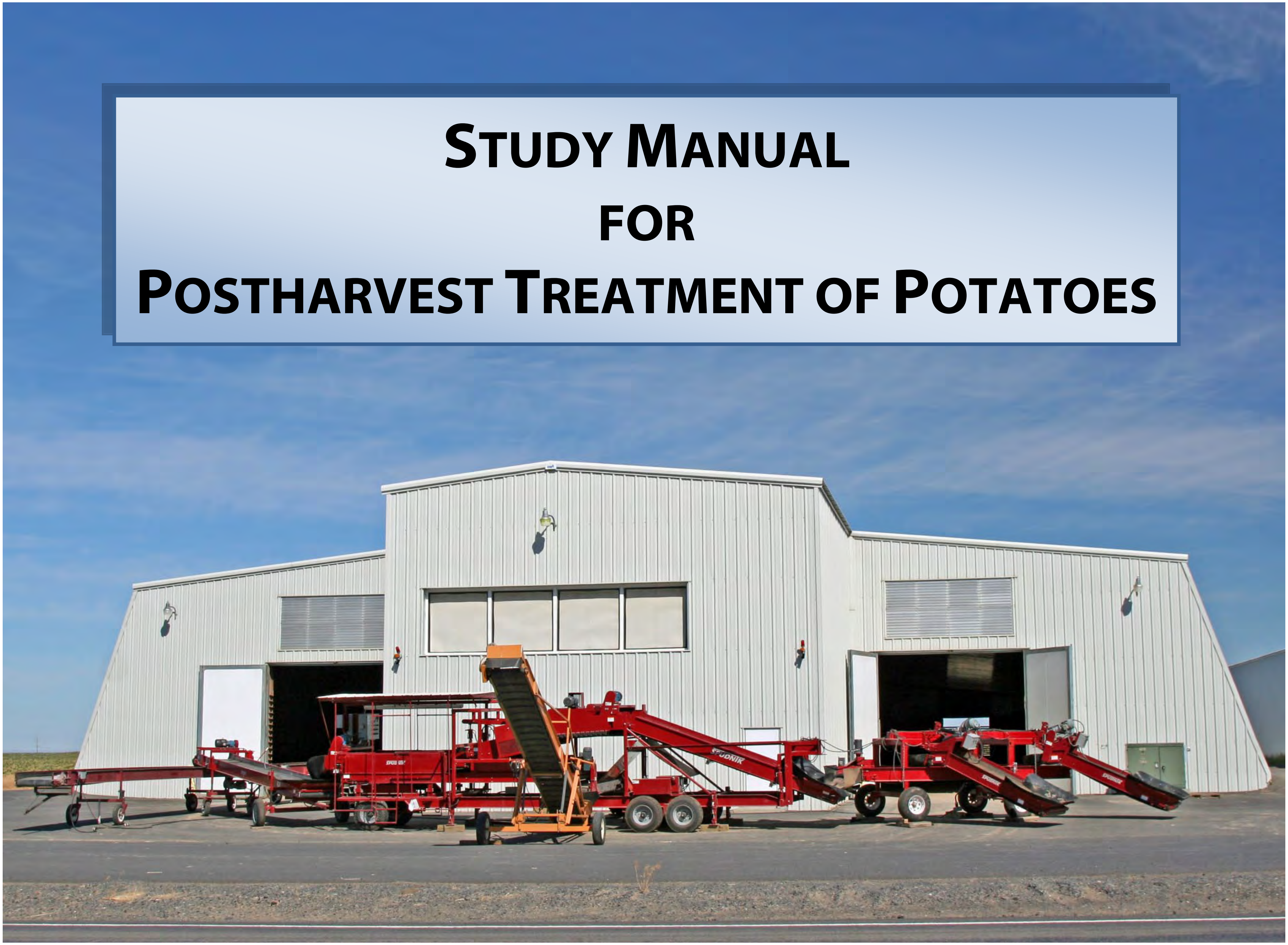
STUDY MANUAL
FOR
POSTHARVEST TREATMENT OF POTATOES



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SCOPE OF MANUAL

This study manual contains information that will provide the reader with a frame of reference concerning the postharvest treatment industry and with the core knowledge in preparing for the pesticide license category “Postharvest Pesticide Applications on Potatoes.” In addition, study manual content will provide the reader with a general understanding of postharvest pesticide application techniques and knowledge of application methods along with entry level core competencies to ensure that pesticide applications are conducted safely and effectively.

BACKGROUND INFORMATION

During the past several decades, the potato industry has become increasingly reliant on some form of sprout control and/or disease control on postharvest potatoes to minimize the loss of product quality and value. The information compiled in this manual is specific to pesticide applications made during the postharvest period, which begins when potatoes are being placed into a storage facility and ends when potatoes reach their final destination.

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No endorsement is intended by the authors of companies or their products mentioned nor is criticism implied of similar companies or their products not mentioned. Although every attempt has been made to produce information that is complete, timely, and accurate, the pesticide user bears responsibility of consulting the pesticide label, understanding its content, and then complying with those instructions.

Learning Objectives

After studying this chapter, you should be able to:

- Explain the need for postharvest potato storage.
- List the most important factors that result in successful postharvest storage.
- Describe the quality criteria for the various potato marketing distribution channels.
- Summarize the potato quality requirements for each market distribution outlet.
- Explain conditions that affect the storage quality of potatoes.
- Describe the three principle postharvest treatment application methods.
- Explain the function of the ventilation system in a storage structure.
- Discuss the use limitations of sprout inhibitors.
- Summarize the limitations with disease control products in postharvest treatments.
- Outline an inspection process to monitor potato condition while in storage.
- Describe the hazards associated with postharvest treatments.

Need for Postharvest Controls

Product Availability

Raw product availability from medium- to long-term storage has become a necessity as a result of inventory requirements from today's potato market distribution outlets. Potato storage provides a grower with increased marketing flexibility while providing the fresh and process markets with a constant, high quality product that is available year-round. Consistent product availability allows the potato industry to adjust to market fluctuation or demand.

Potato Market Distribution Outlets

Potato varieties are continually being developed and selected for improved disease and insect resistance, appearance, taste, storability, and cooking quality. Potato market sectors include the fresh market, the process market (e.g. French fry, chip, frozen, and dehydration), and the seed market.

The fresh market is driven by appearance, which includes size, shape, minimal surface blemishes, and the absence of disease or insect injury and sprouts. Fresh market varieties are managed differently in storage than process varieties to maintain the desired qualities. Fresh market potatoes can be stored at temperatures in the low 40s (degrees Fahrenheit). Prior to packaging, potatoes typically cannot have any visible signs of sprouting.

The process market is concerned with the processing quality of a potato. The potato must have sufficiently low levels of reducing sugars to achieve desired fry color levels. Process potatoes are stored at temperatures in the mid-to-high 40s and even low 50s to maintain a low sugar content. Potatoes can display some visible signs of sprouting prior to being processed.

The seed market is governed by grower preference. Grower selection of a seed potato variety is based on the market criteria into which the potato seed will be sold. Seed potatoes are stored at temperatures in the high 30s to low 40s. Some visible signs of sprouting activity on potato tubers prior to planting are acceptable.

> The intended use of potatoes will dictate the storage temperature. Seed potatoes must be kept near 40°F. Potatoes to be processed into French fries or potato chips must be stored at temperatures in the mid to high 40°F.

Product Quality Control

Production and harvest practices are generally recognized to be the most important factors in maintaining potato quality in storage. Although not directly involved in these activities, the applicator must, nonetheless, have knowledge of potato condition when being placed into storage to ensure the effectiveness of postharvest pesticide treatments.

Historically, growers have depended on storage temperatures of 38° to 42°F to control sprouting, minimize the spread of disease, and maintain raw product quality. This practice is more or less effective based on initial potato condition. Cold temperature storage without sprout control applications is still a common short-term (60 to 90 days) storage management practice for fresh market varieties and potatoes marketed for seed. However, this practice is not an option with varieties for the process market.

Colder storage temperatures result in an increased sugar accumulation in potatoes. The high sugar content causes an undesirable color during the cooking process, known as the Maillard Reaction. (The Maillard Reaction is important in baking, frying, or otherwise heating of nearly all foods that produces a browning.) A potato that cooks or fries dark is typically unacceptable to the potato processing industry.

Current storage management practices include longer and warmer holding periods to meet today's marketing requirements. Accordingly, these market-driven practices have created a need for additional sprout and disease management practices other than simply relying on cold temperature storage.

STORAGE MANAGEMENT

The purpose of potato storage is to maintain tuber quality and provide a uniform flow of potatoes to fresh market and processing plants throughout fall, winter and spring. Good storage practices should prevent excessive dehydration, decay, sprouting, and excessive sugar accumulation that results in unacceptable dark colored products during the frying process.

Optimum storability of potatoes is directly affected by their condition coming out of the field and proper storage management. Although potato quality cannot be improved with postharvest treatments, marketability can be maintained or, in some cases, improved with the management of sprouts or diseases while in storage. Good quality potatoes in storage can also be jeopardized by poor storage practices; so, it is important that applicators understand proper storage management. Maintaining proper temperature, relative humidity, and air circulation are the most important controllable environmental factors affecting the storability of potatoes and can be attained with proper management.

POTATO QUALITY AND STORABILITY

Major quality problems which have occurred in the field or at the time of harvest are very difficult to correct with postharvest applications. What happens to the potato in the field can be the most important factor regarding how well a potato responds to postharvest sprout and disease control applications. Although the person performing postharvest applications has very little involvement with crop production practices, this information can be critical in properly managing potatoes in regard to sprout and disease control products, timing, and application rate.

Conditions that occur in the field as potatoes grow and mature need to be considered in managing the tuber after it is harvested. Good growing conditions include favorable weather, a well-managed irrigation schedule, an appropriate fertility program, limited disease or insect injury, and ample time for the potato to mature before harvest. Good growing conditions and proper handling at harvest are critical to minimize tuber damage and to maintain potato quality while in storage. Adverse growing conditions (e.g., excessively wet soil) and harvest practices (e.g., bruising, mud-caked potatoes) usually require additional effort and monitoring be undertaken in postharvest management.

Therefore, it is important to evaluate the condition of a potato crop in relation to growing conditions and harvest events in order to properly address the potential need for and context of postharvest management practices or pest control strategies. The evaluation should include a discussion with the grower regarding potato quality prior to storage. Desired information should include: environmental conditions (e.g. excessive heat, frost damage), problematic irrigation or fertilization practices, presence of disease, soil conditions, and damage from the harvest and transfer process as well as other observations or concerns.

Additional information for evaluating the condition of the potato crop may include the grower's assessment regarding the physiological maturity of the potato crop at harvest. Physiological maturity of a potato at harvest will affect its condition when placed into storage and its storability. A potato that is immature will typically sustain more damage at harvest and from transfer equipment because of its thin and weak skin. Field stress and disease may cause a potato to age prematurely. A potato that has aged prematurely typically will not store as long as one that has aged properly.

A visual evaluation of the potato pile should be done prior to any postharvest application. The procedure is described in the following sections.

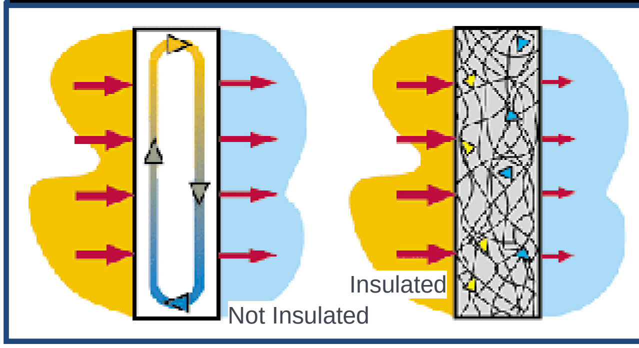
STORAGE FACILITY

To satisfy the demands of the potato market, a storage facility must have structural features and ventilation equipment capable of maintaining the health and quality of the potatoes for the duration of the storage period. The building must be structurally sound to sustain the weight and pressures of the dead load (e.g., framework, installation, roofing, etc,) and all anticipated live loads (e.g., snow, wind, rain, potatoes).

The building should also have appropriate insulation as a first line of defense against condensation forming on the inside of the storage structure. Adequate insulation in the outer walls and ceiling will create a proper barrier between the outside temperature and the inside temperature of the structure and will minimize temperature transfer from within a wall or ceiling (see Figure 1.1). By controlling heat loss or heat gain, insulation can save energy used to maintain storage temperature and minimize water condensation on the ceiling and walls that can ultimately accumulate on the potatoes.

A storage structure should have an inside vapor barrier and outside waterproofing. An inside vapor barrier protects the insulation from inside moisture, which provides the relative humidity that is necessary for stored potatoes. Outside waterproofing is essential to protect the insulation and the building structure from rain or moisture from penetrating the insulating material.

Figure 1.1. Improper insulation can create a convection loop. A convection loop occurs when air rises along a warm surface and falls along a cold surface, creating a circular movement of warm and cold air.



A potato storage facility needs an adequate ventilation system as illustrated in Figures 2.3, 2.7, and 2.8. The ventilation system consists of equipment and controls capable of maintaining proper airflow and air distribution through the potato pile. It also needs to be capable of controlling and maintaining uniform temperatures and relative humidity within the potato pile.

Potatoes absorb oxygen and respire (give off) carbon dioxide, moisture, and heat during the respiration process. The ventilation equipment must be capable of transferring an adequate volume of fresh air (usually from outside the storage facility) through the pile to supply the potato pile with oxygen, to remove carbon dioxide, and to dissipate heat from the pile and the building. This exchange of air is commonly referred to as purging (see Figures 2.7 and 2.8).

Proper management of the storage ventilation equipment limits temperature fluctuations and variations between the bottom of the potato pile and the top of the pile and/or from an outside wall or door. Large temperature fluctuations can adversely affect how long potatoes will store.

With an adequate storage facility and proper storage management, a potato will maintain both its internal and external qualities by receiving a sufficient supply of oxygen and humidity. A proper storage environment will also minimize dehydration (resulting in weight loss and pressure bruising), greening, sprouting, conversion of starch to sugar, and the spread of disease. Furthermore, ventilation and humidity controls are critical for proper suberization and handling of diseased and frost-damaged potatoes.

STORAGE TEMPERATURE AND SUBERIZATION

When placed into storage, the core temperature of the potato is governed by its intended end use. Under seasonal harvest conditions, the potato temperature is initially reduced to 50°F for fresh market varieties and 50° to 55°F for process market varieties. With extreme harvest temperatures where the temperature of potatoes being placed into storage is either more than 65°F or less than 50°F, additional temperature management measures by the storage facility manager may be necessary.

Suberization, the storage period when the wound-healing process takes place, is critical to storage management. Potatoes are held at core temperatures that range from 50° to 55°F throughout the suberization period. This temperature range is desirable because rot organisms can be effectively controlled at temperatures below 48° to 50°F. Higher temperatures during suberization can cause a greater quantity of reduction sugars after the storage set point is lowered to the long-term holding temperature.

Dependent on time and temperature, the suberization period generally lasts about two weeks. When this period is complete, the potato core temperature can be slowly reduced by 0.2° to 0.5°F per day until the desired holding temperature is achieved.

A rapid suberization process is important to minimize weight loss and to maximize disease resistance of the potato tuber.

A mature potato will go into a dormancy period, during which a potato will not sprout (Figure 1.2). Cold temperature storage (38° to 42°F) may lengthen the dormancy period and minimize the need for supplemental sprout control options. If the potato is neither stored at a cold temperature nor chemically treated to prolong dormancy, it will go through its dormancy period within a few weeks or take as long as a few months, depending on the variety of potato and the temperature at which the potato is being stored.

Figure 1.2. A potato sprout eye that is in a state of dormancy, or rest.

If not treated with a sprout control product, the potato will usually begin to sprout from the apical (bud end) where the dominant eye (bud) is located, which is opposite of the stem end (Figure 1.3). Initially, the dominant eye will be the only eye to sprout unless it is removed or the potato is divided. Eventually, apical dominance will weaken and all the eyes will sprout. Sprouting dominance will vary depending on the variety of potato.

Figure 1.3. Untreated potatoes with apical (bud end) sprout dominance, opposite of the stem end.

STORAGE MANAGEMENT

Once potatoes are placed into storage and after their condition is evaluated, a storage manager should prepare a management plan to ensure the potatoes remain healthy and store well. A storage management plan should address specific issues concerning the storage structure and potato condition, and establish a monitoring schedule. A storage manager will visually check the facility and potatoes each day for problems, including:

- Excessive moisture (condensation on the ceiling or standing water) or dehydration of potatoes.
- An increase in the detection of disease or rot (detected visually or by smell).
- Ventilation equipment breakdown or malfunction (e.g., louvers out of position, sensors not functioning properly, etc.).
- Frost damage from improper insulation.
- Unusual or strong odors.
- Sprout development indicating dormancy break.
- Greening (due to lights being left on, doors left open, or exhaust louvers stuck open).

> Potato storage should conserve moisture, prevent excessive decay, retard sprouting, prevent greening, and maintain an acceptable carbohydrate level (sugar/starch balance).

With regular monitoring, the storage manager will be able to determine in a timely manner whether modifications to the ventilation system operation are required or if additional sprout and disease controls are needed.

SPROUT CONTROL ON POSTHARVEST POTATOES

Although many products can control or suppress sprouting on potatoes, only a few are currently U.S. Environmental Protection Agency (USEPA)-registered, affordable, and readily available. The length of time a product will control or suppress sprouts varies, as determined by the product's control characteristics, potato variety, storage holding temperature, timing of the application, and quality of the application.

Three types of products are most commonly used by commercial applicators for sprout control on postharvest potatoes.

CHLORPROPHAM (CIPC)

Chlorpropham is the product most widely used. It has been used by industry for over fifty years and was the only sprout control product commercially applied on stored potatoes until the mid-1990s. It is a carbamate compound and functions as a plant growth regulator to inhibit sprouting by interfering with cell division in the developing eyes on the potato.

CIPC should only be applied after the suberization (wound-healing) period is complete. If applied before healing takes place, it could prevent the proper healing of surface wound areas on potatoes. One application is usually sufficient for medium to long-term sprout control (3 to 9 months).

Advocacy groups are petitioning USEPA with the intent to phase out organophosphate and carbamate pesticides, citing potential adverse health effects on workers, handlers, and children. In response, the potato industry is continually evaluating and developing alternative sprout control products and more effective application techniques. In addition, organic and export markets – where CIPC use is not permitted – have provided an incentive for alternatives to CIPC.

SUBSTITUTED NAPHTHALENES (2,6-DIPN AND 1,4-DMN)

Substituted naphthalenes (2,6-DIPN and 1,4-DMN) are products that also control sprouting. These compounds are used as plant growth regulators to suppress sprouting and to maintain tuber quality.

2,6-DIPN should be applied after the suberization (wound-healing) period is complete while 1,4-DMN can be applied any time after the storage facility is filled. 2,6-DIPN should be applied after the suberization (wound-healing) period is complete while 1,4-DMN can be applied any time after the storage facility is filled. Because the sprout-controlling effect of 1,4-DMN is fully reversible overtime, the product has received a registration for use on seed potatoes.

Both products are registered to be applied alone or in conjunction with a CIPC application. When applied alone – depending on the application rate, storage temperature, and potato variety, one application is usually sufficient for short-term sprout control (30 to 90 days).

Eugenol (Clove oil)

Eugenol (Clove oil), a purified extract from clove, is also used to control sprouts. This product will temporarily suppress sprout growth by damaging the surface tissue of the sprout.

Clove oil is registered to be applied any time after the potatoes have been harvested. It is most effective when applied at the “bud peeping” stage or before the sprouts become one-eighth of an inch long. One application will suppress sprouts for two to three weeks or longer on some varieties under optimum storage and application conditions. Clove oil has been approved for use on organically grown potatoes.

Application Methods

The most common method to apply sprout control products in a potato storage facility is by circulating the material through the potato pile as a thermally-produced aerosol. The aerosol is introduced into the airflow of the storage ventilation system and circulated through the potato pile with existing ventilation equipment or with ventilation equipment set up specifically for the application. This type of sprout control application is typically undertaken by personnel who are licensed to perform commercial pesticide applications.

Another application method is the use of a pressurized spray nozzle or a roller brush assembly. The devices are installed above a conveyor system and apply a sprout control product as an emulsifiable formulation on potatoes prior to being packaged for the fresh market.

Sprout control products are also available as an aerosol formulation. These products are packaged in a pressurized canister for application on potatoes in transport containers.

Disease Control on Postharvest Potatoes

Some disease control products are labeled to prevent specific disease organisms from infecting postharvest potatoes while other disease control products are labeled for application to suppress or control diseases organisms already present on the potato surface. Although it may be impossible to eliminate a disease once colonized on the potato surface, it is possible in most situations to manage the disease during storage. This can be achieved with the proper management of temperature, humidity, and airflow along with the appropriate application of disease control products throughout the postharvest period.

Broad Spectrum Odor and Disease Control Disinfectants

Broad spectrum odor and disease control disinfectants (e.g., sodium hypochlorite, chlorine dioxide, peroxyacetic acid, hydrogen peroxide, peroxyacetic acid and hydrogen peroxide mixtures, soap based organic acid solution, etc.) are formulated into products that are labeled for a variety of uses on postharvest potatoes. When applied as a contact spray, the products are used to control disease organisms on the surface of a potato. Although these products are relatively ineffectual in controlling a disease below the surface of the potato, there still may be some advantage for treatment as a preventative measure or to suppress disease organisms in the initial stages of infection.

Fungicides

Fungicides (e.g., phosphorous acid and thiabendazole [TBZ], etc.) are disease control products used to target specific disease organisms as listed on their respective labels.

BIOLOGICAL FUNGICIDES

Biological fungicides are naturally occurring, non-pathogenic organisms that are used to manage the spread of specific disease organisms. When applied properly, biological fungicides out-compete pathogenic organisms by rapidly colonizing the wound surface, thereby preventing colonization by pathogenic organisms.

Biological fungicides are typically applied onto potatoes while being loaded into storage or as a storage ventilation application. These products may be labeled for use on organic potatoes.

APPLICATION METHODS

One application method uses a pressurized spray nozzle or a roller brush assembly. The device is installed above a conveyor system that transfers potatoes into storage or across a packaging line as the potatoes are being prepared for the fresh market. The disease control product is applied onto the potatoes as they move along the conveyor system.

Another method uses a pressurized spray nozzle or other atomization equipment – such as a centrifugal (spinning disk) fogger – placed in the plenum chamber of a storage facility. The equipment atomizes the product that is dispersed into the airflow of the ventilation system, which is used to circulate the material through the potato pile. Some disease control products are labeled to treat water in holding reservoir(s) of an existing humidification system in a storage facility or in the flume water system of a fresh pack facility.

Disease control applications are typically done by storage or packaging facility employees who are present during the application. Nevertheless, adequate knowledge by commercial pesticide personnel in conducting postharvest applications is important. Their involvement may include consultation with facility personnel regarding the chemical product being applied, the application process, and the application rate. They may also service the application equipment (e.g. setup, calibration, and maintenance) and may handle the chemical being applied.

> Water is the material used to dilute and transfer disease control products onto potatoes; such substances are referred to as “carriers.”

GENERAL APPLICATION HAZARDS AND SAFETY

PESTICIDES

The handling of potato sprout control and disease control pesticides is hazardous, primarily due to dermal and inhalation exposure. <u>Read, understand, and follow label instructions regarding appropriate personal protection equipment (PPE) for safe handling and for effective application.</u> Label requirements for PPE may include protective eyewear (goggles, face shield, or face sealing goggles), chemical resistant gloves (such as nitrile or butyl) and apron, coveralls or a long sleeve shirt and long pants, chemical resistant shoes plus socks, and a respirator and appropriate cartridges.

Before opening the pesticide container, refer to the Personal Protection Equipment section of the pesticide label to ensure that the appropriate equipment is available and that the applicator has been fit tested and properly trained in its use. The applicator must also have been examined by a qualified medical practitioner to ensure physical ability to safely wear the style of respirator to be worn.

ELECTRICITY

Application equipment usually requires access to an existing electrical source at the storage facility. Sprout control application equipment may operate with high voltage (220 volt, single-phase or 240/480 volt, three-phase). Working with and around an electrical source is extremely dangerous. Consequently, applicators must have proper training to safely install the temporary electrical connections.

When working with electrical equipment, always disconnect electrical power at the source, and then verify that the power source has been de-energized by using a voltage tester before installing temporary connections. Never assume that someone else has undertaken the voltage disconnection for you. Always follow correct procedures, electrical codes, state requirements, and safety precautions when working with electricity.

Electricity can cause a fire from an electrical spark, and malfunctioning electrical equipment can generate excessive heat. Ensure electrical equipment is in good operating condition and properly maintained before use.

PROPANE

Some heating units on application equipment are fired by propane. Consequently, there are associated hazards of fire and explosion. Propane has an obvious odor; so, it can be readily detected. Be aware of any leaks that may develop and do not use the equipment until it is repaired. Never use an open flame to test for propane leaks.

BUILDING MATERIAL

Other hazards that an applicator may be exposed to are burning wood, urethane insulation, or electrical equipment. Although very few fires have been associated with postharvest applications, there exists a potential during an application for some types of aerosol generating equipment to cause a fire if not set up or functioning properly, or not operated correctly.

Potato facilities that are made of wood or insulated with urethane foam can be ignited. Once ignited, wood, urethane insulation, and electrical equipment produce a dense black smoke that is very toxic. Smoldering or burning urethane insulation also produces a form of cyanide gas that can be extremely toxic to an applicator. Air purifying respirators normally used for sprout control applications are not adequate to filter the cyanide gas. If involved with a urethane fire, do not enter the building. Leave the site and move upwind. Call the local fire department or the local emergency response system. Let appropriately trained and equipped emergency response crews contend with the fire.

As a safety response measure – and only providing that it can be safely done, turn the application equipment and ventilation fans off and cut off the air supply to the building by closing vent louvers (intake and exhaust) and access doors (bay and walk-in) to the building. Also, move people and equipment away from the building.

Proper equipment setup, operation, and maintenance should virtually eliminate the possibility of a fire.

