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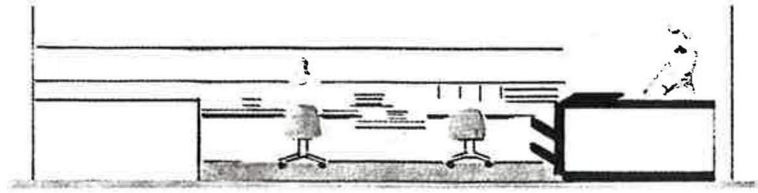
Proper ventilation of offices and conference rooms



A method is described for maintaining acceptable indoor air quality in all zones with one air handler

By Michael J. Filardo Jr.

With more emphasis being placed on indoor air quality, worker productivity and health concerns, it is imperative that the correct quantity of outdoor air be properly distributed to interior spaces in the most efficient and cost-effective manner.

A challenge occurs when a single air handling unit serves spaces with widely varying outdoor air requirements, such as conference rooms and offices. This article describes a method of compliance with ASHRAE *Standard 62-1989* ventilation rate procedure to maintain minimum acceptable indoor air quality in all zones served by one air handler.

In *Standard 62-1989*, Table 2 indicates that conference room density is 50 people per 1,000 sq ft (93 m^2), or one person per 20 sq ft (1.8 m^2). For offices, the density is seven people per 1,000 sq ft (93 m^2), or one person per 143 sq ft (13.3 m^2). The outdoor air requirement per person is 20 cfm (10 L/s) for both offices and conference rooms.

Because one person occupies 20 sq ft (1.8 m^2) of conference room and each person needs 20 cfm (10 L/s) of outdoor air, that equals the requirement of 1 cfm per sq ft (5.6 L/s per m^2)of outdoor air supply. Because one person occupies 143 sq ft (13.3 m^2) of office space and each person needs 20 cfm (10 L/s) of outdoor air, that equals the requirement of 0.14 cfm per sq ft (0.75 L/s per m^2) of outdoor air supply. How does one address these wide variations when the spaces are served by the same air handler?

Minimum outdoor air criteria

To obtain the minimum outdoor air required for an air handler that serves zones with different densities of people, follow the equation provided in *Standard 62-1989.*[1] The ASHRAE equation for multiple spaces is as follows:

$$Y = X/(1 + X - Z)$$

where,

$Y = V_{ot}/V_{st}$ = corrected fraction of outdoor air in system supply.

$X = V_{on}/V_{st}$ = uncorrected fraction of outdoor air in system supply.

$Z = V_{oc}/V_{sc}$ = fraction of outdoor air in critical space. (The critical space is that space with the greatest required fraction of outdoor air in the supply to the space.)

V_{ot} = corrected total outdoor air flow rate.

V_{st} = total supply flow rate.

V_{on} = sum of outdoor air flow rates for all branches on system.

V_{oc} = outdoor air flow rate required in critical spaces.

V_{sc} = supply flow rate in critical zone.

The ASHRAE equation for multiple spaces can be applied to both new and existing systems. A main advantage of applying the equation is that existing systems can be upgraded to meet *Standard 62-1989* without installing a dedicated air handler to serve critical zones. Other advantages are that it offers flexibility and may be the best cost-effective solution.

Outdoor air can be properly introduced into an existing system to meet its critical zone requirements. One major problem for an existing system to meet this ventilation standard may be its ability to heat or cool additional outdoor air.

Note that the cooling/heating capacity is of concern only at or near outdoor design conditions. This means that even with a capacity problem, the majority of the time the space can be ventilated properly to meet the current ASHRAE standard while maintaining comfort conditions.

The need to add cooling/heating capacity to accommodate the increase in ventilation rates must be analyzed for each particular case. Obviously, the cost to upgrade versus the amount of time the additional capacity is really used needs to be addressed.

One air handler that serves both conference rooms and offices gives the user the flexibility of changing the space from conference room to offices or from offices to conference rooms with minimum work to the duct system. The outdoor air intake quantity at the air handler is then adjusted appropriately.

