POTATO STORAGE AIR SYSTEM CALIBRATION

by
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Introduction

Air system design guidelines for the greater Columbia Basin area of Washington and Oregon recommend ventilation air flow of 17 cfm/ton of stored potatoes. In most newer systems the static pressure requirements are from 1-1/4" H_20 to 1-3/4" H_20. The lower figure is for air systems with humidifiers and the higher figure for systems with air washers. Fan selections are made using these figures.

Many growers and people in charge of managing potato storages are concerned about the performance of their air systems. Questions often asked are: Does my system deliver the amount of air that it is designed for (for example, 17 cfm/ton)? Is the air flow distributed evenly throughout the storage? Are there areas that get less air or more air than the rest of the building? Is there a simple method to evaluate the performance of an air system?

Two methods that have been used to evaluate air distribution uniformity of a ventilation system are (1) static pressure measurements and (2) air flow measurements.

Static Pressure Measurements

The amount of air flow through an orifice of a duct is primarily a function of the static pressure differential between the inside and the outside of the duct. A uniform static pressure throughout the air system will indicate equal amounts of air flowing to all parts of the storage. Most air ducts will show some static pressure differential between the duct sections near the plenum and the section toward the end of the duct. This happens because the air velocity near the plenum is high and some of the energy in the air is in the form of velocity pressure rather than static pressure.

The static pressure determinations are made when the building is empty. All ducts are laid out and taped just as you would when filling the storage. The air system is operated and static pressure readings taken along the length of the ducts, and at the end of the ducts. A simple manometer or any other instrument reading very low pressures accurately (in inches of water) should be used.

If the ducts are properly placed and taped, the static pressure readings along the length of the ducts don't vary much. Because of high air velocity near the plenum chamber the static pressure readings are somewhat lower in the first part of the duct section adjacent to the plenum. Throughout the rest of the duct static pressure should be uniform. Ducts with low air flow have a lower pressure than ducts with higher air flow. Usually pressure reading at the end of the lateral (duct cap) is sufficient to provide a comparison between ducts. Ducts with too high air flow can be reduced by closing off part of the entrance from the plenum chamber. If the air flow is too low because of unusual air flow characteristics in the plenum a baffle may be used to direct more air into a specific duct. After adjustments have been made you should check the static pressure again in each duct (at end cap) to assure equal air flow.

Air Flow Measurements in Ducts

Many storage managers don't want to spend the time and money to set up the ducts in an empty building for a static pressure check. They also point out that you have different conditions when the storage is full.

Air velocity measurements can be made with the potatoes in place. These measurements should be made some distance from the duct entrance because of uneven air velocities and turbulence that occur in the duct entrance region. Several feet down the duct the air flow profile is much more uniform, decreasing the chances for errors.

Air flow measurements should be made in the same location for all ducts (for example, 7 ft. downstream from the duct entrance) and in the center of the duct.

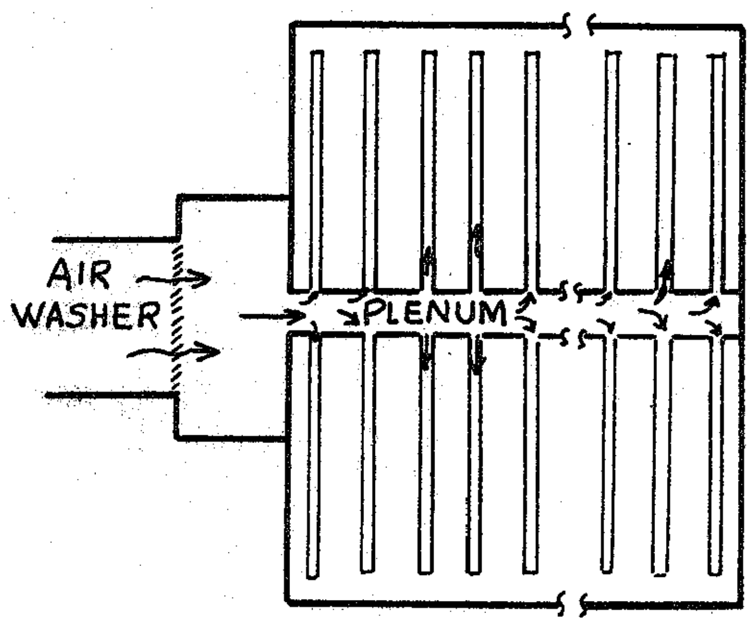
When uneven air flow exists adjustments are made as described above in "Static Pressure Measurement" section.

