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Ministry of Labor and Skills

Fruit and Vegetable Processing Level-II

Based on June 2021, Version 3 Occupational Standard



Module Title: - Applying Hydro-cooling Processes to Fresh Produce

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Ministry of Labor and Skills

Table of Contents

Introduction to the Module **1**

LO #1 Applying Hydro-cooling Processes to Fresh Produce **2**
- **Instruction sheet** 2
- Information Sheet 1 4
  - Self-cheek 1 23
  - Operation sheet 1 25
  - LAP TEST-1 2

LO #2- Conduct hydro-cooling **3**
- **Instruction sheet** 3
- Information Sheet 2 4
- Self-check 2 32
  - Operation sheet 2 34
  - LAP TEST-2 35

LO #3 Monitor hydro-cooling process **36**
- Instruction sheet 36
- Information Sheet 3 37
- Self-cheek 3 50
  - Operation sheet 3 52
  - LAP TEST-3 3

Reference Materials **4**

Introduction to the Module

This module covers the knowledge, skills and attitude required to participate in processes to identify and assess manual handling, contribute to manual handling risk minimization and plan and conduct manual handling.

LG#3	LO #1 Applying Hydro-cooling Processes to Fresh Produce

Instruction sheet

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

- Identifying Key steps in the process of hydro-cooling.
- Identifying Impact of timing and temperature on the hydro-cooling process.
- Identifying and confirming specific cooling and transfer requirement.
- Determining Consequences of incorrect hydro-cooling.
- Checking and adjusting Equipment performance.
- Carrying out Pre-start checks with workplace requirements.
- Locating goods in correct storage areas to meet storage temperature, stores handling and stock rotation requirements.
- Recording Stores information with workplace requirements

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 Key steps in the process of hydro-cooling.
- Identify Impact of time and temperature on the hydro-cooling process.
- Identify and confirm specific cool and transfer requirement.
- Determine Consequences of incorrect hydro-cooling.
- Check and adjust Equipment performance.
- Carry out Pre-start checks with workplace requirements.
- Locate goods in correct storage areas to meet storage temperature, stores handle and stock rotation requirements.
- Record Stores information with workplace requirements.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”

Information Sheet 1

1.1 Identifying Key steps in the process of hydro-cooling, Cooling

1.1.1 Cooling methods

- **Hydrocooling** ; is essentially the utilization of chilled or cold water for lowering the temperature of a product in bulk or smaller containers before further packing. Hydrocooling is achieved by flooding, spraying, or immersing the product in/with chilled water. There are several different hydrocooler designs in operation commercially. Hydrocooling methods differ in their cooling rates and overall process efficiencies. Differences between the individual techniques are evident by the method of cooling and by the way that produce is moved or placed in the cooler. Various types of hydrocooler are available, some of which include conventional (flood) type, immersion type, and batch type. The flood type hydrocooler cools the packaged product by flooding as it is conveyed through a cooling tunnel. With the batch system, chilled water is sprayed over the product for a certain length of **time,** depending on the season and the incoming product **temperature**. These hydrocoolers have a smaller capacity than conventional hydrocoolers and are therefore less expensive. A frequent complaint about both conventional and batch type hydrocoolers is that cooling by these techniques is not uniformly and hence may leave `hot spots' throughout the load. For hydrocooling to be effective, contact between the water and the product surface must be uniform. This may not be achieved by these design of hydrocoolers as the chilled water may not be evenly distributed throughout the load, resulting in undercooling of some parts. The bulk or immersion type cooler uses a combination of immersion and flood cooling. Loose produce is immersed in cold water, and remains immersed until an inclined conveyor gradually lifts the products out of the water and moves it through an overhead shower. The most rapid hydrocooling is obtained by this cooling technique. It is nearly twice as rapid as conventional hydrocooling methods, due to the fact that moving chilled water completely surrounds the exterior surface of the produce and hence facilitates quicker temperature reduction. The bulk type cooler has the added benefit over the flood type cooler of allowing greater packaging flexibility, i.e. packaging after cooling, and therefore it may be more suitable to a wide range of growers.

In general products hydrocooled should tolerate being wetted and not be damaged by falling water or disinfectants that it may contain, hence hydrocooling is recommended for produce for which washing is part of their market preparation. A risk associated with most hydrocoolers is the decay hazard associated with recirculated water, which leads to the possibility of decay producing organisms accumulating in the system, resulting in the contamination of the cooled produce. To prevent this from occurring, mild disinfectant such as chlorine at concentrations of 100 ppm (measured as hypochlorus acid) or approved phenol compounds are used and therefore produce cooled by this technique must not be affected by the use of these chemicals. One of the chief benefits of hydrocooling is that it is seen to prevent loss of moisture during the cooling process. Another advantage of this technique is that it is very rapid in contrast to other pre-cooling techniques available.

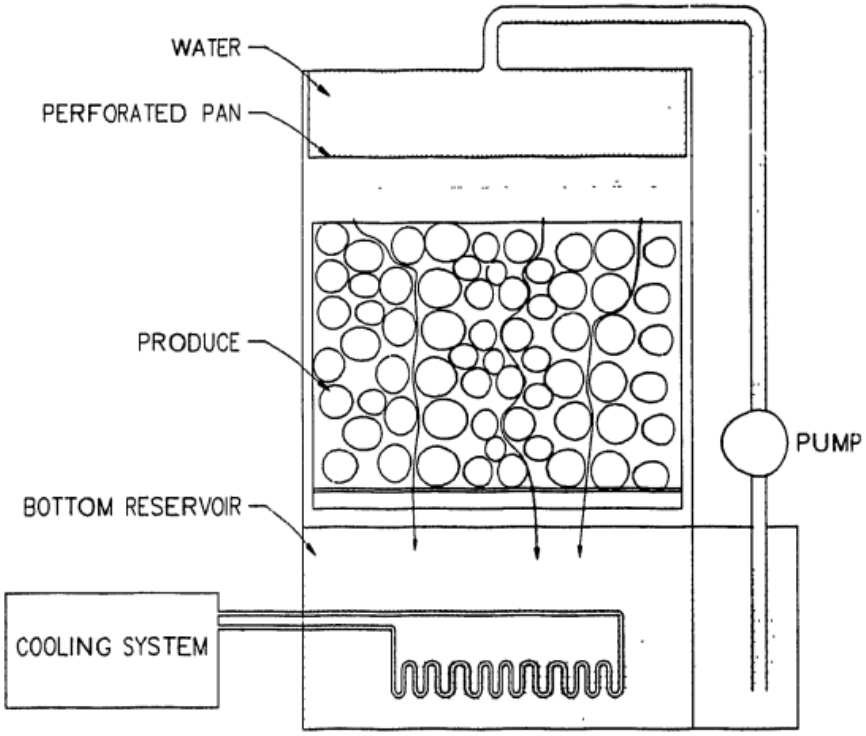


Figure 1.1 Schematic view of a hydrocooler.

Field heat can be removed in 20-30 min using hydrocooling instead of several hours normally needed for forced air-cooling. Hydroair cooling is an important and specialized area of hydrocooling in which a mixture of refrigerated air and water in a fine mist spray is circulated around and through stacks of the produce.

The advantage of hydro-air cooling is the reduced water requirements and the potential for improved sanitation. In hydro-air cooling the ratio of air-water influences the heat transfer capability of the cooling system and the applicability of certain products to this technique Shower coolers distribute water using a perforated metal pan that is flooded with cold water from the refrigeration evaporator. **Shower type** coolers can be built with a moving conveyor for continuous flow operation or they can be operated in a batch mode.



Figure 1.2 Shower type hydrocoolers

Immersion coolers are suited for product that sinks in water. They usually cool slower than shower coolers because water flows at slower rates past the product. Water is a better heat-transfer medium than air and, consequently, hydrocoolers cool produce much faster than forced-air coolers. In well-designed shower coolers, small diameter produce, like cherries, cool in less than 10 min. Large diameter products like melons cool in 45 to 60 min. Immersion coolers usually have longer cooling times than shower coolers because water speed past produce is slower. Packages for hydro-cooled produce must allow vertical water flow and must tolerate water contact. Plastic or wood containers work well in hydrocoolers. Corrugated fiberboard must be wax-dipped to withstand water contact. Hydro-coolers cause no moisture loss in cooling. In fact, they can rehydrate slightly wilted product



Figure1.3 Immersion of water cooler to cool cherries

- **Room cooling**

Room cooling is probably the most widely used refrigeration technique due to its versatility and low cost. However, room-cooled produce must be tolerant of slow heat removal, since much of the cooling is by heat conduction through the container walls. This technique is not considered to be a true precooling method. It involves placing field containers into a room cooled by a refrigeration system. The ventilation system must provide good air circulation through and around the containers

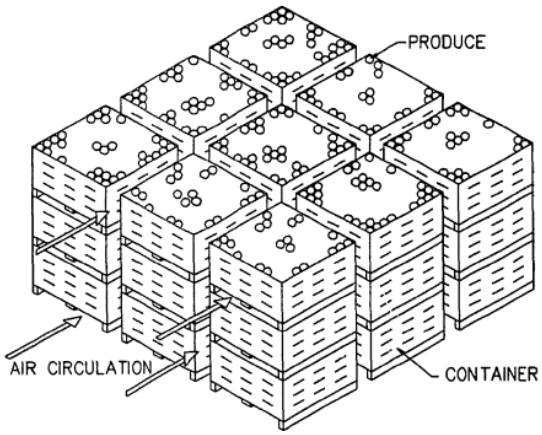


Figure 1.4 Schematic of the air circulation during room cooling.

Cold air from the evaporator enters the room near the ceiling, moves horizontaily under the ceiling, and then sweeps past the produce containers in retuming to the evaporator. For adequate heat removal, the air-flow speed must be at least 1 to 2 mesec-1 and the moving cold air must be in good contact with ail container surfaces, otherwise the centre produce in the containers is not cooled rapidly enough. Container disposition is therefore very important in the handling sequence. Room cooling is best applied to produce having a low respiration rate, a low harvest temperature, and a relatively long storage life and/or which is harvested at the Schematic of the air circulation during room cooling.

- ✓ In room cooling, heat is transferred slowly from the mass of the produce (by convection) to the cold air being circulated around the stacked containers.
- ✓ This is most common and widely used method. Here cold air is passed from the fan and cool by convection process.
- ✓ Its commonest use is for products with relatively long storage life and marketed soon after harvest
- ✓ Advantages of this room air-cooling are that produce can be cooled and stored in the same room without the need of transfer and hence it is economical.
- ✓ Under this system, cold air from evaporator enters the room, moves horizontally and then passed through the produce containers and return to the evaporator
- ✓ Disadvantage
- ✓ It takes more time to cool the products- the removal of heat slowly makes this system unsuitable for highly perishable commodities. This is because the product needs at least 24 hours to reach the required storage temperature.
- ✓ Almost all crops are suitable for this type of cooling but it is mainly used in citrus fruits, potato, onions, garlic, citrus etc.

- **Forced air cooling or pressure cooling**

  - ✓ In this system ‘cold air is passed by force from one side to other side using big fan’.
  - ✓ Cold air movement is through the containers rather than around the containers.
  - ✓ Cooling is 4 to 10 times more rapid than room cooling and its rate depends on airflow and the individual volume of produce
  - ✓ Air is blown at a high velocity leading to desiccation of the crop. To minimize this effect, air is blown through cold water sprays.
  - ✓ It is slow compared to hydro cooling but is a good alternative for crops requiring rapid heat removal which cannot tolerate wetting or chlorine of cooling water.
  - ✓ Adequate airflow is necessary. This is because fruits in the center of packages tend to lose heat at a slower rate, compared to those on the exterior.
  - ✓ This system is also called as high humidifier. High RH of 90 - 95% is to be maintained in the precooler to avoid dehydration during cooling.
  - ✓ This system can be applied to all crops particularly berries, ripe tomatoes, bell peppers and many other fruits, cabbage, green peas, cucumber, brinjal, muskmelon, watermelon and mushroom.
  - ✓ Baby corn : 5 – 6 hr cooling at 2 - 40C,
  - ✓ Leafy vegetables : 1 – 2 hr cooling at 6 - 80C (too low temperature causes chilling injury

- **Ice cooling**

Packing products with ice can provide ‘insurance’ against poor cold-chain practices and may be expected by customers for certain products. However, ice can also cause freezing injury when it is applied, and increase rots and disease if it melts. Using ice is an inefficient method of cooling vegetables.



Figure 1.5 Packed broccoli in ice.

Freeze drying of fruit and vegetable: https://www.youtube.com/watch?v=iG8rpZD-hDo Access date December 2023

Ice can cause freezing damage to broccoli florets (left). If the ice melts, broccoli left sitting in liquid water is likely to split and develop rots (right).

- **Vacuum cooling**

Vacuum cooling involves reducing pressure inside a sealed chamber. Water inside the vegetables turns to vapor, absorbing heat energy. Vacuum cooling works best for products that lose water easily, such as lettuce and baby leaf crops. Hydro-vacuum coolers add a misting system to avoid moisture loss from the product. Vacuum cooling is fast and energy efficient.

