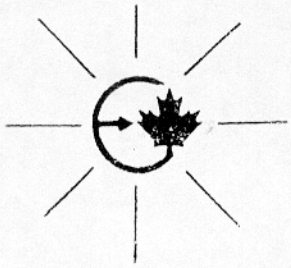
energy task force



groupe de travail sur l'énergie

PROCEEDINGS

Ener-health '84

ENERGY MANAGEMENT IN HEALTH CARE FACILITIES

WORKSHOP AND TECHNOLOGY EXPOSITION — Education, Workshop and Technology

Sponsored by

The Task Force on Energy Management in Health Care Facilities in Canada

October 16 - 17, 1984
Holiday Inn,
Winnipeg, Manitoba

Technical Report No. 12

Task Force on Energy Management in Health Care Facilities in Canada
Groupe de travail sur la gestion de l'énergie dans les établissements de services de santé du Canada
c/o 17 York Street, Suite 100, Ottawa, Ontario K1N 9J6

(Presented at Ener-Health '84, Winnipeg, Manitoba, October 16-17, 1984)

AIR QUALITY IN HEALTH CARE FACILITIES

E.M. Sterling B ARCH * and

T.D. Sterling Ph.D **

---

*Director of Building Research, Theodor D.Sterling Ltd., #70-1507 West 12th Avenue Vancouver, B.C., V6J 2E2, (604) 733-2701

**Professor, Faculty of Interdisciplinary Studies, Simon Fraser University, Burnaby, B.C., V5A 1S6 (604) 291-4685

Many reports, most not published, are available of investigated epidemic outbreaks of building associated illness occurring in sealed, air conditioned public buildings. Many of the outbreaks have occurred in hospitals where potential or severe air quality problems exist. Information contained in these reports has included hygiene measures, indoor air quality, health and occupant comfort.

We have coded and stored this detailed information from about 200 such studies in a computerized building performance data base (BPD) as an analytical tool to explore antecedent conditions of building related illness. We have already reported a number of findings extracted from that data base. Here we analyze 16 reports of studies of hospitals and laboratories, included in the data base.

Unlike office buildings, most investigations of suspected building associated illness occurring among patients and personnel in hospitals have established a clear-cut cause.

Table 1 shows median levels and ranges of anaesthetic gases, of sterilization agents and of other substances measured in the air of 16 hospitals. The first column lists the pollutant, the second gives the median value. The third column shows the number of reports from which the median value was derived and the last column presents the range of values at which the pollutant was measured.

Table 2 presents a compilation of government standards regulating occupational exposure to chemical air contaminants found in hospitals and laboratories. The first column lists the pollutants for which standards exist. The next two columns present the exposure standards in the U.S. which have been adopted by the National Institute of Occupational Safety and the Occupational Safety and Health Administration. The last column provides information regarding exposure standards set by other countries if they are different than those accepted by NIOSH or OSHA.

Comparison of Tables 1 and 2 show that not all substances exceeded occupational exposure standards. Enfluorane, measured at a median level of 1.44 mg/m3, was well below the NIOSH standard of 15.1 mg/m3. Formaldehyde was not detected at all or detected in levels well below the NIOSH standard of .8 ppm. Aromatic hydrocarbons, including ethyl benzene (median 8.14 mg/m3), toluene (median 4.5 mg/m3) and xylene (median 58.2 mg/m3) all were measured below both NIOSH and OSHA standards.

However, median levels reported for the anaesthetic nitrous oxide (67.5 ppm), and for the sterlization agent ethylene oxide

(147 mg/m3) exceeded both NIOSH and OSHA standards of 25 ppm and 90 mg/m3 respectively, while reported median levels for the anaesthetic halothane (5.2 mg/m3) exceeded the NIOSH standard of .05 mg/m3 for use in the presence of nitrous oxide. We see here that levels of anaesthetic gases and sterilization agents often exceed occupational exposure limits. Thus, the most prevalent air quality problem to which hospital staff and patients may be exposed are anaesthetic gases from operating theatres and organic germicides from sterilization areas.

