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THE IMPACT OF BUILDING MANAGEMENT STRATEGIES ON OCCUPANT PERCEPTION OF INDOOR AIR QUALITY

E.N. Light ¹, M. Tyson ², F.J. Sisson ³, R.D. Gay ⁴

¹ Contract Environmental Hygienist, U.S. Public Health Services Region III Division of Federal Occupational Health, USA

² The McClure Co., Harrisburg, Pa, USA

³ U.S. General Services Administration National Capitol Region, Washington, D.C., USA

⁴ Pathway Diagnostics, Reston, Va., USA

ABSTRACT

The Indoor Work Environment (IWE) Study was conducted to identify relatively inexpensive means of improving HVAC operation and communications with occupants. Four large office buildings were selected for the study. Enhanced HVAC operational strategies were implemented in two buildings to improve comfort and ventilation. In addition, complaint response programs were also enhanced in two buildings. Occupant perception of the building environment was measured by questionnaire at the beginning and end of the five month study period to help characterize occupant concerns and to estimate how they were impacted by changes in building management.

Underlying reasons for occupant dissatisfaction appeared to involve a variety of comfort, health, and social concerns. Major improvements in HVAC operation resulted from operator training and waivers from Federal Energy Conservation Regulations. Final questionnaire results showed significant improvements in comfort and greater recognition of building management responsiveness.

INTRODUCTION

In a large office building where occupants perceive poor IAQ, there is rarely a simple cause. Comprehensive IAQ investigations have found that, when occupants perceive the building is making them ill, the problem may be multi-factorial in nature, often including discomfort, stress, and the association of unrelated health problems with air quality (1-4). This presents a most difficult challenge to the facility manager who must correct legitimate IAQ deficiencies and maintain occupant satisfaction (5).

Two often neglected elements of building management are HVAC operation and communication with occupants, particularly in the context of complaints. HVAC systems are commonly operated in a manner which leads to underventilation and/or thermal discomfort, even where the design of the system is adequate (6). Where this occurs, occupants may be more aware of deficiencies relating to comfort than ventilation (7,8).

Less than optimal operation of HVAC equipment may result from lack of engineering oversight, inadequate operator training, or energy conservation measures (6). In the United States, restrictions on the operation of HVAC systems in federal facilities have been in place since 1976 to help meet energy conservation goals. The basic regulations (9) include minimizing energy use by lowering space temperature in the winter (less heating), raising it in the summer (less cooling), prohibiting humidification, prohibiting simultaneous operation of heating and cooling equipment (can be used to provide more accurate zone temperature control), and allowing ventilation to be reduced to 2.4 liters per second per person (L/s.person)(five cubic feet per minute per person). Such energy-saving measures may adversely impact comfort and ventilation.

HVAC systems in large office buildings are complex and require the cooperation of occupants to function properly. For example, over adjustment of thermostats or blockage of vents can result in uncomfortable conditions even where the system is well-operated (6). The manner in which facility management responds to complaints is critical both to the control of legitimate IAQ problems and to resolution of occupant misconceptions regarding the building environment (5).

IAQ has become an important issue to occupants in a growing number of federal office buildings in the U.S. over the past decade. The Indoor Work Environment (IWE) study was funded by the U.S. General Services Administration National Capital Region in a joint effort with the U.S. Public Health Service Region III Division of Federal Occupational Health to better understand occupant IAQ concerns and to develop practical approaches for their resolution. The project was initiated to test the following hypotheses:

- o That operation of in-place HVAC equipment could be upgraded to provide enhancement of comfort and ventilation;
- o That response to occupant complaints could become more effective; and
- o That occupant satisfaction regarding their building environment would improve after the above enhanced measures were implemented.

METHODS

Four federal office buildings in the Washington, D.C., area with occupancies ranging from 1000 to 2200 were selected for study. Each building was constructed (or modernized) between 1954 and 1964. HVAC systems were constant air volume with supply air delivered through induction units (one facility), overhead diffusers (two facilities), and a combination of both (one facility). All buildings had a history of thermal problems and a reputation among some occupants as being a "sick building".

