智 能 冷 凝 器 控 制 器

学 习 如 何 使 用 该 服 务 工 具 来 解 决 冷 凝 器 应 用 中 的 过 度 冰 升 与 冰 雪 问 题。

B Y S E R G E T R E M B L A Y, C M S

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er the last few decades, the industry has witnessed monumental changes in the world of technology and how it affects everyday life. E-mail, texting and social networks have drastically changed the way people communicate, and business more or less happens 24/7 in the wired world.

One industry that has not kept pace is commercial refrigeration. With all of the potential benefits available, the commercial refrigeration industry still utilizes decades old technology in operating and servicing refrigeration equipment.

Jumping right into a problem encountered at a real installation experienced in a quick service restaurant (QSR), this article reviews the advantages of using some of today’s technology to effectively, and quickly, diagnose and service a system.

Common problem

Figures 1 and 2 show a common refrigeration problem: excessive frost and ice on both product packages and walk-in surfaces. This restaurant location has had a recurrent ice problem for the past few years. The presence of a plastic curtain in the doorway, and numerous defrost setups, were not able to overcome the formation of ice in the walk-in freezer.

The normal reaction of the refrigeration technician is to increase the number of defrost cycles on the defrost time clock. While the situation improves temporarily, the problem comes back after a while. In this example, even four cycles of 45 minutes per day were not enough to clear up the problem.

The next step is to work through possible causes and speculate on what should be done to correct the problem.

Analyzing the situation

Some initial analysis for frost and ice forming on these surfaces included the following:

→ The drain was checked to make sure it was not plugged.
→ The defrost termination and fan-delay sensors were checked to make sure they were installed and functioning properly.
→ The rotation of evaporator fans were checked and found to be appropriate.
→ A good plastic strip curtain was installed (instead of a door switch to control evaporator fans) to control humidity infiltration.
Since there is little that can be done to control the door-opening rate, humidity level, inventory level and product sublimation, the controller would be in a position to better decide when defrost was needed.

It was noted that there was a dishwasher 12 ft from the freezer door.

The walk-in temperature setpoint was at -5°F.

More subtle causes, such as those described below, could also cause the problem:

- Lack of silicone in the panel joints can accelerate the humidity transfer. Verification with the walk-in manufacturer certifies that no joint is required since a continuous metal sheet is used behind the interior panels. Indeed, the inside joints of this specific example were not showing more ice than the other surfaces.

- The freezer door is frequently being opened by staff from a hot kitchen. Strip curtains minimize the impact of this activity.

- The use of a remote dishwasher is also a factor in the high humidity level, although a plastic curtain reduces the effect.

- Bakery goods and products are mainly stored in cardboard boxes or open plastic bins. The high demand exposes the products to ambient air. In this specific example, it was believed that water migration from the product to the evaporator surface occurred via sublimation.

Solution

After reviewing all of these possible causes for the recurring problems, the replacement of the conventional defrost timer by an intelligent demand defrost/evaporator efficiency controller was proposed by the service contractor and accepted by the customer. Since there is little that can be done to control the door-opening rate, humidity level, inventory level and product sublimation, the controller would be in a position to better decide when defrost was needed.
The controller manages the evaporator fans, electric defrost heaters and liquid-line solenoid valve. It also controls the room setpoint and determines the appropriate time for defrost, only when the coil heat-transfer capability is reduced by more than 10%.

As frost accumulates on the evaporator coil, the controller utilizes the frost to assist in managing the refrigeration load. Instead of activating the defrost heaters to melt the frost, the controller manages the evaporator fans to sublime the frost. In other words, defrost occurs without adding heat by the defrost heaters. Since the customer already paid to solidify water vapor on the coil, when possible the intelligent controller will use this frost to maintain room temperature without cycling the compressor.

In addition, a defrost temperature sensor installed in the evaporator, rather than a bi-metal sensor installed on the evaporator U-bend, will provide more accurate readings to better manage the defrost heaters and help prevent instantaneous vaporization (fogging) of melting frost during the defrost mode.

Figure 3 shows an interrupted sequence of electric defrost heaters when the measured temperature by the temperature sensor is above the latent point. A steeper curve of temperature could signify a partial or total absence of the frost on the evaporator surfaces. There is no need to energize the defrost heaters permanently. Figure 1 shows water vapor that can potentially solidify on colder surfaces, like fan guards and walk-in panels.

Also, the blue zone in Figure 3 shows a drain cycle that does not exist when using a traditional defrost timer. What is the use of starting the refrigeration cycle if there are still water droplets between the evaporator fins that will quickly freeze, requiring another defrost sooner?

After the intelligent evaporator efficiency controller was installed and operational, the on-board communications technology could be utilized to confirm if the solution was getting the job done.

**Remote communication**

Refrigeration systems controlled by thermostats and time clocks do not offer visibility for the service technician to view the operation of the system. More sophisticated controllers that do offer a communications solution often require special programming, detailed setup and monthly maintenance fees. This is time consuming and costly to the end user.

The communications protocol is largely the same protocol used to view Web-page applications. In short, when you type www.google.com in a Web browser window, such as
Chrome, Explorer or Firefox, the page that opens does not require any software installation or detailed setup. The controller described in the QSR project uses this simple Ethernet-based communication.

