<u>Springtime is Economizer Time</u>

By Ron Prager

Spring is here. The birds are chirping, the insects are buzzing, your eyes are watering due to allergies, and your HVAC contractors <u>hopefully</u> are performing the Spring preventive maintenance on the HVAC systems that serve your stores. One of the most important and most overlooked systems with respect to maintenance is the economizer. In this article, I will attempt to answer the following questions. What is an economizer? How do economizers work? And, why are economizers particularly important during this time of year?

<u>What is an economizer?</u>

Strictly defined, an economizer is a control strategy in an HVAC system that allows the system to provide cooling without the use of mechanical refrigeration or chiller operation. Economizer operation is sometimes referred to as "<u>free cooling</u>." This is due to the fact that economizer operation provides cooling of a space at a significantly reduced cost when compared to mechanical refrigeration. There are two types of economizer cycles that the retail facilities manager should be familiar with.

The first type of economizer, and by far the most common, is known as the outside air economizer. An outside air economizer provides cooling by allowing the unit blower to deliver large quantities of outdoor air through the air distribution system that serves a store when the temperature and humidity levels of the outdoor air are suitable to allow it to be used for cooling purposes. Obviously, it would serve no purpose to bring 80ºF air into a 75ºF store in an attempt to cool it. However, if 55ºF air were available, it could provide the same cooling capacity per cubic foot of air circulated as the mechanical refrigeration system within the unit. This is due to the fact that a typical packaged cooling unit operates at a discharge temperature of 55ºF.

The second type of economizer used in equipment that serves retail stores is known as a water-side economizer. This type of system is utilized where water cooled unitary air conditioners or water cooled chillers provide cooling. Water cooled units use cooling towers to cool condenser water, that is then used by the equipment to condense refrigerant vapor into a liquid. During the summer, cooling towers are typically set to maintain a leaving water temperature of 80ºF. This is pretty much the standard temperature required for water used as a condensing medium. However, during winter, early spring, and late fall, the cooling tower is capable of providing water with a leaving temperature significantly lower than 80ºF. As a mater of fact, during winter, the leaving water temperature can often be maintained at 45ºF and the condenser water can now be substituted for chilled water. If the space in question is normally cooled by chilled water, this tower water can now be circulated through the piping and coils that normally carry chilled water. This use of cold condenser water as a substitute for chilled water is defined as a "Strainer cycle." A strainer cycle is one form of water-side economizer.

In applications where packaged water cooled air conditioners are used to provide cooling during the summer, no chilled water coil is present, so a strainer cycle is not possible.

However, because there is such a significant opportunity for energy savings, manufacturers offer the option of a factory installed water coil on their water cooled equipment. Whenever the condenser water leaving the cooling tower is at lower temperature than the return air entering the air conditioning equipment, this water can be circulated through a finned water coil located upstream of the mechanical cooling coil. The incoming condenser water circulates through this pre-cooling coil before it enters the unit's water-cooled condenser. This allows the cold condenser water to pre-cool the air before it reaches the cooling coil. Depending on current heat load and the current condenser water temperature, the pre-cooling coil can furnish a portion or all of the cooling required.

How do they work?

We already know that an outside air economizer allows outdoor air at suitable temperature and humidity levels to be utilized to cool a space, but how does the equipment determine how much air to bring in, and how does it determine when the temperature and humidity levels are suitable?

Most packaged rooftop air conditioners and split systems are equipped with outdoor air dampers and return air dampers that are linked together to operate in inverse proportion. That means that as the return air damper closes, the outdoor air damper opens and vice versa. If an economizer cycle is present, both the return air damper and ductwork, and the outdoor air damper and ductwork, are sized to handle the total volume of air the unit is specified to circulate. The position of these dampers is controlled by a damper actuator. There is a minimum position control that allows a technician to set the dampers so that the mixture of outdoor air and return air will always contain the minimum quantity of outdoor air required by code for proper ventilation of the space. (Today we are actually seeing this minimum position setpoint approach zero as retailers are opting for demand ventilation options that allow the equipment to determine the minimum percentage of outdoor air to introduce based upon carbon dioxide levels within the space.)

