

MINIMIZING ENERGY USE IN STORAGE

Jack Staples

Doubl-Kold

Jack@Doubl-Kold.com

The need for reducing cost in cold storage operation has never been greater.

At the same time, the need for maximizing fruit quality has also never been greater. We must make sure that what we do to reduce energy costs does not compromise the quality of the fruit.

EVAPORATOR FAN SPEED REDUCTION

We know that we can maintain excellent fruit quality with modern cold storage practices without reducing evaporator airflow after pulldown:

- Properly sized evaporator capacity and surface areas
- Adequate airflow capacities (approx 1.6 to 2 cfm per box) for pulldown
- Minimize evaporator fan hp per cfm.
- Close control of room temperatures and ca atmospheres with a properly designed computer control system

We know that proper application of evaporator fan speed control and/or fan cycling in modern, well-designed ca storages can reduce the fruit shrinkage slightly.

We do not know how much and how soon we can reduce airflow after loading a room without compromising fruit quality. We know that no airflow in a room, or in a portion of a room, will damage fruit by allowing “hot spots” to develop in the bins of fruit.

It is my strong belief that improper application of evaporator fan speed control can decrease fruit quality substantially.

Those of us who have been around this industry for a few years can remember incidents of poor fruit quality (soft or spoiled fruit, etc.) in corners of rooms or other areas where airflow was not present.

If we go back in time far enough, we can remember the old multi-floor storage buildings with pipe coils across the ceilings, and airflow resulted only from gravity, or natural convection (cold air drops, warm air rises). Booster fans were usually added to these rooms to be able to maintain some fruit quality over time.

Poor airflow in areas of a room can result from many factors:

1. Stacking fruit too close to the front and back walls (trying to cram more bins in the room). I have been in many rooms in recent years where bins were stacked so close to the wall that I couldn't squeeze my arm down the wall to measure airflow through the bin runners. You can be assured that you will have a quality reduction in your fruit if you use this practice (particularly on marginal quality years). The extra bins you get in your

storage using this method will probably end up in the cull bin anyhow, so how about leaving these extra bins out and give the remaining fruit a chance to cool?

2. Sprinkler pipes placed across the airstream or bins stacked too high, blocking airflow, or improperly stacked bins (runner spaces don't line up). You can expect the same results as item 1.
3. Rooms that are too long, tight stacked rooms that do not have adequate fan design to overcome the increased back pressure of the stack.

My design for tight-stacked rooms includes integral fan hp (1 hp or above), cast fan blades (not sheet metal fans) and long throw nozzles.

Baffling around the evaporators with plywood or canvas can also be used to prevent short-circuiting of air, but this presents logistics problems and added material cost and installation time during the busy harvest season. I also recommend a minimum of 1-½ feet spacing from the front and back walls.

TEST RESULTS, EVAPORATOR FAN SPEED CONTROL

Some excellent tests have been run to measure the effects of evaporator fan speed reduction on power costs and fruit quality.

Cascade Energy Engineering conducted tests at a number of warehouses during the 1998-1999 storage season to determine energy savings, fruit weight loss and fruit firmness before and after storage. These factors were compared between no speed control, VSD speed control, and fan cycling.

These tests were well designed, used excellent quality measuring equipment, and, I believe, gave very meaningful data.

Mass loss in the VFD speed controlled rooms was typically 0.1% to 0.6% less than the comparable "control" room (full speed or aggressive fan cycling).

Energy savings was significant for VFD rooms compared to the "control" rooms, except for the "aggressive fan cycling" rooms.

The only "fly in the ointment" in these test results was: at 12 of the 17 facilities tested, there was a loss in fruit firmness in the VFD rooms compared to the non-VFD rooms. In one case, this loss in pressure was sufficient to cause rejection of the fruit in the room. (10.7# reds vs. 12.4# reds)

This loss in pressure may be a direct result of the reduced mass loss in the VFD rooms (i.e., fruit which holds its moisture is softer at the surface.)

Nevertheless, as long as fruit firmness (as measured by present techniques) is a criterion for acceptance of fruit, this poses a problem.

