AIR DISTRIBUTION FOR VENTILATION

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There has been a lot of discussion and press regarding the benefits of displacement ventilation. It is generally perceived that the semi-laminar flow of the air from the floor to the ceiling reduces the transmission of infectious diseases to a greater extent than dilution ventilation. The proposed ASHRAE Standard, "Ventilation for Acceptable Indoor Air Quality", Public Review Draft, August 1996 recognizes an increased efficiency for displacement ventilation systems over other mixed air distribution systems by assigning a higher value for air change effectiveness (Eac). Displacement ventilation earns an Eac of 1.2 versus 1.0 for systems which supply relatively cool air at the ceiling or floor, and an Eac of 0.8 for systems which supply warm air at the ceiling. This greater air change effectiveness may or may not result in greater energy efficiency as this technical note will show.

We calculated the required outdoor air quantities for ventilating a typical classroom assuming that the proposed ASHRAE Standard becomes adopted as Code by BOCA. This may or may not happen. **It is important to note that current code does not recognize any increased efficiency due to displacement ventilation, and it would not be proper to reduce ventilation rates below those prescribed by the current code.** There may (arguably) be better ventilation efficiency but there are no energy savings associated with displacement ventilation as things stand currently.

We assumed a typical 1000sf classroom with 26 occupants and calculated how much outside air was required for "typical" ventilation systems versus a displacement ventilation system. We define the typical ventilation systems to be: Case 1, where relatively cool air (less than 15°F above room temperature) is supplied at the ceiling; Case 2A, where supply air is introduced near floor level at a high enough velocity to induce substantial mixing of room air; and Case 2B, where warm air is supplied at the ceiling. Case 1 is very typical of Energy Recovery Unit systems which utilize a heat exchanger to preheat outdoor air before it is ducted to the room. Case 2A is typical of Unit Ventilator type systems. Case 2B is typical of large Central Air Handler systems. Case 3 is the Displacement Ventilation system.

- Case 1 (ERU) requires 390 cfm of outside (and total) air. There is no recirculated air. This is the same value as the current code requirements of 15 cfm/person.
- Case 2A and 2B (UV and Air Handler) requires 266 cfm of outside air, and 473-591 cfm of total air (where the balance of air is recirculated and filtered with a 30% dust-spot filter).

The higher value of total air is for Case 2B where warmer air is introduced at the ceiling. Typically this would be the case when a large central air handling unit was used with reheat coils in the ductwork to heat and ventilate the classrooms.

- Case 3 (Displacement Ventilation) requires 334 cfm of outside (and total) air, assuming no recirculation.

It would probably be cost-prohibitive in this case to lower the outside air requirement further by recirculating and filtering room air (239 cfm outside air and 400 cfm total air) because of the extremely large registers required to keep discharge velocities in the 30-40 fpm range.

In terms of energy use the displacement ventilation system combined with an energy recovery unit would have the lowest energy use (the equivalent of heating 134 cfm outside air assuming a 60% efficient heat exchanger), followed by the ERU system (equivalent of 156 cfm outside air), then the unit ventilator and air handler systems (equivalent of 266 cfm outside air).

It is interesting to note the very small difference, only 22 equivalent cfm per classroom, in equivalent outside air requirements between the standard ERU approach and the displacement ventilation approach. Clearly it is hard to justify spending much more for a displacement ventilation system to save this small amount of energy.

It is also interesting to look at the special case of combining recirculation and filtration with the standard ERU approach. This would typically involve the use of air handling units combined with ERU's. Here 266 cfm of outside air would be introduced through an ERU and combined with recirculated and filtered air from the room. In this case the equivalent of 106 cfm outside air would be provided, the lowest value of all the cases studied.

According to ASHRAE methodology this approach would be superior in terms of air quality too. The central air handling unit would typically supply 1000 cfm of combined outside and recirculated (filtered) air to the room, 266 cfm of which would be outside air introduced through an ERU, and 734 cfm would be recirculated room air. The recirculated air filtered with a 30% dust-spot filter (which typically has a 60-65% efficiency at 3 microns) is considered to be the equivalent of 440 cfm outside air (734 cfm x 60%). **Combining an ERU with an air handling unit therefore has the lowest equivalent outside air heating requirement of the cases studied, and the greatest equivalent air change rate (266 cfm + 440 cfm = 706 cfm).** The displacement ventilation system would have to provide 589 cfm of outside air to be equivalent in terms of air change effectiveness.