Systems Tested

Ventilation systems with different basic plenum arrangement and configuration were tested. During the test all systems were run in the "recirculating" mode with the air washers or humidifiers turned off. The 4 basic systems were:

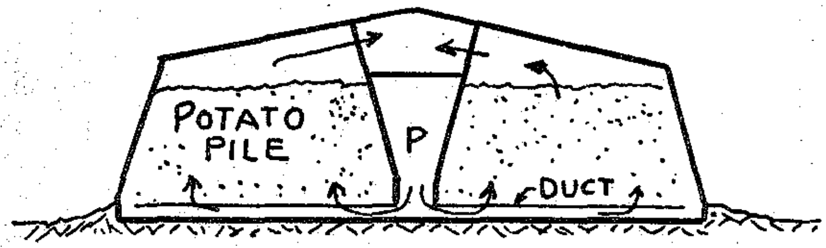
System 1 Rectangular plenum through the center of the building with fan house at one end. Heavy steel columns located inside plenum spaced 25 feet apart. Entrance to plenum chamber restricted with steel columns, bracing members and humidifiers. Figure 1 shows the basic arrangement.

Figure 1. Basic layout for air system with rectangular air plenum located in center of storage building.



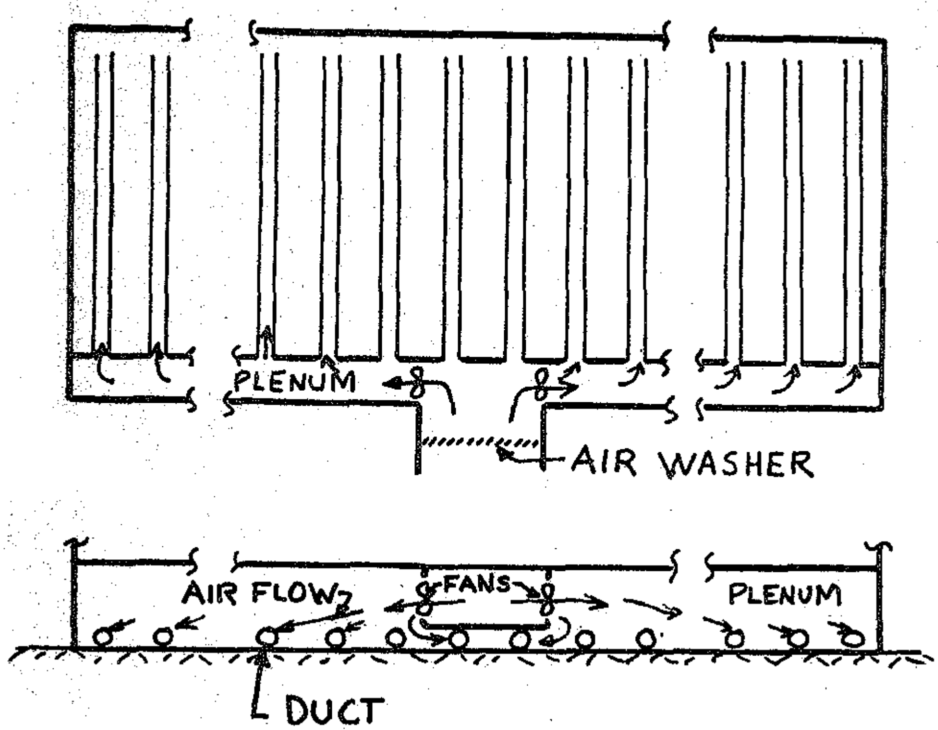
System 2 V-Shaped plenum through the center of the building with fan house at one end. Inside of plenum relatively smooth. Bottom of plenum 4 ft. wide and 4 ft. high vertical walls, above 4 ft. level the walls are sloping toward potato pile at approximately 20^{o} from the vertical as illustrated in Figure 2.

Figure 2. Cross-sectional view of V-Shaped plenum and duct arrangement of System 2.



System 3 Plenum along the side of the building with fan house located in the center. Outside walls of plenum sloped. Two fans located in plenum on a 2-ft. high platform, spaced approx. 20 ft. apart blowing air in opposite directions straight down the plenum. The entrance to two center ducts is located under the platform, thus air coming off the fan has to change direction 180 degrees to reach the ducts under the platform. Basic arrangement is illustrated in Figure 3.

Figure 3. Basic layout (top) of ventilation system for System 3 and side view (bottom) showing fans on platform and ducts.



