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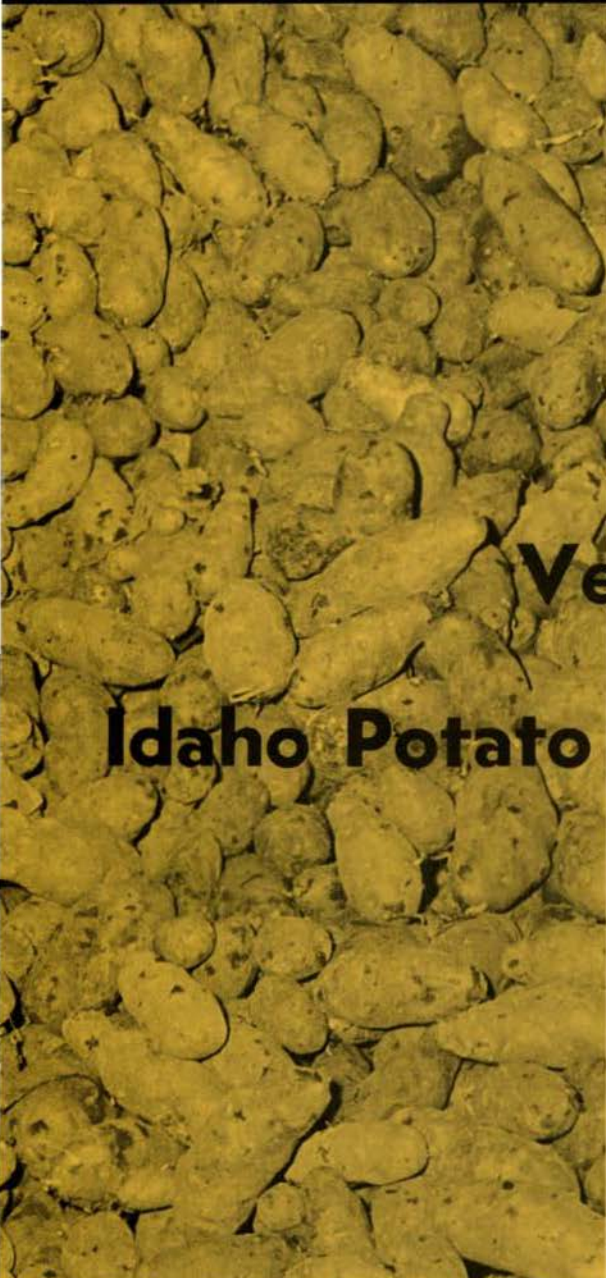

Ventilating Idaho Potato Storages

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IDAHO AGRICULTURAL EXPERIMENT STATION

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Contents

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Successful potato storage depends upon providing the potato tubers with the proper temperature, humidity and ventilation. Temperature and humidity are both critically essential factors which are controlled and regulated by **proper ventilation.** It is almost impossible to consider one of these factors without taking into account its interrelated effects on the other two. In discussing ventilation, therefore, temperature and humidity must also be considered.

Storage Environment

Potato tubers are living, "breathing" organisms. As they respire or "breathe," they give off carbon dioxide, moisture and heat. Ventilation with proper air distribution can prevent these three products from building up to excessively high levels and at the same time can provide the proper environment for the living potato tubers.

The proper potato storage environment requires:

1. An air distribution system which will provide a uniform airflow throughout the pile of potatoes;
2. An airflow of ½ (0.5) cubic foot of air per minute (cfm) per hundred pounds (cwt) of potatoes (½ cfm/cwt);
3. A relative humidity of 95 percent or higher;
4. A uniform temperature of 45° F for fresh market and processing potatoes, or
5. A uniform temperature of 40° F for seed potatoes after they have healed for 2 to 3 weeks at 45 to 50°F.

Under these environmental conditions, tubers treated with an appropriate sprout inhibitor can be maintained sprout-free and in a high state of quality for periods of 10 to 12 months—or longer if necessary.

The proper environmental conditions should be established **before the first potato goes into storage and maintained until after the last tuber is removed.**

Maintaining proper environment within a potato storage facility will:

1. Stimulate healing of bruises, cuts and other injuries.
2. Maintain appearance—external quality—of the tuber.

3. Maintain food value—internal quality—of the tuber.
4. Keep rot development to a minimum.
5. Keep shrinkage to a minimum.
6. Keep pressure flattening to a minimum.
7. Retard the growth of sprouts.
8. Maintain seed potatoes in a healthy, vigorous and productive condition.
9. Prevent greening.