REVIEW QUESTIONS

1. What is the primary reason for postharvest storage?
   a. Maximize profits
   b. Improve potato quality
   c. Control potato diseases
   d. Flexibility in marketing

2. Cold temperature storage is an effective method for the short- to mid-term control of sprouting on potatoes.
   a. True
   b. False

3. Crop production and harvest practices are _____ in maintaining potato quality in storage.
   a. unpredictable
   b. unimportant
   c. minor importance
   d. very important

4. Cold temperature storage remains a suitable sprout control method primarily for what type of potato?
   a. Seed potatoes
   b. Fresh market potatoes
   c. Process potatoes
   d. Both a and b

5. A potato variety has little effect on storage management practices.
   a. True
   b. False

6. What can cause a potato to cook or fry dark?
   a. Humidity
   b. Warm storage temperature
   c. Sugar accumulation
   d. Dirt and debris in potato pile

7. Some visible signs of sprouting on potato tubers are acceptable to which market(s)?
   a. Fresh market
   b. Seed market
   c. Process market
   d. Both b and c

8. It is possible to eliminate disease that is present on potatoes in storage.
   a. True
   b. False

9. Potatoes destined for the fresh market should ideally be stored at what temperature?
   a. Mid to high 30s
   b. Low 40s
   c. High 40s
   d. Mid 50s

10. Cold temperature storage usually promotes what anomaly?
    a. Peeping
    b. Greening
    c. Sugar accumulation
    d. Light fry

11. What is a use restriction in applying CIPC?
    a. Apply only after suberization is complete
    b. Apply over 50°F
    c. Apply to wet potato surfaces
    d. Only apply as a supplemental treatment

12. Potato quality brought out of storage has a direct relationship with the condition of the crop when it is placed into storage.
    a. True
    b. False

13. What factors can affect storage quality?
    a. Relative maturity at harvest
    b. Fertility practices
    c. Mechanical handling during harvest
    d. All of the above

14. What is the function of an insulation barrier?
    a. Maintain carbon dioxide levels
    b. Minimize temperature fluctuations.
    c. Minimize water condensation
    d. Increase ventilation efficiency

15. 2,6-DIPN must be applied only after the suberization period is complete.
    a. True
    b. False

16. What are some of the hazards associated with sprout and disease control applications?
    a. Over exposure to a pesticide
    b. Electrical shock
    c. Fire and explosion
    d. All the above

17. The ventilation system must be capable of:
    a. Removing carbon dioxide
    b. Supplying oxygen
    c. Purging heat
    d. All of the above

18. Dormancy is defined as being over when the following occurs.
    a. Sprout development
    b. Suberization
    c. Greening
    d. Starch conversion

19. Cold temperature storage may lengthen the dormancy period.
    a. True
    b. False

20. Where on an untreated potato does sprout development typically start?
    a. Stem end
    b. Anywhere on the potato
    c. Apical end

21. A storage manager should visually check the facility and potatoes for problems at least once a week.
    a. True
    b. False

22. Urethane insulation is dangerous primarily for what reason?
    a. Small particles create an inhalation hazard
    b. Burns extremely hot
    c. Produces a form of cyanide gas when burning
    d. Easy to ignite

23. Suberization is dependent on what following element(s)?
    a. Oxygen
    b. Time and temperature
    c. Relative humidity
    d. All the above

24. Maintaining proper temperature, relative humidity, and air circulation are the most important controllable environmental factors affecting storability of potatoes.
    a. True
    b. False

25. What is another reference to the water used to dilute and transfer disease control products onto potatoes?
    a. Dilution
    b. Carrier
    c. Surfactant
    d. Formulation

NOTES

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LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Explain the effect of storage conditions on potato quality.
- List storage conditions detrimental to potato storability.
- Discuss procedures in assessing potato condition.
- Explain the principles in determining if a spout control application should be made.
- Differentiate treatment practices based on length of storage.
- Summarize the pre-application evaluation process of a storage facility.
- Describe pre-application procedure in preparing a storage structure.
- Describe pre-application equipment set-up procedures for a sprout control application.
- Diagram the sprout control equipment setup for three treatment methods.
- Explain the effect of airflow on application uniformity.
- Describe an aerosol sprout control application process.
- Outline the post application cleanup process.
- List the procedure in collecting a potato sample for residue analysis.
- Prepare a post application evaluation report.

SPROUT CONTROL APPLICATIONS ON POTATOES IN STORAGE

To successfully manage sprouts on potatoes during storage, applications must be conducted properly and at the appropriate time. Effectiveness of an application and/or a sprout control product is also influenced by potato quality at the time of harvest, postharvest handling, and how well potatoes are managed in storage. An effective postharvest treatment requires that application equipment adequately aerosolize a sprout control product and that the ventilation equipment evenly distributes the aerosolized product within the potato pile.

For most sprout control products, treatment may begin any time after potatoes are placed into storage or after the suberization period is complete. Label instructions may recommend that the application be made while the potatoes are still dormant but before sprouting occurs. For short-term sprout control products, label instructions may recommend that applications be done after bud sprouting occurs.

It is also important for maximum long-term control that the sprout control application be completed before the pile settles. This allows the aerosolized product to contact the greatest amount of surface area on the potato.

Pesticide label provisions indicate when and how the application is to be made. The instructions on the pesticide label must be read and understood prior to the start of an application. Follow all label instructions and comply with all use restrictions throughout the application process.

In planning of an application, the site and surrounding area should be inspected for obstacles, hazards, or other possible limitations that may affect applicator safety or application effectiveness. Safety hazards may include power lines, frayed wiring, tripping or puncture dangers, or explosive materials. Other concerns are proximity to animals (including pollinating insects), humans, and environmentally sensitive sites (e.g., water, wildlife habit, seed potatoes, and organic or other certified production). Risks posed from unrestricted access by domestic livestock, wild animals, and people along with nearby agricultural activities must also be considered.

Written documentation in the form of a pesticide application record is required for every commercial pesticide application. The responsible commercial applicator must complete the application record on the day that the application is completed or within the time period as required in state pesticide rule. State pesticide rule lists the information that must be documented.

THE APPLICATION PROCESS

HUMIDIFICATION SYSTEM

Humidification systems are a component of the ventilation equipment that supplies humidity to the potato pile. However, some sprout control products, such as chlorpropham (CIPC), are attracted to water. Therefore, humidification equipment – humidifiers, spray jets, and evaporative cooling decks – must be turned off several days prior to the application in order to dry the structure.

Allowing the ventilation equipment and building structure adequate time to dry will help prevent sprout control material from becoming entrapped in the water when being applied and circulated in the storage structure. Dry surfaces will also reduce the likelihood of those products adhering to and collecting on the ventilation equipment and building structure during the application process, rather than being circulated through the potato pile. If weather conditions are extremely cold (below freezing), drying of the ventilation equipment and storage facility may take longer.

PRE-APPLICATION EVALUATION

An evaluation of weather conditions, the storage facility, and potato condition should be completed prior to beginning a postharvest application. A pre-application evaluation will help ensure that conditions are satisfactory for an application.

Adverse weather conditions such as very cold temperatures (below -10°F) may affect the operation of application equipment. Excessive winds (greater than 25 mph) may also adversely affect the uniform distribution of sprout control products throughout the potato pile, especially if the storage facility is not adequately sealed. If adverse weather conditions exist, it may be necessary to delay the application until weather conditions become more favorable.

The storage facility's condition must also be evaluated. The evaluation should include the following structures.

- **Bay doors and building structure** to determine if the building will seal adequately for the application and what actions will need to be undertaken to seal problem areas.
- **Ventilation equipment** to ensure that it is functioning properly. (Notify the storage manager of any malfunctioning equipment.)
- **Plenum chamber** to determine if the humidification system has been turned off for a sufficient length of time to dry the ventilation equipment and the storage facility.

Finally, prior to treatment, an evaluation of the potato pile should be performed. Using a pulp thermometer, record the potato core temperature at several locations on the potato pile (Figure 2.1). Compare the set point temperature of the storage ventilation equipment to the potato pulp temperatures on the pile for deviations of more than three degrees. Inspect the potatoes by visually looking over the pile for the presence or indications of the following problematic signs.

- **Field stress:** Misshaped potatoes that may be an indication of disease, unfavorable water management, nutritional imbalance, and/or exposure to extreme weather during the growing season.

Figure 2.1. Using a thermometer to measure the core (pulp) temperature of a potato.

- **Excessive damage from mishandling at harvest**. Mishandled potatoes will likely have excessive cuts, breaks, and abrasions on the skin. These are all entry points for bacterial and fungal rot.
- **Excessive debris in the potato pile or caked dirt on the potatoes**. Excessive dirt and vines will adversely affect the airflow through the pile. This problem will only become worse over the storage season.
- **Sprouting activity:** An indication that dormancy has broken. This may be associated with field stress, fluctuating storage temperatures and humidity, elevated storage temperatures, and/or physiologically aged potatoes.
- **Abnormal pulp temperatures in storage:** Potato pile temperatures that vary more than three degrees higher or lower than the storage facility's ventilation equipment supply temperature set-point. Also, look for visible signs of frost damaged potatoes characterized by potato surface sweating and/or turning black and decomposing.
- **Excessive moisture on the potato pile:** High moisture areas in the potato pile may be attributable to potatoes being placed into storage too wet, condensation on the inside of the building, insufficient building insulation, excessive humidity added with the ventilation system, moisture caused by potatoes rotting from disease, or any combination of these conditions.
- **Dehydration:** Look for potatoes that are spongy and have pressure bruises or depressions. This may be an indication that the potatoes are not retaining moisture or are not being supplied with sufficient humidity to keep from being damaged by the weight of surrounding potatoes. Dehydration will also be noticeable by excessive settling of the pile.
- **Disease and rot:** Look for visible signs of disease organisms and rot on individual potatoes or sunken areas in the potato pile in which disease and rot have affected a large number of potatoes. A sunken area is commonly referred to as a "hot spot" because of the heat produced from decomposing potatoes. A hot spot is typically accompanied by a strong odor and by moisture that accumulates on the underside of surrounding potatoes.
- **Settled pile:** Potatoes that have been in storage for several months may settle, limiting the amount of potato surface area that a sprout control product can contact. Pile settling is also associated with an increase in internal sprouts (Figure 2.2).

Figure 2.2. Internal sprouts are potato sprouts that grow back into the same potato from which they originated or into a neighboring potato.

Most commercial application companies require applicators to document additional pre-application information, which may include observational assessments about the treatment site and/or application conditions. It is recommended that the additional information along with the evaluation of the potato pile to be treated be recorded in the commercial application company's supplemental report or in the "Comments" section of the pesticide application recordkeeping form.

Unfavorable conditions that could jeopardize pesticide performance or treatment effectiveness should be immediately reported to the applicator's supervisor and storage manager so corrective measures can be undertaken or the application can be re-scheduled.

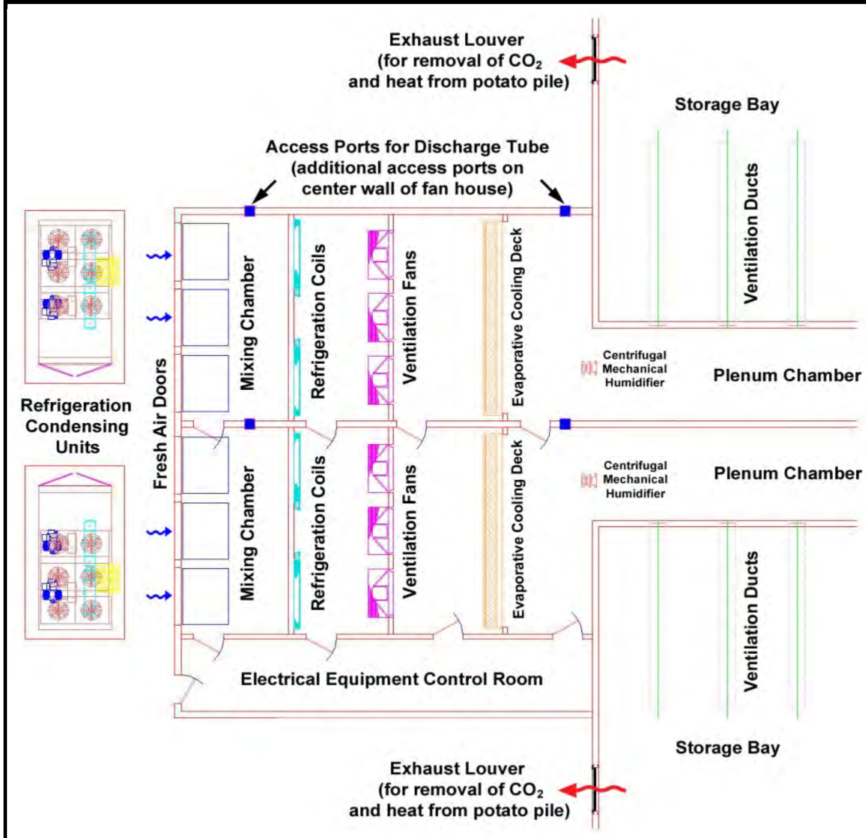


Figure 2.3. Top view of an illustrative potato storage facility.

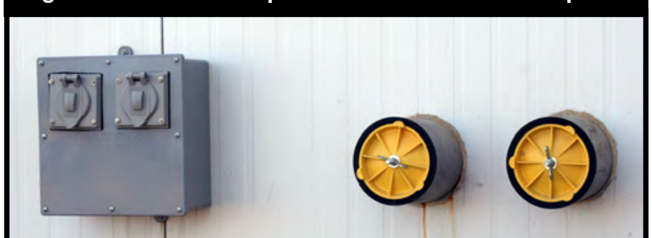
AEROSOL GENERATOR SETUP

Before placement of any equipment, a site assessment should be conducted. Select the best location to introduce the aerosol into the storage facility. The aerosol is typically transferred from the aerosol generator to the storage facility through a flexible discharge tube.

Most potato storage facilities have access ports for the discharge tube (Figures 2.3 and 2.4). Other access options may be through a door or louver opening or by creating a new access port.

The preferred access point would allow the discharge end of the discharge tube to be positioned in the plenum chamber directly downstream from the fans, evaporative cooling deck, and refrigeration coils. An access point downstream of the ventilation equipment will help reduce the accumulation of sprout control product onto the ventilation equipment in the storage facility during the application process, reducing the amount of clean-up after the application. Some building designs may have poor access to the plenum chamber; therefore, an access point upstream from the ventilation equipment may be the only option. In this situation, when applying chlorpropham, additional equipment preparations may need to be undertaken, which may require removing the front guard of each ventilation fan used to eliminate potential plugging during the application.

Figure 2.4. Electrical power source and access ports.



Locate the aerosol generator near the preferred access port. The aerosol generator should be positioned close enough to the building to minimize the length of discharge tube while still allowing application personnel ample room to comfortably work around the equipment. Attach the discharge tube to the outlet end of the aerosol generator. Secure the tube so that it cannot be easily dislodged during the application.

> Always follow correct installation procedures, safety precautions, current electrical codes, and state regulations when undertaking electrical installations.

Insert the discharge end of the discharge tube into the preferred access port of the storage facility. Some storage facilities may have multiple access ports to allow the discharge tube to be routed through interior walls to the preferred discharge point (as illustrated in Figure 2.3).

A 12 to 18 inch length of double-walled pipe, such as a chimney pipe, could be slipped over the discharge tube and then inserted into the access port. The double-walled pipe would serve as an insulation barrier between the discharge tube and the access port. Fiberglass insulation may be used to seal gaps between the double-wall pipe, the access port, and the discharge tube, thus eliminating unwanted venting of the aerosolized sprout control product during the application.

Once inserted into the access port(s), position the discharge tube so that it is clear of obstacles such as wood beams, urethane insulation, and other parts of the building structure that may be directly in-line with the discharged aerosol or that may be vulnerable to the intense heat of the discharge tube. Secure the discharge tube inside the building to prevent dislodging during the application.

The flexible discharge tube becomes very hot (several hundred degrees) during the application, necessitating adequate fireproofing to protect all access ports and surrounding materials.

The discharge end of the discharge tube should be positioned to allow for thorough mixing and optimum distribution of the aerosol into the airflow of the ventilation system. For most sprout control applications, place the discharge end at the center of the plenum chamber or of the mixing chamber and in the direction of the airflow. Placement of the discharge tube in the storage facility may differ when applications are done with reversed airflow, in buildings with unique designs, or if specific areas of the potato pile are targeted.

After the aerosol generator and the discharge tube are in place, connect the aerosol generator to an appropriate electrical source. Once the electrical connections are made, test the electrical devices on the aerosol generator to ensure proper function.

Uniform Distribution & Reduced Airflow

Sprout control products applied in an aerosol form must be distributed evenly within the potato pile. Uniform distribution of the aerosol can only be achieved with a consistent, even airflow. Reduced airflow may adversely alter the consistency and distribution of the aerosol in some building designs. Reducing airflow while maintaining uniform distribution of a chemical can be a challenge but is an important part of an application. Storage facilities with commercially designed ventilation systems are typically the most efficient in distributing air throughout a storage structure.

Most ventilation systems are designed to function with the fan(s) operating at fixed, full speed. For some applications, the airflow requirement for an application may only be a fraction of the airflow generated by fan(s) operating at full speed. However, with some building designs, reducing the airflow may adversely affect air distribution uniformity through the potato pile. The challenge is to maintain uniform air distribution with a reduced airflow (by adjusting fan speed) that is suitable for an application.

Reducing airflow helps to minimize chemical accumulation on the ventilation equipment and the building structure during the application, facilitates the proper distribution of the sprout control product, and minimizes unnecessary escape (venting) of the aerosol from the storage facility. (Refer to the pesticide label for specific instructions regarding reduced airflow.) Properly designed culvert-style ventilation ducts provide the most uniform airflow throughout a potato pile (Figure 2.5). The placement of ventilation ducts and spacing of holes in the ducts are critical to uniform airflow through the pile.

Figure 2.5. Culvert-style ventilation duct.

Some older storage structures do not have automated ventilation systems. These storages often use small fans at the end of each ventilation duct to circulate air through the potato pile. To prepare for an application, these existing fans may need to be removed and temporary fans installed at the end of each ventilation duct.

Storage structures with existing ventilation fan(s) may require reduced fan speed to accommodate an appropriate airflow for the application. For this reason, the use of a variable frequency drive (VFD) controller is essential to manage airflow for most sprout control applications. To achieve the desired airflow, existing (VFD) controller(s) may be used to adjust the speed of the ventilation fan(s) or a portable VFD may be temporarily installed. Always follow correct installation procedures, safety precautions, current electrical code, and state regulations when undertaking electrical installations.

Adjust the fan(s) with the VFD controller(s) to an approximate targeted airflow for the application. Take airflow readings with an anemometer at several ventilation duct openings throughout the plenum chamber (Figure 2.6). Continue to adjust fan speed and retake air readings until the targeted airflow has been achieved.

Figure 2.6. Ventilation duct openings from plenum chamber.

SPROUT CONTROL PRODUCTS AND AIRFLOW

Sprout control products vary in their chemical composition and have different characteristics when aerosolized. These characteristics must be considered when determining the proper airflow for an application. Airflow may be reversed during an application to better distribute the sprout control product to the top of the potato pile.

Chlorpropham (CIPC) and substituted naphthalene (2,6-DIPN) aerosolize into tiny droplets and cool into very small crystals at room temperature. The crystals tend to collect on equipment if the airflow is too high. Reducing the airflow minimizes cleanup by allowing the crystals to be transported through the air stream of the ventilation system at a velocity slow enough for the crystals to avoid colliding with and collecting on ventilation equipment and on the building structure. Therefore, airflow should be adjusted as slow as possible while still maintaining uniform distribution of the sprout control product through the potato pile.

Substituted naphthalene (1,4-DMN) aerosolizes into a gas that distributes evenly in the air space of the storage facility and in the voids between the potatoes. However, with excessive airflow, the gas can be inadvertently exhausted from the storage facility, thereby jeopardizing application effectiveness. Only minimal airflow is normally required to apply this product.

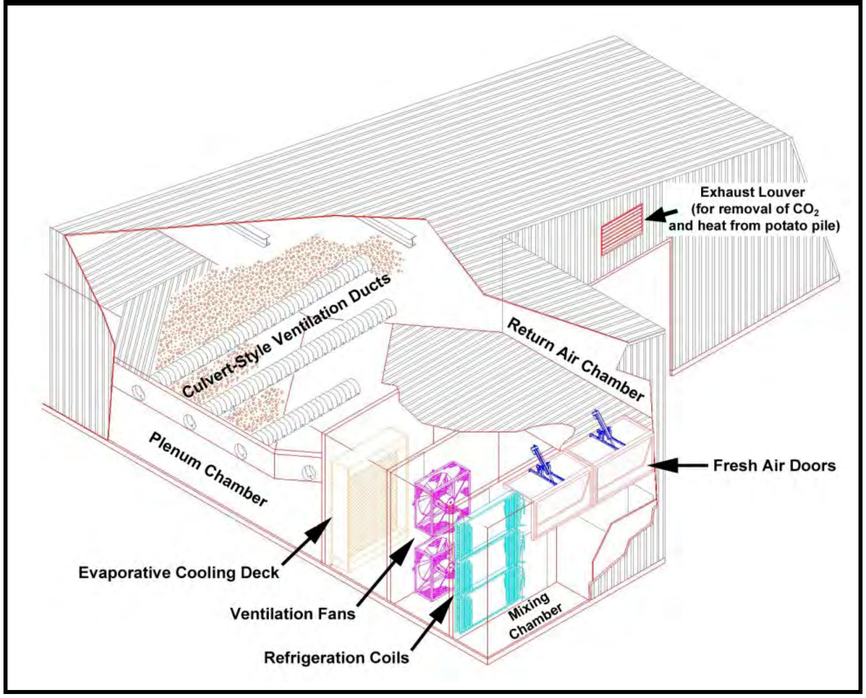
Conversely, eugenol (clove oil) aerosolizes into small vapor droplets that are heavy and may not distribute sufficiently without higher fan speeds and airflow if applied late season to a settled pile.

OTHER CONSIDERATIONS IN DETERMINING PROPER AIRFLOW

In determining proper airflow for an application, it is also important to consider the length of time that potatoes have been in storage. Over the course of the storage season, the pile will settle and become more compact. Increasing airflow for late season applications may be necessary to improve distribution of sprout control products.

Another consideration is the storage facility and ventilation equipment that is being used. Insufficient air distribution, especially in older storage structures, and excessive amounts of dirt and debris in the potato pile may require higher airflow and an increased application rate to achieve satisfactory distribution of sprout control products. Extreme pile settling combined with excessive dirt and debris may make it impossible to attain successful sprout control.

Figure 2.7. Cross section view of an illustrative potato storage facility.



A final consideration when determining proper airflow is the individual preference of the commercial pesticide application company. Drawing on experiences gained from years of commercial pesticide applications, individual businesses may have established guidelines for airflow and fan speeds that have proven successful for their application program.

STORAGE FACILITY PREPARATION

The storage structure should be checked to verify that the humidification system has been turned off and that it has been properly dried. If necessary, reschedule the application until the structure has been properly prepared.

Although sprout control products like chlorpropham can be easily removed by rinsing with water or sweeping, it is still important to protect facility equipment from excess deposits that may accumulate during treatment. With reduced airflow and equipment that has been properly dried, particles will easily move through evaporative cooling deck media and refrigeration coils. If higher airflow is necessary, equipment such as evaporative cooling decks, refrigeration coils, humidifiers, auxiliary fans used for drying the potato pile, and portable heaters may need to be covered to avoid needless cleanup (Figures 2.7 and 2.8).

If the evaporative cooling deck and refrigeration coils must be covered, open the proper bypass to maintain an adequate airflow around them. Plastic sheeting (e.g., Visqueen) or tarps may be used to cover equipment. Secure the coverings to avoid being blown off by air movement during the application. In addition to covering equipment, all portable heaters, auxiliary fans used for drying the potato pile, and lights in the building must be turned off prior to starting the application.

Storage facilities are not airtight. When preparing a storage facility, it is important that the structure is sealed as tightly as feasibly possible to minimize the amount of sprout control product venting from the building during an application. The airflow needed to transfer the aerosolized material from some types of aerosol generators into the potato pile can create positive pressure, forcing some air to vent from the building.

However, precautions can be undertaken before an application to reduce product loss due to unnecessary venting. Exhaust louvers should be closed properly and/or covered (Figure 2.9). Any gaps or holes in the building should be sealed.

Figure 2.8. Side view of an illustrative potato storage facility.

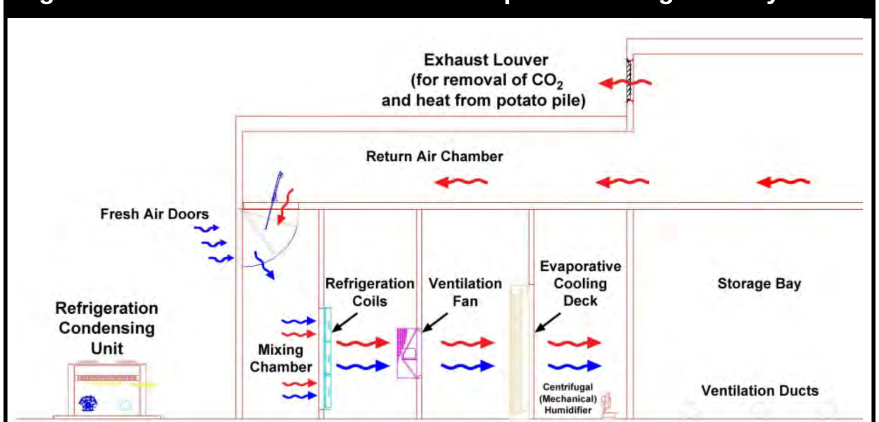


Figure 2.9. Exhaust louvers above access doors.

APPLICATION PROCESS

With the pre-application evaluation, equipment setup, and storage facility preparation complete, a final inspection of the storage facility should be performed to ensure that nobody remains in the building, the lights are off, and the bay doors and walk-in doors are closed and sealed properly. Then, start the ventilation fan(s) at the predetermined speed.

Before handling a sprout control product, wear the required personal protective equipment (PPE) as specified on the product label. Use proper safety protections when working around application equipment that may be noisy or when handling parts that could be extremely hot.

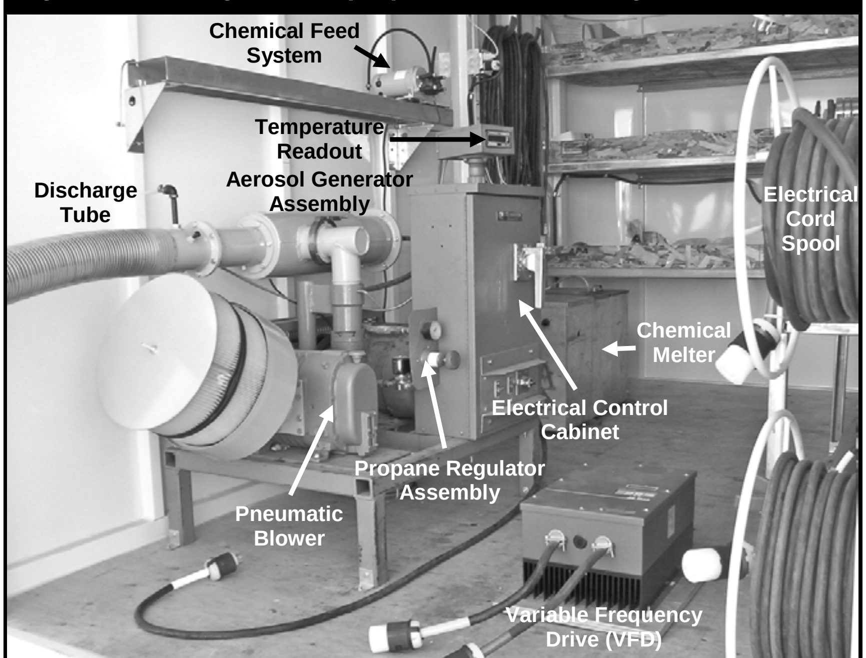
Sprout control products are either solid or liquid, depending on the chemical formulation. Solid formulations are liquefied prior to use by placing the material into the melting chamber of the application unit. To facilitate pumping and to ensure the proper injection rate into the aerosol generator, it may be necessary to heat even liquid formulations because of a change in viscosity with temperature. Some liquid formulations pump easily without supplemental heat in most temperature conditions usually experienced during the application season.

Start the aerosol generator and allow it to heat up to the desired temperature for the application (Figure 2.10). Synchronize preparation of the chemical with the startup of the aerosol generator so both will be ready at about the same time. Document the treatment start-time on the application record.

Do not leave the application equipment unattended during an application.

Start the chemical feed system at a speed that is consistent with the performance output of the aerosol generator being used. Application chemical feed rates may vary with different application equipment. Refer to the feed rates recommended by the commercial application company that is responsible for the equipment.

Figure 2.10. Diagram of a propane-fired aerosol generator.



The chemical feed system must be calibrated. For example, if the target chemical feed rate is one gallon every 12 minutes, monitor the time required to apply one gallon. Adjust the chemical pump speed accordingly until the target chemical feed rate is achieved. Monitor the chemical feed rate periodically throughout the application, making adjustments as necessary. Equipment wear and the affect of temperature variation on product viscosity and the aerosol generator can cause fluctuation to the feed rate. The chemical feed system must have a continuous supply of chemical throughout the application.

