which they are suitable. Note that multipurpose class A, B, and C extinguishers are available.

- Water extinguishers are effective against burning paper and trash (Class A fires). Do not use them for electrical, liquid, or metal fires.

- Carbon dioxide extinguishers are effective against burning liquids, such as hydrocarbons or paint, and electrical fires (Class B and C fires). They are recommended for fires involving computer equipment, delicate instruments, and optical systems because they do not damage such equipment. CO_2 extinguishers are less effective against paper and trash fires and must not be used against metal hydride or metal fires. Care must be taken in using these

extinguishers, because the force of the compressed gas can spread burning combustibles such as papers and can tip over containers of flammable liquids.

• Dry powder extinguishers, which contain ammonium phosphate or sodium bicarbonate, are effective against burning liquids and electrical fires (Class B and C fires). They are less effective against paper and trash or metal fires and are not recommended for fires involving delicate instruments or optical systems because of the cleanup problem. Computer equipment may need to be replaced if exposed to sufficient amounts of the dry powders. These extinguishers are generally used where large quantities of solvent may be present.

• Met-L-X extinguishers and others that have special granular formulations are effective against burning metal (Class D fires). Included in this category are fires involving magnesium, lithium, sodium, and potassium; alloys of reactive metals; and metal hydrides, metal alkyls, and other organometallics. These extinguishers are less effective against paper and trash, liquid, or electrical fires.

Every extinguisher should carry a label indicating what class or classes of fires it is effective against and the date it was last inspected. A number of other more specialized types of extinguishers are available for unusual fire hazard situations. All trained laboratory personnel are responsible for knowing the location, operation, and limitations of the fire extinguishers in the work area. The laboratory supervisor is responsible for ensuring that all personnel are aware of the locations of fire extinguishers and are trained in their use. After an extinguisher is used, designated personnel promptly recharge or replace it.

Heat Sensors and Smoke Detectors

Heat sensors and smoke detectors may be part of the building safety equipment. If designed into the fire alarm system, they may automatically sound an alarm and call the fire department, they may trigger an automatic extinguishing system, or they may only serve as a local alarm. Because laboratory operations may generate heat or vapors, the type and location of the detectors must be carefully evaluated to avoid frequent false alarms.

Fire Hoses

Fire hoses are intended for use by trained firefighters against fires too large to be handled by extinguishers and are included as safety equipment in some structures. Water has a cooling action and is effective against fires involving paper, wood, rags, and trash (Class A fires). Do not use water directly on fires that involve live electrical equipment (Class C fires) or chemicals such as alkali metals, metal hydrides, and metal alkyls that react vigorously with water (Class D fires).

Do not use streams of water against fires that involve oils or other water-insoluble flammable liquids (Class B fires). Water will not readily extinguish such fires; instead, it can cause the fire to spread or float to adjacent areas. These possibilities are minimized by the use of a water fog. Water fogs are used extensively by the petroleum industry because of their fire-controlling and extinguishing properties. A fog can be used safely and effectively against fires that involve oil products, as well as those involving wood, rags, and rubbish.

Because of the potential risks involved in using water around chemicals, laboratory personnel should not use fire hoses except in extreme emergencies. Reserve them for trained firefighters. Extinguish clothing fires by immediately dropping to the floor and rolling; however, if a safety shower is nearby, use it to extinguish a clothing fire

Automatic Fire-Extinguishing Systems

In areas where fire potential and the risk of injury or damage are high, automatic fire-extinguishing systems are often used. These may be of the water sprinkler, foam, carbon dioxide, halon, or dry chemical type. If an automatic fire-extinguishing system is in place, inform laboratory personnel of its presence and advise them of any safety precautions required in connection with its use (e.g., evacuation before a carbon dioxide total-flood system is activated, to avoid asphyxiation).

Respiratory Protective Equipment

The primary method for the protection of laboratory personnel from airborne contaminants is to minimize the amount of such materials entering the laboratory air. When effective engineering controls are not possible, use suitable respiratory protection after proper training. Respiratory protection may be needed in carrying out an experimental procedure, in

dispensing or handling hazardous chemicals, in responding to a chemical spill or release in cleanup decontamination, or in hazardous waste handling.

Under OSHA regulations, only equipment listed and approved by the Mine Safety and Health Administration and NIOSH may be used for respiratory protection. Also under the regulations, each site on which respiratory protective equipment is used must implement a respirator program (including training and medical certification) in compliance with OSHA's Respiratory Protection Standard (29 CFR § 1910.134); see also ANSI standard Z88.2-1992, Practices for Respiratory Protection.

Respirators must fit snugly on the face to be effective. Conduct tests for a proper fit prior to selection of a respirator and verify before the user enters the area of contamination. Failure to achieve a good face-to-face piece seal (e.g., because of glasses or facial hair) can permit contaminated air to bypass the filter and create a dangerous situation for the user. For individuals with

facial hair, do not use respirators requiring a face-to-face piece seal. In such cases, powered, air-purifying, or supplied-air respirators may be appropriate.

Types of Respirators

Several types of non-emergency respirators are available for protection in atmospheres that are not immediately dangerous to life or health but that could be detrimental after prolonged or repeated exposure. Other types of respirators are available for emergency or rescue work in hazardous atmospheres from which the wearer needs protection. Additional protection may be required if the airborne contaminant could be absorbed through or irritate the skin. For example, the possibility of eye or skin irritation may require the use of a full-body suit and a full-face mask rather than a half-face mask. For some chemicals the dose from skin absorption can exceed the dose from inhalation.

The choice of the appropriate respirator in a given situation depends on the type of contaminant and its estimated or measured concentration, known exposure limits, and hazardous properties. The degree of protection afforded by the respirator varies with the

type. Six main types of respirators are currently available:

1. Chemical cartridge respirators are only for protection against particular individual (or classes of) vapors or gases as specified by the respirator manufacturer and cannot be used at concentrations of contaminants above that specified on the cartridge. Also, these respirators cannot be used if the oxygen content of the air is less than 19.5%, in atmospheres immediately dangerous to life, or for rescue or emergency work. These respirators function by trapping vapors and gases in a cartridge or canister that contains a sorbent material, with activated charcoal being the most common adsorbent. Because significant breakthrough can occur at a fraction of the canister capacity, knowledge of the potential workplace exposure and length of time the respirator will be worn is important. Replacing the cartridge after each use ensures the maximum available exposure time for each new use. Difficulty in breathing or the detection of odors indicates plugged or exhausted filters or cartridges or concentrations of contaminants higher than the absorbing capacity of the cartridge, and the user should immediately leave the area of contamination. Check and clean chemical cartridge respirators on a regular basis. Do not store new and used cartridges near chemicals because they are constantly filtering the air. Store them in sealed containers to prevent chemical contamination.

2. Organic vapor cartridges cannot be used for vapors that are not readily detectable by their odor or other irritating effects or for vapors that will generate substantial heat on reaction with the sorbent materials in the cartridge.

3. Dust, fumes, and mist respirators are used only for protection against particular, or certain classes of, dusts, fumes, and mists as specified by the manufacturer. The useful life of the filter depends on the concentration of contaminant encountered. Such particulate-removing respirators usually trap the particles in a filter composed of fibers; they are not 100% efficient. Respirators of this type are generally disposable. Examples are surgical masks and toxic-dust and nuisance-dust masks. Some masks are NIOSH-approved for more Specific purposes such as protection against simple or benign dust and fibrogenic dusts and asbestos. Particulate-removing respirators afford no protection against gases or vapors and may give the user a false sense of security. They are also subject to the limitations of ft.

4. Supplied-air respirators deliver fresh air to the face piece of the respirator at a pressure high enough to cause a slight buildup relative to atmospheric pressure. As a result, the supplied air flows outward from the mask, and contaminated air from the work environment cannot readily enter the mask. This characteristic renders face-to-face piece fit less important than with other types of respirators. Fit testing is, however, required before selection and use.

5. Supplied-air respirators are effective protection against a wide range of air contaminants (gases, vapors, and particulates) and are used in oxygen-deficient atmospheres. Where concentrations of air contaminants could be immediately dangerous to life, such respirators can be used provided (a) the protection factor of the respirator is not exceeded and (b) the provisions of OSHA's Respiratory Protection Standard (which indicates the need for a safety harness and an escape system in case of compressor failure) are not violated. The air supply of this type of respirator must be kept free of contaminants (e.g., by use of oil filters and carbon monoxide absorbers). Most laboratory air is not suitable for use with these units because these units usually require the user to drag lengths of hose connected to the air supply and they have a limited range.

6. SCBA is the only type of respiratory protective equipment suitable for emergency or rescue work. Untrained personnel should not attempt to use one.

Procedures and Training

Each area where respirators are used should have written information available that shows the limitations, fitting methods, and inspection and cleaning procedures for each type of respirator available. Personnel who may have occasion to use respirators in their work must be thoroughly trained before initial use and annually thereafter in the fit testing, use, limitations, and care of such equipment. Training includes demonstrations and practice in wearing, adjusting, and properly fitting the equipment. OSHA regulations require that a worker be medically certified before beginning work in an area where a respirator must be worn

Inspections

Respirators for routine use should be inspected before each use by the user and periodically by the laboratory supervisor. Self-contained breathing apparatus should be inspected at least once a month and cleaned after each use.

Safety Showers and Eyewash Units

Safety Showers

Make safety showers available in areas where chemicals are handled; make sure they meet all installation and maintenance requirements (ANSI Z358.1 Emergency Eyewash and Shower Equipment; ANSI, 2004). Use them for immediate first-aid treatment of chemical splashes and for extinguishing clothing fires. All trained laboratory personnel should know where the safety showers are located in the work area and should learn how to use them. Test safety showers routinely to ensure that the valve is operable and to remove any debris in the system.

The shower should drench the subject immediately and be large enough to accommodate more than one person if necessary. It should have a quick-opening valve requiring manual closing; a downward-pull delta bar is satisfactory if long enough. Chain pulls are not advisable because they can hit the user and be difficult to grasp in an emergency. Install drains under safety showers to reduce the slip and fall risks and facility damage that is associated with flooding in a laboratory.

Eyewash Units

Eyewash units are required in research or instructional laboratories if substances used there present an eye hazard or if unknown hazards may be encountered. An eyewash unit provides a soft stream or spray of aerated water for an extended period (15 minutes). Locate these units close to the safety showers so that, if necessary, the eyes can be washed while the body is showered.

Automatic External Defbrillators (AED)

AED owners should provide or arrange for training and refresher training. Staff that may be on-site during normal working hours and available to operate AED equipment should be

selected for this training. The training should be an American Heart Association cardiopulmonary resuscitation (CPR)/AED course or a nationally acceptable equivalent. Competency is determined by the certified course instructor. Training records, including a description of the training program and refresher training schedule, should be documented. AED owners should be familiar with local laws concerning training and use of these devices.

Storage and Inspection of Emergency Equipment

Establish a central location for storage of emergency equipment. Include the following:

- SCBA (for use by trained personnel only),
- blankets for covering the injured,
- stretchers (generally best to wait for qualified medical help to move a seriously injured person),
- first-aid equipment (for unusual situations such as exposure to hydrofluoric acid or cyanide, where immediate first aid is required), and
- chemical spill cleanup kits and spill control equipment (e.g., spill pillows, booms,

Inspect safety equipment regularly (e.g., every 3 to 6 months) to ensure that it will function properly when needed. The laboratory supervisor or safety coordinator is responsible for establishing a routine inspection system and verifying that inspection records are appropriately maintained and archived as required by law.

Perform inspections of emergency equipment as follows:

- Inspect fire extinguishers for broken seals, damage, and low gauge pressure (depending on type of extinguisher). Check for proper mounting of the extinguisher and that it is readily accessible. Some types of extinguishers must be weighed annually, and periodic hydrostatic testing may be required.
- Check SCBA at least once a month and after each use to determine whether proper air pressure is

being maintained. Look for signs of deterioration or wear of rubber parts, harness, and hardware and make certain that the apparatus is clean and free of visible contamination. Periodically perform fit tests to ensure that the mask forms a good seal to an individual's face. Masks come in different sizes and cannot be considered universal or one-size-fits-all. Facial hair, especially beards, interferes with the mask seal and is not to permitted for SCBA users.

- Examine safety showers and eyewash units visually and test their mechanical function. Purge them as necessary to remove particulate matter from the water line.

- Inspect an AED periodically following the manufacturer's recommendations and procedures as well as after use and before returning to its storage location.

Emergency procedures

The following general emergency procedures are recommended in the event of a fire, explosion, spill, or medical or other laboratory accident. These procedures are intended to limit injuries and minimize damage if an accident should occur. Post numbers to call in emergencies clearly at all telephones in hazard areas. Because emergency response (personnel, contact information, procedures) varies greatly from institution to institution, all laboratory personnel should be properly trained and informed of the protocols for their particular institution.

- Have someone call for emergency help, for instance, 911 or other number as designated by the institution. State clearly where the accident has occurred and its nature.

- Ascertain the safety of the situation. Do not enter or reenter an unsafe area.

- Without endangering yourself, render assistance to the personnel involved and remove them from exposure to further injury.

- Warn personnel in adjacent areas of any potential risks to their safety.

- Render immediate first aid; appropriate measures include washing under a safety shower, administration of CPR by trained personnel if heartbeat or breathing or both have stopped, and special first-aid measures.

- Put out small fires by using a portable extinguisher. Turn off nearby equipment and remove combustible materials from the area. For larger fires, contact the appropriate fire department promptly. Be aware that many organizations limit fire extinguisher use to designated trained personnel only.

- Provide emergency personnel with as much information as possible about the nature of the hazard, including a copy of the material safety data sheet (MSDS).

- In a medical emergency, laboratory personnel should remain calm and do only what is necessary to protect life.

- Summon medical help immediately.

- Do not move an injured person unless he or she is in danger of further harm.

- Keep the injured person warm. If feasible, designate one person to remain with the injured person. The injured person should be within sight, sound, or physical contact of that person at all times.

- If clothing is on fire and a safety shower is immediately available, douse the person with water; otherwise, roll the person on the floor to smother the flames.

- If harmful chemicals have been spilled on the body, remove the chemicals, usually by flooding the exposed area with the safety shower, and immediately remove any contaminated clothing.

- If a chemical has splashed into the eye, immediately wash the eyeball and the inner surface of the eyelid with water for 15 minutes. An eyewash unit should be used if available. Forcibly hold the eye open to wash thoroughly behind the eyelid.

- If possible, determine the identity of the chemical and inform the emergency medical personnel attending the injured person. Provide an MSDS for each chemical that is involved in the incident to the attending physician or emergency responders.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided

1. Work order management involves _____,_____and _____
2. Work order management may be_____or _____

3. _____is a way of identifying an item of supply or equipment as being defective.
4. A good quality control/engineering program improves quality of work and lessens the risk of staff/patient injuries/death.(True, False)

Answer the following question!

Note: Satisfactory rating - 8and 16points **Unsatisfactory - below 9and 16 points**

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

Answer Sheet

Name: _____ Date: _____

Score = _____
Rating: _____

Information Sheet 3 Identifying, Isolating and reporting faulty equipment

Identifying, Isolating and reporting faulty equipment

Faulty Equipment

Malfunctioning or defective equipment be it heavy industrial vehicles like cranes, forklifts and hydraulic lifts, or hand tools cause thousands of injuries, including amputations and crushing injuries every year.

Most workers, especially those in the manufacturing, construction and transportation industries, are required to operate heavy industrial equipment, large industrial vehicles, hand tools and other equipment as part of their daily job. Unfortunately, very often, the equipment or tools are not in a safe condition, or may be malfunctioning. This poses a serious injury risk, and in some cases, those injuries can be serious enough to cause loss of limbs. Some of the injuries that can be caused by malfunctioning equipment include amputations of limbs or fingers, and even crushing injuries.

Causes of equipment-related injuries

Defective equipment

The Danger of Defective Equipment.

Poorly maintained equipment

Lack of repairs

Lack of worker training

Defective equipment and machinery can cause the following types of accidents:

Workers being struck by/caught-in-between parts or equipment

Falls to a lower level

Electrocution

Fires/explosions

Toxic chemical exposure

WHAT IS CONSIDERED HEAVY INDUSTRIAL EQUIPMENT AND MACHINERY?

Heavy industrial equipment and machinery refers to the components, parts, machines, tools, and other products used to complete tasks in the mining, forestry, fishing, drilling/extraction, agriculture, construction, and manufacturing sectors.

