APPENDIX

Healthy School Design and Construction

Healthy School Construction Committee

July, 2003

This appendix is being provided to give some background information on a number of issues including some which are still under investigation and have varying degrees of support from differing points of view.

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1.0 Why Children are More Vulnerable to Toxins Than Adults

Larger Body Surface Area In Relation To Weight

Higher Metabolic Rate and Oxygen Consumption and Intake of Air Per Unit of Body Weight.

Different Body Composition

Greater Energy and Fluid Requirements Per Unit of Body Weight

Special Dietary Needs

Rapid Growth, During Which Chemicals May Affect Growth or become Incorporated Into Tissues

Functionally Immature Organs And Body Systems. (the brain does not slow its fast growth until at least 18 years of age)
- The World Health Organization. Environmental Criteria 59, Principles for evaluating Health Risks from Chemicals during Infancy and Early Childhood: The need For a Special Approach. Geneva, 1986.

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- At present, air quality and workplace hazard standards are based upon research predominantly done on healthy, 175 lb., adult males. There have not yet been safe levels determined for children, the ill, for women or fetuses.

- "There is an urgent need for more and better environmental health indicators and measures. Traditional health indicators, such as life expectancy at birth, do not take into account the changing physical environment of the last fifty years, or recognize its potential implications for human health and longevity.... In order to protect the health of Canada's children today, the Precautionary Principle needs to be applied, leading to action on developing environmental targets through enforceable legislation."
- p.252, The Health of Canada's Children, third edition, Canadian Institute of Child Health. 2000.)

- "The Canadian building code references ASHRAE 62-1989 Ventilation For Acceptable Indoor Air Quality. Applying this standard to students in a school is questionable when this standard is based on 80% of at least 20 untrained subjects tested that perceived the air to be acceptable in 15 minutes, or 15 seconds for unadapted subjects. This test was conducted primarily on students at Yale University, Kansas State University and Denmark. It did not test babies, children, elderly, the infirm or sick, physically and mentally disabled, those with respiratory illness, and many other disenfranchised people. Thus the test may only be valid for a much smaller segment of the total population.
Furthermore, this test is based primarily on elevated carbon dioxide in the test room and the perceived discomfort of the untrained subjects. None of the harmful contaminants such as

formaldehyde, carbon monoxide, moulds, radon, etc. were used. The ASHRAE standard for ventilation is clearly not applicable to all occupancies as it states, 'Considering the diversity of indoor air contaminants and the range of susceptibility in the population, compliance may not be acceptable for everyone.' We should be using housing standards in our schools."
- Professor Tang Lee, University of Calgary

- "The health risk from air pollution is as much as six times greater for children than for adults."
- Medical Researchers at the University of California at Irvine

- "Exposures to building products, furnishings and materials that have toxic potential, as well as poor ventilation in schools, affect all children to some degree. It is becoming more and more evident that the central nervous system is particularly vulnerable to exposures to many toxicants and that these can affect both learning and behavioral abilities in subtle but serious ways."
- B. McElgunn, Learning Disabilities Association of Canada

- "Health symptoms of chemical exposure such as headaches, breathing problems, itchy and watery nose and eyes, intestinal problems, fatigue, and coughing are often misdiagnosed as colds and flu. Behavioral symptoms of chemical exposure such as mood swings, aggressiveness, and hyperactivity are often seen as normal."
- Dr. Gerald Ross, Past President the American Academy of Environmental Medicine.

- "Chemicals have replaced bacteria and viruses as the main threat to health. The diseases we are beginning to see as the major causes of death in the latter part of this century and into the 21st century are diseases of chemical origin."
- Dr. Dick Irwin, Toxicologist, Texas A&M University

- In a study of 52 urban school buildings, the buildings were evaluated as being in "poor", "fair", or "excellent" condition. An assessment of student achievement in the schools was then made. Regression analysis was used to remove variables such as socioeconomic status. A strong correlation was found between building condition and student achievement. Students from schools in "poor" condition fell 5.5 percentage points behind those in the "fair" school buildings, and 10.9 percentage points behind those in the "excellent" school buildings.
- Edwards, Maureen M., Building conditions, Parental Involvement, and Student Achievement in the D.C. Public School System. Georgetown University, 1991.

- We do not know how many children are affected by poor school ventilation and toxic exposure, but as Health Canada's ISSUES paper on environmental sensitivities states, "Prevention is the most important and simplest aspect of this problem."
-Citizens for A Safe Learning Environment

2.0 Source Control

"Careful selection of building materials and furnishings alone will not eliminate VOC problems from buildings. But limiting materials' emissions is within the control of the designers and builders." (Cutter)

One example: Unless wooden chairs are chosen, there aren't many or any alternatives to the propylene ethylene copolymer chair "shells". Source control can be exercised by getting them early and offgassing in a well ventilated area, or requiring the supplier to guarantee they offgas them in a well-ventilated location several months before they are shipped.

In both the Stillwater school in Mineapolis and the Prairie Ridge school in Illinois, Source Control techniques were used for construction materials selection and use and for furniture and equipment choices. Also, the importance of working closely with the contractors during the construction phase was emphasised by those involved in healthy school aspects on both projects.

The five year old Prairie Ridge school has no carpeting, has low-emission paints, openable windows throughout, hardwood or metal furniture and cabinetry, a sophisticated computerized ventilation system with the best filters on the market at the time, and a good maintenance program. Particular attention was paid to large surface area items such as ceiling tiles, floor coverings, paints, and furniture. Bunsen burners were hooded. No plastic chairs. To keep them clean, ducts were capped daily during construction. Materials handling and storage were in the specs. Acoustic issues needed extra design attention because limiting "soft" surfaces caused sound to be more readily reflected. It was found that synthetic gym floors available at the time had less "give" than wood floors, and condensation caused them to become slick.. The school came in on time and on budget, proving it is not necessarily costly to build a healthier school. (Oberg)

The following source control information expands upon the brief points listed in Healthy School Design and Construction.

2.1 Materials:

Among the problem materials found in conventional schools, in order of priority are:

cabinetry with exposed particle board
high-emission carpeting
vinyl or chemically treated materials in sun-exposed areas
high-emission cleaning compounds
badly designed ductwork, with exposed fibreglass
use of strongly-emitting caulking compounds (e.g. some MONO types)

More subtle sources include:

wall paints
vinyl or other wall coverings
partitions with formaldehyde containing compounds
furnishings with long gas-out period

2.1.1 Formaldehyde:
In finished products formaldehyde will continue to offgas indefinitely and it has been linked to significant health problems. Neither Health Canada or the US EPA identify a "safe" level of exposure to formaldehyde. Although woods naturally contain some traces of natural formaldehyde, that can't be an excuse for adding more during manufacture. It is a carcinogen and so the goal is to be exposed to as little as possible, preferably none.

HUD (US Housing and Urban Development Institute) standard is .3 ppm ASHRAE 0.4 ppm for office environment
Health Canada 0.1 ppm target, but does not identify a "safe" level.
OSHA TWA for 8 hr. day is 0.75 ppm, an industry standard.
If a product emits 0.3 ppm (the ACGIH TLV) it is exceeding Health Canada's standard by 300%.
The 'convention' for scientists who work on this issue is to cut the OSHA standard by 1/10 for adults in offices, and cut this by another 1/10 for children.
Emission measurements are best done in an ASTM chamber. (DST Consulting)

2.2 How effective can source control be?

Dr. Greg Miller (Envirotest Brisbane 1997) captured air samples from a newly completed home which had been built entirely of inert or least toxic materials. The samples were analyzed to measure the levels of formaldehyde and VOCs. Australia's standard "safe" TVOC limit recommended is 500 micrograms per cubic metre of air (mg.m3). In new and renovated construction the TVOCs average 1,000 mg/m3. Miller's expectations for his "clean architecture" house was to find TVOC levels of 200-300mg/m3. The actual level found in this house was 25mg/m3. (The Human Ecologist, Fall, 1998)

2.3 How to Conduct a Sniff Test:

According to Envirodesic, earlier projects spent much money on emissions testing but their experience has shown another method works as well or better and is much less expensive. Here is the method:

1. Include certain requirements in the tender call and contract. (see below)
2. Screen the applicant's sample's MSDS to identify and eliminate obvious problem products.
3. Place samples in glass jars (as described in "How to Conduct a Sniff Test"), and have a committee of at least three people open each one and identify those that are not strongly offgassing.

Suggested specs/tender/contract requirements:
1. The preamble would state that it is the goal of the department to attain a healthy indoor environment and it is required that suppliers provide low emission products to assist in achieving this goal.

2. Samples shall be prepared by the manufacturer of fresh materials, for acceptance by (TPW or committee or whoever)
or
Samples of all substraits, coverage, adhesives, sealers, shall be prepared by the manufacturer for approval by (whoever). These shall be freshly made, no larger than...

