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Ministry of Labor and Skills

Dairy Products Processing
Level-II

Based on September, 2021, Version 3 Occupational Standards (OS)

Module Title: Operating Water Purification Process

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Ministry of Labor and Skills

Addis Ababa, Ethiopia

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Introduction to the module

This module covers to provide the trainees with the skills and knowledge required to set up, operate, adjust and shut down a water purification process or sub-system.

In modern times, the quality to which water must be purified is typically set by government agencies. Whether set locally, nationally, or internationally, government standards typically set maximum concentrations of harmful contaminants that can be allowed in safe water. Since it is nearly impossible to examine water simply based on appearance, multiple processes, such as physical, chemical, or biological analyses, have been developed to test contamination levels.

Levels of organic and inorganic chemicals, such as chloride, copper, manganese, sulfates, and zinc, microbial pathogens, radioactive materials, and dissolved and suspended solids, as well as pH, odour, colour, and taste, are some of the common parameters analyzed to assess water quality and contamination levels.

LG # 28	LO 1: Prepare the water purification equipment and process for operation

Instruction sheet-1

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

- Confirming and making materials available to meet operating requirements.
- Identifying and confirming cleaning and sanitizing requirements
- Completing documentation process
- Entering and confirming processing parameters
- checking and adjusting equipment performance

Carrying out pre-start check 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**:

- Confirm and make materials available to meet operating requirements.
- Identify and confirm cleaning and sanitizing requirements
- Complete documentation process
- Enter and confirm processing parameters
- check and adjust equipment performance

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.
4. Accomplish the “Self-Checks” which are placed following all information sheets.
5. If you earned a satisfactory evaluation, proceed to “Operation Sheets.
6. Perform “the LAP Test” which is placed following “Operation sheets”.
7. If your performance is satisfactory, proceed to the next Learning Guide.

Information Sheet 1

1.1 Confirming and making materials available to meet operating requirements.

1.1.1. General over view of water purification principles

Water preparation processes comprise a wide range of technologies and physical-chemical methods. Methods must be selected with a view to the purpose of the use of the prepared water – the preparation of potable water requires a different approach from, e.g., the preparation of cooling water, feed water for boilers, or process water. Most people trust an RO Water Filter or an RO UV Water Purifier for their drinking water needs, but there are other alternative methods that you can try.

- **Applications**
  - ✓ Potable water preparation plants for municipalities, waterworks companies – refurbishment, intensification
  - ✓ Preparation of very clean water – e.g., electrical industry, pharmaceutical and food-processing industry, feed water for boilers
  - ✓ Groundwater processing plants – in places where connection to the public distribution network is not possible
  - ✓ Rinsing water – glassworks, automotive industry, electrical industry, plastic production
  - ✓ Cooling water

- **Application of methods**
  - ✓ In the process a wide range of physical-chemical methods can be used, e.g.:
  - ✓ Coagulation, flocculation, sedimentation – elimination of turbidity and colloid substances
  - ✓ Filtration – mechanical filters to remove rough particles, sand filters
  - ✓ Membrane processes – ultra-filtration, nano-filtration, reverse osmosis
  - ✓ Ion exchanger technologies – softening, removal of NO3 –, dealkalization, production of demineralised water
  - ✓ Adsorption – arsenic removal, active carbon to remove foul odours and tastes
  - ✓ Degasification – reduction of oxygen, CO2, and radon (mostly groundwater) content
  - ✓ Oxidation, reduction – Fe removal, chlorination to reduce microbial propagation

Water purification methods

A. **Boiling:** The simplest method to purify water is to boil it for a good time. High temperatures cause the bacteria and virus to dissipate, removing all impurities from the water. In doing so, chemical additions cease to exist in the water. However, the dead microorganisms and **impurities settle at the bottom** of the water, and boiling does not help eliminate all the impurities. You must strain the water through a micro porous sieve to completely remove the impurities.

B. **Water purifier;** An electric water purifier is the most trusted form of water purification found in most houses today. A water purifier uses a multi-stage process involving UV and UF filtration, carbon block, and modern water filtration technology that eliminates most of the chemicals and impurities, making it the purest drinking water.

C. **Reverse osmosis;** An RO Purifier proves to be one of the best methods of purifying water. Reverse Osmosis forces water through a semipermeable membrane and removes contaminants. The TDS Controller and Mineraliser Technology, like the one found in an A. O. Smith RO UV Water Purifier, help retain the necessary nutrients while doing away with harmful impurities.

D. **Water chlorination;** It is an older technique used usually during an emergency, wherein a mild bleach with approximately 5% chlorine is added to the water. This mixture works as an oxidant and quickly kills microorganisms, making water safe for consumption.

E. **Distillation;** Distillation is a water purification process involving collecting the condensed water after evaporation, ensuring that water is free of contaminants. However, this isn't as effective as an RO filter because it is time-consuming and eliminates minerals.

F. **Iodine addition;** Iodine is a red chemical that is easily available as a tablet or a liquid. It is extremely powerful as it **kills bacteria and viruses**. However, it adds an unpleasant taste and can be fatal if taken in high doses. Therefore, it should only be used if you don't have access to a better method of purification like an electric water purifier.

G. **Solar purification**; an alternative to the UV filtration is solar purification which involves treating water with the ultraviolet radiation of the sun. The process involves

filling a plastic bottle with water, shaking it to activate the oxygen and leaving it horizontally in the sunlight. This effectively kills bacteria and viruses present in the water, making it safe for consumption.

H. **Clay vessel filtration**; Way before people had access to an RO or UV Purifier, they used clay pots which purified muddy water, by blocking out the mud and allowing pure, potable water to pass through. This method is still used in ***some rural regions***.

I. **UV Radiation**: Water is exposed to a UV Light that kills microorganisms, thereby preventing it from breeding further. But if not coupled with an RO Filter, UV Radiation alone cannot remove impurities and heavy metals.

J. **Desalination**: This method is used when water with a certain level of **salinity** needs to be filtered. This process is helpful.

1.1.2. Materials and equipments

A. Dosing equipment

A chemical dosing system is a facility for automated injection of reagents into a wastewater network for the control of **simplicity and odour** emissions. These systems are typically used at pump stations, sewer manholes, and rising mains. However, they can be installed any place where odour containment is required.

Figure 1.1: Dosing Device

Due to release chemicals at a certain pressure and speed into the water, depending on how much of chemicals are dissolved in the wastewater coming through the inlet. It is part of a water treatment plant so water that comes into the inlet goes through various filters of this system.

B. Storage tanks:

The water pipe entry shall be located in an insulated lockable room and maintained in a proper technical and sanitary condition, be **equipped with pressure gauges, valves** for water sampling, check valves that prevent water backflow; duckboards for runoff. Enterprises shall have and present schemes of water supply and sewerage networks upon request of control organizations.

Figure 1.2: Water storage tanks

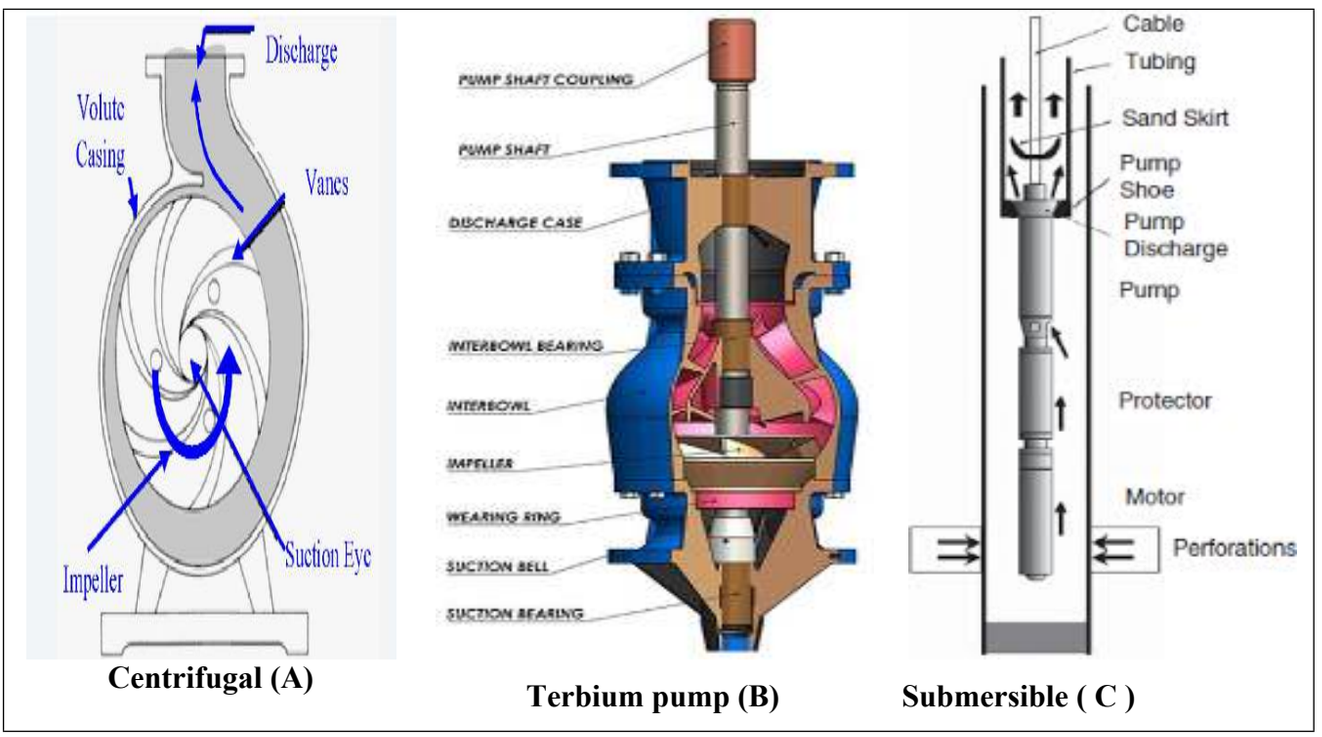
At least two tanks of clean water shall be arranged in the water supply system of dairies to ensure a continuous water provision of the enterprises in the peak consumption periods and in emergencies, as well as to ensure contact time during chlorination or a constant flow rate during disinfection with ultraviolet radiation and for external fire fighting.

C. **Water pumps**:

Pumping Machinery is used for transfer of water from one place to another and pumping of water from water source. Pumping is required for

i. Lifting water might be from the source (surface or ground) to purification works or the service reservoir.
ii. Transfer of water from source to distribution system.
iii. Pumping water might be from sump to elevated/ground surface tanks.

- **Pumping Machinery consists of three major components:**
  - ✓ Pump for lifting of water The function of pump is to transfer water to higher elevation or at higher pressure. Pumps are driven by electricity or diesel or even solar power. They are helpful in pumping water from the sources, that is from intake to the treatment plant and from treatment plant to the distribution system or service reservoir.
  - ✓ Electric/diesel/solar powered motor for pumping, three phase electric connection is required.
  - ✓ Panel board Panel board consists of circuit breaker or switch and fuse starter level controls etc for transmission of electric supply. For water supply system, three main types of pumps are used:



Centrifugal (A) **Terbium pump (B)** **Submersible (C)**

Figure 1.3: Water pumper

D. Valves

A valve is a device or natural object that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Valves are technically fittings, but are usually discussed as a separate category.

The working principle of control valve is opening or closing internal passages in order to regulate the flow of a liquid or gas. Control valves are part of a control loop that controls a process. For proper functioning of the pipeline, valves made of iron or brass are used in the water-supply mains. Valves stop or control the flow of fluid like liquid, gas, condensate, etc. These are classified according to their usage like isolation, throttling and non-return corrector.

Various types of valves are manufactured depending upon their use and type of construction. There are different water valves, some of are listed bellow,

Sluice (A) Scour (B) Air (B) Gate (B)

Figure 1.4: Valves

E. Uv light

Ultra Violet (UV) light disinfection is **one water treatment system that can be used to remove most forms of microbiological contamination from water.** UV systems are an effective means of water disinfection for residential point of entry use to help disinfect the entire home. UV systems are highly recommended to homeowners who may suspect any E.coli, cryptosporidium, giardia or any other types of bacteria and viruses in the water. Other means to kill bacteria or viruses in water would be adding chemical disinfectants.

However, it **is not advised to use chlorine or other chemicals** to disinfect water like private well owners, because of the toxic byproducts they create. It is important to avoid drinking any water that is potentially contaminated from **bacteria** to protect yourself from any water-borne bacterial diseases.

