#5040

DISCOURS SUR

"LES RÉSULTATS D'ÉTUDES DE LA QUALITÉ DE L'AIR ET DE LA VENTILATION DANS 16 ÉDIFICES DU QUÉBEC"

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de
ASHRAE - MONTRÉAL

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formaldehyde in ambient air is 120 ug/m^3. We detected and average value of 14 ug/m^3. Even the maximum of 42 ug/m^3 remains below the recommended amount.

10^e DIAPO

The third chemical contaminant measured was nicotine; the source of which is tobacco smoke, and its health effects are well-known.

The levels found remained well beneath the norme of 50 ug/m^3. We found a maximum value of 20,5 ug/m^3. To give you and idea of what this signifies, one of our colleagues went into a bar and measured an amount of 100 ug/m^3.

11^e DIAPO

Volatile organic compounds were measured next. Whether their toxicity is more or less large, it is generally associated with the central and peripheral nervous systems. The sources of organic solvents in office buildings are numerous and generally unimportant. Some examples are the usage of domestic products (such as paint, varnish, glues, cleaners, and perfume), printing processes, reprography, photography, and photocopiers (if a humid process).

As you can see, these contaminants were present in very low concentrations.

cells, obstructing the normal functioning of the oxygen in the human body. This deficiency is particularly damaging to the heart and brain.

Ashrae-62 states that the average allowable concentration of carbon monoxide in ambient air is 9 ppm. We detected an average value of 2,5 ppm. The offices below ground level showed high carbon monoxide levels due to infiltration from parking garages.

14^{e} DIAPO

Unlike the previous contaminants, carbon dioxide causes asphixiation by replacing the oxygen in air; without interfering with the respiratory system. But, this only happens at very high concentrations. At low levels, it causes headaches, nausea, dizzyness, and fatigue. It can also provoke a sensation of (quote) not enough air. Its major source in office buildings is human exhalation.

Ashrae-62 limits the average concentration in ambient air to 1000 ppm. The levels detected were generally below the norme; except for classrooms, cafeterias, and overpopulated open-areas where the carbon dioxide values reached 1300 ppm.

Oxygen, which is obviously not an air contaminant, was also measured, but is not shown here. The levels are stable at 21%, which is the normal composition of air. Indoor air quality in

office buildings deals with the prescence, in low concentrations, of compounds not normally found in air; oxygen does not fall into this category. To lower by 1% the $\dot{O}_2$ concentration, it must be replaced by another or other gases at 10 000 ppm, which is very high.

15^{e} DIAPO

Finally, microbiological contaminants, such as bacteria, fungi, and mold, were investigated. The humidity level is a major factor to their development. So, they usually grow in ventilation and air-conditioning systems, and consequently, are dispersed throughout the working environment. Microbiological contaminants cause pathogenic infections and act as allergens.

In general, the concentrations found did not reach significant levels, except in a few isolated cases such as in cafeterias, garbage compators, and art classrooms where clay is used.

16^{e} DIAPO

From our results, we found that ventilation effectiveness varied significantly among the 16 buildings studied.

Total air is the theoretical amount of air that is supplied by the ventilation system. In general, these rates satisfied the RQMT regulation of 45 L/s/person.

Supply air by diffusion should be identical to the total air rate. We found that only 50% of the total air was being supplied through the diffusers, with an average lower than the legal standard of 45.

Fresh air is needed to maintain the carbon dioxide concentration at an acceptable level. In general, the values measured and found at the fresh air dampers satisfied the Ashrae-62 recommendation of 10 L/s/person. In one case, we found the dampers were completely closed, not allowing and fresh air in.

The tracer gaz technique shows the effectiveness of the air distribution system. Here, we found that the values are only 30% of those at the dampers. The large range of values (from 0 to 61) shows an inadequate fresh air distribution.

These low rates can cause the impression of air stagnation.

17^{e} DIAPO

Environmental conditions, including air temperature, humidity, vertical temperature gradient, and air motion, were the next objects of our examination.

Although the average temperature met Ashrae standards, recordings showed that some buildings had problems with high temperatures; mostly due to improperly calibrated thermostats.

The extremely low relative humidity (most likely due to the defective humidistats) was a probable cause of much of the discomfort; with levels falling as low as 5%.

With regards to the vertical temperature gradient, only one workstation showed a difference greater than the ISO recommendation of 3°C.

In many buildings, though, there was poor air movement among the workspaces. It was found that, as interior floorplans and employee population changed, no modifications were made to the air distribution system. This resulted in very low velocities in some workplaces and excessive draughts in others.