Some common examples of industrial machinery and equipment include:

Bulldozers Cranes Back hoes Forklifts Circular saws Wheel loaders Graders Trawl winches Excavators Die-casting machines

Injuries caused by defective equipment and machinery

Common injuries experienced by people working with equipment and machinery include:

Burns, electrocutions, and smoke inhalation

Moderate or Severe Traumatic Brain Injuries

Amputations

Broken bones

Neck, back, and spinal cord injuries including paralysis

Torn ligaments

Vision or hearing loss

Disfiguring lacerations

Common types of defects

Defects can occur in the design of the equipment and machinery, during the manufacturing process, or in the marketing stage, meaning that it lacks appropriate warnings or instructions regarding how to use the product safely. Sometimes, equipment or machinery may contain a combination of defects, including:

Machines/equipment lack adequate safety devices (e.g. guarding, automatic shut-off switch)

Machinery/equipment is placed in an improper location, which puts workers at risk of injury from nearby equipment

Mistakes in machine assembly or installation

Use of low quality or incorrect materials in manufacturing process

Machine/equipment is prone to overheating

Faulty wiring

Lacks proper safety warnings or instructions

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided

Answer the following question as directed below

1. Mention at least three Causes of equipment-related injuries
2. **Defective equipment and machinery can cause**_____**,**_____**,**_____**-,**_____**and ,**_____:
3. Mention Common injuries experienced by people working with equipment and machinery include:

Answer the following question!

Note: Satisfactory rating - 8and 16points **Unsatisfactory - below 9and 16 points**

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

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information Sheet 4 Recording and/or reporting faults and any identified causes

Recording and/or reporting faults and any identified causes

information required to complete an inspection report

Diagram of Area

Use drawings of the plant layout or floor plans to help you draw a diagram. Divide the workplace into areas based on the process. Visualize the activities in the workplace and identify the location of machinery, equipment and materials. Show the movement of material and workers, and the location of air ducts, aisles, stairways, alarms and fire exits. Appendix A shows a sample diagram. Use several simple diagrams if the area is large. Ask workers and supervisors for their comments on the information - they know the area better than anyone else.

Equipment Inventory

Know what type of machinery or equipment is present. Review technical data sheets, or manufacturers' safety manuals. Read work area records to become familiar with the hazards of the equipment.

Hazardous Product or Chemical Inventory

Determine which products are used in the workplace and whether safety data sheets are available. Find out if all sources and training in how to safely use, handle and store the

products they work with. Check that all hazardous products are labelled appropriately according to Workplace Hazardous Materials Information System (WHMIS) requirements.

Checklists

of exposure are properly controlled. Make sure that all workers have received education

A checklist helps to clarify inspection responsibilities, controls inspection activities and provides a report of inspection activities. Checklists help with on-the-spot recording of findings and comments but be careful. Do not allow the inspection team to become so intent on noting the details listed in the checklist that it misses other hazardous conditions. Use checklists only as a basic tool. Refer to the related documents for sample checklists that you can use as a guide to develop a checklist that is customized for your workplace.

- Inspection Checklists - General Information
- Inspection Checklists - Sample Checklist for Manufacturing Facilities
- Inspection Checklists - Sample Checklist for Offices
- Inspection Checklist - Sample Checklist for Chemical or Product Inventory
- Inspection Checklist - Sample Checklist for Outdoor Areas

Reports

Keeping inspection records is important. Past inspection records show what has been previously identified. They also show what an earlier inspection team concentrated on and what areas it did not inspect. Do not simply repeat or copy previous inspection results. Use the older inspection reports to help look for issues, and then determine whether recommendations were implemented. Note if the changes have been effective.

types of inspection reports

The following describes three other types of inspection reports:

- Ongoing
- Pre-operation
- Periodic

Supervisors and workers continually conduct ongoing inspections as part of their job responsibilities. Such inspections identify hazardous conditions and either correct them immediately or report them for corrective action. The frequency of these inspections varies with the amount and conditions of equipment use. Daily checks by users assure that the equipment meets minimum acceptable safety requirements.

Pre-operation checks involve inspections of new or modified equipment or processes. Often these are done after workplace shutdowns.

Periodic inspections are regular, planned inspections of the critical components of equipment or systems that have a high potential for causing serious injury or illness. The inspections are often part of preventive maintenance procedures or hazard control programs. Laws and regulations may specify that qualified or competent persons must inspect certain types of equipment, such as elevators, boilers, pressure vessels, scaffolding, and fire extinguishers at determined points in the work process and at regular intervals.

final report

To make a report, first copy all unfinished items from the previous report on the new report. Then write down the observed unsafe condition and recommended methods of control. Enter the department or area inspected, the date and the inspection team's names and titles on top of the page. Number each item consecutively, followed by a hazard classification of items according to the chosen scheme.

Report issues in a concise, factual way. Management should be able to understand and evaluate the problems, assign priorities and quickly reach decisions.

After each listed hazard, specify the recommended corrective action and establish a definite correction date if possible and appropriate. Each inspection team member should review for accuracy, clarity and thoroughness

Example of Workplace Inspection Report

Inspection Location: _____ Date of Inspection: _____

Department/Areas Covered: _____ Time of Inspection: _____

Observations						**For Future Follow-up**		
Item and Location	**Hazard(s) Observed**	**Repeat Item Y / N**		**Priority A/B/C**	**Recommended Action**	**Responsible Person**	**Action Taken**	**Date**

Copies to: _____ Inspected by: _____

Summary of Inspection Information Requirements

- Basic layout plans showing equipment and materials used
- Process flow
- Information on chemicals
- Storage areas
- Work force size, shifts and supervision
- Workplace rules and regulations
- Job procedures and safe work practices

- Manufacturer's specifications
- Personal Protective Equipment (PPE)
- Engineering controls
- Emergency procedures - fire, first aid and rescue
- Incident and investigation reports
- Worker complaint reports regarding particular hazards in the workplace, including psychosocial hazards
- Recommendations of the health and safety committee
- Previous inspections
- Maintenance reports, procedures and schedules
- Regulator inspection reports or other external audits (insurance, corporate specialist)
- Monitoring reports (levels of chemicals, physical or biological hazards)
- Reports of unusual operating conditions
- Names of inspection team members and any technical experts assisting

Defaults and restrictions

It is possible to document defaults and restrictions that the system has to fulfil in the chapter “Requirements” or in a separate chapter. This may include the following aspects:

- usability
- dependability
- effectiveness
- changeability
- transmissibility
- maintainability
- risk assessment
- acceptance criteria

Attachments and supplements includes

- h

e sources and resources already mentioned in the chapter "Introduction". References e.g. to the project application or the project manual with the specified requirements can also be displayed here.

- List of abbreviations, list of tables, list of images.
- other additions such as notes or a list of requirements to be implemented at a later date.

Recommending fault equipment's for replacement or returned to suppliers

Equipment Replacement And Maintenance

Organizations use equipment in production and testing which must be maintained or replaced on planned basis. Manufacturing industries are facing fierce competition therefore companies invest in highly automated production system with good quality equipment. It is necessary to utilize equipment in best way to stay in the global market, and maintain the production operation thus leading to the economical sustainability as well as increase company profit. When an unplanned interruption occurs due to machines or equipment failure, this disturbs the production operation.

Equipment Replacement

The replacement of productive equipment is important strategic decisions faced by both manufacturing and service firms because purchasing a new piece of equipment often involves more cost and can affect the productivity and effectiveness of the firm. Currently,

this issue is highlighted in fast changing technologies and good equipment purchase can soon become obsolete. Under these situations, the driving motivation to take replacement decisions is likely to be technological out modedness instead of physical deterioration, of the existing equipment. This situation is typical of microcomputers, computerized numerically controlled machines, and other electronics technologies.

The replacement problems are associated with the issues that develops when the performance of an item decreases, failure or breakdown occurs. The decline in performance or breakdown may be gradual or sometimes sudden. There is a need for replacement of items when;

The existing item or system has become inefficient or require more maintenance.

The existing equipment has failed due to accident or otherwise and does not work at all.

The existing equipment is expected to fail shortly.

There are numerous reasons for equipment replacement. The first reason is the equipment is depleted of function. Second reason for replacing equipment is if the equipment becomes obsolete. For example, older computers are much slower and have fewer features than their modern counterparts. In addition, older computers are harder to maintain because replacement parts and qualified technicians are much harder to find. Another reason for replacement is deterioration due to aging. Equipment is inadequate and does not meet needs, increased demand. Then it is replaced with a larger asset.

types of failure in equipment:

Gradual Failure: In this, the failure mechanism is progressive. As an equipment becomes old, its performance deteriorates. This results in increased operating cost, decreased productivity of the item and decrease in resale value of item.

Sudden Failure: This type of failure occurs in equipment that do not deteriorate gradually with age but which fail suddenly after some period of service. The time period between installations and failure will not be constant for any particular equipment. However the failure

pattern will follow certain frequency distribution that may be progressive, retrogressive or random in nature.

Progressive failure: progressive failure occurs when probability of failure increases with the age of an item.

Retrogressive failure: Certain items will have more probability of failure in the early years of their life and with the increase in the life of an item the chances of failure become less. That is, the ability of the item to survive in the initial years of life increases its expected life.

Random failure: Random failure occurs when continuous probability of failure is related with equipment that fails because of random causes such as physical shocks that are independent of age. In the case of random failure, virtually all items fail before aging has any effect.

The replacement situations are categorized into the following four types:

Replacement of capital equipment whose performance decreases with time.

Group replacement items that fail completely: Some system usually composed of a large number of low cost items that are prone to failure with age such as failure of a resistor in television, radio, computer etc. In some cases the failure of a component may cause the complete failure of the system. In such cases, the cost of overall failure will be quite higher than the cost of component itself. In such situations, two types of replacement procedures must be considered. First is Individual replacement. In this policy, an item is replaced immediately after its failure. Secondly, Group replacement in which, decision is about the age when all the items should be replaced, irrespective of whether the items have failed or not. In this policy, the items that fail before the optimal time, will be replaced individually.

Problem of mortality and staffing.

Miscellaneous problems.

Replacement Planning Process:

Assess clinical needs

Use multidisciplinary approach

Assess technical/maintenance/safety/regulatory needs/indicators

Review equipment database

Review maintenance criteria and calculations

Assess budget

The current information used to make the decision to replace equipment includes equipment age, failures which cannot be repaired, current program needs, future strategic plans, and reliability assessments, if available. It is established that any equipment that cannot be repaired is typically replaced. This could be equipment that requires a complete deconstruction and rebuild, equipment that no longer has spare or replacement parts available, or the lack of a qualified and available technician.

Who can perform maintenance?

First let's cover who can work on the aircraft. Many think that in order to work on the aircraft one must be certificated by the FAA. Not so. 14 CFR Part 43.3 spells out in detail who can perform maintenance. Basically, limited to their specific certification the following certificate holders can work on an aircraft: mechanic, repairman, repair station, air carrier, pilot, and manufacturer.

In addition to those who are certificated, a person who is working under the direct supervision of a mechanic or repairman certificate holder may work on the aircraft as well - limited by the limitations of the person supervising them.

type of maintenance activity to be performed will depend upon the nature of equipment and its working conditions.

The planned maintenance is classified into following types:

Scheduled Maintenance (SM)

Preventive Maintenance (PM)

Corrective Maintenance (CM)

Reliability Centred Maintenance (RCM)

Corrective (Reactive) Maintenance

Corrective maintenance (CM) involves the replacement or repair of equipment after it fails. In response to equipment failure, CM tasks identify the failure (it may be an equipment component or equipment item) and rectify the failure so that the equipment can be reinstated and the facility production restored. CM tasks are prioritized so that the high-priority tasks that may be safety related or affecting production are addressed first.

CM is in general low cost because it can generally be performed with a fewer number of resources and maintenance infrastructure, including tools, technologies and expertise. The consequence, however, is that it is inefficient and in the long term it can be very expensive because failures generally result in catastrophic events, which means there is more damage that needs to be repaired and hence the MTTRs are longer. CM also does not focus on the root cause of the equipment failure and therefore MTBF will be much lower than with proactive maintenance. In other words, there will be many repeat failures.

Designing for Maintenance

Corrective (reactive) maintenance

Corrective maintenance is reactive in nature. Every time a product or system fails, repair or restoration must follow to restore its operability. The following steps constitute corrective maintenance:

●Once the failure has been detected, it must be confirmed. If the failure is not confirmed, the item generally is returned to service. This no-fault-found problem leads to a considerable waste of time at significant cost. It also entails carrying an unnecessarily large inventory all the time.

●If the failure is confirmed, the item is prepared for maintenance and the failure report is completed.

●Localization and isolation of a failed part in the assembly is the natural next step in corrective maintenance.

●The failed part is removed for disposal or repair. If disposed of, a new part is installed in its place. Examples of repairable parts and connections include broken connections, an open circuit board on a PCB, or a poor solder.

●The item may be reassembled, realigned, and adjusted after repair. It is checked before being put back to use.

The chief disadvantage of this maintenance procedure is the inherent amount of uncertainty associated with it. Similarly, the procedure is extremely reactive in nature, capable of shutting down an entire operation because of a single failure in a single machine under extreme conditions (often leading to a severe bottleneck and lost productivity). As a result of its drawbacks, another, more proactive maintenance method (recognizing that equipment needs periodic maintenance to function smoothly, which should be provided before a breakdown occurs) was developed.

Risk-Centered Maintenance

Corrective Tasks

Corrective maintenance consists of the action(s) taken to restore a failed component to operational status. Corrective maintenance is performed at unpredictable intervals because a component's failure time is not known a priori.

Scheduled Tasks

Scheduled maintenance contains three kinds of maintenances: PM, inspection, and on-condition maintenance.

PM is the practice of repairing or replacing components or subsystems before they fail in order to promote continuous system operation or to avoid dangerous or inconvenient failures. The schedule for PM is based on observation of past system behavior, component wear-out mechanisms, and knowledge of which components are vital to continued system operation. In addition, cost is always a factor in the scheduling of PM. In many circumstances, it is

financially more sensible to replace parts or components at predetermined intervals rather than to wait for a failure that may result in a costly disruption in operations.

Inspections are used in order to uncover hidden failures (also called “dormant failures”). They are also used as part of on-condition tasks to detect impending failures so that PM can be performed.

On-condition maintenance relies on the capability to detect failures before they happen so that PM can be initiated. If, during an inspection, maintenance personnel can find evidence that the equipment is approaching the end of its life, then it may be possible to delay the failure, prevent it from happening or replace the equipment at the earliest convenience rather than allowing the failure to occur and possibly cause severe consequences.

Maintenance Decision Support

Corrective maintenance

Corrective maintenance refers to all activities that restore a system to the specified state when a fault occurs. It may include one or all of the following steps; fault location, fault isolation, decomposition, replacement, reassembly, adjustment, and testing [3], that is, a determining whether the appropriate related maintenance after the fault occurs is corrective maintenance such as break-down maintenance, condition monitoring maintenance, hidden trouble detection, and design change.

Break-down maintenance is a failure-based maintenance mode that determines whether a system is in a good condition or available and restores the system to its original state after a partial or complete failure occurs in the system.

Break-down maintenance is applied when

a. There is no obvious functional failure to the operator;

b. There are unforeseen faults in the system, but there is no immediate harm to the safety of the system or mission;

c. The system is deteriorating. The cost of postfault maintenance is less than the PM; however, time-based or condition-based maintenance (CBM) can also be used.

2. Condition monitoring maintenance is used to indicate where technical resources should be allocated. From an analysis of the overall data from the specific operating system, the most appropriate maintenance method is then determined. Condition monitoring maintenance is not PM but is used to identify where the faults are occurring and what measures should be applied.

3. Hidden trouble detection is carried out to find an existing functional fault that is not obvious to the operators, such as the detection of redundant systems.

Types of Maintenance

Corrective Maintenance

Corrective maintenance is used to repair damage that has already occurred. Usually, when this type of maintenance is performed, the manufacturing process is stopped, decreasing production and increasing costs. Repair time cannot be predicted, nor can the expenses resulting from the breakdown and consequent disturbances on the production line. Therefore, corrective maintenance is applied on assets with low criticality, whose faults do not involve large temporal or economic problems. It is often used for specific equipment where other techniques would be more costly.

Preventive Maintenance

Preventive maintenance is planned in a time horizon and aims to prevent breakdowns. Unlike corrective maintenance, because it is planned, it is not done during production time.

The intention of this type of maintenance is to reduce the number of corrective interventions, performing periodic reviews and replacing worn components.