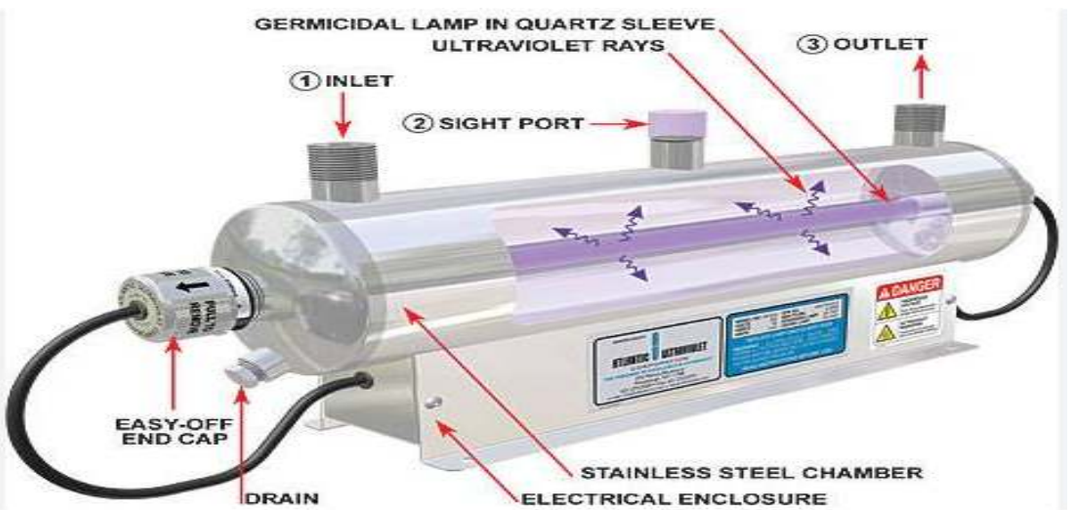


Figure 1.5: UV lighter

https://www.youtube.com/watch?v=z7JTdViHdMI

- **Benefits of UV disinfection**

  Water treatment by UV disinfection has many advantages:

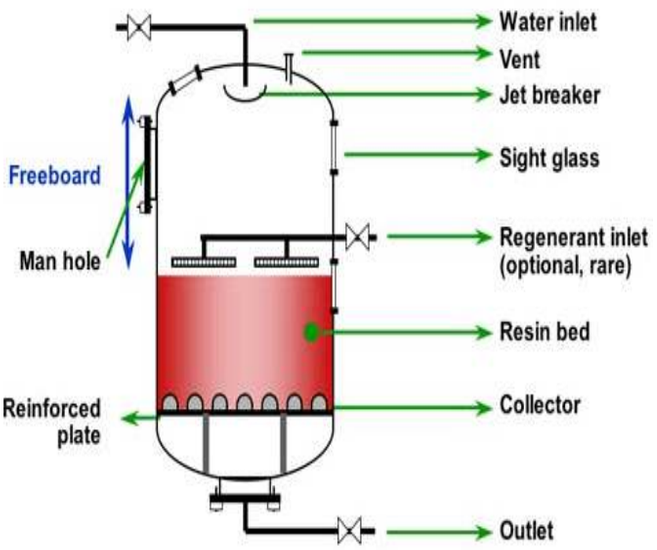
  - ✓ It is a non-chemical treatment, meaning that no harmful chemicals need to be added,
  - ✓ It is easy to install and maintain.
  - ✓ Economical and energy efficient: low power requirements
  - ✓ it presents an effective treatment – it destroys 99,99% of microorganisms
  - ✓ It is an ecological technology. UV contains no disinfection by-products
  - ✓ More effective than chlorine or chloramines
  - ✓ Conserves water, in other words, the UV purification process does not waste water.
  - ✓ Taste and odor – Chemical disinfection methods (such as chlorine) change the taste and odor of water and produce by-products. This is not the case with UV.

- **Disadvantages**
  - ✓ UV light can only eliminate the **micro-organisms** present in the water. In fact, UV technology does not remove any other contaminants from the water such as :
    - heavy metals
    - salts
    - Chlorine
  - ✓ Artificial substances such as petroleum or pharmaceutical products
  - ✓ UV water systems require electricity to operate. A UV may not be suitable for all applications such as emergency or survival needs if electricity is not available.
  - ✓ UV disinfection does not offer the persistence of some other chemicals

E. Deionisation plants

Electrode ionization Plant is unit Process used in treatment of water. It is a common process to purify water from free radical cation and Anion. Deionization is a physical process that uses specially manufactured ion exchange resins to remove mineral ions. Because the majority of water impurities are dissolved salts, deionization results in high purity water that is generally similar to distilled water.

The deionisation process uses cation and anion ion exchange resin beds to remove contaminants from water. Ions are attracted to the resin, becoming trapped on its surface and effectively removed from the water. The impurities are replaced by hydrogen (H+) and hydroxide (OH-) ions which are exchanged from the resins.



Deionization internal systems (A)

Deionisation plants (A)

Figure 1.6: Deionisation plants

https://www.youtube.com/watch?v=BmpknJNDXfE&t=131s

A. Softeners

Home water softeners, also called ion exchange units, are appliances that remove calcium, magnesium, and other minerals from drinking water. Resin beads inside the softener trap the calcium and magnesium and exchange them for sodium or potassium.

The Water Softening Plants are designed to produce treated Water to suit for various applications. Treated Water is of consistency quality with low residual hardness throughout the service cycle. The high synthetic resin is used to exchange Sodium ion with hardness forming Calcium and Magnesium ions.

Activated carbon filters treat water by using a process called adsorption. As the water passes through the activated carbon, the carbon acts like a sponge with a large surface area and absorbs the contaminants in the water.

Softener internal system(A) **Softener plants (B)**

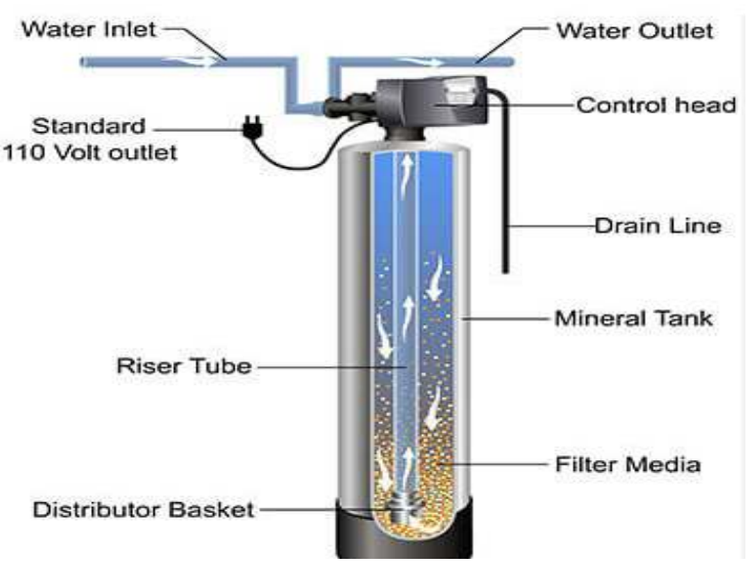
Figure 1.7: water softeners

https://www.youtube.com/watch?v=PGPz9tYKvmQ

I. Carbon tanks

Carbon tanks are utilized in medical water treatment to remove chlorine and chloramines from the supply water to ensure patient safety. The carbon filtration system uses activated carbon with unique properties. It eliminates up to 99% of volatile organic compounds (VOCs), heavy metals, total suspended solids (TSS), chloramines, chlorine, and other contaminants present in the water.

Carbon tanks (A)



Carbon tank filtration systems(B)

Figure 8: Carbon tanker

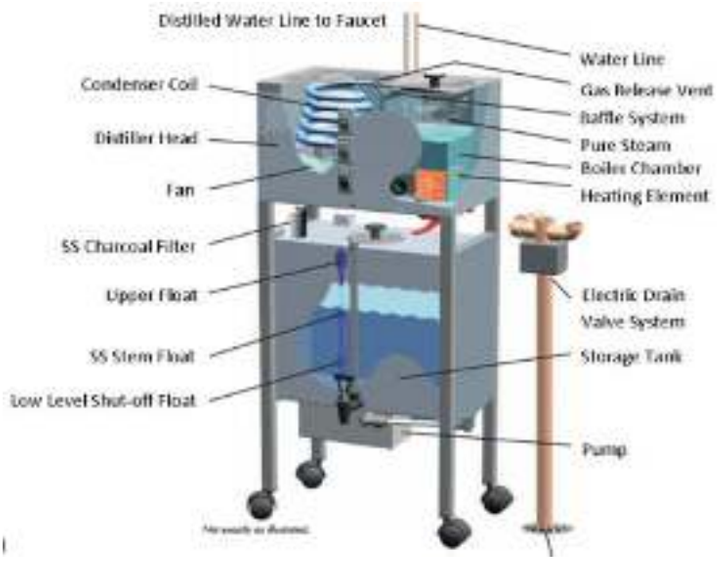
https://www.youtube.com/watch?v=B7qB62Msems

J. Distillation systems

Water distillation is a process in which water is boiled until it evaporates and condenses, leaving behind impurities with different boiling points. Distillation produces clean, pure water. It is an effective water treatment method for removing contaminants like bacteria, heavy metals, and chemicals.

Distillation effectively removes inorganic compounds such as metals (lead), nitrate, and other nuisance particles such as iron and hardness from a con- taminated water supply. The boiling process also kills microorganisms such as bacteria and some viruses. Distillation removes oxygen and some trace metals from water.

Water distiller(A)



water distilling system(B)

Figure 1.9: Water distiller

https://www.youtube.com/watch?v=iq7HjMfzYCI

K. Reverse osmosis systems

Reverse osmosis removes contaminants from unfiltered water, or feed water**,** when pressure forces it through a semi permeable membrane. Water flows from the more concentrated side (more contaminants) of the RO membrane to the less concentrated side (fewer contaminants) to provide clean drinking water. The fresh water produced is called the permeate**.** The concentrated water left over is called the waste or brine**.**

A semi permeable membrane has small pores that block contaminants but allow water molecules to flow through. In osmosis**,** water becomes more concentrated as it passes through the membrane to obtain equilibrium on both sides. Reverse osmosis, however, blocks contaminants

from entering the less concentrated side of the membrane. For example, when pressure is applied to a volume of saltwater during reverse osmosis, the salt is left behind and only clean water flows through.

Figure 1.10: Reverse osmosis plants

https://www.youtube.com/watch?v=B7qB62Msems

- **Advantages of reverse osmosis**

  Some of the advantages of the reverse osmosis process are as follows.

  - ✓ It is the best method for water softening.
  - ✓ The semi permeable membrane will block all ion particles.
  - ✓ The maintenance of the system is very simple.
  - ✓ It gives us clean and pure water by blocking all contaminants.
  - ✓ The available RO systems are very compact, and it requires little space.
  - ✓ The useful life of the full system, including the membrane, is over two years.
  - ✓ This system does not require any use of chemicals to purify water
  - ✓ The energy requirement for the RO system is very low.
  - ✓ RO systems are tot ally automated and are designed to start and stop on their own.

- **Disadvantages of reverse osmosis**
  - ✓ Sometimes reverse osmosis leads to clogging of the whole system.
  - ✓ It requires routine filter changes and maintenance.
  - ✓ The installation cost of a reverse osmosis system is high.

- ✓ The whole process is very slow when it comes to household application, as the pressure used is very low.
- ✓ The process does not help in disinfecting the water. You will require a separate process to disinfect the water.
- ✓ Hard water can damage the system.
- ✓ The damaged membrane will allow any small microorganism to pass through it.
- ✓ The RO system is not self-sustaining

- **Applications of reverse osmosis**
  - Reverse osmosis is widely used in residential and commercial water filtration systems. Other than that, it has plenty of applications in various industries. Some of them are mentioned below.
  - Reverse osmosis is a type of process that is used to remove dissolved chemical particles from water.
  - Reverse osmosis is a type of process that is used to remove dissolved biological entities from water.
  - It has crucial applications in the medical field.
  - Used to purify water to prevent any diseases,
  - It has a wide application in water treatment and water purification.
  - It is used in food industries, and it is applied for the concentration of juices, milk, and other beverages.
  - It is used to provide clean water for the community water supply.

1.2. Identifying and confirming cleaning and sanitizing requirements

1.2.1. Cleaning

It is the process in which complete removal of food soil (unwanted⎦ matter on food-contact surfaces). It is accomplished using appropriate detergent chemicals under recommended conditions from the internal and external surface of the equipment some of the precipitates remains intact to equipment after cleaning and forms white or grayish film. A film over equipment surface called water stone Heat denaturation of protein present on the equipment surface or absorbed by other components forms milkstone quickly over heated surfaces.

1.2.1.1. Cleaning operations

This item requires that all milk contact surfaces be effectively cleaned and sanitized before each use. The only exception to this is the Ordinance provision that milk storage tanks be emptied and cleaned at least every 72 hours and raw milk and heat treated milk storage tanks use to store

products longer than 24 hours and all raw milk silo tanks be equipped with a 7-day temperature recording device.