System 4 Very narrow rectangular-Shaped plenum (2 ft. wide, 12 ft. high) along the side of the building with fan house located in center. Trussed steel arches to support roof and sidewalls are located inside plenum

Procedure

Static pressure measurements were made only in one of the storages tested (System 1). All ducts were placed into the storage with the end caps and all joints taped. The air system was operated in the "fresh air" mode. Static pressure readings were taken at the end cap with a series 6000-P Alnor Velometer.

Air velocity readings were made in all four systems with a Taylor Anemometer mounted on a stand. The height of the anemometer was adjusted so that it was located in the center of the ducts. A remote control cable was used to turn the counter on and off after the instrument was positioned in place. The counter was operated for one minute so that the dial on the counter indicated the air velocity in feet per minute. Taking an air velocity profile over the cross-sectional area of the duct showed that the air velocity in the center of the duct was equal to the average velocity for the duct.

Air flow volumes were calculated by multiplying the air velocity by the cross-sectional area based on the inside diameter formed by the corrugations. With a one-half inch corrugation depth, a 21-inch diameter duct has an effective inside diameter of 20 inches.

Since velocity measurements were taken 7 feet from the entrance to the duct, the resulting air flow calculations represent the amount of air flowing past that point, not the total air flow into the ducts. To obtain the total air flow into the ducts the calculated air flow figures were adjusted proportionally. A conversion was made to CFM/ton.

Results and Discussion

The results for the four systems are presented in Figures 4 through 7. Figure 4 illustrates the uniformity of air flow for system 1. This air system is providing a high air flow averaging approximately 18 cfm/Ton. Variations in air flow in the first section of the plenum are primarily due to excessive air turbulence in this section. This turbulence was caused by heavy steel columns located inside the plenum, and humidifiers located in the entrance to the plenum chamber. In addition uneven airflow into the plenum was caused by offsetting the center of the air washer with the center of the plenum. Some of the higher air flows in the first part of the plenum were in ducts which are located directly upstream from a column, the lower air flows were in ducts which are located directly downstream from a column. Static regain increased air flow in the last ducts.

Figure 4. Air flow in ducts for air system with rectangular air plenum located in center of storage building.

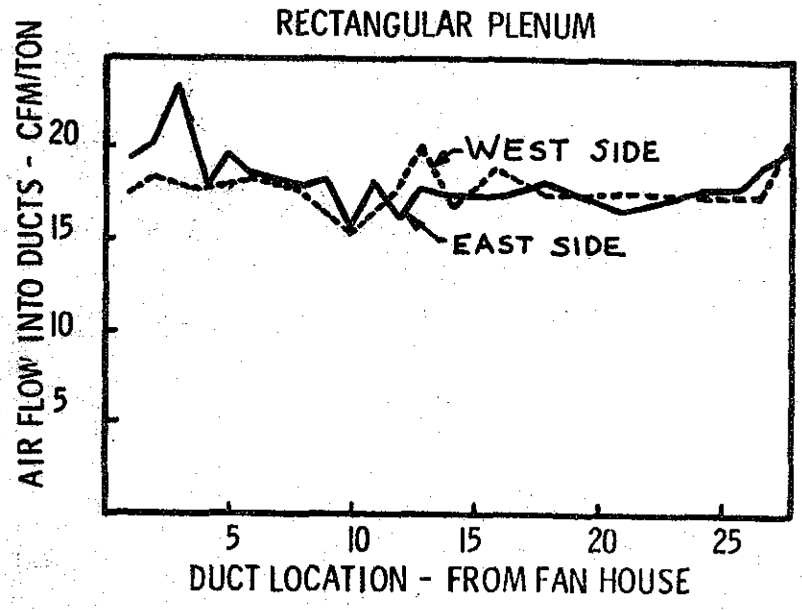


Figure 5 shows air flow in the V-shaped plenum. Air flow is somewhat low, averaging 14 CFM/Ton. Note the uniformity of air flow into the ducts. This uniformity is obtained by having relatively smooth walls in the plenum and lower overall air velocities in the narrower lower section of the plenum.

Figure 5. Air flow in ducts for air system with V-shaped plenum located in center of storage building.

