The use of personal ventilation in open plan offices: a study of the TASK AIR system

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ABSTRACT: This paper presents preliminary findings of a study into the impact and effectiveness of Personal Ventilation (PV) in open plan offices. PV is a generic descriptor for desk- or workstation-mounted air-conditioning registers that deliver conditioned air directly to the breathing zone of office workers. PV systems have the potential to improve occupant comfort by increasing individual control over air conditioning outlets as well as by improving indoor air quality at the point of use. They may also have the potential to reduce energy use by reducing the amount of conditioned air delivered to a workspace. While there are some laboratory-based studies available for PV systems, no published data is currently available for field applications of this technology. This paper is based on a study carried out in association with an Australian furniture manufacturer which has developed a PV system integrated with an office workstation known as ‘Task Air’. The workstation uses the inside of the panels as a plenum space for delivering conditioned air to eyeball-style vents located in front of the user. The current study is based upon an office fitout of 140 Task Air workstations for a government department in Brisbane, housed within a typical modernist style office block. The study consists of measurements of temperature differentials across a number of workstations, as well as questionnaires distributed to occupants regarding comfort levels and frequency of use of the PV outlets. The findings will be used to develop further research into impact and effectiveness of PV as an alternative to traditional air-conditioning systems.

Conference theme: Human

Keywords: Personal Ventilation, Thermal Comfort

INTRODUCTION

Personal ventilation has for many years been suggested as an alternative to traditional air-conditioning systems. Laboratory testing has been carried out testing alternative delivery systems as well as testing user responses to the usability and air quality resulting from such systems. However, field testing of PV systems has not been undertaken, mostly due to the lack of commercially available systems installed in the workplace.

In Australia, furniture company UCI has recently developed a PV system, known as ‘Task Air’ (figure 1). The unique aspect of this system is that it is integrated with an office workstation, using the panels of the workstation as a duct for delivering air to occupants. One of the first large scale clients for this product was a Government department located in Brisbane, Australia, which was fitted out with approximately 140 Task Air workstations in 2008. The department chose to install the workstations because of the potential benefits of increased worker comfort and satisfaction as well as their potential to reduce energy usage and improve the environmental performance of the
The department agreed to take part in a preliminary study of the installation in late 2008, and this paper presents the results of that study.

The name Task Air is derived from its similarity to task-lighting, where low level background lighting is complemented by user controlled desk lamps to provide higher lighting levels as and where needed. Similarly, Task Air delivers air directly to workstations, complemented by ‘background’ air-delivery for circulation and other common spaces. The benefits of Task Air are likely to be similar to those of task lighting, namely reduced energy use, a more varied environment, reduced strain from uniform levels for all occupants, and greater comfort arising from greater user control. By delivering air only to where the occupants are, there is potential system efficiency over traditional systems which deliver air to all parts of the space. This may also result in a more varied thermal environment, with ideal temperatures at the workstation complemented by slightly warmer or slightly cooler temperatures in less frequently used spaces such as circulation or storage areas. This may help to alleviate fatigue or ‘thermal boredom’ associated with exposure to constant temperatures (Kwok, 2000). The supply of clean air near to the breathing zone has the potential to improve inhaled air quality which may help to improve worker performance. And, most importantly, it gives occupants a degree of control over their personal thermal environment by allowing them to adjust air-flow rates and direction at any time.

The key innovation of the Task Air system is that it incorporates Personal Ventilation into the structure of a traditional office workstation, using the panels as a plenum space to deliver air from traditional ceiling- or floor-mounted ducts directly to the workstation. This avoids the problem with most air-conditioning systems, which is that the layout of air-conditioning registers is usually designed prior to, and independently of, the layout of workstations, resulting in uneven air delivery to occupants. The main reason for this is that air-conditioning is usually considered part of the infrastructure of the building, designed, installed, and maintained by the building owner, while furniture tends to be the responsibility of the tenant. The integration of the air-conditioning and furniture systems evident with Task Air represents a radical variation from the usual demarcation of ownership and responsibility between these two parties, providing a flexible and adaptable system that can be changed to suit the needs of the occupants.

Figure 2: Close-up of eye-ball vent in workstation

Personal Ventilation systems are common in airplanes and motor vehicles, where the known seating position of passengers combines with available space overhead or behind the dashboard to make it easy to deliver air to every person. The difficulty of office designs is that seating positions may be varied in both space (more people in one place than another) and in time (people move in and out throughout the day, and office layouts may be changed over a period of several months to several years).