The aerosol generator temperature must also be monitored during the application and adjusted when necessary. Some temperature fluctuation (up to 10°F) is normal with propane heated aerosol generators. Propane tanks tend to freeze in cold weather. A heat belt or blanket may be necessary to maintain vapor pressure in the tank.

Once the desired amount of sprout control product is applied, flush the chemical feed lines by pumping an appropriate cleaner – for example, isopropyl alcohol – through the lines until they are clean. Specific rinsing procedures may vary with different application equipment. Refer to the rinse procedures recommended by the commercial application company responsible for the equipment or to the pesticide label for specific instructions.

Finally, turn the chemical feed system off and follow proper shutdown procedures. The shutdown procedure may require turning off the heat source while continuing to operate the main blower to cool the aerosol generator before the final shutdown.

POST APPLICATION RECIRCULATION

At the completion of the application, air recirculation is necessary to allow the chemical last introduced into the storage facility sufficient time to be adequately transferred by the ventilation system through the potato pile. In addition, recirculation may optimize the performance of the chemical and the success of the application by allowing the chemical to move multiple times through the potato pile. Follow all label instructions regarding air recirculation.

The recirculation time is a part of the application. When the recirculation period is complete, turn off the ventilation system and record the stop time on the application recordkeeping form.

EQUIPMENT DISASSEMBLY AND RE-ENTRY

Some disassembly may be done on the aerosol generator during the recirculation period. The temporary electrical source used to operate the generator may be disconnected, providing that the VFD controller(s) are not connected to the same electrical source. Cords and attachments should be returned to their proper storage location in preparation for the next application. The flexible discharge tube(s), once cooled, may be disconnected from the aerosol generator, removed from the building, and returned to its proper storage location.

If it is necessary to enter the building after an application, follow all PPE and re-entry restriction requirements as required on the pesticide label. Visibility may be very poor if the aerosol-fog has not settled. Use caution when working in these conditions.

CLEANUP

Once the recirculation period is complete, cleanup can begin. The following procedural steps should be verified with the commercial applicator's operational plan.

- Turn off the ventilation fan(s).
- Disconnect the temporary VFD controller(s) or reset the existing VFD(s) to its initial setting.
- Reset all ventilation controls to their original setting(s) and leave them in the "Off" position until the cleanup is completed.
- Also, disconnect the electrical source for the ventilation fan(s) until cleanup is completed.
- Remove plastic sheeting (e.g., Visqueen) or tarps used to protect equipment during the application.
- Close all bypass openings around the evaporative cooling decks and refrigeration coils that were opened in preparation for the postharvest application.

- While wearing the appropriate PPE, remove any sprout control product that may have accumulated on the building structure and ventilation equipment by sweeping or rinsing with water.

POST APPLICATION FOLLOW-UP

EVALUATION REPORT

It is good practice to perform a follow-up evaluation several weeks after the completion of a sprout control application. Post application evaluations allow the commercial applicator to visually assess sprout control performance and to monitor potato condition.

Evaluation information is documented on forms that are specific to a commercial pesticide company. Information should include the date the evaluation was conducted, the name of the person completing it, the customer name, storage identification, and physical location. Other information may include the application date and application rate. It is also important to evaluate and record the general condition of the potatoes. Observations should include

- Relative humidity conditions: whether the potatoes are too wet or too dry.
- Temperature conditions: whether potatoes are too hot or too cold and assessing temperature differences between the top and bottom of the potato pile and next to outside walls and doors.

Figure 2.11. A controlled bud peep exhibiting a rounded cauliflower-shaped appearance.

- Incidence and location of potato rot or deterioration.
- Incidence and location of sprouting.
- Visible signs of sprout control may range from no sprouting activity, to cauliflower-shaped bud peeps instead of the normally elongated or spiked bud (Figure 2.11), to sprouts turning dark, withering, or drying up (Figure 2.12).

It is also important to evaluate and record whether the ventilation equipment was functioning properly. Any problems should be noted along with any corrective actions that were undertaken.

Figure 2.12. A treated potato with visible signs of darkened, withered peeps and sprouts.

SAMPLING FOR RESIDUE LEVELS

Post application evaluation may include pulling samples to be analyzed for chemical residue levels that remain on potatoes after an application. The residue level on potatoes treated with a sprout control product is typically less than 20 parts per million (ppm). Therefore, a standardized procedure must be used to collect a representative sample, and the potatoes must be handled in a manner to prevent cross contamination or loss of sprout control product from the sampled potatoes. Always follow the established protocol of the commercial pesticide application company or that of the analytical laboratory for pulling, handling, documenting, and shipping samples.

Before collecting, select the sampling locations on the potato pile. At each location, dig into the potato pile to a depth of 12 to 15 inches. Use a pulp thermometer probe or a similar device to spear the sample potato and lift it out of the hole. Place the sample potato inside the bag or container, using the bag or container to remove the sample potato from the probe. **Do not touch the potatoes when collecting and placing samples into sample containers.** Collect four to six potatoes that are approximately six to eight ounces in size from each location on the potato pile. The sample size will ensure that the laboratory will have ample material to perform the analysis.

On a diagram of the storage facility, note the location where each sample was pulled. Using a pulp thermometer, record the potato core temperature at each sampling location (refer to Figure 2.1). Also, record the incidence and degree of sprouting. Sampling protocol should include collection procedures, sample location, and handling guidelines.

> Identify each sample container and reference the location on the sampling document from where it was collected on the potato pile.

Prepare sample container(s) according to laboratory guidelines and complete the appropriate paperwork. Keep the samples cool, but do not allow them to freeze. Ship or deliver the samples as soon as possible. When the weather is cold, ship the samples at the start of the week to ensure that the samples will not be left in an unheated warehouse or on an outside shipping dock over a weekend.

SUBSEQUENT APPLICATIONS

It may be necessary to perform a supplementary application if the storage period is to be extended. The information in the follow-up evaluation and the projected period of time that the potatoes will be held can be used to determine the appropriate sprout control product and the application rate. Comply with label instructions for subsequent applications.

SPROUT CONTROL APPLICATIONS ON POTATOES PREPARED FOR FRESH MARKET

Some sprout control products are formulated and labeled for application on fresh market potatoes. Sprout control products are applied after potatoes are removed from storage and washed, but prior to being packaged.

Chlorpropham (CIPC) is specifically formulated as an emulsifiable concentrate for fresh market applications. Standard formulations for eugenol (clove oil) may also be labeled for similar use.

Determining the best location to install application equipment can be a challenge in some fresh pack facilities. The pesticide label may specify the placement of application equipment or operational procedures. Pesticide label instructions should be reviewed for mandatory setup or operational requirements. Possible options and preferences for the installation of application equipment on the conveyor system should be reviewed with the responsible facility personnel.

If application equipment is in close proximity to workers, the responsible facility manager should review precautionary safety measures as outlined in the employee safety plan with the commercial applicator. The purpose is to reduce worker exposure from workplace hazards (e.g., rotating sprockets or shafts, electrical, pesticide, tripping, etc.) or to minimize jobsite hazard sites.

APPLICATION EQUIPMENT

Follow label instructions regarding PPE selection and use, and equipment setup, operation, and maintenance. Equipment components may include:

- A pressurized water source connected to a pressurized spray nozzle or to a roller brush assembly.
- A chemical feed system capable of drawing the product from its container and injecting it into the pressurized water source connected to the pressurized spray nozzle or the roller brush assembly.
- Additional drying equipment if the conveyor system does not have sufficient length to allow adequate time to dry potatoes after the application and prior to packaging.
- Application equipment controls that are functionally interlocked with the conveyor belt system that moves the potatoes through the fresh pack facility.

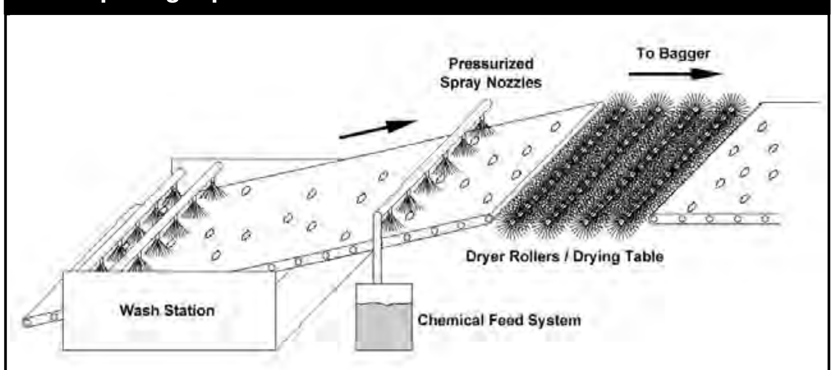
EQUIPMENT SETUP

The pressurized spray nozzle or roller brush assembly should be installed on the drying table after the potato wash station (Figure 2.13).

Position the pressurized spray nozzle or roller brush assembly to achieve even coverage across the conveyor belt surface area and, for best coverage, at a location where potatoes are rolling or tumbling. The remaining application equipment and product container should be placed as close as possible to the pressurized spray nozzle or roller brush assembly to prevent being damaged by moving equipment. Position the application equipment and product container to allow for reasonable access to facilitate the exchange of product containers and to service equipment.

The application equipment controls must be functionally interlocked to the conveyor on/off controls so that the application equipment will operate only when the conveyor system is on and moving.

Figure 2.13. Setup for sprout and disease control applications not requiring a post-treatment rinse.



EQUIPMENT CALIBRATION

Authorized application rates for the product are listed on the pesticide label. With the equipment operating, verify the application rate for a given weight of potatoes, making necessary adjustments to achieve the desired labeled rate.

When applying with a pressurized spray nozzle, use properly sized spray nozzles and adjust the spray nozzle pressure to maximize coverage while minimizing excess misting, off-gassing, and runoff that could result in undesirable odor or worker exposure. When using a roller brush assembly, adjust the product output rate to achieve even coverage with minimal runoff. Periodically analyze treated potatoes to determine if the targeted residual level is being achieved and sustained. (Refer to Chapter 4 for a discussion on calibration calculations.)

EQUIPMENT MAINTENANCE

Application equipment should be inspected regularly to ensure proper operation. Spray nozzles should be inspected for wear and plugging, and replaced when necessary. It is recommended that inspections be performed on a pre-determined schedule rather than when problems are detected.

SPROUT CONTROL APPLICATIONS ON POTATOES AWAITING SHIPMENT

On occasion, it may be necessary to treat potatoes with a sprout control product after the potatoes have been removed from storage, prepared for shipment, and placed into holding rooms or in transport containers (e.g., semi-trailers, railcars, or shipping containers) that are awaiting shipment. Portable, low volume aerosol generators can be used to apply sprout control products to small areas. Standard aerosol generators can be used if portable applicators are not available. Label instructions for treating small areas should be followed.

Portable, low volume generators (such as swing fog units) are powered by gasoline engines and therefore do not require an auxiliary power source. Standard aerosol generators are powered by propane, electricity, or both. When using a standard aerosol generator, the unit must be located near and connected to an appropriate electrical source.

Air circulation is typically not needed to distribute the sprout control product because the area is small and quickly becomes saturated with the product. Follow label instructions for the application rate and proper PPE selection.

Sprout control products may also be labeled and packaged as an aerosol in a pressurized canister to be dispensed on potatoes awaiting shipment. Follow label instructions concerning:

- Application timing and rate.
- Shipping container preparation.
- Canister preparation and placement into the shipping container.
- Canister activation.
- Closure, tagging, and sealing of the exit door.

Label instructions require that application and restricted re-entry information be attached to the exit door of the shipping container. Furthermore, the exit door must be sealed once the application is completed.

REVIEW QUESTIONS

1. What is a characteristic of CIPC that must be considered with a sprout control application?
   a. Plugs nozzles
   b. Wears nozzles
   c. Can be entrapped in water
   d. Can potentially affect potato flavor

2. What devices must be turned off several days prior to an application?
   a. Humidifiers
   b. Evaporative cooling decks
   c. Spray jets
   d. All of the above

3. Dry surfaces on ventilation equipment and the building structure will reduce what?
   a. Likelihood of product accumulation during the application
   b. Incidence of pile hot spots
   c. Application time
   d. Circulation time through the pile

4. What will the pre-application evaluation help ensure?
   a. Conditions are satisfactory for an application.
   b. Potato pile has settled sufficiently.
   c. The correct product is being used.
   d. Proper PPE is available.

5. Winds in excess of this speed can adversely affect product distribution through the pile.
   a. 5 mph
   b. 15 mph
   c. 25 mph
   d. As a structure, wind has no affect.

6. What can influence the dormancy period?
   a. Field stress
   b. Fluctuating storage temperatures
   c. Elevated storage temperatures
   d. All of the above

7. Breaking of dormancy is associated with what event?
   a. Dehydration starts
   b. Respiration increases
   c. Pile settling occurs
   d. Sprouting occurs

8. Sunken areas in a potato pile may be an indication of what condition?
   a. Uneven piling when filing the structure
   b. Excessive insect activity
   c. An area of rotting potatoes
   d. Normal settling process

9. 1,4-DMN aerosolizes into small vapor droplets that are easily distributed at lower fan speeds.
   a. True
   b. False

10. Internal sprouts can be associated with what condition?
    a. Pile settling
    b. Excessive relative humidity
    c. Excessive product application rates
    d. Inadequate ventilation system airflow

11. For most sprout control applications, the discharge end of the discharge tube should be placed at the center of the plenum chamber or mixing chamber, and in what direction?
    a. Directed toward the ceiling
    b. In the direction of the airflow
    c. Directed against the airflow
    d. Where it is easiest to set up

12. Which is true about the discharge tube?
    a. Can be a fire hazard
    b. Should be secured to a wood structure
    c. Must be allowed to flex freely
    d. Must be wrapped with urethane insulation

13. What is the sampling protocol for residue levels on potatoes?
    a. Follow a standardized procedure
    b. Use a random collection procedure
    c. Be done for only long-term storage
    d. Represent the full range of potato sizes

14. What is the function of VFD controllers?
    a. Vary the product injection rate
    b. Measure airflow at ventilation ducts
    c. Adjust ventilation fan speed
    d. Regulate the humidification system

15. It is critical to have adequate air circulation for sprout control applications on potatoes awaiting shipment
    a. True
    b. False

16. When may higher airflow be necessary?
    a. Excessive dirt and debris in the pile.
    b. Clove oil applications.
    c. Late season applications.
    d. All of these conditions.

17. Why should a final inspection be done of the storage facility prior to an application?
    a. Ensure that no one remains in the building
    b. That all lights are off
    c. All doors are closed
    d. All of the above

18. Once the application equipment is calibrated properly, monitoring is unnecessary.
    a. True
    b. False

19. Where does a pressurized nozzle assembly need to be positioned when used to apply sprout control products on potatoes, prior to being packaged for the fresh market?
    a. Location to achieve even coverage
    b. Where installation is convenient
    c. Where potatoes are rolling or tumbling
    d. Both A and C

20. When is the best time to apply a sprout control product?
    a. After the pile settles
    b. Before suberization
    c. After the peeping stage begins
    d. Before the pile settles

NOTES

Learning Objectives

After studying this chapter, you should be able to:

- Identify common potato storage diseases.
- Describe potato storage disease management practices.
- List the three application systems used for postharvest pesticide applications.
- Diagram the three principle postharvest treatment application methods.
- Contrast the application systems suitable to each potato distribution outlet.
- Review inspection procedures for equipment maintenance.
- Calibrate an application apparatus.

Diagnosis and Management of Potato Storage Diseases

Measures undertaken by growers to prevent or minimize diseases from occurring in the field and at harvest will help minimize the incidence of a disease once the potato crop is in storage. However, despite a grower's best efforts to produce and harvest healthy potatoes, bacterial and fungal diseases may still have the potential to cause extensive losses while potatoes are in storage. Thus, storage management decisions may include postharvest pesticide applications to aid in managing storage diseases.

> Prior to considering a postharvest pesticide application, the presence of a disease or diseases must be determined and properly identified, and then a management strategy must be devised. The University of Idaho publication *Diagnosis and Management of Potato Storage Diseases* (July 2006) is an excellent reference on potato storage disease identification and management. The publication is reproduced with permission by the authors in Appendix A.
>
> The publication is the sole reference in this study manual for the identification and management of storage diseases. Its content is an integral part of this chapter in preparation for the postharvest exam.

The application methods referenced in the following sections may be very similar with regard to disease control products, application methods, and application equipment. To adequately describe the application methods, there will be repetition in the general guideline sections of the various application techniques.

Safety Considerations

Label instructions differ among disease control products. The pesticide label should be read and instructions understood before using the product. Pesticide label instructions change periodically. Consequently, use restrictions and instructions – especially PPE requirements and handling and application provisions – should be read prior to each application.

Disease control products may be acidic or corrosive in packaged (or concentrate) formulations. If application equipment will be operated in close proximity to facility personnel, safety measures to limit workplace safety hazards should be reviewed with responsible facility personnel.

Applications on Potatoes being Transferred into Storage

Some disease control products are labeled for applications on potatoes while being transferred into a storage facility. Label instructions may specify restrictions as to when and under what conditions a product may be used. As the best source of information about the material, a pesticide label should be kept at the application site.

EQUIPMENT COMPONENTS

Equipment components may include:

- A pressurized water source connected to a pressurized spray nozzle or to a roller brush assembly. (Refer to the label for potable water requirements.)
- A chemical feed system capable of drawing the product from its container and injecting it into the pressurized water source connected to the pressurized spray nozzle or the roller brush assembly.
- A chemical feed system that is able to draw the product from a mixing or dilution tank and to supply the pressurized spray nozzle or roller brush assembly with a constant, pressurized supply of product.
- Agitation equipment on the mixing or dilution tank to ensure that the product stays in suspension throughout the application.
- Application equipment controls that are functionally interlocked with the conveyor belt system.

EQUIPMENT SETUP

Install the pressurized spray nozzle or roller brush assembly above the conveyor system that transfers the potatoes into storage. Position the pressurized spray nozzle or roller brush assembly to ensure even coverage across the conveyor belt and at a location where potatoes are rolling or tumbling to achieve best coverage. Place the remaining application equipment and product container as close as possible to the pressurized spray nozzle or roller brush assembly and in a location protected from moving equipment. The site must allow for reasonable access to application equipment in order to exchange product containers and to service equipment. Figures 3.1 and 3.2 illustrate an application system that applies a product to potatoes after being unloaded from a truck.

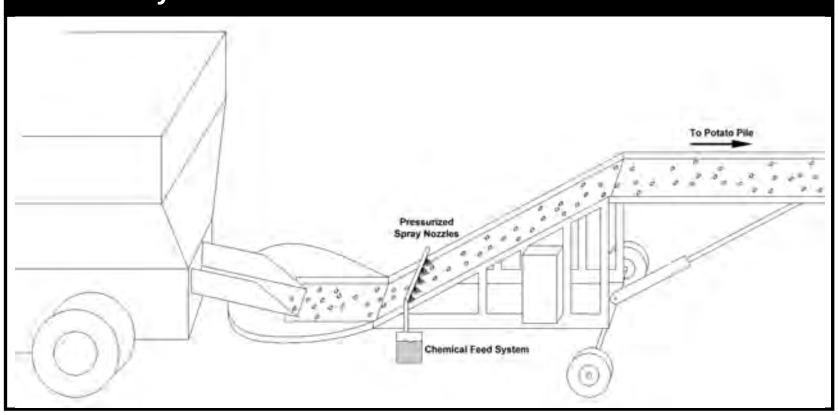
The application equipment should be functionally interlocked to the conveyor system on/off controls so that the application equipment will operate only when the conveyor system is on and moving.

Figure 3.2. Pressurized nozzles applying product to potatoes going into storage.

EQUIPMENT CALIBRATION

Refer to the pesticide label for approved application rates. With the equipment operating, verify that the application rate for a given weight of potatoes is consistent with pesticide label instructions. (Refer to Chapter 4 for a discussion on calibration calculations.) Make necessary injection adjustments. If applying with a pressurized spray nozzle, use properly sized spray nozzles and adjust the spray nozzle pressure to maximize coverage while minimizing excess misting, off-gassing, and runoff that may result in undesirable odor or worker exposure. When a roller brush assembly is used, adjust the output rate to achieve even coverage with minimal runoff.

Figure 3.1. Apparatus layout for a disease control application on a conveyor belt.



EQUIPMENT MAINTENANCE

The application equipment should be inspected regularly – preferably on a pre-determined schedule – to ensure proper operation. Spray nozzles should be inspected for wear and plugging, and replaced when necessary. Nozzles should be replaced when output varies more than 10 percent from the desired rate. Periodically check hoses and fittings for leaks.

APPLICATIONS ON POTATOES IN STORAGE

Some disease control products are formulated and labeled for application on potatoes while in storage.

EXISTING HUMIDIFICATION SYSTEM

Equipment Components

Equipment components may include:

- A chemical feed system that is capable of drawing the product from either its container or a mixing or dilution tank, and then injecting the product into the water supply reservoir of humidification equipment (refer to Figures 2.3, 2.7, and 2.8).
- Agitation equipment on the mixing or dilution tank, a device that keeps the product in suspension throughout the application.
- Application equipment controls that are functionally interlocked with the humidification system controls that regulate the humidity level within the storage facility.

Equipment Setup

The injection line to the water supply reservoir of the humidification equipment must be installed so that the flow is not obstructed. The application equipment and product container should be positioned in the plenum chamber so that doorways or other access points will not be blocked. The location of the application equipment and product container should allow reasonable access to exchange containers and to service equipment.

The application equipment controls must be functionally interlocked with the humidification equipment on/off controls so that the application equipment will operate only when humidification equipment is on.

Equipment Calibration

Authorized application rates for the product are listed on the pesticide label. With the equipment operating, the application rate should be verified, making necessary adjustments to achieve the desired rate. (Calibration is a topic in Chapter 4.)

Equipment Maintenance

Application equipment should be inspected regularly to ensure proper operation. Malfunctioning or broken parts should be immediately repaired or replaced. Periodically check hoses and fittings for leaks. It is recommended that inspections be performed on a predetermined schedule.

EXISTING HUMIDIFICATION SYSTEM – ADDITIONAL COMPONENTS

Equipment Components

Equipment components may include:

- A pressurized water source connected to a pressurized spray nozzle or to additional humidification equipment. (Refer to the product label for potable water requirements.)
- A chemical feed system that is capable of drawing the product from either its container or a mixing or dilution tank, and then supplying the pressurized spray nozzle or additional humidification equipment with a constant, pressurized supply of product.
- Agitation equipment on the mixing or dilution tank to ensure that the product remains in suspension throughout the application.
- Application equipment controls that are functionally interlocked with the ventilation system that circulates air through the plenum chamber and through the potato pile.

Equipment Setup

The pressurized spray nozzle or additional humidification equipment should be installed in the plenum chamber where the product can be carried by the airflow and distributed through the potato pile. Connect the water source to the chemical feed system. Application equipment and the product container should be placed in the plenum chamber so that doorways or other access points are not blocked. Position the application equipment and the product container to allow for reasonable access to exchange containers and to service equipment.

Application equipment controls must be functionally interlocked to the ventilation fan(s) on/off controls so that the application equipment will operate only when the ventilation fans are turned on.

Equipment Calibration

Authorized application rates for the product are listed on the pesticide label. With the equipment operating, verify the application rate for a given weight of potatoes, making necessary adjustments to achieve the desired rate. For better distribution, appropriate spray nozzles and proper nozzle pressure should be used to maximize atomization of the product. (Refer to Chapter 4 for a discussion on calibration calculations.)

Equipment Maintenance

Application equipment should be inspected regularly to ensure proper operation. Malfunctioning or broken parts should be immediately repaired or replaced. Periodically check hoses and fittings for leaks. It is recommended that inspections be performed on a predetermined schedule.

APPLICATIONS ON POTATOES IN FRESH PACK FACILITIES

Some disease control products are labeled for application on potatoes after removal from storage but prior to being packaged for the fresh market.

EQUIPMENT COMPONENTS

Equipment components may include:

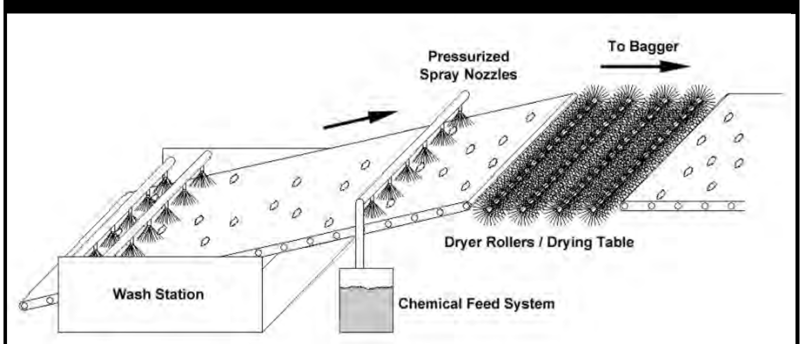
- A pressurized water source connected to a pressurized spray nozzle or to a roller brush assembly. (Refer to the label for potable water requirements.)
- A chemical feed system that is capable of drawing the product from either its container or a mixing or dilution tank, and then supplying the pressurized spray nozzle or the roller brush assembly with a constant, pressurized supply of product.
- Agitation equipment on the mixing or dilution tank to ensure that the product stays in suspension throughout the application.
- Application equipment controls that are functionally interlocked with the conveyor belt system that moves potatoes through the fresh pack facility.

EQUIPMENT SETUP

The pressurized spray nozzle or roller brush assembly should be installed above the conveyor system that moves potatoes through the fresh pack facility. The pesticide label may require a specific layout or may detail the placement of application equipment. The applicator must be familiar with any specific label instructions regarding the application equipment.

The diagram in Figure 3.3 illustrates a general layout for application equipment. Position the pressurized spray nozzle or roller brush assembly to achieve even

Figure 3.3. General layout for sprout and disease control applications not requiring a post-treatment rinse.



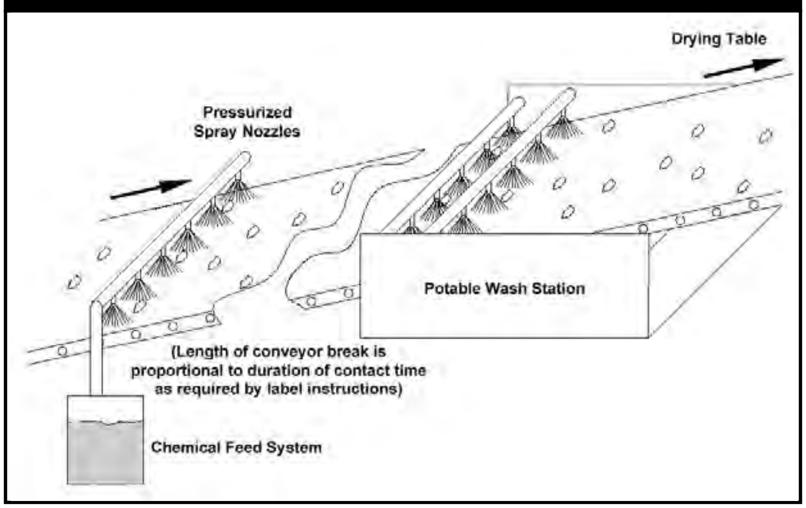
coverage across the conveyor belt surface and at a location where potatoes are rolling or tumbling to ensure thorough coverage. The remaining application equipment should be placed as close as possible to the pressurized spray nozzle or roller brush assembly to prevent being damaged from moving equipment. Position the application equipment to allow for reasonable access to facilitate the exchange of containers and to service equipment.

The application equipment controls must be functionally interlocked with the conveyor system on/off controls so that the application equipment will operate only when the conveyor system is on and moving.

Some product labels require that potatoes receive a potable rinse after the application and prior to packaging. However, to be effective, the rinse cannot occur too soon after the potatoes are treated with the disease control product.