DO'S AND DON'TS OF EVAPORATOR FAN SPEED CONTROL

- Do stack bins properly:
 - Leave at least 1-½ foot spacing from front and back walls
 - Line up bin runner spaces. For cross stacks, leave air spaces between bin stacks

- Use ‘long throw’ nozzles or baffling around evaporators
- Do not reduce fan speed too soon-50% or lower fan speed in September and October will increase fruit shrinkage (not enough air flow to handle heat load without decreasing evaporator temperature).
- Do not use VFD in rooms with centrifugal (squirrel cage) fans, particularly with ductwork. Most of these rooms don’t have enough air at 100% fan speed. Fan cycling could be used in these rooms.
- Do not use VFD in rooms with blow thru fans or draw thru small hp motors with sheet metal fans. Throw is marginal at best even at full fan speed. Fan cycling can be used effectively in these rooms.
- Do not use VFD in rooms containing Fujis, Braeburns, Pink Ladies, or other CO₂ sensitive varieties. The researchers tell me that using low airflow with these varieties greatly increases the chances of CO₂ damage.

The potential problems I have mentioned in the above discussion regarding the use of VFD speed control on refrigeration evaporators may not happen every year, or in every room. Problems are more likely to occur in “weak fruit” years”, or in lots of fruit where fruit maturity or other fruit quality conditions are not optimum. The point is, it doesn’t take much of a loss in fruit quality to wipe out all the energy savings you may achieve.

CONDENSER FAN CONTROL

VFD’s and other means of condenser fan control can be used to lower discharge pressure for energy savings.

My recommendation is don’t overdo it on head pressure reduction with evaporative condensers and water defrost systems.

Excess head pressure reduction will result in:

- Excess cooling of defrost water, poor defrost performance
- Electric defrost tank heaters may come on-defrost tank heat can result in increase in higher energy consumption compared to operation at slightly higher discharge pressure. Alternative means of defrost water heating have been recommended to allow head pressure reduction independent of defrost water temperature. I’m not convinced that these alternatives are acceptable or cost effective.
- Possible oil carryover thru oil separators is another potential problem with excessive head pressure reduction. This is because the refrigerant mass flow rate of a refrigeration compressor increases, and the discharge gas density decreases, as discharge pressure decreases (for a constant suction pressure), resulting in an increase in velocity thru the discharge line and oil separator.

If, after considering the above factors, it is still desired to get the greatest possible decrease in discharge pressure, replacement of discharge oil separators with larger units specifically designed for low discharge pressure operation may be necessary. The cost of this separator

replacement, if necessary, should be factored into the payback analysis for this energy saving measure.

SUMMARY

1. Evaporator fan speed control is a great idea, a “no lose” situation if applied properly, following the fruit stacking guidelines, evaporator design limits, varietal restrictions, etc. I have outlined above. You can achieve significant power savings while maintaining or even improving fruit quality
2. Evaporator fan cycling is a proven, acceptable method of power savings that does not require the addition of expensive speed control equipment. A computer control system is a must for proper temperature and humidity control in a fan cycled room. Fan cycling is difficult, if not impossible, to use in rooms intended for export markets. Air temperature rise with fans off will make it very difficult to meet export requirements, such as the Mexico 40-day requirement. My observation is that far more rooms are targeted for export and qualified for export sale than can possibly be exported. VFD fan speed control can probably be used on export rooms, and fan cycling can certainly be used on a wide variety of rooms not intended for export. It may be advisable to use more selectivity in picking rooms for export market and fan cycle rooms not targeted for export.
3. Don't overdo it on head pressure reduction for the purpose of energy saving at the risk of reducing defrost water temperature to the point where efficient defrost of evaporators can be obtained. Alternate methods of defrost water heating are possible, but I do not believe these alternatives are reliable or economically sound.
4. Use caution when reducing head pressure to assure that oil carryover from compressor oil separators does not occur. Oil carryover at extreme low head pressure conditions may necessitate installation of new oil separators, particularly on older reciprocating compressors. Good energy savings can be obtained at more moderate head pressure levels without blowing oil into the refrigeration piping or reduction of defrost water temperature below acceptable levels.