NEEA EVAPORATOR FAN INITIATIVE CASE STUDY
Larson Fruit - Selah, Washington

Summary

As an energy efficiency measure, a variable frequency drive (VFD) was installed to allow reduced fan speed operation in a 1644 bin controlled atmosphere (CA) room used for storage of red delicious apples.

The impact of VFD operations during a storage season was monitored. The major test parameters are summarized in Table 1.

Table 1 - Major Test Parameters

Test Results - Primary Test Parameters				
		Conditions at the End of CA Holding		
Test Characteristic	Initial Conditions	Control Room Room 27	VFD Room Room 22	Improvement Room 22 - Room 27
Mass Loss (%)	0.00%	0.92%	1.64%	-0.72%
Firmness (psig)	16.4	15.7	15.7	0.0
% Energy Use	N/A	100.0%	34.9%	65.1%

Results from the major test parameters showed:

- Higher mass loss in the VFD room. The VFD room was held in storage for 120 more days than the control room. As a result, no conclusions can be drawn by comparing the mass loss in the VFD room to the control room.
- No change in average fruit pressure in the VFD room.
- Significant energy savings with the VFD versus the full speed control room.

Economics for a full-scale VFD retrofit project are estimated in Table 2. Installation costs are anticipated to be considerably lower for a full-scale retrofit compared to the field trial installation.

Table 2 - Economics for Full-Scale VFD Retrofit Project

Project Economics for Full-Scale Retrofit Project				
Project Cost	Cost Savings per Year			Simple
VFD Retrofit (10 hp)	Energy	Mass*	Total	Payback (years)
$3,500	$534	$440	$973	3.6

*Mass savings based on the average 18 tests in 1998-9.

Field Trial Description and Purpose

The VFD installation was performed through the "Evaporator Fan VFD Initiative" a market transformation program sponsored by the Northwest Energy Efficiency Alliance (NEEA) and operated by Cascade Energy Engineering to promote the use of VFDs in refrigerated warehouses.

The purpose of the VFD installation was to demonstrate the energy efficiency of the VFD technology and to determine the impact of reduced airflow operation on the commodity in storage. Pending a positive outcome of the field trail, the technology could then be safely and profitably installed on a full-scale basis.

Field Trial VFD Installation

A 10 hp VFD was installed to regulate fan speed on two evaporator coils providing refrigeration to a CA storage room. Each evaporator coil was equipped with six 1/2 hp fan motors. An input line reactor and a dV/dT output filter were added to provide harmonic and motor protection.

VFD versus Control Room

Two identical rooms were selected for comparison. VFD speed control was employed in room 22. Fans ran at ~ 50% speed after fruit pull-down. In the control room (room 27), full speed fan operation was employed.

Fruit Selection/Sample Creation

Fruit from two bins for the same load and lot was used to create all test samples. Samples were weighed and labeled. Weights were recorded to 1/100th of a gram. 108 sample bags, each containing 7 fruit, were created for each test room. 36 sample locations with three sample bags each were created. Mesh plastic bags with ~1/2 inch openings were used to minimize the impact on air or moisture flow.

All 216 samples were created during a single day. Samples were stored in a covered bin under refrigeration until placed in the proper test location. 216 fruit were pressure tested by Larson personnel to establish initial fruit conditions.

Sample Placement

Samples were placed in identical locations as the rooms filled. Three sample bags were placed in the center of each test bin and covered by a layer of fruit. Sample bins were place in four cross-sections of the room. Nine sample bins were placed in each cross-section as illustrated in Figure 1. The locations of the four cross-sections are illustrated in Figure 2.

Figure 1 - Sample Locations - Front View

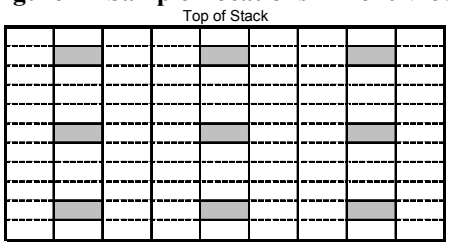
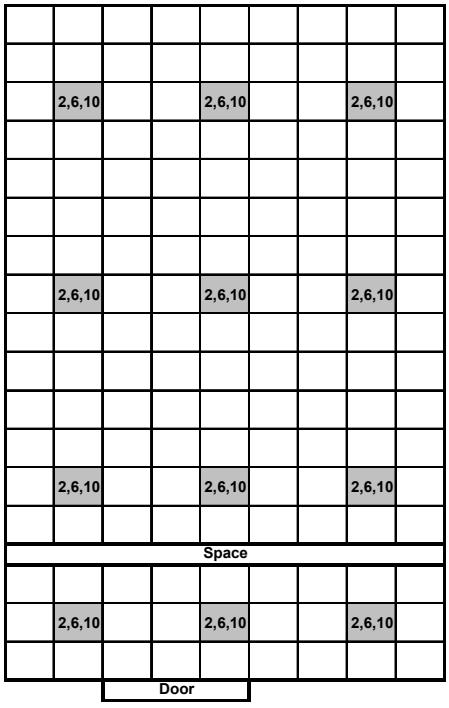


Figure 2 - Sample Location - Top View



CA Conditions and Room Loading and Unloading

The VFD and control rooms were maintained at similar temperature, O_2 and CO_2 conditions throughout the storage period.