Besides coming into contact with the pathogen (disease-causing organism), two other criteria also exist to ensure the effectiveness of a disease control product. First, solution containing the active ingredient, the material effective in controlling the target pest, must be of sufficient concentration. Second, the active ingredient must remain in contact with the target pest for a sufficient length of time; this is referred to as "contact time." The length of contact time, indicated on the pesticide label, dictates the length of the conveyor belt between the pressurized spray nozzles and the potable rinse. The duration of the contact time, as required by the pesticide label, is portrayed in Figure 3.4 as a break in the conveyor line.

Figure 3.4. Setup for sprout and disease control applications requiring a post-treatment rinse.



EQUIPMENT CALIBRATION

Authorized application rates for the product are listed on the pesticide label. With the equipment operating, verify the application rate for a given weight of potatoes, making necessary adjustments to achieve the desired rate. With a pressurized spray nozzle, use properly sized spray nozzles and adjust the spray nozzle pressure to maximize coverage while minimizing excess misting, off-gassing, and runoff that may result in undesirable odor or worker exposure. When a roller brush assembly is used, adjust the product output rate to achieve even coverage with minimal runoff. (Refer to Chapter 4 for a discussion on calibration calculations.)

EQUIPMENT MAINTENANCE

Application equipment should be inspected regularly to ensure proper operation. Spray nozzles should be inspected for wear and plugging, and replaced when necessary. Periodically check hoses and fittings for leaks. It is recommended that inspections be performed on a predetermined schedule.

APPLICATIONS TO CONVEYOR SYSTEMS AND FLUME WATER

In fresh pack facilities, disease control products may also be labeled for application to the conveyor system and/or to the flume water. With the application equipment already in place to treat potatoes, only minimal effort may be required to add additional equipment to treat the conveyor systems and flume water. Refer to label for specific provisions regarding these types of applications.

REVIEW QUESTIONS

1. Despite healthy potatoes being placed into storage, bacterial and fungal diseases can still potentially cause extensive losses.
   a. True
   b. False

2. After determining the presence of a disease, what is the first step that should be taken before applying a postharvest treatment?
   a. Read the label
   b. Check the tuber core temperature
   c. Determine the potato variety
   d. Identify the disease organism

3. What is true about PPE requirements?
   a. Provided by the salesperson
   b. Available from the manufacturer
   c. Not necessary for organic materials
   d. Listed on the pesticide label

4. The agitation unit serves what purpose?
   a. Keep the product in suspension
   b. Atomize the material
   c. Uniformly apply the material
   d. Minimize product misting

5. What is the function of interlocking controls?
   a. Regulate the flow of product to the pressurized spray nozzle
   b. Prevent water contamination
   c. Monitor nozzle pressure to minimize off-gassing
   d. Allow the application system to operate only when the humidification or conveyor system is operating

6. How often should equipment maintenance be performed?
   a. When problems occur
   b. On a predetermined schedule
   c. Weekly
   d. At least twice a season

7. To ensure uniform coverage, where should the pressurized spray nozzle be placed?
   a. As potatoes first enter the conveyor belt
   b. As potatoes leave the conveyor belt
   c. As potatoes exit the spray wash
   d. As potatoes roll or tumble

8. Soft rot is caused by what organism?
   a. Bacteria
   b. Fungi
   c. Virus
   d. Insects

9. Storage diseases are not curable.
   a. True
   b. False

10. A fungicide program and cultural practices to manage diseases in the field will reduce the percentage of diseased tubers placed into storage.
   a. True
   b. False

11. Storage management involves a balanced usage of what three basic tools?
   a. Relative maturity, temperature, and humidity.
   b. Temperature, airflow, and pesticides.
   c. Temperature, humidity, and airflow.
   d. Relative humidity, airflow, & pesticides.

Match the disease with the symptom:

12. ___ Soft rot	A. Shallow, gray to black, dry lesions
13. ___ Late blight	B. Grey to silvery blotches on the surface of the tuber
14. ___ Dry rot	C. Tan- to brown-colored water-soaked areas of granular, mushy tissue often outlined by brown to black margins
15. ___ Early blight	D. Dry, crumbly, and brown in color with collapsed tissue often laced with secondary white- or other-colored fungal growth
16. ___ Silver scurf	E. Reddish or tan brown, dry, granular rot that extends from the skin of the tuber inward an inch or more

NOTES

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Learning Objectives

After studying this chapter, you should be able to:

- Explain why calibration of application equipment is important.
- Calculate storage volume of variously shaped structures.
- Contrast difference between applications based on potato weight and storage volume.
- Describe the process in converting rates from active ingredient to formulated product.
- Explain the principle in using units of analysis in calculating application rates.
- Compute equivalent units of measurement.
- Calculate pump injection rates.

Introduction

Pesticides have specific label instructions, some mandatory in content, others advisory. The effectiveness of any pesticide depends on the accurate interpretation of the instructions along with proper pretreatment preparation, application rate, timing, and placement. An effective postharvest treatment will require an applicator to perform various functions that include, in part, the following. An applicator's ability to competently perform these functions is the most critical aspect of pesticide use:

- Accurately assess the situation.
- Correctly identify the pest and its stage of development.
- Determine appropriate application rate.
- Calculate size of treatment site.
- Determine amount of product required.
- Prepare proper dilution (concentration).
- Calibrate application equipment.
- Select and properly wear appropriate personal protection equipment.
- Site posting and reentry restrictions.

Even with the correct chemical mixture, it is still possible to apply the wrong amount. If application equipment is incorrectly calibrated, the excessive rate may potentially damage the treated crop, adversely affect the environment or beneficial organisms, or result in an illegal pesticide residue level. If a pesticide residue level exceeds the established tolerance for the food or feed (known as the Maximum Residue Limit, or MRL), the crop is subject to quarantine, seizure, or condemnation. Buyer-imposed residue tolerances may also determine suitability for an intended end use market. Conversely, too little pesticide may not provide effective pest control, necessitating retreatment or potentially jeopardizing crop quality, and prompting pest resistance.

> Precise interpretation of label instructions and accurate equipment calibration are essential to effective pest management.

Proper use of a pesticide and treatment performance are dependent on correct pest identification and its stage of development, proper product selection, accurate calibration, proper equipment operation, adequate pretreatment preparation, and comprehensive post application evaluation. Inattentiveness to any of these factors may jeopardize treatment effectiveness. It is the pesticide user's responsibility to attain the knowledge and develop the skills to safely and properly apply a pesticide.

Units of Conversion for Potato Volume and Weight

Whether a field, lawn, right-of-way, waterway, or potato shed, understanding the distinctive units of measurement is necessary for proper application. As an example, acre is the common unit of area measurement for a field, and application rate is frequently reported in ounces or pints per acre. With landscape applications, area is usually referenced in square feet with application rates quoted in milliliters or ounces per 10,000 square feet. In these situations, area is only two dimensional, specifically, length and width.

Units of measurement used by the postharvest potato treatment industry are somewhat unique to the pesticide application profession. Units of measure are weight (e.g., hundredweight, sacks, tons) or volume (e.g., cubic feet). Table 4.1 lists conversions for units of measurement common to the postharvest potato treatment industry.

As a comparison, a storage structure holding 14 million pounds of potatoes has the following equivalent units of measurement.

- 140,000 hundredweight (referenced as cwt.)
- 140,000 sacks
- 7,000 tons
- 350,000 cubic feet (often reported as ft^3)
- 233,800 bushels

Table 4.1. Common Units of Conversion

1 hundredweight (cwt.) = 100 pounds = 1 sack = 2.5 cubic feet = 1.67 bushels
1 bushel = 60 pounds = 1.5 cubic feet
1 ton = 2,000 pounds = 20 hundredweight = 20 sacks

The most common units of measurement referenced by the postharvest potato treatment industry are cwt. and, less commonly, tons. Most diseases and sprout control products report application rates in quantity of formulated product per cwt. of potatoes.

As an example, to determine the quantity of a sprout control product required to treat 60,000 cwt. of potatoes at one pound of product per 600 cwt. of potatoes, the applicator would divide 60,000 cwt. by 600 cwt. The answer: 100 pounds of product will need to be applied.

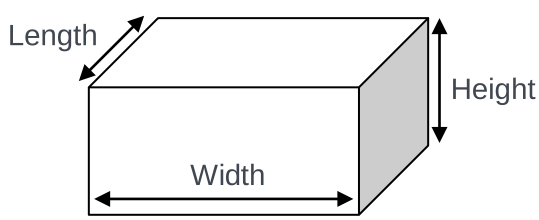
CALCULATING VOLUME OF STORAGE STRUCTURES

In general, the weight of potatoes stored within a structure has been documented and can be obtained from a storage manager for calculating the product application rate. When it is necessary to calculate the volume of the treatment site – whether a structure or a potato pile, the dimension of the area must be determined, and then converted into an appropriate unit of measurement. For potato storage structures, cubic foot (ft^3) is the typical unit of measure, which is then converted to hundredweight (cwt.).

Geometric structures common to potato storage facilities are either rectangles or trapezoids. Calculations can be either done for total structure volume or only for potato pile volume. When calculating just potato pile volume, use pile length, width, height measurements for the variables in the appropriate formulas.

> Accurately calculating the volume of a potato pile can be a challenge in some cases because of irregular sloping and / or uneven pile height. However, calculating an approximate volume of a potato pile is possible by using the appropriate formula and accurate structural measurements.

The volume of a rectangle is calculated by multiplying the length and the width and then the height (see Equation 4.1).

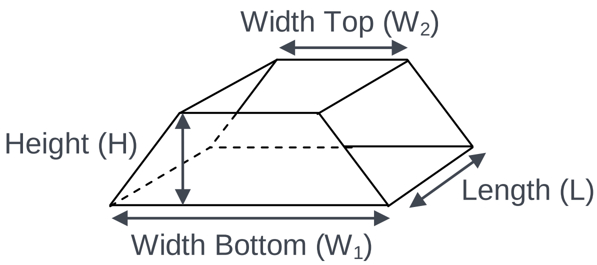


Sometimes, it is necessary to determined the total volume (potato pile and head space) of a storage structure when applying products such as 1,4-DMN.

Equation 4.1.

Volume = Length (L) x Width (W) x Height (H)

The volume of a trapezoid is calculated by the average width of the parallel sides multiplied by the height and then the length (see Equation 4.2). For the height variable in the calculation, the measurement may be either the height of the potato pile or the structure (potato pile and head space), depending on the treatment to be made.



Equation 4.2.

$$\text{Volume} = \left| \frac{W_1 + W_2}{2} \right| \times \text{Height (H)} \times \text{Length (L)}$$

For example: a trapezoid-shaped storage structure was determined to have the following dimensions: Height, 25 feet; Length, 220 feet; Bottom Width, 55 feet; and Top Width, 35 feet. Using Equation 4.2, substitute the values for the variables in the equation.

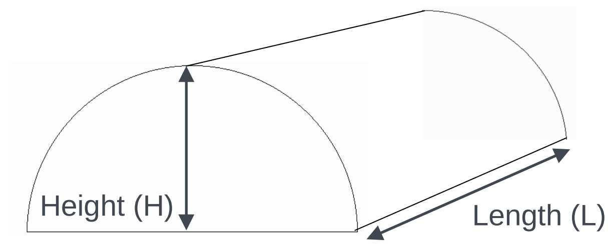
$$\text{Volume} = \left| \frac{55 \text{ feet} + 35 \text{ feet}}{2} \right| \times 25 \text{ feet} \times 220 \text{ feet}$$

Answer:

Volume is 247,500 cubic feet, or 99,000 cwt.

In treating a storage structure, application rate is often in reference to weight (hundredweight, tons) or volume (cubic feet, bushels) of potatoes, not to the storage facility volume (air space).

Determining the total volume of a Quonset (curvet)-style structure uses dimensional units similar to those used to calculate the volume of a rectangle. The exception is that the constant π (pi; generally, 3.1416) is used in the place of width (see Equation 4.3). Calculating the volume of a Quonset-style structure is illustrated below.



Equation 4.3.

$$\text{Volume} = \left| \frac{\text{Height}^2 \times \pi}{2} \right| \times \text{Length (L)}$$

As an illustration, presume that a treatment will be made to a Quonset-style structure with a height of 35 feet and a length of 220 feet. Replace the corresponding values for the terms in Equation 4.3, and then calculate the volume.

$$\text{Volume} = \left| \frac{35 \times 35 \times 3.1416}{2} \right| \times 220$$

Answer: Structure volume is 423,330 cubic feet.

APPLICATION RATE CALCULATION AND CALIBRATION

Calibration is the process of adjusting application equipment to ensure that the desired amount of product is applied to the target site, in this case, potatoes. Equipment must be calibrated carefully and accurately, and then regularly checked to detect and correct for variations in the application rate. Equipment wear, damage, and corrosion; inaccurate gauges; nozzle pressure; product viscosity and specific gravity; and ambient temperature along with many other factors can alter product output during the course of an application. Because of these potentially problematic factors, equipment must be inspected and periodically recalibrated throughout the application process.

Application rate for postharvest treatments is normally expressed as a liquid volume (generally gallons) or pounds per unit area. Unit area is generally referenced in the postharvest treatment industry as hundredweight (cwt.) or tons, but occasionally as cubic feet or bushels. Application rate tables on pesticide labels usually report rate recommendations in pounds active ingredient (a.i.) or gallons formulated product per cwt. or tons. For shipping container applications, the pesticide label will report application rate as a number of canister(s) per cwt. of potatoes.

Application equipment customarily used in the postharvest treatment of potatoes may include aerosol generators, pressurized spray nozzles, roller brush assembly, or humidity equipment (e.g., evaporative cooling decks, centrifugal humidifiers). The treatment site may be comprised of a conveyor belt, potato pile in a storage facility, or a shipping container.

APPLICATION RATE AND CONCENTRATION

Application rate is based on the amount of active ingredient that the product registrant has determined to be necessary in order to achieve a desired level of control for a given weight of potatoes. The application rates may vary among products that have the same active ingredient. Primary reasons may include a difference in product concentration or product formulation or the presence of other active ingredients.

Application rates usually appear on a pesticide label in either a table or a chart format. The range in application rates may be attributed to many factors, a few of which are listed below.

- Target pest
- Level of pest infestation
- Stage of pest development
- Intended length of potato storage period
- Type of storage structure
- Storage temperature
- Potato condition
- Debris in the potato pile
- Cleanness of potatoes (e.g., soil encrusted)
- Potato variety
- End-use (processing, fresh market, seed)
- Method of application (e.g., spray, fog)

With any pesticide application, management of the target pest is dependent on two conditions: (1) sufficient concentration to have the desired effect on the pest and (2) ample length of time that the pest is in contact with the concentration, known as exposure (contact) time. Concentration is customarily reported as parts per million (ppm).

The application rate (as determined from the pesticide label), the operational limitations of the application equipment, and the desired coverage are factors in determining the dilution rate. Accordingly, the dilution rate establishes the concentration of the spray solution.

Concentration applied may be reported as ppm or as percent formulation of the solution.

An application rate of a formulated product, due to its concentration, would be so minuscule that an attempt to effectively apply the material to the target site would be impractical. For example, the challenge to uniformly apply one gallon of formulated product to 100 tons (2,000 cwt.) of potatoes would be unrealistic. Therefore, in an effort to attain an accurate application rate and to achieve uniform coverage, the applicator will dilute the formulated pesticide product (solute) by mixing it with a carrier (solvent) to generate a sufficient volume of a dilution. (The solvent is usually water.) The dilute mixture (dilution) consisting of the pesticide (solute) and water (solvent) is referred to as a solution.

Formulated (pesticide) product means the manufacturer's end use material that is inclusive of the active ingredient(s), inert ingredient(s), and any carrier.

Application rate (or rate of application) is the amount of active ingredient or formulated product of a pesticide that is applied to the treatment site.

A solute (formulated product) is diluted (of lower concentration) whenever a solvent (such as water) is added to the solution (that comprises the formulated product and water).

Always refer to the pesticide label in determining an authorized application rate, the maximum number of applications, timing of application, any market-use restrictions, and safety precautions.

Dilute: to make less concentrated by adding water, another liquid, or a solid to the formulated product.

Dilution: to reduce the concentration of a product.

CONVERTING UNITS OF MEASUREMENT

Not all product use recommendations are reported in formulated product or active ingredient weight (e.g., gram, pound, ton) or product volume (e.g., milliliter, fluid ounce, pint, quart, gallon). Occasionally, a recommendation is listed in ppm (parts per million) or in percent concentration. It is possible that a treatment recommendation may be reported in one unit of measurement (such as percent), but the product label will list an application rate in another unit, perhaps ppm. Possibly, a recommendation may be given in pounds of active ingredient while the product label will list application rates in gallons of formulated product. Consequently, the applicator must be proficient in converting from one unit into an equivalent unit of another measurement.

PARTS PER MILLION AND PERCENT SOLUTION

Parts per million (ppm) is the number of units (or parts) of an item per 1,000,000 units (or parts) of the mixture, solution, or sample. As an illustration, one potato (part) in a pile containing 1 million potatoes (parts) is equivalent to 1 ppm.

1 percent = 10,000 ppm **or** .0001% = 1 ppm

Accordingly, 1,000,000 divided by 1,000,000 equals 100 percent. To illustration this unit of measurement, a potato sample is submitted for a laboratory residue analysis to determine the concentration of CIPC. The laboratory analysis reports a residue concentration of 0.1 ppm. But, the applicator is interested in the weight of CIPC in 1,000,000 pounds (10,000 cwt. or 500 tons) of potatoes. The answer: There is 0.1 pound CIPC.

Likewise, 1 ppm equals 0.0001% (1 ppm divided by 1,000,000 x 100). Thus, 1% equals 10,000 ppm (.01 x 1,000,000). Therefore, a mixture containing a 17,900 percent solution is equivalent to a concentration of 1.79 ppm (17,900 ÷ 10,000).

ACTIVE INGREDIENT & FORMULATED PRODUCT

An application rate is based on the amount of formulated product deemed necessary by the product registrant to effectively treat a given weight or volume of potatoes. Most rate tables on pesticide labels report application rates as the amount of formulated product, not active ingredient (a.i.), per unit volume or weight. However, application rates may occasionally be reported as a.i., not as an amount of formulated product. In these circumstances, it may be necessary for the applicator to convert a rate recommendation from one unit of measurement to the equivalent quantity of another unit.

To illustrate, an applicator will apply the formulated product PIN NIP 2 EC (Figure 4.1) at a rate of one pound a.i. per 40,000 pounds of potatoes. To convert the recommended a.i. rate to an equivalent rate of a formulated product, the percent active ingredient must be known. This information is found on the pesticide label and is reported as percent "ACTIVE INDREDIENT."

Figure 4.1. Partial PIN NIP 2 EC label.

PIN NIP 2 EC

Emulsifiable Concentrate – Potato Sprout Inhibitor

One gallon of product will treat 2,000 cwt. of potatoes.

ACTIVE INGREDIENT:	BY WT.
Chlorpropham* (Isopropyl N-(3-chlorophenyl) carbamate).	23.8%
OTHER INGREDIENTS:..	76.2%
TOTAL..	100.0%

*Contains 2 pounds active ingredient per gallon.

For this particular CIPC formulation, the percent active ingredient (chlorpropham) is 23.8 percent. To calculate the active ingredient equivalent of the formulated product, use Equation 4.4.

Equation 4.4.

$$\frac{\text{Pounds of a.i. recommended}}{\text{Percent a.i. in formulation}} = \text{X pounds formulation}$$

To calculate the variable "X" in this example, substitute the values for the terms in Equation 4.4, as follows.

$$\frac{1.0}{.238} = \text{4.20 pounds of formulated product}$$

Answer:

The recommended rate of 1 pound a.i. is equivalent to 4.20 pounds of formulated product.

SPECIFIC GRAVITY AND SOLUTION DENSITY

Density is the weight of a solution per unit volume (e.g., pounds per gallon, grams per liter). Specific gravity (SG) is a relational comparison between the weight of a material – liquid or solid – relative to that of water. Consequently, if a material has the same density as water, it is assigned a specific gravity value of 1 (SG=1). (A material with a specific gravity less than one will float on water.) Given this fact, if a product's weight per gallon is not given, it can be calculated by multiplying a material's specific gravity times 8.345, the weight of water.

Water weighs 8.345 pounds per U.S. gallon.

If not listed on the product's label, specific gravity is usually referenced under the "Physical and Chemical Properties" section of the product's Material Safety Data Sheet (MSDS). As an illustration, the relevant section of the MSDS for Biox 15 EC is reproduced in Figure 4.2. (Chapter 5 contains a comprehensive explanation of a MSDS and a description of its sections. The MSDS for two products is reproduced in Appendix B.) From this section, it is determined that the material has a specific gravity of 1.17.

In addition to weight, the specific gravity of a liquid affects its flow rate through a nozzle. Manufacturers of spray nozzles base flow rate on water alone at a given pressure. Therefore, conversion factors must be used when spraying solutions that are either heavier or lighter than water to compensate for the flow characteristics of these materials relative to that of water.

Figure 4.2. Partial MSDS for BIOX 15 EC.

BIOX 15 EC

Line Spray

POST-HARVEST

MATERIAL SAFETY DATA SHEET

9. PHYSICAL & CHEMICAL PROPERTIES

- **Appearance:** Clear yellow liquid
- **Odor:** Clove spice
- **Boiling Point:** No data available
- **Flash Point:** Not flammable
- **Flammable Limits:** Not applicable
- **Explosive Properties:** No data available
- **Oxidizing Properties:** No oxidizing properties
- **Vapor Pressure:** No data available
- **pH (@ 25°C):** 8.6 – 9.2
- **Specific Gravity:** 1.17
- **Solubility in Water:** Dispersible

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Thus, when applying a solution with a density heavier or lighter than water, multiply the desired nozzle output in gallons per minute or per hour of the solution by the appropriate conversion factor, that is, the solution's specific gravity (see Equation 4.5). Use the corrected value (compensated for the product's solution density) to select the proper nozzle size from the manufacturers' charts.

Flow rate thorough a nozzle's orifice varies inversely with the square root of the solution's specific gravity.

Equation 4.5 is used to compare flow rates of solutions of any known density.

Equation 4.5.

$$\text{Correction Factor} = \sqrt{SG}$$

To illustrate, an applicator will use five pressurized nozzles that are evenly spaced across the conveyor belt to apply 1.40 gallons per nozzle per hour (GPH), for a total flow rate of 7.0 GPH. Using BIOX 15 EC (Figure 4.2), calculate the correction factor to determine water equivalent output.

$$\text{Correction Factor} = \sqrt{SG} \text{ or } \sqrt{1.17}$$

Answer: 1.0817

Using Equation 4.6, insert the values for the corresponding variables.

Equation 4.6.

$$\text{Adjusted GPH of Solution} = \text{Desired GPH x Correction Factor}$$

Answer:

Adjusted GPM = 1.40 GPH x 1.082

Or: 1.515 GPH adjusted output per nozzle

To achieve the desired cumulative output of seven gallons per hour from the five nozzles, select nozzles from a manufacturer's chart with an output of 1.5 GPH.

EXAMPLES OF CALIBRATING APPLICATION RATES

IN STORAGE AEROSOL SOLUTION IN PPM

An aerosol application for sprout control to stored potatoes is generally reported as a quantity of product applied to a given weight of potatoes or as a rate of application. The rate of application is typically based on a targeted timeframe for sprout control (e.g., 1 month, 3 months, or 6 months). Accordingly, in preparing for an aerosol application, two variables must be known in order to undertake the application. These are the:

- application rate based on the control timeframe and
- weight of potatoes to be treated.

Generally, product labels list the application rate as a quantity of active ingredient or formulated product per hundredweight or ton of potatoes to achieve a treatment concentration, usually reported in ppm. However, if a conversion chart is not available, the applicator must calculate a per unit concentration of the formulated product that is equivalent to the ppm recommendation.

To illustrate this point, a clove oil application will be made to a storage facility to suppress potato sprouts. The facility manager requested that a storage shed be treated with clove oil at a concentration of 31 ppm. For this example, BIOX-C® (Figure 4.3) will be used.

Figure 4.3. Partial label for BIOX-C®.

Aerosol Grade – Potato Sprout & Silver Scurf Control

ACTIVE INGREDIENT:
Clove Oil 100%

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Although most product labels, including the BIOX-C® label, contain a reference chart that equates ppm to an equivalent concentration in gallons or pounds of formulated product per weight unit of potatoes, the following example will assume that this information is not available.

Before an application rate can be determined, the following specific information must be known:

- Desired unit of application, in gallons per ton
- Targeted concentration, provided by the storage manager as 31 ppm
- Percent active ingredient, indicated on the product label as 100% (Figure 4.3)
- Amount of active ingredient by weight in the formulated product OR the weight per gallon of the formulated product, which is either provided or must be calculated

Although the product label lists neither the weight of active ingredient (usually in pounds per gallon) nor the weight per gallon of the formulated product, an applicator can usually obtain this information from the product's MSDS. Referring to Figure 4.4, the specific gravity is 1.04.

With this information, the 31 ppm concentration can be converted into an equivalent application in gallons of formulated product per ton of potatoes.

To calculate the weight of one gallon of formulated product (BIOX-C®), Equation 4.7 is used.

Equation 4.7.

$$\text{Pounds/gallon of formulated product} = \frac{\text{Specific gravity}}{\text{product}} \times \frac{8.345 \text{ lbs.}}{\text{gallon water}}$$

Insert the corresponding values for the variables in Equation 4.7, and then solve.

$$\text{Pounds/gallon of BIOX-C}^{®} = \frac{1.04 \text{ S.G.}}{\text{product}} \times \frac{8.345 \text{ lbs.}}{\text{gallon water}}$$

Answer: 8.6788, or about 8.68 pounds/gallon.

Since 100 percent of the material is active ingredient, it is not necessary to calculate the weight of active ingredient per gallon. Pesticide labels generally reference this value in the "ingredient panel," but sometimes it may need to be calculated, as illustrated in Equation 4.8.

Figure 4.4. Partial MSDS for BIOX-C®.

BIOX-C®

POST-HARVEST

MATERIAL SAFETY DATA SHEET

9. PHYSICAL & CHEMICAL PROPERTIES

- **Appearance:** Clear yellow liquid
- **Odor:** Clove spice
- **Boiling Point:** 482°F (250°C)
- **Flash Point:** Not flammable
- **Flammable Limits:** Not applicable
- **Explosive Properties:** No data available
- **Oxidizing Properties:** No oxidizing properties
- **Vapor Pressure:** 0.009 @ 20°C
- **pH (@ 25°C):** Not available
- **Specific Gravity:** 1.04 (H_20 = 1)
- **Solubility in Water:** Insoluble

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Equation 4.8.

Pounds a.i./gallon of Formulated Product	=	Pounds	Percent, in decimal
		gallon product	active ingredient

Alternatively,

Pounds a.i./gallon of Formulated Product	=	Pounds	Percent a.i., decimal
		gallon product	

Having calculated pounds a.i. per gallon (using Equation 4.8), the relevant terms are inserted for the variables in Equation 4.9a to determine the gallon per ton rate. The expression "1 pound (part) /1,000,000 pounds (parts)" is a conversion factor to convert ppm into a decimal value.

Equation 4.9a.

Gallon of Product/Ton	=	X ppm	1 pound	1 gallon	2,000 lbs.
		desired	1,000,000 lbs.	X lbs. a.i.	ton

Equation 4.9a can be simplified by combining the constants (ppm, ton) into a conversion factor (CF).

Equation 4.9b.

Gallon of Product/Ton	=	X ppm	1 gallon	.002
		desired	X lbs. ai	Conversion Factor

Solve using Equation 4.9b.

Gallon of Product/Ton	=	31 ppm	1 gallon	.002
		desired	8.68 lbs. ai	CF

Answer: 0.007143 gallon per ton of potatoes.

To determine the weight of potatoes (in tons) that can be treated with one gallon of formulated product at the 31 ppm concentration, divide one ton by the previously calculated value.

