Evaporator Fan Controllers

In virtually all walk-in coolers and freezers, small or large, air is cooled by forced-circulation evaporators that contain propeller fans powered by fractional-horsepower motors. Typically, these fans run continuously even though, on average, full airflow is only required about half the time. Controllers are available that slow these fans when full-speed operation is unnecessary, saving 10 to 60 percent of overall refrigeration energy. Some users report paybacks as low as one year. Many businesses—including restaurants, convenience stores, liquor stores, supermarkets, cafeterias, warehouses, florist shops, and laboratories—could benefit from the use of a controller for their walk-in coolers or freezers. Anecdotal evidence suggests that controllers contribute to improved product quality in walk-in coolers: Because less air is circulated when the fan speed is reduced, items such as flowers, produce, or meat do not dehydrate as much. Energy savings from controller use are more certain but can vary widely depending on duty cycle, evaporator motor power, and local utility rates.

How Does an Evaporator Fan Controller Work?

A typical evaporator fan wastes energy in three ways:

- *Inefficient motors.* In the most common applications (those that use single-phase power) an evaporator fan motor is typically one of two types: shaded-pole, which runs at efficiencies that range from 10 to 40 percent, or permanent-split-capacitor, with efficiencies that range from 30 to 60 percent.
- *Continuous operation at full speed.* Full-speed operation is only necessary to transfer heat between the walk-in air and the evaporator coil when the compressor is actually running. At all other times, lower-speed operation would suffice.
- *Excess heat.* All the power input to the motors eventually turns to heat, which the refrigeration system must then remove. As a result, any inefficiencies associated with either the fan or the motor are compounded, because they increase loads on the refrigeration compressor.

An evaporator fan controller reduces the fan speed simply and inexpensively by taking advantage of a basic principle of motor operation: The lower the voltage applied to a motor, the less rotational force it produces. A controller cuts the voltage to the motor by almost 80 percent (from between 110 and 115 volts down to just 20 volts in typical single-phase applications). This reduces the motor's speed, typically from about 1,600 to about 400 rpm. The lower speed is considered the bare minimum required to provide defrosting and prevent the air in the cooler from stratifying into layers of higher and lower temperature. Reducing the operating speed reduces the energy consumption of the fan, and the motor produces less heat at slower speeds, which also saves compressor energy.

Controller Options

There are currently two manufacturers that produce evaporator fan controllers. One manufacturer, RS Services (formerly known as EnergyNSync Inc.), produces two models intended for walk-in coolers that use single-phase power evaporator fans: the ENS Fansaver 4000 and the ENS Fansaver 5000. These units reduce fan speed when they sense that refrigerant has ceased flowing through the evaporator coil. Each can handle 10 amps of current, which is the typical load from six fans. The 5000 model also has a built-in datalogger that records the time of low-speed and high-speed fan operation and how much power is used (**Figure 1**, next page). A personal computer can be connected to the datalogger via a serial port to access this data.

Figure 1: The ENS Fansaver 5000

The ENS Fansaver, made by RS Services, saves energy by sensing refrigerant flow through walk-in cooler evaporators and reducing evaporator fan speeds when there is no flow. The 5000 model, shown here, has a datalogger that records the time of low-speed and high-speed fan operation and how much power is used.

Courtesy: RS Services

Figure 2: The Frigitek

The Frigitek evaporator fan controller, made by Energy Control Equipment Inc., reduces fan speed in response to a signal to shut down the compressor. The unit shown here is for single-phase applications.

Courtesy: Energy Control Equipment Inc.

The other manufacturer, Energy Control Equipment Inc., produces a controller called the Frigitek, which can be used in either walk-in freezers or coolers (**Figure 2**). The Frigitek reduces fan speed in response to a signal from the thermostat or a controlling solenoid to shut down the compressor. Although the Frigitek operates in a very similar way to the ENS Fansaver, its performance has not been independently verified. For single-phase power applications, it is available in configurations that can handle from 3.5 to 25 amps. For three-phase power applications, one configuration is available that uses a master control unit that can handle 480 volts and motors up to 20 horsepower. Additional power units are added for multiple evaporator fans.