But what are the effects of such exposures to hospital patients and staff?

Studies of hospital patients and personnel exposed to the anaesthetic gases nitrous oxide and halothane have described various health consequences. For instance

1. An increased risk of spontaneous abortions and congenital abnormalities in female workers and wives of male workers.

2. An increased incidence of hepatitis and renal disease as well as impairment of psychological functions.

3. An increased incidence of cancer among exposed personnel and children of exposed personnel.

4. Bone marrow and deoxuridine suppression among patients administered anaesthetics for extended periods.

5. Early sensory complaints, loss of balance, leg weakness, gait ataxia, impotence and sphinctes disturbance among dental surgeons.

6. There are few health effects studies of halothane exposure alone using human subjects, however animal studies show teratogenic effects.

7. Investigations have shown between 40% and 50% of operating room and recovery room personnel suffer from acute symptoms including fatigue, headache, dizziness/light-headedness, nausea, drowsiness, cough and skin irritation.

Organic germicides have also been ascribed various health consequences:

1. NIOSH has recommended that ethylene oxide be considered a mutogen and possible carcinogen.

2. In a recent industrial hygiene study of a surgical day care centre in Vancouver, the commonly used organic germicides

isopropyl alcohol, glutar aldehyde and parachlorophenol were shown to be responsible for complaints of drowsiness, headaches, lethargy and swelling and irritation of the eyes among staff. The investigators also noted that the same organic compounds may further contribute to the formation of highly irritating organics in the air through reaction with ozone, nitrogen oxides and other urban air pollutants in a mechanism similar to the formation of photochemical smog.

In addition to exposure to toxic chemicals, hospital workers face the added danger of exposure to airborne organisms and infectious contaminants distributed through the ventilation system. Air supplied to operating theatres and post operative recovery rooms contaminated with aspergillus spores has been shown to be responsible for post operative infection of aspergillus endocarditis resulting in numerous deaths. In fact, a comparative study of aspergillus infections among patients moved from a 43 year old naturally ventilated hospital to a new mechanically ventilated facility, suggests that hospital acquired aspergillus infections could be eliminated if all incoming hospital air were filtered, properly vented and not recirculated.

Another airborne organism, legionella, has turned up in hospitals. Recently, lowering the temperature of the hot water supply to conserve energy has been implicated as an important source of legionella.

Proper venting of laboratories is crucial to the health of the general population as well as the laboratory workers themselves. An additional problem that may exist when laboratories are contained in or near other buildings is contamination or reentrainment of laboratory exhaust into the general ventilation air. For example, fume hoods removing toxic exhaust from a Canadian government research centre were recently shown to be feeding laboratory exhaust back into the building fresh air supply.

The health effects of pollutants are especially severe for individuals at low levels of resistance to toxic insult. Patients are just such individuals. My associate, Professor Sterling, has shown as long as 15 years ago that even slight increases in concentrations of particulates, sulphur dioxide and ozone in the ambient air increases the number of hospitilizations for allergic disorders and acute respiratory infections as well as the length of time required to discharge patients once admitted. Thuse findings have recently been verified by Dr. Bates in a Toronto hospital. These findings are of importance today not only because they demonstrate the deleterious consequences of exposing patients to increased pollutant burdens, but also because they link the cost of hospitalization to the control of pollution inside hospitals as

well as the ambient environment.

CONCLUSIONS

What can be done to reduce indoor pollution in hospitals and laboratories?

Air contaminants of a chemical and biological nature are pervasive in the hospital and laboratory environment. Use of contaminants such as anesthetic gases and sterilization agents cannot be avoided. The only feasible solution is proper design, operation and maintenance of the ventilation and filtration system so as to avoid contamination of the air. The ventilation system should be designed to isolate industrial type source areas (such as laundry facilities) as well as laboratories, operating theatres, recovery wards and wards for highly communicable diseases from the rest of the hospital. The ventilation system should be operated so as to avoid reintrainment and/or entrapment by recirculation of hospital generated contaminants. The ventilation ducts and humidification system should be cleaned regularly and the filters should be cleaned and replaced if required. Finally, leakage from ducts exhausting contaminated areas should be periodically measured and if leakage is occurring the ducts should be resealed.