Ask for more than one sample if they have more than one possible option available.
Use this same process for choosing foam and fabrics (especially vinyl ones) for furniture and other FF&E.

The Sniff Test:

Place the samples from each product in separate clean glass jars. Seal the jars with aluminum foil, dull side facing the sample. Leave the samples at least overnight. Moderate heating(not more than 100 degrees F) for a few hours might be helpful. Do not overheat the samples as that will distort the emissions compared to those which will occur in the building situation. The effort is to replicate the conditions in which the sample will be exposed. The jar test concentrates the emissions and the heating accelerates the process.

Next, open the jars in an odor-neutral environment with good ventilation and sniff the samples. Rate the samples for strength of odor, degree of pleasantness or unpleasantness, and any irritation or other physiological effects you might experience. Several people can participate. The process can be repeated two or three times. Also, try doing the test "blind", without the people knowing which sample they are sniffing.
If there are several jars and several samples, try doing comparisons. Remember, however, your reactions will change during the first few seconds you smell the odors. Do not linger over any one jar. Keep the jars closed except when you are actually sniffing.

All of this effort is useful only if the samples are representative of what will be in the building. Know what you are getting, where it is coming from, and how representative it is. For example do not take showroom samples. They have no doubt been sitting around for a long time. (Cutter)

2.4 For more information on source control see:

* CMHC's *Building Materials for the Environmentally Hypersensitive* for less toxic building materials.
* The Cutter Corporation's *Materials Specification Guide* for more information on materials and equipment.
* *The HOK Guidebook to Sustainable Design*, page 130
* *Product Assessment Matrix*, Toronto Board of Education
* The body of *Healthy School Design and Construction*
* chemical information sites:
    www.dhs.ca.gov/ohb/HESIS/hesispub.htm
    www.dhs.ca.gov/ohb/HESIS/formal.htm
    www.dhs.ca.gov/ohb/HESIS/iso.htm
    www.hc-sc.gc.ca/hecs-sesc/whmis/
    www.cdc.gov/niosh/homepage.html

2.5 Companies/services available for healthy materials choice are:

* DST Consulting, Ottawa, Ontario, Canada
* CMHC Research Division, Ottawa, and their publications such as Building Materials for the Environmentally Hypersensitive.
* Envirodesic Ltd., Bruce Small. Evaluates/provides information on products for healthy building construction. Has done much work for the Toronto school board and others. 1 905 642 8866
* Enviropro Canada (1-800-811-2032 G. Morandin)re: design for the use of low-emission cleaners. They also carry a Gym Finish for hardwood floors that dries to a hard low-emission surface fairly quickly, and portable HEPA/carbon filters for cleaning up after renovation and construction. (Small)
* Environmental Education and Health Services inc., Austin Texas, 1 512 288 2369
* TerraChoice (Environment Canada's Ecologo program) evaluates products and Publishes a guidebook of approved products. 1 613 247 1900.

2.6 Table 1 shows an outline of the procedure and criteria for determining which materials should be included in the solicitation for product information.

Table 1: Procedure and Criteria for Reviewing Materials During Design

a. *Identify generic building materials, products, and furnishings. All textiles, wet products, pressed-wood products, and other products believed to emit chemicals into the air.*

b. *Determine the quantity and type of use for each material.*

Exposed surface area as well as cross-sectional area and mass are important.

c. *Determine whether the material will be exposed to the indoor air or the ventilation air supply and return stream.*

Air movement at the surface will generally increase emission from the surface. Return air ducts and concealed spaces above ceilings serving as return air plenums are as important as supply air ductwork and air handlers, since re-circulated air will have passed through the return air system. Thus, the upper surfaces of ceiling tiles or lay-in panels and insulations on structural floors, beams, and columns will be exposed to the return air.

d. *Determine whether occupants are likely to come into direct or close contact with the material or product based on its contemplated use.*

The closer the occupant is to the product, the less dilution of the emissions can occur before exposure.

e. *Identify high surface area (fleecy) materials.*

Textiles and roughly textured insulation materials present large surface areas, which can emit at higher rates than smooth surfaces. Rough surfaces also act as adsorption sites for chemicals already in the air, then re-emit them later.

f. *Identify materials that will require "wet" maintenance products.*

Maintenance products such as waxes, polishes, cleaners, and solvents can result in indoor air quality problems if not properly applied or ventilated. Drying time available between application and occupancy and ventilation during and after application, are critical elements to reduce air contamination during occupancy.

(Cutter)

2.7 Flush Out and Source Control Reduce Contaminants in New Construction

There are often complaints about adverse health effects from new construction or renovations. Just as often, tests result in conclusions that the air quality is fine. Standard measured levels of this or that factor can provide misleading information and conclusions because they are based on research on isolated substances and often on minimum safety levels for protection of adult males over an eight hour work day. The failure may be (1) not taking into account a more sensitive population (children, or individuals with environmental sensitivities) or (2) not looking at the combined or synergistic effects of temperature, humidity, bioaerosols, VOCs, and other factors of indoor environment quality.

SOURCE CONTROL and GOOD DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE will more surely result in better Indoor Air Quality when the project is finished.

It is wise to include PERIODIC ASSESSMENT throughout the design & building phases so as not to have too many surprises at the end when making corrections would be costly. Humans being human, the temptation at that point would be to let things "slide" by.

What to do when reduction of emissions from new building materials is needed? In cases where least toxic options still have some emissions, a FLUSH OUT is the currently recommended procedure:

FLUSH OUT PROCEDURE:

(1) Remove all porous materials such as furniture, books, paper, fabrics, etc. Otherwise, the chemicals driven off may be absorbed by these materials to be gassed off later, defeating the purpose.

(2) Increase the ventilation throughout the area with the use of fans, open windows &/or turning the in-house ventilation system on high. Include increased exhaust ventilation to the outdoors so as to eliminate the pollution from the area. (Be sure the air intakes, other windows, do not draw the pollution back inside.

(3) Gradually increase the heat to a maximum of 35 degrees C. Ventilation is more important than heat, but heat will help if it can be achieved. Don't sacrifice the ventilation for heat. (Also, in a new construction, heating up or heating up too quickly can cause uneven drying and cracks or other damage to some new materials.)

(4) Maintain the flushout for as long as possible or necessary - usually a minimum of 24 hours, but sometimes as long as several months, depending on the materials being offgassed and the amount being offgassed. Some experts recommend that after completing the aggressive flushout, a high ventilation rate should be maintained for at least a year.

- Citizens for A Safe Learning Environment

Finishing a Fast-Tracked School

A method was devised for finishing and drying out a fast-tracked school (Halifax West High School, 1500 students) so that finish work could be done as early as possible: The planners divided it into four areas and finished one area at a time completely (after reducing the relative humidity by using barriers and portable furnaces and with the main system remaining off). Meanwhile, the next area was worked on at an earlier stage but readying it to be next for drying and finishing, and offgassing, and so on. This process was the responsibility of the contractor as written in the job specifications. The process was timed so the gym will be completed and off-gassed for 2 1/2 months before opening date and one month before substantial completion date. The gym was also not used as a storage area, leaving it free to be finished early, as the second section, so as to avoid IAQ problems when the school opened. A further step is expected in future new schools with the use of lower-emission, water-based floor finish.

Contractors at this school also avoided glue use on site by not laminating window frames or trim. Wooden trim and doors were lacquered off site (at the factory) using approved, low-emission lacquers.

2.8 WHMIS Control - Does it Protect Children?

For several years, Government protection regulations have required that Material Safety Data Sheets (MSDS) be on location for all WHMIS (Workplace Hazardous Materials Information System) controlled products in use in the workplace. This includes many cleaning and maintenance products used in schools. These sheets provide important information for the protection of those who may come in contact with the products. You can get details on the listed ingredients from Hazardous Materials Lists available through Labour or Health departments, or through the internet. The MSDS themselves may, however, give us a false sense of security.

What you need to know may not be found on the MSDS for several reasons. They are prepared by the manufacturer according to government specifications, but there is little or no monitoring of either the products or the MSDS information. It is also possible for manufacturers to apply to have certain materials exempted - If the chemical is determined to be a trade secret, for example, its name can legally be omitted from the MSDS.

When chemicals are tested, they are examined individually. There is usually no attempt to evaluate how they may change or what new compounds they may form when combined with the other ingredients in a product or in the air. For these individual chemicals, standards for safety are set for healthy adult males in the workforce, not for women, children, the old, or the ill - and not to mention those who have developed hypersensitivity to chemicals.

Many chemicals have not been tested at all. The U.S. FDA, whose information is used by Health Canada, receives an average of 50 new chemicals per day to examine and determine if they are safe and suitable for use. It is impossible to adequately test even a fraction of these for carcinogenic, mutagenic, teratogenic, or other hazard, (A teratogen causes birth defects by damaging the fetus.) and many of these chemicals are destined for the cleaning and construction business.

