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Frigitek® Controller

The Frigitek® controller is designed to reduce the energy used by evaporator fans in refrigeration systems by reducing the speed of the fans whenever there is no demand for cooling.

Products

- Single-Phase Frigitek 120V in 5, 10, 15, & 25 Amp models
- Single-Phase Frigitek 208/240V in 5, 10, 15, & 25 Amp models
- Single-Phase Frigitek 480V in 10 Amp model
- Three-Phase Frigitek
- ECMotor Frigitek

Manufacturer

Energy Control Equipment, Inc.
316 Locust Street
Watsonville, CA 95076
Toll Free: (877) 522-6924
Telephone: (831) 768-8848
Fax: (831) 768-8818
Email: *info@frigitek.com*
Website: *www.frigitek.com*

Distributor

Same as Manufacturer

Product History

Energy Control Equipment was incorporated and a laboratory established in March 2000 for research on evaporator fan energy. Beta test sites were set up in March 2001, with production following shortly. Three-phase models were completed in 2005.

Photograph courtesy of Frigitek

Product Function and Application

The following information was primarily provided by the manufacturer and is not evaluated in this section. Refrigeration systems use forced air evaporators to cool the air, or more correctly, to remove the heat. The air is moved across the evaporator coils with fans. These fans are also used to destratify the air to provide even temperatures throughout the room.

The fans on smaller units such as walk-in coolers and freezers in supermarkets are typically

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powered by one of three different kinds of single-phase motors: shaded-pole, permanent split capacitor, and electronically commutated motors (ECMs). Shaded-pole motors are available in only fractional horsepower sizes, have low torque and low efficiency. The efficiency of a shaded-pole motor ranges between 10-35%. Permanent split capacitor motors have a larger range of sizes and a higher efficiency than shaded-pole motors, ranging between 55-60%. ECMs have the best efficiencies of these single-phase motors – at about 70%.

The Frigitek controller is used to reduce the speed of the evaporator fan motor when the evaporator is not actively cooling. This is accomplished by modifying the voltage waveform with proprietary circuitry[1]. Under normal operation the fans operate continuously, even when the evaporator is not actively cooling. Reducing the speed of the fan motor reduces both the energy used by the motor and the additional heat generated by the motor. The heat added to the space from the motor has to be removed from the space by the evaporator. Typically, the single-phase motors operate at 1750 rpm and the controller reduces the speed to 350 rpm and reduces the voltage to 33%.

The Frigitek controller senses whether refrigerant is flowing through the evaporator by one of two means. One sensor is called a Signal Sensor Tee, which is used to sense the state of a solenoid operated control valve in the refrigerant line to the evaporator. The second sensor is called a Temperature Differential Sensor, which detects the temperature difference across the expansion valve of the evaporator coil. This method is used if there is not a solenoid or if the solenoid is inconveniently located. These methods used to control the fan motors are patented.

The Frigitek controller comes in various models for a variety of situations. The models cover ranges for single and three-phase systems in multiple voltages and amperages. The various models allow for use of a Frigitek controller on virtually any refrigeration system, including reach-in, walk-in, and industrial-sized coolers and freezers.

The three-phase Frigitek model allows control for multiple evaporators through one controller. Each evaporator is connected to its own power unit, and each power unit is daisy-chained to the next power unit with control wiring. One control module is connected to the first power unit in the chain and controls all of the power units for each evaporator. Three-phase motors have typical speeds of 1100-1200 rpm and 1600-1800 rpm. With the controller these speeds are reduced to 20% of full speed and 33% of full voltage.

Electronically commutated motors (ECMs) are relatively new compared to the other motors available for evaporator fans. They were designed by General Electric, which now manufactures them under their company named Regal-Beloit. They have much higher efficiencies than either shaded-pole or permanent split capacitor motors. Replacing shaded-pole and permanent split capacitor motors with ECMs is considered an excellent energy efficiency measure. Frigitek has an ECMotor controller that is specifically designed for the ECM. The ECMotor controller is designed to be used with two-speed Regal-Beloit ECMs. These motors have a full speed of 1750 and a reduced speed of 500 rpm. This means that the Frigitek can be combined with an ECM retrofit for additional savings. This method of controlling ECMs is currently patent pending.