Vacuum cooling: https://www.youtube.com/watch?v=x0wFVHv5iJk Access date, **December** 2023

Cooling methods:https://youtube.com/watch?v=J6-Uvn0cD4s Access date **December 2023**

1.2 Identifying Impact of timing and temperature on the hydro-cooling process

High temperature can cause the acceleration of biochemical activities and will result in fruit tissue damage and cause spoilage i.e greater rate of respiration and transpiration rate where it leads to more water loss which eventually contributes in high weight loss. Higher temperatures showed a significantly greater weight loss than those at lower temperatures. The other factors that may cause weight loss are fruit physiological character and fruit size. confirmed weight loss can also due to the fruit physiological properties which is climacteric where during ripening process will produce large amount of ethylene which causes the increase in the respiration peak before it goes down. Respiration in larger fruits like grapefruit is slower compared to smaller

fruits like oranges and ongoing water loss may lead to development of other symptoms such as loss in aroma in flavour or greenness.

The design of hydrocooling systems requires accurate estimation of the hydrocooling times of fruits and vegetables as well as the corresponding refrigeration loads. Numerous methods for predicting the hydrocooling times of fruits and vegetables have been proposed, and the designer is faced with the challenge of selecting an appropriate estimation method from those available.

- **Cooling of fruits**

Mean initial temperature of fruits was 25.1 ± 0.9ºC. Cooling time of all fruits varied proportionally with volume, temperatures dropping to 12.5ºC (TAT1/2) and 3.2ºC (TAT7/8) in time spans ranging from 8.5 min to 125 min. Larger fruits were cooled in time intervals 14 times longer than smaller fruits. Cooled 15 kg of peaches (r=2.3 cm), plums (r=1.85 cm), and pears (r = 2.8 cm) in a hydrocooling system at a temperature of 1ºC; cooling times were 17 min, 15 min, and 25 min, respectively. Pears reached the seven-eight cooling time in intervals 47% to 66% longer. Lime, orange, guava, and melon showed higher sphericity values (E = 1.01 to 1.06, with a slightly prolate geometry) than acerola and plum (E = 0.97 to 0.99, with a geometry tending to oblate shape), differently from mango (E = 1.12), which presented a more prolate geometry

- **Cooling of vegetables**

The mean initial temperature of vegetables was 24.8 ± 0.4ºC, and the half cooling and seven-eight cooling times were attained when they reached a temperature of approximately 12.4ºC and 4.1ºC (Figure 4). Cucumber required 36 times longer time than green bean (37%) to reach 4ºC temperature, as a result of the difference in volume between both vegetables, which was 97% higher. The time period will be longer depending on the final temperature intended for the product. Cooled 20 kg of cucumbers (D=3.8 cm and L=16 cm) to 4ºC in 33 min (seven-eight cooling time) in a hydrocooling system.

Cooling time and volume, could be used to estimate cooling time for fruits and vegetables with similar dimensions For instance, for melons with 1300 cm3 , index 0.107 min cm-3, the approximate time to reach seven-eighth cooling (≈ 3ºC) would be 139 min. Green beans with 18 cm3 would cool to 3ºC in approximately 2 min.

Cooling vegetables :https://www.youtube.com/watch?v=azoGx5aegNc access date December 2023

1.3 Identifying produce and confirm specific cool and heat transfer requirements

Most fresh fruits and vegetables require thorough cooling immediately after harvest in order to deliver the highest quality product to the consumer. Proper cooling delays the inevitable quality decline of produce and lengthens its shelf life. Most wholesale buyers now require that fresh produce items be properly and thoroughly cooled before they are shipped to market.

When warm produce is cooled directly by chilled water, the process is known as hydrocooling. Hydrocooling is an especially fast and effective way to cool produce. With modern technology, hydrocooling has now become a convenient and attractive method of postharvest cooling on a large scale.

of produce respond well to hydrocooling. Produce items that have a large volume in relationship to their surface area (such as sweet corn, apples, cantaloupes, and peaches) and that are difficult to cool can be quickly and effectively hydrocooled. Unlike air cooling, no water is removed from the produce. In fact, slightly wilted produce may sometimes be revived by hydrocooling.

Hydrocooling is one of several postharvest cooling methods available to growers, packers, and shippers.

Hydrocooling:

- Cools produce rapidly (about 15 times faster than air).
- Allows for greater harvesting and marketing flexibility.
- Easily handles large amounts of produce (although hydrocoolers can also be designed for smaller quantities of produce).

There are also some limitations to using hydrocoolers:

- They can be used only for produce not sensitive to wetting. Many diseases are encouraged by wetting.
- Some hydrocoolers are not as energy efficient as other methods and therefore may not be as cost effective in some situations.
- There are some restrictions on the types of packaging and stacking arrangements used for produce that is to be hydrocooled.

Table 1.1 Commodity –wise cooling method

No	Cooling methods	Types of Commodities
1	Room cooling	All fruits and vegetables
2	Forced air cooling	Fruits and fruits type vegetables, tubers and cauliflowers
3	Hydro cooling	Stems, green leafy vegetables, fruits and fruit type vegetables
4	Package icing	Roots, stems, cauliflowers, green onion, brussel sprouts
5	Vacuum cooling	Stems, Leafy and flowers type vegetables

6	Transits cooling -Mechanical -Top iceing & channel icing	All fruits and vegetables Roots, stems green leaf vegetables and cantaloupes

Determining hydrocooling rates

To operate a hydrocooler effectively and efficiently, it is necessary to understand how water removes heat from the produce and the factors that affect the rate of cooling for various types of produce. The next section provides a fundamental description of these points and how to calculate approximate hydrocooling rates for various fruits and vegetables.

Heat Transfer

When any object is warmed or cooled, the physical process is known as heat transfer. There are several different mechanisms of heat transfer. In the process of hydrocooling, the heat in the produce is carried away by the currents of moving water. This type of heat transfer is known as convection. Several factors contribute to the rate at which heat is transferred during convection. One of these factors, called the heat transfer coefficient, remains nearly constant for all types of produce. The heat transfer coefficient is a measure of how fast heat is transferred from the surface of an object.

Read more at Gardening Know How: What Is Hydrocooling – Learn About Hydrocooling Vegetables And Fruits https://www.gardeningknowhow.com/edible/vegetables/vgen/what-is-hydrocooling.htm

Once produce is harvested, it is still alive and reacts to oxygen to form carbon dioxide, water, and heat which begins the process of breaking the produce down. This is called natural respiration. Harvesting at night does nothing to stall natural respiration, which is where the hydrocooling method comes in. With hydrocooling, you are rapidly running chilled water over the freshly picked fruit and veggies, quickly dropping their temperature and eliminating tissue damage, thus extending shelf life. Water may be either cooled with ice, a refrigeration system, or a hydrocooling system specifically for hydrocooling produce. During the process, the water is sanitized with one of a variety of products. Hydrocooling is used to lower temperatures quickly

but cannot be used solely to cool and store produce. Instead, it is often used in conjunction with forced air cooling or room cooling. While there are a number of fruits and veggies that respond well to the hydrocooling method, here are some of the more common ones:

1.4 Determining Consequences of incorrect hydro-cooling

The surface of warm, wet produce provides an excellent site for postharvest diseases. Therefore, it is essential that once hydrocooled, produce should not be allowed to rewarm. Produce is particularly susceptible to postharvest diseases when it is stressed by too much or too little water, high rates of nitrogen, or mechanical injury (scrapes, bruises, or abrasions). Also, since the hydrocooling water is recirculated, it can spread disease from a few infected items to all the produce hydrocooled thereafter.

Pathogenic (disease-causing) organisms may enter the hydrocooling water both in the active vegetative form and in the form of spores

The wastewater from hydrocooling is usually dumped at the end of each workday or more often if necessary. This wastewater often contains high concentrations of sediment, pesticides, and other suspended matter. Hydrocooler water may be considered an industrial wastewater if the product is discharged to a municipal wastewater treatment plant or to surface waters (canals, creeks, or ponds). Land application of this material is normally permitted, but a nondischarge permit may be required. A hydrocooler owner may be required to obtain a wastewater discharge permit.

The disadvantage of hydrocooling is that the beans and peas are wetted. Significant postharvest disease problems will inevitably occur if the produce is allowed to rewarm after hydrocooling or if the water is not properly chlorinated. Warm, wet beans and peas are particularly liable to develop any of a host of postharvest diseases. These include nesting (caused by Pythium species or Rhizopus species), gray mold (caused by Botrytis cinerea), and watery soft rot (caused by Sclerotinia species). Although hydrocooling is the preferred cooling method, it should not be used unless adequate refrigeration facilities are available for continuous cooling and storage.

Although the skin of beans and peas offers considerable protection against infection, pathogens (disease-causing organisms) can enter the produce through a variety of openings. Wounds such as punctures, cuts, and abrasions as well as stems and stem scars provide potential points of entry. The probability of pathogens entering the produce increases with the size of the opening, the depth of submergence, the length of time in the water, and the water temperature.

1.5 Checking and adjusting equipment performance.

Cooling towers play a crucial role in maintaining optimal temperatures for various industrial processes, including power generation, petrochemical, chemical process. These cooling towers are responsible for dissipating excess heat into the atmosphere. Like any mechanical system, cooling towers demand regular maintenance to ensure their longevity and efficiency. Importantly, neglecting maintenance can lead to decreased efficiency, costly repairs, and potential safety hazards. This blog post contains a simple and comprehensive step-by-step cooling tower maintenance checklist that will help you keep your cooling tower operating efficiently and smoothly. This useful checklist will help you gain valuable insights into maintaining your cooling tower, maximizing its performance, and extending its lifespan. Let's dive in and explore the essential steps to keep your cooling tower maintenance checklist to see if it is running smoothly and efficiently.





Figure 1.6a leak checking water cool condenser Figure 1.6b checking equipment performance

What is a Cooling Tower?

A cooling tower is a large, open-air device designed to cool process hot water or other fluids by extracting the heat and releasing it into the atmosphere. Cooling towers can be forced draft, induced draft or natural draft and can be found in industrial & power plants, refineries, and even large commercial buildings



Figure 1.7 Fruits and vegetables hydrocooling equipment

A cooling tower consists of the following main elements:

- Fan System**:** Responsible for creating the airflow necessary for heat dissipation.
- Drift Eliminators**:** These specialized components prevent water droplets from being carried away by the exhaust air.
- Fill Material**:** It facilitates heat transfer by maximizing contact between air and water, promoting efficient cooling.
- Water Distribution System**:** Distributes water evenly across the fill material to ensure optimal cooling efficiency.
- Basin and Sump**:** The basin collects and holds water for recirculation, while the sump allows for proper drainage

1.5.1 Comprehensive cooling tower maintenance checklist

A cooling tower maintenance checklist is a document that outlines the tasks and procedures that need to be performed regularly to ensure the optimal performance and safety of a cooling tower. A cooling tower is a device that cools water or other fluids by transferring heat to the air. Cooling towers are used in various industrial and commercial applications, such as power plants, refineries, chemical plants, and heating, ventilation, and air conditioning (HVAC) systems. There are different types of cooling towers, such as forced draft, induced draft, or natural draft, and each may have specific maintenance requirements. However, some general steps that apply to most cooling towers are:

- Inspect the tower exterior for any signs of damage, corrosion, leaks, or fouling. Check the structural integrity, fan blades, louvers, and access doors. Repair or replace any defective parts as needed.
- Clean the basin and sump of any debris, sediment, or microbiological growth. Use a strainer, vacuum, or skimmer to remove solids and a biocide to control bacteria. Drain and flush the basin and sump periodically to prevent scaling and corrosion.
- Check the water quality and chemistry. Monitor the pH, conductivity, hardness, alkalinity, and dissolved solids of the water. Adjust the water treatment program as needed to prevent scaling, corrosion, and biological growth. Follow the manufacturer's recommendations for the type and dosage of chemicals to use.
- Inspect the fill material for any signs of damage, clogging, or fouling. Clean the fill material with a low-pressure spray or a chemical solution to remove any dirt, algae, or calcium deposits. Replace any damaged or deteriorated fill material as needed.
- Check the water distribution system for any signs of leakage, blockage, or uneven flow. Clean the nozzles, spray headers, and pipes with a brush or a chemical solution to remove any obstructions or deposits. Replace any worn or broken parts as needed.
- Inspect the fan system for any signs of wear, vibration, or noise. Lubricate the bearings, shafts, and couplings as needed. Check the alignment, tension, and condition of the belts, pulleys, and drives. Replace any damaged or worn parts as needed.
- Inspect the drift eliminators for any signs of damage, distortion, or fouling. Clean the drift eliminators with a low-pressure spray or a chemical solution to remove any water droplets or deposits. Replace any damaged or deteriorated drift eliminators as needed.

A comprehensive cooling tower maintenance checklist should include the frequency, method, and criteria for each task, as well as the records, reports, and documentation to be kept. A sample daily cooling tower maintenance checklist can be includes;

- Check for any visible leaks, unusual noises, or vibrations.
- Inspect the water level and ensure its within the recommended range.
- Monitor water temperature and pressure gauges.
- Check fan operation and ensure proper operation
- Inspect chemical concentrations

- Walk the perimeter of the tower to inspect balance in the rain zone

Cooling tower maintenance annual service procedure https://youtube.com/watch?v=I9tV43-Mwvg access date December 2023

1.6 Carry out pre-start checks with workplace requirements.

What is a pre-start checklist?