Ventilation

Ventilation of a potato storage can be described as providing the proper circulation and distribution of air throughout the storage structure and the tubers it contains. The purposes of ventilating potato storages are to provide and maintain the correct, uniform temperature and humidity throughout the pile of potatoes. Ventilating a potato storage with air of the correct amount, temperature and humidity will:

1. Cool tubers and get rid of field heat.
2. Provide oxygen for healing wounds and bruises.
3. Maintain a uniform, constant tuber temperature.
4. Minimize storage losses from water rot, frost, jelly-end and shrinkage.
5. Reduce sprouting (Fig. 1).

Providing adequate circulation and a uniform distribution of air involves:

1. Supplying air up through the

Fig. 1. Effect of airflow on the amount of sprouting in stored Russet Burbank potatoes is graphically indicated in these photographs. The tubers at left received no air. Those at right received ½ cfm/cwt, the equivalent of 10 cfm per ton, and came through the storage period in excellent condition. Fans were operated on an intermittent basis.

Table 1. Storage weight loss as influenced by intermittent and continuous airflow.

Airflow rate	Airflow type	Weight loss* Trial No. 1	Trial No. 2	Mean
cfm/cwt		%	%	%
0.5	Intermittent	4.9	5.4	5.2
0.5	Continuous	6.3	6.8	6.6

*Trial No. 1 from October to May 22; Trial No. 2 from October to June 6.

pile of tubers at the rate of ½ cfm/cwt,

2. Spacing correctly sized ducts not over 10 feet apart, on center, throughout the storage facility (See Fig. 5 and Appendix),
3. Providing fans large enough to deliver the correct quantity of air at 1 inch static pressure, and
4. Operating fans only as long or as often as necessary to provide and maintain the correct and uniform temperature and humidity throughout the pile; if water rot or field frost is present, run fans until **no free water** remains on the tubers, then resume regular management practices.

Recent studies have shown that the airflow need not be continuous, but can be on an intermittent basis. An intermittent airflow of ½ cfm/cwt resulted in 1 to 1.5 percent less weight loss than a continuous airflow (Table 1) and still maintained a uniform temperature throughout the pile. The intermittent operation of the fans can be accomplished in several ways:

1. By burying a temperature sensor approximately 18 inches in the pile of tubers,
2. By thermostat,
3. By time clock, or
4. Manually.

Temperature

Research at the University of Idaho Aberdeen Branch Experiment Station shows that, when ventilation and humidity were held at proper levels, the percentage of rot and weight loss in stored potatoes was less at 45°F than at any other storage temperature. (See Tables 2 and 3.)

Research also shows that a storage temperature of 45 to 50° F, combined with a humidity of 95

Table 2. Effect of storage temperatures on the weight loss of Russet Burbank potatoes (October to August).

Temperature	Weight loss on: Nov. 29	Mar. 1	May 16	Aug. 1
°F	%	%	%	%
42	0.71	1.73	2.68	6.91
45	0.44	1.47	2.40	3.71
48	1.53	3.50	5.67	10.77

Table 3. Effect of storage temperature on rot and weight losses of cut Russet Burbank seed potatoes.*

Temperature	Rot loss	Weight loss	Total loss
°F	%	%	%
38	6.0	5.7	11.7
45	5.8	5.0	10.8
52	6.5	5.9	12.4
59	11.3	7.2	18.5

*From University of Idaho Agr. Res. Prog. Rpt. 63, "A Study of Factors Affecting Storage Losses of Potato Tubers Cut Several Months Prior to Planting," by Walter C. Sparks, et al., March 1962.

percent or more, results in good wound periderm formation. Potatoes stored at 45°F formed as many layers of wound periderm cells as potatoes stored at 47.5, 50, 55, 60, 65 or 70°F. The invasion of rot organisms was also slower at 45°F than at higher temperatures (Fig. 2).

The quality of potatoes stored at 45°F is higher than potatoes stored at 38°F and equal to the quality of potatoes stored at 52°F. Work now in progress shows that potatoes stored at 45°F have a significantly lighter french fry color than those stored at 42° (Fig. 3) and about the same french fry color as tubers stored at 48°F.

There is very little difference between the buildup of sugars in tubers stored at 45 or 48°, but both are significantly lower in sugars than tubers of the same lot stored at 42°F.