Existing Research

The benefits of PV have been demonstrated in a number of laboratory settings. When correctly designed, PV can supply air to the breathing zone such that 100% of the breathed air comes from the outlet and not from mixed air in the space (Melikov et al. 2002, Bolashikov et al. 2003, Faulkner et al. 2004, Niu et al. 2007, Cermak et al. 2006, etc.). This has the potential to decrease the risk of airborne transmission of infectious agents (Seppanen and Fisk 2004, Cermak and Melikov 2007, Nielsen et al. 2007). By providing cool and clean air directly to the breathing zone of inhabitants, PV can improve thermal comfort and perceived air quality (Melikov 2004, Kaczmarczyk et al. 2004, 2006, Melikov and Knudsen 2007, Melikov et al. 2008, Melikov and Kaczmarczyk 2008). Greater control over the movement of air in the breathing zone can also contribute to improved occupant satisfaction (Bauman et al. 1993). There is also the potential for substantial energy savings by using PV (Seem and Braun 1992, Sekhar et al. 2005, Schiavon and Melikov 2008). However, while these results demonstrate positive benefits from PV in laboratory settings, there is little published evidence of their effectiveness in workplace settings.
The Task Air Studies

Figure 3: Installed workstation at the proposed fieldwork site.
(Outlets can be seen as black circles on the panel)

The above methodology was applied to the study of Task Air workstations installed in a State government department (Main Roads) occupying two floors of a commercial office building near the Brisbane CBD. Both floors have recently been renovated by UCI, including installation of Task Air workstations throughout the open plan offices. The study consisted of the measurement of temperatures at 5 workstations across the width of the building for a period of four weeks during September-October 2008. Unfortunately energy use data for the floors in which Task Air units were used was not available.

Set points for the installation are 5l/s/diffuser with two diffusers per workstation. Diffusers are designed to be at chest height for a seated person. Air delivery temperature is 15°C intended to provide 60W of cooling per person. Ambient conditions are designed in the range of 25-27°C, which allows the Task Air system to provide cooling and thus improve conditions at the workstation.

Figure 4: Plan showing locations of dataloggers.
Survey results

A brief questionnaire was distributed to occupants by the manager of the department, with a relatively low response rate \((n=17)\). The questions used a 5-point Likert scale as shown in Figure 5. Responses showed that the air outlet was easy to use \((1.7)\), the temperature at the workstation was comfortable \((2.2)\) and the airflow at the workstation was comfortable \((2.0)\).

<table>
<thead>
<tr>
<th>Response</th>
<th>Strongly A</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly D</th>
</tr>
</thead>
<tbody>
<tr>
<td>The air outlet is easy to use</td>
<td>6</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The temperature at my workstation is comfortable</td>
<td>3</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>The airflow at my workstation is comfortable</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 5: Questionnaire responses

User comments indicate two different types of adjustment techniques. The first are what could be called ‘static’ techniques, allowing the user to direct the air to a position that suits them best and leave it there without further adjustment (eg *Have directed outlet to behind computer away from face*). The second are what might be called ‘dynamic’ techniques, such that the user is able to open or close vents in response to particular conditions or problems (eg *At times temperature has been too cold & vents had to be closed*). These two options correspond to the response to question 4 regarding frequency of adjustment (figure 6).

Datalogger results

Datalogger results generally show localized temperature variation at each workstation throughout the day, as well as slight temperature variation across the space of around 0.5°C. If the vents are being used to affect local conditions, it might be expected that temperature at a particular workstation might vary against the general pattern across the
building. While there is some evidence of this occurring, e.g. as indicated in Figure 8, it is uncertain as to whether this is due to adjustment of the outlets or other factors. To understand the localized effects of individual control over registers, it will be necessary to undertake temperature measurements in a location closer to the breathing zone, and to correlate these measurements with observational data regarding user control.

CONCLUSION

This is a preliminary study only, and more detailed study is currently being developed for implementation in 2010 in association with Professor Arsen Melikov of the Technical University, Denmark. This extended study will examine comfort levels achieved with PV in response to seasonal change throughout the year, along with a more detailed assessment of the usability of the system. With installations of the Task Air system now available in other capital cities, the study will compare the effectiveness of the system in different climate zones across Australia. By installing individual metering to floors with and without Task Air workstations, comparison will also be possible between the energy use of a PV system and that of a typical air-conditioning system. The study will also aim to assess the potential contribution to overall building sustainability, and the potential points value to rating systems such as GreenStar.

Until that study is carried out, the above results appear to indicate that PV in the workplace is able to live up to its promise of improved comfort and control. The main advantage appears to be the option of either static or dynamic control options: either setting the outlets to a preferred position and leaving them in place (e.g. away from the face) or using them to direct air toward or away from the body in response to temporal changes (e.g. the body feeling warm due to activity or the space feeling too cold due to high background levels). Informal responses from occupants – unfortunately not reflected in the surveys – indicated that the air felt more ‘fresh’ than with the previous air-conditioning system. Such advantages are likely to make PV an important alternative as we look to improve the environmental performance of our buildings in the future.

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REFERENCES


