rate and the emergence of virulent drug-resistant TB strains, the technique may be coming back into its own.

In upper-room UV irradiation, inexpensive mercury arc lamps aim a short wavelength UV-C light in the upper room above occupants' heads. UV-C, more biologically active than either the more familiar UV-A or UV-B, penetrates matter less. While it is much less damaging to human tissues than the other forms of UV light, UV-C is very effective on airborne particles because of their small size.

The main benefits of upper-room irradiation, according to Nardell, are that it is inexpensive, can cover large areas, and can be used in almost any setting where persons with suspected or unsuspected TB — or other infectious diseases — congregate. Thus, the devices could be placed in hospital waiting rooms and corridors, and even in non-health-care settings. Referring to his previous example of possible disease transmission in auditoriums or theaters due to reduced ventilation, Nardell says these would be ideal locations for upper-room UV-C irradiation. Another possible location would be schools. While TB hasn't proven a particular problem in schools, it is still a concern, and the UV irradiation could prevent the spread of other airborne infectious diseases.

While some IAQ engineers have considered in-duct UV light for controlling disease transmission, that strategy has several drawbacks. On the plus side, it does remove any danger to occupants from the UV light and it does eliminate or reduce room-to-room transmission. However, it doesn't affect transmission within the room, often the very place where infection takes place.

New Research

Since the arrival of anti-TB drugs in the 1940s, researchers have paid scant attention to the efficacy of upper-room irradiation. All that has changed. A new research project, of which Nardell is part, will study how well the technique works in homeless shelters across the US. Already underway in New York City, the placebo-controlled research program will expand to a total of six cities over five years.

The goal is to see whether the technology can reduce TB transmission within the facilities, with a secondary goal of developing engineering guidelines for using UV light more effectively. At the same time, other researchers from the Harvard School of Public Health and the National Institutes of Health are applying computational fluid dynamics to the problem to see whether they can predict air disinfection in the breathing zone, based on the movement of air in the irradiated space.

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PRACTICAL RESEARCH BRIEFS

Study Indicates VAV Doesn't Necessarily Mean Poor Air Exchange

Some engineers avoid variable air volume (VAV) systems because they fear that such systems could have an adverse impact on air change effectiveness (ACE). A recent study from Lawrence Berkeley National Laboratory (Berkeley, California) indicates that under some conditions, short circuiting doesn't seem to be a problem.

William Fisk, one of the researchers on the study, tells ***IEQS*** that he and his colleagues attempted to mimic VAV conditions and found there were few problems. Fisk reported the research in the journal *Indoor Air* (Vol. 7, No. 1, pp. 55-63).

Fisk and his colleagues note that while numerous studies indicate air change effectiveness under conventional conditions, there were few studies on ACE for adverse operating conditions — those with heated supply air and/or low supply flow rates.

Methodology

The researchers did the studies in a laboratory controlled environment chamber (CEC), which resembles a modern office with two exterior and two interior walls. The researchers divided the CEC, measuring 18 feet square by 8.2 feet high, into two workstations using 5.4-foot-high partitions. In each workstation they placed a desk, a side table, a chair, and a seated manikin that released heat, as a real person would.

They also fitted the CEC with typical heat and air motion sources, using personal computers, a power supply for one of the manikins, and a task light. The two "exterior" walls contained windows against which the researchers directed heated or cooled air to simulate heat loss or gain from ambient conditions.

To introduce supply air into the CEC, the researchers used three different air diffusers typical of those used in office buildings. These included:

- Diffuser 1 — A rectangular, 24 x 24-inch, perforated diffuser that directed supply air horizontally in four directions;
- Diffuser 2 — A diffuser similar to Diffuser 1, but with an improved interior air deflector; and
- Diffuser 3 — A linear diffuser with two parallel slots, 3.94 feet long, with air directed perpendicular to slots horizontally in both directions.

The return air grille was also 24 x 24 inches, and like the diffusers was suspended in the ceiling. Experiments with the linear slot diffusers used either two diffusers — designated 3a — or a single diffuser — 3b.

