3.5.6. Ambient Condition Interlocks

In most locations, the ambient conditions will reach a point where the economizer provides no energy savings benefit. To address this issue, an interlock needs to be provided to disable the economizer and return the system to a recirculating mode with minimum outdoor air. There are two main ways to accomplish this: outdoor temperature based interlocks and enthalpy based interlocks.

3.5.6.1. Outdoor Temperature Based Interlock

Interlocks based on outdoor dry bulb temperature is usually the least complex and least costly to implement. Typically, the economizer cycle is terminated based on some ambient outdoor air temperature, also called the changeover setting. The trick is to select a temperature that will maximize the energy savings obtained from the economizer. The temperature will vary by location depending on the local climate. In dry climates with low mean coincident wet bulb temperatures it is possible to set the changeover setpoint near the design space temperature. However, in a hot and humid climate, this approach can place a significant energy penalty on the air handling system since it will have to do much more dehumidification to cool the outdoor air at or near the design space temperature compared to cooling the return air from the space mixed with the minimum outdoor air requirement.

Figure 3.7: Cooling minimum outdoor air vs. 100% outdoor air

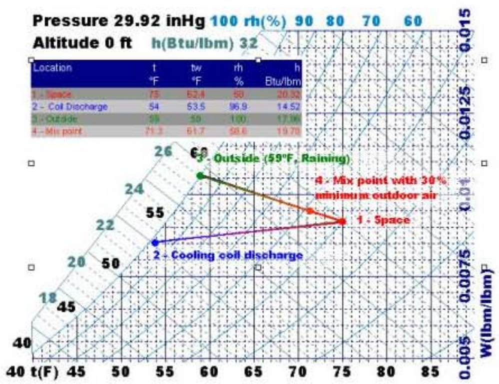

Figure 3.7 shows that cooling and dehumidifying 100% outdoor air to 54�F requires 3.44 Btu of energy be removed from every pound of air (17.96 Btu/lb � 14.52 Btu/lb). Cooling the mix of 70% return air and 30% outside air requires that 5.26 Btu/lb be removed (19.78 Btu/lb � 14.52 Btu/lb). Even though the outdoor temperature is above the required supply temperature, the system will use less energy if it remains on the economizer cycle using 100% outdoor air. Mechanical cooling is still necessary, but not as much as would be required if return air were used.

The energy needed to cool the air depends on the temperature and moisture of the incoming air, which must be taken into account when determining a dry-bulb economizer changeover setting. Figure 3.8 illustrates one possible method of determining an energy-efficient dry bulb changeover temperature. The steps are listed below:

1. A line representing the statistical average of a specific location�s climate conditions is plotted on a psychrometric chart. In the example, bin data from the Air Force Engineering Weather Data Manual was plotted using the Mean Coincident Wet Bulb (MCWB) temperature for each dry bulb temperature bin.
2. A second line is plotted that is a constant enthalpy line for the state of the air in the space at its design condition.
3. The economizer change over controller is set for the dry bulb temperature where the two lines intersect.

Figure 3.8: Determining temperature-based economizer changeover

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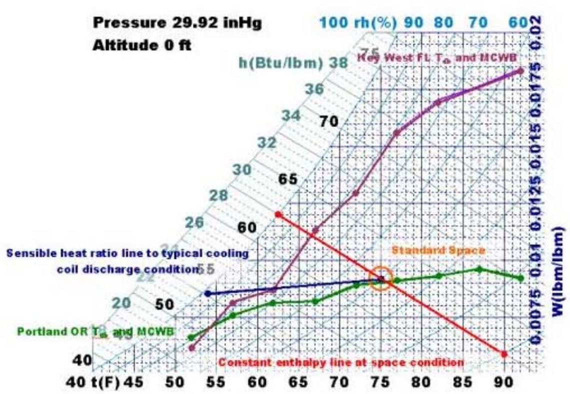

From a statistical standpoint, it will take less energy to cool the outdoor air than the return air at the conditions to the left of the intersection for the particular location being analyzed. Conditions to the right will take more cooling energy to cool the outdoor air compared to the return air. Therefore, the dry bulb controller should be set up to shut down the economizer for temperatures above the intersection point and allow it to function for conditions below the intersection point.

