

# INDIVIDUAL CONTROL BY INDIVIDUAL VAV

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## INTRODUCTION

Individual control is needed and can be cost effective. "Thermal Comfort," Chapter 8 in the ASHRAE Handbook of Fundamentals, 2001, indicates vast differences between people's needs for thermal comfort, strongly indicating the need for individual control. Metabolic heat generation varies in a ratio as high as ten to one (Table 4, Chapter 8, ASHRAE Handbook of Fundamentals, 2001.) The system described below was installed in a bank in 20 work areas. In a two year period there was not a single complaint. Occupants and management enjoyed 100% satisfaction.

Fanger et al. (1973, 1985, 1986 and 1989) demonstrate in many studies that personal comfort will lead to greater employee productivity, greater satisfaction and lower turnover. Note that typical employee costs today are \$3000/sm/yr (\$300/sf/yr), versus \$300/sm/yr (\$30/sf/yr) for other building costs. Therefore the results of individual control are great savings in personnel costs, the greatest cost of an office building operation.

## DISCUSSION

Since maintaining different temperatures in close quarters is impractical, varying air velocity (VAV) through personal air outlets, adjustable by occupants, is the best method of providing personal control. This requires redesign of office buildings. Accomplishing delivery of personal air flow to every workstation is also impractical, except by means of raised access floor, which is now widely and increasingly used in office buildings.

The effectiveness of this approach was tested and proven at the University of California at Berkeley by Fred Bauman, et al., and published as "Lab Test of APACS," 24 April 2000. The tests show that by varying the airflow, occupants can effect a change to achieve individual thermal comfort.

## TEST CONDITIONS

Tests were designed to compare heat removal by moving air compared to changes in ambient temperature. The tests covered two room temperature setpoints (26 and 28°C [79 and 82°F]) and both horizontal and vertical mounting positions of the Argon Personal Air Conditioning System (APACS). For each room temperature a reference test was first performed in which the mannequin was tested with no air flow from the APACS unit. Cooling tests were performed at different air volumes and temperatures at both the 26°C (79°F) and 28°C (82°F) room temperatures. The majority of tests were done at the 26°C (79°F) room temperature with horizontal position of the APACS, for which the supply temperatures studied were 21°C, 23°C, and 25°C (70°F, 73°F, and 77°F). At 28°C (82°F) room temperature with horizontal position and 26°C (79°F) room temperature with vertical position, only the 21°C (70°F) supply temperature was studied. Four air supply volumes were tested to cover the range of supply rates expected from the APACS unit. The volumes tested were 10, 30, 50 and 70 cfm (5, 14, 24, and 33 L/s). All volumes were tested at the 26°C (79°F) room temperature setpoint with horizontal position, while only the 30 and 70 cfm (14 and 33 L/s) rates were tested for the 28°C (82°F)/horizontal and 26°C (79°F)/vertical tests. The APACS unit was tested under focused air flow direction, meaning the air supply was directed toward the mannequin in a way that maximized the overall (whole-body) cooling rate. Tests were designed to measure worst case conditions.

The study only tested for sensible cooling. As reported in the test document, prior tests with a wet mannequin indicate that the cooling effect would be at least doubled ("Lab Test of APACS," p. 11). The result is that, if the occupant can vary airflow, he can increase or decrease the heat removal over a wide range, with the same results as changing the

temperature of the air. The study shows that the cooling effect range is up to 8°C or 14°F. In other words, with a room temperature of 28°C (82°F) an occupant can change his environment from the ambient temperature to 20°C (68°F) with full airflow, and he can do this without affecting his neighbor. This range offers enough variety to make everyone comfortable and happy under almost any circumstance. As the test data clearly show, it is not necessary to change the ambient temperature to provide personal comfort. The tests also show that it is practical to ramp the temperature up to utilize stored cooling in the building and to reduce peak demand as well as required equipment capacity.

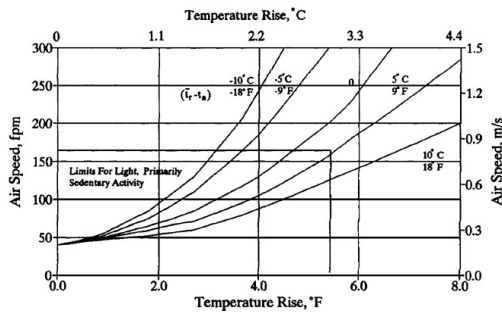


Figure 1

*Air speed required to offset increased temperature. The air speed increases in the amount necessary to maintain the same total heat transfer from the skin. This figure applies to increase in temperature above those allowed in the summer comfort zone with both  $t_r$  and  $t_a$  increasing equally. The starting point of the curves at 0.2 m/s (40 fpm) corresponds to the recommended air speed limit for the summer comfort zone at 26°C (79°F) and typical ventilation (i.e., turbulence intensity between 30% and 60%). Acceptance of the increased air speed requires occupant control of the local speed. [ANSI/ASHRAE 55-1992, p. 9, Fig. 3]*

**DESIGN**

The concept of using air movement for control instead of temperature change is not new. It has been used in airplanes and automobiles for many years. However, the limited space in vehicles, and the need to move sufficient air to effect the necessary cooling, results in too high a velocity, which feels drafty. In general there is not sufficient space to limit the velocity to an

average of less than 1 m/s (200fpm). This is approximately two miles per hour and meets ANSI/ASHRAE 55-1992 (see Fig. 1). In offices there is usually more than enough space to move sufficient air while adhering to the above limits.

