

**The harvest operation accounts for the majority of mechanical damage to potatoes. Trucking, piling into storage and handling for market also contribute to bruising. Train employees to operate equipment in a manner to prevent damage to the tubers.**

### **3.9 Potato Storage Management**

#### **3.9.1 Storage structures and Ventilation**

**(D. Small and K. Pahl)**

Stored tubers are living organisms, which produce heat through respiration and lose moisture (shrink) through respiration and evaporation. An ideal storage environment must be provided if the tubers are to be stored up to 10 months (see section 3.9.2 *Storage Cycle*). Tubers go through four different storage phases (curing, cooling, long-term storage and marketing), each requiring a different environment. To meet all of these requirements the potato storage must be designed to:

- Maintain tubers at a desired temperature by exhausting the heat of respiration and circulating cool fresh air through the pile.
- Maintain a high relative humidity to promote wound healing at harvest and to prevent tuber desiccation (shrink)
- Provide oxygen for tuber respiration
- Remove carbon dioxide, the by-product of respiration and other deleterious gasses, which affect tuber quality.
- Deal with adverse storage conditions where the tubers are wet, rotting, chilled, frozen or too warm.

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There are four factors to consider when choosing a potato storage design:

- Style of structure
- Insulation
- Ventilation and humidification
- Options such as auxiliary heating or refrigeration.

#### **Storage Structure**

Almost any type of building can be adapted to store potatoes, however, commercial rigid frame steel buildings are not normally used because the exposed steel beams and columns are difficult to insulate. The most common storage buildings are concrete, wood stud and pole frame, and metal quonset. The factors that vary between various building types are capital cost, durability and longevity, and the type of insulation required for the exterior building envelope.

Regardless of the type of building, the design should be undertaken by a Professional Engineer to ensure that the structure can withstand the forces exerted by the stored potatoes, wind and snow. Design and construction can typically require three to four months or more; therefore early planning is required to ensure the storage is ready at harvest time.

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The size of individual bins and storage systems vary widely with the needs of individual producers and the cost of construction. Bin sizes in modern buildings normally range from 40,000 to 80,000 cwt. Potatoes from individual fields often behave differently in storage, requiring individual management. Ideally, the potatoes from each field should be stored in a separate bin, but since smaller bins cost more per hundredweight, storage management is compromised when storing potatoes from different fields in large bins.

An enclosed loading area attached to the storage bin(s) is recommended. This will allow workers to comfortably load potatoes in severe weather and minimize potential problems associated with chilled tubers.

#### **Insulation**

Storages must be properly insulated and sealed in order to maintain the environment required to keep stored potatoes healthy. Besides reducing heat loss and thus helping to maintain the desired storage temperature, insulation is also critical in preventing condensation. Condensation water, dripping onto the tubers, will encourage the development of soft rots and can significantly impact potato quality. It is recommended that enough insulation be installed to achieve a minimum thermal resistance (RSI) of 6.1 (R35). This is equivalent to 10 inches (250 mm) fibreglass or 6 inches (150 mm) of polyurethane insulation. Ceiling fans

have also proved beneficial in reducing free moisture on ceiling surfaces and/or the top of the potato pile.

The amount of insulation also impacts interior air quality. Insulation decreases heat loss through the walls and ceilings, resulting in more heat of respiration exhausted from the building via the ventilation system. In extremely cold weather, this allows the ventilation system to bring additional fresh air into the building, thus maintaining adequate levels of oxygen and reducing the level of deleterious gasses such as carbon dioxide.

**Ventilation**

Ventilation is the most important factor for maintaining correct temperature, relative humidity, and air quality in the storage. It is also essential for managing potential storage problems caused by disease or frost. The basic ventilation system design is similar, regardless of the type of storage structure (Figure 3.9-1). A typical ventilation system consists of intake door(s), fan(s), air plenum(s), ducts, exhaust louvers and a control system. Recommended ventilation rates are listed in Table 3.9-1.