Experimental Variables

The variable conditions for the experiments included the diffuser type; the supply flow rate, which was either 80 cubic feet per minute (cfm)

Table 1 — Experimental Conditions and Results

Test	Diffuser	% O/A	Supply Rate (m^3/s)	Supply Temp. minus Chamber Temp. (°C)	Chamber Temp. minus Window Temp. (°C)	Chamber Temp. (°C)	Supply Air Velocity (m/s)	ACE
1	1	100	0.083	7	13	23	1.26	1.03
2	2	100	0.038	8	9	24	0.46	0.99
3	1	100	0.035	-12	-11	27	0.68	1.15
4	1	100	0.036	8	13	23	0.68	0.79
5	1	100	0.037	-10	-3	23	0.68	1.11
6	1	100	0.078	-3 to +15	3	25	1.26	0.77
7	1	100	0.082	8	14	24	1.26	0.74
8	1	62	0.039	7	10	25	0.68	0.81
9	2	100	0.036	7	10	25	0.46	0.87
10	2	100	0.037	-13	-3	26	0.46	1.09
11	2	100	0.040	7	10	25	0.46	0.80
12	2	100	0.075	9	13	24	0.96	0.70
13	2	100	0.080	-1 to +22	14	25	0.96	0.76
14	2	59	0.039	7	10	25	0.46	0.90
15	3a	100	0.039	-11	1	24	0.90	1.03
16	3a	100	0.040	8	9	24	0.90	0.83
17	3a	100	0.074	8	14	25	1.15	0.72
18	3a	100	0.076	9	14	24	1.15	0.74
19	3a	100	0.078	-1 to +22	14	25	1.15	0.69
20	3a	51	0.038	7	10	25	0.90	0.88
21	3b	100	0.038	8	10	25	1.15	0.86
22	3b	100	0.039	-12	-3	25	1.15	0.99
23	3b	100	0.078	7	11	26	1.47	0.83
24	3b	100	0.079	-2 to +23	15	24	1.47	0.89
25	3b	100	0.079	8	15	24	1.47	0.83
26	3b	40	0.038	7	9	24	1.15	0.91

Source: Fisk et al.

or 165 cfm; and the percentage of outside air (O/A) in the airstream. The researchers conducted most tests with 100% O/A because such a condition would accentuate any short circuiting.

Of the 26 tests, 19 involved heated supply air. In 4 of those, the supply temperature oscillated between chamber temperature and about 20°C above the chamber temperature to simulate a thermostatic system. In 5 tests, the supply air cooled the chamber, and in 2 other tests, mixing fans were operating in the chamber.

Results

In the two tests with the mixing fans, the ACE values were 0.99 and 1.03, remarkably close to unity, which is to be expected with vigorous mixing in the chamber. The researchers note that this indicates a small measurement uncertainty.

The researchers say that the overall results show that of all the variables, heating vs. cooling most strongly influenced the ACE. In the 19 heating tests, the ACE ranged from 0.69 to 0.91. In the cooling tests, the ACE ranged from 0.99 to 1.15.

However, other factors also have statistically significant, although more subtle, effects. Recirculation was associated with higher ACE values, ranging from 0.81 to 0.91. Still other factors had no significant effect at all. For example, oscillating temperatures didn't seem to have a consistent impact. (Table 1 shows the test conditions, as well as results.)

Conclusions

The researchers conclude several things from the study:

- Short circuiting can be significant under adverse operating conditions, which would include heated supply air, low air flow rates, and 100% O/A;
- Recirculation can reduce the significance of short circuiting; and
- Short circuiting doesn't seem to be a problem when the space is cooled by the supply air.

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CASE STUDY

*[In each issue, **IEQS** presents a case study on an indoor air investigation in a particular building. The information in the cases comes from various sources, including published material, reports in the public record, and, in some cases, reports supplied by the consultants involved in the case. **IEQS** presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply **IEQS**'s endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case. **IEQS** invited readers to submit comments, suggestions, and questions concerning any case. At the discretion of the editors, correspondence may be presented in a future issue.]*

Employees Complain of IEQ Symptoms During Maintenance

This case involves a large university-related hospital in the midwest US, where maintenance workers complained of various IEQ-related symptoms during floor care activities. Union officials, concerned about glycol ethers, expressed apprehension about possible reproductive effects from exposure.

The investigators, who sampled for various airborne chemical contaminants related to the floor care activities, found no elevated concentrations, but noted that some chemical combinations could have accounted for the symptoms. The investigators also made several recommendations concerning maintenance activities and supplies.

Deborah Friedman and Veronica Herrera-Moreno, M.D., of the National Institute for Occupational Safety and Health (NIOSH — Cincinnati, Ohio) conducted the investigation and reported their results in a NIOSH report (HETA 95-0313-2589), from which this case is taken.

The facility in question contains three main hospitals with a total of 872 beds. The Environmental Services Department (ESD), which