Energy Saving Claims

The following information was provided primarily by the manufacturer and is not evaluated in this section. The Frigitek controller saves energy in two ways. First, the speed of the motor is reduced when the evaporator is not cooling. The reduction in the speed of the motor decreases the energy needed by the motor. Secondly, the heat generated by the motor is reduced when the speed of the motor is decreased. The heat generated by the

1 The voltage is reduced by essentially chopping the waveform at the end of each half cycle so that the amplitude is not reduced, but the RMS voltage supplied is actually lower. Frigitek also provides filters to minimize disruption in power quality.

motor heats up the space and has to be removed by the evaporator, adding to the cooling load. The amount of energy saved relates directly to the size and type of fan motor being used, the number of fan motors, how the cooler or freezer is operated, and the duty cycle of the compressor.

Slowing the fan speed reduces the heat generated by the fans and thus the duty cycle of the compressor. Frigitek estimates the duty cycle reduction of the compressor to be 20% for shaded-pole motors, 15% for permanent split capacitor motors, and 25% for ECMs. Slowing the fan speed also reduces the energy used by the motor. Frigitek calculates the reduction in energy used by the motor at slow speed to be 80% for shaded-pole motors, 72% for permanent split capacitor motors, and 95% for ECMs. All of these reductions were determined by tests performed in the manufacturer's motor laboratory.

Based on an average compressor duty cycle of 40% and a typical installation, Frigitek claims savings in the range of 25-35% of the energy used to operate a refrigerated walk-in cooler or freezer.

Non-Energy Benefits

Three non-energy benefits have been identified by Frigitek:

- A reduction in drying out of the products in the freezer or cooler from reduced air movement;
- A reduction in noise from the fans; and
- The reduced run-time will reduce maintenance on and increase the life expectancy of the compressor.

Independent Testing Results

Testing of the Frigitek has only been done in the manufacturer's laboratory.

Case Studies

No case studies were found.

Cost

Uninstalled costs:

- Single-Phase Frigitek 120V – Manufacturer's Suggested Retail Price (MSRP) $465-$1250 for up to 25 Amps
- Single-Phase Frigitek 240V – MSRP $560-$1,500 for up to 25 Amps
- Single-Phase Frigitek 460V – MSRP $1,686 for up to 10Amps
- Three-Phase Frigitek – MSRP $1,885-$10,615 for up to 20 HP
- ECMotor Controller – MSRP $325

Add about $150-250 per unit for installation, depending on the complexity of the installation. The manufacturer provides a five-year warranty on all units.

Alternative Products and Strategies

Other products exist on the market, but this family of products seems to cover the widest range of applications with both single-phase and three-phase motors and multiple evaporator applications.

One competing product uses a current sensor to determine the state of the compressor and then switches the evaporator fan to low voltage when the compressor is off. This product is not designed for use with rack refrigeration systems or three-phase systems.

ENS FanSaver (formally ART Evaporator Fan Controller) had a similar product, but has since ceased activity. It was similar in operation to the one mentioned in the paragraph above, but used a temperature sensor on the coil to determine if refrigerant was flowing to the evaporator.

When considering energy efficiency in walk-in coolers, the Frigitek controller is just one option. Other strategies could include a reduction in suction pressure, installing an adjustable speed drive on the compressor or evaporator fan motor, additional insulation,

and integration into a complete rack refrigeration[2] system that meets the needs of the whole facility. However, most of these other measures will cause the compressor to run less often, actually increasing the effectiveness of the Frigitek controller, so they are typically complementary rather than competing measures.