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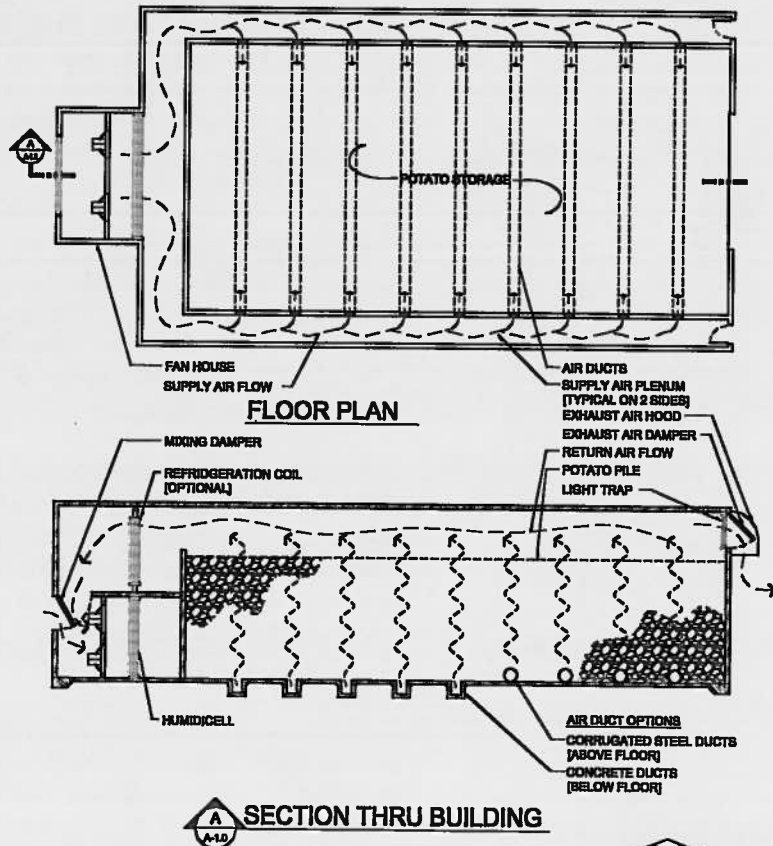
*Table 3.9-1 Recommended Ventilation Rates*

|            | L/s <sup>1</sup> | cfm/cwt <sup>2</sup> |
|------------|------------------|----------------------|
| Seed       | 75. to 10        | 0.75 to 1.0          |
| Processing | 12.5 to 15       | 1.25 to 1.5          |

<sup>1</sup> Litres/second per tonne of potatoes

<sup>2</sup> cubic feet/minute per hundred weight of potatoes

*Figure 3.9-1 Typical Storage Ventilation Design*



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A qualified individual should design the ventilation system. The size of the intake doors, air plenums, ducts, duct outlets and exhaust louvers must be carefully selected to ensure that the ventilation air is evenly distributed throughout the storage. Intake dampers should be designed to close return air supply proportionally as the intake door is opened. As more fresh air intake is required, return air carrying excessive heat or humidity will be forced out of the building through the exhaust vent(s). This can be particularly helpful when trying to remove excessive field heat at harvest. The addition of refrigeration coils, humidification units and light traps in the exhaust louver all impact the resistance to airflow and must be considered when selecting the ventilation fans. Controllers for varying the speed and airflow of the fans are recommended. Contact Manitoba Agriculture or a potato processor for the name of someone qualified to design the ventilation system.

Most control systems utilize a single insulated damper to control the blend of fresh and return air. A heating system, in the perimeter of the damper, is used to prevent freezing of the damper in cold weather. Heavy-duty screw type actuators are used to adjust the position of the damper.

Ventilation controllers vary in complexity, depending on the number of control strategies. The simplest strategy involves running the fans continuously. The volume of air is manually adjusted through the number of fans operating or by adjusting the speed of the fan(s). In this situation, the minimum sensors required are: the temperature control sensor that modulates the mixing damper; a low limit in the supply air to prevent accidental chilling or freezing of the tubers; and an outdoor sensor to prevent outdoor air warmer than the pile from entering the storage.

More advanced systems have carbon dioxide (CO<sub>2</sub>) sensors that will activate the damper to bring in fresh air whenever CO<sub>2</sub> levels exceed a pre-set limit.

Few ventilation control systems include a humidistat because they are inaccurate when the relative humidity is >90% and have been of limited value controlling humidity in a potato storage.