Tons per gallon at 31 ppm concentration	=	1 ton of potatoes
		0.007143 gallon

Answer: 140.0 tons can be treated with 1 gallon.

This value is consistent with the application rate as reported on the BIOX-C® label (Table 4.2).

If hundredweight is the preferred measurement unit, Equation 4.10 should be used.

Equation 4.10a.

Gallons of Product/Cwt.	=	X ppm	1 pound	1 gallon	100 lbs.
		desired	1,000,000 lbs.	X lbs. a.i.	cwt.

As in Equation 4.9a, the constants (ppm, cwt.) in Equation 4.10a can be simplified into conversion factors, as displayed in Equation 4.10b.

Equation 4.10b.

Gallon of Product/Cwt.	=	X ppm	1 gallon	.0001
		desired	X lbs. a.i.	Conversion Factor

Solve using Equation 4.10b.

Gallon of Product/Cwt.	=	31 ppm	1 gallon	.0001
		desired	8.68 lbs. a.i.	CF

Answer: 0. 00035715 gallon per cwt. of potatoes. To determine the weight of potatoes (in cwt.) that can be treated with one gallon of formulated product at the 31 ppm concentration, divide one cwt. by the previously calculated value.

Tons per gallon at 31 ppm concentration	=	1 ton of potatoes
		0.00035715 gallon

Answer: 2,800 cwt. can be treated with 1 gallon. Again, this value is consistent with the application rate reported on the BIOX-C® label (Table 4.2).

Table 4.2. Partial rate table for BIOX-C®.

BIOX-C®
POST-HARVEST
Aerosol Grade – Potato Sprout & Silver Scurf Control

*Rate/CWT	*Rate/Ton	*PPM
3000	150	29
2800	140	31
2600	130	33
2400	120	36

*One (1) gallon (BIOX-C) per cwt or ton.
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To apply this information, a storage manager requests that a potato shed containing 300,000 cwt. be treated to a concentration of 36 ppm. How much BIOX-C® will be needed?

To calculate the quantity needed, a variant of Equation 4.10b can be applied, as follows.

$$\text{Gallons of Product} = \frac{\text{X cwt}}{\text{potatoes}} \times \frac{\text{X ppm}}{\text{desired}} \times \frac{\text{1 gallon}}{\text{X lbs. a.i.}} \times \frac{.0001}{\text{CF}}$$

To solve, insert the corresponding values for the variables in the above equation.

$$\text{Gallons of Product} = \frac{\text{300,000 cwt}}{\text{potatoes}} \times \frac{\text{36 ppm}}{\text{desired}} \times \frac{\text{1 gallon}}{\text{8.68 lbs. a.i.}} \times \frac{.0001}{\text{CF}}$$

Answer:

Approximately 124.42 gallons of BIOX-C® is needed to achieve the concentration of 36 ppm. (Use 125 gallons; refer to Table 4.2.)

IN STORAGE APPLICATION BASED ON WEIGHT

Products registered for postharvest treatment of potatoes typically report application rate as a quantity of product (fluid ounces, gallons, or pounds) per weight of potatoes. Potato weight is usually reported in tons or cwt., occasionally in bushels.

As an example, an applicator will treat a storage facility that is estimated to contain 4,950 tons of potatoes. A **solid formulation** of CIPC (chlorpropham) containing 98 percent active ingredient (Sprout NIP Briquette; Figure 4.5) will be used. The application rate requested by the storage facility manager is 1 pound active ingredient per 25 tons. However, before beginning the application, the applicator must determine the quantity of formulated product that will be required.

Figure 4.5. Label for Sprout NIP Briquette.

SPROUT NIP BRIQUETTE
Aerosol Grade – Potato Sprout Inhibitor

ACTIVE INGREDIENT:	By Weight
Chlorpropham* (Isopropyl N-(3-chlorophenyl) carbamate)	98.0%
INERT INGREDIENTS	2.0%
TOTAL	100.0%

*Contains 9.8 pounds active ingredient per 10 pounds.

(The "bricks" are actually more of a crystalline consistency. The formulated product must be placed into a vat and melted down before being aerosolized by means of an aerosol generator.)

The formulated product concentration of 9.8 pounds active ingredient per 10 pounds (or 98%) will be used to determine the quantity of product required to treat the 4,950 tons of potatoes at the rate of 1 pound a.i. per 25 tons. To calculate the weight of product needed, Equation 4.4 is used.

$$\text{Pounds Formulated Product} = \frac{\text{4,950 tons}}{\text{facility}} \times \frac{\text{1 lb. a.i.}}{\text{25 tons}} \times \frac{\text{10 lbs.}}{\text{9.8 lbs. a.i.}}$$

Alternatively:

$$\text{Pounds Formulated Product} = \frac{\text{4,950 tons}}{\text{facility}} \times \frac{\text{1 lb. a.i.}}{\text{25 tons}} \times .98$$

Answer:

To treat the storage facility, 202 pounds of formulated product will be required.

Liquid formulations of Sprout NIP also exist (Sprout NIP 7A; Figure 4.6). In referring to the partial label in Figure 4.6, Sprout NIP 7A contains seven pounds active ingredient per gallon. The label recommends 1 pound active ingredient per 600 cwt., which is equivalent to 1 gallon formulated product per 4,200 cwt. (210 tons).

Again using Equation 4.4, insert the corresponding terms, and then calculate.

$$\text{Volume, in Gallons} = \frac{4{,}950\text{ tons}}{\text{facility}} \times \frac{20\text{ cwt.}}{\text{ton}} \times \frac{1\text{ lb. a.i.}}{600\text{ cwt.}} \times \frac{\text{Gallon}}{7.0\text{ lbs. a.i.}}$$

Alternatively,

$$\text{Volume, in Gallons} = \frac{4{,}950\text{ tons}}{\text{facility}} \times \frac{20\text{ cwt.}}{1\text{ ton}} \times \frac{1\text{ gallon}}{4{,}200\text{ cwt.}}$$

Answer:

23.57 gallons of formulated product will be required to complete the application.

Figure 4.6. Label for Sprout NIP 7A.

SPROUT NIP 7A

AEROSOL GRADE POTATO SPROUT INHIBITOR

ONE GALLON OF SPROUT NIP AEROSOL GRADE WILL TREAT 4200 CWT OF POTATOES (210 TONS)

ACTIVE INGREDIENT:	By Weight
***Chlorpropham**	78.5%
INERT INGREDIENTS	21.5%
TOTAL	100.0%

* Isopropyl N-(3-chlorophenyl) carbamate)
Contains 7 pounds active ingredient per gallon.
Contains methanol.

IN STORAGE APPLICATION BASED ON VOLUME

Although an infrequent occurrence, application rates may be reported as a quantity of material per volume of potatoes to achieve a desired concentration, which is typically reported in ppm. Usually, the unit of volume being referenced is cubic feet (often reported as ft^3).

Products with application rates on a per volume basis either have chemical properties that are highly volatile or have physical properties that form small, highly transportable droplets that readily permeate the voids between potatoes. A sufficient concentration of these products must be achieved for successful sprout control.

Volatility is the degree to which a liquid or solid changes into a gas by means of evaporation or vaporization at a given temperature. A substance with higher vapor pressure vaporizes more readily than a substance with a lower vapor pressure.

When treating a storage facility, the applicator must determine whether the volume to be treated is only the potato pile or the entire volume of the storage structure. If the entire volume of the storage structure is to be treated, the material must be applied at a rate to saturate both the potato pile and the structural air space around the pile to achieve the target concentration. When treating the entire volume of a storage structure, use Equations 4.1, 4.2, or 4.3 to calculate structural volume; the value is used to determine the amount of material needed.

To illustrate an application based on volume, a storage facility manager requests that an application using a 97.4% formulated product of 1,4-dimethylnaphthalene (Figure 4.7) be applied to a storage facility to suppress sprouting. A target concentration of 10 ppm is indicated.

The storage facility manager informs the applicator that the dimensions of the shed bay are 30 feet high, 45 feet wide, and 150 feet long. The applicator estimates the structural volume (using Equation 4.1) to be 202,500 cubic feet.

Figure 4.7. Partial label for 1,4SIGHT®.

1,4SIGHT®

	By Weight
Active Ingredient: 1,4-Dimethylnaphthalene*	97.4%
Other Ingredients:	2.6%
TOTAL	100%

*Contains 8.2 pounds active ingredient per gallon.

APPLICATION TIMING AND RATES

Applications of 1,4SIGHT® can be made any time after the potatoes are placed into the storage area.

1. Apply at rates of up to 1 pound of active ingredient per 50,000 lbs. (500 cwt.), which is equivalent to 20 ppm on a product to potato basis or 1 gallon per 4,000 cwt.

The label (Figure 4.7) specifies an application rate of 1 pound active ingredient per 50,000 pounds of potatoes. Using information from Table 4.1 and applying Equation 4.10, the following information is determined. (Equation 4.9 could also be used to calculate volume in tons.)

$$\text{Cwt. in Storage Bay} = \frac{1\text{ cwt.}}{2.5\text{ ft}^3} \times \frac{202{,}500\text{ ft}^3}{\text{structure}}$$

Answer: 81,000 cwt. of potatoes in storage bay.

Next, the quantity of 1,4SIGHT needed to attain the target 10 ppm concentration is calculated.

$$\text{Gallons of Product Need} = \frac{10\text{ ppm}}{\text{desired}} \times \frac{1\text{ gallon}}{8.2\text{ lbs. ai}} \times \frac{81{,}000\text{ cwt.}}{\text{storage bay}} \times \frac{.0001}{\text{C.F.}}$$

Answer:

9.878 (or 10) gallons of 1,4SIGHT will be required to treat the 202,500 cubic foot bay to achieve the target 10 ppm concentration.

MIXING SOLUTIONS

A few pesticide labels direct the pesticide applicator to prepare a solution. A solution is a mixture of one or more substances added to another substance (usually a liquid) in which all the ingredients remain dissolved or do not settle out (or precipitate). However, some product labels may require that the mixture be agitated to keep the product(s) in suspension.

Many approaches are used to express the concentration of a solution. With postharvest applications, solutions are usually based on a percentage concentration where the solute is measured and mixed with the solvent to produce a final solution volume. For this reason, solutions are said to be prepared volumetricially.

As an alternative practice, the undiluted product may be metered into a pressurized water source by means of a Venturi injection system. Since the undiluted product is injected directly into the pressurized system, a solution is not formed.

When directed to "prepare a one to ten dilution of solution X," one of two things can be meant regarding the final concentration.

1. Take one part solution X and add ten parts water. This will produce an 11-part solution.
2. Take one part product X and bring the total volume of the mix to a total of ten parts. A 10-part solution is produced.

Solute - The substance which dissolves in a solution.

Solution - A mixture of two or more pure substances.

Solvent - The substance which dissolves another to form a solution. For example, in a sugar and water solution, water is the solvent; sugar is the solute.

To illustrate a solution calculation, the dilution table from the BIOX 15 EC is reproduced, in part, in Table 4.3 for this example. The active ingredient in BIOX 15 EC is clove oil (15%).

An applicator decides to apply a 1.40% solution. From the dilution chart (Table 4.3), the applicator would add one gallon of formulated product (solute) to 11.5 gallons of water (solvent). (The footnote in Table 4.3 specifies that the percentages are based on a weight-in-volume [w/vol] dilution ratio.) To formulate a 1.40% solution, one part (gallon) formulated product will be combined with 11.5 parts (gallons) water, thereby producing a 12.5-gallon solution.

Table 4.3. Partial BIOX 15 EC Dilution Chart.

Dilution Chart for Biox 15 EC

*Emulsion concentration	Gallon(s) of	
	Product	Water
0.83% (8,300 ppm)	1.0	20.0
1.00% (10,000 ppm)	1.0	16.5
1.21% (12,100 ppm)	1.0	13.5
1.40% (14,000 ppm)	1.0	11.5
1.59% (15,900 ppm)	1.0	10.0
1.84% (18,400 ppm)	1.0	8.5

*These percentages are based on w/vol ratio and are rounded to the nearest 100 ppm.

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If an applicator should choose to apply a solution other than that indicated in the dilution chart (Table 4.3), either a proportion could be "extrapolated" or it could be calculated. To calculate a solution proportion, the following values are needed and can be found on the product label or, for specific gravity, the product's MSDS.

- Percent active ingredient (a.i.)
- Weight per gallon or product's specific gravity

To verify the calculation of this example, an applicator decides to use a 1.59% solution, which appears in the dilution chart (see Table 4.3). To begin, the amount of active ingredient must be determined. From Figure 4.2, the specific gravity of BIOX 15 EC is 1.17. When applying Equation 4.7, the formulated product weight is calculated to be 9.76 pounds per gallon (see below).

Pounds/gallon of BIOX EC	=	1.17 SG	8.345 lbs.
		product	Gallon water

Answer:

BIOX 15 EC weighs 9.76 pounds per gallon.

To calculate the pounds of active ingredient in a gallon of BIOX 15 EC, use Equation 4.8.

Once again, replace the variables in the equation with the corresponding values.

Pounds a.i./gallon of Formulated Product	=	9.76 pounds	.15 (decimal a.i.)
		gallon product	

Answer:

BIOX 15 EC contains 1.464 pounds a.i. per gallon.

Next, the amount of water (solvent) that is required to formulate a 1.59% solution must be calculated. Equation 4.11 is used to compute the volume of the percent solution. The term "% solution" must be entered in a decimal format.

Equation 4.11.

Gallons of Solution	=	Pounds a.i.	desired	Gallon water
		gallon product	% solution	8.345 lbs.

Insert the values for the corresponding variables.

Gallons of Solution	=	1.464 lbs. a.i.	Solution	Gallon
		gallon	0.0159	8.345 lbs.

Answer:

11.0 gallons of solution will be produced. The mixture will contain 1 gallon (part) of formulated product and 10 gallons (parts) of water, producing an 11-gallon solution with a 1.59% percent concentration. This is consistent with the dilution chart (Table 4.3).

PRESSURIZED SPRAY NOZZLES ON A CONVEYOR LINE

It may be necessary to treat potatoes moving across a conveyor line with a sprout or disease control product. The solution is applied through pressurized nozzles that are mounted above and evenly spaced across the conveyor drying table or rollers. The nozzles are usually positioned where the potatoes are tumbling for better coverage (refer to Figures 3.1 through 3.4). Ordinarily, several nozzles are used for even coverage across the width of the conveyor. A typical operating pressure for nozzles is between 25 to 30 psi, but can range from 15 to 40 psi, depending on the water pressure at the facility.

When calculating application rate and nozzle output, the goals are to attain complete coverage of the potato surface and to minimize misting (fine spray particles) and runoff.

Product labels will specify either a given concentration (ppm) to be applied at the nozzles or an application rate (i.e., the amount of product needed to treat a given weight of potatoes).

Products such as chlorine dioxide and peroxyacetic acid/hydrogen peroxide mixtures, which are labeled for a given concentration to be applied at the nozzles, are usually calibrated with the use of a test kit or test strip (Figures 4.9 and 4.10, page 49). Supplied by the product manufacturer, the test equipment enables the applicator to test the concentration at the nozzle output with the application equipment operating, allowing for quick recalibration if necessary.

In calculating the application rate, output is established by the weight of potatoes that move across the conveyor line during a predetermined time period. Application rate is the combined output from all the spray nozzles; per nozzle output is calculated by dividing the combined output by the number of nozzles.

If the flow rate of an individual nozzle varies more than 10 percent from an average of all the nozzles, it should be replaced.

The volume of solution prepared is established by the weight of potatoes that traverse a conveyor line in one hour. Industry uses a general guideline that approximately 4,000 hundredweight are treated in a four-hour period, or 1,000 cwt. per hour.

For example, a packer will apply a formulated mixture that contains peroxyacetic acid and hydrogen peroxide for disinfection on potatoes as potatoes are being placed into storage. Tsunami 100 is one such formulated mixture and will be used in this calculation (Figure 4.8). The packer specifies an 80 ppm peroxyacetic acid solution. (Although Tsunami 100 also contains hydrogen peroxide, the application rate is based on peroxyacetic acid.) The washing station and dryer table are operated at 1,000 cwt. per hour. The dilution is applied through five nozzles. The packer is anticipating a 420,000-pound run.

Figure 4.8. Partial label for Tsunami 100.

Tsunami 100

Water Additive for Pathogen Reduction in Fruit and Vegetable Processing Water and Controlling the Growth of Spoilage and Decay Causing Non-Public Health Organisms on Fruit and Vegetable Surfaces.

Active Ingredients

Peroxyacetic acid	15.2%
Hydrogen peroxide	11.2%
INERT INGREDIENTS:	73.6%
TOTAL	100.0%

The applicator will need to know the following information before the application can proceed:

- Solution ratio in fluid ounces formulated product per gallon of water
- Total volume of solution to be mixed
- Length of time to complete the run
- Total nozzle output in gallons per hour

Although the Tsunami 100 label does not provide a dilution chart or a solution ratio, it can nevertheless be calculated. (Before continuing, the reader is encouraged to review the preceding section titled "Parts per Million and Percent Solution.")

The following information has been provided:

- Desired concentration is 80 ppm, based on peroxyacetic acid
- 1% = 10,000 ppm
- 1 gallon = 128 ounces
- Tsunami 100 contains 15.2% active ingredient peroxyacetic acid
- 420,000-pound packing run
- Packing line operates at 1,000 cwt. per hour
- Five pressurized nozzles apply the solution
- Application rate is requested in fluid ounces of formulated product per gallon of water

With this information, the information required by the applicator can now be determined.

Step 1: Calculate for Solution Ratio

Equation 4.12 will be used.

Equation 4.12.

Ounces Product/ Gallon Water =	X ppm	1%	1 gallon	128 fl. oz.
	desired	10,000 ppm	% a.i.	gallon

To solve, replace the variables in the equation with the known values.

Ounces Product/ Gallon Water =	80 ppm	1%	1 gallon	128 fl. oz.
	desired	10,000 ppm	15.2% a.i.	gallon

Answer:

.067368 fluid ounce of formulated product in each gallon of solution (0.933 gallon of water).

Step 2: Determine Time Period of Run

The packer indicated that the packing line operates at 1,000 cwt. per hour and that 420,000 pounds will be packed. From this, the time period can be calculated, as follows:

Packing Run, in Hours =	420,000 lbs.	Hour	1 cwt.
	potatoes	1,000 cwt.	100 lbs.

Answer: 4.2 hours to complete the run.

Step 3: Nozzle Output in Gallons per Hour

Total nozzle flow is dictated by the occurrence of product misting or by the volume of product runoff during the application. As a general rule, nozzle output typically ranges between 1.0 to 2.0 gallons per nozzle per hour. Based on previous applications, the applicator determines a total nozzle output of 8.75 gallons per hour provides the best coverage while minimizing the incidence of misting and runoff. Therefore, per nozzle output is determined as follows:

Nozzle output, in gallons	=	8.75 gallons / total output per hour	Apparatus / 5 nozzles

Answer:

1.75 gallons per nozzle per hour.

Step 4: Volume of Solution to be Mixed

The calculation from Step 2 and the applicator's preferred nozzle output (as reported in Step 3) will be used to determine the solution volume that will be needed for the 420,000-pound run.

Solution Volume, in Gallons	=	4.2 hours / run	8.75 gallons / hour

Answer:

36.75 gallons. To ensure sufficient volume, a 45-gallon batch will be mixed.

Step 5: Solution Proportion – Product:Water

For this calculation, the computed value from Step 1 will be used. In this calculation, it was determined that each gallon of solution will contain 0.067368 fluid ounce (part) formulated product and 0.932632 gallon (part) water. In Step 4, the applicator will prepare a 45-gallon batch to guarantee an adequate quantity. Given this information, the proportion of product-to-water (product:water) that will yield 45 gallons of 80 ppm solution can be determined.

To calculate the relative amounts (parts) of formulated product and water in a 45-gallon solution, a proportion can be used.

0.0674 part product:1 part solution = x:45

Or: $$\frac{.0674}{1} = \frac{x}{45}$$

Solve for x: 1 = 3.03x; x = 3.03

In preparing a 45-gallon solution, 3 parts will be formulated product with 42 parts water.

Step 6: Verify Nozzle Flow Rate

With low flow rates, it may be difficult to calibrate accurately with the volume of solution collected from each nozzle, necessitating a much longer run time to collect a sufficient volume. In these situations, milliliter per second as a volume of measurement may provide a more accurate assessment of flow rate. A conversion factor to equate gallons per hour to ounces per minute is calculated using equation 4.13.

Equation 4.13.

Ounces per Minute	=	X gallons / hour	Hour / 60 minutes	128 ounces / gallon

With the per nozzle output calculated in Step 3, the rate in ounce per second is determined by inserting the known values for the corresponding variables in Equation 4.13.

Ounces per Minute per Nozzle	=	1.75 gallons / hour	Hour / 60 minutes	128 ounces / gallon

Answer: 3.73 ounces per minute per nozzle.

For ease, a conversion factor (2.133; Equation 4.13) can be used to convert nozzle output from gallons per hour to ounces per minute.

1.75 gallons/hour x 2.133 = 3.73 ounces/minute/nozzle

Applicators may prefer to calibrate injection rate using milliliters per second rather than ounces per minute, particularly with very low flow rates. Use Equation 4.14 to make this conversion.

Equation 4.14.

Milliliters per Second	=	X gallons / hour	3,785.41 ml / gallon	Hour / 60 min.	Minute / 60 sec.

Again, to simplify the calculation, a conversion factor (1.0515) can be used to convert nozzle output from gallons per hour to milliliters per second.

1.75 gallons/hour x 1.0515 = 1.84 milliliter/second/nozzle

Finally, if five nozzles are used to apply the solution, the per nozzle flow rate should be 3.73 ounces per minute or 1.84 milliliters per second, with a total flow rate from all five nozzles of 18.7 ounces per minute or 9.2 milliliters per second.

As with any calculation, the computed value must be verified in actual use. Slight adjustments will undoubtedly need to be made to nozzle pressure or to nozzle size, or both, in order to achieve the desired application rate.

PERIODIC SAMPLING FOR CONCENTRATION

Sprout control products applied with pressurized spray nozzle(s) on a conveyor line can be tested for ppm concentration on a treated potato. Samples can be taken from the conveyor line after the potato is treated and then sent to an analytical laboratory for ppm concentration analysis. Always follow the established protocol of the commercial pesticide application company or that of the analytical laboratory for pulling, handling, documenting and shipping samples. Once the ppm concentration on the sampled potatoes is known, the application equipment can be adjusted to reach a targeted ppm concentration.

To simplify the calibration process, some disease control products applied with pressurized spray nozzle(s) on a conveyor line can be tested for concentration of the control product in the final solution. Products such as chlorine dioxide and peroxyacetic acid/hydrogen peroxide mixtures have test strips or test kits that are commercially available and can be used to check the concentration of the product at the nozzles while the equipment is running (Figures 4.9 and 4.10). These simple tests allow the person doing the application to quickly adjust the application equipment according to the results of the test.

Figure 4.9. Test strips to measure the concentration of peracetic acid.

Figure 4.10. Test kit to determine peroxyacid (left) and peroxide concentration.

REVIEW QUESTIONS

1. Even though you may have the correct chemical mixture, it is still possible to apply the wrong amount.
    a. True
    b. False

2. Calibration must consider all of the following factors except
    a. volume of the treatment area.
    b. product's a.i. content.
    c. line pressure of spray nozzles.
    d. size of application tank.

3. What factors can affect the application rate?
    a. Specific gravity
    b. Equipment wear
    c. Nozzle pressure
    d. All of the above

4. A product with 92% active ingredient (a.i.) will be used for sprout control at a rate of 1.15 pounds a.i. per 20,000 cwt. How much product will be needed to treat 140,000 cwt?
    a. 7.00 pounds
    b. 7.04 pounds
    c. 8.05 pounds
    d. 8.75 pounds

5. A rectangular storage structure has the dimensions: height 25 feet; length, 250 feet; width, 45 feet. What is the structure's volume?
    a. 6,250 cubic feet
    b. 11,250 cubic feet
    c. 281,250 cubic feet
    d. Cannot be calculated

6. A product with a specific gravity of 1.21 weights how much per gallon?
    a. 6.89 pounds
    b. 7.58 pounds
    c. 9.71 pounds
    d. 10.09 pounds

7. 1 ppm is equivalent to
    a. 1 percent.
    b. .01 percent.
    c. .001 percent.
    d. .0001 percent.

8. A packaging line running at 950 cwt. per hour will treat 7,500 cwt. of potatoes at a rate of 1.25 quarts solution per 2,000 cwt. When calibrating the pump, what will the total nozzle output need to be?
    a. 19.0 ounces per hour
    b. 19.8 ounces per hour
    c. 31.7 ounces per minute
    d. 59.4 ounces per minute

9. A storage shed with a volume of 186,230 cubic feet is equivalent to how many hundredweight of potatoes?
    a. 18,623
    b. 74,492
    c. 111,515
    d. 279,345

10. CIPC is to be applied at a rate of 1 pound a.i. per 600 cwt. How many pounds of formulated product will be needed to treat 390,000 cwt?
    a. 390
    b. 570
    c. 650
    d. Cannot be calculated

11. A sprout control product with 1.72 pounds active ingredient per gallon will be used to apply a 1.83 percent solution. How many gallons of solution (mixture) will be mixed?
    a. 10.5 gallons
    b. 11.3 gallons
    c. 12.7 gallons
    d. Cannot be calculated

12. Density is the weight of a solution
    a. per unit volume.
    b. relative to water.
    c. relative to formulate product.
    d. at 30°C.

13. The effectiveness of a pesticide treatment depends on accurate pest identification, proper product selection, uniform coverage, and correct application rate.
    a. True
    b. False

14. Pesticide product use recommendations are typically reported as active ingredient.
    a. True
    b. False

NOTES

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Learning Objectives

After studying this chapter, you should be able to:

- Interpret the terms “label” and “labeling.”
- Explain a pesticide user’s responsibilities when using a pesticide product.
- Identify the parts of a pesticide label.
- Distinguish between “active” and “inert” ingredients.
- Explain the purpose of a product’s MSDS.
- Differentiate the type of information contained on the label and in the MSDS.
- Summarize the need for a MSDS during a pesticide application.

Introduction

This chapter is not intended to be replacement for but as a supplement to the pesticide label section in the *Washington Pesticide Laws and Safety* (MISC0056) study manual. The reader is encouraged to review the chapter titled “The Pesticide Label” in the above-mentioned manual.

As a review, by law, a pesticide user is required to follow all of the label instructions and use directions on the pesticide label. Because the label is a legal document, failure to read and follow that information can result in civil action against the user by USEPA (Environmental Protection Agency) as the lead agency in the enforcement of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) or the state lead agency with legislative authority for the enforcement of pesticide regulations, or both.

> The pesticide user is liable for personal injury, crop or site damage, or pollution that occurs through misuse of a pesticide.

Pesticide product labeling is the main method of communication between a pesticide manufacturer and pesticide users. The **label** contains user instructions that are either printed on or attached to the pesticide container or its wrapper. **Labeling** includes the label along with all additional information about the product or its use provided by the manufacturer or registrant at the time of purchase. Labeling may include brochures, leaflets, Section 2(ee) recommendations, MSDS, and other information accompanying the pesticide material. An extension of the product label, pesticide labeling contains instructions on how to use the product safely and correctly. Both the label and labeling are legally binding documents and must be followed by the user. Product labeling, however, may not be used in place of the product label, only in conjunction with it.

> Pesticide users are required by federal law and state regulations to comply with all the instructions and directions for use that appear in pesticide labeling.

When Should You Read a Pesticide Label?