Because ingredients lists are protected information, only those ingredients that must by law be reported may be on the MSDS. Chemicals that are present in amounts less than 1% need not be listed, and carcinogens below .1% can be exempt. Inactive ingredients such as binders, fragrance, or pigments/dyes are not always reportable either. As an example, experts in the industry claim that many liquid handsoaps contain formaldehyde as the preservative - at less than 1% it need not be reported on MSDSs. Environmental Health Professionals and physicians assert there should be zero tolerance for formaldehyde exposure because of its sensitizing quality. That is, people sensitized to formaldehyde often develop broad sensitivity or intolerance to multitudes of chemicals and substances unrelated to formaldehyde. It is also a carcinogen (is known to cause cancer). To further illustrate the limits of usefulness of MSDS, note the MSDS of a room deodorant used in the school system: Although this room deodorant emits a strong chemical odour, its MSDS states, under "Ingredients: NONE".

WHMIS has good value. However it is not wise to rely entirely on WHMIS for ingredient specifics. Professional help may be required to identify good quality low-pollutant products.

- K. Robinson, Healthy Schools Editor, The National UPdate (1999)

2.9 Recovery of Mold-Exposed Books

July, 2001

Many people have expressed interest to ensure that library books and textbooks brought from Halifax West High School to the new school are free of microbial contaminants.

Background on Molds

Molds can be found anywhere; they can grow on any organic substance, as long as moisture and oxygen are present. There are molds that can grow on wood, paper, carpet, foods, and insulation. It is impossible and not necessary to eliminate all mold and mold spores in the indoor environment. However, when moisture accumulates in building materials, mold growth will often occur if the moisture problem persists longer than 24-48h. While all buildings have some mold, respiratory and non-respiratory health effects have been reported when large areas of building materials are contaminated. Mold growth can be controlled indoors by controlling moisture indoors.

Molds reproduce by making spores in the few millionths of a meter size range, small enough to penetrate the lungs. Mold spores waft through the indoor and outdoor air continually. When mold spores land on a damp spot indoors they may begin growing and digesting whatever they are growing on in order to survive. Molds gradually destroy the things they grow on.

Many types of mold exist. All molds have the potential to cause health effects. Molds can produce allergens that can trigger allergic reactions or even asthma attacks in people allergic to mold. Others are known to produce potent toxins and/or irritants. Potential health concerns are an important reason to prevent mold growth and to remediate/clean up any indoor mold growth. (EPA 2001, p 2). Glucans are chemicals found in the cell walls of molds which may cause inflammatory lung and airway reactions. These glucans can affect the immune system when inhaled.(EPA 2001, p 43)

Mold Remediation/Cleanup and Biocides

The purpose of mold remediation is to prevent human exposure and damage to building materials and furnishings. It is necessary to clean up mold contamination, not just kill the mold. Dead mold is still allergenic, and some dead molds are toxic. The use of a biocide such as chlorine bleach is not now recommended as a routine practice during mold remediation (NYC 2000) In most cases, it is not possible or desirable to sterilize an area; a background distribution of mold spores will remain in the air (roughly equivalent to or lower than that level in the outdoor air). These spores will not grow if the moisture problem in the building has been resolved (EPA 2001, p 18) Building materials and furnishings that are contaminated with mold growth and are not salvageable should be double-bagged using 6-mil polyethylene sheeting. These materials can be discarded as ordinary construction waste. It is important to package mold contaminated materials in sealed bags before removal from the containment area to minimize the dispersion of mold spores throughout the building. (EPA 2001, p 18).

Mold-exposed Books, Clean or Discard?

If books had actual water damage or if they were stored in humid conditions, or if the pages had more than 7% water content, then they likely have mold. If the books were not in a wet area, but just exposed to mold spores in the air, then it should be possible to clean them. If you can smell mold then it probably indicates something has been growing, however it could also mean mold VOCs have been absorbed by the paper. Page by page cleaning is very laborious. Instead, read below about fanning books with HEPA suction.

Books, Paper, and Archives.

The clean-up of books, paper, and archives damaged by floods and dampness involves a combination of discarding moldy items, drying out of wet materials, and removal of settled dusts. Fungi can grow rapidly on many of these materials because of the adhesives, gums, starch, etc., often present in book jackets and bindings and also because of the presence of delignified cellulose. Because of the susceptibility of books, paper and archives to biodeterioration, the drying of water damaged or damp materials is of critical importance. Freeze drying of water soaked material can be used in restoration because low temperatures arrest fungal colonization and evaporation of water molecules (subliming) lowers available moisture so that mold growth can not recur. A goal of restoration is to lower the moisture content of paper to its normal range, 5-7% where fungal growth does not occur.

Several simple techniques are available for removing superficial colonization from valuable materials. Miniature aspirators capable of applying a gentle suction to surfaces by a pipette nozzle can be used to carefully remove spores. A small vacuum cleaner can be used to remove spores where a fine screen is placed

firmly over the fragile material being cleaned (28). All cleaning activities involving manual removal of colonization should be performed by persons with adequate personal protective equipment and preferably in a biosafety cabinet.

The cleaning of library materials which are not visually colonized but which were stored in buildings with mold growth problems is a challenge because of the enormous amount of paper surface potentially involved. The following activities can be effective in cleaning dusty library materials that had been stored in a moldy environment: (a) Vacuum (HEPA instrument) the top, bottom, and sides of books and files to remove settled dusts. (B) Vacuum and damp wipe the surfaces of shelves, file cabinets, desks and other non-porous fixtures. The visual presence of dust on books and on nonporous surfaces (e.g. shelves) in the library indicates unsuccessful cleaning. (C) Fan the pages of the books, files, and other archives in the immediate vicinity of the suction orifice of a HEPA vacuum. The objective is to reduce the amount of dust present on surfaces of library materials. (Morey 2000).

Mold VOCs can be absorbed/trapped by paper, and books can readily acquire a moldy smell even if there is no visible mould evident. Try airing the books with the pages spread. If airing and vacuuming do not remove the smell, advisors suggested professional treatment for valuable books and the rest should be discarded. Do not wet wipe books or book jackets or wipe with biocide solutions because you are adding water.

Packing and moving books that are currently in use or in storage presents an opportunity to evaluate them for fungal contamination. Be alert for signs of mold contamination when opening boxes or entering storage areas. Note evidence of mold growth or water damage. Sometimes there may be a musty odour but other times spots of mold growth can be seen. Isolate those with evidence of visible mold. Unless of exceptional value, these should be discarded. The Canadian Conservation Institute in Ottawa can be contacted for help in conserving such materials. Avoid handling moldy books without personal protection equipment.

- K. Robinson Chair, Healthy Schools Construction Committee, President, CASLE

References

AIHA (2001) Report of the microbial task force. AIHA, Fairfax, VA USA

EPA (2001) Mold Remediation in Schools and Commercial Buildings. www.epa.gov/iaq

Morey P (200) Cleaning Procedures for Mold. Proceedings of Healthy Buildings 2000 3:39-48

New York City (2000) Guidelines for the asessment and remediation of fungi in indoor environments. http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html

3.0 Information/Comments on Specific Items:

3.1 The Envelope:

- Primary Building Envelope Design Criteria: (1) No water ingress points anywhere, for short and reasonable long term, (2) No opportunity for condensation on internal or exposed surfaces by judicious use of vapor barriers and thermal break. These are primary design elements in this Maritime climate region. These have been the Achilles heels of most Maritime construction in the past fifty years. (McLaughlin)

- Getting the structure right is paramount, and as much attention should be paid to that task as to the choices of materials and additional features. The primary principle to follow is to create a building envelope that is tight and does not contain toxic or high-emission materials. The tightness of the envelope inhibits drafts that cause condensation within the wall, whether from the inside in the winter, from the outside in the summer or in the rainy/foggy seasons. Having a tight wall allows for much more rigorous control of the intake air and consequently, control of incoming pollutants and moisture.

  We have some experience in tight-wall design, and it is becoming more common as a standard feature of commercial building construction. Detailing must be meticulous to avoid leakage paths. In the U.S., school buildings and "healthy houses" are starting to incorporate the Icynene Insulation System, a system that helps to seal the wall while it insulates, but is emission-free (http://www.icynene.com).

  Every possible precaution to avoid current and future rain/water leakage is warranted. Detailing and choice of quality windows etc. is important. (Also careful installation) Guttering, sloping of adjacent ground or pavement, are all indispensable for ensuring that extra moisture does not enter from above, through walls, or from underneath. (Small)

3.2 Concrete:

3.2.1 Vapor barriers

The concrete slab in the Stillwater High School project (see Oetzel, below) was protected from potential moisture, mold problems and radon gas by installing a polyethylene vapor barrier over the sub grade prior to pouring the concrete. The vapor barrier was upgraded from 6 mil to 10-mil to achieve additional protection.