It is a demanding type of maintenance, as it requires strict supervision and development of a plan to be carried out by qualified personnel. In addition, as it involves routine tasks, personnel may not be motivated. Furthermore, if it is not done correctly, there will be a cost overrun with no significant improvements in productivity.

Condition-Based Maintenance

CBM aims to determine the condition of equipment, so that operation remains safe, efficient, and economic. Monitoring techniques are aimed at measuring physical variables that indicate the condition of the machine and comparing these with normal values to determine if the machine is in good condition or deteriorating. CBM assumes there are measurable and observable characteristics that are indicators of the condition of the machine.

Condition monitoring studies the evolution of selected time-dependent parameters; it identifies trends indicating the existence of a fault, its severity, and the likely time to failure (TTF). Timely decision-making avoids the occurrence of faults and eliminates the possibility of catastrophic failure. CBM can be performed while the machine is running (Gerardo Trujillo and América, 2003).

CBM consists of three key steps

1. Data acquisition (information collecting), to obtain data relevant to system health.

2. Data processing (information handling), to handle and analyze the data or signals collected in step 1 for better understanding and interpretation of the data.

3. Maintenance decision-making (decision-making), to recommend efficient maintenance policies.

Steps to Implement CBM:

Data Acquisition

Data acquisition is a process of collecting and storing useful data (information) from targeted physical assets for the purpose of CBM. This is an essential step in implementing a CBM program for machinery faults (or failure, usually caused by one or more faults). Data collected in a CBM program can be categorized into two main types: event data and condition-monitoring data. Event data include information on what happened (e.g., installation, breakdown, overhaul, etc., along with the causes) and/or what was done (e.g., minor repair, preventive maintenance, oil change, etc.) to the targeted physical asset. Condition-monitoring data are measurements related to the health condition/state of the

physical asset. These are very versatile and can include vibration, acoustic, oil analysis, temperature, pressure, moisture, humidity, weather or environment data, etc.

Data Processing

Data processing consists of two stages. The first is data cleansing; this step is important because usually the data are entered manually. This leads to frequent errors, requiring data cleaning to increase the probability that the data are clean (no errors). The second step is the analysis of the data. There are a variety of models, algorithms, and tools for analysis; selection depends on the types of data collected.

Maintenance Decision Support

The last step of a CBM program is maintenance decision-making. Sufficient and efficient decision support is crucial for determining maintenance actions. Techniques for maintenance decision support in a CBM program can be divided into two main categories: diagnostics and prognostics. Fault diagnostics focus on detection, isolation, and identification of faults when they occur. Prognostics attempt to predict faults or failures before they occur.

Obviously, prognostics are superior to diagnostics in the sense that prognostics can either prevent faults or failures, or be ready (with spare parts and human resources) for the problems, thus reducing the costs of unplanned maintenance.

Nevertheless, prognostics cannot completely replace diagnostics since, in practice, there are always some faults and failures, which are not predictable. In addition, prognostics, like any other prediction technique, cannot be 100% accurate. In the case of unsuccessful prediction, diagnostics can be a complementary tool for maintenance decision-making. Diagnostics are also helpful for improving prognostics; diagnostic information can result in more accurate event data, and a better CBM model can be built for prognostics. Furthermore, diagnostic information can be used as feedback information for system redesign.

Maintainability Measures, Functions, and Models

1. Compare corrective maintenance time and preventive maintenance time.

2. Three subsystems, i, j, and k, form an electronic system. The constant failure rates of these subsystems are $\lambda_i = 0.002$ failures per hour, $\lambda_j = 0.004$ failures per hour, and $\lambda_k = 0.006$ failures per hour. The corresponding estimated corrective maintenance times are $T_i = 2$ hours, $T_j = 3$ hours, and $T_k = 4$ hours, respectively. Estimate the mean time to repair (MTTR) for the overall system.

3. Discuss the following two items:

•Maximum corrective maintenance time

•Median corrective maintenance time

4. Define the maintainability function verbally and mathematically.

5. Obtain maintainability functions for the following distributions:

6. After a detailed analysis of repair data associated with an engineering system, it was concluded that the system mean time to repair (MTTR) is 3.5 hours. Calculate the probability of completing a repair in 2.5 hours, if the times to repair are described by an exponential probability density function.

7. Prove that the mean, M, of the gamma distributed maintenance time is given by

$M=m/k$

where m is the shape parameter associated with gamma distribution.

k is the scale parameter associated with the gamma distribution.

What is the difference between the following types of availability?

• Inherent availability

• Achieved availability

• Operational availability

9. Describe the relationship between system effectiveness and dependability.

10. What are the important assumptions associated with the equation that determines the probability of having a spare of a specific item available when required?

Reactive Maintenance

Reactive maintenance or corrective maintenance is to fix items when needed either through scheduled inspection or field observation. If these unplanned fixes are prioritised then it takes time away from scheduled maintenance Minimal effort is spent to maintain the equipment as the designer originally intended to ensure design life is reached. Studies indicate that this is still the predominant mode of maintenance in the United States and other countries

Preventive Maintenance

This is a better method than reactive maintenance. Maintenance is regularly schedule based on vendor recommendation or breakdown history (Hern, 1995). The schedules are created for routine check and replacement of components based on *time-directed* maintenance. These time cheques are usually determined based upon the life span of previous components of a similar type. Preventive maintenance can be inefficient and may be wasteful as some parts that are far from their breaking point are replaced with new parts – these parts could still work without problems

Predictive Maintenance

This approach detects problems that can be overlooked by preventive maintenance. The onset of a degradation mechanism of equipment is detected by *condition-directed* maintenance. This allows for casual stresses to be eliminated or controlled prior to any significant deterioration in the component physical state. Effective maintenance can catch issues quickly in the potential failure (P-F) interval of the life cycle of a component so appropriate action can be taken. Predictive

Proactive (Reliability-Centred) Maintenance

Proactive/reliability-centred maintenance relies on effective decision making considering benefits and limited resources. It acknowledges equipment has different importance to either the process or plant safety. It takes into account the probability of failures due to different

degradation mechanisms. The maintenance programme is thus built on prioritising actions by also taking into account the limited financial and personnel resources. This helps focus on what is important, items that need to be proactively dealt with, and enhance the MMS

RCM analysis will assess the failure modes for an asset and develop a maintenance strategy to mitigate the consequences for each failure mode. The value in performing RCM is the proactive assessment of these failure modes and the resulting tasks developed to eliminate reoccurring failures. An organization or processing plant needs to have a target that equipment failures are unacceptable. Failures can be categorized to track their occurrences. Some examples of failure codes include:

• Material defect;

• Installation defect;

• Design defect;

• Fabrication errors;

• Unintended service conditions;

• Improper use;

• Inadequate maintenance.

Tracking the frequency or occurrence and impact of failures can help us with an area of focus whether it be certain equipment, a manufacturer or process

Technology-Enhanced Maintenance Management

The MMS can be enhanced by leveraging technology. Computerized maintenance management systems (CMMSs) are widely adopted in various industries. CMMSs have been getting traction since the late 1980s and it is rare that a large company involved in equipment maintenance would not have a specialized software solution to aid in its equipment maintenance efforts. Some of the CMMS are Tab Ware CMMS/EAM, Bentley Systems and FIIX (cloud-based).

Sometimes CMMSs are tied to upstream and downstream workflows where they can be tied to purchasing, receiving, and also connecting to accounting systems for payables – this helps in efficient workflows, on-demand accurate reporting, data governance and expediting decision making in large organizations. Moreover, capital-intensive industries have moved away from standalone software solutions to the integration of their CMMS with their enterprise resource planning software. CMMS solutions are expensive. Moreover, IT hosting, support and maintenance costs can add up. Therefore, the scale of the organization needs to be considered while adopting these systems. Yet, the IT costs are much lower and technology is light ages ahead of two decades ago, making the net benefit much higher

CMMS can be used to effectively plan and schedule maintenance work orders. Using a preset and reviewed template, work orders can be auto-generated, reducing the workload on the planning department. Moreover, there will be a single version of the truth, with the history of work done on as asset or equipment. These systems come with on-demand and enhanced reporting for plant staff, site managers and corporate maintenance leadership.

Vibration Analysis

Vibration analysis monitors vibration frequencies and amplitudes of mechanical units. Comparing the observed data with the benchmarked data, potential bearing problems, alignment corrections, rotating equipment dynamic imbalances, and so on can be detected early and scheduled maintenance can be arranged. Vibration analysis is key for critical equipment whose failure can cause a mine shutdown

Oil Analysis and Contamination

Oil analysis is a central part of any maintenance programme. The correct type of lubricant, proper grade of lubricant, change of lubricant and filter at recommended intervals are of utmost importance for better reliability and performance of a machine (Kumar, 2006).

Anything that doesn't belong in the oil is called contamination, and may include: dirt and other particles, air, wear debris, fuel and other lubricants, coolant, and detergents and other chemicals.

If the lubrication oil is contaminated, it can cause harm to the equipment and performance will deteriorate. The lubricant becomes abrasive when debris makes its way into it, which may lead to bearings or other moving parts failing.

Better lubrication practices can have an enormous impact on plant operation and the bottom line. The best condition-based lubrication techniques as part of a larger maintenance programme should be in place. Plant efficiency and optimising work hours can be improved by filtering oil and finding contaminants in bearings before they can cause failures (http://www.uesystems.com/news/controlling-contamination-to-control-costs).

Motor Meggering

The condition of motor winding insulation can be continuously monitored and determined by measuring megohms of resistance from the winding insulation. This measure decreases as the winding insulation deteriorates. With a benchmark threshold for replacement, these motors can be replaced, which prevents major unscheduled plant downtime (Hern, 1995).

There are special measuring instruments that may be used to detect and diagnose malfunctions. The insulation resistance tester, generally known by its trade name, Megger, is capable of providing critical information regarding the condition of motor insulation.

Thermographic Analysis

Through the use of an infrared camera it is possible to estimate the temperature and to produce a surface thermal map of an object's surface. Once high-temperature areas are located, scheduled repairs including disassembly, cleaning and reassembly are planned.

Other Maintenance Strategies

The discussion in the preceding sections shows that structures are very seldom subject to just one of the two basic maintenance strategies—corrective or preventive. In most cases, a mix of activities typical for both strategies will be applied. If it is not evident which of these two strategies is dominant, we will classify it as combined maintenance.

The very division into corrective and preventive maintenance also allows for different interpretations depending on the considered case. One example, the classification of typical maintenance approach to bull gears in mechanical drive systems, has already been given in the preceding section. Another example can be the classification of maintenance painting approaches. The USACE manual [6] distinguishes three maintenance painting approaches, all resulting from collected survey data:

- touching up (recoating small, localized areas);
- touching up with a full overcoat; and
- complete removal and replacement.

The third approach is typically considered when the coating deterioration exceeds 3%–10%. This range is wide and the operational decision will depend on a number of other factors, like the actual corrosion distribution, scale of overlaps in case of touching up, and the intended time schedule for repainting. Although the first two approaches show signs of preventive maintenance, and the third approach looks like corrective maintenance, applying these terms here has no sense because the point of coating failure is not sharply defined.

Also the focus can in this case result in different classifications. Let us assume for this moment that the 10% of deterioration is a hard acceptance criterion. The complete replacement of a coating that deteriorated beyond this limit is then a corrective, “fix as fail” measure as regards the coating. As regards the gate structure, however, it is a preventive, “change before fail” measure.

This discussion shows that while the development of theoretical maintenance strategies is, generally, a good aim, the developed models should assist the engineering logic rather than replace it. It is not that important to create more and more complex, computerized maintenance systems. More important is that the existing systems, including the classifications of maintenance strategies, are transparent and flexible. The most essential ground of operational decisions concerning maintenance of hydraulic gates should remain to be field surveys and investigations and the risk analyses based on their results.

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided

Answer the following question as directed below each contain (2%)

1. What is the need to replace defective equipment
2. What is the reason for equipment replacement.
3. **Mention types of failure in equipment**:

4. **in Gradual Failure mechanism is progressive**.(True, False)
5. _____**is a** failure occurs in equipment that do not deteriorate gradually with age but which fail suddenly after some period of service.
6. **Mention type of** maintenance activity.

Answer the following question!

Note: Satisfactory rating 7and 12points **Unsatisfactory – below7and 12 points**

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

Answer Sheet

Name: _____ Date: _____

Score = _____
Rating: _____

L #42	**LO 2 :** Assess quality of service

Instruction sheet

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

Documenting information on the quality and other indicators

checking completed work against documented workplace

Identifying and correcting faulty items or below standard services

Documenting and reporting deviations from specified quality standardsand its causes

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

Document information on the quality and other indicators

check completed work against documented workplace

Identify and correct faulty items or below standard services

Document and report deviations from specified quality standardsand its causes

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information Sheet 1 Documenting information on the quality and other indicators

Documenting information on the quality and other indicators

What is Quality?

- The ongoing process of building and sustaining relationships by assessing, anticipating, and fulfilling stated and implied needs.
- Quality is the customers' perception of the value of the suppliers' work output.
- A product or process that is Reliable, and that performs its intended function is said to be a quality product.
- Quality is nothing more or less than the perception the customer has of you, your products, and your services!
- Quality is nothing more or less than the perception the customer has of you, your products, and your services!

Quality policy

Quality policy is a document jointly developed by management and quality experts to express the quality objectives of the organization, the acceptable level of quality and the duties of specific departments to ensure quality.

Your quality policy should:

- State a clear commitment to quality.
- Recognize customer needs and expectations.
- Be actively supported by senior management.
- List the quality objectives you want to achieve.
- Be understood by everyone in the organization.
- Be consistent with your organization's goals.
- Be maintained throughout your organization.
- Be applied throughout your organization.

Responsibility and authority

Define quality system responsibilities, give quality system personnel the authority to carry out these responsibilities, and ensure that the interactions between these personnel are clearly specified. And make sure all of this is well documented. This requirement must be met for those who:

- Manage quality system work.
- Perform quality system work.
- Verify quality system work.

Resources

Identify and provide the resources that people will need to manage, perform, and verify quality system work. Make sure that:

- Only trained personnel are assigned.
- Managers have the resources they need to verify work.
- Internal auditors have the resources they need.

Management representative

Appoint a senior executive to manage your quality system and give him or her necessary authority. This senior executive must ensure that your quality system is developed and implemented. This executive must:

- Monitor the performance of your quality system.
- Control the performance of your quality system.
- Report on the performance of your quality system.
- Help improve the performance of your quality system.
- Act as your organization's spokesperson on quality.

Quality system

Develop a quality system and a manual that describes it. Your quality system should ensure that your products conform to all specified requirements.

- Your quality manual should:
    - State your quality policy.
    - List your quality objectives.
    - Provide an overview of your quality system.
    - Describe the structure of your organization.
    - Discuss your quality system procedures.
    - Introduce your quality documents and records.
    - Teach people about your quality system.
    - Control quality system work practices.
    - Guide the implementation of your quality system.
    - Explain how your quality system will be audited.

Quality Assurance

Quality Assurance is a system of management activities involving planning, implementation, assessment, and reporting to make sure that the end product (i.e., environmental data) is of the type and quality needed to meet the needs of the user.

Quality Control

Quality Control is the overall system of operational techniques and activities that are used to fulfill requirements for quality. The QC activities are used to produce and document the quality of the end product.

Quality Management Plan (QMP)?

A QMP is a formal plan that documents an entity's management system for the environmental work to be performed. The QMP is an "umbrella" document which describes the organization's quality System in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces with those planning, implementing, and assessing all environmentally related activities conducted.

Quality system procedures

Develop and implement quality system procedures that are consistent with your quality policy.

- Develop your procedures for all areas of your quality system.
- Document your procedures, and keep them up to date.
- Each procedure should:
    - Specify its purpose and scope.
    - Describe how an activity should be carried out.
    - Describe who should carry out the activity.
    - Explain why the activity is important to quality.

    - Describe when and where it should be carried out.
    - Explain what tools and equipment should be used.
    - Explain what supplies and materials should be used.
    - Explain what documents and records should be kept.

- Procedures may also refer to detailed work instructions that explain exactly how the work should be done.

Quality Management Plan (QMP)?

A QMP is a formal plan that documents an entity's management system for the environmental work to be performed. The QMP is an "umbrella" document which describes the organization's quality System in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces with those planning, implementing, and assessing all environmentally related activities conducted.

Quality planning

Develop quality plans that show how you intend to fulfill quality system requirements. You are expected to develop quality plans for products, processes, projects, and customer contracts.