This recorder shall have a scale span of not less than 50 F, be accurate to plus or minus 2 F, include the normal storage temperatures plus and minus 5 F, with 2 F minimum scale divisions not less than 0.040 inch apart and time scale divisions of not more than 1 hour. The recording chart of these devices must be capable of recording temperatures up to 180 F.

Computer generated temperature recorders which provide a printout which is readily discernible and meets the intent of the Ordinance are acceptable as are devices equipped with multiple sensors or recording pens. Records are a significant part of the cleaning and sanitizing process. All CIP charts are to be retained by the plant for a minimum of three (3) months. This includes records for cleaning and sanitizing of all plant product processing equipment.

Note: Cultured product storage/processing vessels may not have to meet the 24 hour emptying and cleaning requirements if their process demands extended periods of storage, however, a plant should package cultured product within 24 hours of breaking the curd.

1.2.1.2. Basics of cleaning

- Cleaning is reversal of soiling and requires supply of energy usually in the form of mechanical and chemical energy.
- To overcome the forces binding the soil to the surface both mechanical and chemical effect must be provided by cleaning system

1.2.1.3. Proper cleaning of dairy equipment

- Reduces the chance of product contamination at each step by reducing the high initial load of micro-organism through removal of their available nutrients
- Promotes clean and tidy environment that improves operator's moral/confidence and helps to maintain safe work place, creates cleaner production area, prevent/avoid accidents
- Increases the life of equipment by increasing plant efficiency, improves process economy thus profit of the organization.

  E.g. Efficiency of milk pasteurizer reduces with increase in process time due to scale deposition on its heat exchanger plates and the same can be regained after its adequate cleaning, also true with Separator.

2.1.1.4. Cleaning agents

- Cleaning agents are mixture of several chemical compounds employed for a particular function to perform like washing of floors and walls, used in cleaning modes →Manual, cleaning out of place (COP) , cleaning in place (CIP)
- Mainly used to reduce surface tension of water that results in dislodging and loosening of soil followed by flushing away of the suspend soil particles
- Classified as strong, heavy duty and mild alkaline and acids, employed for a particular use
- Usually, fats, oils, greases, and proteins can be removed with alkaline cleaners at pH ≥11
- Sodium hydroxide (caustic soda) potassium hydroxide (caustic corrosion and tissue damage◊strong alkali potash)
- Sodium carbonate (soda ash, mild), and sodium silicates, Trisodium phosphate (TSP)
- Acid based cleaning agents are the blend of phosphoric, nitric, sulfuric and sulfamic acid used to remove encrusted (having a hardened crust as a covering) surface materials and dissolve mineral scale deposits
  - ✓ Strong (hydrochloric, hydrofluoric, sulfamic, sulfuric & phosphoric acids)
  - ✓ Mild (hydroxyl acetic, acetic, gluconic acid, levulinic)

1.2.2. Expression of cleaning results

- **Degree of cleaning results are expressed in terms of :**
  - ✓ **Physical cleanliness –**removal of all visible dirt from cleaned surface⌋
  - ✓ **Chemical cleanliness** – removal of both visible and microscopic residues not detected by naked eye but by taste or smell only.
  - ✓ **Bacteriological cleanliness** – attained by disinfection
  - ✓ **Sterile cleanliness** – destruction of all micro-organisms

- **Mechanism of cleaning**
  - ✓ Wetting of soiled surface i.e. bringing the cleaning solution into intimate contact with the soil to be removed. For this the solution should have adequate wetting and penetrating properties.
  - ✓ •Displacement of the soil from the surface by emulsification, saponification and / or mechanical action
  - ✓ Dispersion of soil removed from the surface in the cleaning solution by dispersion, de-flocculation.
  - ✓ Rinsing to prevent re-deposition of the dispersed soil on the cleaned surface

1.2.2.1. Sanitization

Sanitation was originated from Sanitas (Latin word) having meaning “health” but the same word has another meaning “creation and maintenance of hygienic and healthful conditions” in food industry**.** It is considered as a joint venture of principles of design, development, execution, maintenance, restoration, improvement of hygienic practices and conditions**.** Applied for the creation of hygienic practices is intended to continue a clean and healthy environment from food production to storage**.** Usually applied after cleaning operation for the **complete elimination of all types of bacteria.**

1.2.3. Dairy Sanitizers

- ✓ Most frequently used dairy sanitizers includes steam, hot water and chemical sanitizers
- ✓ In steam sanitizing, steam is subjected and maintained on the equipment surfaces for desired time duration
- ✓ The International Dairy Federation (IDF) recommends circulation of hot water 85°C for 15 minutes for milk pasteurizer sanitization.
- ✓ For enclosed system, minimum circulation of hot water (77°C) for 15 minutes or >5 minutes circulation at 94°C recommended by Food and Drug Administration (FDA)
- ✓ In chemical (chlorine, iodine etc.) sanitization, sanitizing solution of desired concentration is kept in the contact (circulation) of equipment surface for 2-5 minutes with slight back pressure in the pipe lines
- ✓ Also be applied as fogging, spraying and with help of brushes

- **Water quality important to cleaning and disinfection**
  - ✓ **Sanitary quality**: **Water** used in food plant sanitation must be potable – that is, fit for human consumption
  - ✓ **Microbiological standards**: The following are the main microbial specifi cations for water, measured in **colony forming units (cfu)** mL−1 : total bacterial count < 100, coliforms absent in 100 mL, and Escherichia coli absent in 100 mL.
  - ✓ **Taste, odour and colour**: Objectionable tastes, odours and colours are usually acquired from rotting vegetation and algae, and are best removed by activated carbon filtration Suspended matter comprises clay, silt and other organic materials; suspension of more than 1 part per million (ppm/mg/L) causes visible turbidity, and is best removed by sedimentation/filtration.
  - ✓ **Total dissolved solids (TDS).** This is a measure of all the chemicals dissolved in the water, and is generally not problematic for cleaning and disinfection.
  - ✓ **Dissolved gases**. Some, such as carbon dioxide, can form weak acids, resulting in the need for additional alkali, or in some cases may cause corrosion.

- ✓ **pH**: This should ideally be between 6.5 and 7.5. Below pH 6.5 corrosion problems will occur. The maximum alkaline pH value allowed is 10.
- ✓ **Alkalinity**: High bicarbonate alkalinity may contribute to scale formation.
- ✓ **Silica**. This is generally not significant in cleaning and disinfection, but on stainless steel surfaces it can form dull layers that are difficult to remove. Sulphides/ sulphates. allowable level is 250 µg SO4 L^{-1}
- ✓ **Chlorides:** These should not be more than 250 µg mL^{-1} (maximum), but preferably should be below 50 µg mL^{-1} because of the possibility of corrosion, especially in acidic conditions.
- ✓ **Iron**: The maximum is 200 µg Fe L^{-1} ; staining will be the main issue here.
- ✓ **Manganese**: The maximum is 50 µg Mn L^{-1}
- ✓ **Total hardness**: This is the total of all dissolved calcium and magnesium salts, usually expressed as equivalent CaCO3.

1.3. Completing documentation process/records

1.3.1. Batch records:

These documents are typically used and completed by the manufacturing department. Batch records provide step-by-step instructions for production-related tasks and activities, besides including areas on the batch record itself for documenting such tasks.

1.3.2. Documentation:

It is the key to GMP compliance and ensures traceability of all development, Manufacturing, and testing activities. Documentation provides the route for auditors to assess the overall quality of operations within a company and the final product.

1.3.3. Documentation system and specifications

Documentation is an essential part of the quality assurance system and, as such, should be related to all aspects of GMP. Its aim is, to define the specifications for all materials and the method of manufacture and control to ensure that all personnel concerned with manufacture have. The information necessary to decide whether or not to release a batch of a drug for sale, and to provide an audit trail that will permit investigation of the history of any suspected defective batch. The specifications should describe in detail the requirements with which the products or materials used or obtained during manufacture have to conform. They serve as a basis for quality evaluation.

- **Keep good records**: Good records enable one to track all activities performed during batch manufacture, from the receipt of raw materials to the final product release; they provide a history of the batch and its distribution. It is an essential part of GMP to keep accurate records, and during an audit it helps convey the message that procedures are being followed. It also demonstrates that the processes are known and are under control.

  Note;

  - ✓ Record all necessary information immediately upon completion of a task
  - ✓ Never trust your memory or write results on loose pieces of paper
  - ✓ Write your name legibly in ink. Remember that by signing records you are certifying that the record is correct and that you have performed the task as per the defined procedure.
  - ✓ Draw a single line through any mistakes, and initial and date the correction. Include a reason for the correction at the bottom of the page.
  - ✓ Record details if you deviate from a procedure. Ask your supervisor or the quality department for advice if a deviation should occur.
  - ✓ Do not document someone else's work unless you are designated and trained to do so.
  - ✓ Never assume that undocumented work has been properly completed – if it's not written down, then it didn't happen!

1.4. Entering and confirming processing parameters

1.4.1. Classification of water

Water can be divided into ground water and surface water. Both types of water can be exposed to contamination risks from agricultural, industrial, and domestic activities, which may include many types of pollutants such as heavy metals, pesticides, fertilizers, hazardous chemicals, and oils. Water quality can be classified into **four** types.

A. **Potable water:** It is safe to drink, pleasant to taste, and usable for domestic purposes.
B. **Palatable water**: It is esthetically pleasing; it considers the presence of chemi- cals that do not cause a threat to human health
C. **Contaminated (polluted) water**: It is that water containing unwanted physical, chemical, biological, or radiological substances, and it is unfit for drinking or domestic use
D. **Infected water**: It is contaminated with pathogenic organism

Characteristics of pure water

Pure ordinary water (H_20) consists of hydrogen (11.1888 %) by weight and oxygen (88.812 %). It has a slightly blue color and is very slightly compressible. At its maximum density at 39.2 °F or 4 °C, it is the standard for the specific gravities of solids and liquids. Its specific heat is the basis for the calorie and the B.T.U. units of heat. It freezes at 32 °F or 0 °C".

Any source of water to meet basic requirements for a public water supply needs some form of treatment. In general, water to be used for public water supply;

- ✓ Should contain no disease-producing organisms,
- ✓ Should be colorless and clear,
- ✓ Should be good-tasting, free from odors and preferably cool,
- ✓ Should be non-corrosive,
- ✓ Should be free from gases, such as hydrogen sulfide and staining minerals, such as iron and manganese and
- ✓ Should be low cost.

Table 1.1: WHO purified water standards

	Characteristics pure Water				
	Substance or Characteristic	**Requirement (Desirable Limit)**	**Undesirable effect outside the desirable limit**	**Permissible limit in the absence of alternate source**	**Remarks**
1.	**Colour Hazen Units, Max**	5	- Above 5, consumer acceptance decreases	25	- Extended to 25 only if toxic substances are not suspected in absence of alternate source
2.	**Odour**	Unobjectionable	-	--	- a). Test cold and when heatedb). Test at several dilutions
3.	**Taste**	Agreeable	-	--	- Test to be conducted only after safety has been established
4.	**Turbidity NTU Max**	5	- Above 5, consumer acceptance decreases	10	-
5.	**pH**	6.5 to 8.5	- Beyond this range it will affect mucous membrane and water supply system	No relaxation	-
6.	**Total hardness (as CaCO3) mg/L, Max**	300	- Encrustation in water supply structure and adverse effects on domestic use	600	-
7.	**Iron (as Fe) mg/L, Max**	0.3	- Beyond this limit taste/ appearance are affected, has adverse effect on domestic uses and water supply structures, and - promotes iron bacteria	1	-
8.	**Chlorides (as Cl) mg/L, Max**	250	- Beyond this limit, taste, corrosion and palatability are affected	1000	-
9.	**Residual, free chlorine mg/L, Max**	0.2	-	-	- To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be Min 0.5 mg/L.

1.5. Checking and adjusting equipment performance

1.5.1. Evaluate equipment performance

To measure the quality output for a piece of equipment, divide the number of good pieces produced during an operating cycle by the total unit output. For a defect-free production cycle, a machine will earn a quality score of 100 per cent. There are ways to measure manufacturing equipment efficiency.

i. **Availability;** Put simply, a machine's availability score measures how often a machine is available for use in production. When equipment availability is 100 per cent, it is always available during planned production times. Equipment availability is negatively affected by unplanned equipment downtime, material shortages and the time taken for machine changeover.To calculate a machine's availability score, divide the operating time by planned production time.

ii. **Performance**; A machine's performance score compares the number of units it produces per hour with the ideal production rate it would meet if it ran at its maximum rated speed at all times. So a score of 100 per cent means that the equipment is running as fast as possible. This is a useful benchmark to assess a machine's speed loss. The ideal cycle time is the time taken to produce one unit at rated speed, while the actual cycle time is the machine's operating time divided by the number of units produced. To work out the performance score for a machine, divide the ideal cycle time by the actual cycle time.

iii. **Quality**; another factor affecting productivity is material wastage and quality shortfalls. Rejected materials, factory seconds and products that need to be reworked after production can negatively affect a business' productivity. To measure the quality output for a piece of equipment, divide the number of good pieces produced during an operating cycle by the total unit output. For a defect-free production cycle, a machine will earn a quality score of 100 per cent.

iv. **Big losses**; most efficiency losses in manufacturing are caused by six subsets of equipment availability, performance and quality. These are:

- Planned downtime
- Breakdowns
- Minor stops
- Speed loss

- Production rejects
- Rejects on startup

Categorizing incidents into these six subsets can help operators better understand the factors that are affecting plant efficiency.