Passive or mechanical radon protection methods are available. A vapour barrier is only as good as the lack of penetrations.

3.2.2 Admixtures

Caution was recommended with regard to admixtures; their usage should be minimized when possible. Some (for example the air entrainment or detergent that adds air bubbles) can be eliminated entirely if the concrete work is scheduled during favorable weather conditions. Use low-toxicity separators for form work. Use non-chemical curing, water-based sealants, hardeners, and caulks, and minimize plasticizers according to performance needs. When plasticizers, set accelerators, set retarders, and air entrainment are necessary, use low VOC products.

Curing, Sealing and Dust-proofing

The solvent-based cure, seal and dust-proofers specified often contain aromatic hydrocarbons in amounts up to 86 percent by weight. Lower toxicity, water-based counterparts recommended by manufacturers were substituted at Stillwater. The construction workers and the environment were the primary beneficiaries. (Oetzel)

The US EPA provide stringent recommendations regarding allowable VOC emissions from building materials. There are relatively low VOC water-based hardeners that prevent damage and powdering from foot traffic and use.

3.3 Insulation:

Cavity Wall Insulation

- Three coats of paint with vapor barrier qualities were applied to the warm side of all cavity walls. This procedure should reduce the low-level fumes volatilizing approximately 50-60 percent. Recommendations for the foam board insulation specified encouraged the use of products manufactured with reduced ozone depleting potential. Alternative control measures not used at Stillwater but that could be used in other situations include installing an appropriate vapor barrier in the wall cavity or replacing the polystyrene foam board insulation with a cementitious foamed-in insulation. (Oetzel)

- In Canada, air barriers have proven more effective than vapour barriers because they bridge all openings (cracks, holes, windows, doors, etc.) more effectively, thus preventing moisture laden air from migrating into the walls and causing condensation and mould propagation. This is explained well in the appendix of the Canadian Building Codes. (Lee)

- Thermal and fireproofing insulation materials do not necessarily need fleecy surfaces in order to work. For economic reasons from a manufacturer's or application perspective, it often results in using fleecy surfaces. Where possible, coat materials with a smooth and impermeable membrane to reduce the adsorption of VOCs on their surfaces.

- Reduce the potential for microbial growth, control humidity within the ducts. Prevent condensation by properly locating humidification or de-humidification equipment. Be sure that ductwork can be inspected and cleaned. (Cutter)

3.3.2 Acoustic Insulation

- Insulation materials emit indoor air contaminants from their original composition. They also re-emit chemicals which are adsorbed on their very large surfaces. Insulation used for acoustic control is often "fleecy" in order to enhance its sound adsorption capabilities. The fleeciness enhances adsorption of VOCs and retention of VOCs within the building.

  Acoustic insulation materials, especially those used in HVAC ductwork, are particularly challenging from an indoor air quality perspective. Fleecy duct linings inevitably become contaminated by particles and by biological aerosols leading to microbial amplification. Covering them with impermeable membranes reduces their effectiveness for noise control purposes.

  Limit the use of acoustical insulation. Where acceptable, apply it to the exterior of ductwork. Use sound baffles rather than insulation where they will do the job. (Cutter)

  - Reverberation control can be accomplished by non-parallel surfaces and by surfaces with texture and curvature. (Lee) This is particularly important in non-carpeted, low-fabric, healthy schools, as was found in the Prairie Ridge school. (Oberg)

3.4 Walls:

At Stillwater School, the acrylic plaster specified in the plans was replaced with gypsum plaster and Portland cement plaster. Latex enamel paint was used on the gypsum plaster as well as on all interior gypsum wallboard. Alternative control measures not used at Stillwater School but that could be used in other situations include using a low-emission joint and texturing compound and finishing with a low-biocide latex paint. The typical compounds have some toxicity. Because of this and the volume present in a school, it would be beneficial to use the lower toxicity alternatives. (Oetzel)

- Masonry (concrete) is preferred. Minimize use of gypsum board where possible, and use only water resistant gypsum board. (Lee)

If using gypsum board, leave a 1 to 2 inch gap between the floor and lower edge of drywall to prevent wicking from daily mopping or from minor flooding. Seal baseboard well as a barrier to mopping seepage. Softer baseboards may require support by placing a removable waterproof strip of durocrete behind but leaving a gap between the durocrete and the bottom of the gyproc wall. Immediately after a flood, the baseboard and durocrete would be removed so that drying of the cavity behind can be facilitated within the 36-hour mould-free "window" of time. Much remedial expense

can be avoided by preventing wicking of water into the gyproc and through ease of drying out of wall cavity.

Or, create another form of water barrier at floor level by making the base of each wall a single row of concrete block with the gyproc wall placed on top of the concrete.

Green drywall contains wax compounds which offgas profusely forever. Substitute waterproof (not just regular) cement board (it still has emissions) or Dens-glass tile backer for tile applications and regular drywall (preferably with some recycled content) in all non-wet areas, drywall with no paper face is better, additive free plaster is best but expensive, blue board and skim coat plastercan be substituted (still expensive). If the primer and paint chosen have significant gas phase sealing properties then the concern over drywall emissions is lessened, poly-vinyl acetate primers and 100% acrylic paints have better sealing properties than latex. (DST Consulting)

3.5 Ceilings:

- Ceiling tiles are the second largest surface area. Ceiling tiles have two sides exposed to the air stream. Ceiling tiles are exposed to the circulating indoor air, and the temperatures at the ceiling are often the highest within the space. (Cutter)

  They are made of fibers and glue. Some have a strong, permanent odour so a sniff test of samples of tiles is important. Also, vinyl and vinyl coated tiles should be avoided due to offgassing. Movement from shifts in air pressure can cause movement of the tiles and breaking off of particles that then enter the breathing space. Sealing all sides of tiles and any cut edges can help solve both offgassing and particulate issues. One possible solution is very heavy, fire barrier tiles that may not require clips to hold them in place. They are required to be kept in place for fire code reasons.

- Do not use the space above the T-bar ceiling as a return air plenum. The ceiling space is impossible to clean and easily contaminated by leaks, offgassing from hot lighting, insects, etc. Always provide for a ducted return air plenum. (Lee)

3.6 Floor Treatments:

Gym floors:

Water based polyurethane (100%) works well for gym floors if it is properly applied. The isocyanates in the water based products are in a different and less hazardous form than in the oil-based ones. The number of coats is less of an issue than the thickness of the final product. Two ml is not thick enough.. Short cuts on preparation and thickness have sometimes caused water-based floor finishes to underperform. Professional basketball associations use water based floor finish successfully. (Sorensen)

In halls and classrooms, avoid baseboards. Continuous cove is better for water containment as floor washing tends to cause water to go behind baseboards over time, causing potential for mold growth.

Carpeting should be avoided. The industry now produces carpeting with low potential for the initial chemical exposures characteristic of new carpeting and accompanying adhesives. However, carpets are harder to keep clean than hard flooring, and schools are particularly challenging to carpet use for several reasons. Use hard-surface flooring materials throughout the building. Terrazzo is cost effective in the long term. It requires annual sealing. Stained sealed concrete is nearly as good. Baseboards can be eliminated as with terrazzo. Also, ceramic tile with dark grout. VCT flooring with low toxicity adhesive is the third choice.
(Oetzel)

Illinois' five year old Prairie Ridge school used low-emission VCT flooring and low emission adhesives successfully. (Oberg)

3.7 **Table 2:** Comparative Costs of School Floor Coverings. (USA, mid-1990's)

Vinyl Composite Tile (VCT) vs Terrazzo and Carpeting

Study based on a 50,000 Sq ft School

Frequency of Replacement and Initial Flooring Cost

Floor covering	Replaced	Current Cost/sq ft	materials & Labour/50,000 sq ft
VCT	33 years	$1.32	$65,800.00
Carpeting	8 years	$1.83	$91,300.00
Terrazzo	Never	$6.00	$300,000.00

Maintenance Costs / 50,000 sq ft

Day to Day Cleaning - School Year of 36 weeks

Floor Covering	Per Year	20 Years	40 Years
VCT	$113,249.00	$2,264,980.00	$4,529,960.00
Carpeting	$204,394.00	$4,087,880.00	$8,175,760.00
Terrazzo	$113,249.00	$2,264,980.00	$4,529,960.00

Average Replacement Costs

Floor Covering	40 Years
VCT	$49,315.80
Carpeting	$389,938.40
Terrazzo	none

Total Cost of School Floor Coverings

Materials, Installation, Maintenance

Floor Covering	20 Years	40 Years
VCT	$2,655,091.00	$5,105,539.00
Carpeting	$5,290,976.00	$10,581,952.00
Savings w/VCT	*$2,635,885.00*	*$5,476,413.00*
Terrazzo	$2,564,980.00	$4,829,960.00
Savings w/Terrazzo	*$2,725,996.00*	*$5,751,922.00*

(Oetzel)

3.8 Entryway Design:

See Environmental Building News Vol 10 Number 10, October, 2001 for information on keeping pollution out of buildings through good entryway design. In short, the article says 70-80% of the dirt in commercial buildings and two-thirds of dust in houses comes in on shoes. This dirt and dust can carry a wide range of materials such as pesticides, VOC's NVOC's, and a wide range of allergens, bacteria and mold, lead and asbestos. Also tracked in are moisture and organic material which feed dust mites or may be allergens themselves. Research on what is called the Personal Activity Cloud shows between 1.5 and 7 times as many particles in the "breathing zone" around people than there are in the undisturbed room. (What was unclear from the article is if this is in a carpeted room or a hard floor room, however the research article is referenced.)

