# INDIVIDUAL AIR DISTRIBUTION CONTROL SYSTEM ON PARTITION PANEL AT PERSONAL TASK AREA

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## ABSTRACT

A general trend in intelligent buildings is the decentralization of environmental control systems. Decentralized environmental control systems have many advantages over centralized systems. In order to fully utilize a decentralized control system, the control zone should be completely individualized so that one occupant can feel free to adjust the air volume and temperature without being concerned about affecting the comfort of other occupants. A furniture integrated air distribution control system can provide highly individualized environmental control. The supply air is brought up through raised floors and supplied to outlets located on the partition panels. This paper aims to find out the proper location of outlets for the comfort of occupants within a personal task area. The supply air distribution of different designs for the personal task area were visually measured. Visual experiments of mock-ups were conducted on a fluid mapping table to allow comparison of various system designs. Experimental results indicate that the location of an outlet is the most critical factor in improving the supply air distribution efficiency of the personal task area.

## INTRODUCTION

Conventional HVAC systems of large office buildings supply air from the ceiling. This results in the inability to adjust the volume and direction of the supplied air according to the individual needs of the occupants. Another issue is the inability in removing excess heat generated from office equipment near an occupant's personal task area. Ironically, the environmental controls in an automobile are far superior to those of a building. Although people generally spend one to two hours per day inside an automobile, the occupants have the ability to control the volume, direction and temperature of supplied air.

There is a need to develop an individual air distribution control system for a personal task area in an office building to improve the air and thermal comfort of occupants. Thus, increasing the occupant's productivity. Based on these concepts, we developed a furniture integrated air distribution system to provide an individualized environment. In this system, supply air is brought up through raised floors and supplied to the occupant through outlets on the partition panels.

## METHODS

Several different designs for distributing supply air to a personal task area were visually measured. The experiments were conducted on a fluid mapping table where the various systems could be compared to one another. (See Figure 1.) Scaled plastic mock-ups of various plans and sections of a personal task area were constructed to determine proper

location of air outlets on partition panels of a personal task area. Because computational flow dynamics is very complex, the fluid mapping table was utilized to obtain immediate results for the first stage of experiments.

The top surface of the mock-ups was finished in clear plastic to allow illumination by a fluorescent lamp. The speed of the water's flow was controlled by the supply valve and the inlet for the ink was located at the upper portion of the water stream. The plan and section mock-ups were individually placed on the top surface of the fluid mapping table and ink was injected into the water. The ink made it possible to visualize the distribution of supply air from the various outlets of the different system designs.

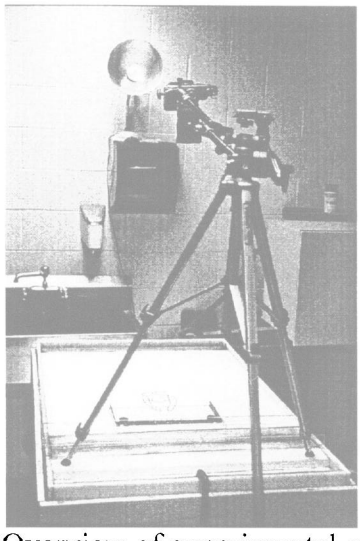


Figure 1. Overview of experimental equipment

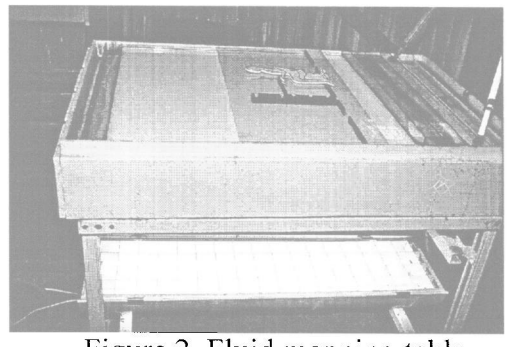
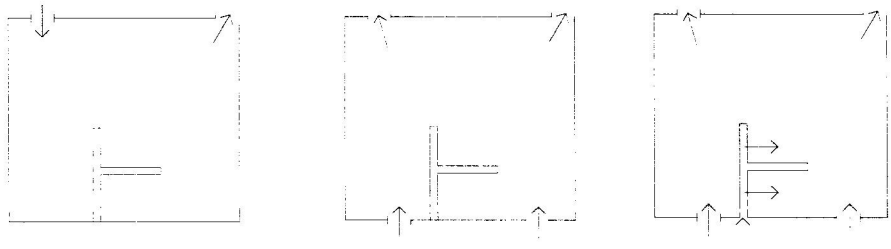


Figure 2. Fluid mapping table

## RESULTS

To make a comparison of three different air distribution systems - ceiling, under-floor and partition, a visual experiment was conducted on the fluid mapping table using mock-ups. Each mock-up consisted of three personal task areas and two return air grills located in the ceiling.



a: ceiling supply system b: under-floor supply system c: partition supply system

Figure 3. Concept diagram of air supply systems

### Ceiling supply system

In a ceiling supply system, air is supplied from the ceiling and returned back through the ceiling. Experimental results indicate that supply air cannot effectively reach every personal task area given the location of the supply and return grills in this conventional system.