1.5.2. Overall equipment effectiveness

Once you have determined a machine's availability, performance and quality scores, you can calculate the overall equipment effectiveness (OEE).

To obtain the OEE for a piece of equipment, multiply its availability, quality and performance scores together. For an OEE of 100%, a machine needs to be free of defective output, run at rated speed and have no unplanned outages. While a single OEE score just indicates, what a machine can do better, calculating OEE regularly and assessing trends for individual equipment and the plant as a whole can provide valuable insight into how to optimize productivity. Target OEEs vary between plants and application categories, so it is important for owners and plant operators to determine the appropriate benchmark for their operations.

1.5.3. Total effective equipment performance

Total Effective Equipment Performance (TEEP) is a performance metric that provides insights as to the true capacity of your manufacturing operation. It takes account both Equipment Losses (as measured by OEE) and Schedule Losses (as measured by Utilization). Let's briefly contrast OEE and TEEP:

- OEE measures the percentage of Planned Production Time that is truly productive.
- TEEP measures the percentage of All Time that is truly productive.

If your TEEP score is 100% then you are making only Good Parts, as fast as possible, with no stops, around the clock (24/7). In other words, you have no Schedule Losses and no

TEEP is calculated as:

- ✓ **TEEP** = OEE × Utilization
- ✓ **Utilization** = Planned Production Time / All Time
- ✓ **Performance** = (Ideal Cycle Time × Total Count) / Run Time
- ✓ **Performance** = (Total Count / Run Time) / Ideal Run Rate
- ✓ **Quality** = Good Count / Total Count
- ✓ **OEE** = Availability × Performance × Quality

1.5.3.1. The preferred OEE calculation

OEE scores provide a very valuable insight – an accurate picture of how effectively your manufacturing process is running. In addition, it makes it easy to track improvements in that process over time. What your OEE score does not provide is any insights as to the underlying causes of lost productivity. This is the role of Availability, Performance, and Quality. In the preferred calculation, you get the best of both worlds. A single number that captures how well you are doing (OEE) and three numbers that capture the fundamental nature of your losses (Availability, Performance, and Quality).

1.6. Carrying out pre-start check equipments

1.6.1. Equipment installation of RO

A. The water supply should be sufficient to provide a minimum of 20- pounds per square gauge (psig) pressure at the design feed flow.

B. Proper pretreatment must be determined and installed prior to the RO system.

C. A fused high voltage disconnect switch located within 10 feet of the unit is recommended. This disconnect is not provided with the RO system. Responsibility for meeting local electrical and plumbing codes lies with the owner /operator.

D. Install indoors in an area protected from freezing. Space allowances for the removal of the membranes from the pressure vessels should be provided. This system requires 42" minimum clear space on each side.

1.6.2. Plumbing Connections

Notice: It is the responsibility of the end user to ensure that the installation is done according to local codes and regulations.

A. Connect the pretreated feed water line to the inlet side of the prefilter housing.
B. A feed water shutoff valve should be located within 10 feet of the system.
C. Temporarily connect the outlet of the product water flow meter to drain. The product water line should never be restricted. Membrane and/or system damage may oc- cur if the product line is blocked.
D. Connect the outlet of the reject water flow meter to a drain. The reject drain line should never be restricted. Membrane and/or system damage may occur if the reject drain line is blocked. An air gap must be located between the end of the drain line and the drain. The use of a standpipe or other open drain satisfies most state and local codes and allows for visual inspection and sampling.

1.6.3. Electrical Connections

Notice; It is the responsibility of the end user to ensure that the installation is done according to local codes and regulations.

A. A safety switch or fused disconnect should be installed within 10 feet of the system.
B. Verify that the disconnect switch is de-energized using a voltmeter.
C. Connect the outlet of the disconnect switch to the terminals on top of the motor starter. Attach the power supply ground to the chassis ground. It may be necessary to drill a hole in the enclosure and install a watertight strain relief or conduit connector. The hole size and location must be determined by the installer. Check the pump motor nameplate for the amper- age draw at various voltages to determine the wire size required.
D. Do not apply power to the RO unit at this time.

Self-check 1	Written test

Full names Name…… ID…… Date…….

Directions: Answer the following Question accordingly to the instructions

Test I: Choose the best answer (4 point)

1. Which of the following used as continues supply of water for dairy processing
   A. Dosing equipment
   B. Storage tanks
   C. Pumps
   D. Valves
   E. Distillation systems

2. The function of valves applied only transferring of water into the system.
   A . True B. False

3. One of the following purification equipment is used for disinfection of micro organizes?
   A. Distillation systems
   B. Reverse osmosis systems
   C. Uv light
   D. All

4. Which of the following purification methods use an ion?
   A. Distillation systems
   B. Reverse osmosis systems
   C. Deionisation plants
   D. Carbon tanks

Test II: Short Answer Questions (2 point)

1. Way we need to have cleaning and sanitizing the water for dairy processing?
2. What are the characteristics of pure water?
3. What mean over equipment electiveness (OEE) at equipment performance in water processing?

Note: Satisfactory rating 12 points Unsatisfactory below 12 points

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

Operation Sheet -1

1.1. Techniques/Procedures/Methods of CIP program for a pasteurizer processing circuit

A. Materials, Tools and equipments

- Smart Glasses
- Respiratory Equipment
- Cooling PPE
- Flame & Water-Resistant Clothing
- Home-Testing Kits
- Smart Cameras
- Nitric acid
- Smart Helmets
- Cut-Resistant Gloves
- Slip-Resistant Gloves
- Contact-Tracing
- Fatigue Monitoring
- Warm water and cold water
- Alkaline detergent

B. Procedures/Steps/Techniques

1. Rinsing with warm water for about 10 minutes
2. Circulating the alkaline detergent solution (0.5 – 1.5%) for about 30 minutes at 75°C
3. Rinsing out alkaline detergent with warm water for about 5 minutes
4. Circulation of (nitric) acid solution (0.5 – 1.0 %) for about 20 minutes at 70°C
5. Post-rinsing with cold water
6. Gradual cooling with cold water for about 8 minutes
7. Disinfect the circuit with 90 – 95°C for 10 –15 minutes.

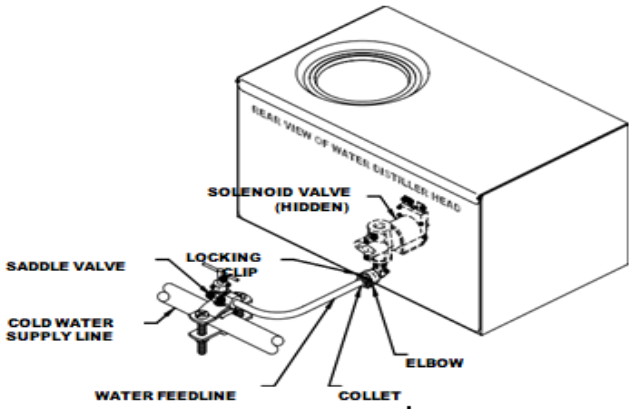
1.2. Techniques/Procedures/Methods of distillation of water

C. Tools and equipments

- Smart Glasses
- Respiratory Equipment
- Cooling PPE
- Flame & Water-Resistant Clothing
- Home-Testing Kits
- Smart Cameras
- Smart Helmets
- Cut-Resistant Gloves
- Slip-Resistant Gloves
- Contact-Tracing
- Fatigue Monitoring
- Water distiller Equipments (Model-PWS 12-12)

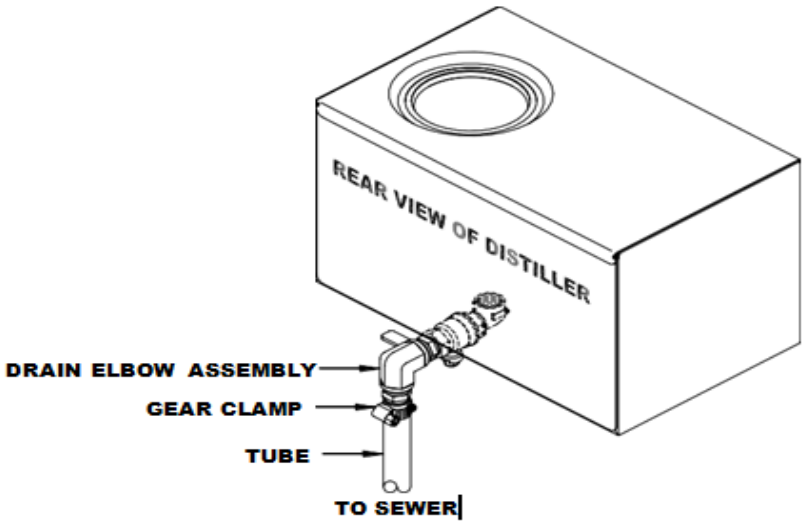
D. Procedures/Steps/Techniques/pre staring of water Distillation equipments

1. Ensure the boiling and storage tank lids are in place and tight.
2. Make sure all control switches are turned off
3. Ensure the water supply saddle valve is turned fully on by turning counter- clockwise from tight.
4. Allow the product water to flow to drain for 30 minutes.
5. Turn Power, Fan and Water switches ON (Do not turn Water switch on if filling manually).
6. Water should be entering the boiling tank. Remove the boiling tank lid to check. Replace lid if water is entering. The fan and heater should turn on as soon as the water level is above the heating element.
7. Check for leaks around the saddle valve and supply pipe and around the water solenoid on the water distiller head. See



E. Operation procedures

1. Ensure boiling and storage tank lids are in place and tight.
2. Ensure all electrical plugs are properly connected and the water supply valve is turned on.
3. Turn the Power, Fan and Water switches to the ON position. Water will enter the boiling tank, the heating element will energize and the cooling fan will start.
4. Ensure distiller will continue operating and distilling water until the storage tank is full, water distiller will turn off until the storage tank is drained to approximately 2/3 full and then the automatic water distiller will start producing distilled water again.
5. Ensure prevent a build up of scale and contaminants in the boiling tank, it is recommended that the impurities from the boiling tank be drained after each distillation process or ten gallons of distilled water.



6. Ensure water distiller boiling tank can be drained by opening the ball valve and draining into a suitable floor drain or container (valve is shown in the close position).

LAP Test-1	Performance Test

Full Name…….…… ID…… Date……...

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is will expected from each student to do it.

Task 1: Perform CIP program for a pasteurizer processing circuit

Task 3: Apply Water distillation process on series PWR4021 equipments

LG # 29	LO 2: Operate and monitor the water purification process

Instruction sheet-2

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

- Starting and operating the process procedures
- Monitoring equipment
- Identifying and reporting equipment operation
- Monitoring the process of purified water produced.
- Identifying, rectifying and reporting out-of-specification process outcomes
- Maintaining work area
- Conducting work
- maintaining workplace records

Carrying out pre-start check 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**:

- Start and operate the process procedures
- Monitor equipment
- Identify and report equipment operation
- Monitor the process of purified water produced.
- Identify, rectify and report out-of-specification process outcomes
- Maintain work area
- Conducting work
- Maintain workplace records

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Accomplish the “Self-Checks” which are placed following all information sheets.
4. If you earned a satisfactory evaluation, proceed to “Operation Sheets.
5. Perform “the LAP Test” which is placed following “Operation sheets”.
6. If your performance is satisfactory, proceed to the next Learning Guide.

Information Sheet -2

2.1. Starting and operating the process procedures

2.1.1. Reverse osmosis works

The normal osmosis process, the solvent naturally moves from an area of low solute concentration (High Water Potential), through a membrane, to an area of high solute concentration (Low Water Potential). The movement of a pure solvent to equalize solute concentrations on each side of a membrane generates osmotic pressure.

2.1.2. The stages in a reverse osmosis

Below (figure 2.1) is a simplified and exploded diagram of a typical 4-stage reverse osmosis system. The stages have been numbered and the arrows show the directional flow of the water as it moves through the system. A larger diagram of the membrane is featured at the bottom to show its many layers, the component of the system that makes it a 'reverse osmosis' system.

A. Sediment pre-filter

Melt Blown Polypropylene removes **dirt, rust** and **sediment** particles down to **5 microns**. There are several different types of sediment cartridges. Pleated filters feature increased surface area and longer life. These cartridges are washable and reusable. Melt blown polypropylene filters are designed for the removal of dirt, rust and sediment from water. 5 and 20 micron are the most popular sizes for drinking water applications. String wound filters are an inexpensive solution to your filtration needs. These cartridges come in a variety of media types and have a wide range of applications.