The articles states that "...removing the dust from office space results in large reductions in eye, nose, throat, and respiratory illness - but not in central nervous system symptoms. Particulates are largely responsible for the former problems, while volatile gasses are responsible for the latter."

Recommendations: a three-part "track-off" system that extends at least 10 meters into the building. Outside, a scraper mat or grill for removing loose dirt, snow, etc., and designed for regular hosing. Next, "trapper" or "wiper" mat of bristle. Finally, a "finish" mat. The article gives more detail of such features as ventilated cavities below mats. Also part of a successful system is good outdoor walkways etc, and a good maintenance program. It also helps if people will actually wipe their feet on the mats!

3.9 Wood Products:

- Not all interior engineered wood products have urea or phenol formaldehyde glues. Exposed MDF should be laminated or sealed with three coats of clear waterborne acrylic. All cuts or drill holes should also receive two coats of acrylic primer or waterborne urethane. See fact sheets from bydEsign for more details. (DST Consulting)

- Arborite and Formica are acceptable encapsulating materials. Any cutting or drilling through the encapsulating material must be "re-encapsulated" with several coats of a non-VOC sealant. (Lee)

- Thick, fused not glued industrial-grade melamine is as good as other laminates, but hardware store grade stick-on or painted-on melamine are not .

- The E-1 Standard (European Standard) was developed to avoid exposure to formaldehyde. It combines low formaldehyde materials with a four week, well ventilated, offgassing period of finished products. (Sorensen)

  Some low emission MDF manufacturers are listed at

  www.oikos.com/products/category2.lasso?cat=200

Multicore plywood

LONG-LAC is a manufacturer of multicore plywood with an emission rate equal to or lower than even the European standard. Multicore does not add any formaldehyde in the process, but does have what is called "background" formaldehyde because all wood has some naturally occurring formaldehyde. (DST Consulting)

Laminates will work in place of sealants/lacquers. Melamine doesn't hold up as well as formica or laminate, but the American National Standards Institute has tests such as the AWARE test that measure product durability. Painted melamine tends to perform poorly as a barrier for emissions. Also, the T-shaped edge banding that is sometimes used to finish edges doesn't provide a good barrier. (DST Consulting)

Examples:

Some compromises were necessary at Stillwater school, Minnesota:

Glued up wood products are potential sources of formaldehyde. The plywood and chipboards intended for exterior application are manufactured using a phenol-formaldehyde resin. Phenol resin products are more stable and emit far less formaldehyde than interior-grade hardwood plywood, particleboard and medium-density fiberboard, all of which are manufactured with a urea-formaldehyde resin. The specifications were revised to reflect the following control measures for glued-up wood products:

Although exterior-grade plywood is more stable, it was separated from the building atmosphere where possible.

a) Particleboard sub-flooring was eliminated from the specifications.

b) Urea resin plywood, particleboard and medium-density fiberboard used in specified casework, shelving and furniture was encapsulated on all surfaces with plastic laminate (manufacturers contacted complied with this request.)

c) Urea resin hardwood plywood was omitted from the specifications except for a minimal amount in the auditorium.

d) Hardwood veneered solid-core doors were coated with an appropriate sealant to reduce formaldehyde emissions.

e) All tack-boards and marker-boards were constructed with formaldehyde-free core materials. (Oetzel)

Note that M. Oetzel's recommendations on materials and methods used in the design and construction of the Stillwater High School Project are not specific to only this school, but can be applied broadly to new school construction. We understand that the Minneapolis State Education Department went on to include 80% of Oetzel's recommendations in their design requirements manual.

At Prairie Ridge, industrial grade metal cabinetry and shelving were chosen for their strength, flexability and low emission characteristics. Heavy duty handles/locks are recommended. (Oberg)

3.10 Sealants/caulks:

Sealants such as those used in glazing systems and in assembling exterior wall components can be important. The reason is not their surface area, so much as it is the mass of material, which often is inherently a long term emitter of VOCs. Data is currently being gathered on the relative quantities of various materials. When the quantity of material and emission characteristics are both known, the contributions to occupant VOC exposure can be calculated. (Cutter)

3.11 Adhesives:

Adhesives are ubiquitous in new construction. Concerns revolve around the frequency and amount of use, the high levels of numerous VOCs in these substances, and the fact that decisions as to their usage are frequently left to the discretion of the manufacturer. Specifications for the Stillwater High School were modified to eliminate adhesives whenever possible. Only mechanical fasteners were used to install gypsum panels, acoustical wall panels, tack boards and marker boards.

Guidelines were submitted for the selection of lower-emitting adhesives, such as silicones and latex products. Manufacturers of these lower-emitting products agreed to review construction procedures and determine the specific adhesives necessary to ensure performance. (Oetzel)

3.12 Paints/Lacquers:

1)Paint products contain a variety of VOCs incorporated as drying agents, flattening agents, mildewcides, fungicides, and others. These VOCs have been measured in indoor air many months after application of the paints. There is a wide range of formulations with an equally wide range of emission rates and chemical contents. Data from the EPA Public Access Buildings Study (IAQU) December 1988) showed a hundredfold difference in the VOC emissions from one latex paint and another.

Some paint products are being marketed as "natural" or "environmentally safe." Ask manufacturer's to recommend the products with will create minimal indoor air contamination. Heavy duty latex paint having no VOCs is best. (Cutter)

2)At the time of painting, including undercoating, all windows should be opened and the supply air operating to flush the paint fumes out the window. If it is raining, don't paint. Use least toxic paints designed for occupants with environmental sensitivities. (Lee)

3)Particularly with water borne paints and with second or third coats. Rain and high humidity do not allow water borne paints to set properly. If the first or second coat skins over the surface, the first or second coat will require far longer to cure (sealed by the skin and by the second and/or third coat) and therefore can be a long term source of VOCs. (DST Consulting)

Environment Canada's Ecologo program lists some low emission paints and lacquers. Chemcraft, Bona Kemi and Enviropro are examples.

Polyurethane lacquers without harmful isocyanates perform well on desks and furniture, and also seal emissions from MDF . (Sorensen)

Some low emission lacquers don't work well on some low-emission MDF, apparently because the MDF is very dense. Sometimes it is just a matter of surface preparation. If the MDF and lacquer are not compatible then use formica or other glued-on barriers over the low-emission board on all sides. Coat any drilled holes. The goal is to have no exposed composite board. Sometimes board is cut out before adding hinges. That needs to be sealed before hinges go on.

3.13 **Interior Partitions** (Movable Room Dividers, Workstation Panels):

The fabric coverings on free standing partitions offer a considerable amount of surface for adsorption of VOCs from the air. They can act as important sinks for adsorption and re-emission of VOCs into the indoor air. They are fairly low in thermal mass. Their temperature can change quite quickly in response to changes in air temperature. They are generally exposed to the air stream in the indoor environment, thus, VOC vapor pressure will increase and cause increased emissions.

The location is important, since building occupants are usually in close proximity to the panels. It is difficult to develop ventilation distribution systems that will eliminate or minimize exposure of occupants to emissions from the panels. Free standing partitions are constructed using various insulation materials, press-wood products, and adhesives known to emit VOCs.

One type of interior partition contains chipboard material used for septum. It is made from recycled paper materials similar to the composition of food boxes. Manufacturer inspectors will often have soiled panel fabric cleaned at the plant before shipment. About 25% of panels must have some cleaning with a common cleaning solvent (trichloroethane). It is a volatile compound, evaporating very quickly when exposed to air. A substantial portion of the residue on the fabric at the time of packaging is released into the building when the packaging is removed. Trichloroethane is one of many known eye and mucous membrane irritants commonly found in indoor air. It is also used as a pesticide. (Cutter)

3.14 Shelving:

An easily cleanable school makes a big difference. Open shelving in classrooms leads to random accumulation of vast amounts of books and other items that can't be easily dusted. Closable cupboards are easier for avoiding both dust accumulation and emissions from books and other classroom materials. (Small)

3.15 Low E and Tinted Glazing:

The current trend is to look at energy efficiency above health impacts, however CMHC did a study of twenty-five homes where low-e windows were either installed in a new home or used to replace old glazing. Some occupants developed SAD within a year or so. An avid orchid grower who always had blooming orchids failed to get any blooms after he put low-e windows in his home. Even ivy, which thrives in low light died. In addition, when a solar blanket was stuck onto the window in an apartment, a ten year old jade plant withered over the next weeks. Plants that had survived many moves and been with owners for a long time withered or died.