Under normal storage conditions, the relative humidity of the supply air should be maintained near 98 percent (see section 3.9.2 *Storage Cycle*). Humidifiers should be installed immediately downstream from the fan(s). Three types of humidifiers are commonly used: high-pressure nozzles, centrifugal spinning disk, and water-saturated fibrous media. The first two types are

used less frequently as they are difficult to regulate, resulting in either too much or not enough water added to the air streams. The third type humidifies the air as it passes through a fibrous media without the pressure of free water droplets that can effect potato quality. This type of humidification unit will create resistance to the airflow and must be sized accordingly. The design of a humidifier is critical and must be undertaken by someone with expertise in ventilation and humidification.

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#### **Heat Requirements**

Heat from tuber respiration must be removed from the storage to keep the potato pile at the appropriate temperature. Warm air is exhausted and a small amount of cool fresh air is blended with return air to keep the potato pile cool. The quantity of cool fresh air required for temperature control is dependent upon outside temperatures. Under normal storage conditions, no auxiliary heat is required to maintain a constant pile temperature. There are circumstances however where cool outside air in excess of that required for temperature control, is brought into the storage. This situation occurs when:

- Excess moisture must be removed from the storage. Moisture is released into the storage pile when tubers break down from disease or frost; or
- Outside temperatures are extremely cold. Fresh air is brought into the storage to exhaust carbon dioxide and to replenish oxygen.

In these situations supplemental heat is required to warm the incoming air. A heater capacity of approximately 7.5 kilowatts per 10,000 cwt (500 tonnes) of potatoes is normally adequate. Propane or natural gas heaters must be vented to eliminate the possibility of depleting oxygen and increasing carbon dioxide gases.

#### **Refrigeration**

Refrigeration should be available for any potatoes stored through the late spring and summer, and can be an asset when trying to remove field heat during a hot harvest season. The basic system consists of an evaporator coil, located in the return air stream, and a compressor/condenser unit located outdoors. The design of a refrigeration system is very complex and should only be undertaken by a person specializing in this area.

The very high humidity in a potato storage requires an evaporator coil with a large surface area to prevent desiccation (drying) of the air, or even worse, frosting of the coil. A minimum capacity of one ton of refrigeration per 2,000 cwt (0.4 kW per tonne) of potatoes is recommended. Note this capacity is only adequate for healthy, high quality potatoes. It may not maintain potatoes that are diseased or have broken dormancy.

### 3.9.2 Storage Cycle (J. Holley)

Several distinct storage phases exist. The best management practices of each stage depend on tuber conditions, weather and the intended use of the crop. These conditions and related management practices are summarized in table 3.9-3 and discussed below.

#### Pre-harvest Period

Management over the entire growing season affects the storability of potatoes. Most storage problems usually start in the field before harvest begins. Growers should aim to place a mature, disease and bruise free crop into storage. Research has demonstrated that potatoes from healthy vines are much more resistant to storage decay than potatoes from vines that have been weakened from physiological stress or from foliar diseases, e.g. early or late blight. Good storage design and management practices help to lessen the effects of problem tubers, but storage will never improve a poor-quality crop. The storage should be prepared well in advance of harvest. Check all mechanical systems and clean and repair ducts. Use an accurate thermometer to check ventilation controls and check operation of the humidification system.

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Thoroughly clean then disinfect the storage, handling and harvesting equipment with a quaternary ammonium compound such as Ag-Services Incorporated General Storage Disinfectant, Bardak 2210 Disinfectant Sanitizer, or DMR-23 Disinfectant. Since most disinfectants are inactivated by soil and plant debris, it is essential that this material be removed by thoroughly cleaning equipment and storage with a pressure washer or steam cleaner before the disinfectant is applied. Surfaces must remain wet for at least 10 minutes for the disinfectant to destroy disease organisms.

#### Harvest Period

Vine killing is not employed in all types of potato production (see section 3.8.3 Vine Killing) When vine killing, desiccate or flail far enough in advance of harvest to allow potato vines to dry as much as possible, and for the skin to set. Tubers with mature skin are more resistant to mechanical damage, bruising, shrink and pathogens (e.g. late blight, leak or pink rot), which cause tuber decay in storage.

Storage management is easier and the quality of potatoes coming out of storage will be better if steps are taken to reduce bruising, mechanical injury and infection from diseases at harvest. The ideal harvest temperature is between 50 and 59°F (10° and 15°C). To avoid shatter bruises, do not harvest when the tuber pulp temperature is less than 41°F (5°C). Tubers warmer than 64-68°F (18-20°C) and under drought stress are susceptible to black spot bruising. Harvesting when tuber pulp temperature exceeds 68°F (20°C) increases the risk of leak and pink rot diseases, which can result in extensive storage decay. Don't bring severely frosted, chilled or diseased potatoes into storage. For more information see *Reducing Harvest Damage* in section 3.8.4 *Bruise Prevention* and section 3.9.4 *Special Storage Problems*.

