Energy and Comfort Characteristics of User-Controlled Localized Environmental Systems (UCLES)

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1. Introduction

During the last few years, an increasing interest in user-controlled, localized environmental systems has emerged. In the specialized technical literature such systems are referred to as local thermal distribution systems, task ventilation systems, personal environment units or occupant-controlled systems. In the present paper the term **U**ser-**C**ontrolled, **L**ocalized **E**nvironmental **S**ystems (UCLES) is used.

According to this environmental control philosophy, building users are allowed to adjust their microclimates in response to individual preferences and perceived comfort conditions. UCLES are designed to effect local/zonal control near the occupant rather than environmental tempering of the total space normally provided by conventional environmental centralized systems. Moreover, they seek to provide individual control for each occupant and respond to variations in the perceived ambient conditions (air temperature, humidity, airflow speed, sound, and light) caused by changing occupancy patterns and internal heat gains during the working period. For objective reasons (which will be discussed later on), the current focus is on the application of UCLES in office buildings.

The development of UCLES has preceded the evolution of the modern electronic office which demands different environmental control to that provided by conventional systems. There are a number of factors which are important for choosing effective environmental systems for modern offices:

(i) conventional systems are not designed to take account of the high sensible heat gains at spot zones due to a variety of electronic hardware;
(ii) open-plan offices bring together into the same space and environment, different occupants performing a range of diverse tasks. Each employee, however, would probably prefer discrete conditions matching his/her subjective sensation of comfort and health throughout the work period;
(iii) the rapid technological and organizational changes in companies, as well as frequent relocations due to fast development and growth, require flexible environmental systems which can be altered to match the needs of changing occupants;
(iv) growing awareness of employees and employers about comfort and health conditions at the workplace, and the adverse implications for the productivity of workers if proper conditions are not provided; and
(v) the huge amount of power and communication cables which

often require raised floors to be installed; the resulting floor void lends itself as an accommodation for services cabling and conditioned air distribution facilities.

UCLES provide effective remedies to some of the above adverse effects of the modern office characteristics, and benefit from high-tech opportunities now available.

2. Description and Application

A few UCLES are already found at various stages of development. Different systems are distinguished from each other by certain operational and control features such as the environmental elements which the system can control, the method of supply of conditioned air, and the technology used for control.

In this paper, two systems are presented for the sake of acquaintance with UCLES. Both are still at an early stage of development. The first is the Personal Environment Unit (PEM) of Johnson Controls (Johnson Controls, 1988). The system comprises two air vents mounted on either side of the desk in a typical modern workstation. A control panel at desk level lets the user adjust the temperature as well as the quantity and direction of the air. A radiant heating panel under the desk, also controlled by the employee, supplies additional warmth to the lower part of the body. Task lighting can be modulated from the control panel and adjusted for the kind of work being done at the moment. A white noise generator providing a sound like a rush of air masks other background noise, thus allowing extra privacy. An occupancy sensor is used to shut off al unnecessary equipment, thus maximizing energy conservation. Basically, the PEM acts as a variable air volume (VAV) system for each person with a primary air supply of 13 C and discharge temperatures in the range 16-26 C. Raised floors and/or vertical chases in partitions can be used for distribution of conditioned air between different spaces in the building.

The second UCLES presented here is the Environment 2000 system manufactured by Atlas Compac Ltd. (Atlas Compac, 1989). A raised modular floor of about 220 mm height is provided above the floor slab to create a plenum through which primary air may be delivered from any conventional airconditioning system. It is the secondary conditioned air supply terminals which form the heart of the system. The bulk of the secondary air supply is provided by the Air Treatment Terminals (ATTs). Supplementary supply of cooled air for the personal comfort of occupants is provided by Individual Environment Controllers (IECs). The primary air is returned to the primary air handling unit through a ceiling void which need be no more than 200 mm in height. Users of Environment 2000 are able to control the temperature and direction of the discharge air. The number of ATT units needed in a space is determined by the total load. Usually, these are located adjacent to workstations.

3. Aims of Research

3.1 Verification of UCLES Advantages

From the limited operational experience with UCLES, the following advantages seem to be likely but need to be verified by an objective field study, namely:

(i) UCLES introduce conditioned air directly to locations where the heat load from electronic peripherals is generated;
(ii) they have the potential for creating good air circulation in the conditioned space, by spreading the supply over the floor area or the space rather than in fixed spots;
(iii) they enable the introduction of supply air directly to the occupancy zone, thus preventing inconvenient thermal stratification;
(iv) they provide individual control for occupants so that they can control their conditions, not only in response to thermal sensation, but to psychological and other subjective needs as well;
(v) they offer the flexibility required from environmental systems when reshaping the workplace in response to new technologies and changing needs of the occupants.

Despite these apparent advantages, further development and application of UCLES is dependent on various characteristics which have not been explored yet.

3.2 Principal Research and Development Needs

Research is needed to explore the energy and comfort characteristics (Arens et al., 1990; Fisk et al., 1990), and the effectiveness of UCLES, namely:

(i) to explore the energy saving potential of UCLES under a variety of performance conditions;
(ii) to study the implications of UCLES on indoor air quality;
(iii) to study the relationship between local fresh air supply rate and odour concentration;
(iv) to develop an understanding of total comfort (i.e. thermal, light, and sound) of occupants under "real" dynamic working conditions;
(v) to develop a monitoring and self-assessment electronic facility (i.e., sense diary) attached to UCLES; and
(vi) to develop a tangible quantitative correlation between productivity of workers and the perceived environmental conditions at the workplace.

An extensive research programme has been launched in our department to study the above issues. Our goal is to gain better understanding of the field performance of UCLES. The findings of the research will enable us to devise the salient features of improved UCLES prototypes.

4. Conclusions

User-controlled, localized environmental systems have a very good potential for environmental control in office buildings. They are most suitable for use in workstations equipped with high

heat-generating electronic peripherals.

However, there are still various aspects of UCLES to be explored before this new environmental control strategy can be implemented on a big scale.

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