In order to limit the air velocity as described above, to provide air to the occupants below room temperature, and not to lose the effectiveness of the moving air, the air must be discharged very near the person. The ideal distance is in the vicinity of 30 centimeters (one foot) or less. This proximity also provides the individual occupant with immediate response to changing environmental conditions or personal comfort preference.

Being close to the occupant also increases ventilation efficiency. ANSI/ASHRAE Standard 62-1999, "Ventilation for Acceptable Indoor Air Quality," (Second Public Review, August 2001), p. 6, suggests a zone air distribution effectiveness greater than 1.0 for low velocity displacement ventilation. This means a substantial reduction in required outside air and a very substantial energy saving. This arrangement permits the use of a simple manual damper control within easy reach of the occupant.

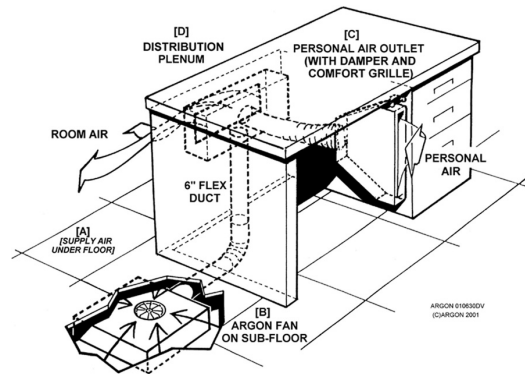


Figure 2

*Desk air terminal (vertical)*

Giving everyone personal control with a personal air outlet leads to a question: what to do with common space. A simple solution is to combine the personal outlet with a room outlet that keeps direct room air away from the occupant. The introduction of room air needs to be far enough from the occupant so that it

does not interfere with the personal control. The combined airflow is designed to meet the cooling load of the person, the workstation and the adjacent area. If properly designed, the occupant can turn off the personal air supply without materially affecting total airflow. With this arrangement total airflow is relatively constant. Overall room temperature is then controlled from a space thermostat which can control the capacity of the air handler to meet the load requirements (see Figs. 2, 3 and 4).

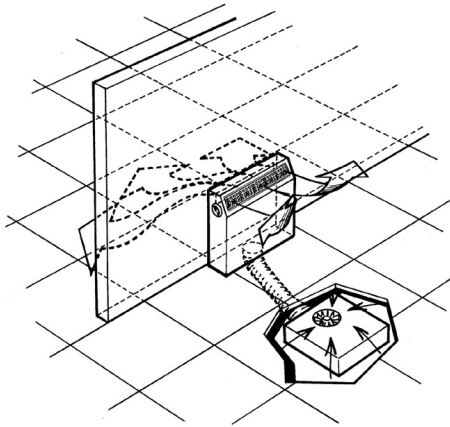


Figure 3  
Partition air terminal

The room outlet can be a floor grille outside the workstation, or a separate grille mounted either in the furniture or in a space partition pointing to open space. This outlet may also exhaust through the top of furniture partitions (as was done at the bank installation mentioned above). The latter arrangements eliminate floor grilles and leave the floor clear for furniture placement and easier housekeeping.

Fan air terminals are used in the access floor plenum 1) to produce the necessary static pressure for personal and room air outlets, 2) to eliminate air leakage out of the building (buildings are not airtight), and 3) to reduce distribution ductwork. They must be efficient, with low noise levels and a trouble free, long life. The additional energy use by these fans is offset by reduced energy consumption in the main air handler. The system reduces overall energy consumption by eliminating air leakage and reducing total fan horsepower because of greatly reduced ductwork. Additional reduced

energy consumption stems from the higher operating room temperatures and the reduced fresh air requirement.

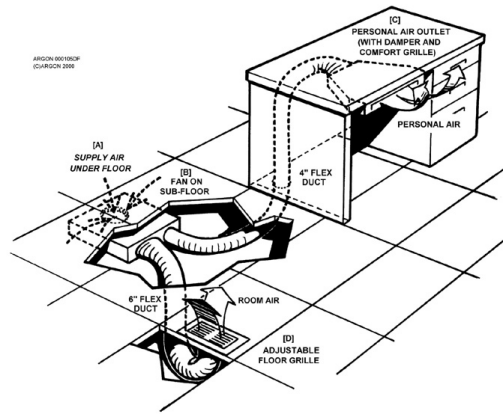


Figure 4  
Floor/desk air terminal (horizontal)

This arrangement also makes balancing the system much simpler. Fans can be added for additions in load at any time. For relocation and remodeling of workstations the fans can be easily moved, since there is no need to fasten them in place. They are simply located on the sub floor where needed.

ANSI/ASHAE 55-1992, Para 5.1.6.3, stipulates a minimum underfloor temperature of 18°C (65°F). When supplying air at this temperature through a cooling coil, it is difficult to properly control humidity and impossible to use ice storage. The best strategy is to design the air handler cooling section to suit the chilled water or dx system and to bypass sufficient return air to get the leaving air temperature up to the desired temperature. This approach can use face and bypass dampers to control humidity and eliminates all saturated air from the space. Also, elimination of mixing in the occupied space produces a cleaner environment. Particles lighter than air will float up to high air returns and the system filters, instead of being recirculated by secondary air movement.

#### CONCLUSION

The system described above will air condition individual people instead of the building. It thus will eliminate dissatisfaction with thermal conditions (the number one complaint in most offices), lead to greater productivity and reduce the greatest cost in any office building, the

payroll. By offering sustainability, reduced energy cost and a cleaner environment, it is the basis for a more efficient, more productive "green building."

#### ACKNOWLEDGEMENTS

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