- Your quality plans should list the quality objectives you intend to achieve, and the steps you intend to take to achieve these objectives.
- When you construct your quality plan, consider
  the following questions:
  - Do you need to purchase any new equipment or instruments, or any new inspection and test tools?
  - Do you need to carry out any special training in order to fulfill all quality system requirements?
  - Do you need to improve design, production, testing, inspection, installation, or servicing procedures?
  - Do you need to improve your quality measurement and verification procedures?
  - Do you need to develop any new measurement methods or instruments?
  - Do you need to clarify your organization's standards of acceptability?
  - Do you need to develop any new documents, forms, reports, records, or manuals?
  - Do you need to allocate more resources in order to achieve the required levels of quality?

Quality management standards

Quality management system (QMS) standards establish a framework for how a business manages its key processes. They can help whether your business offers products or services and regardless of your size or industry. They can also help new businesses start off on the right foot by ensuring processes meet recognized standards, clarifying business objectives and avoiding expensive mistakes.

To comply with the standard you'll first need to implement a QMS. Implementing a QMS can help your business to:

- achieve greater consistency in the activities involved in providing products or services
- reduce expensive mistakes
- increase efficiency by improving use of time and resources
- improve customer satisfaction
- market your business more effectively
- exploit new market sectors and territories
- manage growth more effectively by making it easier to integrate new employees
- constantly improve your products, processes and systems

For example, the quality system of a manufacturing business might include looking at more efficient manufacturing processes or speeding up distribution.

The **ISO 9000 series** of standards is the main set of International Standards applying to the management of quality systems. It includes ISO 9001, the key internationally agreed standard for a QMS. Businesses can be certified against this standard when they meet its requirements.

The ISO 9001:2008 standard

ISO 9001:2008 is the key internationally agreed standard for quality management systems. It is used by over 951,000 businesses in 175 countries worldwide (source: British Standards Institution (BSI), 2010).

The ISO 9001:2008 standard has four elements:

- **management responsibility** - ensuring top level management shows commitment to the quality system and develops it according to customers' needs and the business' objectives
- **resource management** - ensuring the people, infrastructure and work environment needed to implement and improve quality systems are in place

- **product realization** - delivering what customers want, looking at areas such as sales processes, design and development, purchasing, production or service activities
- **measurement, analysis and improvement** - checking whether you have satisfied customers by carrying out other measurements of your system's effectiveness

The advantages of ISO 9001:2008 for your business can include:

- greater efficiency and less waste
- consistent control of major business processes, through key processes lists - see our example key processes master list - Opens in a new window
- regulation of successful working practices
- risk management
- increased customer satisfaction
- greater consistency in the quality of products and services through better control of processes
- differentiation of your business from its competitors
- increased profits
- exploitation of new markets, both in the UK and overseas

However, you should also be aware of some of the **disadvantages** to implementing the standard. These can include:

- the cost of getting and keeping the certification
- the time involved
- overcoming opposition to implementing change from within the business

The standard is adaptable to your business' needs and resources, though you may need the help of a consultant.

The ISO 9004:2009 standard

ISO 9004:2009 goes beyond ISO 9001:2008 and provides guidance on how you can continually improve your business' quality management system. It also contains information on managing for sustained success. This can benefit not only your customers but also:

- employees
- owners
- suppliers
- society in general

By measuring these groups' satisfaction with your business, you'll be able to assess whether you're continuing to improve.

The ISO 9000 series, which includes 9001 and 9004, is based around eight quality management principles that your senior managers should use as a framework for improvements to the business:

- **Customer focus** - they must understand and fulfill customer needs.
- **Leadership** - they should demonstrate strong leadership skills to increase employee motivation.
- **Involvement of people** - all levels of staff should be aware of their responsibilities within the business and the importance of providing what the customer requires.
- **Process approach** - identifying your essential business activities and considering each one as part of a process.
- **System approach to management** - managing your processes together as a system, leading to greater efficiency and focus. You could think of each process as a cog in a machine, helping it to run smoothly.
- **Continual improvement** - this should be a permanent business objective.
- **Factual approach to decision-making** - senior staff should base decisions on thorough analysis of data and information.
- **Mutually beneficial supplier relationships** - managers should recognise that your business and its suppliers depend on each other.

Processes to sharpen your project management skills

Small projects don't necessarily require much knowledge of project management or much project management discipline. But as a project gets larger, formal processes and techniques become essential. Different project management methodologies organize and structure these processes in various ways, but we're going to focus on 10 basic areas:

1. Define the project
2. Plan the work
3. Manage the work plan
4. Manage issues
5. Manage scope
6. Manage risks

7. Manage communication
8. Manage documentation
9. Manage quality
10. Manage metrics

1. Define the project

As the project manager, you must make sure that the work is properly understood and agreed to by the project sponsor and key stakeholders before the project work begins. You'll work with the sponsor and stakeholders to ensure that the project team and the client have common perceptions of what the project will deliver, when it will be complete, what it will cost, who will do the work, how the work will be completed, and what the benefits will be.

2. Plan the work

In this stage, you determine how the work will be completed. This involves building the Project Work plan. You'll take different approaches according to the size of the project. For example, the work plan for small projects can be built using a project management package like Microsoft Project, a

3. Manage the work plan

At this point, you've finished defining the project and planning the work. The major deliverables in place are the Project Definition and Project Work plan. You'll never be a successful project manager if you don't keep the work plan up to date. Remember, the work plan is only a deliverable. It describes the work that needs to occur, the order of the work, how much effort is required, and who is assigned, but it represents only your best guess as to how to complete the remaining work at any particular point in the project.

4. Manage issues

An "issue" arises when a problem will hinder the progress of the project and can't be resolved by the project manager and project team without outside help. If a major problem emerges, you have no choice but to resolve it. The only question is whether you'll actively apply issues management to the situation or struggle through uncertainty about how the issue should be resolved.

5. Manage scope

Scope describes the boundaries of the project and defines what the project will deliver, what data is needed, and which organizations are affected. Given a set of resources and time, an infinite number of things can be delivered.

6. Manage risk

Risk refers to future conditions or circumstances that exist outside the control of the project team and that will have an adverse impact on the project if they occur. In other words, whereas an issue is a current problem that must be dealt with, a risk is a potential problem. Reactive project managers resolve issues when they arise. Proactive project managerstry to identify and resolve potential problems before they occur. This is the science and art of risk management.

7. Manage communication

Properly communicating on a project is critical for managing the clients and the shareholders. If they're not kept well informed of the project progress, there is a much greater chance of problems and difficulties due to differing expectation levels.

8. Manage documents

Project managers on smaller projects don't need to give as much thought to managing documentation. As projects get larger, the documentation definitively needs to be actively managed. Problems at their simplest include documentation that gets lost or is hard to find and work that ends up being duplicated. At its worst, document versions get out of order, document updates get over-posted and lost, and confusion and uncertainty reign.

9. Manage quality

Quality is represented by how close the project and deliverables come to meeting the client's requirements and expectations. In other words, quality is ultimately measured by the client.

10. Manage metrics

Gathering metrics on a project is the most sophisticated project management process and can be the hardest. Because metrics can be difficult to define and collect, they're usually ignored or handled poorly. All projects should be gathering basic metric information regarding cost, effort, and cycle time.

Documentation Analysis

With this qualitative approach you read or listen to your respectively written or recorded service records. You'll definitely want to go through the documentation of low-rated service deliveries, but it can also be interesting to read through the documentation of service agents that always rank high.

The hurdle with the method isn't in the analysis, but in the documentation. For live chat and email support it's rather easy, but for phone support it requires an annoying voice at the start of the call: "This call could be recorded for quality measurement."

Reasons why specification is crucial

Let's look at the main reasons why the specification is so important

It provides clear instructions on the intent, performance and construction of the project.

It can reference the quality and standards which should be applied.

Materials and manufacturers' products can be clearly defined.

The requirements for installation, testing and handover can be identified.

Classification in the specification can be used to support handover and running of the asset.

The drawing or model does not need to be overloaded with detailed information, which can sometimes be difficult to identify.

It can be used to support the costing of a project: not only the materials and products but also the performance and workmanship

The specification forms part of the contractual documents, along with the drawings, and therefore can help minimise project risk and provide support should there be any legal disputes.

It supports the interpretation of the client brief and gives the client assurance that the asset which they commissioned is being delivered.

It is not only essential for the construction phase but also used as part of the soft landing process, subsequent asset management and the lifecycle plan.

By being clear and concise and containing all the information, it saves the project team, the client and the contractor time and money by providing answers to many of the on-site construction questions.

There is the option for the design team to build a suite of office masters, which would improve efficiency, provide quality assurance and project consistency.

Office masters can save the team time and money by being developed over a period of time and then being adapted to suit the project specifics, therefore drawing on specialist knowledge when needed.

The specification should be used by all the project team throughout the construction phase; it should be a living document and not stop being used at the design phase.

The specification and any variations or value engineering can also be used for the project audit trail and should form part of the handover documents. It will then form the basis for the running of the asset by the asset management team

Functional and Nonfunctional Requirements: Specification and Types

Clearly defined requirements are essential signs on the road that leads to a successful project. They establish a formal agreement between a client and a provider that they are both working to reach the same goal. High-quality, detailed requirements also help mitigate financial risks and keep the project on a schedule. According to the **Business Analysis Body of Knowledge** definition, requirements are a usable representation of a need.

Creating requirements is a complex task as it includes a set of processes such as elicitation, analysis, specification, validation, and management. In this article, we'll discuss the main types of requirements for software products and provide a number of recommendations for their use.

Classification of requirements

Business requirements. These include high-level statements of goals, objectives, and needs.

Stakeholder requirements. The needs of discrete stakeholder groups are also specified to define what they expect from a particular solution.

Solution requirements. Solution requirements describe the characteristics that a product must have to meet the needs of the stakeholders and the business itself.

Nonfunctional requirements describe the general characteristics of a system. They are also known as *quality attributes*.

Functional requirements describe how a product must behave, what its features and functions.

Transition requirements. An additional group of requirements defines what is needed from an organization to successfully move from its current state to its desired state with the new product.

Functional requirements and their specifications

Functional requirements are product features or functions that developers must implement to enable users to accomplish their tasks. So, it's important to make them clear both for the development team and the stakeholders. Generally, functional requirements describe system behavior under specific conditions. For instance:

Requirements are usually written in text, especially for Agile-driven projects. However, they may also be visuals. Here are the most common formats and documents:

Software requirements specification document

Use cases

User stories

Work Breakdown Structure (WBS) (functional decomposition)

Prototypes

Models and diagrams

Finally, all user stories must fit the **INVEST quality model**:

I – Independent

N – Negotiable

V – Valuable

E – Estimable

S – Small

T – Testable

Independent. This means that you can schedule and implement each user story separately. This is very helpful if you implement continuous integration processes.

Negotiable. This means that all parties agree to prioritize negotiations over specification. This also means that details will be created constantly during development.

Valuable. A story must be valuable to the customer. You should ask yourself from the customer's perspective "why" you need to implement a given feature.

Estimatable. A quality user story can be estimated. This will help a team schedule and prioritize the implementation. The bigger the story is, the harder it is to estimate it.

Small. Good user stories tend to be small enough to plan for short production releases. Small stories allow for more specific estimates.

Testable. If a story can be tested, it's clear enough and good enough. Tested stories mean that requirements are done and ready for use.

Design documents and prototypes

Design requirements are usually collected and documented using three main formats that morph into one another:

Wireframes. Wireframes are low-fidelity graphic structures of a website or an app. They help map different product pages with sections and interactive elements.

Mockups. Once wireframes are ready, they are turned into mockups, visual designs that convey the look and feel of the final product. Eventually, mockups can become the final design of the product.

Design prototypes. These documents contain visuals and allow for some interface interactions, like scrolling, clicking on links, or filling in forms. Design prototypes can be built from scratch using HTML and CSS, but most UX teams use prototyping services like In Vision.

Nonfunctional requirements

Nonfunctional requirements describe how a system must behave and establish constraints of its functionality. This type of requirements is also known as the system's *quality attributes*.

Typical nonfunctional requirements.

Usability

Usability defines how difficult it will be for a user to learn and operate the system. Usability can be assessed from different points of view:

Efficiency of use: the average time it takes to accomplish a user's goals, how many tasks a user can complete without any help, the number of transactions completed without errors, etc.**Intuitiveness:** how simple it is to understand the interface, buttons, headings, etc.

Low perceived workload: how many attempts are needed by users to accomplish a particular task.

Security

Security requirements ensure that the software is protected from unauthorized access to the system and its stored data. It considers different levels of authorization and authentication across different users roles. For instance, *data privacy* is a security characteristic that describes who can create, see, copy, change, or delete information. Security also includes protection against viruses and malware attacks.

Reliability

Reliability defines how likely it is for the software to work without failure for a given period of time. Reliability decreases because of bugs in the code, hardware failures, or problems with other system components. To measure software reliability, you can count the percentage of operations that are completed correctly or track the average period of time the system runs before failing.

Performance

Performance is a quality attribute that describes the responsiveness of the system to various user interactions with it. Poor performance leads to negative user experience. It also jeopardizes system safety when it's is overloaded.

Availability

Availability is gauged by the period of time that the system's functionality and services are available for use with all operations. So, scheduled maintenance periods directly influence this parameter. And it's important to define how the impact of maintenance can be minimized. When writing the availability requirements, the team has to define the most critical components of the system that must be available at all time. You should also prepare user notifications in case the system or one of its parts becomes unavailable.

Scalability

Scalability requirements describe how the system must grow without negative influence on its performance. This means serving more users, processing more data, and doing more transactions. Scalability has both hardware and software implications. For instance, you can increase scalability by adding memory, servers, or disk space. On the other hand, you can compress data, use optimizing algorithms, etc

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Answer the following question as directed below each (3%)

1. Explain at least three Classification of requirements
2. **Business requirements** include_____,_____and____

Answer the following question!

Note: Satisfactory rating 4 and 6 points **Unsatisfactory - below 4and 6points**

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

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet 2 checking completed work against documented workplace

Checking completed work against documented workplace

Documentation in the Workplace

Maintaining a system of organized, accurate and consistent documentation in the workplace is both necessary and beneficial. Making documentation a priority, especially when it comes to the company's HR department, can help mitigate disputes, offer resources when they are needed and answer important questions about the company. In this article, we will discuss why documentation is important and ways you might consider improving your documentation process.

Documentation

Documentation refers to a set of records that exist online, on paper or on hard drives. It is material that provides evidence or information to serve as a record. In the workplace, documentation is retained records of employment and company actions and events as required by legal mandates and company policy.

The best human resource practices involve maintaining both formal and informal records about employment events. This can include items such as:

- Actions
- Contributions
- Disciplinary actions
- Disputes
- Investigations
- Performance evaluations
- Policy violations

Maintaining extensive records allows the human resources department to preserve a written history of events. Documentation can guide managerial staff on employee promotions, disciplinary actions, pay raises and terminations. Documentation should always be factual, supporting insights without relying on the opinions of others.

Importance of documentation

1. It demonstrates professionalism
2. It provides helpful guidance for performance

3. The business can be more profitable.

Formal vs. informal documentation

While certain documentation such as records of employment should be formal, it is appropriate for others to be informal. For example, a manager might keep a casual record of

discussions she's had with employees throughout the year to address during one-on-one check-ins with them about their goals, projects or level of morale.

Informal documentation can even consist of notes or letters saved in an employee's personnel file. If an employee writes down a suggestion and gives it to management, they can file it away for future reference. Email and online interoffice communications can also serve as informal documentation when the need arises.

By contrast, formal documentation adheres to certain standards and conventions as determined by the company and official HR procedures.

How to properly maintain employee documentation

Maintaining employee personnel files is one of HR's most important responsibilities. While your company's requirements might vary, a strong employee personnel file should include, but is not limited to, the employee’s:

- Job application
- Resume and cover letter
- Employment and education verification
- Position job description
- Emergency contact information
- Job offer letter, employment contrast or rejection letter
- Signed employee handbook acknowledgment form
- Relocation documents and agreements
- Employee orientation checklist
- Disciplinary action reports
- Self-assessments
- Recognition
- Suggestions and company responses
- Requests for training
- Co-worker complaints
- Training expense reports

If an employee is terminated or leaves the company for another reason, HR should continue documentation with the employee's:

- Resignation or termination letter
- Exit interview
- Insurance information
- Remaining paycheck information

Documentation examples beyond HR

Documentation isn't just for employee records and management practices. It also can also include items such as tech specifications, requirements, business logic and company manuals. Here are a few industry-specific documentation examples:

1. Software development

Software development is one industry where the importance of documentation is apparent. Whether you're talking about a small team or a large corporation, many people are often involved in software development projects. Therefore, proper technical documentation is important to complete tasks in a quality way.