Furthermore, air returns without reaching nearby occupants at their personal task areas, suggesting that energy is wasted. (See Figure 4.)

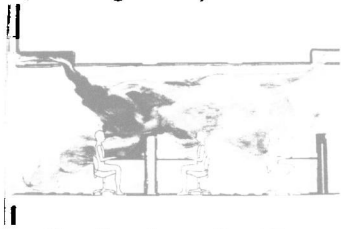


Figure 4. Air distribution of ceiling supply system

**Under-floor supply system**

Air distribution effectiveness of a raised floor was measured by varying the location of air supply grills. Four grills, each the size of a typical access floor module, were placed at various locations in the plastic mock-ups. In cases A and D, the grills were located near occupants. In such schemes, supply air efficiency proved to be high but air distribution efficiency varied according to the location of the return air grills. (See Figure 5 and 6.)

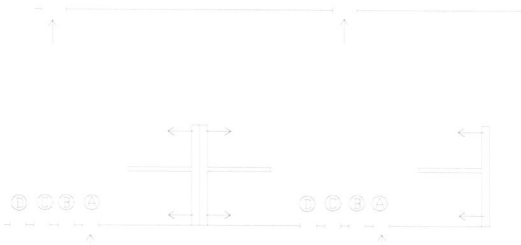
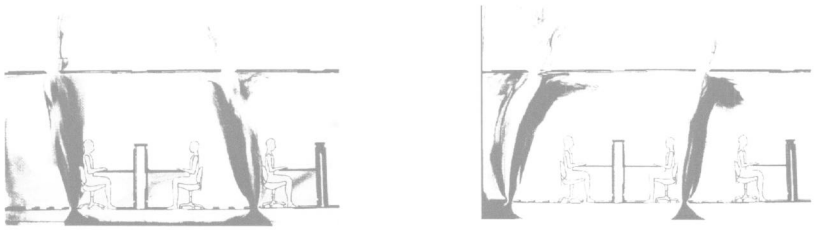


Figure 5. Outlet location of under-floor supply system

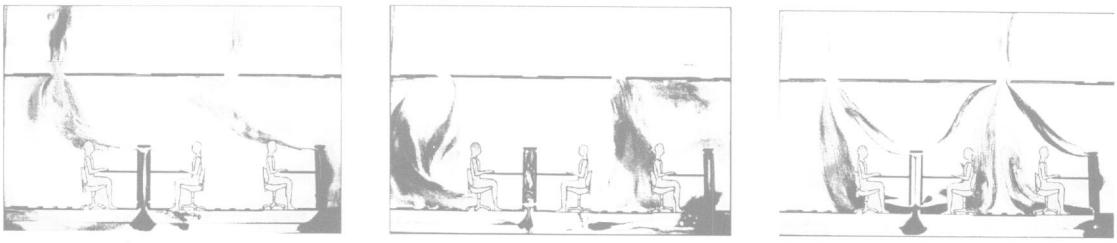


a: case A b: case D

Figure 6. Air distribution of under-floor supply system

**Partition supply system**

In a partition supply system, air is supplied to the personal task area through the partition panels by means of a raised floor and returned through the ceiling. In the case of an air outlet located solely above the task surface, air is supplied directly to the face of the occupant. Thus, occupant comfort level is low. When air outlets are located under the task surface, air is moved across the lower portion of the occupant and returned through the ceiling. In the case where an outlet is located both above and below the task surface, air is moved past the whole occupant. This layout of outlets is shown to be effective for a partition supply system. (See Figure7.)