The first step in the IWE study was to develop a detailed profile of each building's HVAC system, general building conditions, and management's interaction with building occupants. Enhanced building operation measures were then designated based on improvements which were feasible within the existing facility budget. Changes were allocated between the buildings as follows:

Building	Enhancement: HVAC Operation	Complaint Response	Occupant Education	Control (no change)
A	X	X	X	
B	X			
C		X	X	
D				X

Following implementation of the changes, the buildings were tracked for five months.

Measures developed for improving comfort and ventilation in Buildings A and B included modifications of outside air damper openings, controls strategies, and fan schedules. These changes necessitated enhanced training of the HVAC operators and variances from energy conservation requirements. Enhanced complaint response in buildings A and C involved providing operators with systematic trouble-shooting strategies and setting guidelines for communicating with occupants. These were implemented after a training session for facilities and HVAC personnel.

Questionnaire Administration

Self-administered questionnaires were completed by occupants throughout each building at the beginning, in the middle, and at the end of the IWE study. The questionnaires were designed both to learn about an occupant's perception of his or her work environment and underlying sources of those perceptions. Approximately half the questions were taken from a NIOSH questionnaire designed for the Library of Congress which had been previously validated. (10).

Questionnaires were distributed to approximately one-fourth of each building's occupants located in representative areas throughout the facility. The rate of questionnaire return per building was well over 60% in most cases.

A complete statistical evaluation of all questionnaire results was beyond the scope of this project. Chi-squared tests were calculated for changes in six measures of occupant perception.

RESULTS

HVAC operational improvements which were implemented and successfully demonstrated in Building A and/or B included:

- o Implementation of new fan schedule to assure proper space conditioning during occupied hours.
- o Increase in minimum outside air intake (dampers originally shut during warm and cool weather) to admit 9.4 L/s.person (20 cfm/person).
- o Higher winter HVAC hot water temperature to allow better control of the building.
- o Balancing part of the building.
- o Improving AHU supply air control through use of control panels.
- o Activating reheats (one zone only).

Enhancement of the complaint response program was implemented and successfully demonstrated at Building A. This included:

- o Prompt and courteous response to occupant concerns.
- o On-site measurement of space conditions, sharing information with occupants.
- o Systematic trouble-shooting of mechanical problems.
- o Follow-up discussion with occupants.

The questionnaire administered to building occupants covered 36 separate issues. Results for selected questions involving general building satisfaction and perception of IAQ factors before and after the IWE study measures were implemented in Buildings A, B, and C are summarized below:

Table 1. Percent Questionnaire Response (Before/After)

Building: N:	A 451 / 419	B 180 / 115	C 311 / 176	D 162 / 100
Issue				
"Too Hot"	40% / 26%	56% / 38%	51% / 34%	44% / 42%
"Too Stuffy"	46% / 36%	49% / 33%	57% / 44%	52% / 57%
"Air Quality" ¹	45% / 39%	50% / 43%	59% / 55%	60% / 48%
"Uncomfortable" ²	40% / 36%	63% / 51%	62% / 57%	57% / 56%
"Reduced Work" ³	31% / 27%	51% / 42%	59% / 41%	47% / 41%
"Not Satisfied" ⁴	34% / 23%	63% / 37%	60% / 44%	66% / 56%
"Maintenance Slow" ⁵	22% / 11%	41% / 35%	39% / 34%	43% / 42%
"Management Poor" ⁶	32% / 21%	48% / 46%	52% / 42%	54% / 54%

KEY

¹"Air Quality Causes Building Related Symptoms", ²"Many Uncomfortable in Building", ³"Building Environment Has Reduced My Ability to Work", ⁴"Not Satisfied with Overall Physical Environment of Building", ⁵"Maintenance is Slow or Not Responsive", ⁶"Building Management's Effectiveness is Poor"

DISCUSSIONUnderlying Causes of Perceived Poor IAQ

Questionnaire results in all four buildings indicated a high rate of occupant dissatisfaction with their work environment. For example, approximately half the occupants polled agreed with the following statements throughout the study period:

- o "I have been made ill by the building because of poor air quality."
- o "Many occupants in this building are uncomfortable."
- o "The building environment has reduced my ability to work."

Continuing observations made over the course of this demonstration project suggest that a variety of factors, some real and some perceived, contributed to occupant dissatisfaction. These included deficiencies in ventilation, comfort control, lighting and noise, relatively minor problems involving sanitation and source emissions, unrelated illnesses blamed on IAQ, stress, job dissatisfaction, and strained relations between management and occupants.