B. Carbon pre-filter

Coconut Shell Carbon Block Cartridge(s), **10 Micron** removes chlorine, taste, odor and chemical contaminants. Activated carbon block filters typically have a 0.5 to 10 micron filtration capability, making it also helpful for particulate filtration, removing taste and odor from chlorine, insoluble lead reduction, and demonstrating, in some cases, removal of Giardia and Cryptosporidium.

C. Reverse osmosis membrane

Thin Film Composite **(TFC)** rejects (removes) 95% of Total Dissolved Solids **(TDS)** down to 0.0001 Microns. **Thin film composite membranes** (TFC or TFM) are semi permeable membranes manufactured principally for use in water purification or water desalination systems.

D. Post carbon filter

Coconut Shell Activated Carbon (CSAC) is the final polishing filter after storage tank, just before you use the water. Inline post filters typically clip onto the top of a reverse osmosis system's membrane housing. The post filter **removes any chlorine** or contaminants missed by the other cartridges or membrane.

2.1.3. Makes up a reverse osmosis

The following components make up your reverse osmosis system (figure 2.1.).

- **Reverse osmosis module**; The **RO module** is the main component and holds the pre-filters and membrane, and post filter. A bracket is provided so they can be mounted under the sink or in a basement.
- **Feed water valve**: **feed water valve** connects to the cold water line to supply water to the RO system. This valve comes in several different types. An **angle stop valve** screws onto the cold water line directly above the cold water shut-off valve. A **faucet adaptor** connects to the cold water line just below an existing faucet. A **self-piercing valve** clamps onto the cold water line and makes a small puncture in the pipe.
- **Pre-filter #1;** Melt Blown Polypropylene filter removes larger particles such as dirt, rust & sediment.
- **Pre-filter #2**; (And #3 If Applicable) 10 Micron Carbon Block removes chlorine and chemical contaminants in the feed water and protects the RO membrane.
- **Automatic shut-off valve; Automatic shut-off valve** closes when the storage tank is full and shuts off the water supply to conserve water. The valve activates when the tank pressure is 2/3 of the feed pressure.

- **Membrane**; **Reverse Osmosis Membrane** Thin Film Composite Membranes reduces dissolved minerals, metals, and salts. In this process, the membrane from the water separates harmful compounds, and the contaminants are flushed to the drain.
- **Drain valve**; **Wastewater saddle valve** connects to the drain to remove reject water from the RO system.
- **Post filter**; A coconut shell activated carbon **post filter** is provided for a final "polish" and to remove tastes, odors and to provide great tasting water**.**
- **Bladder storage tank**; **Bladder tank** holds RO purified water, ready to use.
- **Drinking water faucet;** The **RO Faucet** is used to distribute purified water when you want it.
- **Tubing**; **Tubing** connects all RO components.
- **Quick-connect fittings**; **Quick-Connect fittings** are used for necessary tubing connections. See: Instructions for Quick-Connect Fittings.

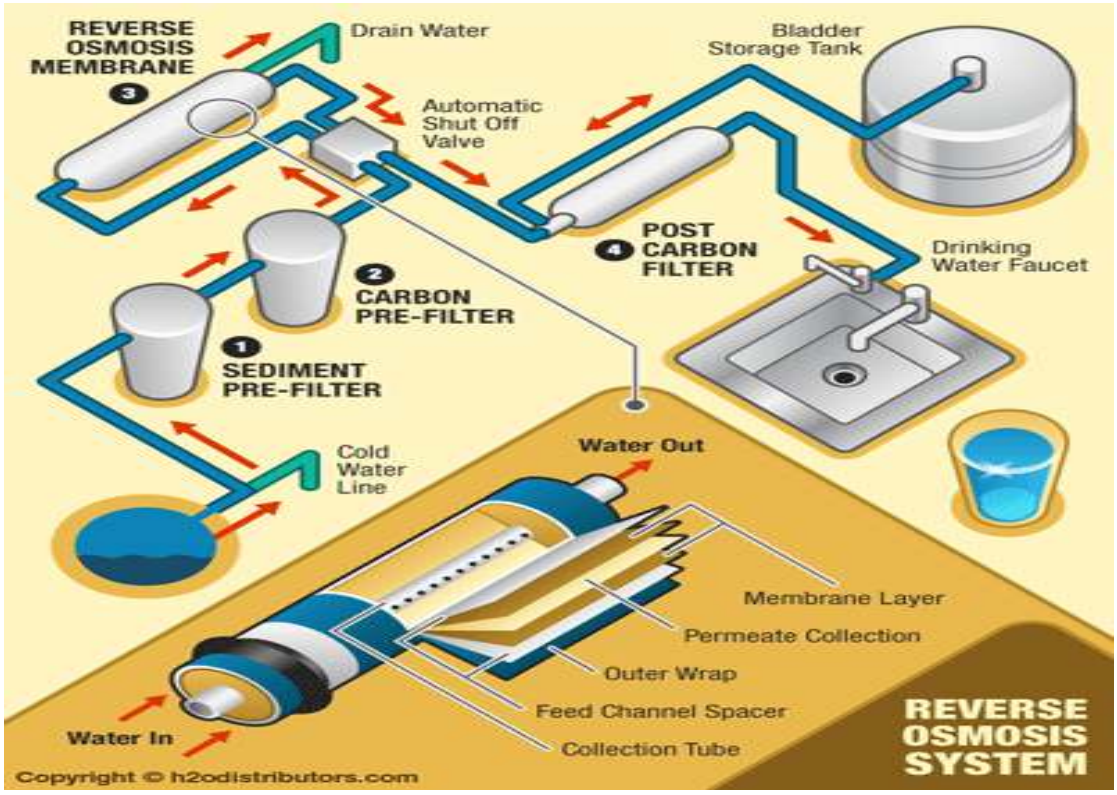


Figure 2.1: Over view reverse osmosis system

2.2. Monitoring equipment

2.2.1. Reverse osmosis (RO) systems

The RO membrane is the focal point of a reverse osmosis system, but an RO system also includes other types of filtration. RO systems are made up of 3, 4, or 5 stages of filtration**.** Every ROS contains a sediment filter and a carbon filter in addition to the RO membrane. The filters are called either prefilters or postfilters depending on whether water passes through them before or after it passes through the membrane. Each type of system contains one or more of the following filters:

A. **Sediment filter**: Reduces particles like dirt, dust, and rust
B. **Carbon filter**: Reduces volatile organic compounds (VOCs), chlorine, and other contaminants that give water a bad taste or odor
C. **Semi-permeable membrane**: Removes up to 98% of total dissolved solids (TDS)

When water first enters an RO system, it goes through pre filtration. Pre filtration typically includes a carbon filter and a sediment filter to remove sediment and chlorine that could clog or damage the RO membrane. Next, water goes through the reverse osmosis membrane where dissolved particles, even too small to be seen with an electron microscope, are removed. After filtration, water flows to the storage tank, where it is held until needed. A reverse osmosis system continues to filter water until the storage tank is full and then shuts off. Once you turn on your drinking water faucet, water comes out of the storage tank through another post filter to polish drinking water before it gets to your faucet.

2.2.3. Maintain reverse osmosis system.

Maintaining an industrial ROS involves replacing essential filters to prevent clogging. The individual responsible for maintaining an industrial reverse osmosis system will need to keep track of each filter in the following phases:

- **Phase 1: pre-filter;** during this phase reverse osmosis, water passes through a pre-filter to protect fragile reverse osmosis membranes. Pre-filters filtrate sediments such as sand, dirt, silt and other particles. Individuals should change the pre-filter every six to nine months to prevent it from clogging. If this filter becomes clogged, it can cause the pre-

filter to collapse or cause particulates to enter the membranes. The person responsible for maintaining an RO system should create a schedule to regularly change the pre-filter.

- **Phase 2: carbon filter:** During phase 2 of reverse osmosis, water passes through a carbon filter. The carbon filter removes chlorine and some total organic carbon (TOC). An individual responsible for an RO system should maintain the carbon filter, testing for chlorine should be done daily. The carbon filter maintenance schedule should be followed per your water treatment guidelines. Chlorine can cause irreversible damage to the RO membranes.

- **Phase 3: RO membrane:** In this the reverse osmosis phase. During this phase, strong pressure pushes water through the RO membrane. After the water passes through, the membrane holds contaminants on one side while pressure pushes the water back through the membrane to the previous side. Water travels through the membrane at approximately two drops per second, which is 35 pounds for every square inch. Contaminants travel down the drain after the membrane catches them. The filter and membrane's lifespan will vary based on facility use and water quality, but the person responsible for maintaining the system should clean the RO membranes when needed and try to replace the RO membrane every two to three years.

2.3. Identifying and reporting equipment operation

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

- Check that the machine is complete, with all safeguards fitted, and free from defects**.** The term 'safeguarding' includes guards, interlocks, two-hand controls, light guards, pressure-sensitive mats etc. National legislation often requires the supplier to provide the right safeguards and inform buyers of any risks ('residual risks') that users need to be aware of and manage because they could not be designed out.
- Produce a safe system of work for using and maintaining the machine. Maintenance may require the inspection of critical features where deterioration would cause a risk. They

should also look at the residual risks identified by the manufacturer in the information/instructions provided with the machine and make sure they are included in the safe system of work.

- Ensure every static machine has been installed properly and is stable (usually fixed down).
- Choose the right machine for the job and do not put machines where customers or visitors may be exposed to rise.

Listed below are examples of tasks that might be included in your Operations and Maintenance Manual and instructions to persons involved in servicing your water supply equipment system. Use these check lists only as examples for creating your own lists appropriate to your system.

Table 2.1: Reverse Osmosis maintenance check list

√	Maintenance checklist operation	Description
	Visual Inspection	Visual inspection, check all tubing, gaskets, fittings and solenoids for leaks and wear. Clean all external surfaces.
	1-micron filters	Change filters at predetermined time frame or when pressure drop is greater than 8-10 psi.
	Control Panel	Isolate panel, visually check for overheating, check tightness of all terminals and clean panel interior
	High Pressure Pump	Check for vibration, overheating in the bearing frame, mechanical seal leaks. Check oil levels where applicable.
	Horse power (HP) Pump Motor	Visually check motor for vibration and temperature. Grease Bearings.
	Conductivity Sensor	Remove, clean and perform calibration using standard solution.
	Oxidation reaction potentials (ORP) Sensor	Remove and clean ORP probe
	pH Sensor	Remove and clean pH probe. Calibrate in solution standards. Replacement may be required as often as every 6 months
	Flow Sensors	Verify slow sensor settings.
	Pressure Transmitter	Verify pressure transmitters against local gauges.
	Pressure Gauge	Visually check all pressure gauges for leaks and accuracy
	Pressure Switch	Verify operation- alarm at set-point
	Temperature Transmitter	Verify temperature transmitters
	Membrane Change	Change membranes. Sanitize machine interior and all permeate
	valves	Check all valves for leaks and wear. Be aware of valve ages- valve
	Detergent Clean-in-Place	Maintenance program may be required.
	Silt Density Index	Detergent Clean with low and high pH cleaner. (Membrane type must be determined before conducting cleaning.) Conduct Silt Density Index at RO Inlet
	Tri-Clamps	Check for leaks at tri-clamp fittings- tighten or re-sent where necessary

2.4. Monitoring the process of purified water produced.

2.4.1. Equipment performance calculations (RO)

There are a handful of calculations that are used to judge the performance of an RO system and for design considerations. To accurately measure the performance of an RO system you need the following operation parameters at a minimum:

A. Salt rejection %

This equation tells you how effective the RO membranes are removing contaminants. It does not tell you how each individual membrane is performing, but rather how the system overall on average is performing. A well---designed RO system with properly functioning RO membranes will reject 95% to 99% of most feed water contaminants (that are of a certain size and charge). You can determine how effective the RO membranes are at removing contaminants by using the following equation:

$$\text{Salt Rejection \%} = \frac{\text{Conductivity of Feed Water} - \text{Conductivity of Permeate Water} \times 100}{\text{Conductivity of Feed}}$$

The higher the salt rejection, the better the system is performing. A low salt rejection can mean that the membranes require cleaning or replacement.