Pesticide labels periodically change. For this reason, the product label should be read <u>each</u> time prior to its use. In fact, the pesticide label and labeling should be read:

- <u>Prior to purchase</u>: Is the pesticide registered for the intended use? Are there any restrictions or other conditions of use that prevent the use of the pesticide at the application site? What PPE or special application equipment is needed and are you trained in its use?
- <u>Prior to use</u>: Do you understand how to mix and apply the materials safely? What precautions need to be taken to prevent exposure to people and nontarget organisms? What first aid and medical treatments are necessary should an accident or human exposure occur? Are there compatibility concerns with equipment being used or with other products being mixed?

- Prior to storing: How should the product be properly stored? What special precautions must be followed to prevent fire or leakage hazards or possible deterioration?
- Prior to disposal of unused pesticides and empty containers: Do you understand how to properly rinse the pesticide container, use the rinsate, and dispose of the empty pesticide container? What measures must be taken to prevent environmental contamination and hazards to people? What are appropriate decontamination procedures?

In summary, remember that the format for pesticide labels is not the same. Label format typically differs among manufactures or distributors and even between product labels of the same company.

PARTS OF THE PESTICIDE LABEL

Pesticide labels contain basic information to aid the user in clearly identifying the product and in the proper handling and use of the pesticide. Some of the information on pesticide labels is required by law (FIFRA) to appear in a specific part of the label or under a particular section heading. Other information may be located anywhere on the label at the preference of the submitting company. Regardless of where information may appear, a pesticide user has the legal responsibility to read, understand, and follow all label instructions

FIFRA requires that some use information must appear on the front panel of the product label. This chapter will focus on the front panel label, which comprises human safety and critical emergency response information.

> Anyone who applies a pesticide has the legal responsibility to read and follow label instructions from the time of purchase through the product's eventual use or disposal.

FRONT PANEL – REQUIRED INFORMATION

The front panel of a pesticide label may include the following eight parts. Usually, label parts are arranged in the order presented below. Not all eight sections must appear on every label; for example: the skull and crossbones symbol along with the phrase "DANGER-POISON."

- Federal restricted use pesticide statement.
- Product name, brand name, or trademark.
- Ingredient statement.
- Skull and crossbones symbol with the word "DANGER-POISON."
- Child hazard warning statement.
- Signal word.
- First aid statement.
- Net contents or net weight.

Since all pesticides intended for agricultural use are subject to the USEPA Worker Protection Standard, the signal word must appear in both English and Spanish. Immediately following the signal word, the statement "If you do not understand the label, find someone to explain it to you in detail" must be in English and Spanish.

The label for Sprout NIP Briquette (Aceto: EPA Reg. No. 2749-520; Figure 5.1) will be used to reference the specific requirements for the front panel. Since Sprout NIP Briquette is neither a federal restricted use pesticide (RUP) nor a highly toxic pesticide, the front panel will contain only six parts. These are explained below.

❶ Pesticide Name

Every pesticide has a product name or a trade name. It is the name registered or trademarked by a company for distribution and sale.

When comparing different products containing the same active ingredient(s), the amount of active ingredient in each product should be compared since this concentration will dictate the use restrictions. Label instructions are exclusive to the material on which the label is attached.

Sometimes, the same pesticide active ingredient is available in different formulations. The formulation is oftentimes abbreviated and included in the product name. A formulation is the form in which the material is sold: wettable power (WP), dry flowable (DF), flowable (F), granular (G), emulsifiable concentrate (EC), solution (S), etc. Likewise, the product name may allude to the active ingredient concentration (percentage or weight). For example: PIN NIP 2 EC (EPA Reg. No. 72790-1-65726) is an emulsifiable concentrate (i.e., EC) that contains two pounds active ingredient per gallon of product. In comparison, Sprout Nip is sold as a “Briquette” formulation (Figure 5.1).

❷ Ingredient Statement

The ingredient statement lists the name and percentage by weight of the active ingredient(s) and the percentage by weight of the inactive (or inert) ingredient(s). The active ingredient is the product responsible for controlling the target pest. Application rates are primarily based on the percentage of active ingredient.

Inert Ingredients are the non-active component of the formulation, such as wetting agents, diluting agents, emulsifiers, carriers, etc. Inert ingredients, referred to as “Other Ingredients” on pesticide labels, do not have to be listed by name, but their percentage by weight must be indicated.

The active ingredient in Sprout NIP Briquette is chlorpropham, which is also the product’s common name. Only common names that are officially accepted by USEPA may be used in the ingredient statement. This name is approved and adopted by professional societies to distinguish the material. The official common name may be followed by the chemical name in the list of active ingredients. Sprout NIP Briquette is comprised of 98 percent chlorpropham by weight (Figure 5.1).

Percentage of active ingredient and the product’s net weight are necessary to calculate the application rate. In this case, Sprout NIP Briquette contains 9.8 pounds active ingredient per 10 pounds of material (0.98 x 10 pounds). For liquid formulations, the weight of active ingredient per gallon of material is usually given.

❸ Child Hazard Warning Statement

The child hazard warning statement (“Keep Out of Reach of Children”) appears on labels in association with the signal word. This statement is required on all containers or packages of agricultural pesticides.

❹ Signal Word

Signal words are found on pesticide product labels, and they describe the acute (short-term) toxicity of the formulated pesticide product. Acute toxicity (i.e., single exposure) studies assess a product’s toxicity as it relates to six types of exposure: acute oral, acute dermal, acute inhalation, primary eye irritation, primary skin irritation, and dermal sensitization. The signal word is not based on the active ingredient alone but on the contents of the formulated product; this includes the human hazard potential of the active ingredient along with any carrier, solvent, or other inert material.

A product is assigned a toxicity category for each type of exposure based on the results of five of the six acute toxicity studies, which designates the assigned signal word. The sixth study, for dermal sensitization, evaluates the potential for allergic contact dermatitis. This determination does not affect the signal word designation.

A product’s signal word is determined by the most severe toxicity category assigned any of the five acute toxicity studies. Signal words used to indicate how dangerous a pesticide is to humans are DANGER-POISION (most toxic), DANGER, WARNING, and CAUTION (least toxic). The signal word for Sprout NIP Briquette is “Caution.” (Products that display only the signal word DANGER are corrosive and can cause irreversible eye damage or severe skin injury.) Signal words help alert users to special hazards of a pesticide product. For further explanation of signal words, refer to the *Washington Pesticide Laws and Safety* (MISC0056) study manual.

❺ First Aid Statement

The first aid statement – which appears on the label as “Statement of Practical Treatment” – contains instructions concerning appropriate response procedures in the event of an accidental exposure. Instructions include first aid measures for the various routes of exposure. First aid statements include instructions for the

Figure 5.1. Front panel of sample Sprout NIP Briquette label.

❶ **SPROUT NIP BRIQUETTE**

❷ Aerosol Grade – Potato Sprout Inhibitor

	By Weight
ACTIVE INGREDIENT:	
Chlorpropham* (Isopropyl N-(3-chlorphenyl) carbamate)	98.0%
OTHER INGREDIENTS	2.0%
TOTAL	100.0% ❻

*Contains 9.8 pounds active ingredient per 10 pounds

FOR AGRICULTURAL USE ONLY

❸ KEEP OUT OF REACH OF CHILDREN

❹ CAUTION

❼ PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS & DOMESTIC ANIMALS

CAUTION. Harmful if swallowed or absorbed through the skin or inhaled. Causes moderate eye irritation. Avoid contact with eyes, skin or clothing. Avoid breathing vapor. Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove contaminated clothing and wash clothing before reuse.

❺

FIRST AID	
If Swallowed	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to by a poison control center or doctor.
If in Eyes	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If on Skin or Clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 - 20 minutes. • Call a poison control center or doctor for treatment advice.
If Inhaled	• Move person to fresh air. • If person is not breathing call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth if possible. • Call a poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center or doctor or going for treatment.	

⓫ EMERGENCY INFORMATION

For spill, leak, fire, exposure or accident call CHEMTREC® 1-800-424-9300. Outside the USA 1-703-527-3887

EPA REG NO: 2749-520 ❾ ❻ Net Contents : 10 lbs ❿ EPA EST. NO ____________

Batch Code: ____________

❽ Manufactured For:
Aceto Agricultural Chemicals Corporation
One Hollow Lane
Lake Success, NY 11042
Phone: 516-627-6000

ACETO

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user, medical directives to the physician, and a telephone number to call for emergency information. The "NOTE TO PHYSICIAN," if present, provides emergency medical personnel with poison treatment information and suggests antidotes.

A first aid statement is required on a label of pesticide classified as category I, II, or III. For toxicity results that classified a product as category IV, it is at discretion of the registrant whether to include a first aid statement.

In summary, the "Statement of Practical Treatment" is medical guidance to the user in case of product exposure. As such, this information should be read before using the product and referred to in the event of an emergency. Thus, the label should be at the application site and immediately available. By law, the pesticide label must be at the mixing and loading site.

❻ Net Contents or Net Weight

The net contents/net weight section lists the amount of material (active and inactive ingredients) in the product formulation. It may be expressed as pounds or ounces for dry formulations or as gallons, quarts, ounces, or pints for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product. The reported net contents must

- not include any wrappers or other packaging materials.
- be stated in terms of the largest suitable units. (For example, "1 pound 10 ounces" rather than "26 ounces.")
- be consistent with directions for use. The label's directions for use should not require a quantity of pesticide product that exceeds the net contents/net weight of the package.

FRONT PANEL – OTHER INFORMATION

In addition to eight parts listed in the preceding section, the front panel of a pesticide label can, and typically does, include additional information. These additional items, referenced on Figure 5.1, are discussed below.

❼ Precautionary Statement

Pesticide labels include additional statements indicating the potential hazards of the material along with recommended practices to minimize or avoid exposure risk. Pesticide labels list three types of hazards inherent with the use of the product:

- Hazards to Humans and Domestic Animals
- Environmental Hazards
- Physical and Chemical Hazards

These statements guide the applicator in identifying potential hazards and in taking proper precautions to protect humans, animals, and the environment (i.e., soil, water, air, wildlife, aquatic organisms, and nontarget plants) from exposure. Potential hazards include, in part, routes of entry into the body, adverse weather conditions (such as an atmospheric inversion), soil permeability, groundwater hazards (such as a shallow aquifer), explosiveness, corrosiveness, and flammability.

❽ Name and Address of Manufacturer

The name and address of the manufacturer, formulator, or registrant of the product is required to be on the label. If the registrant is not the manufacturer, then contact information will be preceded by statements like "packaged for," "distributed by," or "sold by." Regarding Sprout NIP Briquette, the product was manufactured for Aceto Agricultural Chemicals Corporation.

❾ EPA Registration Number

An EPA registration number (EPA Reg. No.) is listed on every pesticide label, with the exception of Section 25(b) products. The number usually appears on the front panel near the registrant's name and address. This number designates that the pesticide has been registered with and the label approved by USEPA. The EPA registration number is the single most important piece of information for tracking a pesticide product.

Most EPA registration numbers include two sets of numbers that are separated by a hyphen. The first number indicates the company that holds the registration for the pesticide product. The sequence in which a product is submitted to USEPA is represented by the second number. Occasionally, a distributor's identification number may also be present, which appears only on labels of distributor products (EPA Reg. No. xxxx-xxx-xxxx). If present, the distributor's identification number is the second set, with the third set distinguishing the product.

The EPA Registration Number for Sprout NIP Briquette is 2749-520. The first set of numbers, 2749, identifies the manufacturer or company (Aceto Agricultural Chemicals Corporation). The second set, 520, identifies the product. In this instance, a distributor identification number is not included in the EPA registration number.

❿ EPA Establishment Number

An establishment number must also appear either on the pesticide label or the container. It is usually grouped with the EPA Registration Number, as it is in Figure 5.1. This number identifies the physical location (facility) where the pesticide product was produced or labeled. The establishment number is necessary to trace the product's origin in case of a concern about possible adulteration (i.e., impurity) or a problem with product performance.

The final establishment (facility) where the product will be produced might not be known at the time the draft label was submitted to USEPA. Consequently, the establishment number might not appear on the draft label submitted for USEPA review, as with Sprout NIP Briquette (Figure 5.1). Also, the distributor may intend to place the establishment number directly onto the container rather than on the label.

⓫ Emergency Information (Hot Line Number)

The front panel of a pesticide label will list a 24-hour, toll-free phone number of an emergency assistance contact in event of a poisoning, spill, fire, or another catastrophic event involving human health, animals, or the environment (Figure 5.2). In the event a pesticide accident or spill cannot be safely stopped or contained, additional 24-hour emergency assistance phone numbers may be listed in Section 1: Chemical Product and Company Identification section of a product's MSDS (see Appendix B).

Figure. 5.2. Emergency contact information for Tsunami 100.

FIRST AID

FOR EMERGENCY MEDICAL INFORMATION IN USA OR CANADA, CALL: 1-800-328-0026.

FOR EMERGENCY MEDICAL INFORMATION WORLDWIDE, CALL: 1-651-222-5352 (IN THE USA).

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

Washington State Emergency Management Division (800-562-6108 or 253-512-7000) notifies state agencies and local governments of impending emergencies and disasters and may issue emergency warnings or disseminate critical information and instructions to government personnel and the public. The Division's Emergency Operation Center (EOC) serves as the focal point for state responses to emergencies and disasters, whether the result of natural, technological, or human-caused hazards. During these events, the EOC is designated as the central location for information gathering, disaster analysis, and response coordination. EOC staff coordinates with state, federal, and local government agencies, non-government organizations, private businesses, and industry. The Emergency Management website is **http://www.emd.wa.gov/about/contact.shtml.**

Another source of emergency information involving a spill, leak, or fire during product transport is the **Chemical Transportation Emergency Center (CHEMTREC**, 800-424-9300**)**. CHEMTREC is a 24-hour emergency call center that provides immediate critical response information during incidents involving chemicals, hazardous materials, and dangerous goods.

Some product registrants list a company-sponsored, emergency response "Hot Line" phone number for medical assistance (human and animal) and/or for chemical assistance (spill, leak, fire, accident). Generally, for medical and transportation emergencies or for treatment information, label language will direct the caller to 800-334-7577 (DART). The Disaster Assistance and Rescue Team (DART) is an all hazard Federal emergency response and recovery team home-based out of NASA's Ames Research Center at Moffett Field, California.

Emergency or disaster means an event or set of circumstances which demands immediate action to preserve public health, protect life, or protect public property.

OTHER LABEL INFORMATION

Only one other label section will be reviewed in this chapter: "Directions for Use." The "Directions for Use" section always begins with the sentence, "It is a violation of Federal laws to use this product in a manner inconsistent with its labeling." As written in a previous section, misuse of a pesticide is a violation both of federal law and state regulations.

Instructions in the Directions for Use section explain to the user the proper way in which to apply the product. Use instructions include:

- Pests that the product is registered to control.
- Crop, animal, or site on which the product can be applied.
- Proper mixing instructions.
- Compatibility with other products.
- How much pesticide to use (application rate).
- Application equipment that can be used.
- Timing and frequency of application.
- Restrictions on the number of applications and/or the total amount applied per season/year.
- Preharvest interval.
- Re-entry restrictions.

Figure 5.3. Directions for Use section of PIN NIP 2EC label.

DIRECTIONS FOR USE

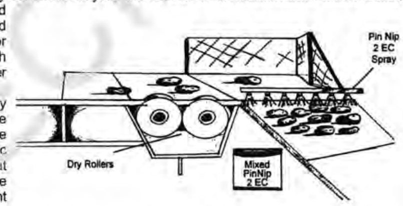
It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

STORAGE AND DISPOSAL

PROHIBITIONS: Keep container closed. Do not contaminate water, food, or feed by storage or disposal.
PESTICIDE STORAGE: Avoid storage below freezing temperatures. Prolonged storage may cause crystal formation.Warming contents and agitation will restore material to usable condition, but do not heat above 120° F. Vent caps when using indirect heat such as a warm water bath, and do not use direct heat or flame.
PESTICIDE DISPOSAL: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these washes cannot be disposed of by use according to label instructions, contact your State pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.
CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begns to drip. Repeat this procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or, if allows by state and local authorities. by burning. If burned, stay out of smoke.

APPLICATION

This product is used for treating potatoes to inhibit sprouting after storage and washing. This product will prevent wound periderm formation of potatoes, therefore, it should be used only after bruises and cuts have healed (normally a minimum of two weeks).
DO NOT APPLY IN THE FIELD.
IMPORTANT NOTE: Potatoes may deteriorate or otherwise be damaged by bacteria, fungi, insects, old age effects such as internal sprouting, environmental factors (such as humidity, temperature and airflow), and other causes which are unrelated to the application of this product, and which may occur whether or not this product is applied to the potatoes.
DO NOT USE ON SEED POTATOES. This product will inhibit the sprouting of seed potatoes. The inhibition of sprouting at recommended rates is usually effective for up to a year. The time period of effective sprout inhibition may vary depending on many conditions beyond the control of the manufacturer and/or seller, including, but not limited to, timing and method of application, variety and condition of stored crop, and mixtures or treatments with other chemicals. Wash equipment thoroughly with soap and water before using with seed potatoes.



EQUIPMENT: This product is usually applied as a 1% emulsion spray on the drying table, or similar station, after the potatoes have been washed. Automatic proportioners or injection systems that apply an equivalent rate of active ingredient may also be used. Equipment should be set to spray evenly across the rolls moving the potatoes. Rolling or tumbling action improves coverage compared to flat conveyor belts. Thorough coverage of the potato by this emulsion will provide the best sprout inhibition.
APPLICATION: For dilute spray, prepare a 1% emulsion by adding 1 gallon of this product to 24 gallons of water. Agitate enough to form a uniform emulsion. For best results, agitate or recirculate emulsion while in use. Apply at a rate of 1 quart of 1% emulsion per 20 bags of potatoes (100 pounds per bag). For proportioner/injector applications, use sufficient water for thorough coverage while maintaining the application rate of 1 gallon product per 2000 cwt. potatoes.

- Phytotoxicity (damage to plants), other possible injury (domestic animals and wildlife) or unwanted stains.
- Re-cropping, composting, grazing, and other restrictions.
- How to minimize vapor drift.
- Pesticide storage and disposal.
- Worker Protection Standard (requirements for training, decontamination, notification, and emergency assistance; instructions for personal protective equipment, restricted-entry intervals, and notification to workers).

Application restrictions (i.e., "DO NOT USE ON SEED POTATOES") and application criteria (i.e., "EQUIPMENT" and "APPLICATION") are included in this section of a pesticide label (Figure 5.3). In referencing the "Application" section to Figure 5.3, the PIN NIP 2EC label specifies a one percent emulsion for sprout inhibition when applied to potatoes on the drying table (refer to bracket).

MATERIAL SAFETY DATA SHEETS (MSDS)

ORIGIN OF MATERIAL SAFETY DATA SHEETS

The Occupational Safety and Health Administration (OSHA) is responsible for administering the Hazard Communication Standard. The standard requires manufacturers or distributors of hazardous materials to assess the physical and health hazards of the chemical or product. This information must be included in the material safety data sheets (MSDS), which are a critical component of the OSHA Hazard Communication Standard (HCS).

The purpose of this standard is to ensure that the hazards of all chemicals produced or imported are evaluated, and information concerning their hazards is shared with employers and employees. The standard mandates that workers have a right to know what hazards are associated with the chemicals they use in the workplace.

Dissemination of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training. Employers must maintain any MSDS that are received with incoming shipments of hazardous chemicals, which must be provided to the purchaser at the time of initial shipment.

> The Hazard Communication Standard mandates the use of a Material Safety Data Sheet (MSDS), and that this information is readily accessible to people who use, handle, or store hazardous industrial chemicals.

OBTAINING A PRODUCT MSDS

A MSDS must be provided with the first shipment of a hazardous chemical either by the manufacturer (producer) or importer of the chemical. The MSDS may be obtained from the distributor who sold the product. MSDS may also be downloaded from an Internet site. Employers must provide the MSDS upon request.

INFORMATION CONTAINED IN A MSDS

The MSDS is a detailed information bulletin prepared by the chemicals manufacturer or the importer that provides specific information about or describes the material's: (1) physical and chemical properties; (2) manufacturer information; (3) physical hazards (pH, flashpoint, flammability, etc.); (4) health hazards (carcinogenicity, teratogenicity, etc.); (5) emergency information; (6) instructions on what to do if a hazardous situation has occurred; (7) information on the prevention of hazardous situations; as well as (8) other technical information of their chemicals to the end user. Recognizing the importance of this document, many other countries (e.g. the EU, Australia, Canada) have adopted the HCS into their own chemical safety initiatives.

OSHA's Hazard Communication Standard (HCS) specifies certain information that must be included on MSDSs, but does not require that any particular format be followed in presenting this information – although a suggested format is given. Manufacturers or suppliers may include additional information to that required by OSHA.

However, information for the eight basic categories must always be in a MSDS.

- Section I. Manufacturer's Name and Contact Information
- Section II. Hazardous Ingredients/Identity Information
- Section III. Physical/Chemical Characteristics
- Section IV. Fire and Explosion Hazard Data
- Section V. Reactivity Data
- Section VI. Health Hazard Data
- Section VII. Precautions for Safe Handling and Use
- Section VIII. Control Measures

In 1993, the American National Standard for Hazardous Industrial Chemicals Material Safety Data Sheets Preparation was developed to address the need for a MSDS format that was comprehensive, understandable and consistent. The American National Standards Institute (ANSI) introduced the standardized 16-section MSDS. In order to promote consistent presentation of information, OSHA recommends that the ANSI 16-section format be used in the preparation of MSDSs. The purpose of this standard is to provide information in a consistent manner and to make it easier to find information regardless of the supplier of the MSDS.

With the ANSI format, information of greatest concern to a worker is featured at the beginning of the data sheet, including information on chemical composition and first aid measures. More technical information that addresses topics such as the physical and chemical properties of the material and toxicological data appears later in the document. While some of this information (such as ecological information) is not required by the HCS, the 16-section MSDS is becoming the international norm.

The 16 sections of the MSDS as prescribed by the ANSI standard are as follows:

- Section 1. Chemical Product & Company Information (Identification)
- Section. 2. Hazard(s) Identification
- Section. 3. Composition/Information on Ingredients
- Section. 4. First Aid Measures
- Section. 5. Fire Fighting Measures
- Section. 6. Accidental Release Measures
- Section. 7. Handling and Storage
- Section. 8. Exposure Controls/Personal Protection
- Section. 9. Physical & Chemical Properties
- Section. 10. Stability and Reactivity
- Section. 11. Toxicological Information
- Section. 12. Ecological Information
- Section. 13. Disposal Considerations
- Section. 14. Transport Information
- Section. 15. Regulatory Information
- Section. 16. Other Information

While the ANSI format is recommended, the OSHA required categories must be addressed in the MSDS; these are legally enforceable.

MSDS IN THE WORKPLACE

MSDSs are not intended for consumers. An MSDS reflects the hazards of working with the material in an occupational fashion.

EMPLOYER RESPONSIBILITIES

Employers must ensure that each employee has a basic knowledge of how to find information on an MSDS and how to properly make use of that information. Employers also must ensure that:

- Complete and accurate MSDSs are available during each work shift to employees when they are in their work areas.
- Information is provided for each hazardous chemical.
- Training is provided on MSDS content.

EMPLOYEE RIGHTS

Employers use the MSDSs to provide employees who are exposed to hazardous chemicals with effective information and training. Employees must be trained on the physical and health hazards of the chemicals in the workplace, the measures they can take to protect themselves, and emergency procedures for cleaning up a spill or release of chemicals.

While in the workplace, the MSDS

- Must be available for every hazardous chemical or substance that the employee uses or encounters as a part of his/her job.
- Must be readily available for employee review at all times.
- Must be provided within one working day, if requested by an employee.

EXPLANATION OF MSDS SECTIONS

MSDSs for PIN NIP 98% Chlorpropham (1,4Group, Inc.) and Tsunami 100 (EcoLab) are reproduced in Appendix B. The reader is advised to refer to the corresponding sections of the MSDSs after reading the following synopsis for each of the ANSI-prescribed sixteen sections.

<u>Section 1: Chemical Product and Company Identification</u>

The introductory section of the Material Safety Data Sheet (MSDS) includes the chemical manufacturer's or importer's name and address, manufacturer or distributor who provides the chemical, the chemical name , trade name, and chemical formula. The product's EPA registration number is listed. Twenty-four hour emergency contact phone numbers are listed and, usually, a local emergency contact phone number.

<u>Section 2: Hazard Identification</u>

This section describes the appearance of the material, the potential health effects and symptoms associated with exposure, routes of entry, and target organs that could be affected. It is divided into four subsections: emergency overview, OSHA regulatory status, potential health effects, and potential environmental effects. The physical state of the material and the health, physical and environmental hazards that require immediate attention in emergencies are listed in the emergency overview. The OSHA regulatory status subsection indicates if the material is hazardous or non-hazardous with respect to the Hazard Communication Standard. Potential adverse health effects and symptoms associated with exposure to the material are given in the potential health effects subsection. The potential environmental effects subsection provides information on the potential effects associated with release of the material into the environment.

This section also describes the health effects associated with being exposed to the chemical through ingestion, inhalation, and skin or eye contact. Information may include the acute (immediate) and chronic (long-term) effects of exposure to the chemical, whether the chemical is a known carcinogen (cancer-causing agent), emergency and first aid procedures to follow in case of exposure, whether exposures may require immediate medical attention, and medical conditions that may be aggravated upon contact with the chemical.

<u>Section 3: Composition/Information on Ingredients</u>

This section must identify all the components, by-products, and impurities that contribute to the material's hazards. This section may also include Threshold Limit Value (TLV) and OSHA Permissible Exposure Limits (PELs). Both terms are used to express the airborne concentration levels of a chemical to which most persons can safely be exposed during a normal workday. The chemical name, common name or synonym, along with the corresponding Chemical Abstracts Service (CAS) Registry Number and percentages or ranges of percentages are also included in this section. C.A.S. numbers identify specific chemicals according to information published by the American Chemical Society.

<u>Section 4: First Aid Measures</u>

This section is divided into two subsections: first aid procedures and notes to physicians. First aid procedures should be brief, easily understood emergency and first aid instructions for each potential route of exposure. Procedures are to be written so that an untrained individual can understand the information. Notes to physicians convey additional information on antidotes, specific treatments, and diagnostic procedures and are intended for use by healthcare professionals.

Also described are possible first aid procedures for each route of entry and offers appropriate first aid procedures to follow should an employee be exposed to a hazardous chemical. Typically provided is an explanation of the type of aid that should be given to the exposed person such as administering oxygen, induction of vomiting, or the immediate rinsing of skin to prevent absorption or irritation.

Section 5: Fire Fighting Measures

This section describes specific hazards arising from the fire and explosive properties of the material. Also provided is information in determining the chemical's flash point, which is the temperature at which a chemical will release enough flammable vapor to ignite. Chemicals that ignite at or above 100°F are classified as combustible; those that ignite below 100°F are classified as flammable. Usually listed are the chemical's upper and lower flammability limits, proper types of extinguishing media required to safely extinguish the fire (example: CO_2, water, foam, etc.), special fire fighting procedures and protective equipment, precautions for fire fighting, and any unusual fire and explosion hazards associated with the chemical.

Section 6: Accidental Release Measures

This section contains information for responding to spills, leaks, or releases into the air in order to prevent or minimize adverse health effects on persons, property and the environment. Information on personal protective equipment, containment equipment, clean-up equipment and techniques, proper disposal of the chemical, environmental precautions, and specific reporting requirements may also be included.

Section 7: Handling and Storage

This section contains information on special precautions to be taken during the handling and storage of the material, such as keeping away from heat, sparks, or flame, or if there are any hazards associated with the empty containers. Information may include general warnings to prevent overexposure and handling procedures, and hygiene instructions to prevent continued exposure. Any other health or safety concerns – such as unique properties of the material – that have not already been mentioned in another section of the MSDS may appear here.