A pre-start checklist is a tool that outlines the systematic process used to identify potential hazards and ensure that all necessary safety precautions are in place before commencing any task, activity, process, or operation.

The primary goal of a pre-start checklist is to minimize the risk of accidents, injuries, and equipment damage by addressing potential issues before they escalate into more significant problems. Pre-start checklists are relevant in numerous sectors and industries, such as construction, manufacturing, production, logistics, and shipping. While pre-start checklists may vary from workplace to workplace, they typically include sections on personnel safety, facility and equipment safety, personnel qualifications, and any relevant procedures or regulations.

1.6.1 The four(4) -Step in a pre-start check

To help identify and mitigate potential risks, ensure that equipment or systems are in proper working order, and establish a standardized procedure for pre-start checks, make sure to follow these four steps:

- Inspect the equipment, vehicle, or system thoroughly**:** This includes checking the overall condition, components, fluids, and safety features to identify any visible damage, wear, tear, or potential issues.
- Verify the functionality of critical elements**:** This may involve verifying the availability of required tools, inspecting safety guards, checking fluid levels, and testing emergency stop functionality to ensure safety and efficiency during operation.
- ensure that all necessary preparations have been made: This step involves reviewing plans, obtaining permits or licenses, communicating details to stakeholders, and ensuring that team members are aware of their roles and responsibilities before starting the activity or operation.
- Complete any required documentation, paperwork, or checklists **:**

- This includes recording the inspection results, documenting completed tasks, and maintaining relevant records for future reference or compliance purposes associated with the pre-start check.

1.6.2 Benefits of using pre-start checklists

The goal of a pre-start checklist is to boost safety, efficiency, and operational effectiveness by systematically addressing potential risks or critical elements associated with the task at hand. Using a checklist when conducting pre-start checks offers several benefits including:

- **Consistency** Pre-start checklists help establish a standardized procedure, ensuring that all critical elements are addressed and no missed steps.
- **Safety** Checklists guide operators in systematically inspecting safety features, verifying emergency functionalities, and ensuring that all necessary precautions are taken.
- **Compliance** A pre-start checklist ensures all required inspections and tasks are completed, proper maintenance of documentation, and also compliance with all relevant regulations.
- **Efficiency** A pre-start checklist provides a clear and structured approach to pre-start checks, promoting an efficient and organized process.
- **Recordkeeping** Checklists serve as a record of pre-start checksit provides a comprehensive record of inspections, maintenance, and any potential issues or concerns.
- **Continuous Improvement** pre -start checklists assist organizations in identifying areas for improvement, refining their processes, and implementing necessary changes to enhance overall safety and efficiency.

1.6.3 Items to include in a pre-start checklist

When creating a pre-start checklist for construction, manufacturing, production, or logistics tasks, it’s essential to consider each industry’s specific requirements and risks. Organize your pre-start checklist using the following sub headings:

- **Title Page**

Include essential information such as the name of the task or operation, date, location, and the names of the personnel responsible for conducting the pre-start check.

- **Before start-up checks**

Before starting the equipment, vehicle, or system, these checks should be performed. Some items to include in this section are:

- ✓ Equipment inspection for damage, wear, or malfunctions
- ✓ Verification of safety devices (guards, emergency stops, etc.)
- ✓ Availability and quality of personal protective equipment (PPE)
- ✓ Proper training, orientation and certification of workers
- ✓ Verification of appropriate permits and licenses
- ✓ Housekeeping and organization of the work area
- ✓ Communication and coordination between team members or departments

1.6.4 After start-up checks

Once the equipment, vehicle, or system is started, perform additional checks to ensure everything is functioning as expected. Some items to include in this section are:

- Verification of proper operation and performance
- Monitoring of gauges and meters for any abnormal readings
- Confirmation of no leaks, unusual noises, or vibrations
- Assessment of proper ventilation and lighting
- Evaluation of emergency stop functionality after start-up

Completion Page

This section should document the results of the pre-start check, including any issues identified, actions taken to address them, and also the final status of the equipment, vehicle, or system. Additionally, include the signatures of the personnel responsible for conducting the pre-start check and any supervisors or managers who reviewed the checklist.

Remember that each industry or task may have unique requirements, so it's crucial to tailor your pre-start checklist to address your operations' specific risks and needs.

1.6.5 How to create a pre-start checklist

Creating a practical pre-start checklist involves several steps to ensure that all critical aspects are covered, and the process is organized and efficient. Follow these steps to create a pre-start checklist tailored to your specific needs:

- : Determine the specific purpose of the pre-start checklist
- Identify the checklist's primary goal, whether for safety, compliance, or efficiency purposes and consider the unique requirements and risks associated with the task or operation.
- **:** Compile a list of all essential items that must be checked before starting the activity or operation. Consider equipment, safety devices, permits, personnel training, and also other relevant factors.
- Group related items together under appropriate categories
- Organize the checklist by grouping related items under suitable categories or subheadings, such as "Equipment inspection," "safety devices verification," or "personal protective equipment."
- Define specific checkpoints or actions for each itemFor each item on the checklist, outline the specific checkpoints or actions to take. This step ensures clarity and helps prevent misunderstandings or oversights during the pre-start check process.
- Identify High-Priority Items or Safety ConcernsDetermine which items on the checklist have the utmost importance or higher safety implications. Highlight or emphasize these items to ensure they receive adequate attention during the pre-start check.Arrange items in a logical and sequential order Organize the checklist logically and sequentially for it to align with the typical flow of the pre-start check. This arrangement helps improve efficiency and ensures that all steps are followed correctly.

1.6.6 How to use a pre-start checklist

A pre-start checklist follows a systematic approach in ensuring to conduct all necessary inspections prior to starting an activity or operating an equipment. To give you an idea of how to use this checklist, here's a step-by-step guide on proper and effective use:

- Familiarize yourself with the Checklist**:** Before beginning, understand the checklist's structure, items, and instructions to ensure you know what is expected during the pre-start check process.
- Prepare the checklist and required tools**:** gather the specific checklist and any necessary tools relevant to your equipment or activity.

- Perform a Visual Inspection**:** Conduct a thorough visual inspection to identify any signs of damage, wear, or abnormalities that could affect the equipment's safety or performance.
- Verify equipment readiness: check equipment readiness, including critical components, safety features, controls, and indicators, to ensure they work properly.
- Conduct functional tests (if applicable): If necessary, perform functional tests to ensure the equipment operates correctly and meets the required performance criteria.
- Document Your findings and actions**:** Record your findings on the pre-start checklist, including any identified issues and the actions taken to address them.
- Retain a Copy of the Completed Checklist**:** Always keep a copy of the completed pre-start checklist for record-keeping purposes or as required by your organization's official SOP. This documentation will help maintain compliance and can also serve as a reference for future audits or inspections.

https://www.youtube.com/watch?v=2BjN7MW2Khc Access date December 2023 How to use a pre-start checklist

1.6.7 Create a pre start checklist using a low-code platform

Now that you understand the importance of pre-start checklists, it's time to consider how you can create and manage them effectively. Low-code platforms provide an intuitive and user-friendly environment for quickly building applications, such as pre-start checklists. This approach allows all the required data and information to be easily captured, stored and also tracked in a centralized system.

Pre-start checklist inspections help ensure vehicles and equipment are safe to use. Safety benefits of vehicle and equipment pre-start checklist inspections include: identification of faults and defects before vehicle or equipment use. Decreased likelihood or severity of injury from catastrophic equipment failure

1.7 Locating goods in correct storage areas to meet storage temperature, stores handling and stock rotation requirements.

Optimal quality and safety, dairy products should be stored at refrigerated temperatures between 34°F and 38°F, meats between 33°F and 36°F, and eggs 33°F to 37°F. Fresh vegetables and ripe fresh fruits should be stored between 35°F and 40°F. Always store refrigerated foods at temperatures less than 40°F.

Frozen foods should be stored at –18°C (0°F) or lower. If the temperature rises above –18°C, food can become discolored and lose vitamin content. Lowering the temperature after it has risen does not correct the damage.

These dry foods should not be in contact with air and moisture; this is the main thing to consider. While storing dry foods, you must consider these: The ideal temperature should be 10°C to 15°C(50°F to 59°F), to store the dry foods. The area should have the needed light.

Always store perishable foods in the refrigerator at 40 °F or below or in the freeze at 0 °F or below. You can find refrigerator and freezer storage information, a cold storage chart at Safe

Three types of food storage

- Dry food storage. Firstly, dry food storage includes any food that needs to be stored in an environment without climate control.
- Refrigerated food storage. Refrigerated food storage refers to storing foods at a cool, but not freezing, temperature. ...
- Frozen food storage

1.7.1 Store handling and stock rotation requirements for fruits and vegetables

- Store handling and stock rotation are important practices to ensure the quality, safety, and freshness of fruits and vegetables in your store. They can also help you reduce waste, save money, and attract customers.
- Store handling refers to how you handle, display, and store fruits and vegetables in your store. some of the tips for good storage handling:

Keep the storage area dry, cool, clean, and well-ventilated to prevent spoilage, mold, and pests.

- ✓ Use shelves that are at least 15 cm (6 in.) above the floor and do not stack produce too high or too deep to allow air circulation and prevent bruising or crushing.
- ✓ Separate ethylene-producing fruits and vegetables (such as apples, bananas, tomatoes, and avocados) from ethylene-sensitive ones (such as broccoli, cabbage, carrots, and lettuce) to avoid premature ripening or wilting.
- ✓ Remove any damaged, rotten, or shriveled produce from the display and storage areas and dispose of them properly.
- ✓ Use clear, attractive, and easy-to-read signs to label the produce items and their prices. If possible, sell produce by the unit rather than by weight to avoid surprises at the register.

- Stock rotation refers to how you arrange and use the fruits and vegetables in your store according to the order of their delivery or purchase. The most common stock rotation system is the first-in first-out (FIFO) method, which means that you should use the oldest produce first and the newest produce last. Some benefits of stock rotation:
  - ✓ It ensures that you always have fresh and high-quality produce for your customers.
  - ✓ It reduces the risk of foodborne illness and contamination from spoiled or expired produce.
  - ✓ It helps you avoid overstocking or understocking of produce and optimize your inventory and usage records.
  - ✓ It improves your customer satisfaction and loyalty by offering them the best produce possible.

To implement first in first out (FIFO)

- ✓ Mark the delivery or purchase date on each box or bag of produce and store them in the order of their arrival.
- ✓ Place the newest produce at the back or bottom of the storage area and the oldest produce at the front or top of the storage area.

- ✓ When replenishing the display area, remove the older produce first and place the newer produce behind or below them.
- ✓ When selling the produce, pick the older produce first and leave the newer produce for later.

Freeze drying of fruit and vegetable https://www.youtube.com/watch?v=eE993Vs7j8s Access date, December 2023

1.8 Recording and Storing information with workplace requirements

Record keeping is a very important aspect of any business or organization. It involves keeping track of financial transactions, activities, documents, and other information that are relevant for the operation and management of the business. Record keeping helps businesses to comply with laws and regulations, monitor their performance, plan their future, and protect themselves from various risks.

There are different types of records that a business should keep, such as:

- **Accounting records**: These include invoices, receipts, bank statements, tax returns, and other documents that show the income and expenses of the business. Accounting records help businesses to prepare financial statements, file taxes, and audit their accounts.
- **Employee records**: These include contracts, payroll, benefits, performance reviews, training, and other documents that show the employment relationship between the business and its workers. Employee records help businesses to manage their human resources, comply with labor laws, and resolve disputes.
- **Progress records**: These include reports, plans, goals, objectives, and other documents that show the achievements and challenges of the business. Progress records help businesses to evaluate their performance, identify areas of improvement, and make strategic decisions.
- **Correspondence records**: These include letters, emails, memos, and other documents that show the communication between the business and its stakeholders, such as customers, suppliers, partners, and regulators. Correspondence records help businesses to maintain good relationships, resolve issues, and document agreements.

There are different methods of keeping records, such as manually or digitally. Manual record keeping involves using paper, files, folders, and cabinets to store and organize records. Digital record keeping involves using computers, software, databases, and cloud services to store and organize records. Each method has its advantages and disadvantages, depending on the size, nature, and needs of the business.

Some of the principles of good record keeping are:

- **Authenticity**: Records should be genuine and trustworthy, and show who created or sent them and when.
- **Reliability**: Records should be accurate and complete, and reflect the transactions or activities they represent.
- **Integrity**: Records should be protected from unauthorized changes or deletion, and any authorized changes should be clearly indicated.
- **Usability**: Records should be easy to find, access, use, and understand, and have links to other related records..