#### Post-harvest Curing Period

The greatest amount of shrink occurs after harvest and before curing is complete. Harvested potatoes are skinned and there is no barrier to moisture loss until suberin is formed over the wounds. This initial storage period promotes wound healing (suberization) and skin set, which are critical for long-term storage quality of potatoes. The temperature, relative humidity and length of the curing period are determined by the condition of the harvested potatoes. High humidity (95%) during the curing period is critical to prevent excessive shrinkage and to promote wound healing. Mature, healthy potatoes should be cured for about two weeks at 50-60°F (10-15°C) and 95% relative humidity.

**The greatest amount of shrink occurs after harvest and before curing is complete. Harvested potatoes are skinned and there is no barrier to moisture loss until suberin is formed over the wounds.**

Immature potatoes with high sugars should be cured for an extended period of time at 60°F (15°C) and 95% relative humidity until fry or chip colour is acceptable (see section 3.9.3 *Storing Chemically Immature Potatoes*). Frozen or rotting tubers should be cured at a lower temperature and relative humidity (see section 3.9.4 *Special Storage Problems*) and marketed as soon as possible.

The ventilation regime used during curing is determined by the cooling requirement and the need to provide fresh air (oxygen) to the tubers. Ventilate to maintain the pile at the desired suberization temperature. You may have to ventilate more frequently if there is condensation on the surface of the tubers. Sweating or condensation on surface tubers occurs when the upper tubers are cooler than those inside the pile. A small amount of free water is usually harmless, but any excess surface moisture will encourage soft rot. Continuous ventilation is recommended when condensation is present.

Cool tubers as quickly as possible from field temperature to curing temperature. Never cool with outside air that is significantly colder than the desired storage temperature, as tubers near the air ducts will be chilled. Plenum temperature should be no lower than 3-5°F (1.5-3°C) below tuber temperature.

Tubers that are harvested cold should be warmed to the desired curing temperature at a rate of about 2°F (1°C) per day, then suberized (see section 3.9.4 *Special Storage Problems*). Warm air will cause condensation on the cool tubers, making them more susceptible to soft rot infection.

Following the curing period, the potatoes should be cooled to the long-term storage temperature at a rate of 4-5°F (2-3°C) per week. Rapid cooling can cause colour problems in processing potatoes.

#### Mid and Long-Term Storage

The objective of long-term storage is to maintain a consistent, ideal environment for the duration of the storage period. Long-term storage demands more critical control than short-term storage. Recommended storage temperatures depend upon crop condition, variety and intended end use. General recommendations for storage temperatures are listed in table 3.9-2. A 2°F (1°C) difference between pile top and bottom is acceptable.

*Table 3.9-2 Long Term Storage Temperatures*

|               |         |        |
|---------------|---------|--------|
| Seed potatoes | 36-39°F | 2-4°C  |
| Table stock   | 38-41°F | 3-5°C  |
| Processing    |         |        |
| -French fries | 45-48°F | 7-9°C  |
| -Shepody      | 48-50°F | 9-10°C |
| -Chips        | 45-50°F | 7-10°C |

Ventilation can be either intermittent or continuous. When storing healthy mature tubers, ventilation at intervals of 8 - 12 hours per day at full airflow rates is sufficient to maintain pile temperature. However, continuous ventilation maintains more uniform storage

temperatures, particularly when outdoor temperatures are extremely low. Reducing airflow through the pile can minimise weight loss in storage. One way of accomplishing this is to operate fewer fans.

Maintain a relative humidity of 95% or higher unless special storage disorders are present.

#### Marketing Period

Reconditioning is a storage procedure that improves chip or fry colour. Reconditioning is accomplished by increasing storage temperatures to 50-64°F (10-18°C) for two to four weeks before marketing. The higher temperatures increases tuber respiration rate, which reduces sugar levels and improves chip or fry colour. Growers are advised to consult the processor prior to reconditioning as problems can develop when tubers are exposed to reconditioning temperatures. Higher storage temperatures increase shrinkage and rot, reduce specific gravity and may break dormancy of sprout-inhibited tubers. Potatoes may require immediate processing if serious storage decay develops. Reconditioned tubers should be processed within one month; otherwise a condition called irreversible senescence sweetening may occur. A storage facility containing several smaller (30,000 cwt or 1,360 t) bins is far more flexible with respect to reconditioning than a storage facility with only one or two 60,000 cwt (2,720 t) bins. Small bins can be individually reconditioned (warmed) prior to opening and moving.