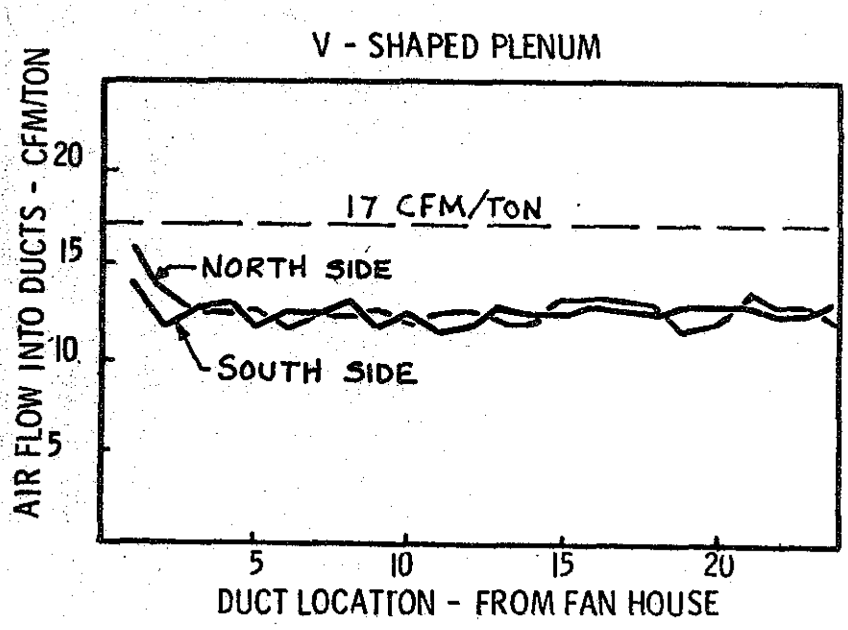
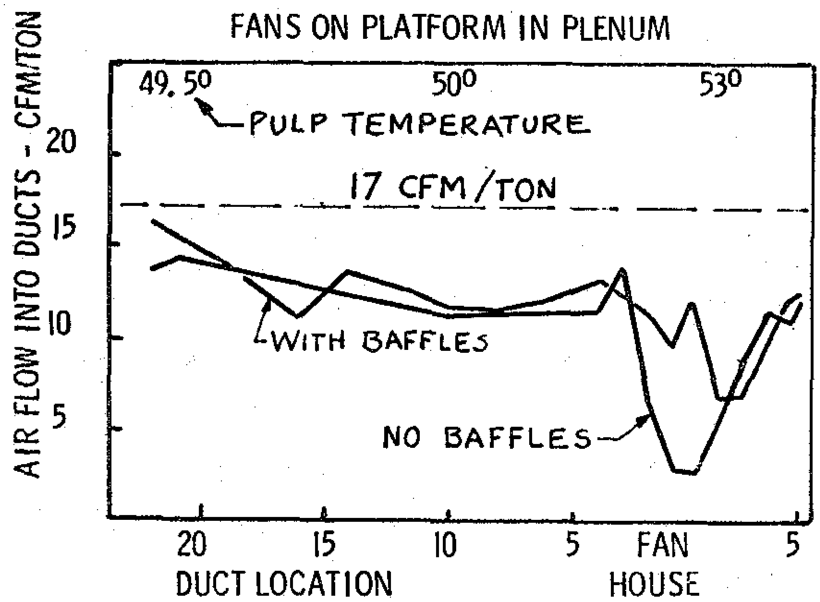


Figure 6 illustrates air flow in System 3. Only the fan house section and one section of the plenum is shown. The opposite section is similar to the one shown. Two lines are shown, one with the system running as originally installed and one with several 3 ft. by 4 ft. plywood baffles installed in appropriate places to direct air into the ducts located below the platform. Note that in the original installation the two center ducts received less than 5 CFM/Ton and the adjacent ducts less than 7 *CFM/Ton. After air baffles were located in appropri*ate places, the air flow into the center ducts improved but it was still lower than for the rest of the ducts. Average air flow was only about 12 CFM/Ton.

Low air flow affected cool-down of the stored potatoes. The center section did not cool down properly. Pulp temperature on top of the pile in this section remained at 53° F pulp temperature in other sections of the building were 3 to 3-1/2° F lower. The center section also remained humid until the potatoes were removed from the storage in December due to accelerated rot.

Figure 6. Air flow in ducts for system 3 with fans located on a platform inside the plenum chamber. Plenum is triangular shaped and running along the side of storage building.



Results of air distribution in the very narrow plenum are shown in Figure 7. The average air volume is 14.5 CFM/Ton. Only one section of the plenum is shown, the other section being similar. Note that the air flow is fairly uniform despite high air velocity in the first part of the plenum (1,500 ft/min). Calculated air velocities in the ducts were also high (1,600 ft/min). A rule of thumb for air systems is that the maximum air velocity in the ducts should at least be equal or somewhat higher than the maximum air velocity in the plenum.

Figure 7. Air distribution inducts for very narrow rectangular plenum located along the side of storage building.