- **Effective File Management**

  - ✓ Avoid saving unnecessary documents
  - ✓ Follow a consistent method for naming your files and folders.
  - ✓ Store related documents together, whatever their type
  - ✓ Separate ongoing work from completed work.
  - ✓ Avoid overfilling folders.
  - ✓ Organize documents by date.
  - ✓ Make digital copies of paper documents

Self-cheek 1

Name……. ID…… Date……

Starting time: _____ Time finished: _____

PART I Say True If the stamen is correct and say false if the statement is incorrector false

1. Compliance is pre-cheek list a clear and standard approach promoting an efficient organized process.
2. A pre -start cheek list is follow a systematic approach in ensuring to conduct all nessasery inspection in starting actively or operating an equipment.

Frozen food should store at 18 and above degree centigrade

PART II Choose the best answer

1--------is produce cools passively inside a cool room?

A. Vacuum cooling
B. Ice cooling
C. Room cooling
D. Hydro cooling

2. One of the following is not importance of cooling system?
   A. It gain excess heat from the engine.
   B. maintain the engine operating temperature
   C. Bring the engine up to the right temperature
   D. D. All

3. Which one of following is the most common type of air conditioner?

A. Heat pump
B. evaporate air conditioner
C. Central air conditioner
D. All

4. What is the contribution of effective file management?
    A. Avoid overfilling folders
    B. Organize documents by date
    C. Make digital copies of paper documents
    D. All
    E. None of the above
5. One of the following is not type of record keeping.
    A. Accounting records
    B. Employee records
    C. Correspondence records
    D. Authenticity

PART III Write short answer for the followings

1. Write down the 3 types of storage
2. Write two types of hydrocooling.

Operation sheet 1

1.1 Step-by-step cooling tower maintenance checklist

A. Tools and equipment

Personal protective equipment PPE

Screw driver

Pipe wrenches

B. Procedure/steps/ technique

Step 1: Inspect the tower exterior

Step 2: Clean the basin and sump

Step 3: Check the water treatment system

Step 4: Examine drift eliminators and fill material

Step 5: Check the fan system

Step 6: Inspect the water distribution system

Step 7: Clean and inspect the water piping

Step 8: Test water quality

Step 9: Document and schedule maintenance tasks

1.2 Pre-start checklist

A. Tools and equipment

- Paper
- Pen
- Computer
- Printer

- PPE
- List of equipment

B. **Steps**

Step 1: Determine the specific purpose of the pre-start checklist

Step2: Compile a list of all essential items that must be checked before starting the activity or operation..

Step 3: Group related items together under appropriate categories. Organize the checklist by grouping related items under suitable categories or subheadings, such as “Equipment inspection,” “safety devices verification,” or “personal protective equipment.”

Step 4: Define specific checkpoints or actions for each item

Step 5: Identify high-priority items or safety concerns

Step 6: Arrange items in a logical and sequential order

Organize the checklist logically and sequentially for it to align with the typical flow of the pre-start check.

LAP TEST-1	Performance Test 1

Name……. ID…… Date……

Time started: _____ Time finished: _____

Instructions:

- To perform wearing PPE and cleaning tools, considerate to check presence of all required facility which is listed in information sheet and operation sheet.
- Identify and check the presence of required or necessary tools and equipment that enable you to perform the task you want to perform.
- Given necessary templates, tools and materials you are required to perform the following tasks within **4** hour. The project is expected from each student to do it

Task-1 perform preventive maintenance of hydrocooling equipment

Task 2 performe pre-start checklist

LG#4 LO #2- Conduct hydro-cooling

Instruction sheet

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

- Checking Storage facility for readiness and allocation of space for produce.
- Using handling equipment maintain produce quality.
- Setting Operating parameters for hydro-cooling equipment.
- Applying Hydro-cooling produce.
- Transferring Produce to storage.
- Recording Process information to workplace requirements.
- Maintaining the work area with housekeeping standards.
- Conducting Work with workplace environmental guidelines

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:

- Check Storage facility for readiness and allocation of space for produce.
- Use handling equipment maintain produce quality.
- Set Operate parameters for hydro-cooling equipment.
- Apply Hydro-cooling produce.
- Transfer Produce to storage.
- Record Process information to workplace requirements.
- Maintain the work area with housekeeping standards.
- Conduct Wok with workplace environmental guideline

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
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 2

2.1 Checking Storage facility for readiness and allocation of space for produce

Most fresh fruit, including apples, berries and grapes, will last longer if kept in their original packaging and stored in the crisper of your fridge. Berries can last in the fridge for about a week. It's a good idea to eat as soon as possible so they don't spoil.

- **There are five methods of storing vegetables and fruit**:
  - ✓ Drying
  - ✓ canning
  - ✓ curing and salting,
  - ✓ freezing and common storage. Which method is chosen depends upon the type of produce, the quality desired and the facilities available for storage.

2.1.1 The guidelines for food storage

- Keep high-risk food at 5 °C or below or above 60 °C to avoid the temperature danger zone and food poisoning.
- Store raw foods below cooked foods and away from other foods
- Store food in suitable, covered containers and label them with the type of food and the date
- Avoid refreezing thawed foods and use ready-to-eat foods as soon as possible.
- Check and observe the use-by dates and storage directions on food poducts
- Take special care with high-risk foods.

The pros and cons of six ways to store food

- Canning can be a cost-effective way to preserve the quality of food at home.
- Freezing. A great option for preserving most foods. ...

- Drying or Dehydration. An excellent preservation method for fruits, vegetables, and herbs.
- Fermentation.
- Pickling.
- Cold Storage.

2.2 Using handling equipment maintain produce quality

Quality is a set of characteristics that impart value to the buyer or consumer quality attributes can be external (appearance, touch or defects), internal (texture, flavor or odor), or hidden (nutritive value or food safety quality can affect everything from the consumers eating experience to their health if the product is unsafe. Ensuring the quality of horticultural products requires careful attention to pre- and post-harvest management practices. Post-harvest losses are usually related to a quality attribute of the product, such as a physical, cosmetic, food safety or nutritional characteristic. If the quality of the product is compromised, it can likely not be restored. Therefore, it is important to focus on those practices that prevent problems. The best practices are often related to the specific crop in a certain environment but there are many common principles and methods that will aid in protecting the value of your product and return on investment. This will cover the biological and environmental factors involved in product deterioration and the pre- and post-harvest practices that can maintain quality and safety. The pre- and post-harvest practices are the primary means by which you can control the change in the products living tissue

Using handling equipment to maintain produce quality is an important aspect of post-harvest management for fresh fruits and vegetables. some of the principles of appropriate post-harvest handling are:

- Reducing the respiration rate of the produce by lowering the temperature and humidity.
- Minimizing the water loss and wilting of the produce by providing adequate ventilation and hydration.
- Controlling the ethylene production and sensitivity of the produce by separating ethylene-producing and ethylene-sensitive fruits and vegetables.
- Preventing the mechanical, physical, and biological damages of the produce by using proper harvesting, handling, packaging, and storage methods.
- Reducing the microbiological contamination of the produce by using clean and sanitized equipment, containers, and facilities.

- Storage and handling equipment, such as pallets, racks, bins, crates, baskets, bags, and boxes, that can facilitate the movement, stacking, and storage of the produce.
- Engineered systems, such as conveyors, sorters, graders, washers, dryers, and coolers, that can automate and optimize the processing, cleaning, grading, and cooling of the produce.
- Shortening the operating cycle and increasing the throughput of the produce.
- Reducing the handling costs and saving labor and energy resources.
- Eliminating unproductive handling and minimizing waste and losses of the produce.
- Reducing idle machine capacity and improving the utilization of equipment and facilities.
- Eliminating factory hazards and improving the safety and health of workers and consumers.

Therefore, using handling equipment to maintain produce quality is a vital strategy for improving the quality and safety of fresh fruits and vegetables and ensuring customer satisfaction and market competitiveness.

2.2.1 The living plant organ

Fruits and vegetables are living organs. From the moment of harvest, the organ will continue to metabolize the substrates (carbohydrates, organic acids, proteins and fates) available through respiration. Substrates that are consumed through respiration will not be replenished. As such, the rate of deterioration is proportional to the rate of respiration. Therefore, faster respiration rates will lead to loss of saleable /weight, poorer flavor and overall reduced product quality Understanding the biological and environmental factors that govern deterioration of the product will help to inform practices that can reduce loss and maintain quality and safety.

2.2.2 Product biology and deterioration

Respiration, ethylene production, water loss, physiological breakdown, physical damage and pathological breakdown are the five primary biological factors involved in the deterioration of horticultural products.

- **Respiration**

Respiration is the process whereby substrates are broken down to produce energy for the living plant organ. Energy is released as heat, along with carbon dioxide, water and oxygen. The rate of respiration hastens the loss of substrates and subsequent senescence and deterioration of the product. Energy released as heat can build up around the commodity, which can further increase respiration if not vented. If a commodity has inappropriate venting, carbon dioxide can build up around it, decreasing oxygen and potentially leading to fermentation. Increased temperature is closely associated with increased respiration.

Reducing the rate of respiration involves paying close attention to temperature management. Products should be removed from direct sun and cooled as soon as practical for your operation. Ensure appropriate ventilation for the product, as this also helps to reduce heat and buildup of ethylene and carbon dioxide around the product.

- **Ethylene Production**

Ethylene is a compound produced by all plant cells that affects growth and development. Ethylene can be beneficial or detrimental, depending on the fruit or vegetable. It is detrimental to most non fruit vegetables (broccoli) and ornamentals. Exposure to ethylene increases water loss and energy expenditure in the plant organ. Its production increases with maturity, physical injury, increased temperature and water stress. Exposure to ethylene can result in a number of undesirable characteristics, including yellowing of green vegetables, lignification of asparagus, spotting in lettuce and sprouting in onion and potato.

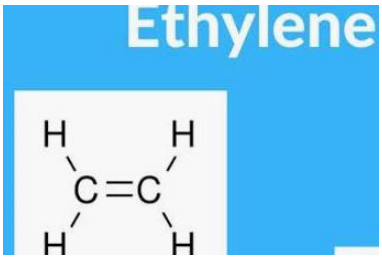


Figure 2.1 Ethylene structure

Avoid mixing or holding ethylene-sensitive produce with produce that is considered a high-ethylene producer (cantaloupe or tomato with brassicas or asparagus). In smaller operations with rapid turnover, ethylene management may be less critical. However, proper ventilation during

transport will help ensure a quality product. Also, avoid wounding (physically damaging) the product, as this can increase ethylene production and cull wounded produce immediately.

Water loss Water loss occurs through the plants dermal system (cuticle, stomata, epidermal cells, etc.). Water loss is heavily influenced by environmental factors such as temperature, relative humidity and air movement. Water loss results in weight loss of the product and is visualized as shriveling or wilting. The product can also be soft or limp or lose crispness and juiciness.

Reducing the respiration rate will decrease water loss. Therefore, removing the product from heat and cooling will reduce water loss. Relative humidity is an important factor in water loss as well. In general, it is important to have a high relative humidity, though specific products have associated optimal relative humidity.

Temperature and relative humidity are inversely correlated, so as temperature goes down, relative humidity goes up. Increasing the relative humidity can be done by wetting the storage room floor with potable water, adding crushed ice to tolerant crops or using potable water to mist the product (leafy vegetables, cool-season root crops or immature fruit crops), among other methods. Do your research on your specific crop before making any management decisions on relative humidity or storage.

- **Physiological breakdown**

Physiological disorders can develop from a number of factors. Primarily physiological disorders are caused by temperature abuse or nutritional imbalances. Inappropriate atmosphere is also a factor that can lead to physiological disorders and decay.

Temperature can cause physiological disorders through freezing injury, chilling injury, heat injury or sunburn. Freezing injury is the collapse of tissues and complete loss of the product. Chilling injury is a result of holding temperatures above their freezing point and below 49°F-59°F, resulting in browning and/or the product appearing water soaked.

Heat injury is a result of exposure to direct sunlight or high temperatures and results in bleaching, scalding or product softness. Removing a crop from the field just after harvest, avoiding direct sun and managing cooling and holding will help to ensure a high quality product

with minimal losses. Proper nutrient management is essential for crop productivity, product quality and environmental quality.

Nutritional imbalances that can lead to poor quality and decay result from inappropriate pre-harvest nutrient management practices. Calcium content is related to improved firmness and decreases the incidence of rot. Calcium deficiency causes blossom end rot in tomatoes and bitter pit in apples. Over-fertilizing with nitrogen leads to a number of issues related to product size and respiration rate, increased incidence of decay, storage rots and loss of flavor. Soil testing and developing an appropriate nutrient management plan for crop demand is essential in maintaining quality and safety.