Seed potatoes, marketed late in the season, should also be pre-warmed to break dormancy prior to planting and to reduce injury during handling.

#### 3.9.3 Storing Chemically Immature Potatoes (M. Pritchard)

Weather conditions or management practices sometimes delay crop maturity. Prompt harvest before the crop reaches chemical maturity may be necessary to avoid autumn frosts. Alternative storage management steps may be required to ensure that chemical immaturity (high sugars) of tubers does not affect processing quality out of long-term storage. Chemical immaturity can cause excessive accumulation of the reducing sugars, which results in darkening of potato products during frying.

Processing tubers are usually held at storage temperatures near 59°F (15°C) with Relative Humidity near 95% for up to two weeks after harvest to promote suberization and wound healing. This *curing or preconditioning* period may need to be extended if tubers are chemically immature at harvest to prevent excessive

reducing sugar accumulation in storage. During this period, sugars are either used up in respiration or are converted into starch. Depending on how much sugar is in tubers at harvest, it may take several weeks of preconditioning before reducing sugars begin to decrease and it may take several more weeks before they have dropped to a level acceptable for processing.

Extended preconditioning would not be recommended for severely diseased tubers or tubers which have been damaged by frost. Prompt marketing of such tubers would be recommended. Tubers can also be *reconditioned* prior to marketing, which involves gradually raising the storage temperature to lower sugars that accumulated during storage. Reconditioning just before sale may be preferred for diseased or frosted tubers since storage losses may be excessive if tubers are held at high temperatures for extended periods after harvest.

Long exposure of stored tubers to high temperatures will increase the chance of weight loss due to respiration and water loss. The more physically and chemically immature the tubers at harvest, the greater the weight loss. However, the additional weight loss during preconditioning or reconditioning is justified if processing quality is improved.

For further information on storage of immature potatoes refer to the following bulletins on the Department of Plant Science, University of Manitoba webpages: *Storage of Immature Russet Burbank and Shepody Potatoes* ([http://www.umanitoba.ca/afs/plant\\_science/extension/potatoesstorage.pdf](http://www.umanitoba.ca/afs/plant_science/extension/potatoesstorage.pdf)).

### 3.9.4 Special Storage Problems (D. Schwarz and B. Geisel)

Storage problems most often occur because of conditions in the field and not conditions in storage. Adverse weather, disease or improper harvesting and handling of tubers can cause problems in storage. Tubers that are rotting, frozen, chilled or diseased must be managed differently than mature, sound tubers. Good storage management will help to salvage problem tuber lots, but storage will never improve a poor quality crop. A summary of the techniques used for storing problem potatoes is included in table 3.9-3.

**Good storage management will help to salvage problem tuber lots, but storage will never improve a poor quality crop.**

### 3.9.5 CIPC Sprout Inhibition (R. Dreger)

Sprout inhibition is essential to maintain tuber quality for the table and processing markets. Sprouting causes tuber dehydration, physiological aging and affects the appearance of the tuber for the table market. Sprout inhibition is achieved through a combination of proper storage management and the use of a sprout inhibitor. There are two sprout inhibitors registered for use in Canada. MH60, which is applied to the crop approximately 2-3 weeks before harvest or vine kill (see section 3.7 *Sprout Inhibition in the Field*) and Chloroprotham (CIPC), which is applied to potatoes after harvest.

CIPC is available either as an aerosol or an emulsifiable concentrate. CIPC aerosol may only be applied to stored potatoes by trained applicators using specialized equipment. The grower applies the emulsifiable concentrate as a direct spray onto fresh market potatoes during the grading and packaging process. The balance of this section deals with the application of CIPC aerosol.