Fig. 2. Storage temperature affects penetration of rot organisms. These tubers were stored for 20 days. Dark areas on each end of the tubers indicate the point of inoculating with rot organisms.

A constant temperature will prevent sprouting longer than a fluctuating temperature in the storage unit.

In brief, when the proper ventilation and humidity conditions are provided, tubers for fresh market and processing can be maintained in a high state of quality for periods of 10 months or longer at a storage temperature of 45°F. Potato tubers to be used for seed can be maintained in a healthy, vigorous and productive condition for 8 months or more at a storage temperature of 40°F.

Humidity

Results from the 1966-67 season show that potatoes stored at a humidity of 80 to 85 percent lost over 1.2 percent more in weight and had about 8 percent more flattened tubers than those stored at 90 to 92 percent (Table 4).

Tubers stored at low humidities often fail to form a wound periderm, while those stored at humidities of 95 percent or higher usually form a wound periderm in a few days or weeks, depending on temperature.

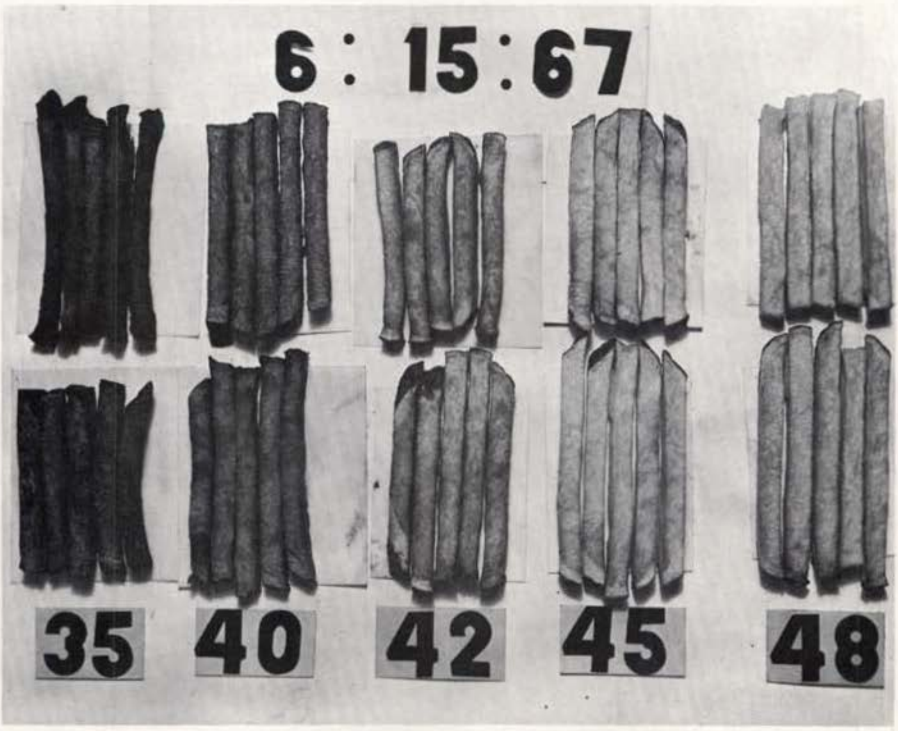


Fig. 3. The effect of storage temperature on potato quality characteristics is demonstrated by french fry color of tubers stored at five different temperatures. Potatoes stored at 45°F have a significantly lighter french fry color than those stored at 42° and lower, and about the same french fry color as tubers stored at 48°F.

Table 4. Effect of humidity on storage losses of Russet Burbank potatoes in storage from October 1966 to September 1967.

Relative humidity	Storage losses	
	Weight	Flattened*
%	%	%
80-85	7.7	14.6
90-92	6.5	6.8

*These are the percentages which were scored as not meeting U.S. No. 1 grade.

The measurement of humidity is sometimes a difficult and often an inaccurately performed operation. The measurement should be made in the airstream in the main delivery duct, far enough down the duct that no water from the humidifier or water on the floor will affect the measurement. Some of the more accurate instruments for measuring humidity include the psychrometer, a hygrograph or a hygrothermograph.

Good methods to attain and maintain a high humidity during and following harvest—to insure conditions for rapid wound healing and reduce storage losses—and throughout the storage period include:

1. Wet down cellar thoroughly before storage begins. The floor should be completely saturated so it is moist but not muddy at harvest time. This is especially important on new, unused storages.
2. Use centrifugal-type humidifiers. This method has been found to provide best humidity control (Fig. 4).