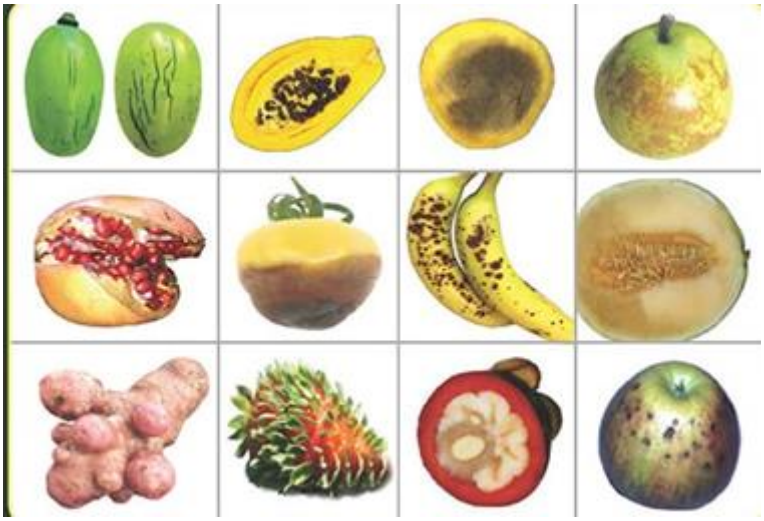


Figure 2.2 **Physiological post harvest disorders of fruits**

- **Physical Damage**

Physical damage or product wounding can be caused primarily by mechanical shock and abrasion or cuticle disruption. Wounding can provide a nutrient rich medium for human and plant pathogens to grow. Wounding also accelerates water loss and increases ethylene and carbon dioxide production, browning and decay. The opportunities for wounding are many and varied in an agricultural system. Commodities will respond poorly when they are treated poorly. Therefore, it is best to make those harvesting aware that they are food handlers, handling a living organ

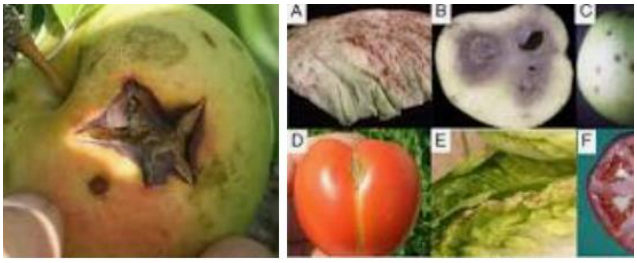


Figure2.3 physical damage of fruit and vegetable

- **Pathological Breakdown**

Microorganisms that can cause decay can be introduced through the seed, during crop growth, during harvesting and post-harvest handling or during distribution .The onset of ripening and senescence in commodities renders them more susceptible to infection by plant and human pathogens. In addition, stresses such as physical or physiological damage, make commodities more susceptible to human and plant pathogens. Sanitizing production and processing equipment on a regular basis and following good agricultural practices (GAPs) and good handling practices (GHPs) will reduce human and plant pathogens in the production system and aid in maintaining product quality and safety.



Figure 2.4. Sample images of fruit and vegetable data set with multiple objects and various backgrounds: (**a**) fresh fruits, (**b**) rotten fruits, (**c**) fresh vegetables, (**d**) rotten vegetables.

Product environment and deterioration

- **Temperature**

Temperature is one of the most important factors in maintaining product quality and safety. The term Q10 refers to a single chemical reaction and is known as the temperature accelerating factor. For each 10°C (18°F) increase the rate of chemical reaction (respiration) will increase approximately twofold or threefold As such, higher temperatures cause greater rates of respiration which, in turn, accelerates the use of stored substrates in the plant organ and water loss. This is of particular concerns for plants that have few reserves, such as leafy greens. Temperature also influences the growth rate of human and plant pathogens. Once harvested, produce continues to gain heat through respiration and conduction. Lowering temperature as fast as possible and removing the product from sun will slow the rate of respiration, reduce the incidence of pathogens and extend the product shelf life.

- **Relative Humidity**

Relative humidity is the ratio of water vapor in the air at a certain temperature to the maximum amount of water vapor that the air can hold at that same temperature. Essentially, water loss from the product is dependent on the deficit between the commodity and the surrounding air. Water loss influences the development of decay, incidence of physiological disorders and uniformity of ripening. If you store your product, monitor storage rooms by measuring temperatures in multiple locations. The use of plastic strip curtains on doorways will help reduce the flow of warm air and water loss

Product Biology and Environment

Understanding product biology and environment will help you to adopt appropriate management strategies that will improve or maintain product quality, safety and shelf life. Other environmental factors that should be considered are presence of light (potato storage), presence of ambient ethylene (broccoli storage) and the atmospheric composition. These are less of an issue to small growers who might have rapid turnover, have limited storage or do not ship their products in specialized packages.

Pre- and post-harvest practices for product quality, safety and shelf life

A. Pre-harvest

The following are practices or considerations that can aid in maintaining quality and safety. Each practice should be put in the context of the specific production system in question.

- ✓ Avoid over-fertilizing with nitrogen to reduce quality disorders and susceptibility to decay-causing pathogens, among others.
- ✓ Avoid over-irrigation in weeks prior to harvest to increase firmness and reduce storage problems.
- ✓ Installation of drip irrigation can reduce the spread of disease.
- ✓ Choose quality cultivars that are resistant to common pests and use clean, high-quality planting materials.
- ✓ Practice field sanitation, such as removing culls from the field, sanitizing field bins and removing diseased product, to prevent the spread of plant and human pathogens.
- ✓ When using manures, ensure that proper application methods and time intervals between planting and harvest are followed

B .Harvest and Post-harvest practices

Product quality is largely determined by pre-harvest practices and growing conditions. The intrinsic quality of the product cannot be improved during post-harvest management. As such, post-harvest management aims to reduce the metabolic rate, reduce water loss, minimize wounding and prevent physiological disorders. The following practices or considerations are non-comprehensive and should be set in the context of your operation.

C. Harvest

- ✓ Harvest at proper maturity for your product.
- ✓ Harvest early when product temperatures are their lowest, except watermelon, which should be harvested later in the day to prevent cracking.
- ✓ Remove the product from the field as quickly and efficiently as possible.
- ✓ Provide shading with a light colored tarp to cool and protect from direct sunlight.
- ✓ Round the tips of harvesting utensils and sharpen often to prevent wounding.
- ✓ Trim fingernails and remove jewelry to reduce product injury.
- ✓ Sanitize field containers and prohibit their use for any purpose other than carrying produce.

- ✓ Harvesting containers should be smooth and free of rough edges.
- ✓ Do not pick up produce that has fallen to the ground as this can spread human and plant pathogens.
- ✓ Train pickers to recognize proper maturity stage and to handle produce with care.
- ✓ Cool produce as soon as possible after harvest.
- ✓ Disinfect all equipment that comes into contact with produce to reduce the spread of human and plant pathogens.

D. Packing

- ✓ Cure root and tuber crops and bulb crops before packing, storing or marketing.
- ✓ Pre-sort produce to remove damaged, diseased, immature or over mature product.
- ✓ Provide shade for produce that has yet to be packed.
- ✓ Do not wash green beans, cabbage, okra, peppers or summer squash before packing due to bruising.
- ✓ Provide clean, sanitary conditions for all packing and harvest supplies.

E. Transport

- ✓ Avoid overfilling of containers and stack heavier produce on the bottom to reduce compression damage.
- ✓ Make sure vehicles and produce have adequate ventilation to prevent heat gain.
- ✓ Avoid mixed loads if possible or increase the space between ethylene producers and ethylene sensitive crop



Figure 2.5 transporting produce

2.3 Setting operating parameters for hydro-cooling equipment.

Important parameters of cooling water are: conductivity, total dissolved solids (TDS), hardness, pH, alkaline and saturation index. Total conductivity and total dissolved solids (TDS): Conductivity is a measure of the conductivity of water and is correlated with the amount of dissolved solids (TDS) in water.

When warm produce is cooled directly by chilled water, the process is known as hydro cooling. Hydro cooling is an especially fast and effective way to cool produce. With modern technology, hydro cooling has now become a convenient and attractive method of postharvest cooling on a large scale. Many types of produce respond well to hydro cooling. Produce items that have a large volume in relationship to their surface area (such as sweet corn, apples, cantaloupes, and peaches) and that are difficult to cool can be quickly and effectively hydro cooled. Unlike air cooling, no water is removed from the produce. In fact, slightly wilted produce may sometimes be revived by hydro cooling. Hydro cooling is one of several postharvest cooling methods available to growers, packers, and shippers.

- **Hydro cooling:**

  - ✓ Cools produce rapidly (about 15 times faster than air).
  - ✓ Allows for greater harvesting and marketing flexibility.
  - ✓ Easily handles large amounts of produce (although hydro coolers can also be designed for smaller quantities of produce).
  - ✓ There are also some limitations to using hydro coolers:
  - ✓ They can be used only for produce not sensitive to wetting. Many diseases are encouraged by wetting.
  - ✓ Some hydro coolers are not as energy efficient as other methods and therefore may not be as cost effective in some situations.

There are some restrictions on the types of packaging and stacking arrangements used for produce that is to be hydro cooled. This is intended to help growers, packers, and shippers of fresh produce make informed decisions concerning the application of hydro cooling. It discusses various types of hydro coolers, calculation of hydro cooling rates, postharvest disease control, wastewater discharge considerations, and the energy efficiency of hydro cooling compared to other types of cooling.

- **About hydro coolers**

A hydro cooler produces chilled water and then moves this water into contact with the produce. When considering a hydro cooler as a method of cooling produce, it is important to understand the water cooling methods that are used and to know the produce packaging and stacking requirements.

Caution. Not all types of fresh produce may be successfully hydro cooled. Some are sensitive to wetting, which promotes the growth of decay organisms. For a listing of produce items that may be hydro cooled, refer to folder

2.3.1 Produce Packaging and Stacking Considerations

The design of the produce package and the stacking arrangement is critical to the heat transfer process in hydro cooling. A variety of produce packages have been successfully used in hydro cooling. These packages include wire-bound wooden crates, waxed fiberboard cartons, mesh poly bags, and bulk bins. Palletized packages can be hydro cooled if they are carefully stacked to allow water to enter the packages.

If the water flows around and not through the packages, little cooling will occur. Produce in waxed cardboard cartons with solid tops is particularly difficult to cool because the top does not allow water to enter.

Wire-bound cartons and crates with a large percentage of open space are more suitable for hydro cooling because they allow for sufficient entry of water. Produce in 20-bushel bulk bins cools especially well because the cool water can easily percolate down through the product.

2.4 Applying hydro-cooling to produce

Hydro cooling is the process of bathing fresh produce in freezing water to remove heat. Methods of cooling fruits and veggies before sending them off to market play a key role in slowing their deterioration. In other words, reducing the rate that produce deteriorates can be thought of as extending its shelf life. Producing the consistently high-quality produce that spells success in a highly competitive market does not stop at the end of the row.

The ability to deliver a quality product to the market and ultimately to the consumer commands buyer attention and gives the grower a competitive edge. Proper postharvest cooling and handling can help to ensure that quality is maintained until the product reaches the consumer. Postharvest cooling rapidly removes field heat from freshly harvested commodities before shipment, storage, or processing and is essential for many perishable crops.

Proper postharvest cooling can:

- Suppress enzymatic degradation and respiratory activity (softening)
- Slow or inhibit water loss (wilting)
- Slow or inhibit the growth of decay-producing microorganisms (molds and bacteria)
- Reduce production of ethylene (a ripening agent) or minimize the product's reaction to ethylene.

In addition to protecting quality, postharvest cooling provides marketing flexibility by making it possible to market at the optimum time. Being able to cool and store produce eliminates the need to market immediately after harvest, which can be an advantage for high-volume growers as well as pick-your-own (P-Y-O) operators who wish to supply restaurants and grocery stores. To select the best cooling method, it is necessary to understand the basic principles of cooling.

The choice of cooling method depends on the following factors.

- **The nature of the product**. Different types of produce have different cooling requirements. For example, strawberries and broccoli require near-freezing temperatures, whereas summer squash or tomatoes would be damaged by such low temperatures.

Likewise, because of problems that can be caused by wetting of certain products, hydro cooling or icing may not be appropriate.

- **Product packaging requirements**. The best choice of cooling method may depend on whether the produce is in a box, bin, or bag. The package design can have an effect on the method and rate of cooling.
- **Product flow capacity**. Some methods of cooling are much faster than others. If the volume of produce to be cooled per season, per day, or per hour is large, it may be necessary to use a faster cooling method than would be used for lower volumes.
- **Economic constraints**. Construction and operating costs vary among cooling methods. The expense of cooling must be justified by higher selling prices and other economic benefits. In some cases – for example, when the volume of produce is low – the more expensive methods cannot be made to pay for themselves.

2.5 Transferring produce to storage

Best ways to store produce

- ✓ Store produce at reduced temperatures to increase its shelf life.
- ✓ Don't stack produce.
- ✓ Keep produce unwashed in storage.
- ✓ Don't cut produce until you're ready to use it.
- ✓ Store your fresh produce where there is some airflow (not in airtight containers or bags).