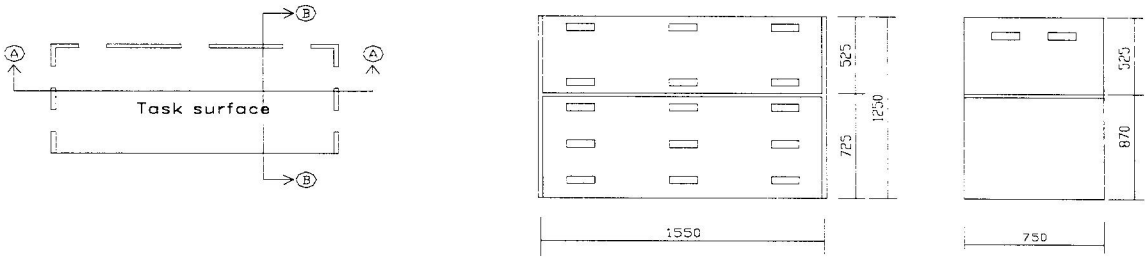


a: outlet above desk b: outlet under desk c: outlets above and under desk

Figure 7. Air distribution of partition supply system

**Air distribution of partition supply**

Experimental results indicate that a partition supply system is better than the other two systems in the distribution and ventilation of air. In testing alternative designs for the partition supply system, the location of outlets on the partition panels were disposed in order to determine an efficient design. We arranged three outlets on the front panel, two outlets on each side panel, two above the task surface and three under the task surface. Experiments were conducted to visualize the air distribution of the alternative outlet layouts. (See Figure 8.)

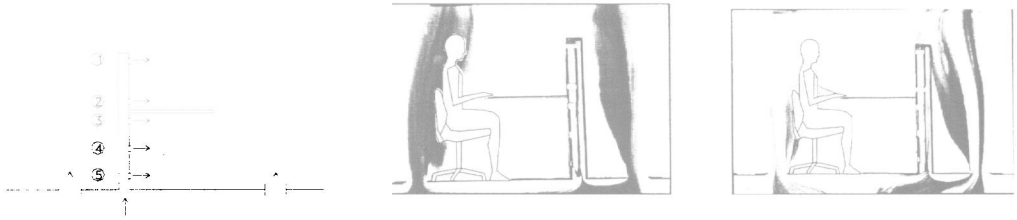



a: plan of task area b: front panel (A-A) c: side panel (B-B)

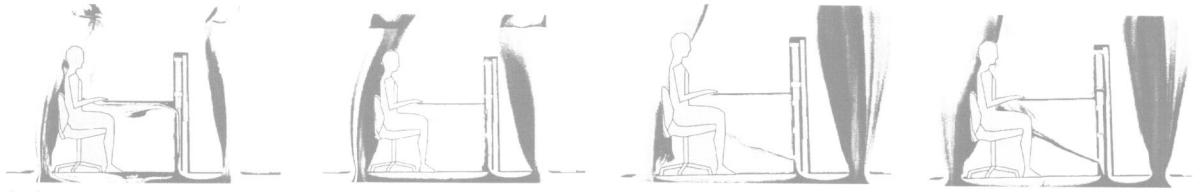
Figure 8. Outlet locations of partition supply system

**Air distribution according to outlet location - section mock-ups**

In order to compare the air distribution of outlets without direction adjustable grills, we tested six cases based solely on the location of outlets. These outlets were located on the front panel of the sectional mock-up along with under-floor supply outlets. (See Figure 9.)
The first and second outlets supplied air directly to the occupant's face. This resulted in a low comfort level suggesting those outlets be fitted with adjustable grills to redirect the direction of the supply air. The third and fourth outlets supplied air to the abdomen area of the occupant. This suggested possible discomfort for female occupants wearing skirts. The fifth outlet supplied air to the lower portion of the occupant. (See Figure 9.) This experiment indicated that two supply outlets, one above the task surface and one below the task surface on the front panel, would improve the comfort for the occupant.



a: outlets location in section b: the case of 1st outlet c: the case of 2nd outlet



d:the case of 3rd outlet e:the case of 4th outlet f:the case of 5th outlet g:the case of 1st and 5th outlets