Less efficient but sometimes useful methods used are:

1. Place wet burlap sacks in air stream.
2. Blow air across a free-water surface.
3. Spray mist into the air stream.

Storing Injured Potatoes

Bruises and injuries affect the storageability of tubers. Injured tubers must receive special care and even then tremendous losses can result. If labor and time permit, all tubers with cuts, serious

Table 5. Effect of various types of mechanical injury upon the storage losses of Russet Burbank potatoes.*

Injury type	Weight loss	Rot loss	Total loss
	%	%	%
Digger Cut	6.5	59.9	66.4
Serious bruises	5.8	45.2	51.0
Hard bruises	2.8	20.5	23.3
Slight bruises	2.5	1.5	4.0
Sound	1.9	0.0	1.9

*From University of Idaho Agr. Expt. Sta. Bul. 220, "Effects of Mechanical Injury Upon the Storage Losses of Russet Burbank Potatoes" by Walter C. Sparks, Nov. 1954.

Fig. 4. A centrifugal-type humidifier in an air distribution duct.

bruises, water rot, ring rot or field frost should be removed before potatoes are put into the storage structure. Table 5 indicates how costly various types of injury can be.

Two trials were run at the Aberdeen Branch Station to determine how much storage losses can be reduced by removing injured tubers before storage. One trial compared the storage losses of graded vs. ungraded or field run tubers; the second compared graded, ungraded and ungraded plus 1 percent water rot. The results (Table 6) show that storage losses can be reduced considerably by grading the tubers before putting them into storage.

Table 6. Storage loss as influenced by removal of injured tubers prior to storage.*

Lots	Weight loss	Rot loss	Total loss
	%	%	%
Trial No. 1			
Ungraded	4.4	3.6	8.0
Graded	3.6	1.0	4.6
Trial No. 2			
Ungraded + 1% water rot	5.4	5.6	11.0
Ungraded	4.6	4.3	8.9
Graded	3.3	0.4	3.7

*From University of Idaho Agr. Expt. Sta. Bul. 220, "Effects of Mechanical Injury Upon the Storage Losses of Russet Burbank Potatoes" by Walter C. Sparks, Nov. 1954.

Construction*

Potatoes can be successfully stored in any suitable structure provided the correct temperature, humidity, and ventilation can be maintained. The internal and external type of the structure is comparatively unimportant, but it still must fulfill certain requirements. The potato storage building must be:

1. Structurally sound. The structure must be able to withstand the load pressure exerted by outside forces (wind, snow, etc.) as well as the pressure of the potatoes inside.
2. Adequately insulated. The amount of insulation required depends on the difference between the inside and outside temperatures. The heat transfer rate through the walls and ceiling should be no greater than 0.05 BTUs per square foot of surface area for each hour for each degree difference between the inside and outside temperatures (in Idaho this is equal to about 6 inches of batt-type insulation). Cold surfaces cause condensation of moisture and will result in wet spots throughout the cellar.
3. Waterproof. The roof and building must protect the insulating material and potatoes from rain, snow and other hazards.
4. Vapor proof from inside. The vapor barrier must prevent moisture from the respiring potatoes from getting into the insulating material.
5. Provided with a ventilation and an air distribution system which will supply and maintain the desired temperature, humidity and air composition.

Equipment Requirements, Calculations

Information and factors for calculating the amount of air needed and size of ducts required include:

1. Air needed is ½ cfm per cwt of potatoes (½ cfm/cwt is equal to 10 cfm/ton).
2. Static pressure at fan should be 1″ to 1¼″ of water=0.036 lb/sq in.
3. Static pressure in delivery ducts should be ½ (0.5) inch of water.
4. Velocity of airflow in ducts should generally be not more than 1,000 ft/min.
5. Mixing chamber or main plenum should be large enough to handle necessary volume of air at a velocity of 1,000 ft/min.
6. Lateral (delivery) ducts should be placed not over 10 feet apart.
7. Lateral ducts must be large enough to provide correct amount of air at proper velocity.
8. Holes in lateral ducts should be 1″ to 1¼″ diameter properly spaced. (12 inches apart for a pile of potatoes 10 feet deep. See worksheet calculation No. 10.)