Also, a Swedish study looked at ninety volunteers in a blind study of responses to the use of glazed rooms. One room had low-e and another clear glazing. The condition responses in the low-e room were midway between responses reported on the room with clear glass and a windowless room below grade.

Low-e technology is still focused on energy efficiency. Research and development is producing different kinds of low-e glazing. It narrows the spectrum and cuts down the amount of transmitted light, so both the amount of light and the quality of that light is changed, depending on the type of low-e coating used. For example, a coating designed for Florida will allow in only a fraction of the light as compared to clear glass.

Research shows light has subtle but important effects on how the body functions modulated by light received through the eye. It nurtures metabolism, affects hormones, circadian rhythm, mood, and well-being.

RECOMMENDATION: Use clear glazing and shades if necessary to control glare and overheating.

Alternatives for increased energy inefficiency of windows:
(1) use good quality sealers
(2) use good quality spacers between the panes
(3) use argon (or other) gas between the panes
(4) fit the windows well in the opening
(5) conserve heat by closing blinds at night (Salares)

(6) triple glazing (Oetzel)

Rather than choosing which rooms should risk being overheated by sun in the wrong seasons, it may make sense to arrange for proper shading of windows. (Small)

Fixed awnings outside can serve several purposes in a well-designed healthy building. (Lee)

3.16 Blinds/window coverings and PVC/vinyl

Window coverings may cover 10% of the wall surface or more and therefore can be a significant area offgassing. There appears to be no "perfect" window covering. Issues such as maintenance, cleaning, light penetration, and more, vary from option to option. One school district reports successful use of heavy duty metal mini-blinds for elementary schools but fire-retarded cotton roller blinds or drapery for high schools.

Options include vinyl/PVC roller blinds, cotton/fabric roller blinds, inherently fire retardant drapes, cotton or other drapes, panels, shutters, vertical or horizontal slat blinds of metal or plastic/vinyl. When window coverings are heated by sun or nearby radiators they tend to give off their volatiles at an increased rate. Hard vinyls tend to offgas less than soft vinyls. Over time the rate decreases, however, vinyls tend to continue to offgas for the life of the product. Moisture contributes to offgassing as well. Fire retarding fabrics can add pollutants, however there are less toxic retardants being used commercially.

PVC, Poly Vinyl Chloride, is a frequent component in blinds and other equipment (vinyl flooring, baseboards, chairs, equipment etc.). A building science engineer quoted in Environmental Building News (Vol 10, No. 11, Nov., 2001) called it "The worst of the plastics". Vinyl chloride is a carcinogen and the Pthalates in PVC are both carcinogens and hormone disruptors. Pthalates bioaccumulate in the body because the body can't detoxify them. This source also said PVC has many additives, sometimes lead and cadmium, which may leach out of the plastic. Lets hope there is never a fire with vinyl/PVC blinds, chairs, etc. because burning PVC produces hydrogen chloride and Dioxin, one of the most toxic chemicals known.

(When we put "no vinyl flooring, wallpaper, blinds" in Healthy School Design and Construction task lists it was because of the VOC's, but as with most of what is in the task lists, we weren't specific as to the nature or the implications of using such products that are made from persistent toxic chemicals. - K Robinson)

Illinois' Prairie Ridge school used heavy duty metal blinds with 1/2 inch blades everywhere except the cafeteria. After five years, they are holding up well and have not suffered from any vandalism. (Oberg)

3.17 Lighting:

Natural light without glare is best. Artificial light which approximates natural light and does not flicker or glare and is neither too little nor too much, is desirable. The kind of light does more than let students see the page. It can influence mood, behaviour, and well-being.

(For more on Lighting: see chapter 10, HSH and Rousseau's *Your Home your Health your Well-being)*

3.18 Electromagnetic Fields (EMFs) and Radio Frequencies:

Can the magnetic and electrical fields that emanate from electrical equipment cause health problems? Since the late 1970's this question has been discussed and studied, and much is still unknown. Scientists disagree about the potential risks of exposures, and on what, if any, measures should be taken to avoid risks from exposure. Some say that avoidance just for the sake of possible, but so far unproven, harm is unnecessary. Based on what we do know, others advise erring on the side of caution until more is known, especially when children are involved. Certainly the EMF "canaries", those who are hypersensitive to EMFs, are pointing the way toward the possibility that just because you can't see them doesn't mean they can't hurt you.

Electromagnetic Field (EMF) is the common term often used (inaccurately) to refer to several kinds of radiation. Radio frequencies (RF), for example, are not EMF's, but they are also being examined

for potential impacts on health and well being. RF sources include ham radio antennas, walkie talkie, CB radio, radio towers, TV towers, cell phone towers, and microwave transmitters. (Lee)

Dr. Andrew A. Marino, in Chapter 11 of The Healthy School Handbook, gives us seven basic facts to help us understand the health risks from EMFs:

1) EMFs come in various kinds, but they can be measured.

2) They are real, but are not composed of atoms. They are forms of energy.

3) Because they are forms of energy, not matter, they have their own properties. One plus one can equal two, or three, or even zero, depending on various factors.

4) EMFs are created by every electrical device from battery operated toys to power lines. It is not possible or desirable, Dr. Marino points out, to eliminate all EMFs in classrooms because there are so many benefits from the electrification of society that were not there to help us in previous centuries. Instead he suggests focusing on removing unusual or excessive sources in the classroom.

5) EMFs radiate outward through surrounding space and become weaker as the distance increases. He points out that it is this property of spreading that enables TV and communication waves to work. However, the radiating waves from a computer are more like by-products, and not of inherent value to the operation. He suggests possible vanishing points where EMFs can no longer be detected,(they would have to be measured to be sure) as being: One mile from a TV antenna, 1,000 ft. from a radar source, 500 ft. from a high voltage power line, 100 ft. from a telephone communications tower, 50 ft. from a building transformer, 10 ft. from an electric motor, 5 ft. from a computer screen, 1 ft. from a light bulb, 3 inches from an electric clock.

6) The absence of research showing possible harm should not give us a sense of security. Dr. Marino concludes that "the existing state of scientific evidence warrants the inference that EMFs can be a health risk and, for this reason, that steps ought to be taken to avoid exposure."

7) Estimates of risk are just that - estimates. They are influenced by many subjective factors, and can vary from risk assessor to risk assessor. For example, if Dr.X believes it is important to protect the unlimited use of EMFs by society, the amount of evidence needed to convince Dr. X of risk would be much greater than that needed to convince Dr. Y, who himself suffers from EMF hypersensitivity.

Researchers have found links between EMFs from high-voltage electrical lines and increased rates of childhood leukaemia. Other diseases can also result because EMFs combine with other factors to affect the body's resistance to disease in general. It should be noted, however, that although illness (usually cancer) has been connected to some EMF exposures, not all who are exposed develop cancer or other illness. High level exposures from such sources as high tension power lines, have well documented effects including cataracts and neurological damage. Less well known are the effects of lower level exposures. While many individuals display no apparent affects from EMF exposure,

some individuals experience profound symptoms even to low levels. This can not be overlooked when trying to determine the cause of, for example, a child's difficult behaviour or other unexplained symptoms.

Dr. Doris Rapp, in her book, Is This Your Child's World? provides practical information for us for recognizing an existing sensitivity to EMFs:

If your child "experiences any of the following symptoms at school or at home, EMFs might be the cause.

1) Chest pain, headaches, blurry vision, or any unexplained discomfort while sitting directly in front of a standard upright computer.(By contrast, laptops cause fewer health difficulties.)

2) Looking, feeling, or behaving in ways other than normal after exposure to a computer, television, set, or microwave oven

3) Feeling ill or different just before or during a thunderstorm or certain other weather changes

4) Not feeling right near high-power electric wires

5) Tics or seizures"

Dr. Rapp also tells of evidence that EMFs can increase the toxicity of chemicals by allowing them access to nerve cells. She also reports research which shows that low-level magnetic fields can affect the blood-brain barrier and allow particles to enter the brain and disrupt normal function.

Common EMF Sources:

Common sources of EMFs or RFs are High-tension wires, electrical transformers, radio and television transmitters, power plants, telephone lines, computers, TVs, kitchen appliances, lighting fixtures, and more. Electric fields are found even in a building's wiring, and are often present when the electrical equipment is not turned on. For example, hair dryers, power tools, clocks, and other electric appliances have localized EMFs, some of which are there even while the object is switched off. The amount of electricity used by an appliance does not reflect its EMF levels.