As can be seen from Figure 3.8, the exact value for this point can vary significantly from location to location. In the very hot and humid climate of Key West, the change-over point is somewhere in the 66-67�F range. In the mild climate of Portland Oregon, the changeover point is 75-76�F. The lines on this graph were developed from bin weather data in the Air Force Engineering Weather Data Manual but could also be developed from other readily available sources such as NOAA.

It is important to understand that the statistical weather data reports average conditions. The changeover temperature selected by plotting this data on a psychrometric chart will be correct most of the time, but probably not all of the time. However, this method provides more insight and better criteria for the correct changeover set point selection compared to simply shutting down the economizer function when the outdoor temperature is warmer than the required supply temperature or warmer than the space design temperature. When properly applied and then verified by the commissioning process, the optimized set point selection saves energy.

3.5.6.2. Enthalpy Based Interlock

When properly applied, using an enthalpy-based interlock has the advantage of providing an exact solution to determining the changeover point, while the preceding approach provided an approximate solution. Unfortunately, enthalpy is a property that is more difficult to understand and measure than temperature. Several approaches to applying enthalpy-based economizer control can provide reliable performance if they are properly implemented, adjusted, and maintained.

The importance of proper adjustment and maintenance of enthalpy sensors cannot be overemphasized. Verification of operation requires a basic understanding of psychrometrics and access to a sling psychrometer or some other reliable indicator of atmospheric moisture content. Most of the maintenance problems are related to the portions of the equipment that sense humidity and often can be traced to contamination of the sensing element by dust and water or failure due to exposure of the plastics used to the direct or reflect rays of the sun and their associated ultraviolet component. The Enthalpy Change Over functional test included later in this chapter as well as the information in the following paragraphs and in the Sensing Elements section of this chapter are targeted at providing guidance for an enthalpy-based economizer interlock.

There are two main ways to implement an enthalpy based change-over from economizer to non-economizer operation.

- The most common approach simply assumes an enthalpy state of the return air based on design conditions and then allows the economizer to function only if the measured outdoor air enthalpy is less than the assumed return air state. This approach avoids the cost of an enthalpy sensor or switch for the return air and allows the change over decision to be made by one master switch for the building. The approach will provide the desired result as long as the fundamental assumption regarding the constant enthalpy state of the return air is valid. In projects where constant return enthalpy is not a good assumption, a differential enthalpy-based strategy is often employed.
- Differential enthalpy-based economizer change-over cycles require at least one enthalpy switch or sensor in the outdoor air stream for the building or system and another switch or sensor in each air handling system�s return air. The control strategy is arranged to change over from economizer mode to non-economizer mode if the actual measured enthalpy of its return air stream is less than the current outdoor air enthalpy. This approach provides the most precise solution to determining the changeover setting, but it also adds first cost for

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To measure enthalpy, two position switches and enthalpy transmitters. As an alternative, it is possible to use a temperature transmitter and a humidity or dew point transmitter and calculate enthalpy based on ASHRAE psychrometric equations.

3.5.7. Alarms

There are several alarms and smart alarms that can provide benefit for economizer-equipped systems. The minor commissioning costs to verify the alarms are typically small relative to the potential benefits if the alarms are properly applied. The alarm requirements should be identified before the system is programmed, allowing the logic to be developed in conjunction with the rest of the operating software. Alarms to consider include:

- A mixed air low limit alarm set to provide a warning of an impending freezestat trip.
- Low and high alarms on the set point used by the system for the mixed air low limit control as well as the normal mixed air control cycle. These alarms will alert the operating staff to inadvertent changes to these set points that could cause operational problems.

Smart alarms require the development of program logic as opposed to simply entering a value in a point parameter screen. Thus, there can be some cost associated with implementing them. Options to consider include:

- Alarm if the system is not on minimum outdoor air but is using preheat.
- Alarm if the system is using mechanical cooling but is not on maximum outdoor air when the conditions are suitable for using outdoor air.
- Alarm if the outdoor or return air dampers are hunting.

3.6. Supplemental Information

There are many hyperlinks throughout Chapter 3 that reference supplemental information regarding components of an economizer. In addition to accessing this information by clicking the hyperlinks, the supplemental information document can be accessed using the link below.

Economizer and Mixed Air Supplemental Information

[1] This has some other advantages since it is often better to have a small actuator on each section rather than a large actuator with a jackshaft running multiple sections to ensure that the dampers achieve their leakage rating.