Questionnaire results throughout the study period indicated over three times the number of occupants got their information on building conditions from non-management sources (fellow employees, union, media, etc.) than from GSA or their agency's facilities office. Misinformation was thus another underlying cause of negative perceptions about the building.

Improved Occupant Satisfaction

The following table summarizes statistically significant improvements in occupant perception based on a comparison of questionnaire results from the beginning and end of the IWE study (less any improvements in control Building D).

Table 2. Improvements in Occupant Perception

	Building A	Building B	Building C
Many uncomfortable	NS	NS	NS
Too stuffy	-10%	-19%	-12%
Too hot	-14%	-17%	-17%
Management Responsiveness	+12%	NS	NS
Management Effectiveness	+14%	NS	NS

Note: All improvements listed have less than a 5% chance of being due to chance.
NS = Improvement from first to third survey not significant.

These results suggest significantly less complaints at all three test buildings in terms of too hot and too stuffy and at Building A in terms of better management response and effectiveness. No significant improvements were noted in control Building D. Occupant perception of other work environment variables not enhanced by the IWE study generally remained relatively stable from the beginning to the end of the study period (e.g., noise, privacy, and lighting response).

Enhanced HVAC Operations

Despite problems involving the aging and reconfiguration of the three test buildings, each appeared to be capable of providing adequate ventilation and temperature control under most conditions. HVAC changes during the IWE study focused on operational strategy and complaint trouble-shooting. Increased minimum outside air damper settings and upgraded controls were found to improve ventilation and pressurization. Specific changes made which appeared to improve overall comfort included adjustment of supply air temperature control, space pressurization, air handler fan schedules, and air balancing.

Conflicts with Energy Conservation Measures

During the course of this study, it became apparent that there were fundamental conflicts between federal energy conservation requirements and IAQ (both in terms of comfort and ventilation). For example, prior to the IWE study, the following problems had been experienced in Building A due to energy conservation restrictions on HVAC operation:

- o Overcooling in the winter and overheating in the summer due to limits on thermostat set points.
- o Closing outside air dampers under some weather conditions.
- o Lack of pressurization and supply air because low ventilation rate not compatible with AHU design.
- o Inadequate space temperature control, particularly in the spring and fall months (limitation on simultaneous heating and cooling).
- o Start-up of HVAC systems too late for achieving comfortable conditions during morning occupancy.

Operation of Building A and B without regard for federal energy conservation regulations resulted in improved comfort and ventilation through increased minimum outside air, activation of reheats, and maintaining space temperatures within the optimum comfort zone as much as possible.

Enhanced Complaint Response

While each test building already had a mechanism to receive complaints, several new measures were successfully demonstrated. These helped to resolve the building problem (where there was one) but also helped to improve relations with occupants and their perception of the building environment.

Previous to the study, Building A operators frequently responded to the same complaint several times before the problem was resolved. Parts were adjusted or replaced without evaluation of the system as a whole. As part of the study, operators systematically evaluated the entire system serving the troubled zone, checking all possible variables. At Building A, fewer repeat complaints were reported by facilities management by the end of the study.

Training - The Critical Ingredient

Training operators in HVAC fundamentals and site specific operating strategies was most effectively introduced at Building A. Building management found this contributed to both more intelligent system operation and more efficient trouble-shooting.

In addition to better training for building management staff, the IWE study also recognized the need to train building occupants as to their responsibilities for achieving good IAQ. An occupant education plan was developed during the IWE study but could not be fully implemented due to time constraints.

STUDY LIMITATIONS

Improvements could not be related to specific measures because the study design involved enhancement of several factors simultaneously. Due to the relatively short monitoring period, mild weather, and lower response rate to the final questionnaire, any trends must be considered preliminary. After the five-month study period, occupant dissatisfaction remained relatively high in some respects. Many building management modifications were not completely implemented due to the voluntary nature of the program and limited time frame. Also, long held beliefs about a building may not be expected to change immediately after conditions improved due to lingering mistrust among occupants.

CONCLUSIONS

This investigation demonstrated that typical federal office buildings can be made more comfortable and the building environment more acceptable through relatively inexpensive changes in HVAC operation and complaint response procedures. Keys to these changes were improved operator training and exemptions from energy conservation regulations.

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