18^{e} DIAPO

Thermal comfort is a function, not only of air temperature, but also of mean radiant temperature, air velocity, humidity, activity level, and the warmth of the clothing worn by occupants.

Thermal comfort is expressed in terms of the PPD and the PMV. The PPD is the predicted percentage of those that would be uncomfortable in similar conditions. The PMV is a value between -2 and +2, indicating that the temperature is either cold (if negative) or warm (if positive); the optimum being zero.

These values, based on environmental measures, reflect the relative

level of satisfaction occupants of a space would feel with their surrounding environment.

19e DIAPO

ISO (International Standards Organization) sets the recommended PPD value at 10% (Ashrae sets it at 20%). In our investigation, we found that the average values supported the occupants' claims of thermal discomfort, when using the ISO criteria.

We found that an average of 19% of occupants would be dissatisfied under similar conditions and that they would find the environment too cold.

But, it must be noted that these results are valid assuming the occupants are constantly seated. If they were to move, say, from the desk to the filing cabinet, we would find that the environment would appear warmer to them (explaining the high temperatures shown previously).

20e DIAPO

Environmental conditions also included lighting and noise.

From our tests, we found only isolated cases of inadequate lighting, values less than 550 lux (usually found at computer terminals), and high noise levels, values greater than 55 dB(A)

23e DIAPO

Si l'on fait une synthèse des résultats de cette étude, il n'y a aucune inquiétude au Québec en ce qui concerne le radon, les oxydes d'azote, le bruit et l'éclairage.

24e DIAPO

Les micro-organismes (moisissures, champignons et bactéries) ainsi que le monoxyde de carbone peuvent être un sujet d'inquiétude dans certains édifices, tandis que le formaldéhyde, les poussières (y compris les fibres de verre), les composés organiques volatils et la nicotine, même s'ils ne dépassent pas les normes, sont l'objet de débats scientifiques et de nouvelles normes plus sévères.

25e DIAPO

Les concentrations de contaminants comme l'ozone et le gaz carbonique devront être réduites car ils peuvent être sources d'inconfort. Le manque d'air total, d'air frais, d'air de diffusion constituent d'autres sources de problèmes dans une minorité d'édifices ainsi que les variations de températures et de vitesses d'air dans d'autres.

26e DIAPO

Les points suivants méritent une action immédiate d'après nous:

- Le manque d'humidité relative et la surveillance de ces taux en hiver. Une étude épidémiologique récente de l'Université McGill et de la Finlande prouve qu'il y a plus de plaintes de la part des occupants dans un environnement sec que dans un milieu plus humide.

- L'entretien des contrôles, surtout les humidistats, les thermostats ainsi que les indicateurs de pression. Je vous rappelle que dans 13 des 16 édifices étudiés, les humidistats sont mal calibrés ou carrément défectueux.

- La formation du personnel d'entretien quant à l'utilisation des instruments de mesure et de vérification et l'information sur les normes et standards.

27e DIAPO

Comme conclusion, nous pouvons affirmer que notre étude suit la tendance générale d'autres études étrangères selon laquelle 60% des problèmes sont reliés à la ventilation et à l'entretien. Une cédule d'entretien régulier permettra de résoudre un grand nombre de ces problèmes. L'utilisation d'instruments de mesure adéquats comme un psychromètre, un vélomètre, un ballomètre permettra au personnel d'entretien de répondre aux plaintes des occupants. Le détecteur du gaz carbonique CO_2 sera de plus en plus utilisé comme indicateur des problèmes de la qualité de l'air intérieur.

Enfin, les normes de ASHRAE (le standard 55-1981 pour le confort thermique, et celui 62-1981 pour la ventilation) qui sont en état de révision devront servir de guide aux gestionnaires ainsi qu'au personnel d'entretien.

28e DIAPO

Il reste 40% des problèmes qui peuvent provenir de sources diverses. Et les solutions pour les résoudre ne sont pas faciles. Je vous donne ici une liste de perspectives d'avenir qui sont discutées dans les milieux scientifiques:

- l'utilisation des matériaux de fabrication non- ou moins polluants dans le futur pour abaisser les concentrations de contaminants à l'intérieur des édifices;
- l'incorporation des moniteurs de contaminants (surtout le CO_2) dans les contrôles des systèmes de ventilation (par exemple pour régulariser les débits d'air frais dans l'édifice);
- le développement et l'utilisation des logiciels d'entretien préventif;
- l'adoption de la nouvelle norme de confort thermique ISO-7730 par ASHRAE qui amène plusieurs critères nouveaux de confort thermique comme les votes moyens prévisibles, les pourcentages prédits d'insatisfaction, les asymétries de température, etc.;
- l'augmentation du débit d'air neuf de 2,5 l/s/personne à un chiffre encore inconnu (peut être 7,5 l/s/personne);
- Enfin l'amélioration de l'efficacité de ventilation qui permettra une meilleure dilution de contaminants, une distribution plus égale d'air frais et un meilleur confort thermique.