Unlike electric fields, magnetic fields are present only when electricity is flowing.

The closer one is to an electric or magnetic source, the stronger the field, and the field strength drops quite quickly with distance. For example, computer EMFs are reported to be negligible at arms length, or at about 30 inches. Students should be kept at least 40 inches from the back and sides of computers. Place the keyboard as far as possible from the computer and screen, and add a grounded screen. There are protective boxes available and even protective barrier clothing if maximum protection is necessary to prevent symptoms.

According to the Report to the New York State Board of Regents on the Environmental Quality of Schools, p.32, "Most U.S. homes have background magnetic field readings ranging from 0.5 to 4 milligauss" (mG).

Example EMF measurements from page 33 of the New York State Board of Regents Report:

centre of a living room	0.2-3 milligauss (mG)
under an electric blanket	5-25 mG
hair dryer at 4 inches	3-400 mG
operating toaster (at 4 inches)	10-60 mG
connection at home (electric meter)	5-20 mG
directly under high voltage line	50-500 mG
edge of right-of-way high voltage line	10-200 mG

Dr. Rapp suggests renting or buying a gaussmeter to measure the EMFs. "In general, a level of about one milligauss measured about two feet from the item being checked, is considered safe, while levels over 10 mG are cause for concern. Although the acceptable level in Sweden is 2.5 mG, scientists there have warned that as little as one or two mG can produce adverse health affects in very sensitive individuals." This leaves the area between 2.5 and 10 mGs as an unknown risk range.

Although some workplaces have standards for exposure to video display terminals, few standards exist for acceptable levels of EMFs in industry - let alone for dwellings or schools. There are no laws requiring testing of schools for EMFs.

New York State looked closely at the issue of EMFs and schools. They found 32 of their schools were located near high power lines. They negotiated a voluntary agreement with power suppliers to prevent future location of high EMF sites near schools, and for assistance with correcting existing problems. The NY State Dept. of Health does EMF tests for schools upon request and provides information on "prudent avoidance measures" as needed.

The following are recommendations from the Report to the New York State Board of Regents on the Environmental Quality of Schools, p56:

At the School Level:

1) Plan new construction away from fixed EMF fields.

2) Use existing space already exposed to fixed EMF fields only intermittently, if at all.

Keep adequate distance between people and the EMFs generated by electrical equipment; of particular concern is the design of work spaces in which students and staff use computers.

3) Reduce exposure to EMFs when this can be accomplished at no great expense or inconvenience by practicing "prudent avoidance".

4) Remove EMF exposure from the school vicinity.

5) Require students to maintain a distance of, at least 40 inches from the back and sides of video display terminals.

At State Level:

1) Recognize the current limitations of scientific knowledge about electromagnetic fields and their health effects.

2) Use restraint in establishing any policy on EMF exposure in light of the lack of concrete evidence to support a policy direction.

3) Establish safe EMF exposure levels for children.

Dr. Marino advises in the Healthy School Handbook:

Radio and television towers radiate intense levels of RFs and schools should not be located closer than 1,000 to 2,000 ft.

(Dr. Rapp quotes experts as recommending that schools be no closer than one mile from high RF sources.)

In schools, the feed from the power grid should be underground, and the circuitry should be away from inhabited rooms.

The lay out of school wiring should take EMFs into account. The wiring, if done in sequence, can cause a classroom located near the power source to have EMFs about four times higher than a room four rooms away, simply because the power for the fourth classroom (and the second, and third) must pass through the first classroom on its way to the others.

EMF audits should be done in all classrooms. Broadcast EMFs, electrical power EMFs, and cellular telephone EMFs all need to be detected. Dr. Marino suggests as well that for externally generated EMFs the ones responsible for generating the EMFs should be involved in the decisions for correcting the exposure.

Dr. Marino also advises that cellular phones not be used around children because of the very high EMF levels.

Overall, the wise choice seems to be to keep children's exposure to EMFs to a minimum. There are some experts knowledgeable in matters of environmental health impacts from EMFs and who can help advise school officials. It would be wise to be sure those consulted are well informed and trained in the concerns and issues voiced in the reference materials quoted in this article.
(AEHA, HSH, Culver)

3.19 Mechanicals (heating, ventilation):

- Choice of heating system is important, particularly to find equipment that does not leak fumes and is easy to maintain. Also to insist that if there are either raw fuel or gas leaks, or combustion leaks, that these be repaired. It is not as crucial to create a separate building for the heating plant, as it is to make sure that the equipment space is well sealed, and that air flow is controlled so it flows from the school to the equipment room and not the other way around.

  Consider using building automation to allow proper regulation of humidity of the buildings while still conserving energy. It may be important, for example, in some seasons, to continue to run the heat and air after the occupants have left until the humidity is reduced, before reducing the heat, so that there is no condensation on cold surfaces as the temperature drops. Designing the outside walls meticulously to avoid cold spots will also minimize problems due to fluctuations in relative humidity. (Small)

- All ranges must have a very effective range exhaust directed to the exterior. The hood must be designed to be as large and low as possible to capture as much of the cooking fumes as possible. The range hood exhaust must be hard wired to an outdoor supply of air into the space to equalise the air pressure to prevent chimney backdrafting and to prevent pressures that may result in water and mould infiltration through the building envelope. (Lee)

Sheet metal and ducting usually has a coating of oil from the manufacturing process. This oil is not necessary for the performance of the product and may pose an added indoor air quality problem both from the offgassing of the oil and from the tacky surface which causes dust and other debris to stick to the surface. The oil can be removed by the supplier or on site with a degreasing agent such as TSP (Tri Sodium Phosphate). Washing and rinsing would be done with power washing equipment prior to installation. *(Hygienic Aspects of Processing Oil Residues in Ventilation Ducts*. Pasanen et. al. Indoor Air, ISSN 0905-6947, 1995.)

No biocides, pesticides, rodenticides, fungicides, fragranced products, or air fresheners should be used in the HVAC system at any time.

3.20 Filtration:

March, 2002

Research has suggested that schools tend to have poor indoor air quality (IAQ) for several reasons, including a concentration of classroom materials (such as art and science supplies), tight budgets that reduce maintenance, and because of high occupant density (approximately four times as many people as office buildings). There is much pollution-generating activity amongst these people, and often there are non-existent, outdated or poorly maintained mechanical ventilation systems. Source control (avoiding the problem of dirty air) and ventilation (diluting pollution) help provide good air quality. Filtration of the air can also improve IAQ.

Kinds of Air Cleaners:

Note the difference between air "filters" and air "purifiers". Electrostatic purifiers and ozone generating purifiers are under examination for possible health impacts. Manufacturers and salespeople with these products are not happy about the controversy, but international health and safety agencies recommend use of proven alternatives such as source control, ventilation and filtration.

1. Ionizers disperse negatively (or positively, depending on the design) charged ions into the air. They attach themselves to particles and cause them to become negatively (or positively) charged so they will attach themselves to surfaces such as walls or furniture. Research has shown ionizers to be less effective in removing particles of dust, tobacco, smoke, pollen and fungal spores than high efficiency particle (HEPA, see below) filters.

2. Turbulent Flow Precipitation (TFP) units target particulate, but they don't remove VOCs. Before HEPA filters became less expensive, TFP units were a good but somewhat less effective alternative. TFP claim to remove about 95% of 1 micron size and 90% of .5-.9 micron, as compared to HEPA's 95% of 0.1 micron particles and 99.97% of 0.3 micron particles. Some TFP manufacturers are augmenting their particulate removal efficiency by adding HEPA filters. One should watch for foam parts, as offgassing foam can be a problem for some people.

3. Electrostatic air purifiers can be up to 50% efficient (particle removal) on average (MERV 5-8), but these can create finer particles when dirty and create ozone when clean. They tend to be expensive to repair and require high maintenance.

4. Ozone Generating Air Purifiers. Ozone doesn't remove particles. It destroys odours. There is controversy over the safety of ozone-producing purifiers. Ozone is a gas that reacts readily with

other chemicals/substances to form many byproducts, from harmless water to harmful breakdown products such as aldehydes. Manufacturers insist purifiers that use low level ozone clean the air without causing harm. International health and safety regulators have strong doubts about this, and recommend avoiding ozone-producing units. Ozone reacts with and can damage lung tissue. NIOSH recommends the upper limit of .01 ppm not be exceeded at any time. The US FDA limits ozone to .05 ppm for medical devices. The US EPA's standard is a maximum 8 hour exposure of .08 ppm. No agency in the US or Canada has approved ozone air cleaning devices for use in occupied spaces. There is also evidence that at concentrations that don't exceed public health levels, ozone doesn't effectively remove viruses, bacteria, mold, or many chemicals. Also, variations in outdoor ozone levels, and indoor conditions such as ventilation and proximity to the ozonator make it difficult to control the actual level of ozone in the breathing space. When there are other more effective, no-risk air cleaning devices available, why choose ozone?