There is also the flexibility of being able to add conference rooms without

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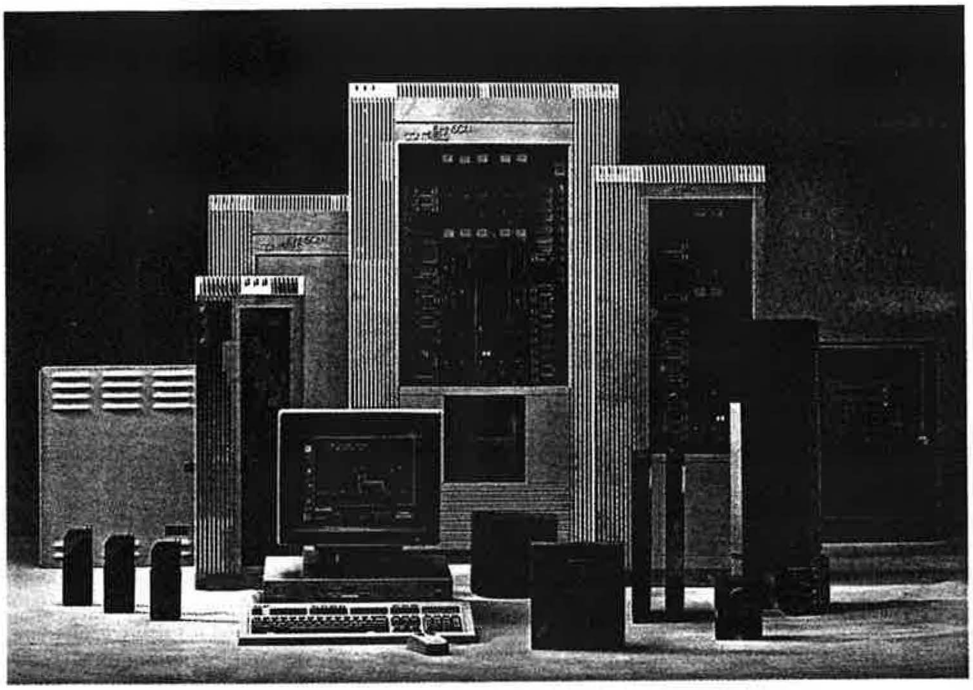

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adding dedicated air handlers and ductwork. This may be a very important consideration if the conference room is far removed from the fan room and outdoor air intake openings.

One large air handler with ductwork to all areas is less expensive than two small air handlers with dedicated ductwork to their respective zones. Also, using one air handler should result in simpler design and require less maintenance.

Alternatives

Five case studies are listed in *Table 1.* These studies were formulated for an assumed area of 10,000 sq ft (929 m^2), which is made up of 9,500 sq ft (883 m^2) of office space and 500 sq ft (46 m^2) of conference room.

The primary variable is the total supply air quantity to the conference room, which is the critical zone. The analysis shows how the outdoor air requirements in a common air handler system can vary just by changing the quantity of total supply air to the conference room.

Table 1. Case Studies

	Office			Conference Room		
Case	Area (sq ft)	Supply Air (cfm/sf)	Req. O.A. (cfm/sf)	Area (sq ft)	Supply Air (cfm/sf)	Req. O.A. (cfm/sf)
A	9,500	1.0	0.15	500	1.5	1.0
B	9,500	1.0	0.15	500	2.0	1.0
C	9,500	1.0	0.15	500	2.5	1.0
D	9,500	1.0	0.15	500	3.0	1.0
E	9,500	1.0	0.15	500	3.5	1.0

A ventilation credit was not taken for intermittent or variable occupancy in the conference room. However, this is permitted by *Standard 62-1989.*[2]

Each of the alternative cases depicts a simple example to illustrate the impact of a critical zone on the common air handling system, under a given load condition.

Temperature control

Although the primary emphasis in these case studies is to achieve the proper outdoor air quantities for the critical zone, proper temperature control in offices and the critical zone is also important. The offices and conference room were assumed to be on interior zones that require cooling all year.