I. Salt passage %

This is simply the inverse of salt rejection described in the previous equation. This is the amount of salts expressed as a percentage that are passing through the RO system. The lower the salt passage, the better the system is performing. A high salt passage can mean that the membranes require cleaning or replacement.

$$\text{Salt Passage \%} = (1 - \text{Salt Rejection\%})$$

Recovery %

Recovery is the amount of water that is being 'recovered' as good permeate water. Another way to think of recovery is the amount of water that is not sent to drain as concentrate, but rather collected as permeate or product water. The higher the recovery means that you are sending less water to drain as concentrate and saving more permeate water. However, if the recovery is too high for the RO design, then it can lead to larger problems due to scaling and fouling. The recovery for an RO system is established with the help of design software taking into consideration numerous factors such as feed water chemistry and RO pre--treatment before the RO system. Therefore, the proper recovery at which an RO should operate at depends on what it was designed for. By calculating the recovery, you can quickly determine if the system is operating outside of the intended design. The calculation for recovery is below and is expressed as a percentage.

$$\% \text{ Recovery} = \frac{\text{Permeate Flow Rate (gpm)} \times 100}{\text{Feed Flow Rate (gpm)}}$$

For example, if the recovery rate is 75% then this means that for every 100 gallons of feed water that enter the RO system, you are recovering 75 gallons as usable permeate water and 25 gallons are going to drain as concentrate. Industrial RO systems typically run anywhere from 50% to 85% recovery depending on the feed water characteristics and other design considerations.

2.4.2. Calculate the Uv dose

A. UV dosing

UV at 254nm is usually a dose in the range of 40mJ/cm^2. This is high enough to destroy the DNA of microbes such as E.coli, Salmonella, Hepatitis virus, Poliovirus and Rotavirus. You will need to consider the distance of the water from the UV lamp and the process of the treatment cycle. Does the water pass over the lamp once or does it recalculate? This will usually depend on the purpose of your treated water. Drinking water, water for swimming pools or aquaculture requires a different UV system setup for each process.

B. Water quality

The quality of the water is also significant as it can affect the Ultraviolet Transmittance (UVT)**, t**his is the measurement of UV that can pass through a water sample. Several factors can affect UVT including the water source, water turbidity and the level of organic compounds within the water. There is commonly used formula to calculate the UV dose you will need for disinfection.

UV Dose = UV Intensity (μW/cm2) x Exposure Time (seconds)

C. Disinfection effectiveness

Log inactivation: The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) listed the following UV doses required for 2-log inactivation of target pathogens:

- Cryptosporidium - 5.8 millijoules per square centimeter (mJ/cm2)
- Giardia - 5.2 mJ/cm2
- Viruses - 100 mJ/cm2

2.5. Identifying, correct and reporting out-of-specification process

I. Fix the reverse osmosis system

A. No, slow, or very little water

- Permeate flow rate: Close the tank valve, and then open the faucet handle. After a steady drip begins, measure the output for 60 seconds.
- Drain flow rate: Disconnect the tubing connection where the 3/8 tube hooks to the drain line. Allow it to run into a large measuring cup for 30 seconds.
- Feed pressure: At this point, recording what the feed pressure is in your system would help, but that may not be possible. If you're installing your system for the first time, there's no set pressure reading to go on, but this could be part of the issue.
- Tank pressure: A simple tire gauge applied to the air valve under a blue cap on the side of the tank will give a close reading. It should be 5-7 psi-power square inch.
- Improper hook up: Look at pictures of installation that show feed connection and drain connection.

B. The RO storage tank; Check the tank to see if it's full of water or not. If it's full, open the faucet and check the flow rate. If nothing is flowing, check to make sure the valve is in the open position (handle in line with the tubing). If everything looks right, check to see if any pressure is in the tank with a tire pressure gauge. If none, add pressure with a bicycle pump with the faucet open until the tank empties. Once the tank is emptied, regulate the pressure to 5-7 psi. If water spurts out when checking for pressure, then the tank's diaphragm has lost integrity, and the tank should be replaced.

If the tank is full and pressure exceeds 20-25 psi, with no water to the faucet, make sure the tank is functioning. First, turn off the tank valve, then, disconnect the tank tube from the RO system and see if water flows into a bucket when the valve is on. If so, check the post filter to make sure it's not clogged.

C. **Constant run to the drain;** The reverse osmosis system shuts down when tank pressure reaches 2/3 of supply line pressure and the automatic shut-off (ASO) valve closes. Constant water running to the drain simply means that the ASO is not shutting off. The ASO operates if the membrane, flow restrictor, tank, and check valve are all performing properly. You can test this quickly by turning the tank valve off to see if the ASO stops water flow to the drain. This may tank a few minutes depending on membrane output.

❖ **Possible causes:**

- **Flow restrictor** is missing or failed. Flow rate test should identify a large amount of water to the drain, this is accompanied by lots of noise.
- **Tank** is not filling enough to build needed pressure. A flow rate test should identify if there is a membrane production issue.
- **ASO valve** is stuck in a closed position. This problem is solved by completely disconnecting the valve to make sure all pressure is off the assembly.
- **Check valve** is bleeding pressure, preventing the system from reaching shut off pressure. Test this with a full tank of water while the tank valve is open. Turn the water supply off. If the water still flows to the drain, then

the check valve is bleeding pressure. This type of failure is unusual, but still important to look for.

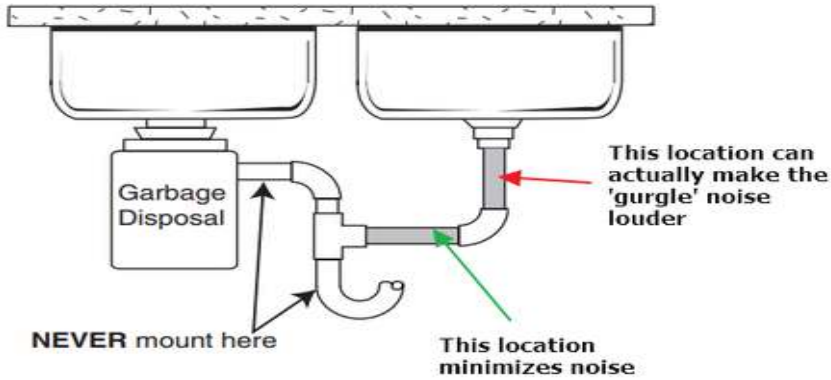


Figure 2.2: Valve system

D. **Noisy gurgle;** Loud, noisy water running to the drain is typically the result of too much water to the drain. Use the drain flow rate test to identify this problem. The location of the drain saddle could be another contributor. Locating the saddle on the crossover is best for noise reduction since a pipe placed directly under the sink may produce amplified sound. However, an RO system will always make some noise when it runs over.

E. **Taste and odor;** Taste and odor are mostly associated with filters that need changing, a complete tank and system sanitation need, or a membrane failure (from high TDS breakthrough). A well water application that may contain dissolved gas, like hydrogen sulfide or methane (rotten egg smell) will concentrate and enhance the odor. It's possible that you may not know you have a hydrogen sulfide issue until it concentrates through the membrane. On-board carbon filtration will not hold gases for long, so you may not detect an odor in a new system for several days. These issues must be corrected prior to installing a new reverse osmosis system.

F. **Leaks from a faucet air gap;** These leaks are common in newly installed RO systems. The air gap directs water from the RO system through an air gap or backflow preventer on the way to the drain. Water flows from the air gap to the drain by gravity alone. Leaving too much tubing on this connection is the most common installation error. If the tubing is not as straight as possible to the drain saddle connection, water will come out of the air gap hole in the base of the faucet, especially with declined and inclined connections.

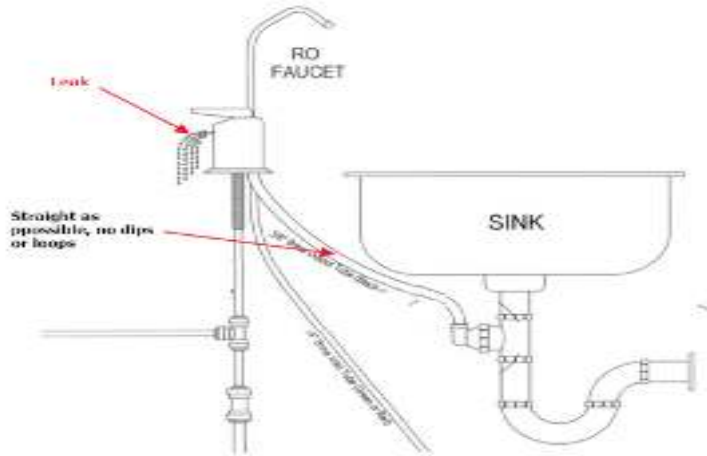


Figure 2.3: Faucet system

Other causes for system malfunction could include a clogged drain line or connection where the tube attaches to the drain. This can happen over time as debris collects in the base of the fitting. If all is clear, then make sure the hole in the drain line itself is in line with the saddle fitting.

G. Drain flow rate

To determine whether you have the right amount of flow restriction to provide the driving force pressure, disconnect the drain line where it connects to the drain saddle. Point the open tube into a bucket and then measure the water with a large measuring cup for 30 seconds. Multiply the results by two and compare the drain flow rate numbers to the chart above.

II. Determine the results

- **Both results are within the acceptable range:** The problems are not the pressure, membrane, or prefilters. The membrane has adequate pressure and flow and no clogs.

- **Both results are equally below the acceptable range:** If the system's design allows, remove the profilers from their housings and run the flow rate test again. If there is not change, you may have a pressure problem. If the flow rates return to the acceptable range, then you need to replace your profilers.
- **The drain flow rate is close, but the permeate flow rate is next to nothing:** This could be an indication that the membrane has calcified or is scaled with hardness or the has fouled. It should be replaced, and additional pre-treatment may be required. This could also indicate high TDS and low pressure. The higher the TDS, the more pressure is needed to create reverse osmosis.
- **Drain flow rate is beyond acceptable, but the permeate flow is next to nothing:** Check to see if the flow restrictor is in place. If the restrictor has failed or is lacking driving force pressure to the membrane, then the membrane will not produce water.
- **Both the drain and permeate flows is zero:** Check pre filters and make sure the water supply is on. Then, disconnect the feed line where it connects to the inlet of the system to ensure that the system is receiving water. To do so, turn the water off and disconnect the tubing. Point the tubing into a bucket as you turn the water back on.
- **Fitting or housing leaks**, Housing leaks are usually O-ring related. Either the O-ring is not where it should be, or it has been compromised. Reused O-rings may stretch when removing the housing to change filters. It's always a good idea to have an extra set of O-rings and some silicon O-ring lubricant on hand.

- **Fitting the leak**
  - ✓ **Tubing is not pushed fully into the fitting to create a proper seal.** Small diameter tubes, such as 1/4 and 3/4 will insert nearly 1" into the fitting. To ensure the seal, make a mark on the end of the tubing at 3/4", and make sure the line disappears when the tubing is inserted.
  - ✓ **Tubing was not cut straight.** Thus, it did not pass through the internal O-ring for a proper seal.
  - ✓ **A deep scratch on the tubing is allowing water to pass through.** Each time tubing is inserted then released from fittings, the tubing gets scratched. Eventually, these scratches become deep enough that the O-ring can no longer

seal it completely. It's a good idea to replace any worn or scratched tubing that inserts into a fitting.

2.6. Maintaining work area

2.61. Workplace safety

A number of measures related to workplace layout and design can be effective in minimizing accidents. One such measure is to ensure that machines are firmly fixed on an even surface and that there is adequate space around them for workers to perform their tasks safely. The provision of adequate work space for workers who handle sharp hand tools is particularly important in order to prevent injuries to those working around them.

2.6.2. Good housekeeping

Keeping the workplace tidy and orderly is a simple yet fundamental principle for ensuring the safety and health of the workers. Tools, especially

- Dangerous hand tools, must not be left lying around, or hidden beneath other objects
- Once used, they need to be cleaned and returned to their proper positions. Passageways and staircases should be cleared of obstacles
- Even if boxes and crates are stacked in the appropriate area, the piles have to be stable, with the heaviest items at the bottom.
- If stacks are unstable, they should be tied with a rope to prevent them from falling. The floors and passageways need to be kept as grease-free and dry as possible in order to prevent any falls and slips.
- Should they become wet or slippery during the course of work, they need to be cleaned and mopped as frequently as necessary.

Solvents, acids, alkalis, chemical substances used as cleaning agents and other caustic materials are used if frequently in the food and drink industries. It is essential that suppliers' labels are not removed, defaced, modified or altered. In order to avoid any risk of misunderstanding, the substances should never be transferred to other containers, nor should they be stored together with foodstuffs. In the context of good housekeeping at the workplace, almost more than any of the other areas covered in this paper, it is clear that a little common sense can go a long way towards preventing accidents.

2.6.3. Maintenance of electrical installations

Although electrocution is not reported as frequently as some other types of accidents in the food and drink industries, the risk is constantly present, particularly in view of the abundant use of water around machines. The basic rules in this context include:

- The proper installation of all electrical equipment, including grounding; periodical maintenance by a competent electrician;
- The checking of wires for cracking and fraying; the use of appropriate fuses;
- The use of splash proof, hose proof or watertight equipment where there is a danger of contact with water during the operation or cleaning of machinery;
- and the installation of an adequate number of sockets and outlets to minimize the need for trailing cables.
- Faulty wiring and inadequate maintenance of electrical installations can result in burns, fires and even loss of life.