Project documentation in software development can:

- Define the project
- Describe how the product should look
- Set coding standards
- Outline style guides and design patterns
- Formulate testing standards
- Define the subject of testing
- Document test results
- Provide instructions for product installation, usage and maintenance

Documentation must be comprehensive in an industry like software development because any errors create gaps between those having access to the information. For example, if stakeholders don't fully grasp the product, they may have different expectations for it than

what the engineers are trying to deliver. Not only does documentation clearly outline relevant information, but it also prevents mishaps and misunderstandings.

2. Computer system management

System documentation refers to a solution that serves as a reference for future software and hardware update or maintenance efforts. In other words, it describes the capabilities and requirements of software and informs readers about the software's functionality. System documentation is more technical than other forms of documentation because it includes aspects like:

- Testing documentation
- Source code documentation
- API documentation
- Software architecture documentation
- Solution instructions for advanced users

User documentation within the realm of system documentation refers to information a non-IT user can more readily digest. Types of user documentation include user manuals, training manuals, installation guides and release notes.

3. Research

Performing research and writing up findings requires you to build and support an argument. Documenting your studies and giving credit to those whose ideas you've built upon is crucial. Reasons for documenting your research might include:

- Providing credit or attribution to the original creator or author
- Making the sources you used in your research accessible
- Enabling your readers to follow up on the research
- Enabling others to verify the completeness and accuracy of your research
- Communicating transparency, integrity and trust to avoid plagiarism

Part of being a professional researcher is keeping written, audio and visual documentation about your research. This includes recording their hypotheses, findings, questions and

conclusions. Scientists must also collect data in order to analyze it—a form of documentation. Additionally, scientists may want to replicate an experiment to see if the test results vary based on a certain variable. In order to repeat the experiment precisely as before, they need documentation from the previous experiment or original scientist.

Those who perform scientific research need an accurate set of instructions to test hypotheses, repeat experiments, produce results and publish their findings. Without proper documentation in research, we wouldn't have the advanced technology, medications and agricultural methods we enjoy today.

Consequences of improper documentation

Many industries require thorough documentation performed in a specific way. If organizations fail to maintain organized records, some of the consequences may include:

- Ongoing audits
- Improper billing
- Inefficiencies for employee growth
- Lost revenue
- Compromised safety

Documentation is used in all organizations to record a variety of information. No matter your career path, it's important to understand the role documentation plays in the workforce and how you can benefit from keeping organized records for your own career.

Why are workplace inspections important?

Workplace inspections help prevent incidents, injuries and illnesses. Through a critical examination of the workplace, inspections help to identify and record hazards for corrective action. Health and safety committees can help plan, conduct, report and monitor inspections. Regular workplace inspections are an important part of the overall occupational health and safety program and management system, if present.

Purpose of inspections

Inspections are important as they allow you to:

- listen to the concerns of workers and supervisors
- gain further understanding of jobs and tasks
- identify existing and potential hazards
- determine underlying causes of hazards
- recommend corrective action
- monitor steps taken to eliminate hazards or control the risk (e.g., engineering controls, administrative controls, policies, procedures, personal protective equipment)

How do you plan for inspections?

Planning is essential for an effective inspection.

What to Examine

Every inspection must examine who, what, where, when and how. Pay particular attention to items that are or are most likely to develop into unsafe or unhealthy conditions because of stress, wear, impact, vibration, heat, corrosion, chemical reaction or misuse. Include areas where no work is done regularly, such as parking lots, rest areas, office storage areas and locker rooms.

Workplace Elements

Look at all workplace elements – the people, the environment, the equipment and the process. The environment includes such hazards as noise, vibration, lighting, temperature, and ventilation. Equipment includes materials, tools and apparatus for producing a product or a service. The process involves how the worker interacts with the other elements in a series of tasks or operations.

What types of hazards do we look for in a workplace?

Types of workplace hazards include:

- Safety hazards such as those caused by inadequate machine guards, unsafe workplace conditions, unsafe work practices.
- Biological hazards caused by organisms such as viruses, bacteria, fungi and parasites.
- Chemical hazards caused by a solid, liquid, vapour, gas, dust, fume or mist.
- Ergonomic hazards caused by physiological and psychological demands on the worker, such as repetitive and forceful movements, awkward postures arising from improper work methods, and improperly designed workstations, tools, and equipment.
- Physical hazards caused by noise, vibration, energy, weather, heat, cold, electricity, radiation and pressure.
- Psychosocial hazards that can affect mental health or well-being such as overwork, stress, bullying, or violence.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Answer the following question as directed below each (2%)

Purpose of inspections

1. Mention importance of Inspections:
2. mention Consequences of improper documentation
3. Why documentation is Important

Answer the following question!

Note: Satisfactory rating 4 and 6 points **Unsatisfactory - below 4and 6points**

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

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet 3 Identifying and correcting faulty items or below standard services

Identifying and correcting faulty items or below standard services

Types of defects

Quality control professionals typically classify quality defects into three main categories: minor, major and critical. The nature and severity of a defect determines in which of the three categories it belongs.

Minor defects

Minor defects are usually small, insignificant issues that don't affect the function or form of the item. In most cases, the customer wouldn't even notice a minor defect on a product. And the customer wouldn't likely return an item due to a minor defect alone.

Major defects

Major defects are more serious than minor defects. A product with  a major defect departs significantly from the buyer's product specifications. Major defects are those which could adversely affect the function, performance or appearance of a product.

These defects are readily noticeable by the customer. And these defects would likely cause a customer to return the product, lodge a complaint or request a refund in response.

Critical defects

Critical defects are the most serious of the three defect types. Critical defects render an item completely unusable and/or could cause harm to the user or someone in the vicinity of the product.

These defects put businesses at serious risk of product liability issues, lawsuits and product recalls..

Examples of quality defects in different products

Different quality defects can appear in different products depending on materials, production processes and standards used. Below are some common examples of minor, major and critical defects in different product types.

Softlines

Softline products include raw fabric, home textiles, garments and other woven or knitted products and footwear. Garments, in particular, tend to be more vulnerable to quality defects because of the labor-intensive production processes involved in their manufacturing.

Human hands involved in sewing and stitching, for example, raise variability in production. Whereas more automated production processes, like the use of injection molding in hardlines goods or robotics in electronic assembly, tend to lower variability. This typically results in more consistent product quality throughout a production run.

Some common soft line defects include:

Minor defect: Untrimmed thread – these are a common quality issue in garment manufacturing. Factories can easily rework this defect by simply cutting the excess threads. You might also classify untrimmed threads as a major defect depending on your customers.

Major defect: Missing stitches – these typically appear due to a fault with the sewing machine or an operator error. Missing stitches impact the visual appearance of the product and can even affect seam strength, making this a more serious quality issue.

Critical defect: Needle found in item – needles can pose a hazard to the end user if they end up in the finished goods. This quality issue is almost always classified as a critical defect. And the presence of one such defect typically results in the item failing inspection.

Hardlines

Hardline products include a broad range of goods typically made of metal, wood or plastic materials. This category includes most furniture, sporting equipment, cookware, building materials and tools.

Some common hardline defects include:

Minor defect: Light abrasion on surface – an abrasion on the surface of a hardline item could be related to a production process or simply rough handling. Abrasions and other damage to the surface of an item typically won't hurt the product's salability, making this a minor defect.

Major defect: Deep scratch on item logo – damage to an item's logo is often considered a major defect. Scratches on the logo can be difficult to repair. And they're generally not tolerated in large number, as they can impact product salability and consumer perception of a brand.

Critical defect: Sharp point or burr on item – sharp points can cause harm to the end user and are often cause for failing an inspection. These hazards often lead to product recalls, which is partly why importers commonly classify them as critical defects.

Electrical and electronic products

Electrical and electronic (E&E) products include consumer electronics, many household appliances, certain toys, power tools and other products that require electricity to function.

Some common defects in electronics include:

Minor defect: Removable mark on item – marks on the surface of a product can include dirt or excess glue. These are often considered minor if they can easily be wiped away or are otherwise removable.

Major defect: Non-function or malfunction – malfunction issues with an electronic product might include a failure to turn on, display issues or connectivity issues. Depending on the complexity of the product, rework of software or hardware may be needed to correct the issue.

Critical defect: Damaged wiring – damaged wiring with copper exposed can endanger a product's end user. Such a critical defect presents risk of fire, electric shock, or in severe cases, electrocution

Industrial components

Industrial components is a broad term that can include fabricated steel, conduit piping, gas valves, wind turbines, maritime equipment and other machinery or materials designed for industrial use.

Some common defects in industrial products include:

Minor defect: Surface imperfections – a surface imperfection like a welding protrusion on a steel pipe typically won't affect the use or functionality of an industrial product. But consider both the type of imperfection and the product's intended use before classifying such a defect as minor.

Major defect: Non-critical dimensions out of tolerance – minor deviances in dimensions are undesirable in finished goods but often won't impact the overall function of an industrial product. You might consider dimensional deviations more serious if they affect product function, performance or subsequent production processes.

Critical defect: Rust – corrosion before shipping can be a sign of accelerated degradation and product failure. Rust should be a serious concern for you if you're importing gas or water pipes, for example.

Classifying defects in quality control checklists

A QC professional can often suggest appropriate tolerances for known defects for your product. But it's ultimately up to you as the buyer to specify your tolerance for each kind of quality defect.

Importers often list their defect classifications and tolerances in a document known as a quality control, or QC, checklist A QC checklist also typically includes other information like packaging requirements, on-site testing procedures and required inspection equipment.

This document should include an exhaustive list of common and known quality defects with your product type.

Accounting for every single quality defect may not be possible. But the more complete the list of potential defects you provide, the more likely your supplier will be to heed your tolerances. Your QC inspector is also far more likely to apply the same standard when checking your products against a complete QC checklist.

A defect classification list might look something like the below example for footwear:

Defect description	Defect classification		
	Critical	Major	Minor
Uncut thread end			X
Wrinkle			X
Uneven stitches			X
Right/left foot position reversed inside shoe box			X
Open seam		X	
Loose yarn		X	
Broken yarn		X	
Wrong sizing within same pair		X	
Protruding nail or sharp point	X		
Missing suffocation warning	X		
Mildew or mold on shoe	X		

This **defect classification information can help:**

Improve your supplier's ability to proactively self-identify and correct quality defects before outside inspection

Ensure more accurate inspection results that match your quality tolerances and expectations

Reduce any cases of "pending" results reported by the inspector due to unclear quality tolerances

This defect classification list might extend to include 20 or even 30 different types of defects depending on your product type. The more information you can provide, the better prepared your QC team and supplier will be.

How to address quality defects with your products

Identifying quality defects in your order before shipment is essential to ensuring your goods meet your customers' expectations.

Third-party inspection companies can inspect your order and report to you the number and types of defects found in the inspected sample size. Their report will typically show you the total number of defects found in comparison to the number of defects allowed based on your tolerances.

The order will fail inspection if the number of defects found exceeds the allowed number. As you can see in the below excerpt, this order would fail inspection due to the number of minor defects exceeding the allowed number:

Defect description	Defect classification		
	Critical	Major	Minor
Uncut thread end			11
Wrinkle			3
Uneven stitches			2
Open seam		2	
Loose yarn		1	
Broken yarn		2	
Total defects found	**0**	**5**	**16**
Total defects allowed	**0**	**10**	**14**

While this order would fail inspection based on AQL standards, it's up to you as the importer to decide whether to ship the order

You might want to address any quality defects before approving a shipment. To address product defects found in your order during inspection, you might:

Ask your supplier to correct quality issues through product rework or production of replacement goods

Re-inspect to ensure product defects have been removed or corrected

Chargeback your supplier for any re-inspections and quality issues, if you've previously set this condition as part of your agreement with them

Destroy any unsellable goods to prevent defective goods from reaching customers through the grey market

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below each (2%)**

1. mention quality defects defect categories

Answer the following question!

Note: Satisfactory rating 4 and 6points **Unsatisfactory - below 4 and 6 points**

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

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 4 Documenting and reporting deviations from specified quality standards and its causes

Documenting and reporting deviations from specified quality standards and its causes

Quality performance in workplaces

Quality Performance

Performance measures designed to move associates toward business goals can be a powerful method for action. Because "you get what you measure," it is important to think through how and what you measure so you can achieve the desired results. And measuring profitability is attractive because it goes straight to the heart of every builder's existence.

Performance measures of profitable builders are as varied as their business strategies. A good place to start is examining your own business goals and tune-up your measures at the company level. Then proceed to create department measures that align with company goals. Your organization will be the winner.

The Six-Factor Model of Personality in the Workplace

The following are the five-factor model with job performance and other job-related activities. Motivation, deviation, absences, and job satisfaction are related to the five factors.

This is a review of the relation between the Six-factor model of personality and performance in the workplace.

Motivation in the Workplace

Motivation is the driving force by which humans achieve their goals. Motivation is said to be intrinsic or extrinsic. The term is generally used for humans but it can also be used to describe the causes for animal behavior as well. According to various theories, motivation may be rooted in a basic need to minimize physical pain and maximize pleasure, or it may include specific needs such as eating and resting, or a desired object, goal, state of being, ideal, or it may be attributed to less-apparent reasons such as selfishness, morality, or avoiding mortality.

Job Satisfaction

Job satisfaction has been defined as a pleasurable emotional state resulting from the consideration of one's job; an affective reaction to one's job; and an attitude towards one's job. Weiss (2002) has argued that job satisfaction is an attitude but points out that researchers should clearly distinguish the objects of cognitive evaluation which are affect (emotion), beliefs and behaviors.

Departure in the Workplace

Workplace deviance occurs when an employee voluntarily pursues a course of action that pressures the well-being of the individual or the organization.

Employees who had a positive perception of their workplace were less likely to pursue deviant behavior. Research indicates that personality acts as a moderating factor: workplace deviance was more likely to be endorsed with respect to an individual when both the perception of the workplace was negative and emotional stability.

Performance in the Workplace

Of the five factors, the single factor of carefulness is the most predictive of job performance.

Absences

Job absence is very much a part of job performance: employees are not performing effectively if they do not even come to work. Shy, careful employees are much less likely to be absent from work, as opposed to extraverted employees who are low on carefulness.

Teamwork

Oftentimes in the workplace the ability to be a team player is valued and is critical to job performance. Although this strengthen the case that job performance is related to the five-factor model via increased cooperativeness among coworkers, the role of personality by implying that actual job performance (task performance) is related to cognitive ability and not to personality .

Using 5S to Increase Performance in the Workplace

5S is the name of a workplace organization methodology that uses a list of five Japanese words which are **seiri** (Sorting), **seiton** (Straightening or setting in order / stabilize), **seiso** (Sweeping or shining or cleanliness / systematic cleaning),**seiketsu** (Standardizing) and **shitsuke** (Sustaining the discipline or self-discipline). Translated into English, they all start with the letter "S". The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. The decision-making process usually comes from a dialogue about standardization which builds a clear understanding among employees of how work should be done. It also instills ownership of the process in each employee.

The QCDSM program ensures this will happen on a daily basis. In addition to QCDSM, members of senior management must carry out periodic inspections of each target area. One common error by senior management is never being visible on the factory floor.

5S provides the foundation for improving performance through continuous improvement. It focuses on:

- Increasing quality by removing waste from the workplace.
- Provide reduction in operating costs by reducing non value added activities.
- Improving delivery by by simplifying processes and removing obstacles
- Improving safety through improved housekeeping and identification of hazards

Provide an environment where continuous improvement is embraced through workers problem solving and suggestions, thereby improving morale.

Simply put, 5S works best if the implementation of the program is based on the 5S Performance Improvement Formula:

P=Q+C+D+S+M

Where;

- **P** - Increase productivity.
- **Q** - Improve product quality.
- **C** - Reduce manufacturing costs.
- **D** - Ensure on-time delivery.
- **S** - Provide a safety working environment
- **M** - Increase worker morale.

Quality Performance in Production Management

The challenge is increasing production while maintaining high quality. This process can be difficult to measure, but best way to gauge quality is to first measure it. Use key performance indicators (KPIs) to improve quality. KPIs help management to manage and measure both production and quality. Financial analysts and mangers also use KPIs as a measure of productivity.

Instructions

1. Identify the three most important processes in production. Examples include inventory purchases, assembly, distribution and accounts payable.
2. Map out each process on a flow chart diagram. Start with first step in each process and end with the last step. This helps all parties involved in the process to visualize the process as well as where possible errors in production may occur.