Fruit and vegetable growers work diligently to ensure that they bring the best quality products to market. They possess the necessary skills to improve the value of their crops during the growing season. However, once the harvest begins, good postharvest handling practices must be used to safeguard the product throughout the distribution environment objective of postharvest handling is to maintain quality by

- reducing metabolic rates that result in undesirable changes in color, composition, texture, flavor and nutritional status, and undesirable growth such as sprouting or rooting;
- reducing water loss that results in wilting, shriveling, softening, and loss of salable weight and crispness;
- minimizing bruising, friction damage, and other mechanical injuries;
- reducing spoilage caused by decay, especially of damaged or wounded tissues, and preventing contamination by human pathogens that can cause food poisoning; and
- Preventing development of freezing injury or physiological disorders, such as chilling injury or senescent (i.e., aging-related) disorders.
- In practice, "products must be harvested at optimum maturity or quality, handled carefully to avoid mechanical injury, cooled quickly to remove field heat, stored in modified atmospheres if appropriate for the product, and maintained at acceptable temperatures during storage, distribution and marketing Products should always be harvested, if possible, when they are free of moisture, or they should be immediately dried off after harvest.
- Prolonged wetness almost always leads to a wide range of problems, such as excessive decay, mold, and cosmetic blemishes that render the product unsalable. Proper ventilation

and maintaining proper relative humidity during storage are essential to maintaining the highest possible postharvest quality

Table 2.1. Storage requirements for fruits and vegetables

No	Commodity	Storage temperature (°F)	Relative humidity (%)	**Average Storage life**
1	Artichoke, Jerusalem	31–32	90–95	2–5 months
2	Asparagus	32–36	95–100	2–3 weeks
3	Bean & pea, dry	32–40	65–70	1 year
4	Bean, green or snap	40–45	90–95	7–10 days
5	Bean, lima	37–41	90–95	5–7 days

Storage Notes:

- Do not wash, brush off excess soil
- Wash with 1 teaspoons of 8.25 percent liquid chlorine bleach in one gallon of water, but do not allow produce to sit and soak in wash water
- Do not wash before storing, rinse just before using
- See detailed section on storing this product

Fruits and vegetables of tropical and subtropical origin may be damaged by cool temperatures. Chilling injury, a result of prolonged exposure to low but not freezing temperatures may interrupt the ripening process. Symptoms of chilling injury include dark, circular pits on the surface, shriveling, internal darkening, loss of the ability to ripen and the development of off-flavor and poor texture. Careful attention to the storage conditions will help achieve maximum post-harvest life.

Table 2.2 Ideal temperatures and humidity levels for curing vegetables

No	Commodity	Curing Temperature (°F)	Curing relative humidity	Length of curing time	Storage temperature after curing (°f)
1	Irish Potato	31–32	80–90	10–14 days	35–45
2	Onion	32–36	40–50	7–14 days	32
3	Pumpkin	32–40	80–90	10 days	55–60
4	Sweet Potato	40–45	95	10 days	55
5	Winter squash except acron	37–41	80–90	7–14 days	55–60

2.6 Recording Process information to workplace requirements

Poor housekeeping can be a cause of incidents, such as:

- tripping over loose objects on floors, stairs and platforms
- being hit by falling objects
- slipping on greasy, wet or dirty surfaces
- striking against projecting, poorly stacked items or misplaced material
- cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

Effective housekeeping results in:

- reduced handling to ease the flow of materials
- fewer tripping and slipping incidents in clutter-free and spill-free work area
- decreased fire hazards
- lower worker exposures to hazardous products (e.g. dusts, vapors)
- better control of tools and materials, including inventory and supplies
- efficient equipment cleanup and maintenance
- better hygienic conditions leading to improved health
- more effective use of space
- reduced property damage by improving preventive maintenance
- less janitorial work
- improved morale
- improved productivity (tools and materials will be easy to find)

2.6.1 An effective housekeeping program elements are

A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling.

The plan also makes sure that work areas are not used as storage areas by having workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organizing must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this task is done. A good housekeeping program identifies and assigns responsibilities for the following:

- clean up during the shift
- day-to-day cleanup
- waste disposal
- removal of unused materials
- inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

2.7 Maintaining the work area with housekeeping standards.

2.7.1 Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment, and machinery in safe, efficient working order and in good repair.

It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing, and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. It is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep, and repair of tools, equipment, machines, and processes.

Dust and dirt removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high-efficiency particulate air) filters may be used to capture fine particles of asbestos or fiberglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards, and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt, or chips from equipment or work surfaces.

Employee facilities

Employee facilities need to be adequate, clean and well-maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed.

If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home. Smoking, eating or drinking in the work area should not be allowed where hazardous products are handled.

The eating area should be separate from the work area and should be cleaned properly each shift.

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings, and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

Walls: Light-colored walls reflect light while dirty or dark-colored walls absorb light. Contrasting colors warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colors.

Maintain light fixtures Dirty light fixtures reduce essential light levels. Clean light fixtures can improve lighting efficiency significantly.

Aisles and stairways Aisles should be wide enough to accommodate people and vehicles comfortably and safely. Aisle space allows for the movement of people, products and materials. Warning signs and mirrors can improve sight lines in blind corners. Arranging aisles properly encourages people to use them so that they do not take shortcuts through hazardous areas. Keeping aisles and stairways clear is important.

They should not be used for temporary "overflow" or "bottleneck" storage. Stairways and aisles also require adequate lighting.

Spill control The best way to control spills is to stop them before they happen. Regularly cleaning and maintaining machines and equipment is one way. Another is to use drip pans and guards where possible spills might occur. When spills do occur, it is important to clean them up immediately. Absorbent materials are useful for wiping up greasy, oily or other liquid spills. Used absorbents must be disposed of properly and safely.

Tools and equipment Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean, and repair all tools and take any damaged or worn tools out of service.

Waste disposal The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities.

Allowing the material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier. All waste receptacles should be clearly labelled (e.g., recyclable glass, plastic, scrap metal, etc.).

Storage Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one meter (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross-tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations.

All storage areas should be clearly marked. Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in

the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction

2.8 Conducting work with workplace environmental guidelines

Environmental compliance and workplace safety are essential in numerous industries. If you run a business or supervise a team, there's a good chance you're responsible for making sure you comply with all regulations and achieve a safe working environment for every project. The following tips will help you do just that. Just remember, while these safety and compliance examples are helpful, they're also general. The specific nature of your work may require taking additional steps to optimize environmental compliance and overall safety.

Six best ways to ensure environmental compliance and workplace safety

- Train thoroughly
- Review past mistakes
- Ensure proper communication
- Check your equipment
- Focus on risk management
- Coordinate with professionals

Key aspects of an effective training program should include:

- ✓ Regular training**:** Conduct environmental compliance and workplace safety training on an annual basis.
- ✓ Continuous improvement**:** Review your program throughout the year to determine its effectiveness and make improvements as needed.
- ✓ Adaptive training**:** Update your safety training program to address new hazards or situations as your company takes on different projects.
- ✓ Inclusion: All employees should be part of the training program to maintain a comprehensive knowledge of safety procedures.

Throughout the year, you should also review your program to determine if it's yielding results or if you need to make improvements. Keep in mind that your employees shouldn't undergo

environmental compliance and workplace safety training once. All workers must remember everything they need to know about keeping one another safe on the job.

Therefore, you should require employees to undergo training on an annual basis. Additionally, if your company begins working on projects that potentially involve hazards and situations that past projects did not involve, you might also need to update your safety training program accordingly. For example, maybe your company is starting to work on job sites that could potentially expose workers to hazardous chemicals. You need to update your training to account for this.

Review past mistakes

Your goal should be to ensure workplace safety and environmental compliance. Unfortunately, accidents can occur. Even if you manage to avoid them in the future, there's a good chance your company has had incidents in the past.

Consider these steps when reviewing past incidents:

Ensure proper communication

Regardless of your specific industry, you probably understand the importance of communicating your goals to all participating team members when preparing to work at a job site. You don't want to waste time and money because your employees don't know what they're specifically supposed to achieve. This same principle should apply to workplace safety and environmental compliance.

When preparing for jobs, thoroughly assess all potential risk factors (as well as what you can do to mitigate them), and communicate this information carefully to all employees involved in the job.To enhance communication effectiveness, consider implementing the following strategies:

- Interactive communication: encourage a two-way dialogue about safety, and listen to employees' concerns and suggestions.
- Informative & positive communication: Provide employees with necessary safety information under all conditions and foster a positive exchange of ideas and information to improve workplace safety.
- Avoid communication barriers: Try to eliminate obstacles that can disrupt the communication process. For instance, ensure your safety message is clear, concise, and

not overwhelming and that expectations are well defined. Also, remember to listen to employees' feedback as part of the communication process.

- Plan you're message**:** Be clear about the points you want to make, organize your thoughts logically, and keep your communications simple and precise. This will help prevent any misinterpretation.
- Repetition and demonstration**:** Repeat your safety message as needed and use demonstrations when appropriate for better understanding and retention of safety information.

Remember, failure to communicate safety information effectively can lead to accidents, inability to comply with regulations, and even risks to the community and environment. With a thorough document, you can share this information with employees at the last minute when situations like this one arise, thus ensuring effective communication in your workplace

Check your equipment

You probably don't need to be told that using the proper equipment is key to workplace safety and environmental compliance. This includes both the tools your employees may use on a given job, as well as any safety gear or equipment they may bring with them to job sites. However, it's also essential that you regularly test and inspect your equipment. Don't make the mistake of assuming your gear is in good shape. Checking your equipment routinely will help you identify potential risks you would have otherwise overlooked. Depending on the nature of your work, you might even want to check all equipment before each and every job. Hydrocooling is a process of cooling produce with chilled water. It is a fast and effective way to preserve the quality and shelf life of fresh fruits and vegetables. Hydrocooling equipment consists of a water chiller, a pump, and a cooling chamber where the produce is exposed to the water. To check your hydrocooling equipment procedures, you may follow these steps: To check your hydrocooling equipment procedures, you may follow these steps:

- Make sure the water chiller is working properly and maintaining the desired water
- Check the water flow rate and adjust it according to the amount and size of produce to be cooled. A higher flow rate will result in faster cooling, but it will also consume more water and energy.

- Inspect the cooling chamber and ensure that it is clean and free of debris. The cooling chamber should have enough space for the produce to be spread evenly and not block the water flow. The produce should be in contact with the water for as long as possible to achieve uniform cooling.
- Monitor the water quality and add a wetting agent if needed. A wetting agent can help reduce the surface tension of water and improve the heat transfer from the produce to the water.
- After cooling, drain the excess water from the produce and package it in suitable containers. Avoid rewarming the produce by storing it in a cool and dry place or transporting it to a cold storage facility as soon as possible

- **Focus on risk management**.

Environmental compliance for workplace safety shouldn't simply involve striving to comply with all applicable regulations. After all, you might know that regulations are frequently changed and updated. In fact, one of your top responsibilities may involve regularly reviewing regulations to stay abreast of these changes.

At this point, it's important to remember a few key points in risk management:

- Develop a transparent company culture where potential hazards and mitigations are clearly communicated to all employees.
- Identify, assess, manage, and monitor risks regularly to be prepared for them.
- Get the necessary help in terms of policy/compliance infrastructure to ensure worker protection and minimize risk. This might involve hiring the right people for the team or seeking advice from external advisors.
- Conduct a risk and SWOT analysis to proactively identify exposure and address potential concerns around employee physical and mental health.
- Create contingency plans and get the right types of insurance. communicate these plans to your workers for shared responsibility and protection.
- Strive for a balance between managing workplace complexities and protecting the company from fines, penalties, and lawsuits.

- **Coordinate with professionals**

Environmental compliance can be a complicated subject. Without the proper training and education, there's a good chance you don't understand it as thoroughly as you need to if workplace safety is your goal. That's a key reason it's important to coordinate with environmental compliance experts. It allows you to leverage their expertise when assessing risks, performing compliance audits, developing accident prevention plans, and much more. It also gives your workers the peace of mind that comes from knowing their employer is working with professionals to ensure complete safety. This has actually been shown to improve employee engagement. Workers have more respect for their employers (and find it easier to focus on their tasks) when they believe safety is a top priority.

Self-check 2	**Written test**

Part I Choose the best answer

1. One is an excellent preservation method to fruit vegetable and herbs?
   A. Freezing
   B. pickling
   C. Fermentation
   D. Drying or dehydration
2. -------- is produced by all plant cell that affect growth and development?
   A. Respiration
   B. ethylene production
   C. water loss
   D. D. all
3. ------ -is most important factor in maintaining quality and safety?
   A. Relative humidity
   B. Temperature
   C. .A and B
   D. None
4. Key aspects of an effective training program should not include:
   A. Regular training
   B. Continuous improvement
   E. Exclusive training program
   F. None
5. what are the best ways to ensure environmental compliance and workplace safety
   A. Train thoroughly
   B. B. Review past mistakes
   C. Improper communication
   D. All
   E. A and B

6. One is not the proper function of postharvest cooling can:
   A. Suppress enzymatic degradation and respiratory activity (softening)
   B. Slow or inhibit water loss (wilting)
   C. Allows water loss excessively and increases ethylene production
   D. All E.None of the above

Part II Write short answer for the following questions

1. What are 5 methods of storing fruit and vegetable?
2. Jot down at least five (5) effective housekeeping results.

Operation sheet 2

2.1 Review past mistakes

A. Tools and equipment

- pen
- paper
- PPE

B. Steps

Step 1. Analyse incident

Step 2. Identify root cause of the incident : Determine the potential causes of each incident.

Step 3. Prevention strategies**:** Identify ways to prevent these incidents from occurring again in the future.