Unless the thermostat in the space is calling for cooling, the outdoor air damper remains in the minimum position and the return air damper remains at its maximum open position. If the thermostat calls for cooling, a "Change-over control," determines if the outdoor air is suitable to be used to provide some degree of cooling. This change-over control measures the enthalpy (temperature and moisture content, or total heat content) of the outdoor air. This is called enthalpy change-over. If the enthalpy of the outdoor air is below a predetermined threshold, the unit will use outdoor air induction as the first stage of cooling. The changeover control may be set up to measure the enthalpy content of both the return air and the outdoor air. In this case, theoretically, whenever the outdoor air contains less total heat than the return air, outdoor air can be utilized as first stage cooling. The least complex changeover control, simply measures the temperature of the outdoor air and if the temperature is lower than a predetermined setpoint, outdoor air is utilized for first stage cooling.

In each case described above, if the changeover control determines the outdoor air is capable of providing some degree of cooling the damper actuator begins to open the outdoor air dampers and close the return dampers. We need to keep in mind that if the unit is located in Kentucky, the outdoor air introduced may be 60ºF. On the same day, if the unit is located in Minnesota, the air being introduced may be 10ºF. For this reason, a device known as a "Mixed air controller," measures the temperature of the air being supplied to the space. The mixed air controller varies the position of the damper actuator, and hence varies the position of the dampers in order to maintain a discharge air temperature no lower than 50ºF. If the discharge air temperature were allowed to go below this threshold, occupants might be uncomfortable due to cold drafts.

If we assume that a store is a sealed box, and we are now bringing in large quantities of outdoor air to cool the space in lieu of running compressors, it stands to reason that we need to provide some means of removing the same quantity of air from the store as we are dumping into the store. If we consider a 30,000 square foot store with 100 tons of packaged rooftop units; assuming all units are running in economizer mode, we must introduce and exhaust 40,000 cubic feet of air per minute. We exhaust this air via dedicated exhaust system such as toilet exhaust fans, and via unit mounted relief dampers and power exhaust accessories that operate based upon the position of the outdoor air dampers. If you find you have complaints of the entry doors on your stores blowing open particularly during spring and fall, it is usually an indication that the power exhaust accessories or relief dampers are not working properly. The result is that the store becomes pressurized and the air is forced to escape any way it can. Usually the air escapes via the front doors, but we have seen extreme cases where the air pressure is great enough to blow holes in a single-ply unballasted roof membrane. This is far more of an issue in free standing stores than it is in mall stores, but good design practice dictates that the equipment be capable of exhausting almost as much air as it is capable of introducing.

Water-side economizers operate similarly with some exceptions. The change-over control on a water side economizer allows economizer operation when the condenser water temperature falls below a predetermined setpoint, or when the condenser water temperature is a few degrees lower than the entering return air. Rather than outdoor air and return air dampers being modulated based on discharge air temperature, a three way valve is modulated to allow cool water to enter or bypass the water coil. Most water-side economizers are equipped with a freezestat. This is a safety control that shuts down the unit in the event the temperature of the water coil falls below 35ºF. If the water coil were allowed to freeze, the tubes would burst causing extensive damage to the coil and possible flood damage. Possible causes of a frozen water coil are outdoor air dampers that fail to close, or frosting of a mechanical cooling coil located close to the water coil.

Why are economizers particularly important now?

Either type of economizer has the potential to save huge amounts of money in the form of utility cost and repair cost. If a store is located South of the Mason Dixon Line, you may be hard pressed to see significant savings due to economizer operation. In addition, depending on the type of changeover control used, economizers have been responsible for some indoor humidity issues in certain climates. However, depending on geographic location and hours of operation, an economizer has the potential to save 20% of your mechanical refrigeration run time. Theoretically, this translates into a reduction of 20% on mechanical refrigeration repair costs. It is also important to realize that if a 10 ton packaged rooftop unit draws 46 amps at full load, 36 amps is used just to power mechanical cooling. It then follows that an economizer has the ability to save up to 20% of 78% of the power used to cool your stores depending on geographical location. If one looks at the distribution of cooling degree days, across the country, it becomes apparent that the greatest potential cost savings due to economizer use occurs during the spring and fall. It also becomes apparent that there is more potential savings at night than during the day. This is due to several factors. Most of the cooling loads in retail stores are internal loads due to lighting and people. As outdoor temperatures fall, we reach a balance point where the heating load due to shell losses and ventilation air equals the cooling load produced by internal loads. For most free standing stores, we find this balance point occurs around 45ºF. Therefore, the potential for energy savings during winter is limited by the limited amount of cooling required in winter. In summer, the potential is limited by the higher temperature and humidity levels of the outdoor air. So, it makes sense to make certain that a thorough operational check of your economizers is part of your Spring and Fall preventive maintenance requirements.