Suggestions for Further Research and Testing

The testing that has been done by the manufacturer of Frigitek has been fairly extensive. Independent testing to verify the results of the manufacturer's testing would be helpful in validating the claims. This product would also benefit from case studies with verified results through monitoring and verification.

Additional Reviewer Comments

The Frigitek controller has claims of typical savings ranging from 25% to 35%, which is a reasonable amount of savings given the reduction in both energy used by the motor and the reduction in heat from the motors, if installed in an appropriate application.

The more often the compressor is off, the more savings will occur. If the compressor is oversized for the load, then the compressor is off more of the time. When this is the case, as is typical of new installations, the fans can run at a reduced speed more of the time. This is one product that actually saves more energy when the system has good efficiency than when it has poor efficiency. On that note, if the compressor is undersized for the load and thus runs all the time, or if the walk-in is in poor repair and insulation losses cause the compressor to be overworked, then the Frigitek will not save much energy. In these cases, there is not enough opportunity to reduce fan speed. Frigitek recommends that a pre-inspection of the application be done before a decision is made to purchase this product.

Most cooler and freezer walk-ins can use a Frigitek controller, but each situation should be evaluated for applicability. An evaluation form for determining the appropriate application is provided by the manufacturer. Applications where the Frigitek controller is not appropriate include:

- HVAC systems, home air-conditioners, or small, stand-alone reach-in boxes.
- If the fan cycles off when there is no call for cooling (no benefit to using the Frigitek controller).
- When the duty-cycle of a refrigeration compressor is high. This usually occurs if the walk-in is in poor repair, has missing or poor insulation, or has the door open frequently or for extended periods. In these situations, other energy savings measures should be taken first.

There are also some motors that the Frigitek controllers are incompatible with. These motors are single-phase, split-phase, or capacitor-start motors that are larger than ¼ horsepower.

To gain some perspective on the magnitude of savings for a typical application, consider a typical walk-in freezer application in a grocery store[3]. The typical annual energy usage for all energy used in a walk-in freezer is shown as 83,800 kWh/yr and a demand of 19 kW. The evaporator fan energy used by the motors for this application is 35,000 kWh/yr and a demand of 4 kW. This means that the energy used to operate the fans is 41.7% of the total load of the energy used by the walk-in and 21% of the demand. Evaporator fans have a 100% duty cycle. With the Frigitek installed, based on a typical 40% duty cycle for the compressor, the evaporator fans will now have a duty cycle of around 48%, due to its internal control strategy, and operate between full speed and low speed. Assuming that these are split-capacitor motors, and given this typical situation as a base case the annual savings would be 22,519 kWh/year. This would be a

2 A rack refrigeration system is a modulating or varying capacity system that can closely follow the refrigeration demand by use of multiple compressors and multiple evaporators that operate in parallel. These are very common in grocery stores where there are multiple loads and temperatures.

3 Little Inc., Arthur D. *Energy Savings Potential for Commercial Refrigeration Equipment.* Ref.No. 46230-00. Arthur D. Little, Inc. Washington, DC: U.S. Department of Energy, 1996. 1+.

27% savings of all of the energy used to operate the walk-in freezer. At the prices given for the product and installation costs this would give roughly a 15-month simple payback at $0.06/kWh.

Conclusion

The theory of the Frigitek controller is sound and testing by the manufacturer indicates that it saves energy. It has a simple installation, and the manufacturer makes reasonable claims for energy savings. It also has a wide range of applications from small commercial to industrial. Once initial case studies have been conducted to verify savings, the product appears to be a logical choice for a prescriptive utility program that clearly defines appropriate applications. For suggested guidelines, contact the manufacturer.

Additional Information

Northwest businesses and electric utilities can contact the *Energy*Ideas Clearinghouse for additional information on this or other energy technologies or products. Contact:

Phone: 1-800-872-3568
Email: *info@EnergyIdeas.org*
Website: *www.EnergyIdeas.org*

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Reviewer

Craig Meredith, PE
WSU Extension Energy Program

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