Step 4. Update training programs**:** Use your findings to update your training program and safety plans.

2.2 Review past mistakes

A. Tools and equipment

- Pen
- Paper
- PPE
- Thermometer
- Hygrometer

B. Procedure/steps/ technique

Step 1. Make sure the water chiller is working properly and maintaining the desired water

Step 2. Check the water flow rate and adjust it according to the amount and size of produce to be cooled. A higher flow rate will result in faster cooling, but it will also consume more water and energy.

Step 3. Inspect the cooling chamber and ensure that it is clean and free of debris.

Step 4. Monitor the water quality and add a wetting agent if needed.

Step 5. After cooling, drain the excess water from the produce and package it in suitable containers.

LAP TEST-2	Performance Test 2

Name……. ID…… Date……

Time started: _____ Time finished: _____

Instructions:

- To perform wearing PPE and cleaning tools, considerate to check presence of all required facility which is listed in information sheet and operation sheet.
- Identify and check the presence of required or necessary tools and equipment that enable you to perform the task you want to perform.
- Given necessary templates, tools and materials you are required to perform the following tasks within **6** hour. The project is expected from each student to do it

Task-1 perform past mistake rviews

Task 2. Perform hydrocooling equipment

LG#5	LO #3 Monitor hydro-cooling process

Instruction sheet

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

- Monitoring and ensuring process quality standards.
- Checking and maintaining temperature with required levels.
- Identifying Non-compliances.

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:

- Monitor Process to ensure quality standards.
- Check and maintain temperature with required levels.
- Identify Non-compliances.

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
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 3

3.1 Monitoring process to ensure quality standards

Monitoring process to ensure quality standards is an important aspect of quality management. It involves establishing standards, guidelines and procedures to prevent quality issues and maintain the integrity of the product or service throughout its development. There are different methods and tools that can be used to monitor and measure quality, such as:

- Conduct quality inspections and process audits to ensure all teams, leaders, and employees are complying with quality standards for maximum efficiency.
- Use quality control inspection checklists to easily spot issues, assign corrective actions, and standardize regular inspections for a streamlined QMS.
- Determine the systems of care to be monitored and define performance standards and indicators.
- Choose appropriate data collection methods and design and test monitoring tools.
- Analyze and apply quality data

2.2.1 Some of the factors that need to be monitored are:

- The temperature and flow rate of the water. The water should be cold enough to cool the produce quickly, but not too cold to cause chilling injury. The flow rate should be sufficient to remove the heat from the produce and prevent the water from warming up.the water temperature should be 0.5 to 1^0C and flow rate of 0.5 to 1 L/sperkg of produce
- The cleanliness and sanitation of the water. The water should be free of dirt, debris, and microorganisms that can contaminate the produce. The water should be chlorinated or othe disinfectants maintain a residual level to of 100 to 200ppm.
- The water should also be filtered and recirculated to reduce water consumption and waste.
- The packaging and stacking of the produce. The produce should be packed in containers that allow water to drain and air to circulate. The containers should be stacked in a way that does not block the water flow or create pressure on the produce..

- The quality and safety of the produce. The produce should be checked for signs of damage, decay, or contamination before and after hydrocooling. The produce should also be tested for temperature, firmness, color, acidity, soluble solids, anthocyanins, and other quality parameters.
- These are some of the aspects that need to be monitored to ensure quality standards in hydrocooling fruits.

2.2 Checking and maintaining temperature with required levels

Once a crop is harvested, it is almost impossible to improve its quality. Losses of horticultural crops due to improper storage and handling can range from 10 to 40 percent. Proper storage conditions—temperature and humidity—are needed to lengthen storage life and maintain quality once the crop has been cooled to the optimum storage temperature.

Fresh fruits and vegetables are living tissues, although they are no longer attached to the plant. They breathe, just as humans do, and their composition and physiology continue to change after harvest. They continue to ripen and, finally, they begin to die. Cellular breakdown and death (senescence) are inevitable, but can be slowed with optimal storage conditions.

Fresh fruits and vegetables need low temperatures (32 to 55°F) and high relative humidity (80 to 95 percent) to lower respiration and to slow metabolic and transpiration rates. By slowing these processes, water loss is reduced and food value, quality and energy reserves are maintained.

Relative humidity: Transpiration rates (water loss from produce) are determined by the moisture content of the air, which is usually expressed as relative humidity. At high relative humidity, produce maintains salable weight, appearance, nutritional quality and flavor, while wilting, softening and juiciness are reduced. Leafy vegetables with high surface-to-volume ratios; injured produce; and immature fruits and vegetables have higher transpiration rates. External factors affecting transpiration rates are temperature, relative humidity, air velocity and atmospheric pressure. High temperatures, low relative humidity and high air velocity increase transpiration rates.

Relative humidity needs to be monitored and controlled in storage. A hygrometer or a sling psychomotor, not the appearance of the produce, should be used to monitor humidity. Control can be achieved by a variety of methods:

- ✓ Operating a humidifier in the storage area.
- ✓ Regulating air movement and ventilation in relation to storage room load.
- ✓ Maintaining refrigeration coil temperature within 2°F of the storage room air temperature.

- ✓ Using moisture barriers in the insulation of the storage room or transport vehicle, and in the lining of the packing containers.
- ✓ Wetting the storage room floor.
- ✓ Using crushed ice to pack produce for shipment.
- ✓ Sprinkling leafy vegetables, cool-season root vegetables, and immature fruits and vegetables with water.



Figure 3.1 hygrometer

Temperature

Respiration and metabolic rates are directly related to room temperatures within a given range. The higher the rate of respiration, the faster the produce deteriorates. Lower temperatures slow respiration rates and the ripening and senescence processes, which prolongs the storage life of fruits and vegetables.

Low temperatures also slow the growth of pathogenic fungi which cause spoilage of fruits and vegetables in storage. Producers should give special care and attention to proper storage conditions for produce with high to extremely high respiration rates—those crops will deteriorate much more quickly.

It is impossible to make a single recommendation for cool storage of all fruits and vegetables. Climate of the area where the crop originated, the plant part, the season of harvest and crop maturity at harvest are important factors in determining the optimum temperature. A general rule for vegetables is that cool-season crops should be stored at cooler temperatures (32 to 35°F), and

warm-season crops should be stored at warmer temperatures (45 to 55°F). There are exceptions to this rule, though.

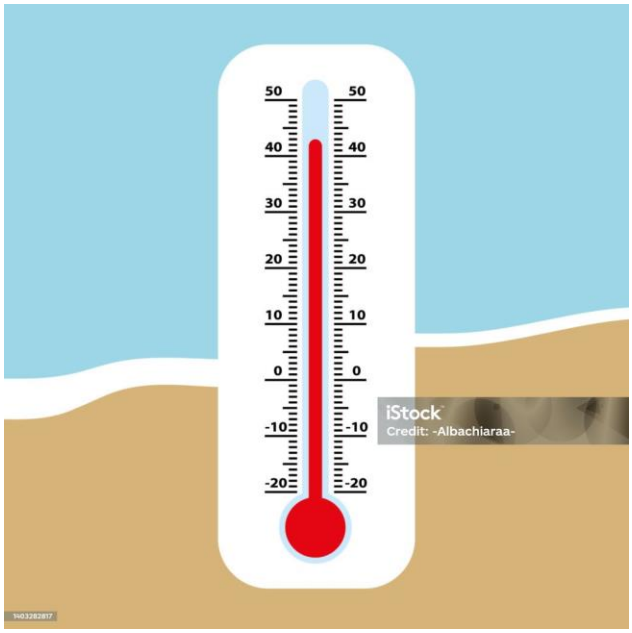


Figure 3.2 thermometer

Freezing injury

Temperatures that are too low can be just as damaging as those too high. Freezing will occur in all commodities below 32°F. Whether injury occurs depends on the commodity. Some can be repeatedly frozen and thawed without damage, while others are ruined by one that is likely to be injured by one freezing is classified as “most susceptible.” The “moderately susceptible” produce will recover from one or two freezing. Produce which is “least susceptible” can survive several freezing without injury.

Injury from freezing temperatures can appear in plant tissues as loss of rigidity, softening and water soaking. Injury can be reduced if the produce is allowed to warm up slowly to optimum storage temperatures, and if it is not handled during the thawing period. Injured produce should be marketed immediately, as freezing shortens its storage life.

Chilling Injury fruits and vegetables that require warmer storage temperatures (40 to 55°F) can be damaged if they are subjected to near freezing temperatures (32°F). Cooler temperatures interfere with normal metabolic processes. Injury symptoms are varied and often do not develop until the produce has been returned to warmer temperatures for several days. Besides physical damage, chilled produce is often more susceptible to disease infection.

Storage Facilities

Crops that require different storage conditions will need three different storage facilities.

- **Cold storage** (temperatures 32 to 36°F).
- **Cool storage** (temperatures 40 to 55°F).
- **Warmer storage** (temperatures 55 to 60°F for sweet potatoes, squash, pumpkins or similar crops).

A recording thermometer can be helpful in determining whether storage facilities are maintaining ideal conditions and are not fluctuating. A maximum/minimum thermometer could be substituted. The thermometer should not be the same as the thermostat controlling the refrigeration equipment. Relative humidity also should be monitored with a hygrometer or a sling psychrometric.

Controlling and monitoring temperature and relative humidity will enable a grower to maintain optimum conditions for maximum storage life of the crop, and to minimize crop damage from chilling, freezing and/or too-high temperatures and water loss from the crop. Close attention to storage conditions will yield returns through greater customer satisfaction, less waste and spoilage, and in the flexibility to hold a crop without significant storage losses to wait for better markets.

2.3 Identifying Non-compliances

Non-compliance refers to the act of failing to adhere to or follow established rules, regulations, standards, or obligations. It can manifest in various contexts, including legal, ethical, industry-specific, or organizational requirements. Non-compliance can involve deliberate actions to disregard or violate established guidelines, as well as unintentional failures to meet the prescribed expectations.

One area where non-compliance can have a profound impact is in the realm of financial regulations. The 2008 global financial crisis stands as a stark reminder of the dangers of non-compliance within the banking and investment sectors. Banks and financial institutions that engaged in risky and unethical practices, sidestepping regulations and exploiting loopholes, triggered a catastrophic chain reaction that reverberated across the globe.

The consequences were devastating, with millions losing their homes, jobs, and life savings. The collapse of these institutions served as a wake-up call, highlighting the urgent need for stricter compliance measures and robust oversight to prevent such a crisis from happening again.

Non-compliance can take different forms depending on the context. It could be:

- Failure to meet legal obligations such as breaking laws, regulations, or contractual agreements.
- Non-compliance due to ignorance or a lack of awareness
- Intentional non-compliance for personal gain or other motivations.
- Non-compliance can also occur at different levels ranging from individuals to organizations or even entire industries. It can encompass a wide range of behaviours such as failure to maintain records, inadequate reporting, ignoring safety protocols, unethical practices, etc.

The consequences of non-compliance in fruits and vegetables hydrocooling are mainly related to the quality and safety of the products, as well as the market access and profitability of the exporters. Hydrocooling is a method of rapidly cooling fresh produce by immersing it in cold water or spraying it with chilled water. It is used to preserve the freshness, flavor, texture, color, and nutritional value of fruits and vegetables, as well as to prevent decay, shrinkage, and wilting.

Some of the benefits of hydrocooling are:

- It reduces the respiration rate and metabolic activity of the produce, extending its shelf life and reducing weight loss.
- It removes field heat and lowers the temperature of the produce to the optimum storage level, preventing deterioration and spoilage.
- It washes away dirt, dust, and insects from the produce, improving its appearance and hygiene.
- It reduces the risk of microbial contamination and growth, enhancing the safety and quality of the produce.

However, hydrocooling also poses some challenges and risks, especially if it is not done or in compliance with the standards and regulations of the export markets. Some of the consequences of non-compliance in hydrocooling are :

- It can cause physical damage to the produce, such as bruising, cracking, splitting, or peeling, due to the impact of water or the pressure difference between the produce and the water.
- It can introduce chemical hazards to the produce, such as pesticide residues, chlorine, or other additives, if the water is not clean or treated appropriately.
- It can facilitate the spread of pathogens and diseases, such as Salmonella, E. coli, or Listeria, if the water is contaminated or not changed frequently, or if the produce is not dried properly after hydrocooling.
- It can result in loss of quality and nutritional value, such as flavor, aroma, color, or vitamins, if the water temperature is too low or too high, or if the produce is overcooled or undercooled.
- It can lead to rejection, recall, or legal action, if the produce does not meet the quality and safety requirements of the export markets, such as the United States, the European Union, or Japan, which have strict standards and regulations for fresh produce.

Therefore, it is important for the producers and exporters of fruits and vegetables to comply with the best practices and guidelines for hydrocooling, as well as to monitor and control the critical

factors that affect the quality and safety of the produce, such as the water quality, the water temperature, the cooling time, the drying method, and the packaging and storage conditions . By doing so, they can ensure the quality and safety of their products, as well as increase their market access and profitability.