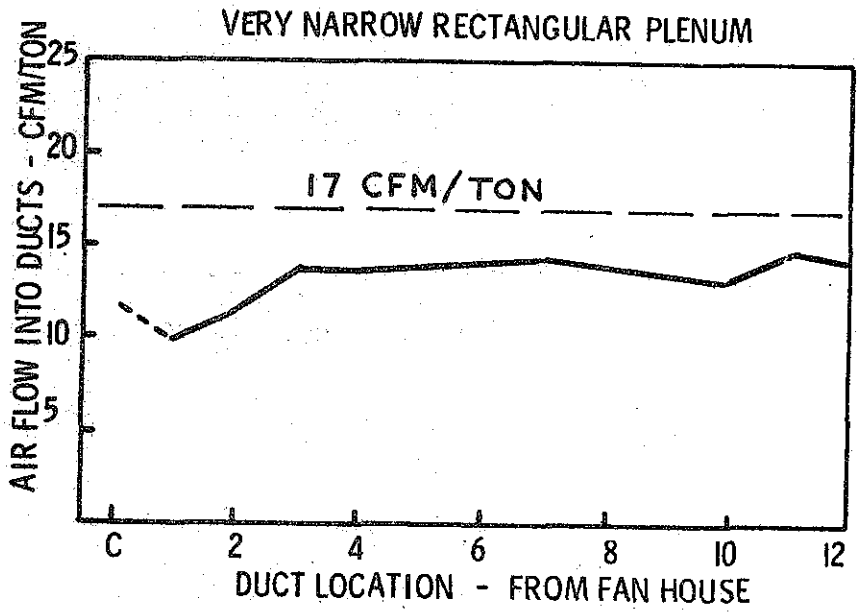
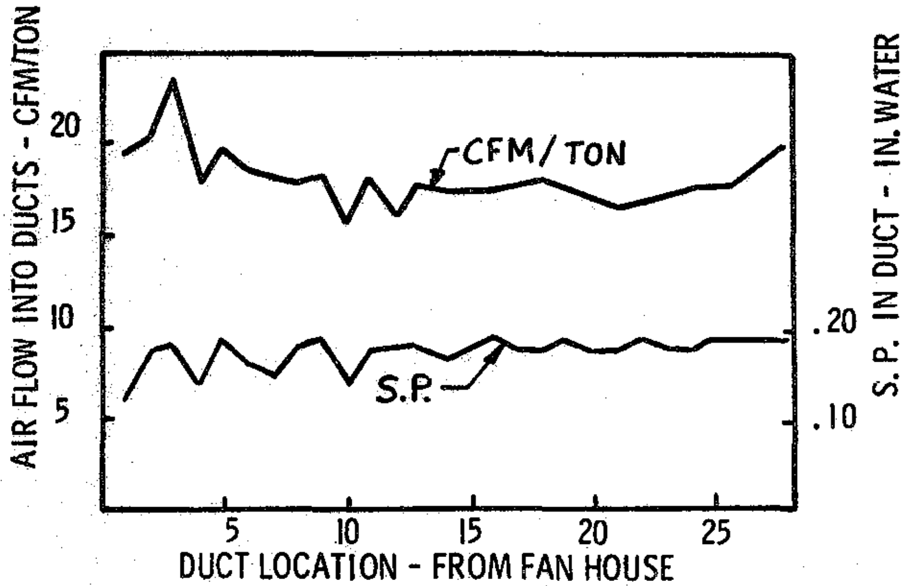


Figure 8 shows the static pressures taken at the end of the ducts and air flow, CFM/Ton, for system 1. The static pressure variations are greater in ducts which are located in the section near the fan house. Similar variations were obtained with the air flow measurements. The static pressure readings were slightly lower near the fan house than those further away. It must be pointed out that the static pressure readings were obtained under different conditions, the building was empty and the entrance to the plenum unobstructed. After the static pressure readings were taken, two humidifiers were installed in the plenum entrance affecting the air flow patterns to the first ducts resulting in higher air flows to the first ducts than is normally the case.

Figure 8. Static pressure at the end of the ducts and air flow (CFM/Ton) for air system with with rectangular air plenum located in center of storage building.



Conclusion

Static pressure measurements or air flow measurements are a useful tool for checking and balancing ventilation systems in potato storages.

Static pressure measurements have the disadvantages that the ducts must be installed in an empty building and then removed again before filling the storage. Also static pressure measurements can't be used to accurately calculate air flows.

Air flow measuresments can be done any time during the storage season. These measurements can be used for balancing the system as well as for calculating the overall performance (CFM/Ton) of an air system.