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INDOOR AIR QUALITY & VENTILATION

Office buildings

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1. Introduction

- Overall aims of the study:
  - To identify the major problems in Quebec's office buildings;
  - To identify corrective measures for these problems;
  - To develop a simple air quality evaluation protocol; and,
  - To develop short- and long-term solutions to the indoor air quality problems in energy-efficiency buildings, either through research or through joint projects with building owners, consulting engineers, and universities.

Introduction

Ventilation problems	% of Buildings
1) Inadequate ventilation	
- No fresh air	35%
- Insufficient fresh air	64% ←
- Inefficient distribution	46%
2) Inadequate filtration	
- Low-efficiency filters	57% ←
- Poor conception	44%
- Faulty installation	13%
3) System contamination	
- Excessively contaminated ducts	38% ←
- Humidifiers	16%

Introduction

IRSST study:

Public buildings	16
Occupants	25 000

Evaluation

- Chemical contaminants
- Micro-organisms
- Ventilation
- Comfort
- Environment

Standards

- Québec. Regulation respecting the quality of the work. S-2.1, r. 15. 1982
- Canada. Canadian Guidelines for Residential Indoor Air Quality, Health and Welfare. Federal-Provincial Advisory Commitee on Environmental and Occupational Health. April 1987.
- ASHRAE. Proposed American National Standard Ventilation for Acceptable Indoor Air Quality. 62-1981 R
- ACGIH. Report of the Commitee on Bioaerosols. 1985.

Results

Action Needed

	Average	Minimum	Maximum	Standard (the most severe)
Relative humidity (%)	20	5	42	>30

10-20% improperly calibrated thermostats

15/16 defective humidistats

13/16 unbalanced air distribution systems

16/16 non-confirming lead times

Chemical contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Dust (ug/m^3)	41	6	218	<40
Formaldehyde (ug/m^3)	14	4	42	<120

Chemical contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Volatile organic compounds (mg/m^3)	1,5	<1	27,0	<1350 (naphta)
Nicotine (ug/m^3)	2,2	<1	20,5	<50

Chemical contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Toluene (mg/m^3)	0,11	0,003	0,42	< 37
Xylene (mg/m^3)	0,11	0,01	0,28	< 43

Radio-active contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Radon (pCi/L)	0,42	0,10	1,50	< ~~2~~ 4

Chemical contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Ozone (ppm)	0,010	0,001	0,130	< 0,1
Carbon monoxide (ppm)	2,5	0,5	~~170,0~~ 460,0	< 9

Chemical contaminants

	Average	Minimum	Maximum	Standard (the most severe)
Carbon dioxide (ppm)	590	280	1300	≤1000

Micro-organisms

	Average	Minimum	Maximum	Standard
Bacteria (cfu/m^3)	155	12	4460	< 1000
Fungi, mold (cfu/m^3)	30	6	357	<300