3. Identify the best way to manage production for each process. For instance, assembly can be managed with the number of items produced and distribution can be managed by the total number of items delivered.
4. Define what an error or issue is within the process. For instance, for assembly, measure the number of errors or mistakes by determining how many of the total device being produced did not work or were permanent. For distribution, you could determine the number of errors by monitoring on-time delivery. The error depends on the process and your firm's definition of quality.
5. Assign a quality metric to each production process. Combine Step 3 and 4. For instance, for assembly, one metric can be the number of products assembled incorrectly or the number of malfunctions. For distribution, the metric can be the number of on-time deliveries. Again, the metric depends on what's most important for your organization.

Records all production processes and outcomes

Production process

The production process is concerned with transforming a range of inputs into those outputs that are required by the market.

The transforming resources include the buildings, machinery, computers, and people that carry out the transforming processes. The transformed resources are the raw materials and components that are transformed into end products.

Any production process involves a series of links in a production chain. At each stage value is added in the course of production. Adding value involves making a product more desirable to a consumer so that they will pay more for it. Adding value therefore is not just about manufacturing, but includes the marketing process including advertising, promotion and distribution that make the final product more desirable.

It is very important for businesses to identify the processes that add value, so that they can

enhance these processes to the ongoing benefit of the business.

Types of process

There are three main types of process: **job, batch and flow production**.

Job production

Job or \'make complete\' production is the creation of single items by either one operative or a team of operative\'s. Job production is unique in the fact that the project is considered to be a single operation, which requires the complete attention of the operative before he or she passes on to the next job. Examples from the service industries include cutting hair, and processing a customers\' order in a store.

Batch production

The term batch refers to a specific group of components, which go through a production process together. As one batch finishes, the next one starts. For example on Monday, Machine A produces a type 1 engine part, on Tuesday it produces a type 2 engine part, on Wednesday a type 3 and so on. All engine parts will then go forward to the final assembly of different categories of engine parts.

Flow production

Batch production is described as \'intermittent\' production and is characterized by irregularity. If the rest period in batch production disappeared it would then become flow production. Flow production is therefore a continuous process of parts and sub-assemblies passing on from one stage to another until completion.

Different type of requirements of document

1. Business Requirements Document (BRD)

Also known as a Business Needs Specification, a BRD is the first stage in a product life cycle. It details the problems that a product/service/system is trying to solve by logically listing high-level business requirements in relation to customers' needs.

As well as non-negotiable, it also details features the project *should* provide, which can be interpreted as goals for the development team.

It often includes:

- An outline of the requirements of the project
- Objectives of the project
- A needs statement detailing *why* the project is needed and *how* it will meet those needs
- Financial statements, demonstrating how the project will be funded and its effect on the company's balance sheet
- Functional requirements and features
- A SWOT analysis of the business and how the project fits into it
- Personnel needs. Who do we want to work on the project?
- Schedule, timeline and deadlines
- A cost-benefit analysis.

A BRD is normally prepared by the project manager or business analyst.

2. Functional Requirements Document (FRD)

An FRD defines in logical terms, how a system or project will accomplish the requirements laid out in the BRD. It outlines the functionality of the system in detail by capturing the intended behaviour of the system, expressed as services, tasks or functions that the developers have agreed to provide.

Rather than define the 'inner-workings' and specifications, an FRD focuses on what users might observe when interacting with the system.

An example functional requirement might be: "*When the user clicks the OK button, the dialog is closed and the user is returned to the main window in the state it was in before the dialog was displayed."*

An FRD sometimes includes screen mockups or wireframes to illustrate the system's design.

Depending on the complexity, FRDs can vary in length from 10 pages to several hundred.

An FRD is normally written by the business analyst or systems analyst.

3. Market Requirements Document (MRD)

Sometimes referred to as a Marketing Requirements Document, an MRD focuses on the target market's needs. It typically explains: What the product is, who the target customers are, what products are in competition with it and why customers are likely to want this product.

An MRD typically includes:

- A definition of the target market, an imagining of the potential buyer or user
- A comprehensive list of market requirements the solution will need to satisfy
- Indicators of success for each requirement
- A prioritized list of requirements from your market's point of view
- A timeframe for the product's launch

An MRD is normally prepared by the marketing manager or product manager.

4. Product Requirements Document (PRD)

A PRD is used to communicate everything that must be included in a product release for it to be considered complete. It is written from a user's point-of-view to understand what a product *should* do.

It usually includes the same content as an FRD, but with 'non-functional requirements' added. Although non-functional requirements are not related to the functionality of the product, it's often important to identify them - they may include such needs as reliability, security and scalability.

A typical PRD might contain:

- Objectives for the product
- Features
- User experience (UX) flow & design notes
- System and environment requirements
- Assumptions, constraints & dependencies - What's expected as well as any limitations or obstacles that may impede the project's progress

A PRD is normally prepared by the product manager.

5. User Interface Requirements Document (UIRD)

A UIRD describes the look and feel of the User Interface (UI) of the system.

It often defines:

- How the content is presented to the user
- User navigation
- Colour codes to be used
- Hints, tips and suggestions to be displayed

- ‘Save data’ options
- Shortcut keys

A UIRD more often than not includes mockup screenshots and wireframes to give readers an idea of what the finished system will look like..

6. Technical Requirements Document (TRD)

A TRD contains the software, hardware and platform requirements of the product. It includes requirements like the programming language the system should be developed in and the processor speed required to run the system.

It might also consider the limitations of the system and its performance.

A good TRD will include the following key items:

- An executive summary of the project and its background.
- Assumptions, risks, and factors that may affect the project
- Functional and non-functional requirements
- References or a list of supporting documents

7. Quality Requirements Document

The quality requirements document outlines the expectations of the customer for the quality of the final product. It consists of various criteria, factors and metrics that must be satisfied.

Quality requirements might revolve around reliability, consistency, availability, usability, maintainability and customer experience.

8. Software Requirements Document or Software Requirements Specification (SRS)

An SRS outlines the features and the intended behaviour of a system. It describes the business’s understanding of the end user’s needs while laying out functional and nonfunctional requirements.

An SRS is related to the FRD and PRD but written with a specific IT project in mind.

Its contents may include:

- A product overview
- A summary of the current system
- The proposed methods and procedures
- Design considerations

- Security considerations

An SRS is normally compiled by the lead engineer of the project.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below each (2%)**

1. mention Different type of requirements of document

2. A good TRD will include _____,____,_____and ,_____-

3. An MRD typically includes_____,_____,_____,_____-and_____

Answer the following question!

Note: Satisfactory rating 9 and 16 points Unsatisfactory - below 9and 16points

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

Answer Sheet

Name: _____ Date: _____

Score = _____
Rating: _____

L #10	**LO #3-** Engage in quality improvement
Instruction sheet	

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

Participating process improvement procedure

Carrying out work process improvement procedure

Monitoring performance of operation or quality of product or service

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

Participate process improvement procedure

Carry out work process improvement procedure

Monitor performance of operation or quality of product or service

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information Sheet 1. Participating process improvement procedure

Participating process improvement procedure

Quality Improvement

Quality improvement (QI) is a systematic, formal approach to the analysis of practice performance and efforts to improve performance.

A variety of approaches or QI models exist to help you collect and analyze data and test change. While it's important to choose a reputable QI model to guide your efforts, it's more important that you fully commit to using the QI process and good QI practices.

Benefits of QI

Understanding and properly implementing QI is essential to a well-functioning practice, and is necessary for any practice interested in improving efficiency, patient safety, or clinical outcomes.

MIPS: Explaining the Quality Performance Category

The Merit-based Incentive Payment System includes a category on quality performance. Read more to learn about how to report and how the category is scored. Learn More »

In addition, good QI practices and improved patient outcomes position your practice for success by:

Helping you prepare for the transition to value-based payment models.

Allowing you to participate in the public reporting of physician-quality data.

Giving you the opportunity to participate in the federal Quality Payment Program (QPP) following one of two tracks: the Merit-based Incentive Payment System (MIPS) or the Alternative Payment Model (APM).

Equipping you with the skills necessary to apply for and complete national recognition programs, such as National Committee for Quality Assurance's (NCQA) Diabetes, Heart/Stroke, and patient-centered medical home (PCMH)-recognition programs.

Quality Improvement Basics

The QI process is grounded in the following basic concepts:

Establish a culture of quality in your practice

Your practice's organization, processes, and procedures should support and be integrated with your QI efforts. The culture of a practice—attitudes, behaviors, and actions—reflect how passionately the practice team embraces quality. The QI culture looks different for every practice, but may include establishing dedicated QI teams, holding regular QI meetings, or creating policies around your QI goals.

AAFP Office Champions Projects

The AAFP's Office Champions Project are an example of QI demonstration projects in which participating family physician practices select staff and physician office champions to lead the implementation of an intervention.

Determine and prioritize potential areas for improvement

You will need to identify and understand the ways in which your practice could improve. Examine your patient population (e.g., to identify barriers to care, frequently diagnosed chronic conditions, or groups of high-risk patients) and your practice operations (e.g., to identify management issues such as low morale, long patient wait times, or poor communication). Use established quality measures, such as those from the National Quality Forum, Agency for Healthcare Research and Quality, and the Quality Payment Program(qpp.cms.gov) to guide your efforts.

Collect and analyze data

Data collection and analysis lie at the heart of quality improvement. Your data will help you understand how well your systems work, identify potential areas for improvement, set measurable goals, and monitor the effectiveness of change. It's important to collect baseline data before you begin a QI project, commit to regular data collection, carefully analyze your results throughout the project, and make decisions based on your analysis.

Communicate your results

Quality improvement efforts should be transparent to your staff, physicians, and patients. Include the entire practice team and patients when planning and implementating QI projects, and communicate your project needs, priorities, actions, and results to everyone (patients included). When a project is successful, celebrate and acknowledge that success.

Commit to ongoing evaluation

Quality improvement is an ongoing process. A high-functioning practice will strive to continually improve performance, revisit the effectiveness of interventions, and regularly solicit patient and staff feedback.

Spread your successes

Share lessons learned with others to support wide-scale, rapid improvement that benefits all patients and the health care industry as a whole.

Quality Improvement Models and Tools

Quality improvement models present a systematic, formal framework for establishing QI processes in your practice. Examples of common QI models include the following:

Model for Improvement : The Institute for Healthcare Improvement's Model for Improvement combines two popular QI models: Total Quality Management (TQM) and Rapid-Cycle Improvement (RCI). The result is a framework that uses PDSA cycles to test interventions on a small scale.

Six Sigma(asq.org): Six Sigma is a method of improvement that strives to decrease variation and defects.

Quality improvement tools are standalone strategies or processes that can help you better understand, analyze, or communicate your QI efforts.

Service quality (SQ), in its contemporary conceptualization, is a comparison of perceived expectations (E) of a service with perceived performance (P), giving rise to the equation SQ=P-E. This conceptualization of service quality has its origins in the expectancy-disconfirmation paradigm.[2]

A business with high service quality will meet or exceed customer expectations whilst remaining economically competitive.[3] Evidence from empirical studies suggests that improved service quality increases profitability and long term economic competitiveness. Improvements to service quality may be achieved by improving operational processes; identifying problems quickly and systematically; establishing valid and reliable service performance measures and measuring customer satisfaction and other performance outcomes.

Individual service quality states the service quality of employees as distinct from the quality that the customers perceived

Technical quality: *What* the customer receives as a result of interactions with the service firm (e.g. a meal in a restaurant, a bed in a hotel)

Functional quality: *How* the customer receives the service; the expressive nature of the service delivery (e.g. courtesy, attentiveness, promptness)

The technical quality is relatively objective and therefore easy to measure. However, difficulties arise when trying to evaluate functional quality.

The five dimensions of service quality

A customer's expectation of a particular service is determined by factors such as recommendations, personal needs and past experiences. The expected service and the perceived service sometimes may not be equal, thus leaving a gap. The service quality model or the 'GAP model' developed in 1985, highlights the main requirements for delivering high service quality. It identifies five 'gaps' that cause unsuccessful delivery. Customers generally have a tendency to compare the service they 'experience' with the service they 'expect'. If the experience does not match the expectation, there arises a gap.[11] Given the emphasis on expectations, this approach to measuring service quality is known as the *expectancy-disconfirmation paradigm* and is the dominant model in the consumer behaviour and marketing literature.

amodel of service quality, based on the expectancy-disconformation paradigm, and developed by A. Parasuraman, Valarie A. Zeithaml and Len Berry, identifies the principal

dimensions (or components) of service quality and proposes a scale for measuring service quality, known as SERVQUAL. The model's developers originally identified ten dimensions of service quality that influence customer's perceptions of service quality.[13] However, after extensive testing and retesting, some of the dimensions were found to be autocorrelated and the total number of dimensions was reduced to five, namely - reliability, assurance, tangibles, empathy and responsiveness. These five dimensions are thought to represent the dimensions of service quality across a range of industries and settings. [14] Among students of marketing, the mnemonic, **RATER**, an acronym formed from the first letter of each of the five dimensions, is often used as an aid to recall.

In spite of the dominance of the expectancy-disconfirmation paradigm, scholars have questioned its validity. In particular scholars have pointed out the expectancy-disconfirmation approach had its roots in consumer research and was fundamentally concerned with measuring customer satisfaction rather than service quality. In other words, questions surround the *face validity* of the model and whether service quality can be conceptualised as a *gap*.

Measuring service quality may involve both subjective and objective processes. In both cases, it is often some aspect of customer satisfaction which is being assessed. However, customer satisfaction is an indirect measure of service quality. Research has also indicated that the presence of service quality leads to several outcomes including changes in perceived value, customer satisfaction and loyalty intentions with consumers

Measuring subjective elements of service quality

Subjective processes can be assessed in characteristics (assessed be the SERVQUAL method); in incidents (assessed in Critical Incident Theory) and in problems (assessed by *Frequent Relevant Analyze* a German term. The most important and most used method with which to measure subjective elements of service quality is the Servqual method.

Measuring objective elements of service quality

Objective processes may be subdivided into primary processes and secondary processes. During primary processes, silent customers create test episodes of service or the service episodes of normal customers are observed. In secondary processes, quantifiable factors

such as numbers of customer complaints or numbers of returned goods are analysed in order to make inferences about service quality.

Approaches to the improvement of service quality

In general, an improvement in service design and delivery helps achieve higher levels of service quality. For example, in service design, changes can be brought about in the design of service products and facilities. On the other hand, in service delivery, changes can be brought about in the service delivery processes, the environment in which the service delivery takes place and improvements in the interaction processes between customers and service providers.

Various techniques can be used to make changes such as: Quality function deployment (QFD); failsafing; moving the line of visibility and the line of accessibility; and blueprinting.

Approaches to improve the conformity of service quality

In order to ensure and increase the 'conformance quality' of services, that is, service delivery happening as designed, various methods are available. Some of these include Guaranteeing; Mystery Shopping; Recovering; Setting standards and measuring; Statistical process control and Customer involvement.

Service quality and customer satisfaction

The relationship between service quality and customer satisfaction has received considerable attention in academic literature. The results of most research studies have indicated that the service quality and customer satisfaction are indeed independent but are closely related that and a rise in one is likely to result in an increase in another construct.

Quality Control (QC)

Quality is a relative concept. It is related to certain predetermined characteristics such as shape, dimensions, composition, finish, colour, weight, etc. In simple words, quality is the performance of the product as per the commitment made by the producer to the consumer. J.

M. Juran (1970) who is considered the father of quality research has defined quality as “the performance of the product as per the commitment made by the producer to the consumer.”

There are two main elements in this definition of quality. First, the commitment may be explicit such as a written contract or it may be implied in terms of the expectations of the average consumer of the product. Second, the performance of the product relates to the ultimate functions and services which the final product must give to the final consumer.

Quality Vocabulary, quality is the “The totality of features and characteristics of a product or service that on its ability to satisfy stated or implied needs.”

In practice, when we say any product as a quality product, it means the product satisfies certain criteria for its functioning. For a quality product, it is necessary that it should satisfy the laid down criteria not only at the time of its manufacture, but also over a reasonable length of time. In India, Bureau of Indian Standards (BIS) lays down certain criteria for a number of products both – industrial and domestic.

Quality control is also a strategic decision. It can be defined as the systematic control of those variables which are encountered in the manufacturing process and which adversely affect the excellence of the final product in one way or other.