Section 8: Exposure Controls/Personal Protection

This section comprises engineering controls and personal protective equipment (respirator, gloves, eye protection, ventilation) that are recommended to help reduce human exposure. Necessary personal protective equipment is indicated for eye/face protection, skin protection, and respiratory protection.

This section is divided into three subsections. Established exposure guidelines for the material and/or its components are identified in Subsection 1. Established exposure guidelines include, but are not limited to: OSHAs Permissible Exposure Limits (PELs) and American Conference of Governmental Industrial Hygienists (ACGIHs), Threshold Limit Values (TLVs), and Biological Exposure Indices (BEIs). Personal protective equipment guidance eye/face protection, skin protection, respiratory protection, and general hygiene considerations are detailed in Subsection 2. Engineering controls that may be appropriate to help minimize the hazards are discussed in Subsection 3.

Remember, there are various types of protective equipment that are specially designed for certain tasks. The suggested personal protective equipment listed in this section is a general recommendation only; it is up to the employer to properly assign appropriate PPE based on usage and concentration of the chemical. Specifically, when using the chemical every 10 to 20 minutes in an 8-hour period versus using once per day for 20 minutes, there is a greater need for a higher level of PPE protection. Consult your supervisor to ensure that the PPE is adequate for the type of work being performed.

Section 9: Physical and Chemical Properties

This section includes information about the physical and chemical properties of the material. If applicable and relevant, the following characteristics are usually described: appearance, odor and odor threshold, physical state, pH, vapor pressure, vapor density, initial boiling point and boiling range, flash point, freezing/melting point, solubility in water, percent volatile, flammability (solid, gas), upper/lower flammability or explosive limits, auto-ignition temperature and decomposition temperature, evaporation rate, and specific gravity or relative density. If these characteristics do not apply to the material, it must be indicated as such.

This information helps determine the degree of hazard associated with the chemical in different work environments. For example, vapor density describes the weight of a vapor relative to an equal volume of air (air = 1). If a chemical has a vapor density greater than 1, the vapor will be heavier than air and tends to descend and stay near to the ground.

Section 10: Stability and Reactivity

This section describes the potential hazards associated with the stability and reactivity of the material under specified conditions. Identified are potentially hazardous chemical reactions to help determine if the chemical will react with other chemicals or conditions. Chemicals that are reactive (unstable) may explode, burn, or release toxic substances under certain conditions. Also examined are chemical stability, conditions to avoid, incompatibility with other materials, hazardous decomposition products, and hazardous polymerization (reactions with other products). Incompatible products are listed.

Section 11: Toxicological Information

This section discusses data used to determine the hazards that are given in Section 3: "Hazard Identification."

Toxicological information (oral or dermal testing data) that can be used to assess human health hazards or potential health effects of the material and/or its components is given. Acute dose effects, repeated dose effects, irritation, corrosivity, skin and respiratory sensitization, carcinogenicity, neurological effects, genetic effects, reproductive effects, developmental effects, and target organ effects data may be listed.

Data cited in this section may include acute toxicity tests used to predict potential adverse health effects from a single exposure to the chemical. The tests may also include chronic toxicity testing that is conducted for a 12-month to more than 8-year time frame to ascertain potential long-term exposure to the chemical.

Section 12: Ecological Information

Aquatic testing information to assist in the evaluation of the environmental impact of the material and/or its components if released to the environment is provided in this section. Ecotoxicity, persistence/degradability, bioaccumulation/accumulation, mobility in environmental media, and other adverse effects may be addressed. A specific species of fish and/or microorganism is chosen for the test to see the effects of the chemical on the organism.

Section 13: Disposal Considerations

This section provides information that may be useful in the proper disposal, recycling, or reclamation of the material and/or its container. It is important to follow local, state and federal regulations when disposing of the chemical. Information may also include site reclamation.

Section 14: Transport Information

This section is intended to give basic shipping (hazard classification) information and special precautionary information to help a knowledgeable user prepare a material for shipment. The basic shipping information could include the hazardous materials description, hazard class, and the identification number (UN or NA numbers). This section is not intended to contain every regulatory detail involving the transportation of a material.

Section 15: Regulatory Information

This section provides information on the regulatory status of the material that is useful for compliance with health, safety, and environmental regulations. Content and organization of this section depends on where the material is manufactured or used. It is not intended to be a comprehensive list of all of the regulations that may apply.

Regulatory agencies and federal regulations may include: the Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation and Liability Act

(CERCLA), Drug Enforcement Administration (DEA), Food and Drug Administration (FDA), OSHA, Safe Drinking Water Act (SDWA), Superfund Amendments and Reauthorization Act (SARA) Title III (Superfund Amendments and Reauthorization Act), Toxic Substance Control Act (TSCA), Occupational Safety and Health Administration (OSHA), and United States Department of Agriculture (USDA).

Section 16: Other Information

This section should include any other important information that may be pertinent or useful concerning the material not covered in the other sections. Information can include hazard ratings, preparation and revisions of the MSDS, label information, or key/legend that explains the abbreviations used in the MSDS.

In case of a pesticide poisoning, medical advice may be obtained by calling a physician or the nationwide Poison Center (toll free) at 800-222-1222. Calls are answered by the nearest Poison Control Center.

REVIEW QUESTIONS

1. Which of the following label parts do not appear on the front panel of a pesticide label?
   a. Restricted use pesticide (RUP) statement
   b. Product name, brand name, or trademark
   c. Ingredient statement
   d. Directions for use

2. Which label part should appear first on the front panel of a pesticide label?
   a. Product name, brand, or trademark
   b. First aid statement
   c. Restricted use pesticide statement
   d. Warranty statement

3. What indicates the final physical location where a pesticide product was produced or labeled?
   a. USEPA establishment number
   b. USEPA registration number
   c. Signal word
   d. Manufacturer name and address

4. Any employer using a pesticide is required to keep a current MSDS and to make it available to employees who may come into contact with the product or its residues.
   a. True
   b. False

5. The MSDS or product labeling may be used in place of the pesticide label.
   a. True
   b. False

6. Who is required to develop the MSDS?
   a. USEPA.
   b. Manufacturer
   c. Distributor
   d. Applicator

7. The chemical(s) in a formulated product responsible for the pesticide effect is the
   a. solvent.
   b. solute.
   c. active ingredient.
   d. other ingredients.

8. Which agency has direct authority over a product's MSDS?
   a. USEPA
   b. Federal Food and Drug Administration
   c. U.S. Department of Agriculture
   d. OSHA

9. The MSDS is considered to be product labeling.
   a. True
   b. False

10. Who is responsible to ensure that each employee has a basic knowledge of how to find information on an MSDS and how to properly make use of that information?
    a. Registrant
    b. OSHA
    c. Employer
    d. USEPA

11. Emergency information involving a spill or leak during product transport can be obtained from where?
    a. MSDS
    b. CHEMTREC
    c. Pesticide label
    d. Poison Control Center

12. The signal word on the pesticide label that references human health effects associated with pesticide exposure refers to this type of toxicity.
    a. Chronic
    b. Lifelong
    c. Acute
    d. Transitory

13. In event of a human exposure, which label part contains emergency medical procedures?
    a. Ingredient statement
    b. Precautionary statement
    c. Directions for use
    d. Personal protection equipment

NOTES

Aerosol generator – A device that vaporizes or aerosolizes a liquid material into small particles or droplets that remain suspended in air, allowing them to be easily transported to an intended target.

Bud peep – A small white spot of growth or bud forming in the center of a sprout eye on the potato's surface. It is generally not more than 2 mm in length; it is the initial bud formation of a sprout.

Chemical feed rate – An application rate at which a pesticide is applied, usually measured by the length of time required to apply a given quantity of pesticide, such as gallons per hour or pounds per hour.

Chemical feed system – A pump or device designed to transfer a pesticide from its container to an intended point of use or application.

Culvert-style ventilation duct – A round, corrugated pipe with appropriately sized and spaced holes that is positioned at the bottom of a potato pile and is used for distributing airflow evenly throughout the potato pile.

Dormancy – A period in the life cycle of a potato during which the buds of potato tubers will not sprout.

Evaporative cooling deck – A device used to add humidity to and to cool the air that will be circulated through a potato pile. This is accomplished by directing the air through cooling deck media that is saturated with water.

Eye – a collection of several buds on the surface of a potato tuber, one or more of which will sprout and form a stem under favorable conditions.

Fresh market – A segment of the potato industry involved in selling fresh potatoes, usually washed, sized, and packaged but not cooked or processed.

Greening – A natural coloring (i.e., chlorophyll formation) of plant tissue as a result of being exposed to sunlight – also known as greening of potatoes.

Holding temperature – A temperature at which potatoes are held for the majority of the time when in storage. The holding temperature is determined by the potato variety and its intended use.

Internal sprouts – A sprouting condition generally caused by a settled (compacted) potato pile where a sprout, as it develops, has no place to grow but into an adjoining potato or back into the potato from where it originated.

Mechanical humidifier – A device that atomizes water into a fine fog by means of centrifugal force or pressurized nozzles. The humidified air is distributed throughout the potato pile by means of the storage ventilation system.

Mixing chamber – A room or chamber in a potato storage facility that is upstream from the storage ventilation fans where fresh air from outside the storage structure is mixed with air being re-circulated from the potato pile.

Non-pathogenic – A micro-organism that does not cause disease.

Pathogenic – A micro-organism capable of causing a disease.

Physical maturity – A term used to identify the stage of maturity of a potato in reference to skin set (thickness).

Plenum chamber – A room or chamber in a potato storage facility that is downstream from the storage ventilation fans and, when supplied and pressurized with air from the ventilation equipment, distributes air through the ventilation ducts positioned under the potato pile.

Process market – A segment of the potato industry involved in selling potato products that are processed by means of cooking, cutting, freezing, or dehydrating.

Sprout – the new stem formed from the eye of a potato tuber.

Suberization period – A period of time when the potato suberizes (i.e., develops a corky tissue layer) to heal surface wounds sustained at harvest or when being transferred from the field and placed into storage.

Thermally-produced aerosol – A fog or vapor formed by equipment that uses heat and airflow to change a liquid into tiny droplets or particles.

Tuber – an enlarged, fleshy, underground stem, such as a potato, with buds from which new plants will form. In the potato industry, tuber is often used synonymously with potato.

Variable Frequency Drive – an electrical device used to increase or decrease the rpm or speed of a ventilation fan motor to attain desired airflow for sprout control applications.

Wound healing – Also known as suberization.

Diagnosis and Management of Potato Storage Diseases

University of Idaho Publication CIS 1131

by

Nora Olsen
Jeff Miller
Phil Nolte

University of Idaho
College of Agricultural and Life Sciences

CIS 1131

Diagnosis & Management of Potato Storage Diseases

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U.S. potato losses during storage have averaged about 7.5% over the past several years, according to the *National Potato Council 2004-2005 Potato Statistical Yearbook*. Individual farm losses can be much more severe, with complete losses all too frequent. While a portion of the average yearly losses is due to transpiration and respiration, the more serious losses usually are due to storage diseases.

Storage diseases are not curable, but there are ways to help limit pathogen spread from diseased to healthy potatoes and to keep the problem from getting worse. Appropriate storage management depends, however, on proper identification of the disease responsible for a rot problem. Pathogen identification will also help in making future field management decisions.

The major diseases that plague potatoes in storage include pink rot, Pythium leak, late blight, dry rot, soft rot, silver scurf, black dot, and early blight. Some diseases cause more severe damage and progress more rapidly than others, especially when secondary bacterial soft rot creates “hot spots” that can rapidly lead to the breakdown of an entire pile of potatoes in storage.

Selecting tubers for diagnosis

The first step in diagnosing the type of rot either coming out of the field or developing in storage is to select partially rotted potato tubers. “Partially rotted” means that half or more of the tuber is healthy. Careful selection is important because tubers that are completely rotted often have succumbed to secondary soft rot invasion, and ascertaining the initial problem becomes much more difficult, if not impossible. If they are available, take several dozen tubers from each of the affected areas in the storage. Dissect the tubers by cutting them in half and peeling off areas of the skin. Most of the pathogens responsible for tuber decay in storage can take advantage of damaged areas on tubers such as nicks, cuts, abrasions, broken knobs, or shatter-bruised areas. Look for evidence of these possible disease entry points and examine each tuber’s natural weak points such as the area of stolon attachment, the lenticels, and the eyes.

Unfortunately, many tuber diseases vary in their appearance, and often they do not look exactly like the textbook pictures. Further examination by a disease expert (university scientist or other disease diagnostician) may be necessary. The expert will require intact tubers to perform a proper diagnosis. Collect new samples for this purpose or leave some of the tubers in your samples uncut. Also, provide healthy tubers not expressing any of the symptoms for comparison.

Identifying the disease

Match your observations to the disease descriptions and photographs that follow.

Areas on tubers affected with most of the described diseases are also easily invaded by the ultimate nemesis of the potato storage manager: bacteria that cause bacterial soft rot.

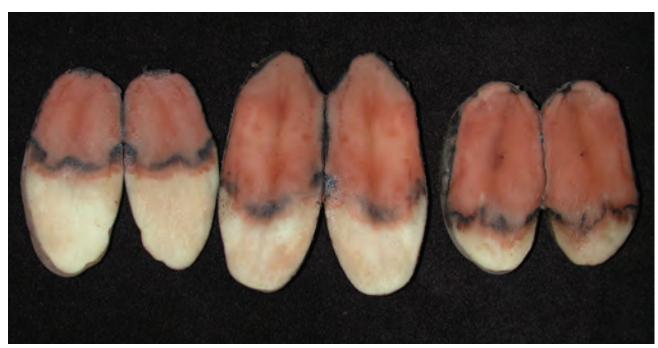

Figure 1. Tuber symptoms of pink rot. Infected tubers first appear cream colored when sliced open. The salmon-pink coloration appears after 15 to 20 minutes at room temperature.

Pink rot

Tubers affected by pink rot, caused by the oomycete *Phytophthora erythroseptica*, often maintain a normal shape, but the outer skin turns dark and the internal flesh when cut has a rubbery, "boiled potato" consistency (fig.1). The internal tissue turns pink after about 15 to 20 minutes of exposure to warm air and approximately 30 to 40 minutes under cool temperatures.

It is easy to confuse the pink rot color reaction with the lighter pink color that occurs due to oxidation when healthy tissue is exposed to air. Look for a distinct line between healthy and infected tissue. Your nose can also help in diagnosing this disease. Pink rot in storage is usually accompanied by a distinctive ammonia odor.

Pythium leak

Pythium leak, caused by *Pythium* spp., is often described as a "shell rot," but the term "leak" comes from the extremely wet nature of the rotted tissues. One method to confirm the presence of leak is to gently squeeze the rotten tuber and watch for a clear liquid to stream out (fig. 2). This disease also tends to cause a grey/brown/black rot in the interior of the tuber, leaving the outer cortex, or "shell," of the tuber intact. Since the leak pathogen typically needs a wound to infect, inspect the tuber for any potential disease entry points.

Late blight

Tubers with late blight, caused by the oomycete *Phytophthora infestans*, tend to have a reddish or tan-brown, dry, granular rot that extends from the skin of the tuber inward an inch or more (fig. 3). Tissues with late blight are firm to the touch, not wet or mushy. The amount of rot development will depend upon the duration of the infection, temperature, and potato variety. Peeling away the skin over the affected areas of the tuber and looking for the characteristic reddish color is a good way to identify this disease, but confirmation by an expert is always recommended.

Dry rot

Dry rot, caused by the fungus *Fusarium sambucinum* or *F. coeruleum*, typically progresses to tuber decay that is dry, crumbly, and brown in color with collapsed tissue often laced with secondary white- or other-colored fungal growth (fig. 4). While infected tubers eventually shrivel and mummify, the initial stages of dry rot can look very different.

F. sambucinum-infected tuber tissues initially have a wet, dark brown-black appearance. Except for the color changes, infected tuber tissues have the same firm, wet texture as the surrounding healthy tissues. The fungus

Figure 2. Cross section of a tuber affected by Pythium leak. Infected areas appear grey-black. When pressure is applied to the tuber, a clear fluid will usually drip or "leak" from the tuber, giving the disease its name.

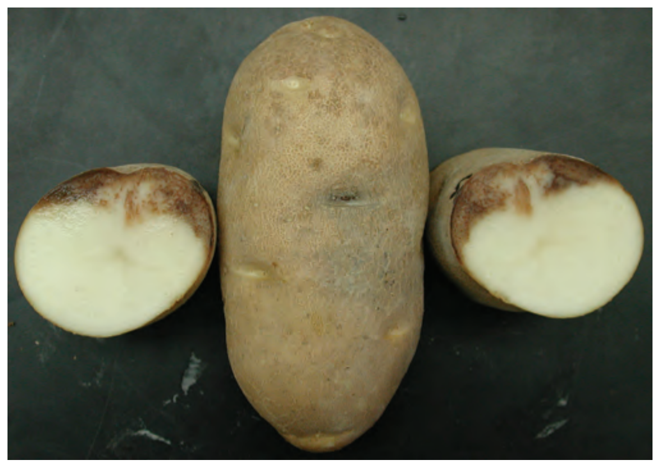

Figure 3. Potato tubers with late blight infection. The tuber in the center shows symptoms of infection through an eye. The tuber slices on either side depict the granular, brown dry decay associated with late blight.

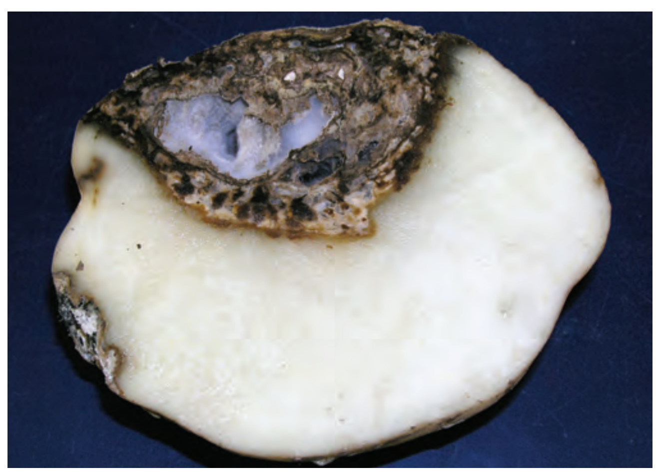

Figure 4. Dry rot caused by *Fusarium sambucinum*. This brown, dry rot is characterized by a nonuniform progression of rot through the potato tuber, usually starting at an injury site.

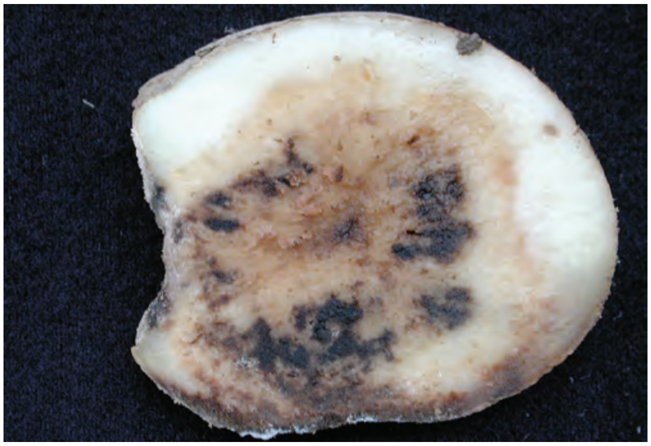

Figure 5. Dry rot caused by *Fusarium coeruleum*. In contrast to dry rot caused by *F. sambucinum*, this dry rot progresses uniformly throughout the tuber.

Figure 6. Advanced stages of bacterial soft rot occurring prior to tuber harvest. Rot begins at the point of stolon attachment and continues through the central pith tissue of the tuber. These two tubers additionally show rot caused by secondary tuber rot organisms.

Figure 7. Potato tubers infected with silver scurf. Black dot symptoms on tubers can look similar.

Photo courtesy of Brad Geary.

almost appears to be tunneling through the tuber, following the path of least resistance. With time, the disease progresses into the more familiar dry or papery rot stage.

In contrast, early infections caused by *F. coeruleum* appear yellowish-tan. The fungus spreads radially and uniformly outward through the tuber tissues from the point of initiation (fig. 5).

Soft rot

The most serious of all storage diseases is soft rot, caused by the bacterium *Erwinia carotovora*. Symptoms include tan- to brown-colored water-soaked areas of granular, mushy tissue often outlined by brown to black margins (fig. 6). The rotted part of the tuber is clearly differentiated from the healthy part of the tuber, although with time the healthy part will succumb to the bacteria.

Soft-rotted tubers tend to break down easily, thus spreading bacteria to surrounding tubers, resulting in localized pockets of rot or "hot spots." Spread from tuber to tuber is favored by high temperatures (the bacterium is not very active below 50°F) and anaerobic (low oxygen) conditions. Under these conditions, soft rot bacteria can invade previously healthy tubers, primarily through the lenticels.

Under most storage conditions, there is a danger that soft rot bacteria will invade tubers already infected with any of the previously described diseases. Once a soft rot pocket begins, the intense respiration occurring within the pocket can generate heat that accelerates the rotting process. The combination of high temperatures and wet, decaying tuber tissues laden with soft rot bacteria can result in extremely rapid disease progression.

Soft rot pockets generally spread downward in the pile, in response to gravity. A runaway soft rot problem can lead to the breakdown of an entire storage in a matter of a few days. Other bacteria, such as *Clostridium, Pseudomonas*, and *Bacillus*, can also cause tuber soft rot, but these have not been very well researched and are only poorly understood at present.

Silver scurf

Although not a disease that causes the internal tuber tissues to rot, silver scurf, caused by the fungus *Helminthosporium solani*, causes grey to silvery blotches on the surface of the tuber (fig. 7). Affected skin has a silvery sheen, appears thicker, and can be unappealing to consumers.

This disease has two distinct phases. One phase occurs while the tubers are still in the field and consists of infected areas on or near the stem end of the tuber called "primary lesions." Probably more important from a cosmetic standpoint are the "secondary lesions" that result from infections that develop while the tubers are in storage. Secondary lesions may occur anywhere on the tuber and can be so numerous as to cover virtually the entire tuber surface. In storage, infected tubers lose water at a higher rate than healthy tubers due to the pathogen's disruption of the periderm.

Black dot

Black dot, caused by the fungus *Colletotrichum coccodes*, causes unappealing lesions that look very similar to those of silver scurf, especially in the early stages of disease development. As the infection progresses, the lesions usually become more prominent and thicker than those associated with silver scurf. Within the lesions, small black sclerotia may be visible with the aid of a magnifying lens (fig. 8).

Early blight

Early blight in tubers is characterized by shallow, gray to black, dry lesions (fig. 9). Early blight can be caused by the fungus *Alternaria solani* or the fungus *Alternaria alternata*. (Tuber lesions caused by *A. alternata* are also called black pit.) Lesion margins may appear water-soaked and have a yellow color. Tuber early blight is often associated with wounding. This disease is seen most often when tubers with immature skins are harvested from sandy soils.

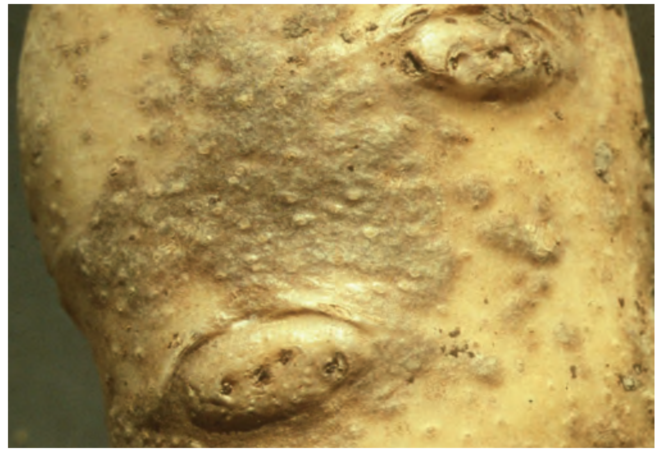

Figure 8. Potato tuber infected with black dot.
Photo courtesy of Dennis Johnson.

Figure 9. Tuber early blight symptoms are characterized by shallow, dry, gray to black lesions with margins that may appear water-soaked.

Managing storage diseases

Disease prevention

Storage management can be greatly simplified by taking steps to prevent diseases from occurring in the first place. A fungicide program and cultural practices to manage diseases like late blight, pink rot, and early blight in the field will reduce the percentage of diseased tubers placed into storage.

Avoidance of physical damage to tubers is one of the best management tools available. All the disease organisms discussed here are able to gain entry through wounds inflicted on tubers during the rigors of harvest and handling.

Some fungicides and disinfestants can be applied to tubers as they are being placed into storage to protect against late blight, pink rot, dry rot, and silver scurf development. Contact university personnel for the latest recommendations for registered and effective post-harvest products.

Management between storage seasons

Some pathogens, such as the silver scurf pathogen, may survive from one season to the next in the storage facilities themselves. Storages and handling equipment should be cleaned and sanitized or "disinfected" after the storage is emptied and before handling and storing the new crop. Disinfection of storages and handling equipment is a three-step process.

1. **Remove dirt and debris**. All the disinfectants approved for use in potato storages are rapidly tied up and rendered ineffective by dirt and organic matter. The next two steps of the process will be much more effective if the debris from last year's crop is removed.
2. **Wash with soap and water**. This step is often accomplished with a pressure washer and a detergent solution. Warm or hot water will be more effective than cold water. Steam washers are also a good choice but will not actually disinfect storage surfaces or equipment because the duration of the exposure to steam is too short. Water and detergent help to dissolve and remove dried tuber sap and bacterial slimes that are deposited on storage surfaces and equipment, and detergents have some disinfection capability. Cleaned surfaces allow the disinfectant, used in the next step, to work properly.
3. **Disinfect**. Use an appropriate and registered disinfectant and make sure that the surfaces to be disinfected remain wet with the disinfection solution for *at least 10 minutes*. Use sufficient sprayer pressure and volume to effectively clean all surfaces.

Many fungal spores have tough, resilient cell walls, and bacteria in storages often occur in the form of dried slime. Ten minutes provides the necessary time for the disinfectant to penetrate the fungal cell wall or dissolve the bacterial slime and kill the pathogen.

Management during storage

Identify the major storage disease problem prior to making any changes to storage management procedures. Be aware that changes in storage management can impact other potato quality attributes, such as fry color and tuber sugar concentrations.

There are three basic tools of storage management: temperature, humidity, and airflow. Balanced use of these tools is the key to managing potato diseases in storage.

Cooling period. If potatoes are harvested with pulp temperatures above 60°F, cool them to at least 60°F within the first 2 to 3 days after harvest and maximize the duration of fresh-air intake. This is especially important for tubers with late blight, pink rot, Pythium leak, and soft rot because warmer temperatures promote faster decay.

Supply a high volume of air to the potatoes to decrease tuber temperature and to help dry out rotted or wet potatoes. Set-point temperatures may need to be decreased in a stair-step manner to optimize the duration of fresh air intake per day. Start operating the ventilation system as soon as the first two to three ducts are covered during loading. Continue to decrease storage temperatures to the desired curing temperature.

Some special circumstances such as colder-than-recommended pulp temperatures or excessive disease may require the advice of an expert. For instance, rapidly warming cool potatoes may cause condensation to form on the surface of the potato and elevate the potential for disease progression.

Curing period. Proper management of the storage facility during the wound healing or "curing period" is critical. The curing period is important for proper healing of cuts and bruises, reducing pathogen spread, and keeping shrinkage losses at a minimum. Wound healing requires oxygen, high humidity, and favorable temperatures.

The recommended storage regime for wound healing and curing is typically 50 to 55°F for 2 to 3 weeks with good ventilation and a relative humidity of 95% and above. Even these relatively cool temperatures will promote rapid breakdown when storage diseases such as pink rot and Pythium leak are present. Therefore temperatures during curing may need to be lowered to 50°F if disease incidence and severity are high (more than 5% wet rot). However, curing temperatures below 50°F may delay wound healing and are generally not recommended.