Single-phase controller prices start at about US$500. Three-phase applications are considerably more expensive, particularly if fans from multiple evaporators are to be controlled. Installation costs for single-phase units are typically about US$100 per unit, but they will vary depending on the region, the number of fans controlled, and the installer.

Is a Controller Appropriate for Your Business?

Controllers don't work for every application, so before you decide to install one on a given cooler, you should give some consideration to several issues, including compressor run time, fan run time, and fan motor type (**Table 1**, next page).

The cost-effectiveness of any controller must be evaluated on a cooler-by-cooler basis. For coolers that have three-phase fans, which are typically found in warehouses or distribution centers, cost-effectiveness calculations can be complicated. They need to factor in the cost of installing conduit and wiring to reach multiple evaporator coils that are potentially spread across a large area. And the number of necessary master control and power units will vary widely by application.

Table 1: When to use a controller

It is a little tricky to tell whether a particular walk-in cooler is a good candidate for an evaporator fan controller. In applications where a single compressor serves a single walk-in cooler, here is a list of the most important things to look for.

Do use a controller if . . .	**Do not use a controller if . . .**
The compressor *does not* run all the time, and	The compressor runs all the time, or
The evaporator fan runs at full speed all the time, and	The evaporator fan *does not* run at full speed all the time (for example, it turns off with the compressor or it switches between full speed and half speed), or
The evaporator fan motor in single-phase applications is of shaded-pole or permanent-split-capacitor design.	The evaporator fan motor in single-phase applications is any type *other than* shaded-pole or permanent-split-capacitor.

Source: Platts

Single-phase applications, however, don't have these issues. Controllers and installation fees for single-phase fans are relatively inexpensive and usually highly cost-effective, so evaluations for them need not be especially detailed or complicated. To help determine the cost-effectiveness of single-phase systems where a single compressor serves a single walk-in cooler, we have put together a set of formulas. Before you begin, you will need four pieces of information, usually available on-site: evaporator fan power, compressor duty cycle percentage, electricity rate, and purchase and installation cost.

Evaporator fan power, in kilowatts (kW), may be determined by any of the following techniques, listed here in order of accuracy:

- Measure the power drawn by the evaporator fan motor(s) using a wattmeter.
- Measure the current flowing through the evaporator fan motor(s) using an ammeter and the voltage applied to the motor(s) using a voltmeter. Multiply these values and multiply this product by the power factor (power factor for shaded-pole motors is about 0.6; for permanent-split-capacitor motors it is about 0.9)
- Read the rated amperage and voltage located on the motor nameplates. Multiply these two values and multiply the product by the power factor.

Compressor duty cycle percentage may be calculated by first wiring an analog clock in parallel with the compressor motor or by attaching a run-time logger to the compressor motor. The amount of time the compressor motor runs divided by the total time of the test equals the duty cycle. If possible, conduct the measurements during a two- to four-week period when conditions are average. For walk-in coolers that are exposed to outdoor conditions or that have outdoor condensing units, conduct a regression analysis that correlates run hours to outdoor temperature.

Electric rate, in dollars per kilowatt-hour (kWh), may be obtained from a recent electric bill.

Purchase and installation cost can be estimated by a refrigeration technician.

After you gather this information, use the simplified formulas below (which have built-in energy and equipment constants) to determine annual savings, both in dollars and in kilowatt-hours, and simple payback period in years.

- Energy savings (kWh) = fan power x (1 – [compressor duty cycle ÷ 100]) x 8,758 – (compressor duty cycle x 0.11)
- Annual savings (dollars) = electric rate x energy savings
- Payback period = installed cost ÷ annual savings

Here's an example that assumes a measured fan power of 0.736 kW (6.4 amps and 115 volts), a measured compressor duty cycle of 35 percent, an electric rate of $0.10/kWh, and an installed controller cost of $600. (This example uses U.S. dollars.)

Because our example motor is of shaded-pole design, we multiply the fan power by its power factor, 0.6, to get a true evaporator fan power of 0.44 kW.

Energy savings

= 0.44 kW x (1 – [35 ÷ 100]) x 8,758 – (35 x 0.11)
= 2,500 kWh

Annual savings

= $0.10/kWh x 2,500 kWh
= $250

Payback period

= $600 ÷ $250
= 2.4 years