2.3.1 Risks and consequences of regulatory non-compliance

Non-Compliance is regulatory non-compliance occurs when an organization fails to comply with the policies, standards, regulations or laws relevant to its operation

Examples of noncompliance include:

- Failure to wear personal protective equipment (PPE)
- Insufficient administration of operations
- Failure to obtain proper certifications/illegal operations
- Failure to follow operation procedures
- Failure to report to relevant

Vacuum cooling **https://www.youtube.com/watch?v=c_eNBcBwNnU** Access date, October 2023

The Consequences of Non Compliance

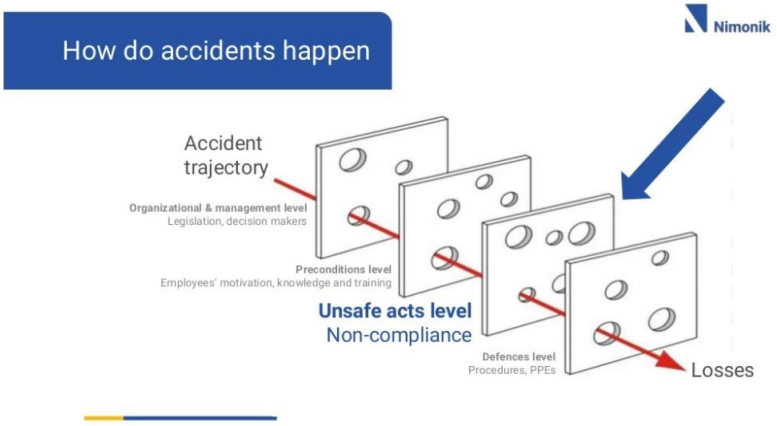


Figure 3.3 the Consequences of Non Compliance diagram

The consequences of regulatory non-compliance can be costly. Worker injuries and deaths, property damages, lost production, and jail time are just a few examples. Even though compliance improves efficiency and protects businesses from heavy penalties, most companies continue to wrongly view it as an operation cost rather than an investment.

Companies therefore minimize or completely overlook the purchase of compliance software, data and services and tend to under-staff their compliance teams. However, as Henry Ford once said about buying machines, In other words, in the context of regulatory compliance, the cost and risk of non-compliance can very easily outweigh the cost of investing in compliance efforts. What we see, over and over, is that businesses that ignore the importance of proactive compliance still end up paying for compliance– only it is through penalties, reputational issues, and product delays.

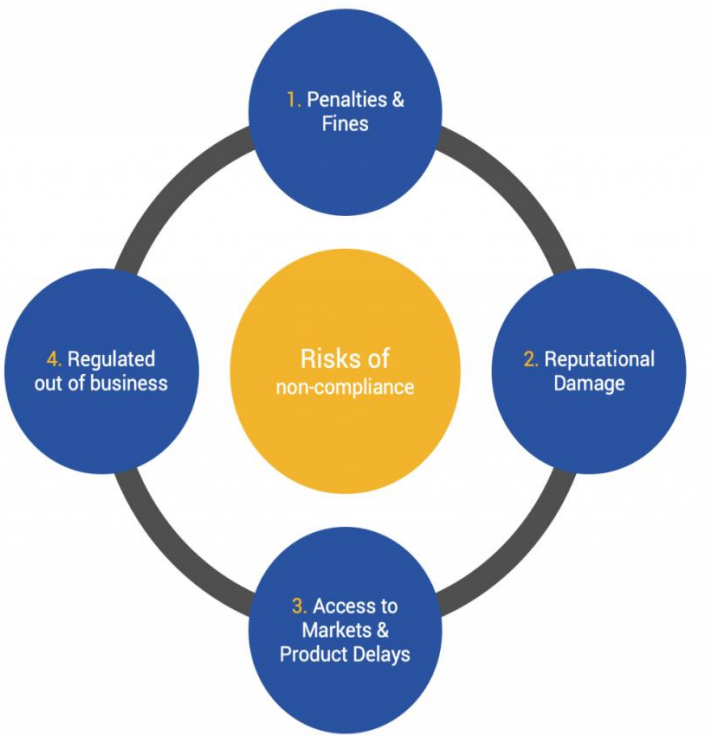


Figure 3.4 the risk of non compliance

- **Penalties and fines**

Penalties on regulatory noncompliance come in multiple forms: financial fines, limitations on activities, additional barriers to approval and even prison. Even if your organization is not given an actual penalty, an investigation by a government body will cost you many hours of work and potential legal and contractor fees. To minimize your risk of a penalty or fine, Nimonik has outlined a six step guide to comprehensive compliance to help businesses ensure EHS regulatory compliance. With the key pillars of documentation,

- **Reputational damage**

Reputational damage is the loss of financial capital, social capital, and/or market share resulting from damage to a firm's reputation. This can be caused by ethics violations, safety issues, security issues, lack of sustainability, poor quality, or unethical innovation. Reputational damage can have severe consequences for a company, such as lower customer loyalty and trust, declining sales, and even legal action. Some examples of reputational damage are:

Reputational damage can be prevented or mitigated by taking proactive measures, such as:

- Establishing a clear code of ethics and values for the organization and its employees.
- Implementing effective risk management and compliance systems to identify and address potential issues before they escalate.
- Communicating transparently and honestly with stakeholders, customers, and the public about the company's performance, goals, and challenges.
- Responding quickly and appropriately to any crisis or negative feedback, and taking corrective actions to restore trust and confidence.
- Building and maintaining a positive reputation through social responsibility, customer satisfaction, and innovation.

Reputational damage is a serious threat to any organization's success and survival. Therefore, it is important to monitor and protect the reputation of the company and its brand. A good reputation can be a valuable asset that can enhance the company's competitive advantage and long-term growth.

3.3.2 Access issues to markets and product delays

Access issues to markets and product delays are two common challenges that many businesses face in today's globalized economy. They can affect the profitability, competitiveness, and

customer satisfaction of a company. Here are some possible causes and effects of these challenges:

- This can reduce the potential demand and revenue for the company, as well as limit its opportunities for growth and innovation.
- This can create uncertainty and risk for the company, as well as affect its supply chain and logistics operations.
- This can increase the cost and waste for the company, as well as damage its reputation and customer loyalty. For example, the global semiconductor shortage has caused production delays and price hikes for many industries, such as automotive, consumer electronics, and gaming.
- This can reduce the efficiency and effectiveness of the company, as well as cause customer dissatisfaction and lost sales. For example, the COVID-19 pandemic has caused unprecedented fluctuations in consumer demand and preferences, making it challenging for many businesses to adapt and optimize their product offerings and inventory levels.

To overcome these challenges, businesses need to adopt agile, resilient, and sustainable strategies that can enhance their access to markets and reduce their product delays. Some possible solutions include:

- This can help them mitigate the impact of trade barriers, geopolitical risks, or supply chain disruptions, as well as explore new opportunities and markets.
- This can help them monitor and manage their supply and demand, optimize their production and delivery processes, and respond quickly and effectively to changing customer needs and expectations.
- Developing innovative products and services, to differentiate themselves from their competitors and create value for their customers. This can help them increase their market share and revenue, as well as enhance their customer satisfaction and loyalty.

Self-cheek 3

Part I Choose the best answer

1. At which temperature °F food can enters in to damage?
   A. . 31-125
   B. 41-135
   C. 45-135
   D. D.35-105

2.what are the exaples of regulatory non-compliance?
   A. Wearing personal protective equipment (PPE)
   B. Insufficient administration of operations
   C. Failure to obtain proper certifications/illegal operations
   D. All
   E. All except "A"

3. Transpiration rates (water loss from produce) are determined by the moisture content of the air, which is usually expressed as _____
   A. Temperature
   B. Relative humidity
   C. Dew point
   D. All

4. Which one of the following is not the benefit of hydro cooling?
   A. It reduces the respiration rate and metabolic activity of the produce
   B. It removes field heat and lowers the temperature of the produce
   C. It reduces the risk of microbial contamination and growth
   D. It can damage or spoil some produce items

5. . Reputational damage can be prevented or mitigated by taking proactive measures _____
   A. Implementing effective risk management
   B. Establishing a clear code of ethics
   C. Penalties on regulatory noncompliance
   D. Communicating transparently and honestly
   E. All

F. All Except “C”

▪

Part II Fill the blank the missing word

1. ---------- temperatures that are too low can be just as damaging as those too high. freezing will occur in all commodities below 32°F
2. ---------- Process quality standards protect the business owner from unnecessary costs in product repair or manufacturing rejects

Part III Write short answers

1. What are three different storage facilities? (2point)
2. Write examples of noncompliance? (3point)

Operation sheet 3

2.1 Ensure quality standards in hydrocooling

A. Tools and equipment

- Personal protective equipment PPE
- Screw driver
- Pipe wrenches
- Themometer
- PH meter
- Fruits and vegetables(produce)

B.steps t

Step1. Use potable water of high microbiological quality for hydrocooling.

Step 2. Monitor the water temperature, pH (6.0 and 7.5) and chlorine level regularly.

Step3. Recycle the water with fresh water

Step4. Select produce

Step5. Use appropriate packaging and stacking methods for hydrocooled produce

Step 6. Store and transport hydrocooled produce at the recommended temperature and humidity levels.

2.2 Performe/measure relative humidity

A. Tools and equipment

- Personal protective equipment PPE
- Hygrometer
- Screw driver
- Pipe wrenches
- Themometer
- PH meter
- Fruits and vegetables(produc

Step 1. Operate a humidifier in the storage area.

Step 2. Regulate air movement and ventilation in relation to storage room load.

Step 3. Maintain refrigeration coil temperature within 2°F of the storage room air temperature.

Step 4. Use moisture barriers in the insulation of the storage room or transport vehicle

Step 5.Wetting the storage room floor.

Step 6. Use crushed ice to pack produce for shipment.

Step 7. Sprinkle leafy vegetables, cool-season root vegetables, and immature fruits and vegetables with water.

LAP TEST-3	Performance Test 3

Name……. ID…… Date……

Time started: _____ Time finished: _____

Instructions:

- To perform wearing PPE and cleaning tools, considerate to check presence of all required facility which is listed in information sheet and operation sheet.
- Identify and check the presence of required or necessary tools and equipment that enable you to perform the task you want to perform.
- Given necessary templates, tools and materials you are required to perform the following tasks within **5** hour. The project is expected from each student to do it

Task-1 Perform ensuring quality standards in hydrocooling

Task 2- Perform/measure humidity of the hydrocooler.

Reference Materials

Books

Arifin, B. B., & Chau, K. V. (1987). Forced-air cooling of strawberries. *American Society of Agricultural Engineers (USA)*.

Bennett, A. H. (1965). *Hydrocooling peaches: A practical guide for determining cooling requirements and cooling times* (No. 293). Agricultural Research Service, US Department of Agriculture.

Collins, J. K., & Perkins-Veazie, P. (1993). Postharvest changes in strawberry fruit stored under simulated retail display conditions 1. *Journal of food quality*, *16*(2), 133-143

Ferreira, M. D., Bartz, J. A., Sargent, S. A., & Brecht, J. K. (1996). As assessment of the decay hazard associated with hydrocooling strawberries.

Goble, W. E., & Cooler, F. W. (1962). Quality and consumer acceptance of hydrocooled strawberries.

.

Gooding, H. J. (1976). Resistance to mechanical injury and assessment of shelf life in fruits of strawberry (Fragaria× ananassa). *Hort. Res.*, *16*, 71-82.

JG, H. (1945). An improved grading system for measuring plant disease. *Phytopathology*, *35*, 655.

Horsfall, J. G. (1945). An improved grading system for measuring plant disease. *Phytopathology*, *35*, 655.

Kader, A. A. (2002). *Postharvest technology of horticultural crops* (Vol. 3311). University of California Agriculture and Natural Resources...

Lill, R. E., & Laundon, G. F. (1984). Chlorination of asparagus hydrocooling water for the control of post-harvest decay organisms. *New Zealand journal of experimental agriculture*, *12*(1), 43-45.

Web sites

https://www.youtube.com/watch?v=iG8rpZD-hDo hDo

https://www.youtube.com/watch?v=x0wFVHv5iJk

3.https://www.youtube.com/watch?v=VCcKU52Xy1s

. https://www.youtube.com/watch?v=2BjN7MW2Khc

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

Vacuum cooling https://www.youtube.com/watch?v=c_eNBcBwNnU Access date, October 2023

https://www.youtube.com/watch?v=2BjN7MW2Khc Access date December 2023 How to use a pre-st Cooling tower maintenance annual service procedure https://youtube.com/watch?v=I9tV43-Mwvg access date December 2023

https://www.gardeningknowhow.com/edible/vegetables/vgen/what-is-hydrocooling.htm

Cooling vegetables :https://www.youtube.com/watch?v=azoGx5aegNc access date December 2023

Vacuum cooling: https://www.youtube.com/watch?v=x0wFVHv5iJk Access date, October 2023

Cooling methods:https://youtube.com/watch?v=J6-Uvn0cD4s Access date December 2023

Freeze drying of fruit and vegetable: https://www.youtube.com/watch?v=iG8rpZD-hDo Access date December

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The experts who developed the learning guide

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3	Kiros Mezgebo	Food Science	A	FTVI	0921310111	kirosmez@gmail.com
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