The air supply system for the office area can be variable air volume (VAV) or constant volume. The conference room air supply can be a constant volume terminal unit with a form of reheat, or a VAV terminal unit with volume limiting devices and reheat if necessary. The conference room terminal unit can reduce the supply air quantity to a minimum during unoccupied times with devices such as motion detectors.

The graphs in *Figure 1* were established by calculating for each case the quantity of "unused" outdoor air coming

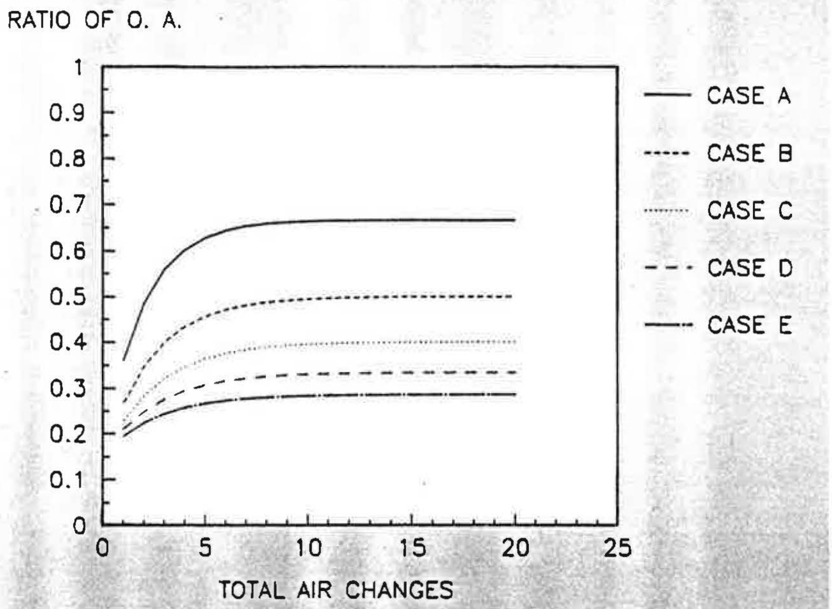

Figure 1. System fraction of outdoor air.

back to the air handling unit with the return air during each successive air change. Then, this quantity of unused outdoor air was added to the quantity of outdoor air entering from the intake. This gives a cumulative enrichment of outdoor air in the system. The ratios of outdoor air in the supply are then plotted as shown in *Figure 1.*

Figure 1 shows that, in each case, the system takes in the required amount of outdoor air and, after a few air changes, the outdoor air ratio reaches the designated ratio for the conference room or the critical zone. At that point, the system reaches a steady-state condition. This will assure the user that, soon after start-up, the space will be properly ventilated.

Summary of results

Calculations of the corrected outdoor air requirements in a common air handling system for these five cases are summarized in *Table 2.* These calculations are generated from the ASHRAE equation for multiple spaces. The calculations for Case A are as follows:

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$X = V_{on}/V_{st}$

$= (1{,}425 + 500)/10{,}250$

$= 0.1878$

$Z = V_{oc}/V_{sc} = 500/750 = 0.666$

Then using the ASHRAE equation,

$Y = X/(1 + X - Z) = 0.3599$

Now solving for V_{ot} yields the corrected total outdoor air flow rate:

$V_{ot} = 0.3599\,(10{,}250 \text{ cfm})$

$= 3{,}689 \text{ cfm}$

In *Table 2*, the column that indicates the "outdoor air required" (1,925 cfm) is the sum of the office area multiplied by the outdoor air per square foot for the offices and the conference room area multiplied by the outdoor air per square foot for the conference room. For example,

9,500 sf (0.15 cfm/sf)

+ 500 sf (1.0 cfm/sf)

