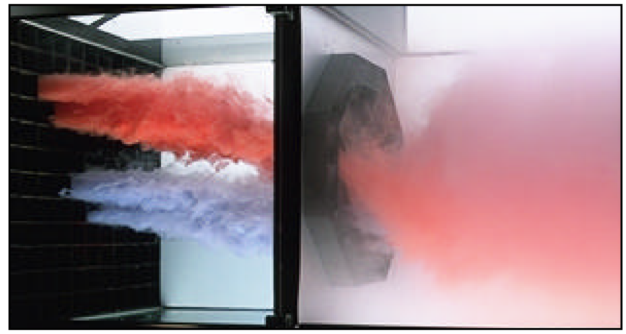
Blender Products, Inc.

# HVAC Mixing Update



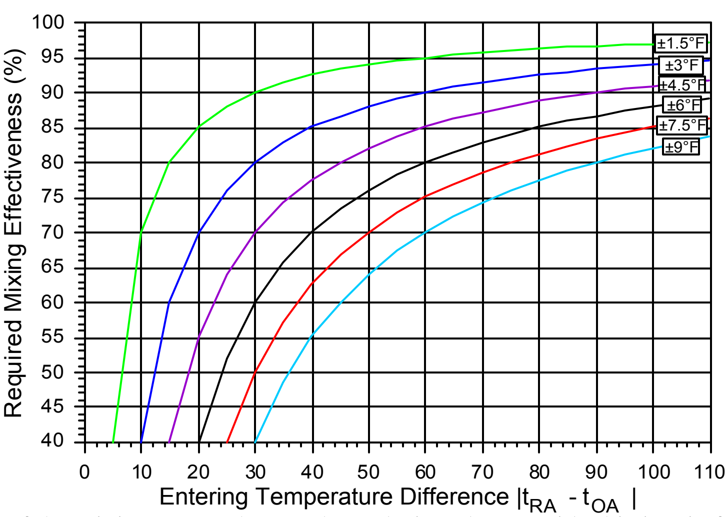
## Mixing and Sensor Errors: An Overview

One of the most important changes in the HVAC industry over the past 20 years has been the development of direct digital control (DDC) systems. These systems combine the “thinking” power of the computer with a control system to increase the operating efficiency of HVAC systems. While these systems can result in substantial savings in energy and operating costs, it is important to remember one of the fundamental rules concerning computers: “Garbage In, Garbage Out”.

Because of this, one of the biggest factors which can affect the operation of a DDC control system is the accuracy of the sensors whose inputs are being used to make the decisions concerning the operation of a system. If a temperature sensor is reading the wrong temperature, the computer may make an incorrect decision thereby increasing energy usage rather than decreasing energy usage. According to James Kao (“Sensor Erros”, *ASHRAE* Journal, 1985, pg. 100), the coil discharge temperature sensor has the greatest effect on the energy usage of the system, while the mixed air temperature sensor has the second largest effect on the energy usage of the system. One of the biggest causes of error in the mixed and coil discharge temperatures is stratification (Kao, 1985).

This stratification is the result of poor mixing within the air-handling unit mixing box and occurs throughout the year. Unless the velocity profile across the duct or plenum is uniform, it is necessary to make both a temperature and velocity traverse in order to get an accurate mixed air temperature reading (ASHRAE 1993).

If the velocity profile in a plenum is ignored, the maximum possible error for a temperature sensor is equal to the range of temperatures that exist at the point where the sensor is located. If the mixing effectiveness of the mixing box is known, the temperature range at the inlet to the cooling coil can be estimated using the following equation:




$$\text{Temp Range}_{\text{Cooling Coil}} = (1-\text{Mixing Effectiveness}_{\text{Mixing Box}}) * (\text{Temp}_{\text{Return Air}} - \text{Temp}_{\text{Outside Air}})$$

One-half of this temperature range represents the uncertainty in the mixed air temperature reading. For example, if the estimated temperature range at the coil face is 18°F, the uncertainty in the mixed air temperature readings is ±9°F.

The figure to the left may be used to determine the mixing effectiveness required to reduce the error in the mixed air temperature reading to several different levels. This figure shows that the sensor error is a function of the temperature difference between the outdoor and the return air streams. For example, a mixing effectiveness of 0.76 is required to achieve a sensor error of ±3° when the entering temperature difference is 25°F. These conditions occur when the outside air is 95°F and the return air temperature is 70°F.

If the mixing system has not been designed to provide this level of mixing, the error in the mixed air temperature sensor can result in excess energy usage. This excess energy will either be the result of the sensor calling for too much mechanical cooling or it will be the result of the occupants turning down the thermostats because they are too hot.

Traditionally, stratification has been thought to be a problem only in areas that have cold winter weather. However, the effect of sensor error upon the energy usage indicates that good mixing is important in all HVAC systems. Using Figure 1 to determine the mixing required to reduce the sensor error to an acceptable amount provides the design engineer an objective method that may be used to specify what type of mixing equipment and mixing effecitveness is required for each system. This will help insure that the error in the mixed air and coil discharge temperature is minimized so that costly excess energy usage is avoided.

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