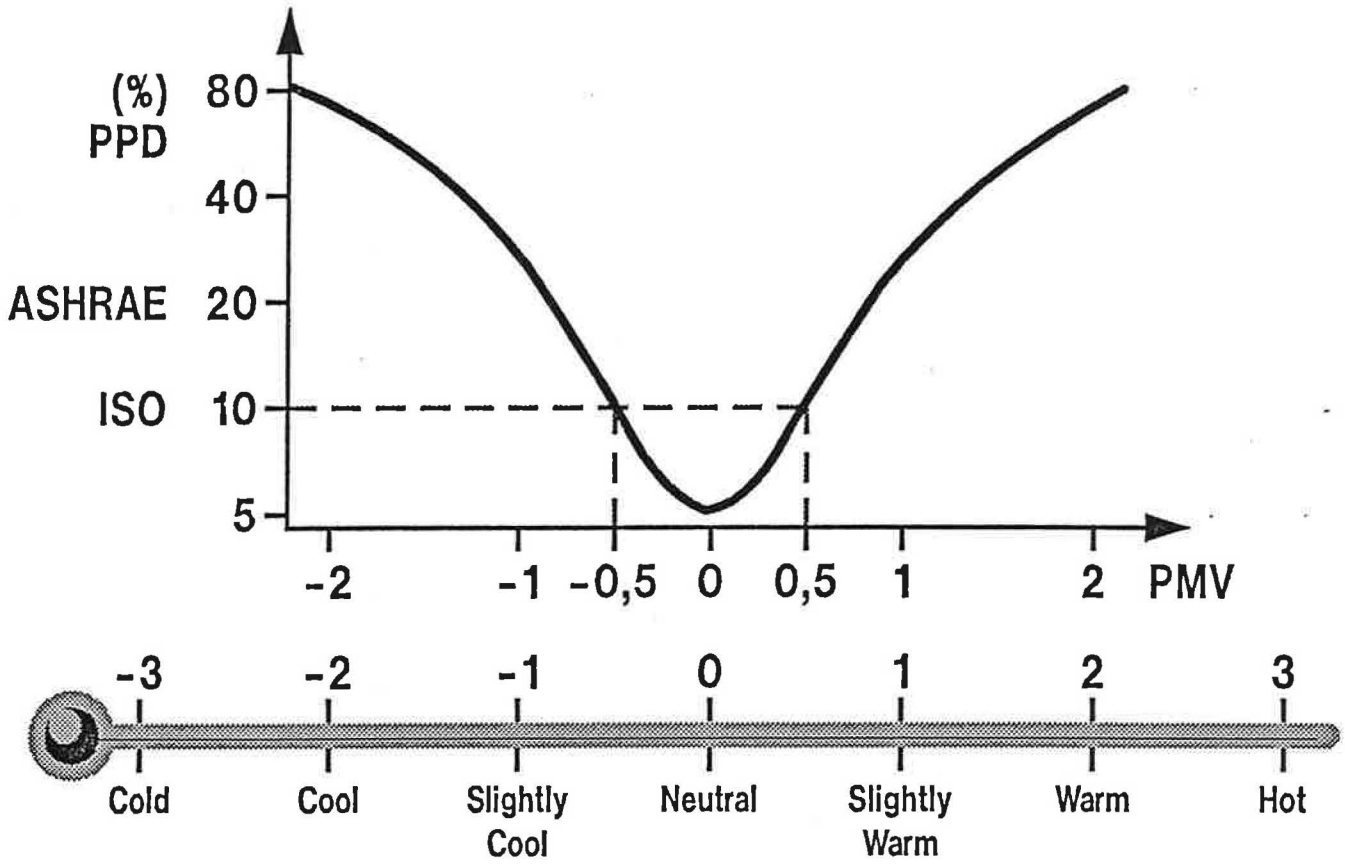
Ventilation

Air flow (L/s/person)	Average	Minimum	Maximum	Standard
Total air	65	5	317	>45
Diffused air	30	1	215	>45
Fresh air (dampers)	37	0	107	~~>7,5~~ 10
Fresh air (tracer gas)	11	0	61	~~>7,5~~ 10

Comfort

	Average	Minimum	Maximum	Standard
Temperature (°C)	23,0	19,8	29,8	20 to 23
Relative humidity (%)	20	5	42	>30
Vertical gradient (°C)	0,4	0,0	3,5	<3
Air velocity (m/s)	0,08	00,0	0,50	0,09 to 0,25

Predicted percentage of dissatisfied vs Predicted mean voxe (PPD vs PMV)



(ISO-7730)

Comfort

Comfort meter indications	Average	Minimum	Maximum	Standard
Predicted percentage of dissatisfied (PPD) (%)	19	6	82	< 10
Predicted mean vote (PMV) (-2 to +2)	-0,7	-2,0	-1,8	-0,5 to +0,5

Work environment

	Average	Minimum	Maximum	Standard
Lighting (lux)	978	20	12160	>550
Noise (dB(A))	52	36	83	< 55

Ventilation system

10-20% improperly calibrated thermostats

15/16 defective humidistats

13/16 unbalanced air distribution systems

16/16 non-confirming lead times

2/16 low-efficiency filters

Maintenance personnel

- Unfamiliar with standard
- Not equippped with necessary measuring instruments

Results

No cause for worry

	Average	Minimum	Maximum	Standard (the most severe)
Radon (pCi/L)	0,4	0,1	1,5	< ~~2~~ 4
Lighting (lux)	978	20	12160	> 550
Noise (dB(A))	52	36	83	< 55

Synthesis of results

Action to be taken

- Relative humidity
- Maintenance
- Training, information