= 1,925 cfm

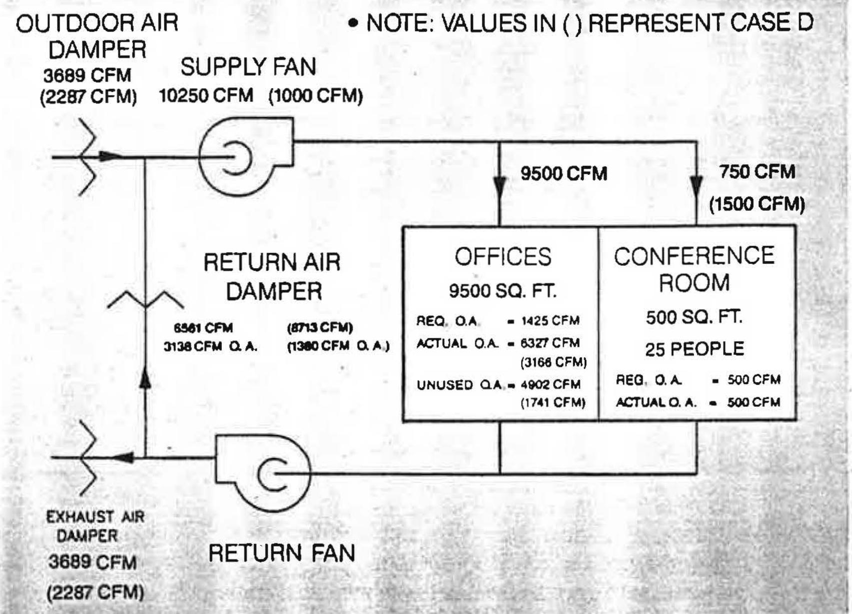

Figure 2. Schematic of Case A and Case D.

Figure 2 shows an analysis of a given load condition—a snapshot in time—of what is occurring in the system. It is a schematic showing data for Case A and Case D where the outdoor air requirements for all zones are met by a common air handling unit. This schematic shows the steady-state condition and indicates the unused portion of outdoor air that comes back from the office zone to the supply fan as a constituent of the return air.

Analysis of results

Table 2 shows that the "corrected outdoor air" column is greater than the "required outdoor air" column for every case. Note that in Case A and Case B, there is a significant difference between these two outdoor air quantity columns. This proves that, in an office environment, the conference room air rate (cfm/sq ft) must be taken into account to establish the proper outdoor air fraction at the air handler.

It also shows that the sum of the individual outdoor air requirements does not equal the proper system outdoor air requirements when using one common air handler for multiple zones.

Although Case A shows the highest percentage of outdoor air required by the system, the conference room has the lowest rate of supply air that may require little or no reheat. In geographical locations where the annual cost of treating additional outdoor air in the air handler is low compared to reheating the air in the conference room, Case A should be considered.

Where the annual cost of treating additional outdoor air is high or where the air handler capacity is a problem, consider Case D or Case E because they require the least amount of additional outdoor air at the air handler.

Table 2. Corrected Outdoor Air Requirements

Case	Supply Fan (cfm)	Req. O.A. (cfm)	Corrected Req. O.A. (cfm)	Outside Air (%)	Conference Supply Air (cfm/sf)
A	10,250	1,925	3,689	36	1.5
B	10,500	1,925	2,816	27	2.0
C	10,750	1,925	2,470	23	2.5
D	11,000	1,925	2,287	20	3.0
E	11,250	1,925	2,174	19	3.5

Selection of the optimum solution depends on geographical location (weather data for additional outdoor air) and local cost for reheat energy.

Conclusion

To maintain the proper outdoor air supply for ventilation, be sure the correct method is used in establishing the outdoor air percentage, and that the system design ensures the proper amount of outdoor air to each zone.

Note that the minimum outdoor air quantity requirement for a common air handling system is not the sum of the minimum outdoor air requirements of the individual areas served by the system, but rather some greater quantity depending on the air supply rate delivered to the conference room or "critical zone" within that air handling system.

Maintaining good indoor air quality to sustain a healthy work environment is imperative. Providing the proper outdoor air quantity for ventilation is not only conducive to higher worker productivity, but is also cost-effective. ■

References

1. ASHRAE. 1989. *Standard 62-1989*, "Ventilation for acceptable indoor air quality." Paragraph 6.1.3.1 Multiple Spaces. Atlanta, Georgia.
2. Ibid. Paragraph 6.1.3.4 Intermittent or Variable Occupancy.