Having taken these steps it is also important in hospitals, as in other public buildings, to maintain adequate fresh air rates to all areas. Reduced fresh air ventilation to achieve energy conservation has created air quality problems in many other building types. Hospitals, because of potentially hazardous conditions, may be even more prone to such problems. Even in an energy conserving era, adequate hospital environment services must be maintained.

Of course, it is necessary to search for energy conservation alternatives in hospitals. However, appropriate conditions for health care must be maintained or health care costs will increase.

Take, for instance, the question of to what extent health care costs are increased by Hospital Air Quality. Two studies, one by my associate Professor Sterling, the other by Dr. Bates, have linked patient recovery time to even a slight increase of air contaminants inside hospitals.

Two costs are hidden here.

1. The first, and most obvious cost is patient hospitalization. This cost directly affects the Province that subsidizes hospitalization, the insurance carrier who pays the bills and the patient.

2. The other, but not so obvious cost is the less than optimal

use of scarce and expensive hospital resources due to overcrowding of beds with recovery patients. A patient who has already received treatment and is in the process of recovery does not use the expensive clinical and laboratory diagnostic and treatment facilities of the hospital, but keeps others from doing so. As a consequence, the use cost per patient of clinical and laboratory facilities are increased.

There is a lot of work still needed both to quantify the scope of the hospital air quality problem and to identify the associated health care costs. We are now in the process of doing this. Our objective is to develop strategy of Energy and Environment Optimization for Health Care Facilities which can be implemented in hospials and other treatment centers across Canada.

References

(1) Ames, J.A.L., Rees, B.M., Barman, J.F., Nancekievill, D.G., and Mullin, D.L. Lancet, 1978, 2(8085), 339-342.

(2) Bates, D.V., and Sizto, R. Canadian Journal of Public Health, 1983, 74, 117-122.

(3) Callan, H. Energy Management in hospitals, presented at ASHRAE (BC Chapter) Seminar on Energy and Environment Management in Health Care Facilities: Are They Compatible, Vancouver, B.C., May 27-28, 1982.

(4) Cohen, E.N., et al. Journal of the American Dental Association, 1980, 101, 21-31.

(5) Cohen, E.N. Anaesthesiology, 1974, 41(4), 321-340.

(6) Cohen, E.N., Bellvile, J.W., and Biow, B.W. Anaesthesiology, 1971, 35(4), 343-347.

(7) Corbett, T.H., and Ball, G.L. Anaesthesiology, 1971, 34, 532-537.

(8) Corbett, T.H., Cornell, R.G., Enders, J.L., and Kieding, K. Anaesthesiology, 1974, 41(4), 341-344.

(9) Doll, R., and Peto, R. British Medical Journal, 1977, 1, 1433-1436.

(10) Gunter, B.J. HE 77-100-468, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1978.

(11) Gunter, B.J. HE 78-80-521, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1978a.

(12) Gunter, B.J. TA 78-36, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1978b.

(13) Gunter, B.J. HE 78-103-561, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1979.

(14) Gunter, B.J. HE 79-106-635, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1979a.

(15) Gunter, B.J. HE 79-145-718, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1980.

(16) Gunter, B.J., and Thorburn, T.W. HETA 81-108-883, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1981.

(17) Gunter, B.J. HETA 81-198-917, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1981a.

(18) Hollett, B.A. TA 77-31, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1977.

(19) Knill-Jones, R.P., Newman, B.J., and Spence, A.A. Lancet, 1975, 2(7939), 807-809.

(20) Knill-Jones, R.P., Moir, D.D., Rodriguez, L.V., and Spence, A.A. Lancet, 1972, 1(7764), 1326-1328.

(21) Layzer, A.B. Lancet, 1978, 2(8102), 1223-1230.

(22) NIOSH, U.S. Department of Health, Education and Welfare, NIOSH Publication No. 77-140, Washington, D.C. p.3, 1977.