Use continuous ventilation to dry out wet potatoes. If "hot spots" begin to develop during curing, supply high airflow to the area to help prevent additional pathogen spread. Airflow must be sufficient to remove water given off by the decaying tubers. Supplemental ventilation can be supplied by auxiliary fans on top of the pile or in the ducts below troublespots.

Holding period. After the required curing period, reduce the storage temperature from the curing to the holding temperature as quickly as possible but generally no faster than 0.5°F per day. Limiting the amount of time diseased tubers are held at warmer temperatures will decrease the rate of disease progression. A slower ramping rate may be more appropriate for potatoes to be processed where sugar concentrations and fry color are a concern.

Although lower holding temperatures typically decrease the rate of disease progression, any storage decision involving temperature adjustments must take into consideration the end-use of the potato. Processing potatoes typically need to be stored at higher temperatures (44° to 55°F) than seed and fresh market potatoes (37° to 45°F) and therefore the luxury of low storage temperatures is not available. Continuous fan operation and high airflow may still be necessary to dry out wet or problem potatoes, especially those with soft rot, pink rot, or Pythium leak. Continuous ventilation will also reduce the chance for condensation to occur in the storage facility. Keep in mind that low holding temperatures, while an effective management tool for many situations, are no guarantee that disease progression will stop.

Depending upon the nature and percentage of rot in the storage, the pile may need additional drying ventilation with reduced-humidity air. However, reduced humidity results in additional shrinkage and also delays wound healing, which can increase the incidence of dry rot. Decreasing relative humidity in storage to 85% or less can also decrease the secondary spread of the silver scurf pathogen. Still, evaluate other management strategies before reducing relative humidity.

Final thoughts

The three basic storage management tools available are temperature, humidity, and airflow. Properly identifying the disease responsible for a storage problem allows the optimal use of these tools to limit pathogen spread and disease development in storage. Keep in mind that any deviation from normal storage practices can reduce the quality of your stored potatoes. *Under some conditions, early marketing may be the only option available to preserve the value of your crop.*

The authors—Nora Olsen, potato specialist, UI Twin Falls Research & Extension Center; **Jeff Miller**, potato pathologist, UI Aberdeen Research & Extension Center; **Phil Nolte**, seed potato specialist, UI Idaho Falls Research & Extension Center.

Further Readings

All but the potato disease compendium are available from

Educational Publications Warehouse
University of Idaho
P.O. Box 442240
Moscow, ID 83844-2240

Phone: (208) 885-7982
Fax: (208) 885-4648
Email: calspubs@uidaho.edu

Compendium of Potato Diseases, 2d ed. 2001. The American Phytopathological Society.

Integrated Pest Management for Potatoes in the Western United States, 2d ed. 2006. University of California Agriculture and Natural Resources Publication 3316.

Managing Benzimidazole Resistance in the Potato Dry Rot Fungus. 1994. University of Idaho EXT 769.

Managing Late Blight on Irrigated Potatoes in the Pacific Northwest. 2003. PNW 555. Available online at *http://info.ag.uidaho.edu/pdf/pnw/pnw0555.pdf*

Potato Production Systems. 2003. University of Idaho.

Preventing Potato Bruise Damage. 1998. University of Idaho BUL 725. Available online at *http://info.ag.uidaho.edu/resources/PDFs/BUL0725.pdf*

Silver Scurf of Potatoes. 1997. University of Idaho CIS 1060. Available online at *http://info.ag.uidaho.edu/pdf/CIS/CIS1060.pdf*

University of Idaho
Extension

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NOTES

Product Material Safety Data Sheets (MSDS)

PIN NIP 98%
Chlorpropham
(1,4Group, Inc.)

Material Safety Data Sheet

PIN NIP® Technical Chlorpropham and PIN NIP® 98% Chlorpropham

Revision Date: September 3, 2009

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: PIN NIP® Technical Chlorpropham; PIN NIP® 98% Chlorpropham
Chemical Name: Isopropyl N-(3-chlorophenyl) carbamate
Synonyms: Isopropyl 3-chlorocarbanilate; 1-methylethyl(3-chlorophenyl) carbamate; CIPC Chemical Family: Carbamate
Formula: C10-H12-Cl-N-02
General Use: Potato sprout inhibitor
EPA Registration Number: PIN NIP® Technical Chlorpropham (65726-2);
PIN NIP® 98% Chlorpropham (65726-3)

Company Identification:
Pin/Nip, a division of 1,4GROUP, Inc.
P.O. Box 860
Meridian, ID 83680-0860

24-Hour Emergency Telephone Numbers
Transportation: PERS 1-800-633-8253
Other Emergencies: 1,4GROUP, Inc.: 208-887-9766

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chlorpropham (CAS No. 101-21-3) 98.0%
Impurities 2.0%

* Chlorpropham is considered hazardous under criteria of the Federal OSHA Hazard Communication Standard, 29 CFR 1910.1200, based on irritation potential and target organ effects.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Brown; light grayish, yellowish low-melting solid/viscous liquid. Harmful if swallowed. inhaled or absorbed through the skin. Avoid contact with skin, eyes or clothing. Avoid breathing vapors or aerosol spray. Not considered a fire hazard.

POTENTIAL HEALTH EFFECTS

POTENTIAL ROUTES OF ENTRY: Inhalation; skin contact; eye contact, Ingestion
SYMPTOMS OF OVEREXPOSURE
Inhalation: Expected to be only slightly toxic via inhalation. Inhalation may cause respiratory tract irritation.
Skin Contact: Technical grade chlorpropham is expected to be minimally toxic by skin absorption and a mild skin irritant. Repeated dermal exposure could result in skin reactions and adverse effects on the blood, liver, bone marrow and spleen.
Eye Contact: Chlorpropham dust or aerosol mist may cause mild eye irritation.
Ingestion: This material has shown a low degree of acute toxicity in animal studies; however, rats fed very high doses evidenced muscular weakness, prostration and convulsions. Subchronic and chronic exposure to chlorpropham may cause a toxic response in liver, blood-forming organs (spleen and bone marrow), on blood cells and on the thyroid.
Carcinogenicity: Chlorpropham does not cause cancer in animals based on results of long-term feeding studies.

- NTP Not Listed as a carcinogen
- IARC Animals: inadequate evidence; humans; not classifiable - IARC Group 3
- OSHA Not regulated as a carcinogen
- ACGIH Not listed as a carcinogen

Teratogenicity: Chlorpropham is not expected to cause birth defects in the offspring of pregnant women exposed to the pesticide.

4. FIRST AID MEASURES

Skin Contact: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
Swallowed: Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not

give anything by mouth to an unconscious person.
Inhalation: Move person to fresh air. If person is not breathing, call 911 or ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. Call a poison control center or doctor for treatment advice.
Eye Contact: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 15 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: None known

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES
Flash Point: Not Determined; expected to be high
Flash Point Method: Not Applicable
Flammable Limits in Air: Not Determined
Autoignition Temperature: Not Determined
Extinguishing Media: Material burns with difficulty. Use dry chemical, alcohol foam, water fog, carbon dioxide or other extinguishing agent suitable for surrounding fire.
Fire Fighting Procedures: Prevent human exposure to fire, smoke, vapors and products of combustion. Firefighters should wear full-face, self-contained breathing apparatus and impervious protective clothing. If possible, move containers from fire area. Keep non-leaking containers cool with water fog or spray to prevent rupture from excessive heat. Dike fire water for later disposal. Do not allow contaminated water to enter waterways.

NFPA Hazard Rating	HMIS Hazard Rating
H = 1	H = 1
F = 0	F = 0
R = 0	R = 0
O = None	PP = F

H = Health; F = Flammability; R = Reactivity; O = Other Hazard; PP = Personal Protective Equipment

6. ACCIDENTAL RELEASE MEASURES

Cleanup: Sweep up spilled material and place in a labeled chemical waste container with lid. Wash spill area with detergent/water. Dike wash water for proper disposal. Observe all local, state and federal laws and regulations regarding disposal, spill. cleanup, removal and discharge.
Waste Disposal: Chlorpropham. as sold, is not a hazardous waste under federal Resource Conservation and Recovery Act (RCRA) regulations. Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of federal and state Law. If such wastes cannot be disposed of by application according to label instructions, contact your State Pesticide or Environmental Control Agency or the Hazardous Waste Section of the nearest EPA Regional Office for guidance. Do not allow waste to enter sewers or surface waters.
Container Disposal: Do not reuse empty container. Triple rinse (or equivalent), then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by local and state authorities.

7. HANDLING AND STORAGE

Handling: Keep containers closed when not in use. Use only approved equipment for transporting containers to avoid puncturing or rupturing. Wear appropriate protective equipment (see Section 8) when working with this product. During application procedure wear designated protective equipment to avoid inhalation, skin or eye contact.
Storage: Store away from foodstuffs and animal feed. Store containers In a cool. dry, well-ventilated area away from flammable, combustible or incompatible material such as strong oxidizers, strong bases and sources of heat or flame. Keep containers tightly closed when not in use. Post warnings and restrict access to storage area. Precautions apply to emptied containers. Comply with all applicable regulations for storage, handling and application. Do not heat or cut empty container with a cutting torch. Keep product away from children.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Respiratory Protection: Use a NIOSH-approved organic vapor acid gas respirator (OVAG) with dust, mist and fume filter to reduce potential for inhalation exposure when use conditions generate dust, vapor, mist or aerosol. When exposure potential requires a higher level of protection, for example, when workers enter storage or treatment areas during or following application, that is, before the aerosol fog has settled or in emergency conditions, use a NIOSH - approved, positive-pressure, pressure demand air-supplied respirator and wear appropriate protective clothing. Respirator cartridges or canisters must be changed frequently to assure that breakthrough exposure does not occur. Observe OSHA regulations for respirator use (29 CFR 1910.134).

Skin Protection Requirements: Skin contact with solid, liquid or aerosol spray must be prevented by the use of impervious clothing, chemical resistant gloves and footwear, each selected with regard to use conditions and exposure potential.
Eye Protection Requirements: Wear safety glasses with side shields, splash goggles or face shield. Contact lenses should not be worn.
Exposure Guidelines: No exposure guidelines have been established for chlorpropham by OSHA, ACGIH or NIOSH Isopropanol, a low level impurity in this product, has an OSHA PEL and ACGIH TLV of 400 ppm (983 mg/m^3); both the OSHA and ACGIH STEL's are 500 ppm (1230 mg/m^3).
Engineering Controls: This material, when aerosolized, is required to be handled under specific process conditions according to the EPA-registered product label instructions. Local exhaust ventilation may be needed to control emissions for some operations.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Solid at 20 °C
Color	Brown; light grayish, yellowish
Odor	Halide; Unsaturated
Boiling Point	>150 °C (302 °F) 760 mm mercury
Melting Point	38 - 41°C (100- 106 °F)
Solubility	89 mg/L in water at 25 °C; Soluble in ketones and lower alcohols
pH	5.8 at room temperature
Bulk Density	0.994 g/ml
Vapor Pressure	<10^{-6} mm mercury (20 °C)
Octanol/Water Partition Coefficient	3.47

10. STABILITY AND REACTIVITY

Stability: Considered stable below 100 °C (212 °F). Stable at 55 °C for 14 days. Stable to sunlight and toward aluminum, iron and tin to 150 °C.
Reactivity: Hydrolyzes slowly in acidic or alkaline media. In 0.5 N sodium hydroxide solution hydrolyzes slowly.
Polymerization: Hazardous polymerization is not expected to occur.
Incompatibilities: Avoid acids, bases and strong oxidizers.

11. TOXICOLOGICAL INFORMATION

Chlorpropham technical has low acute toxicity.

Oral LD_{50}, rats: 2030 mg/kg	Skin Irritation: Mild Irritant
Dermal LD_{50}, rabbits: > 2000 mg/kg	Skin Sensitization: Negative
Eye Irritation: Mild Irritant	

A subchronic feeding study was conducted in which rats were fed chlorpropham for 90 days. At the higher dose levels, adverse effects on the liver, blood forming systems, *i.e.*, bone marrow and spleen, were observed. At the highest dose level, some animals had elevated cholesterol. A NOEL was not identified.

A subchronic feeding study was conducted in which mice were fed chlorpropham for 90 days. The NOEL was 420 mg/kg/day. At the LOEL (lowest observable effect level), 856-857 mg/kg/day, adverse effects were observed in the blood, liver, spleen and bone marrow.

A chronic feeding study was carried out in which chlorpropham was fed to beagle dogs for 60 weeks. Thyroid changes occurred at the LOEL (50 mg/kg/day). Effects on the blood were also seen. The NOEL was 5 mg/kg/day.
Chronic carcinogenicity bioassays were carried out in rats and mice. The test material was not found to be carcinogenic in these studies.

In a 21-day dermal study with rabbits, chlorpropham was applied daily to the skin. Dermal irritation and alterations occurred at even the lowest dose level. Adverse effects on the blood, possibly related to spleen weight increases, were also observed. An NOEL was not identified.
Long term feeding studies were conducted with no carcinogenic effects.
Mutagenicity testing gave mixed results.
No teratologic changes were observed in rats or rabbits.

Reproductive Toxicity: Chlorpropham did not affect fertility or reproduction in a multi-generation reproduction study.

Target Organs: Overexposure to chlorpropham may affect the blood, spleen, liver, and bone marrow.

12. ECOLOGICAL INFORMATION

ECOLOGICAL TOXICITY

Oral LD_{50} (Mallard) > 2000 mg/kg
Dietary LC_{50} (Bobwhite) > 5620 ppm
LC_{50} (Bluegill) 6.8 mg/L
LC_{50} (Rainbow Trout) 5.7 mg/L
EC_{50} (*Daphnia magna*) 3.7 mg/L

DISTRIBUTION

No appreciable bioconcentration is expected in the environment. Chlorpropham will not bioconcentrate in aquatic organisms. Moderate water solubility and low vapor pressure should prevent volatilization from water.

CHEMICAL FATE INFORMATION

Chlorpropham absorbs strongly to soil and clay and will exhibit low mobility. It is readily biodegraded by microorganisms in soil, with a half life of about 30 days.

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD - Dispose of in accordance with label instructions. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal and State Law. If wastes cannot be disposed of by application according to label instructions, contact your State Pesticide or Environmental Control Agency or the Hazardous Waste section of the nearest EPA Regional Office for guidance. Do not allow waste to enter sewers or surface waters.

14. TRANSPORTATION INFORMATION

Product is **Not Regulated** for shipping by any mode of transport, i.e., United States DOT, IATA/ICAO (air) or IMO (water).

15. REGULATORY INFORMATION

OSHA Status	Chlorpropham is considered hazardous under the criteria of the Federal OSHA Hazard Communication Standard, 29 CFR 1910.1200, based on irritation potential and target organ effects.
TSCA Status	Not on TSCA Inventory; it is sold as an EPA-registered pesticide.
CERCLA	Not listed; no reportable quantity ("RQ")
SARA Title III, Sections 311/312 Hazard Categories	Immediate Health Delayed Health
SARA TITLE III, Section 313	Not reportable
CALIFORNIA PROPOSITION 65	Not listed

16. OTHER INFORMATION

PREPARED FOR: Pin/Nip, a division of 1,4GROUP, Inc.
REVISION DATES: December 6, 2002, December 14, 2004, January 9, 2006, March 31, 2006, September 3, 2009

DISCLAIMER

Information presented herein is based upon data obtained from the manufacturer and/or other recognized technical sources considered to be reliable. While the information is believed to be reliable, 1,4GROUP, Inc. makes no representations as to its accuracy or sufficiency. Conditions of use are beyond 1,4GROUP's control; therefore, users are responsible to verify this data under their own operating conditions. Users assume all risks of their use, handling and disposal of the product, or from the publication, or use of, or reliance upon information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other manner.

Tsunami 100

(EcoLab)

Material Safety Data Sheet

TSUNAMI 100

Section 1. Chemical product and company identification

Trade name : TSUNAMI 100

Product use : Cleaning product

Supplier : Ecolab Food and Beverage
5105 Tomken Road
Mississauga ON L4W 2X5
1-800-352-5326

Code : 984484-18

Date of issue **05-May-2009**

EMERGENCY HEALTH INFORMATION: 1-800-328-0026
Outside United States and Canada CALL 1-651-222-5352 (in USA)

Section 2. Hazards identification

Physical state : Liquid. [Liquid.]

Emergency overview : DANGER !

CAUSES DIGESTIVE TRACT, EYE AND SKIN BURNS.
HARMFUL IF SWALLOWED. MAY BE FATAL IF SWALLOWED.
CAUSES RESPIRATORY TRACT IRRITATION.
OXIDISER.
CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE.

Do not ingest. Do not get in eyes, on skin or on clothing. Avoid breathing vapours, spray or mists. Keep only in the original container. Avoid contact with combustible materials. Avoid all possible sources of ignition (spark or flame). Keep away from heat and direct sunlight. Decomposes on heating. Keep container closed. Use only with adequate ventilation. Wash thoroughly after handling.

Routes of entry : Skin contact, Eye contact, Inhalation, Ingestion

Potential acute health effects

Eyes : Corrosive to eyes.

Skin : Corrosive to the skin.

Inhalation : Severely irritating to the respiratory system.

Ingestion : Harmful if swallowed. May be fatal if swallowed. Causes burns to mouth, throat and stomach.

See toxicological information (section 11)

Section 3. Composition/information on ingredients

Name	CAS number	% by weight
ACETIC ACID	64-19-7	15 - 40
peracetic acid	79-21-0	10 - 30
HYDROGEN PEROXIDE	7722-84-1	7 - 13

Section 4. First-aid measures

Eye contact : In case of contact, immediately flush eyes with cool running water. Remove contact lenses and continue flushing with plenty of water for at least 15 minutes. Get medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Inhalation : If inhaled, remove to fresh air. If exposed person is not breathing, give artificial respiration or oxygen applied by trained personnel. Get medical attention immediately.

Ingestion	:	If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Do not induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Section 5. Fire-fighting measures

Auto-ignition temperature	:	Not available.
Flash point	:	96.1111 °C (Closed cup) Product does not support combustion.
Flammable limits	:	Not available.
Hazardous thermal decomposition products	:	Decomposition products may include the following materials: carbon dioxide carbon monoxide
Fire-fighting media and instructions	:	Use an extinguishing agent suitable for the surrounding fire. Use water spray to keep fire-exposed containers cool. Dyke area of fire to prevent runoff. Contact with combustible material may cause fire. This material increases the risk of fire and may aid combustion. In a fire or if heated, a pressure increase will occur and the container may burst.
Special protective equipment for fire-fighters	:	Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Risk of explosion of the product in the presence of mechanical impact: Not available.

Risk of explosion of the product in the presence of static discharge: Not available.

Section 6. Accidental release measures

Personal precautions	:	Immediately contact emergency personnel. Stop leak if without risk. Eliminate all ignition sources. Use suitable protective equipment. Keep unnecessary personnel away. Do not touch or walk through spilt material.
Environmental precautions	:	Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).
Methods for cleaning up	:	If emergency personnel are unavailable, contain spilt material. For small spills, add absorbent (soil may be used in the absence of other suitable materials), scoop up material and place in a sealable, liquid-proof container for disposal. For small spills, add absorbent (soil may be used in the absence of other suitable materials) and use a non-sparking or explosion-proof means to transfer material to a sealable, appropriate container for disposal. For large spills, dyke spilt material or otherwise contain it to ensure runoff does not reach a waterway. Place spilt material in an appropriate container for disposal.

Section 7. Handling and storage

Handling	:	Do not ingest. Do not get in eyes, on skin, or on clothing. Do not breathe vapour or spray. Avoid contact with combustible materials. Keep container closed. Keep only in the original container. Use only with adequate ventilation. Wash thoroughly after handling. Do not mix with bleach or other chlorinated products – will cause chlorine gas.
Storage	:	Keep out of reach of children. Keep container in a cool, well-ventilated area. Keep container tightly closed. Separate from reducing agents and combustible materials. Store between the following temperatures: -10 and 50°C

Section 8. Exposure controls/personal protection

Engineering measures : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapour or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. Provide suitable facilities for quick drenching or flushing of the eyes and body in case of contact or splash hazard.

Personal protection :

Eyes : Use chemical splash goggles. For continued or severe exposure wear a face shield over the goggles.

Hands : Use chemical-resistant, impervious gloves.

Skin : Wear suitable protective clothing.

Respiratory : Wear appropriate respirator when ventilation is inadequate and occupational exposure limits are exceeded.

Name	Exposure limits
ACETIC ACID	**CA Alberta Provincial (Canada, 6/2008).** 15 min OEL: 37 mg/m³ 15 minute(s). 15 min OEL: 15 ppm 15 minute(s). 8 hrs OEL: 25 mg/m³ 8 hour(s). 8 hrs OEL: 10 ppm 8 hour(s). **CA British Columbia Provincial (Canada, 6/2008).** STEL: 15 ppm 15 minute(s). TWA: 10 ppm 8 hour(s). **CA Ontario Provincial (Canada, 6/2008).** STEV: 37 mg/m³ 15 minute(s). STEV: 15 ppm 15 minute(s). TWAEV: 25 mg/m³ 8 hour(s). TWAEV: 10 ppm 8 hour(s). **CA Quebec Provincial (Canada, 6/2008).** STEV: 37 mg/m³ 15 minute(s). STEV: 15 ppm 15 minute(s). TWAEV: 25 mg/m³ 8 hour(s). TWAEV: 10 ppm 8 hour(s). **ACGIH TLV (United States, 1/2008).** STEL: 37 mg/m³ 15 minute(s). STEL: 15 ppm 15 minute(s). TWA: 25 mg/m³ 8 hour(s). TWA: 10 ppm 8 hour(s).
HYDROGEN PEROXIDE	**CA Alberta Provincial (Canada, 6/2008).** 8 hrs OEL: 1.4 mg/m³ 8 hour(s). 8 hrs OEL: 1 ppm 8 hour(s). **CA British Columbia Provincial (Canada, 6/2008).** TWA: 1 ppm 8 hour(s). **CA Ontario Provincial (Canada, 6/2008).** TWAEV: 1.4 mg/m³ 8 hour(s). TWAEV: 1 ppm 8 hour(s). **CA Quebec Provincial (Canada, 6/2008).** TWAEV: 1.4 mg/m³ 8 hour(s). TWAEV: 1 ppm 8 hour(s). **ACGIH TLV (United States, 1/2008).** TWA: 1.4 mg/m³ 8 hour(s). TWA: 1 ppm 8 hour(s).

Section 9. Physical and chemical properties

Physical state	:	Liquid. [Liquid.]
Colour	:	Colourless.
Odour	:	Acetic acid.
pH	:	1.8 [Conc. (% w/w): 100%]
Boiling/condensation point	:	>100°C (>212°F)
Melting/freezing point	:	Not available.
Relative density	:	1.114
Vapour pressure	:	Not available.
Vapour density	:	Not available.
Odour threshold	:	Not available.
Evaporation rate	:	Not available.
$LogK_{ow}$	:	Not available.
Dispersibility properties	:	Easily dispersible in the following materials: cold water and hot water.
Solubility	:	Easily soluble in the following materials: cold water and hot water.

Section 10. Stability and reactivity

Stability	:	The product is stable. Decomposes on heating. Under normal conditions of storage and use, hazardous polymerisation will not occur.
Conditions of instability	:	Not available.
Reactivity	:	Reactive or incompatible with the following materials: organic materials, metals and alkalis. Do not mix with bleach or other chlorinated products – will cause chlorine gas.
Hazardous decomposition products	:	Oxygen
Hazardous polymerisation	:	Under normal conditions of storage and use, hazardous polymerisation will not occur.

Section 11. Toxicological information

Potential acute health effects

Eyes	:	Corrosive to eyes.
Skin	:	Corrosive to the skin.
Inhalation	:	Severely irritating to the respiratory system.
Ingestion	:	Harmful if swallowed. May be fatal if swallowed. Causes burns to mouth, throat and stomach.

Potential chronic health effects

Carcinogenic effects	:	No known significant effects or critical hazards.
Mutagenic effects	:	No known significant effects or critical hazards.
Teratogenic effects	:	No known significant effects or critical hazards.
Reproductive effects	:	No known significant effects or critical hazards.
Sensitization to Product	:	No known significant effects or critical hazards.
Synergistic products (toxicologically)	:	Not available.

Toxicity data

Ingredient name	Test	Route	Result	Species
acetic acid	LD50	Dermal	1060 uL/kg	Rabbit
	LD50	Oral	3310 mg/kg	Rat
peracetic acid	LD50	Dermal	>12000 mg/kg	Rat
	LD50	Oral	10 mg/kg	Guinea pig
	LD50	Oral	263 to 1026 mg/kg	Rat
	LD50	Oral	210 mg/kg	Mouse

Hydrogen peroxide	LD50	Oral	500 mg/kg	Rat

Target organs : Contains material which may cause damage to the following organs: upper respiratory tract, teeth.

Section 12. Ecological information

Ecotoxicity

Ingredient name	Species	Period	Result
acetic acid	Daphnia	48 hours	Acute EC50 65 mg/L
	Fish	96 hours	Acute LC50 79 mg/L
	Fish	96 hours	Acute LC50 75 mg/L
	Fish	96 hours	Acute LC50 88 mg/L
peracetic acid	Fish	96 hours	Acute LC50 13 mg/L
	Fish	96 hours	Acute LC50 3.3 mg/L
Hydrogen peroxide	Daphnia - 24 hours	48 hours	Acute EC50 24 to 32 ppm Fresh water
	Fish - Bluegill	96 hours	Acute LC50 26.7 to 56 ppm Fresh water
	Fish	96 hours	Acute LC50 22 to 32 ppm Fresh water

Section 13. Disposal considerations

Waste disposal : The generation of waste should be avoided or minimised wherever possible. Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements.

Consult your local or regional authorities.

Section 14. Transport information

Certain shipping modes or package sizes may have exceptions from the transport regulations. The classification provided may not reflect those exceptions and may not apply to all shipping modes or package sizes.

UN Classification

UN number	UN3109
Proper shipping name	ORGANIC PEROXIDE TYPE F, LIQUID (Peroxyacetic acid, Type F, stabilized)
Class	5.2 (8)
Packing group	-

See shipping documents for specific transportation information.

Section 15. Regulatory information

WHMIS : Class C: Oxidising material.
Class E: Corrosive material

Canada inventory : All components are listed or exempted.

This product has been classified in accordance with the hazard criteria of the *Controlled Products Regulations* and the MSDS contains all the information required by the *Controlled Products Regulations*.

Section 16. Other information

Hazardous Material Information System (U.S.A.) :

Health	*	3
Flammability		0
Physical hazards		1

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Responsible name : **Regulatory Affairs**
1-800-352-5326

Date of previous issue : **20-July-2006.**

Notice to reader

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

NOTES

Chapter Review Questions

Chapter 1

1. d
2. a
3. d
4. d
5. b
6. c
7. d
8. b
9. b
10. c
11. a
12. a
13. d
14. c
15. a
16. d
17. d
18. a
19. a
20. c
21. b
22. c
23. d
24. a
25. b

Chapter 2

1. c
2. d
3. a
4. a
5. c
6. d
7. d
8. c
9. a
10. a
11. b
12. a
13. a
14. c
15. b
16. d
17. d
18. b
19. d
20. d

Chapter 3

1. a
2. d
3. d
4. a
5. d
6. b
7. d
8. a
9. a
10. a
11. c
12. c
13. e
14. d
15. a
16. b

Chapter 4

1. a
2. d
3. d
4. d
5. c
6. d
7. d
8. a
9. b
10. d
11. b
12. a
13. a
14. b

Chapter 5

1. d
2. c
3. a
4. a
5. b
6. b
7. c
8. d
9. a
10. c
11. c
12. c
13. b