A. Lighting

The best lighting is natural light from windows. The recommended size of window-area is one-tenth of the room area. However, artificial -lighting is evidently necessary at certain times of the day, in certain weather conditions and during specific seasons, particularly in large plants, even if there are no night shifts·. The light levels suggested by law vary between countries. The following are some examples

.

B. Personal protective equipment

Labor legislation in many countries provides that it is the duty of the employer to provide personal protective equipment to workers engaged in hazardous tasks. Under this legislation, workers who handle dangerous hand tools and machines, under extreme temperatures, handle hazardous substances or run the risk of inhaling such substances, or are exposed to radiation, have to be provided with appropriate protective equipment and have the duty to utilize them properly. Personal protective equipment is clearly essential in protecting workers from risks at the workplace. However, such equipment should be regarded only as supplementary protection. The main challenge facing any industry is to eliminate.

2.7. Conducting works

2.7.1. Working environment

Your working environment is affected by factors including health and safety, security and working hours. A poor working environment can damage your health and put your safety at risk. Operator is legally responsible for ensuring good working conditions, but you also have a responsibility to work safely.

2.7.2. Clarification of work procedure requirement

Before allowing start to use any machine think about;

- What risks there are
- How these managed. So, you should:
- Check complete with all:
  - ✓ Safeguards fitted
  - ✓ Free from defects.

A. Safety program

Make sure the machine/ equipment safe for any work during:

- ✓ Setting up
- ✓ During normal use
- ✓ Clearing blockages
- ✓ Carrying out repairs for breakdowns
- ✓ Planned maintenance
- ✓ Properly switched off
- ✓ Isolated
- ✓ Locked-off before taking any action to remove blockages, clean or adjust the machine.

B. Written safety rules

A set of basic rules for your operation as well as specialized safety rules for specific tasks, equipment or processes need to be developed. The list should not be long and unmanageable. Rules should be simple and easy to understand and may need to translate into a worker's language. The rules should reviewed with all new employees, as well as posted for all employees to see Identify and deal with the risks from:

- Electrical

- hydraulic or pneumatic power supplies
- Badly designed safeguards
- Inconvenient to use or easily overridden, which could encourage your workers to
  - ✓ Risk injury
  - ✓ Break the law.
  - ✓ Find out why they are doing it and take appropriate action to deal with the reasons/causes.

C. Safety director/coordinator

Need to appoint someone to look after safety as a part of job. Want to have a safety committee or safety representatives from both workers and management. This will keep safety out front all the time.

D. Employee training

- Employees should receive periodic training as necessary to review safety procedures.
- New employees should receive safety training both before and on the job.
- Close -calls or accidents should trigger an immediate review of procedures and safety with employees.

E. Workplace inspection

- System of workplace inspection should be set up to review hazards and practices in the workplace.
- Any time that there is a new process introduced or new machinery installed, an inspection should take place
- Employees should be encouraged to report hazards, close calls or anything out of the ordinary that could lead to

F. Injury Emergency Plan

- There should be an emergency plan for any accident, fire, disaster or other unexpected event that may occur
- Employees should know what their responsibilities are during an emergency.
- Plan could include what to do during fires, power failures etc.
- Documentation important
  - ✓ To keep records of training
  - ✓ Safety meetings/concerns
  - ✓ Corrective actions for accident investigations etc. as “Due Diligence”

2.8. Maintaining workplace records

Records are observations, measurements, and other data recorded manually or by means of monitoring equipment, to document the devotion to critical limits or other processes requires Records are the collected information produced by the industry in the process of performing and reporting industry operation. Characteristics of records are that they:

- Need to be easily retrieved or accessed;
- Contain information that is permanent, and does not require updating.

2.8.1. All Records should be

- Legible and clear
- Dated
- Readily identifiable and retrievable;
- Carry authorization status;
- Retained for a designated period;
- Protected from damage and deterioration while storage.
- All calculations should be duly recorded

2.8.2. Recording information

Records are observations, measurements, and other data recorded manually or by means of monitoring equipment, to document the devotion to critical limits or other processes requires. Records are a tool used to confirm that things are working effectively. Records can:

- Provide a means to track/path and review deviations
- Identify the root cause of an issue
- Help improve a process
- Identify trends/tendencies indicating that a process is moving towards deviation

2.8.3. Production batch records

Documentation is the electronic or written record of all information regarding methods, conduct, and/or results of industry work; the factors affecting results of industry work; and the regular or corrective actions taken. Batch records should include documentation that each significant step in the production of the batch was accomplished including;

- Specific identification of each batch, including
- materials used during manufacturing
- Reagent record

- Identity of major equipment used;
  - ✓ COA records
  - ✓ Equipment log

Good records enable one to track all activities performed during batch manufacture, from the receipt of raw materials to the final product release; they provide:

- History of the batch
- Distribution
- Essential part of GMP to keep accurate records,

2.8.4. Signing all records

- The initials or signature of the person who performs each test and the date the tests were performed;
- The initials or signature of a second person verifying for:
  - ✓ Accuracy
  - ✓ Completeness
  - ✓ Compliance with established standards
- The initials or signature of a person (supervisor/QA) reviewing the document.

2.8.5. Communicating recorded information

Communication is the transfer of facts, ideas, opinions, feelings and information from one person or group to another. It is how we come to know and understand everything around us.

2.8.5.1. Operator communicate and seeking advice from supervisor to fulfil the job

- How to collect samples and conduct tests
- How to take corrective action.
- operational health and safety (OHS) hazards and controls
- common causes of variation and corrective action required
- Good Manufacturing Practice (GMP
- Inspection or test points (control points) in the water purification process
- Basic operating principles of process control
- Basic operating principles of equipment and main equipment components
- Workplace information such as;

- ✓ Standard Operating Procedures (SOPs)
- ✓ Specifications
- ✓ Production schedules and instructions
- ✓ Manufacturers' advice
- ✓ Standard forms and reports
- ✓ Critical control points

Self-check 2	Written test

Full names Name…… ID…… Date…….

Directions: Answer the following Question accordingly to the instructions

Test I: Choose the best answer (4 point)

1. Which of the following is a part of ROS system?
   F. Sediment pre-filter
   G. Carbon pre-filter
   H. Reverse osmosis membrane
   I. Post carbon filter
   J. All of the above
2. Which one is not a filter system of RO?
   A. Sediment filter
   B. Carbon filter
   C. Semi-permeable membrane
   D. Automatic shut of valve
3. Which one not daily check practice for operation?
   A. Inspect well pumps, motors, and controls.
   B. Conduct weekly security check.
   C. Inspect chlorine and fluoride testing equipment.

Test II: Short Answer Questions (2 points)

4. What means good housekeeping practice of food processing plants?
5. What are thing to be consider in matinee period your equipments?
6. What it mean by GMP?

Note: Satisfactory rating 9 points Unsatisfactory below 9 points

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

Operation sheet-2

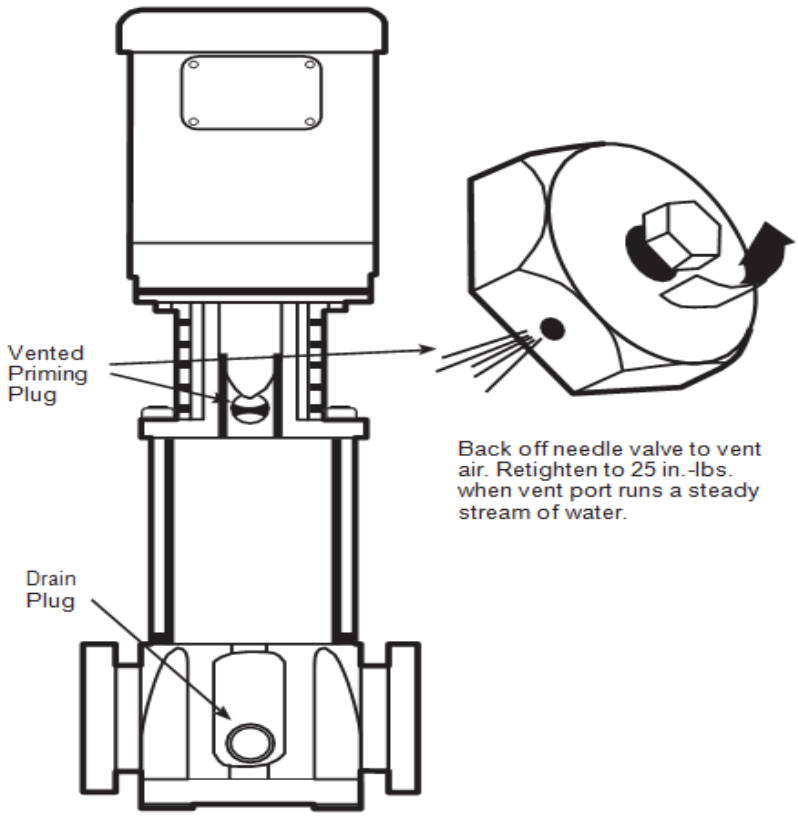
2.1. Techniques/Procedures/Methods operating reverse osmosis systems

A. Tools and equipments

- Smart Glasses
- Respiratory Equipment
- Cooling PPE
- Flame & Water-Resistant Clothing
- Home-Testing Kits
- Smart Cameras
- Smart Helmets
- Cut-Resistant Gloves
- Slip-Resistant Gloves
- Contact-Tracing
- Fatigue Monitoring
- Series PWR4021

B. Procedures/Steps/Techniques/pre starting of ROS equipments

1. A safety switch or fused disconnect should be installed within 10 feet of the system
2. Verify that the disconnect switch is de-energized using a voltmeter
3. Connect the outlet of the disconnect switch to the terminals on top of the motor starter Attach the power supply ground to the chassis ground, Check the pump motor nameplate for the amper- age draw at various voltages to determine the wire size required, do not apply power tothe RO unit at this time.



C. Operation procedures

1. Verify that no free chlorine is present in the feed water.
2. Verify that the pump discharge valve (Figure 2.4.item D)
3. Install a 20" five micron filter cartridge in the prefilter housing (Figure 2.4.item k)
4. Open the reject control valve completely counterclockwise (Figure 2.4 item K)
5. Close the reject recycle control valve completely by turning it clockwise (Figure 2.4.item C)
6. Open the feed water shutoff valve installed in step III-B-1 above.
7. Open the inlet solenoid valve by turning the white lever located near the valve outlet (Figure 2.4.item L)
8. Ensuring water flow through the system and to drain through the reject flow (Figure 2.4.item H)
9. Close the inlet solenoid valve after the air has been purged from the system, after 10 minutes, whichever occurs first
10. Close the pump discharge valve half way (Figure 2.4.item D)
11. Engage the safety switch or disconnect and apply electrical power to the RO system.
12. Press the on/off button on the controller.
13. Verify proper pump rotation before continuing.
14. Turn the system on.
15. Allow the product water to flow to drain for 30 minutes.