Figure 4 shows evaporator controllers attached to a communication network. Once the controllers are connected via an Ethernet cable to the router, the service technician can use a laptop, a smartphone or a tablet to interact with the controller. Once the controller parameters are set up or changed, the router can be withdrawn, unless the customer would like to receive alarms and monitor the refrigeration system via the Internet.

This sample network utilizes a local area network (LAN) connection, which can be connected to an existing customer network.

When establishing communications, it is important to differentiate between a LAN and a wide area network (WAN). LAN is the proper terminology used for a network similar to the one shown in Figure 4. When the user is connected wirelessly to the evaporator controller and walks outside of the router range, the communication is disrupted. The evaporator controller is still managing the refrigeration system, but it is now impossible for the user to see the controller information. WAN is used for a network that covers very large areas geographically.

The LAN used in Figure 4 can be connected to an existing customer network. Therefore, any access point at this network can allow the user to communicate with the controller. For example, from a mechanical room in a high school the user can remotely communicate with the cafeteria walk-in controller to monitor or modify parameters. In fact, when properly set up, the user can communicate with the controller from any place that has Internet access.

For security matters, technicians must obtain the authorization from the customer IT personnel. Most likely a virtual private network (VPN) will be created for these needs. Therefore, technicians can have access to the controller with a password through the Web. Most of the end users are already familiar with these simple procedures. Another simple option is to utilize the existing WiFi, as many national restaurant chains already have a WiFi connection for their customers’ use.

Once the connection is established, the internet protocol (IP) address of the controller is needed. Each controller has an IP address that allows for communication over networks. Like a letter in the mail, it requires the postal address to reach the final destination. Once the communication is made on
the LAN or WAN, the IP address of the controller must be used in the browser window to access the application.

Figure 5 shows that instead of typing www.google.com, the controller’s IP address is entered, in this case 10.10.50.1. Press enter and the Web page will appear. Note in Figure 6 that no software installation was required to access the controller. The Web server is embedded in every controller.

Once the controller is available, performance graphs (under the graphs tab) that will help diagnose the system can be accessed. Figure 7a shows the system status in week one, prior to the intelligent controller being activated; Figure 7b shows the system status in week two, the first week after the controller begins managing the system. Figure 7a shows the room temperature. The right part of the graph shows that the room setpoint was impossible to maintain because of too many defrosts. There were 36 defrosts required in five days to manage the current load and reduce the frost on surfaces.

During the second week, using the new intelligent evaporator efficiency controller, most of the frost was eliminated, and the defrost cycles were down to two per day, for an average of 10–15 minutes, instead of four cycles of 45 minutes each, which is an 83% reduction of the defrost time. Before, the average compressor runtime was 17.6 hours, compared to 10.7 hours the second week. The evaporator frost sublimation and the proper demand defrost maintained a high compressor suction pressure and reduced the compressor runtime by 40%. In addition, the room setpoint became achievable.
One week after the installation, the customer already noticed frost-free surfaces. The controller can defrost at the proper time and use sublimation of the frost on the evaporator to achieve energy savings. A projection, based on a complete year, established that the system would save around $710 per year (based on $0.10 kWh).

**Conclusion**

Owners of restaurant chains, convenience stores and schools are seeking cost effective solutions that will generate energy savings, and provide proper monitoring and operation of their refrigeration systems. Some owners are using this type of intelligent evaporator efficiency controller as a low-cost solution to monitor room temperature remotely when the store is closed.

This type of controller is becoming more prevalent in the industry. Air-conditioning systems are already incorporating newer technologies, including electric expansion valves, compressor and fan-motor dc drives. It is only a matter of time that this technology will be implemented in equipment designed to control temperatures lower than 45°F.

There are many energy consulting firms that are approaching end users with solutions to control light power, temperature night setback thermostats and reduce outside air in ventilation systems. However, the major portion of the energy used in restaurant industries is coming from the refrigeration equipment. Studies show that up to 30%–40% of the total energy goes into refrigeration.

Who is in a better position than refrigeration consultants and contractors to give advice to end users? Competition will always seek opportunities. No doubt that the applications will increase in HVACR in the following years.

Service technicians have no control on the product type and packaging, the height of the stockpiles that temporarily block the air flow of the evaporator fans, level of stock, door opening rate and the humidity level in most of the applications. When a service call is requested and an analysis of these variables is required to identify the cause of frosting of the evaporator and surfaces, it is normal that the first reaction is to increase the number of defrosts. When several evaporators are installed, it is more useful to see a global picture of the system instead of measuring temperature inside the cold space. Monitoring a refrigeration system over the Internet can save gas and time.

Finally, the industry now has technology that will provide more efficient system operation and at the same time act as an effective service tool. Industry professionals can make optimal use of this technology, but it is up to them to take advantage of it.

Serge Tremblay, CMS, is a Regional Sales Engineer with KE2 Therm Solutions. He is an active Member of RSES and is an RSES CMS Refrigeration Specialist. Tremblay has more than 30 years of HVACR industry experience at both the wholesale and OEM levels, is a licensed professional refrigeration teacher with seven years of teaching experience. Tremblay's formal training includes a refrigeration and air-conditioning diploma, as well as degrees in HVACR design and a B.SC. Administration from Sherbrooke University. For more information, visit www.ke2therm.com.