(23) NIOSH, U.S. Department of Health, Education and Welfare, NIOSH Publication No. 77-200, Washington, D.C., 1977a.

(24) NIOSH, U.S. Department of Health, Education and Welfare, NIOSH Publication No. 77-181, Washington, D.C. pp 235-253, 1978.

(25) Sandberg, D.K., Kluckner, P.D. (unpublished report) Environmental Laboratory, Ministry of Environment, Vancouver, B.C., 1981.

(26) Sterling, T.D., Phair, J.J., Pollack, S.V., Runsky, D.A., DeGroot, I. Archives of Environmental Health, 1966, 13, 158-170.

(27) Sterling, T.D., Pollack, S. V., and Phair, J.J. Archives of Environmental Health, 1967, 15, 362-374.

(28) Sterling, T.D., Pollack, S.V., and Weinkam, J. Archives of Environmental Health, 1969, 18, 485-494.

(29) Sterling, T.D., Sterling, E.M., and Dimich-Ward, H.D. ASHRAE Transactions, 1983, 89(A and B), 198-207.

(30) Strunim, L., Strunim, J., and Mallios, C.C. British Medical Journal, 1973, 4, 459-460.

(31) Tomlin, P.J. British Medical Journal, 1979, 1, 779-784.

(32) Witcher, C.E., Cohen, E.N., and Trade, I.I. Anaesthesiology, 1971, 35(4), 348-353.

Table I. Anesthetic gases, sterilization agents and other substances measured in the air of 16 hospitals

POLLUTANT	MEDIAN VALUE	# OF REPORTS	RANGE OF VALUES
Aromatic Hydrocarbons	10.27 mg/m³	4	ND - 104 mg/m³
Ethyl Benzene	8.14 mg/m³	1	8.14 mg/m³
Toluene	4.5 mg/m³	1	ND - 12 mg/m³
Xylene	58.2 mg/m³	2	ND - 104 mg/m³
Enflurane	1.44 mg/m³	1	0.5 - 3.0 mg/m³
Ethylene Oxide	147 mg/m³	2	ND - 770 mg/m³
Formaldehyde	ND	3	ND - 0.12 ppm
Halothane	5.2 mg/m³	5	ND - 33.6 mg/m³
Nitrous Oxide	67.5 ppm	5	ND - 1200 ppm

ND: tested but no detectable levels found

Table 2: Standards[+] Regulating Occupational Exposure to Air Contaminants Found in Hospitals

	NIOSH	OSHA	OTHER
Aromatic Hydrocarbons			
Ethyl Benzene		100 ppm (435 mg/m³) IDLH* 2000 ppm	
Toluene	100 ppm (375 mg/m³) 200 ppm 10 min Ceiling**	200 ppm 2000 IDLH 300 ppm ceiling 500 ppm peak***	
Xylene	100 ppm 200 ppm 10 min Ceiling	100 ppm (435 mg/m³) 10,000 ppm IDLH	
Enflurane	2 ppm (15.1 mg/m³)[x]		
Ethylene Oxide (ETO)	50 ppm (90 mg/m³) 75 ppm Ceiling	50 ppm (90 mg/m³) 800 ppm IDLH	USSR - 0.5 ppm (1 mg/m³) W.Ger. - 50 ppm Sweden - 20 ppm
Formaldehyde (HCOH)	0.8 ppm 30 min Ceiling	3 ppm 100 ppm IDLH 5 ppm Ceiling 10 ppm peak	
Halothane	2 ppm (16.2 mg/m³)[x] 0.5 ppm when used with H_2O		Denmark 1 ppm[x]
Nitrous Oxide (N_2O)	Less than 25 ppm[x] 50 ppm for dental offices		Denmark 10 ppm[x]

\+ are typically eight hour time weighted averages (TWA) unless otherwise specified.
* IDLH - immediately dangerous to life and health
** Ceiling - value for which recommended level can be exceeded for a 15 minute period unless otherwise specified.
*** Peak - level which should never be exceeded.
x For locations where anesthetics are administered. These are not necessarily safe levels, but are considered "readily achievable" levels (24).