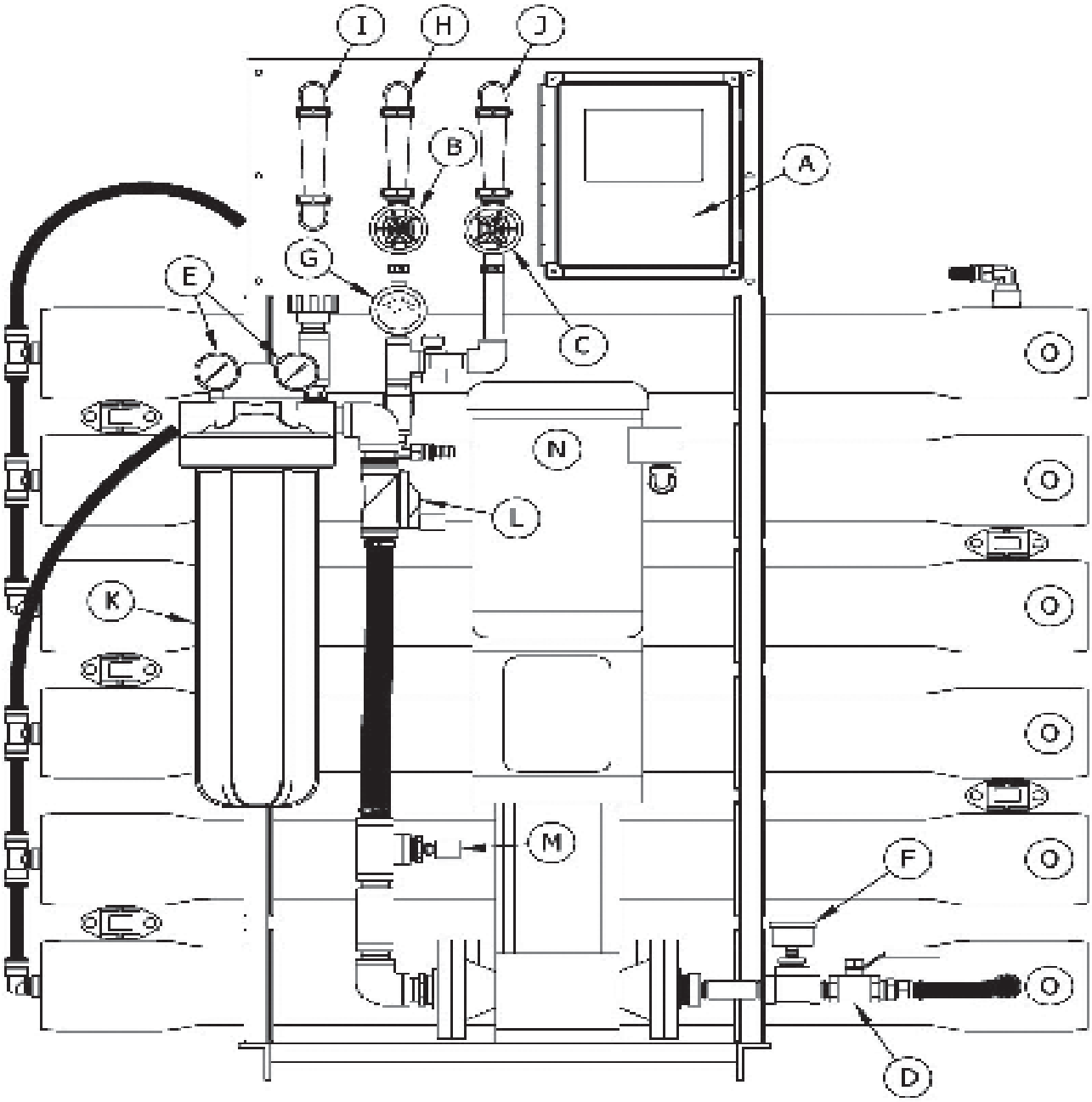


Figure 2.4.: Reverse Osmosis Systems of Series PWR4021

LAP Test-2	Performance Test

Full Name…….…… ID…… Date……...

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1.5** hour. The project is will expected from each student to do it.

Task 1: Apply ROS water purification process on series PWR4021 equipments

LG # 30	LO 3: Shut down the water purification process

Instruction sheet-3

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

- Identifying appropriate shut down procedure
- Shutting down the process
- Completing workplace documentation
- Identifying and reporting maintenance requirements

Carrying out pre-start check 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**:

- Identify appropriate shut down procedure
- Shute down the process
- Complete workplace documentation
- Identify and reporting maintenance requirements

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.
4. Accomplish the “Self-Checks” which are placed following all information sheets.
5. If you earned a satisfactory evaluation, proceed to “Operation Sheets.
6. Perform “the LAP Test” which is placed following “Operation sheets”.
7. If your performance is satisfactory, proceed to the next Learning Guide.

Information sheet -3

3.1. Identifying appropriate shut down procedure

Process shutdown (PSD) definition: Process shutdown (PSD) is defined as the automatic isolation and the activation of all part of a process. During a PSD the process remain pressurized. Typical action from PSD systems are:

A. Shutdown the whole process
B. Shutdown part of the process
C. Depressurize/Blow down parts of the process

3.1.2. Emergency Shutdown (ESD) definition

The Emergency Shutdown (ESD) shall minimize the consequences of emergencies, related to typically uncontrolled flooding, escape of hydrocarbons, or outbreak of fire in hydrocarbon carrying areas or areas, which may otherwise be hazardous.

3.1.3. SD vs ESD

Process shutdown (PSD) system is a part of plant (facility) safeguarding system with a purpose to minimize the frequency and consequences of excursions outside the facility-operating envelope. Emergency shutdown (ESD) system is a part of plant (facility) safeguarding system with a purpose to keep the process within the design.

3.1.3. Identifying appropriate shut down procedure

Shut down/isolation means and includes isolation of mechanical, electrical drives, pipework (pressure) rotating equipment etc. utilizing electrical lock-off isolators, mechanical and power driven valves etc. in accordance with standard operating instructions. Relevant regulations

- Shutdown sequence is undertaken safely and to standard operating procedures.
- Machine/equipment is depressurized/emptied/de-energized/bled to standard operating procedures.
- Safe shutdown of machine/equipment verified.
- Safety/security lock-off devices and signage installed to standard operating procedures.

- Machine/equipment is left in clean and safe stat
- When working with tools at height makes sure they cannot fall
- Do not leave power tools switched on when disconnected from their power as unexpected starting will occur when power is re-connected.
- Ensure that cables, power lines, pipes and hoses are not allowed to trail across gangways or work areas
- Check insulation, switches and fuse boxes for possible hazards. Ensure warning signs are clear and easily seen.
- Ensure that correct type of firefighting equipment
- Remove empty cartons, wrappings and other flammable waste as soon as possible

3.2. Shutting down the process

3.2.1. Precautions when reverse osmosis system shut down

- By using treated water, flush the reverse osmosis system to flush out the concentrated water on the surface of membrane to prevent salt precipitation pollution.
- During low-pressure flushing, do not add other chemicals such as inhibitor
- First, please open the product water discharge valve to prevent backpressure
- The drop of flow rate and pressure shall be slow, pay attention to the feed water flow rate should not excced the limit value.

3.2.2. Management during daily shutdown (0-48 hours)

- During the daily shutdown period, shuold flush once every 24 hours to prevent the growth of microorganisms

3.2.3. Management of system shutdown (2-25 days)

- After shutting down, ensure that the pressure vessel is filled with product water produced by RO, and close all inlet valves, concentrated water valves and product water valves to prevent the membrane elements from drying out and the growth of microorganisms.

- When the temperature is greater than 20 degrees Celsius, it is necessary to flush once every 12 hours; when the temperature is less than 20 degrees Celsius, flush once every 24 hours.
- For ground water or water sources with high microbial pollution, the reverse osmosis system shall be flushed with a solution containing 1.0% sodium bisulfate prepared from RO product water. If the membrane elements are soaked with this solution at the same time, the effect will be better. The flushing cycle also shall be extended accordingly.

3.2.4. Management during long-term system shutdown (25 days or more)

- Follow the normal shutdown procedure and flush the system with product water at low pressure.
- It is better to perform a chemical cleaning and sterilization treatment process. After cleaning, flush the system with RO product water at low pressure until the conductivity of the concentrated water is same as feed water.
- Prepare a protective solution containing 1.0% sodium bisulfite with product water produced by reverse osmosis. Rely on the chemical cleaning system to circulate the membrane elements to remove the air from the pressure vessel and completely soak the membrane elements in the protective liquid to prevent the membrane elements from drying. , Close all inlet valves, concentrated valves and product valves, to prevent air from entering and invalidating the protection liquid.
- Check the pH value of the protection liquid every week. When the pH is lower than 3, please replace the protection liquid timely.

3.2.4. Shutdown sequence of reverse osmosis system

- Slowly close the inlet water control valve and open the concentrated water control valve to maintain the designed concentrated water flow
- When the discharge flow of the high pressure pump drops to the minimum flow, stop the operation of high pressure pump
- Adjust the state of the pretreatment dosing device

- Flush the system by RO product water, ensure that the concentrated water is completely removed from the pressure vessel (at this time, concentrated water conductivity = flushing water conductivity)
- When the flushing is completed, close the concentrated water valve and product water valve
- The back pressure of product water side must not exceed 0.07Mpa, reverse osmosis system shall be filled with water, suggest that install a check valve on the concentrated water and product water pipes, to prevent siphoning.
- Ensure that the membrane elements have been kept moist, and have undergone proper disinfection and antifreeze protection during the entire shutdown period
- During the shutdown period, make sure that the temperature and PH value of the preservation solution are in full compliance with the specifications.

3.3 . Completing workplace documentation

Documentation provides the route for auditors to assess the overall quality of operations within a company and the final product. The key to GMP compliance and ensures traceability of all development, manufacturing, and testing activities. Good documentation constitutes an essential part of the quality assurance system. Clearly written procedures prevent.

- Errors resulting from spoken communication
- Clear documentation permits tracing of activities performed
- Must designed, signed, and dated by the appropriate component
- Authorized persons
- Must have clear contents
  - ✓ The title
  - ✓ Nature
  - ✓ Purpose
  - ✓ Clearly stated
  - ✓ Laid out in an orderly fashion
  - ✓ Easily to check
- Documents provide written information about:
  - ✓ Policies
  - ✓ Processes

- ✓ Procedures

3.3.1. Characteristics of documents:

- Communicate information to all persons who need including:
  - ✓ Laboratory staff
  - ✓ Users
  - ✓ Laboratory management personnel;
- Need to be updated or maintained;
- Must change when a policy, process, or procedure changes;

Established formats for recording and reporting information by the use of standardized forms. Once the forms are used to record information, they become records. Some examples of documents include a

- Quality manual
- Standard operating procedures (SOP)
- Job aids

Records are the collected information produced by the laboratory in the process of performing and reporting a laboratory test.

A. **The important of documents;** Documents are the essential guidelines for all of the industry operations. Some of the important documents industry should have include:
B. **Quality Manual;** This is the overall guiding document for the quality system and provides the framework for its design and implementation. Industry is required to have a Quality Manual for ISO accreditation
C. **Standard Operating Procedures (SOP);** Contain systematic written instructions for each procedure performed in the industry. These instructions are essential to ensure that all procedures performed consistently by everyone in the operating processing.

3.4. Identifying and reporting maintenance requirements

3.4.1. Introduction

What is maintenance and why is it performed? Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: “the work

of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order.

3.4.2. The benefits of equipment maintenance procedures

Though you may have a strategy for equipments maintenance, following equipment maintenance procedures is just as important to ensuring fleet efficiency. Developing a set of equipment maintenance procedures for your organization enables you to closely monitor the condition of your small tools and equipment. Tracking equipment health and conducting routine maintenance maximizes uptime and allows you to get the most out of your tools.

3.4.3. Types of maintenance

A. Reactive maintenance

Reactive maintenance is the "run it till it breaks" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached.

- **Advantages**
  - ✓ Low cost.
  - ✓ Less staff
- **Disadvantages**
  - ✓ Increased cost due to unplanned downtime of equipment,
  - ✓ Increased labor cost, especially if overtime is needed,
  - ✓ Cost involved with repair or replacement of equipment.
  - ✓ Possible secondary equipment or process damage from equipment failure,
  - ✓ Inefficient use of staff resource

B. Preventive maintenance

Preventive maintenance can be defined as follows: Actions performed **on a time- or machine-run-based** schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

- **Advantages**
  - ✓ Cost effective in many capital-intensive processes,
  - ✓ Flexibility allows for the adjustment of maintenance periodicity,
  - ✓ Increased component life cycle,
  - ✓ Energy savings,
  - ✓ Reduced equipment or process failure,
  - ✓ Estimated 12% to 18% cost savings over reactive maintenance program.
- **Disadvantages**
  - ✓ Catastrophic failures still likely to occur,
  - ✓ Labor intensive,
  - ✓ Includes performance of unneeded maintenance,
  - ✓ Potential for incidental damage to components in

C. Predictive maintenance

Predictive maintenance can be defined as follows: Measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Results indicate current and future functional capability.

- **Advantages**
  - ✓ Increased component operational life/availability,
  - ✓ Allows for preemptive corrective actions,
  - ✓ Decrease in equipment or process downtime,
  - ✓ Decrease in costs for parts and labor,
  - ✓ Better product quality,
  - ✓ Improved worker and environmental safety,
  - ✓ Improved worker morale,
  - ✓ Energy savings,
  - ✓ Estimated 8% to 12% cost savings over preventive maintenance program.
- **Disadvantages**
  - ✓ Increased investment in diagnostic equipment,
  - ✓ Increased investment in staff training,
  - ✓ Savings potential not readily seen by management

Self-check 3	Written test

Full names Name…… ID…… Date…….

Directions: Answer the following Question accordingly to the instructions

Test I: Choose the best answer (4 point)

1. Witch of the following is not to be considering as precaution of shutdown processing of ROS?
   K. Equipment verification
   L. Safety/security lock-off devices
   M. Machine/equipment in clean and safe stat
   N. When working with tools at height makes sure they cannot fall
   O. None of the above
2. Documentation in the processing plants might incorporate the following.
   E. Policies
   F. Processes
   G. Procedures
   H. All

3. One of the following is not a characteristic of documentation?
   A. Communicate information to all persons who need
   B. Need to be updated or maintained
   C. Must change when a policy, process, or procedure changes
   D. Only clear for protection

Test II: Short Answer Questions (4 points)

1. What is process and emergency shutdown?

Note: Satisfactory rating 9 points Unsatisfactory below 9 points

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