CIPC aerosol, which prevents cell division, must be applied after wound healing (suberization) and curing and before dormancy breaks. Historically, CIPC aerosol was applied with equipment originally designed for insecticide fogging. The by-products of combustion used to generate the CIPC aerosol have negative effects on potato quality. These by-products include heat, carbon dioxide and ethylene. This problem was resolved by designing an applicator specifically for CIPC aerosol application. The new applicator technology eliminates the deleterious effects of combustion by-products and improves the effectiveness of the treatment. Both the old and new style applicators are used in Western Canada.

Storage managers should contact the custom applicator for specific recommendations before preparing the storage for CIPC application. CIPC has an affinity for water, so the humidifier should be turned off at least two days prior to application to ensure the plenum and air ducts are dry. Before applying CIPC into the potato storage, the custom applicator checks and adjusts the air system, protects the refrigeration coils and reports any factors (disease, dirt, frost damage, etc) that may affect sprout inhibition. If storage conditions are suitable, the storage is sealed and the treatment is applied. After the treatment is complete and the fog has cleared from the storage, the applicator enters the building to perform post treatment cleaning of fans, fan guards, plenum, and other surfaces in contact with the chemical. Sealing materials are removed and the storage controls are reset to pre-treatment conditions, allowing the grower to resume normal operations.

**WARNING:** Only trained personnel wearing protective clothing should enter the storage during treatment.

Occasionally, CIPC treated potatoes sprout prematurely. Poor performance of the sprout inhibitor could be caused by:

- Temperature fluctuations and “hot spots”. These increase the rate of tuber respiration resulting in poor sprout inhibition. Temperature fluctuations and “hot spots” are caused by an improperly designed or malfunctioning ventilation system or excessive dirt and tuber rot in the bulk pile.
- Physiological stress. Field-stressed potatoes may respond differently to CIPC application than potatoes grown under normal conditions. Studies have shown that potatoes grown with deficient nitrogen will sprout earlier than adequately fertilized potatoes. Other field stresses (disease, drought, excessive moisture, and extreme temperatures) may also reduce the effectiveness of the sprout inhibitor.
- A low CIPC concentration on the sprout can cause internal sprouting where the sprout grows inward into the tuber or outward into an adjacent tuber (Figure 3.9-2). This defect occurs mainly in long-term storage. Late application, pile settling or the presence of excessive dirt and debris may interfere with the application, resulting in a low concentration of CIPC on selected tubers.
- Improper application.
- Poor storage management including fluctuating temperatures, high levels of respiration gases, low humidity, etc. shorten the dormancy period and reduce the effectiveness of sprout inhibition.

*Figure 3.9-2 Internal Sprouting*



#### **CIPC and Seed Potatoes**

Contamination of seed lots by CIPC can occur one or more years after a storage treatment. Do not store seed potatoes in a structure that was recently treated with CIPC or in a structure adjacent to a building where CIPC will be applied. There are no effective methods to rapidly decontaminate a storage structure after CIPC application. Seed can only be safely stored in a structure one year after the fans, ducts, and plenums are thoroughly cleaned of all CIPC residues and warm air has been circulated through the storage during the summer period.





Table 3.9-3 Management of Special Storage Problems

| Field or Storage Period                      | General Requirements   | Crop Conditions   |  |   |
|--|--|---|--|---|
|  |  | Normal  | Wet soil   | Wet Tubers  |
| <b>Pre-Harvest</b>                           | Repair, clean & disinfect the harvest, handling and storage equipment as well as the storage structure.  | Under dry soil conditions, apply pre-harvest irrigation as required to soften clods and prevent black spot bruising.  | Segregate affected areas by desiccation or discing.  | Do not overirrigate prior to harvest. Keep an eye on low spots to ensure water doesn't pool.  |
| <b>Harvest</b>                               | Follow best management practices for bruise prevention. Record the harvest conditions (tuber temperature, precipitation, etc.) of each load. Record the location of each field in storage. |   | Do not harvest segregated areas.   | Never harvest when there is precipitation. Tarp loads in case of sudden rain showers and do not windrow too far ahead of the harvester.   |
| <b>Post-Harvest (Curing or Suberization)</b> | Ventilate to bring storage to suberization temperature, suberize for appropriate period then reduce temperature by 4-5°F (2-3°C)/week for long term storage.                               | Ventilate and humidify (R.H. 95%) to bring storage to suberization temperature [50-60°F (10-15°C)], suberize for 2 weeks then reduce temperature by 4-5°F (2-3°C)/week for long term storage. When humidifying, ensure there is no free moisture dripping onto the tubers.  | Ventilate continuously without humidifying to bring storage to suberization temperature [50-55°F (10-13°C)], suberize for two weeks then reduce temperature by 4-5°F (2-3°C)/week for long term storage. Return to normal humidity (R.H. 95%) after soil on tubers is dry. | Market immediately or segregate affected lots in storage. Ventilate continuously without humidifying to bring storage to suberization temperature [50-55°F (10-13°C)], suberize for two weeks then reduce temperature by 4-5°F (2-3°C)/week for long term storage. Return to normal humidity (R.H. 95%) after tuber surface is dry. |
| <b>Long-Term Storage</b>                     | <b>Long Term Storage Temperatures: Table 41-43°F (5-6°C), Processing 47-50°F (8-10°C) Shepody 50-54°F (10-12°C), Seed 37-39°F (3-4°C)</b>  | Fan operation - continuous or intermittent or reduce fan speed with VFDs (Variable Fan Drives). Inspect storage frequently. Monitor oxygen levels, and add fresh air as necessary. Fresh air may require warming to prevent shocking the tubers. Heaters should be electrical or exhausted to the outside of the storage. |  |   |
| <b>Marketing</b>                             | a) Warmth to reduce handling damage.<br>b) Recondition.<br>c) Pre-warm to break dormancy.  |   |  |   |