Alfort and Beaty defined quality control

“Quality control is the mechanism by which products are made to measure up to the specifications determined from the customer’s demands and transform into sales, engineering and manufacturing requirements. It is concerned with making things right rather than discovering and rejecting those made wrong. Quality control is a technique by means of which products of uniform acceptable quality are manufactured.”

Some of the important advantages to quality control are as follows:

1. The brand products build up goodwill or image which ultimately increases sales.

2. It helps the manufacturers/ entrepreneurs in fixing responsibility of workers in the production process.

3. Quality control also helps in minimizing the costs by increasing efficiency, standardization, working conditions, etc.

4. It also enables the entrepreneur to know the cost of his / her product quite in advance which helps him in determining competitive prices of his product.

5. Last but not the least; the entrepreneur can confirm whether the product manufactured by him / her is in accordance with the standard set by the Government. It further facilitates the entrepreneur to take necessary actions to comply with the standard set.

Methods or Tools of Quality Control:

Any variations in the quality of a product, i.e., standards set are mainly caused by variations in raw material, men, machines, methods, and procedures of procedures of production and inspection. In order to produce the quality products, these variations need to be checked and controlled. There are mainly two methods of quality control.

1. Inspection:

Inspection, in fact, is the common method used for quality control purposes not only in production but also in services.

As regards inspection in production, there are three important aspects involved in it:

(i) Product Inspection:

As the name itself suggests, the product inspection relates to the final product sent into the market. The main purpose of product inspection is to ensure that the products sent into the market comply with the set standard for quality. In other words, it is to ensure that the product ready for sale is perfect and free of defects.

(ii) Process Inspection:

Process inspection proceeds to product inspection. It is aimed at ensuring that the raw material and machines and equipment's used in the production process are of prescribed quality and mark.

Process inspection benefits the unit in two ways:

Advertisements:

(1) It ensures the manufacturing of a quality product.

(2) It saves wastages of material by preventing process bottlenecks.

(iii) Inspection Analysis

This is a method based on the analyses of inspections made. The conclusions derived from the inspection analyses help the entrepreneur locate the exact points in manufacturing process where faults lie. In other words, it enables the entrepreneur to identify the points at which deviations from standard set start..

2. Statistical Quality Control

It is an advanced method or technique used to control the quality of a product. This method is based on statistical techniques to determine and control the quality. Sampling, probability, and other statistical inferences are used in this method for controlling the quality of a product. It is widely used in process control in continuous process industries and in industries producing goods on a mass scale.

Under this method, the entire lot is, firstly, sampled on the basis of its specific characteristics and, then, is divided into three parts as mentioned below

(i) Analysis of Samples

(ii) Use of Control Charts

(iii) Corrective Measures.

(i) Analysis of Samples

This is based on sampling techniques. First of all, the universe i.e., the population to be analyzed, is identified. After this, following the sampling technique, the sample representing the whole population is selected and analyzed.

It is important that we do not need to analyze all the units of the population, but only a few units called 'sample units' are studied and analyzed. The result drawn from these sample units are then generalized as a whole. In other words, inspection of samples means statistical inspection of the whole manufactured lot.

(ii) Use of Control Chart

Realizing that figures/ charts are always welcome to depict the fact of findings, the results obtained from analysis of samples are presented in a chart.

The method to draw a chart is as follows

(i) Measure the quality characteristics of sample selected.

(ii) Find out the mean of the sample and also measure its range of dispersion.

(iii) Then, data regarding mean and dispersion are gathered.

(iv) Take a graph paper and plot the gathered data on it.

Thus, you have a control chart ready to guide you about the quality deviation of your product.

(iii) Corrective Measures

Having drawn quality control chart, the entrepreneur can easily and clearly locate the points of deviations and causes of it. This enables him to evolve corrective measures to control the quality of the product accordingly. For example, if variation in quality is caused by inferior quality raw material, the quality of raw material will be increased. Similarly, in case of traditional machinery, new and modem machinery will be installed.

Quality Control in Small-Scale Industries

Although quality control is necessary for all units, yet it is more necessary for small-scale units. This is because of the great use of manpower in small-scale industries during the manufacturing processes. But, the application of quality control is difficult in them because of several limitations like financial, technical and managerial. Quality implementation is total organizational effort..

The quality control in small-scale industries is generally based on

(a) Indian Standards specification.

(b) Quality marketing schemes.

(c) Company Standards in case of ancillary units.

(d) Any other standard specification prescribed by the Government or other purchasing agencies.

The Indian Standards Specifications have been playing an important role in persuading small-scale industries to adhere to the quality of their products.

For controlling quality of products manufactured by small units, the following Indian Standards have been published so far

(a) Methods of statistical quality control during the production period.

(b) Manual on basic principles of lot sampling; and

(c) Sampling inspection table.

Several State Governments have been operating quality marketing schemes and standards for various products of small-scale industries. When the small units manufacture their products according to the standards set, the Quality Marketing Centers of the Government stamp the “Q” mark on their products. This is an assurance for the customers that the product has been manufactured adhering to certain quality standards.

Quality Control of Export Production

Implementation of quality control has been very useful in raising exports from an economy. A product can be sold in foreign markets only when it is not only cheaper but up to a certain quality also. Standardization of these products convinces the foreign customers better than any sales campaign.

Cost of Quality Control

Lastly, let us also address to an important aspect of quality control, i.e., cost involved in ensuring quality products. In fact, it is difficult, if not impossible, to precisely define cost incurred in quality assurance due to so many imponderables involved. But there is no denying of the fact that it should be a minor proportion of the total product cost incurred. How much minimum should be the proportion of quality cost to total cost depends upon various factors?

Some of the important ones are

(a) Type of product, its functional use and hazards involved in its use.

(b) The degree of quality awareness prevailing in the enterprise by implementation of the concepts like Total Quality Management (TQM) and Quality Control (QC).

(c) Lastly, additional costs to be incurred for ensuring higher quality standards. It must be kept in mind that there is no optimum value between quality and product cost.

One last word before we leave our discussion on quality control. Quality control in the Indian small-scale industry has been satisfactory. Eugene Staley's observation in this regard aptly supports our statement. He observes: "A surviving unit in India is a strategic planner and makes its grade anywhere in the world, because his survival here against all odds is by itself the best testimony."

Practical Methods for Measuring Service Quality

We like to measure stuff. How long we can hold our breath, our weight before and after a workout, the IQ of our kids... Through measurement we can compare, aim, and improve. But some things are less straightforward to measure. Like service quality.

But measuring service quality is absolutely crucial. Although it's not the same as customer satisfaction which has its own methods there's a strong and positive correlation between the two .

SERVQUAL

This is the most common method for measuring the subjective elements of service quality. Through a survey, you ask your customers to rate the delivered service compared to their expectations.

Its questions cover what SERVQUAL claims are the 5 elements of service quality : RATER.

Reliability - the ability to deliver the promised service in a consistent and accurate manner.

Assurance - the knowledge level and politeness of the employees and to what extend they create trust and confidence.

Tangibles - the appearance; of e.g. the building, website, equipment and employees.

Empathy - to what extend the employees care and give individual attention.

Responsiveness - how willing the employees are to offer a speedy service.

Characteristics of services

It is therefore important to establish the extent to which these characteristics reflect the perspective of the consumer.

Intangibility

Inseparability

Heterogeneity

Perishability

Service Quality Dimensions

The SERVQUAL Instrument

The SERVQUAL instrument developed by Parasuraman et al (1991) has proved popular, being used in many studies of service quality. This is because it has a generic application and is a practical approach to any area. A number of researchers have applied the

SERVQUAL model to measure service quality in the hospitality industry with modified constructs to suit specific hospitality situations..

The servqual instrument consists of 22 statements for assessing consumer perceptions and expectations regarding the quality of a service. Respondent are asked to rate their level of agreement or disagreement with the given statements. Consumer's perceptions are based on the actual service they receive while consumer's expectations are based on past experiences and information received. The statements represent the determinants or dimensions of service quality.

The five dimensions of service quality measured by the SERVQUAL Instrument

The SERVQUAL Instrument measures the five dimensions of Service Quality. These five dimensions are: tangibility, reliability, responsiveness, assurance and empathy.

Customer has needs and expectations

Customers buy goods and services to meet specific needs. Needs are often deeply rooted in people's unconscious minds and may concern long-term existence and identify issues. When people feel a need, they are motivated to take action to fulfil it. In many instances, purchase of a good or service may be seen as offering the best solution to meeting a particular need. Subsequently, consumers may compare what they received against what they expected, especially if it cost them money, time, effort that could have been devoted to obtaining an alternative solution.

Customer expectations embrace several elements, including desired service, adequate service, predicted service and a zone of tolerance that falls between the desired and adequate service levels

Desired and Adequate Service Levels

The type of service customers hope to receive is termed as desired service. It is a wished-for level: a combination of what customers believe can and should be delivered in the context of their personal needs. However, most customers are realistic and understand that companies can't always deliver the desired level of service; which is defined as the minimum level of

service customers will accept without being dissatisfied. Among the factors that set this expectation are situational factors affecting service performance and the level of service that might be anticipated from alternative suppliers? The levels of both desired and adequate service expectations may reflect explicit and implicit promises by the provider, word-of-mouth comments, and the customer's past experience,

Predicted Service Level

The level of service that customers anticipate receiving is known as predicted service, which directly affects how they define "adequate service" on that occasion. If good service is predicted the adequate level will be higher than if poorer service is predicted. Customer predictions of service may be situation specific.

Zone of Tolerance

The inherent nature of services makes consistent service delivery difficult across employees in the same company and even by the same service employee from one day to another. The extent to which customers are willing to accept this variation is called the zone of tolerance. A performance that falls below the adequate service level will cause frustration and dissatisfaction, where as one that exceeds the desired service level will both please and surprise customers. Another way of looking at the zone of tolerance is to think of it as the range of service within which customers don't pay explicit attention to service performance. When service falls outside the range, customers will react either positively or negatively. The zone of tolerance can increase or decrease for individual customers depending on such factors as competition, price or importance of specific service attributes. These factors most often affect adequate service levels which may move up or down in response to situational factors where as desired service levels tend to move up very slowly in response to accumulated customer experiences.

It is known that expectations are not stable in the sense that they may change over time due to changes in aspiration levels or need at a particular moment in time. Customers' expectations about what constitutes good service vary from one business to another. Expectations are not determined by individuals themselves but also by reference groups,

external situations, norms, values, time and service provider. Generally speaking, expectations can be formulated in terms of “what should be done” and in terms of what should be done” Expectations change over time influenced by both supplier-controlled factors such as advertising, pricing, new technologies and service innovation as well as social trends advocacy by consumer organization and increased access to information through the media and the internet.

two levels of expectations and concluded: “Our finding indicates that customer’s service expectations exist at two different levels; a desired level and an adequate level. The service level reflects the service the customer hopes to receive. It is blend of what the customer finds acceptable. It is part, a function of the customer’s assessment of what service will be i.e. the customers predicted service level. The difference between the desired service; level and the adequate service level can be called zone of tolerance, the extent to which customers recognize and are willing to accept heterogeneity.

Customer satisfaction

the customer is the judge of quality. Understanding customer needs, both current and future and keeping pace with changing market require effective strategies for listening to and learning from customers, measuring their satisfaction relative to competitors and building relationships. Satisfaction and dissatisfactions information are important because understanding them leads to the right improvements that can create satisfied customers who reward the company with loyalty.

Satisfaction can be expressed in many ways, like positive word-of-mouth, giving compliments to the service provider and brand loyalty to the service organization. Quite often it is assumed that satisfied consumers will be brand loyal. That needs not be the case, especially even now entrants have come to the satisfied customers will show a higher repurchase rate than dissatisfactions of customers is an important one. Customer satisfaction leads to repeat purchases and repeat purchases lead to loyal customers. In turn, customer’s loyalty leads to enhanced brand equity and higher profits.

On the other hand the only measure of acceptable quality is customers satisfaction, which takes into account both objective and subjective interpretations of the needs and expectations of customers. If the customers are satisfied with the products and services offered, the organization has not only correctly interpreted customer needs and expectations but it is also providing products and services of acceptable quality.

Customer Loyalty

Loyalty is an old-fashioned word that has traditionally been used to describe fidelity and enthusiastic devotion to something. More recently, it has been used in a business context to describe a customer's willingness to continue patronizing a firm over the long-term purchasing and using its goods and services on a repeated and exclusive basis and recommending the firm's products to friends and relatives. However, brand loyalty extends beyond behaviour to include preference liking and future intentions. What a loyal customer can mean to a firm: a consistent source of revenue over a period of many years. However, this loyalty cannot be taken for granted. It will continue as long as the consumers feels that he or she is receiving better value including superior or quality relative to price.

Service encounter

For service science to be a complete discipline it must address how customers experience services with the same depth of analysis as it studies the analytics of information and physical flow processes that deliver the service. The heart of a service is the encounter between the server and the customer. It is here where emotions meet economics in real time and where most people judge the quality of the service. As currently conceived, service science treats satisfaction with an encounter predominantly as a function of engineering measures of throughout and output quality. Thus, if a service is performed efficiently and process output variability is low, it is assumed that the service process has been optimised. Our view is that this misses critical psychological variables that lie at the subconscious level, and which if understood by management could be managed in such a way to enhance customer satisfaction.

The most immediate evidence of service quality occurs during the service encounter or "moment of truth" (Gronroos, 1990) where the customer and service provider interacted with one another. Memorable incidents that occur during this encounter whether can determine whether a customer leaves satisfied or dissatisfied and ultimately whether he or she returns. Besides, the service encounter involves at least two people, it is important to understand the encounter from multiple perspectives in or to uncover some of the underlying reasons for poor service quality.

Understanding customer behaviour lies at the heart of marketing. High contact service encounters between customers and service organizations differ sharply from low-contact ones. Some services, such as restaurants, hospitals and airlines require customers to have active contact with the organization including visits to its facilities and face-to-face interactions with employees. By contrast, customers of service industries such as insurance and cable TV companies

Customers expressing dissatisfaction

When customers are dissatisfied, they can undertake different kind of action as well. One can express dissatisfaction in many ways, for example by complaining to the service provider or to a customer union. Another action can be to never visit the service provider again, Two models exist in explaining the ways to express dissatisfaction, the economic model and behavioural model. The economic model, basically the perceived cost, the perceived benefits and the probability of success determine whether consumers will express their dissatisfaction. In the behavioural model, this is determined basically by ability and motivation to do so.

Model of service quality gaps

There are five major gaps in the service quality concept, The model is from Parasuraman et al (1985). For this survey, we are only studying the gap between the customer expectation and customer perception of service quality at the FFR. The starting premise for the model is that "perceived service quality (or satisfaction with service) is a function of the difference between expected service levels and delivered (perceived) service.

The challenge to the organization is to isolate which variables are influencing service quality perception negatively and how to eliminate them. Of key importance to the organization is Gap 1. Gap 5 relates to the overall perception the client-base has of the unit's ability (for this survey, the FFR'S unit ability) to deliver on service commitments made

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed each contain (3%)

1. _____ is a systematic, formal approach to the analysis of practice performance and efforts to improve performance
2. Customer expectations embrace several elements, including_____,____,and _____
3. _____ is the performance of the product as per the commitment made by the producer to the consumer.
4. Mention two main elements of quality
5. _____ is the "The totality of features and characteristics of a product or service that on its ability to satisfy stated or implied needs."
6. _____ is the mechanism by which products are made to measure up to the specifications determined from the customer's demands and transform into sales,
7. _____ is a technique by means of which products of uniform acceptable quality are manufactured."

Note: Satisfactory rating 12 and 21 points Unsatisfactory below 12and 21points

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

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 2. Carrying out work process improvement procedure

Carrying out work process improvement procedure

Strategies on how to promote quality

Knowing how to promote quality is essential for any organization. Every quality professional understands how important engagement is for embedding a culture of quality.

So how can you get your stakeholders to engage with quality? There's no 'one size fits all' solution and it isn't easy even veteran quality professionals struggle to drive this kind of engagement, and every organization will be different. You need to be bold, creative and flexible – and ideas may not come that easily when you're preparing for an upcoming audit.

Here are 10 proven strategies to inspire you and your team on how to promote quality in your organization.

8. Ask for opinions

When employees don't feel as if they can speak up, they may be withholding valuable ideas and solutions that could help propel your organization forward. Asking your staff for opinions will give you valuable insight and help you to create an 'open-door policy'.

You could ask for opinions by:

Inviting groups of employees to a monthly roundtable

Building feedback into processes using systems

Sending your employees a survey

Whether you've acted on your employees' ideas or not, the key is to always give them feedback!