Table 3 - Room Loading and Unloading

Room Loading and Unloading Information				
Mode of Operation	VFD Room	Control Room	Difference	Storage Advantage
Loadings Days	15	5	10	Control
CA Holding Days	184	74	110	Control
Unloading Days	7	7	0	NONE
Total Storage Days	204	84	120	

- The VFD room fruit was stored for 120 more days than the control fruit.
- The VFD room fruit experienced 10 additional days of non-CA conditions during the room-loading period.
- ***The differences in the overall room loading and unloading significantly favored the control room to a point to where the room to room mass loss comparison is of no value.***

Sample Retrieval

Test samples were retrieved from test bins as the bins were removed from storage. Individual sample bags were reweighed. All samples were then pressure tested.

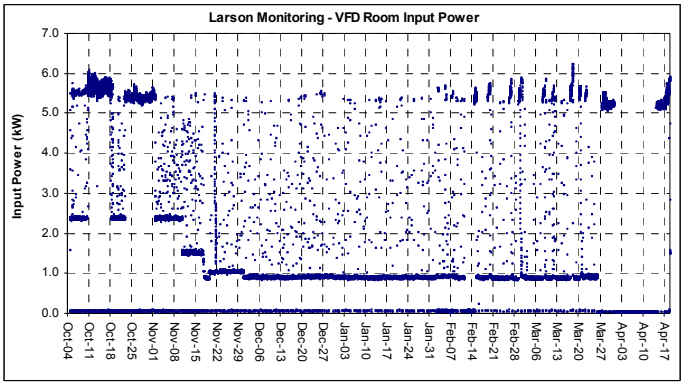
Mass Loss and Fruit Firmness Results

Due to the large difference in the storage duration between the two test rooms no room to room comparison results are presented.

Energy Savings

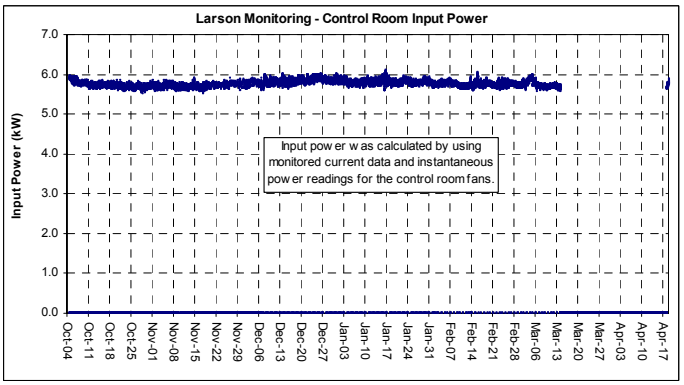
Motor current and input power were monitored on the control and VFD room evaporator fans respectively. Energy savings were calculated based on the monitored data.

Figure 3 - VFD Room Input Power



- VFD input power dropped from ~ 5.3 kW at 100% speed to 1.0 kW at 53.4% speed (a 81% reduction in power).

Figure 4 - Control Room Input Power - All Data



Economic Calculations

The following values were used in the calculations.

Table 4 - Annual Savings Calculations

Product Savings	
Bins per Room	1644
lbs. per Bin	900
% Packout	80.0%
Total lbs	1,183,680
Mass Loss Savings	0.26%
Product Savings (lbs)	3,078
Fruit Weight per Box (lbs)	42
Product Savings (boxes)	73
Value of Packed Box	$13
Packing Cost Per Box	$7
Fruit Value ($/box)	$6
Product Value Saved	**$440**
Energy Savings (kWh)	15,016
*Effective Energy Cost ($/kWh)	$0.0355
Energy Savings	**$534**
Total Annual Savings	**$973**

*Includes Energy and Demand Savings

The "Mass Loss Savings" value of 0.26% is the average of 18 similar tests where room to room mass loss comparison results could be quantified.

Table 5 - VFD Retrofit Cost

VFD Cost	
VFD HP	10
VFD Installed Cost/HP	$350
Installed Cost	**$3,500**

The VFD installation cost was based on a multiple room retrofit project. A retrofit project would have a simple payback of ~ 3.6 years (excluding potential utility savings).

A new construction VFD installation would cost ~ 2/3 that of a retrofit. The simple payback on a similar sized new construction VFD installation would be ~ 2.4 years.