| Crop Conditions  |   |  |   |   |
|--|---|--|---|---|
| Chilled  | Frozen  | Wet Rot  | Dry Rot   | Hot Tubers  |
| Plan to complete harvest before first week in October to avoid chilling.   | Potatoes that are hilled properly are less likely to freeze. Plan to complete harvest before first week in October to avoid frost damage.   | Segregate affected areas by desiccation or discing.  | Under dry soil conditions, apply pre-harvest irrigation as required to soften clods and prevent black spot bruising.  |   |
| Dig when tuber pulp temperature is above 41°F (5°C) to avoid shatter bruising.   | Dig after tuber pulp temperature is above 41°F (5°C) to avoid shatter bruising. Let frozen tubers rot before harvest, making it easier to identify and grade out before storing.  | Do not harvest segregated areas of field. Grade out affected tubers before storing.  | Follow best practices for bruise prevention. See x.xx Bruise Prevention for more information.   | Do not harvest when tuber pulp temperature exceeds 65°F (18°C). Do not windrow too far ahead in order to keep tubers cool.  |
| Ventilate continuously and humidify (95% R.H.) to warm storage to suberization temperature [39°F (15°C)]. Carry out normal suberization process for table and seed potatoes, and for processing potatoes suberize until fry colour improves. Then reduce temperature by 4-5°F (2-3°C)/week for long term storage. When humidifying, ensure there is no free moisture dripping onto the tubers. | Market immediately or segregate affected lots in storage. Ventilate continuously without humidifying to warm storage to 47-50°F (8-10°C). Consider adding supplemental heat to remove excess moisture. Reduce temperature by 4-5°F (2-3°C)/week for long term storage and return to normal humidity (R.H. 95%) after frozen tubers are mummified. | Market immediately or segregate affected lots in storage. Ventilate continuously without humidifying to bring storage to 47-50°F (8-10°C). Consider adding supplemental heat to remove excess moisture. Reduce temperature by 4-5°F (2-3°C)/week for long term storage and return to normal humidity (R.H. 95%) after affected tubers are mummified. | Apply appropriate fungicides to tubers going into storage. Ventilate and humidify (R.H. 95%) to cool storage to suberization temperature [50-60°F (10-15°C)], suberize for 2 weeks then reduce temperature by 4-5°F (2-3°C)/week for long term storage. When humidifying, ensure there is no free moisture dripping on to the tubers. | Ventilate and humidify (R.H. 95%) to bring storage to suberization temperature [50-60°F (10-15°C)], suberize for 2 weeks then reduce temperature by 4-5°F (2-3°C)/week for long term storage. |
| <p><b>Fan operation - continuous or intermittent or reduce fan speed with VFDs (Variable Fan Drives). Inspect storage frequently. Monitor oxygen levels, and add fresh air as necessary. Fresh air may require warming to prevent shocking the tubers. Heaters should be electrical or exhausted to the outside of the storage.</b></p>  |   |  |   |   |
|  | Market as soon as possible.   | Market as soon as possible   |   |   |