*More specific information on construction of potato storages can be found in University of Idaho Agr. Exp. Station Bulletin 410, "Idaho Potato Storages—Construction and Management," by Walter C. Sparks et al., Sept. 1963.

WORKSHEET

The following worksheet can be used to calculate approximate airflow and duct requirements:

To find:	Do this:
1. Amount of potatoes in cwt	1. Multiply length x width x depth and divide by 2.5 (or multiply by 0.4).
2. Volume of air needed in cfm	2. Divide cwt of potatoes by 2 (½ cfm/cwt).
3. Sizes of mixing chamber or main plenum in square feet	3. Divide volume of air in cfm by 1,000 (the velocity of air in feet per minute).
4. Number of lateral ducts needed	4. Divide one dimension of the storage (length or width, depending upon design) by 10, the distance between ducts. (See Appendix)
5. Size of lateral ducts in square feet	5. Divide size of main plenum (calculation 3) by number of laterals.
6. Size of main ducts in square feet	6. Multiply size of lateral ducts in square feet x number of laterals on each main duct.
7. Shape of ducts	7. Can be any shape (See Fig. 5). If ducts are rectangular, width should not exceed 2½ times the height. Comparisons of rectangular and round ducts are given in Table 7.
8. Materials for making ducts	8. Can be any material—metal, rough lumber, plywood, plastic, concrete. The rougher the internal surface, the more friction resistance there will be to the airflow and the higher the static pressure will have to be.
9. Size of air holes	9. Round holes 1″ to 1¼″ in diameter placed so they will not be covered or plugged by dirt or tubers. (See Fig. 5) Use 1¼″ holes if CIPC is to be used as a sprout inhibitor.

10. Distance between air holes in inches

10. 120 divided by depth of potatoes in feet.

11. Fan size

11. See manufacturer's specifications. Fan must be able to deliver volume of air needed (calculation 2) at 1 to 1¼ inches of static pressure.

12. Horsepower requirements

12. Approximately ⅓ hp per 1,000 cfm. This is a rough estimate only. Consult individual manufacturer's specifications for more critical information on requirements.

Table 7. Round and rectangular ducts with approximately equal capacities.

Pipe diameter	Rectangular W x H (Approx.)	Approximate air capacity*
in.	in.	cfm
6	6 x 5	200
8	8 x 7	400
10	10 x 8	550
12	12 x 10	800
14	14 x 12	1070
16	16 x 13	1450
18	18 x 15	1870
20	20 x 17	2360
22	22 x 18	2750
24	24 x 21	3500
26	26 x 22	4000
28	28 x 23	4500
30	30 x 25	5200
32	32 x 27	6000
34	34 x 30	7100
36	36 x 32	8000
38	38 x 33	8700
40	40 x 34	9400

*Based on 1,000 ft/min for rectangular ducts.