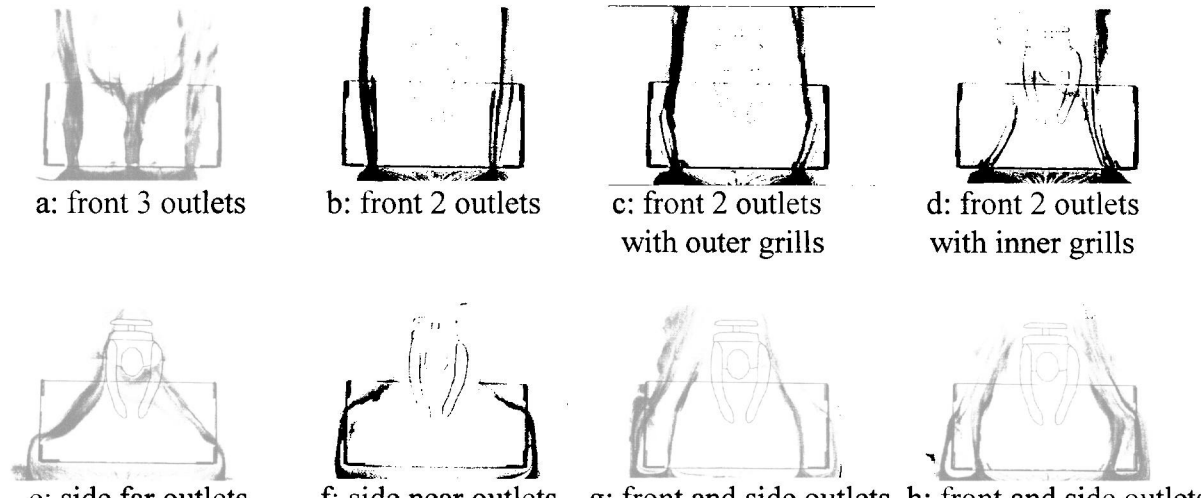
Figure 9. Air distribution according to outlet location

**Air distribution according to outlet location - plan mock-ups**

In examining air distribution from front panels, we compared the cases of panels consisting of three outlets and two outlets. In the case with three outlets, although the air speed was low, its distribution directly to the occupant's face suggested a low comfort level. In the case with two outlets, the center outlet removed, the effect was similar to that of the previous case with the exception of air being directly distributed to the occupant's face. Experimental results suggested that the case with two outlets is more efficient than the case with three outlets in respect to occupant's comfort. (See Figure 10.)

For side partition panels, three cases were considered. The first case consisted solely of outlets placed far from the occupant. In this case, air travels some distance before moving across the occupant's body. In the second case, outlets were placed near the occupant. This resulted in air being distributed to the side of the occupant's body. The third case incorporated both near and far outlets. The result was similar to that of the first case. (See Figure 10.)

The key variable affecting the efficiency was the location of the outlets on the partition panels. Therefore, we suggest utilizing two outlets on the left and right side of the front partition panel and placing outlets near the occupant on the side panels. To further increase the comfort of the occupant, the outlets should consist of operable directional grills that the occupant can control to open, close, and redirect the supply air.



a: front 3 outlets b: front 2 outlets c: front 2 outlets with outer grills d: front 2 outlets with inner grills

e: side far outlets f: side near outlets g: front and side outlets h: front and side outlets with outer grills

Figure 10. Air distribution of outlets

## CONCLUSION

In the study, comparisons were made between three means of air distribution - ceiling, under-floor and partition air supply systems. Experimental results suggest that the partition air supply system is more efficient than the ceiling supply system in terms of cooling and heating. The results also suggest that the under-floor supply system is more efficient than the ceiling supply system in heating. Because occupants cannot individually control their air supply and thermal comfort utilizing a conventional ceiling air supply system, such control needs to be transferred to the occupants through the use of a partition air supply system. Such a system will allow an occupant to individually control their immediate environment, resulting in higher productivity. We suggest locating outlets on both the right and left side of the front partition panel and near the occupant on the side panels. These outlets should have operable directional grills that the occupant can control for comfort.

Finally, a key issue that remains to be addressed is the fact that the experiments were conducted using mock-up scale models on a fluid mapping table. In order for this individual air distribution control system to be feasible, it must demonstrate the ability to efficiently and economically increase occupant comfort under real conditions and during various times of the year.

## REFERENCES


1. Arnold, D., *Raised Floor Air Distribution-A Case Study*, ASHRAE Transaction, Vol. 96,2,1991.

2. Faulkner D. et al., *Indoor Air Flow and Pollutant Removal in a Room with Desk-Top Ventilation*, Lawrence Berkeley Laboratory,LBL-34010,1993.

3. Faulkner D. et al., *Indoor Airflow and Pollutant Removal in a Room with Floor-Based Task Ventilation : Results of Additional Experiments*, Lawrence Berkeley Laboratory,LBL-36131,1994.

4. Fisk, W. J. et al., *Indoor Air Flow and Pollutant Removal in a Room with Task Ventilation*, Indoor Air, Vol. 3, p. p.247-262, 1991.

5. Kim, Jong-Jin, *Intelligent building technologies: a case of Japanese buildings*, The Journal of Architecture, Vol. 1, Autumn 1996.

6. Sodec, F. et al., *The Under-floor Air Supply System- The European Experience*, ASHRAE Transaction, Vol. 96, 2, 1991.