9. Make time for mentoring

Taking the time to sit with struggling employees and discuss their challenges will not only make those people feel more valued, it'll also help them to understand and engage more with quality.

You could improve quality mentoring by:

Following a structured approach

Setting goals

Using systems such as Ideagen's training records management software to track competency requirements

Assessing performance on an ongoing basis

10. Reward good performance

Good performance can be rewarded either financially or with recognition, yet few quality professionals are in a position to offer the former (even though quality and compliance performance metrics should be considered for all financial rewards, in every organization). What this means is that you'll probably need to find more creative ways to reward good performance.

You can recognize good performance:

Internally: by sending emails or newsletters to the organization, by sharing a sponge or by promoting through your organization's intranet.

Externally: on social media, by hosting a quality awards ceremony with all of your employees, suppliers and customers, or by sharing the news on your blog.

11. Improve accountability

Accountability is key to improving engagement with quality. Holding individuals accountable, rather than teams or departments, will help to prevent a phenomenon known as social loafing, when people in groups exert less effort than when they work alone.

Using systems such as Q-Pulse improves accountability as it'll enable you to track individual performance, keep an accurate record of all activity, and learn what went wrong and why.

12. Clarify goals and responsibilities

One of the biggest issues employees have is confusion over their actual role. Sometimes things get lost in the mix, and it can take time to identify issues and act upon them.

To avoid this inertia, every employee should have a set of goals and responsibilities. Keeping these goals in a centralized system such as Ideagen's document management module means you can remind employees of their roles and responsibilities and easily manage any changes to them.

13. Perfect your on boarding process

If you don't already have an initiation programme for new starters, you'll be missing an important opportunity to nurture and embed a culture of quality and compliance.

If you don't think you'll have time to manage an on boarding training programme, systems such as our training records management software can help. Through pre-configured workflows, you can automatically send training emails, notifications and documents to your new employees over a set period of time.

It's also worth adding a 'quality gatepost' for all new staff. Add hiring criteria such as 'quality understanding' or 'GRC awareness' to your job advertisements and explore them in interviews.

14. Celebrate World Quality Day

Held every November, World Quality Day gives you the opportunity to promote quality to the rest of your organization. How and what you do is up to you. But the CQI always has a number of workshops, activities and event ideas on their website. They give you (free) downloadable posters, promotional materials and much more to help you raise the profile of quality. Many quality professionals who've taken part in these activities tell Ideagen that they believe World Quality Day is one of the most valuable ways to drive engagement.

15. Provide ongoing training and support

On top of compulsory training, you can arrange for employees to take part in less formal training sessions. By getting employees to guide their own learning or using our CAPA

software module to spot gaps in their skills, you can suggest a programme of interactive learning sessions.

You could team up with other departments to put on a series of webinars, roundtables or even lunchtime 'hot seat' sessions. This will help you to embed a culture of learning and continuous improvement.

Records of these sessions can then be added to your document management module so those who were absent can still keep up to date.

16. Host your own events

It may sound like a lot of hard work and you may even be thinking, "where will I get the budget for this?!" But a well-executed event can give you the opportunity to really engage in a dialogue with your employees, suppliers and partners.

17. Start a weekly quality circle

At the end of each week, get some biscuits, buns or beers and invite your stakeholders to your 'quality circle.' It'll give you an opportunity to share stories and talk to people in departments with whom you may not normally have much contact.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed each contain (2%)

1. **Mention Strategies on how to promote quality**

1**Note: Satisfactory rating 11 and 20 points** **Unsatisfactory - below 11and 20points**

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

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet 3. Monitoring performance of operation or quality of product or service

Monitoring performance of operation or quality of product or service

How to monitor workplace operations

Productivity

Continually monitoring and looking for ways to improve **workplace operations** can help an organization stay on financial track and keep delivering top quality products and services. You need to monitor workplace operations so you can develop strategies to improve procedures and protocols. As a business scales up in sales or in size, the task of monitoring becomes more important and complicated.

Monitoring operations requires management oversight, employee feedback and customer reviews. It can help provide specific directions for employees, which can lead to improved time management and increased productivity.

Improving workplace operations requires analysing collected data to identify the underlying problems and to find resolutions and methods to deal with them.

steps to quality monitoring your business operations to ensure your organisation remains competitive.

Measurement of the operative performance

To measure your company's performance company in an effective way, you need to establish indicators that allow you to know the results and how to make the suitable adjustments when it is necessary. Each area within the company has its own mechanisms, needs and resources. It is important to have an analysis of how each separate area is performing to achieve its specific objectives.

Implement operational process improvements

A results-oriented improvement plan focuses on improving cost, quality, service or speed. Action steps range from making minor changes that eliminate duplicate steps or other workflow redundancies to redesigning an entire process. An implementation includes analysing, prioritizing and reassembling tasks and operational steps.

Collect relevant data

There are many ways to collect data via regular monitoring and surveying. Many businesses use a customer retention management (CRM) software. Software capabilities vary but most offer several ways to monitor workplace operations. All relevant information coming out from outbound calls, prospect contacts calls, correspondence, offline and online surveys, follow-ups and sales should be registered and analysed. Right now you can find in the market software that even help track orders and send follow up offers.

Beyond technology, you can use site operations, employee surveys and customer feedback to collect valuable data about how your company is delivering its product or service. Site operations may be done by management, owners or by a third-party consulting firm, offering an outsider's perspective on operations. Employee surveys provide valuable feedback on areas of inefficiency that employees experience daily, such as consistent inventory issues. Customer reviews, whether solicited or gathered via online social media channels, tell companies about the user experience. At times, when everything seems to be going smoothly, it might be the customer review that points out something otherwise overlooked.

Analyse all collected information

As a business owner, you should look at data regularly to understand patterns and to look for anomalies. Although there might not be a monthly site review, employers can use other collected data to get an understanding what's working well and what isn't.

Engage your employees

Start by creating a workplace environment that accepts and embraces change. An open-door policy, fair and respectful treatment and open communications are some of the most important ingredients. If you take the time to lay a foundation that encourages and rewards employee contributions before implementing a monitoring and operational improvement plan, it will be much easier to get their cooperation.

Establish communication channels and strategies

IT managers and administrators must establish mechanisms to visualize the operational strategies within the organization and establish communication strategies that allow all the members of the company to easily know the results of each of the areas.

Implement new protocols and workflows

Once the issue is identified in the existing process, it is imperative that the company take steps to improve workplace operations. If a new call or sales protocol is implemented, it needs to be written in as part of the operations manual, and then distributed to employees. On top of the distribution of the written protocol, employers need to train employees consistently and regularly to make the new protocol habitual. Additionally, employers should ask for feedback on new policies and procedures to fine tune them.

Sometimes, improving workflow changes is easier than at other times. If inventory issues exist, managers need to make arrangements with suppliers or find new ones that can handle the demand.

The key to monitor work operations and to develope an excellent performance management model according to the company's objectives is to get constant feedback from your employees and customers.

We are in 2018, when technology and digital transformation are tools that allow us to advance every day using automated services that streamline processes, improve the results in companies and the performance of employees.

If you need a software to help you to monitor your company's operations, contact us.

DataScope can provide you task management tools for smart teams.

DataScope is a platform which allows various industries to streamline, organize and evaluate the work of their **field staffs** thanks to **online forms** which provide **real time indicators** 100% adaptable to any field.

Monitoring of Customer Satisfaction

Customer satisfaction is a term used to measure how business product and service offerings meet or surpass the expectation of its customers. It is a requirement of the ISO 9001 standard that the organization will monitor customer satisfaction. Customer satisfaction is important because it provides business owners with a measure to manage and improve their businesses.

Here are the top 5 reasons why customer satisfaction is so important

It is a point of differentiation

It reduces the churn

It increases customer lifetime value

It limits negative word of mouth

It is much cheaper to retain existing customers than to acquire new ones

A point of differentiation

Businesses who succeed in a competitive marketplace are the ones that make customer satisfaction a key element of their business strategy. In today's competitive environment, a recommendation to use one business over the other can influence prospective clients decision. Companies who offer outstanding customer experiences create environments where satisfaction is high and so customer advocates are plenty. collecting customer feedback also helps you identify differentiation opportunities to further stimulate customer satisfaction.

Reducing Churn

Knowing what your business customer satisfaction levels are, will help you better implement processes and tactics to enhance and improve the overall quality of your customer service.

Try putting an emphasis on exceeding customer expectations and ‘wowing’ customers at every opportunity.

These should be implemented for a period of about six months; thereafter customer satisfaction levels should be measured again to see whether the newly implemented initiatives had positive or negative implications on customer satisfaction.

Increasing customer lifetime value

Customer satisfaction plays a significant role in how much revenue a customer generates for your business over the period of your relationship, which is also known as lifetime value.

Any successful business is aware of the importance of customer retention as well as creating customer lifetime value. Increasing customer lifetime value subsequently increases your business returns.

Customer lifetime value is a result of high customer satisfaction and excellent customer retention. Think about what you are doing to keep customers coming back and spending more.

Limiting negative word of mouth

Generally speaking, an unhappy or unsatisfied customer tells between 9-15 people about their experience. That’s a lot of negative word of mouth.

How much will that affect your business and its reputation in your industry?

Customer satisfaction is closely linked to revenue and repeat purchases. What often gets forgotten is how it negatively impacts your business. It’s one thing to lose a customer because they were unhappy, but it’s another thing completely to lose 20 customers because of negative word of mouth.

To reduce or completely eliminate this, you need to measure customer satisfaction on an ongoing basis. Tracking changes in satisfaction will help you identify if customers are actually happy with your product or service.

More cost effective to retain existing customers

This is probably the most publicized customer satisfaction statistic out there. It costs up to ten times more to acquire new customers than it does to retain existing customers.

If that statistic does not resonate with you, then there's not much else anyone can do to demonstrate why customer satisfaction is important.

Customers cost a lot of money to acquire. You and your marketing team spend hundreds or even thousands of dollars getting the attention of prospects, nurturing them into leads and closing them into sales, therefore it should then come as no surprise that it would require more money to keep these acquired customers.

Imagine if you allocated one sixth of your marketing budget towards customer retention. How do you think that will help you with improving customer satisfaction and retaining customers?

Customer satisfaction plays an important role within your business. It is one of the key indicators of customer loyalty, tracking customer complaints and dissatisfaction, and it is also the key to unlocking business product and services differentiation strategies. Over and above all of these great benefits, it allows the business to compete with competitors on the sole basis that the business knows what their customers want.

Learn how

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed each contain (4%)

1. **Mention stepsof quality monitoring in your business operations**
2. explain roles of Customer satisfaction within your business.
3. _____ is a term used to measure how business product and service offerings meet or surpass the expectation of its customers.
4. Why Customer satisfaction is important
5. **Mention the reasons why customer satisfaction is so important**

1**Note: Satisfactory rating 11 and 20 Unsatisfactory below 11and 20points points**

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

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Answer Key for self-check

Module Title: Apply Quality Control

- LO #1- Assess quality of received equipment

:

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page

1. **process hierarchy**
2. **process** .
3. **procedure**
4. A **work instruction** – or work guide, job aid or standard operating procedure – describes in detail how an activity within a process (or procedure) is performed.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next pag

1. systematic, measurable, and traceable methods to all acceptance/initial inspections, preventive maintenance, and calibrations, or repairs by generating scheduled and unscheduled work orders.
2. paper-based or computer-base
3. **Quality** Assurance
4. True

Self-Check 3	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Defective equipment

The Danger of Defective Equipment.

Poorly maintained equipment

Lack of repairs

Lack of worker training

2. Workers being struck by/caught-in-between parts or equipment

Falls to a lower level

Electrocution

Fires/explosions

Toxic chemical exposure

3. :Burns, electrocutions, and smoke inhalation

Moderate or Severe Traumatic Brain Injuries

Amputations

Broken bones

Neck, back, and spinal cord injuries including paralysis

Torn ligaments

Vision or hearing loss

Disfiguring lacerations

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Burns, electrocutions, and smoke inhalation

   Moderate or Severe Traumatic Brain Injuries

   Amputations

   Broken bones

   Neck, back, and spinal cord injuries including paralysis

   Torn ligaments

   Vision or hearing loss

Disfiguring lacerations

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The need for replacement of items when;

The existing item or system has become inefficient or require more maintenance.

The existing equipment has failed due to accident or otherwise and does not work at all.

The existing equipment is expected to fail shortly.

2. The first reason is the equipment is depleted of function.
   Second reason for replacing equipment is if the equipment becomes obsolete..
3. **Gradual Failure and Sudden Failure**
4. True
5. **Sudden** failure
6. maintenance activity.

The planned maintenance is classified into following types:

Scheduled Maintenance (SM)

Preventive Maintenance (PM)

Corrective Maintenance (CM)

Reliability Centred Maintenance (RCM)

LO2: Assess quality of service	
Self-Check 1	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Stakeholder requirements.
2. Solution requirements. .
3. Nonfunctional requirements.

4. Functional requirements
5. Transition requirements.
6. Business requirements
7. high-level statements of goals, objectives, and needs.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. listen to the concerns of workers and supervisors
   - gain further understanding of jobs and tasks
   - identify existing and potential hazards
   - determine underlying causes of hazards
   - recommend corrective action
2. Ongoing audits
   - Improper billing
   - Inefficiencies for employee growth
   - Lost revenue
   - Compromised safety
3. It demonstrates professionalism

   It provides helpful guidance for performance

   The business can be more profitable

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. minor, major and critical.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Business Requirements Document (BRD)

   Functional Requirements Document (FRD)

   Market Requirements Document (MRD)

   Product Requirements Document (PRD).

   User Interface Requirements Document (UIRD)

   Technical Requirements Document (TRD)

   Quality Requirements Document

   Software Requirements Document or Software Requirements Specification (SRS)

2. An executive summary of the project and its background.
   - Assumptions, risks, and factors that may affect the project
   - Functional and non-functional requirements
   - References or a list of supporting documents
3. A definition of the target market, an imagining of the potential buyer or user
   - A comprehensive list of market requirements the solution will need to satisfy
   - Indicators of success for each requirement
   - A prioritized list of requirements from your market's point of view
   - A timeframe for the product's launch

LO3: Engage in quality improvement

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Quality improvement (QI)
2. desired service, adequate service, predicted service and a zone of tolerance that falls between the desired and adequate service levels
3. quality
4. First, the commitment may be explicit such as a written contract or it may be implied in terms of the expectations of the average consumer of the product.

   Second, the performance of the product relates to the ultimate functions and services which the final product must give to the final consumer.

5. quality
6. Quality control,
7. Quality control

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. **Ask for opinions**

   Make time for mentoring

   Reward good performance

   Improve accountability

   Clarify goals and responsibilities

   Perfect your on boarding process

   Celebrate World Quality Day

Provide ongoing training and support

Host your own events

Start a weekly quality circle

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. To ensure organisation remains competitive.
   To ensure measurement of the operative performance
   to ensure implement operational process improvements
   to ensure collect relevant data
   to ensure analyse all collected information.
   To ensure engage your employees
   to ensure establish communication channels and strategies.
   To ensure implement new protocols and workflows
2. It is one of the key indicators of customer loyalty, tracking customer complaints and dissatisfaction, and it is also the key to unlocking business product and services differentiation strategies. Over and above all of these great benefits, it allows the business to compete with competitors on the sole basis that the business knows what their customers want.
3. Customer satisfaction
4. because it provides business owners with a measure to manage and improve their businesses.

5. It is a point of differentiation

   It reduces the churn

   It increases customer lifetime value

   It limits negative word of mouth

   It is much cheaper to retain existing customers than to acquire new ones

REFERENCES

1. Westgard JO, Barry PL. Total quality control: Evolution of quality systems in health care laboratories.
2. Lab Med Westgard JO, Burnett RW. Precision requirements for costeffective operation of analytical processes.
3. Clin Chem Westgard JO, Burnett RW, Bowers GN. Quality Management Science in Clinical Chemistry: A dynamic framework for Continuous Improvement of Quality. Clin Chem 1990;36:1712-6.
4. West gard JO, Quam EF, Barry PL. Quality control selection grids (QCSGs) for planning procedures. J Clin Lab Sci 1989;20:241-7. 1990;36:1629-32. 1990;3:271-8.
5. ISO 8258:1991, “Shewhart control charts”.
6. ISO 7873:1993, “Control charts for arithmetic means with warning limits”.
7. ISO 7870:1993, “Control charts - general guide and introduction”.
8. ISO 7966:1993, “Acceptance control charts”.

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