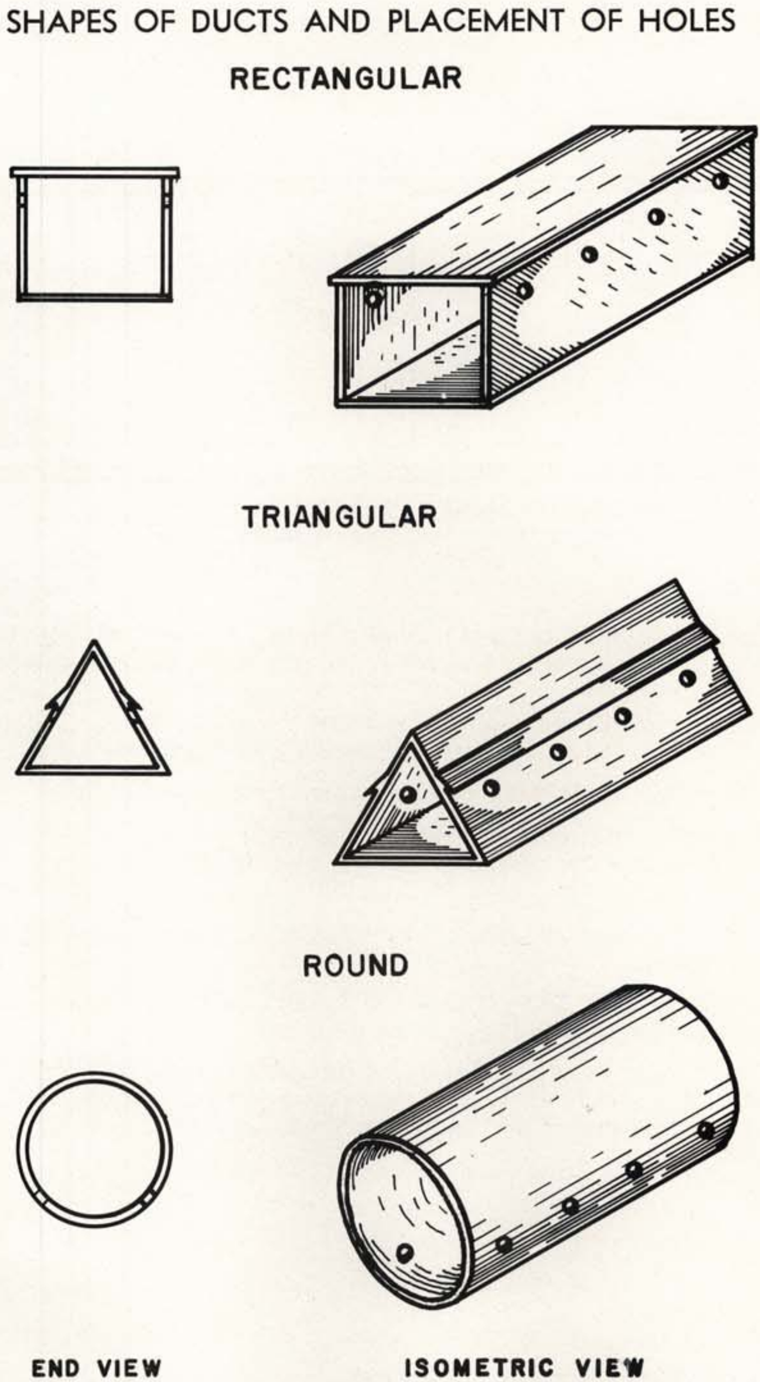
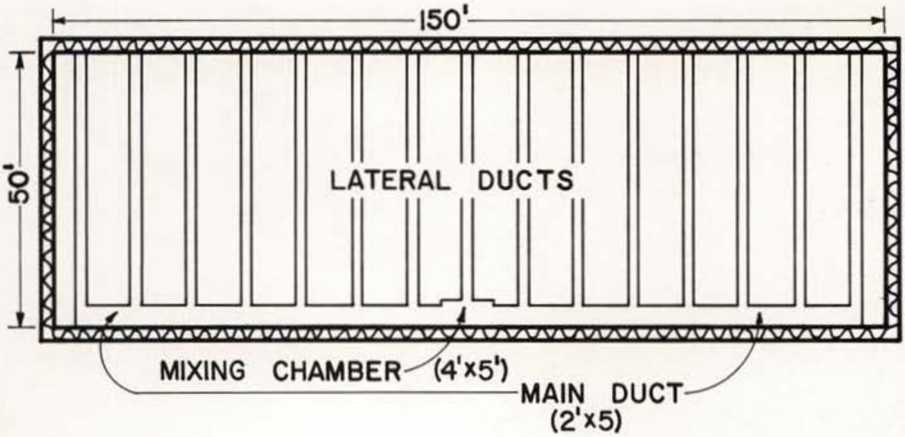


Fig. 5. This drawing illustrates how air holes should be placed in lateral ducts of different shapes.

Appendix

POTATO STORAGE VENTILATION



Design 1—Main air ducts at side of storage. Fan and mixing chamber at mid-point. Lateral or delivery ducts go across storage.

1. Capacity of storage: Multiply length x width x depth (150x50x12) =90,000 cu ft. Divided by 2.5=36,000 cwt potatoes.
2. Volume air needed: 36,000 cwt divided by 2=18,000 cfm.
3. Size of mixing chamber (main plenum): 18,000 cfm divided by 1,000 (**maximum** velocity)=18 sq ft. Suggest at least 4 x 5 feet (20 sq ft) to allow space for humidifier and humidity fall out.
4. Number of laterals: 150 divided by 10=15 (one comes out of mixing chamber).
5. Size of laterals: 20 sq ft (see No. 3 above) divided by 15=1.33 sq ft inside (12 x 16 inch inside measurement).
6. Size of main ducts=1.33 sq ft x 7 laterals=9.33 sq ft. Suggest 2 x 5 feet. This would allow a man to crawl down duct and regulate air into each lateral if necessary, i.e., frost or water rot in a particular spot.