5. Particle Filters. Particulate are minute droplets of liquids or physical solids suspended in the air. Some are large enough to be seen and some are microscopic. (One source estimates about .01% of house particles can be seen. That 8% of those not visible are fungus and spores, dust mites and their feces. Ninety percent of house dust is microscopic. Of course this depends on the house!)

Examples of particle types:

Biological: pollens, spores, molds, bacteria, viruses, hair, skin cells, insect byproducts, and food byproducts.

Mineral: asbestos, clays/silica, carbon, lead, man-made fibres, hydrocarbons.

Combustion products: tobacco or wood smokes, particles generated by cooking or heating appliances, and industrial processes.

Radioactive: radon-decay products

Particles are measured in microns. Particles between 5 and 10 microns tend to be caught in the nose and throat. particles smaller than this travel readily into the lungs.

Examples of particle sizes:

10 microns heavy atmospheric dust and flyash

5-10 microns molds, pollens, average dust

1-5 microns bacteria, light dust (ie:fine chalk or drywall dust)

.3 microns tobacco smoke, bacteria

.1 microns viruses & bacteria (some are smaller than .01 microns. Some are larger. Anthrax is 1 micron wide & 4-10 microns long.)

About 2 years ago ASHRAE developed a performance rating based on knowing the composition of test dust and size, and also on particles that are respirable. This is called a MERV rating (Minimum Efficiency Reporting Value). MERV ratings are on a scale of 0 to 20, with 20 being the best rating. There are 3 or 4 labs in the US that test for MERV ratings.

This rating system removes the ambiguity of the "% efficiency" claims made by manufacturers. For example, 95% efficient (95% of what? Is it 95% efficient at filtering out .3 micron particles? .1 micron particles? Is the claim based on the number of particles removed or mass removed?) "Ninety-five percent efficient" referred to particle weight means that the filter will remove 90% of the weight of particles. This is deceiving because only 10% of airborne particles contribute about 90% of the weight of all particles in air. In other words, this 95% efficient filter can let 90% of the air's particles through.

An analogy would be:

It is like having a big dog that weighs 200 lbs and 99 one-pound pups. When they come to a fence, the 99 pups easily run through but the heavy dog cannot. It can be claimed the fence was 67% efficient because it stopped 67% of the dogs (particles). Reality is that the fence is like a filter that let 99% of the particles through! It is the little particles that can cause most of the problems.

Furnace dust filters (rock-catcher) 2-3% efficient at particle number removal. MERV 1-4

Media filters up to 8% efficient at particle removal, MERV 1-4

electrostatic up to 8% efficient, MERV 1-4

DC charged electrostatic (up to 12VDC) up to 10%efficient, MERV 5-8

All of these can be advertised as being up to 95% efficient if the claim refers to weight and not particle number removal.

The following have commercial applications:

High density media filters (used in hospitals in general surgery) MERV 13-17

HEPA filters 99.97% efficient down to .3 microns and a MERV rating of 17-20

Typically, a MERV rating of 12 or higher represents a filter that can help sensitive students and staff.

Health effects from inhaling various particles:

irritation of eyes, throat, nose, lungs

impaired respiratory mechanics such as coughing, wheezing, shortness of breath

aggravating existing respiratory conditions such as asthma, allergies, or bronchitis

impacts on the immune system or central nervous system

cancer

How many particles per square foot is the safety target?

It is a moving target because different people have differing needs. Some individuals may have an asthma attack triggered at 500,000 particles per cubic foot while others are much more tolerant. At 300,000 particles per cubic foot, one dealer I consulted reported his worst client sleeps well through the night, feels well rested, is less congested and uses less medication.

If a company states its filter will remove 90% of allergens such as pollen, they are probably referring to 2 microns in size. Good filtration usually means that the target area will have only 1/3 or less of the contaminant level outside. Depending on outside levels, that may or may not be adequate for the occupants, however.

6. Airborne Chemical Filters. Volatile Organic Compounds (VOCs) such as those from furnishings, personal care products, combustion, and mold mycotoxins are missed by particle catchers, but can be absorbed by carbon and other media filters. Some VOCs are removed by HEPA filters, but mostly because a few chemicals attach themselves to particles that are caught in the filter. Cutter defines VOCs as "one of a class of chemical compounds that contain one or more carbon atoms and tend to evaporate at room temperature and normal atmospheric pressure."

There are naturally occurring organic compounds too, such as mold mycotoxins and aldehydes and keytones which are breakdown products from mold mycotoxins, that won't be removed by particulate filters. Activated carbon or other media such as zeolite are needed to remove VOCs from the air.

Activated carbon filters: Tiny cavities trap gasses. Natural ozone which is trapped actually helps to break down chemicals within the "pockets". Several kinds of media filters are available for use in removing different target chemicals.

Also important is the possibility that building occupants may be sensitive to materials in the filters. Most people do well with activated carbon filters, but sometimes highly sensitive individuals need alternatives such as VOC cartridges or filter beds of tiny glass beads.

Further to this, some carbon filters have a microbial pesticide in the form of a silane-modified quaternary amine that is bonded to the carbon. While it does kill molds and bacteria/viruses, it may create unexpected and subtle adverse health effects in sensitive individuals. Basic, unmodified, activated carbon tends to be preferable.

7. Other:

Some promote the use of vacuum cleaners with either water filters or HEPA filters as combination vacuums and air filters. Use vacuums as vacuums (with HEPA filtration) and air filtration systems for air filtration. They are not equally interchangeable for several reasons despite manufacturers claims. Motor size and motor noise for one, capacity/amount of air filtered, and others.

Filters Need Maintenance:

One drawback of filtration is that filters need replacing. Manufacturers can only give estimates of the life of filters. It all depends on how polluted the area being cleaned is and how long the filters have been in.

For media filters there comes a point where they begin to shed the pollution they have collected. One house I was helping with had a strong odour of fish throughout the house and no one knew where it was coming from, as no fish had been cooked in months. It was the air filter in an upstairs bedroom in need of clean filters. In a tour of the old Halifax West High School we noted that rooms with HEPA and carbon portable filter units smelled of sweat and stinky sneakers! The filters were over-loaded.

HEPA filters become more efficient as they fill up - until they reach a point where they are clogged. The rate of air flow slows down and consequently the machine loses the desired rate of air cleaning ability. As well, the filter may collapse and therefore lose its filtering capabilities. Reinforced media filters are recommended. Typically, HEPAs can last up to five years and high density media up to one, depending on the pollution load.

So, maintenance is important to effective filtration. Systems need to be designed for ease of maintenance. A service schedule (or a professional service package) that will maintain filter units is important.

The cost of replacement HEPA filters has gone down by more than half ($300.00 vs $125.00) in the past 3 years.

It is extremely important to view a particle count demonstration before purchasing.

A filter is less effective when it does not have a 100% air seal.

Air changes and cfm (Cubic Feet per Minute)

Reported cfm can be misleading. For example, the cfm of a motor in a filter unit may be 400 cfm, but the cfm of the same motor within the machine, but with filters slowing down the air flow, could be half that. Air changes per hour are more useful to know. Four air changes per hour is approaching "hospital" standard and isn't usually necessary. One air change per hour is a common target, and care needs to be taken to avoid stagnant areas.

Integrated Systems:

Some supplementary filter units can be integrated into new building systems or can be added to existing buildings, usually above the T-bar. They can serve single or multiple rooms, but should be sized accordingly. The systems can have zero pressure drop, and should be sized for close to 1 air filtration per hour. If ducted to the outside, they can be set with either a positive or negative pressure. Systems can have flexible, semi-rigid ducting to help improve air circulation. Supply and exhaust point away from each other and as far apart as possible. Polypropylene soft plastic is more stable than some flexible ducts, and some manufacturers are colouring their polypropylene ducts to differentiate them from the cheap dryer ducts. Rust-proof metal ducts are preferable, and should be washed to remove any surface oil film. Be sure installation is done by a professional.

Farming or industrial communities may need more filtration, not only against polluted outdoor air, but also because farm children tend to bring more pollution into the classroom on their clothing.

If filters are being used in a newly built school it may be recommended to replace the filters after the first six months and then less frequently after that.

- *K. Robinson*

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3.21 Relative Humidity

Relative Humidity is measured as a percentage indicating the amount of moisture in the air relative to the maximum amount the air can hold at that temperature. The higher the temperature the more moisture air can hold. If the humidity exceeds 100%, moisture will begin to condense from the air. CMHC recommends relative humidity of between 30% and 50%. The target is 40%. Less than 30% may cause increases in health symptoms from dryness, while RH over 50% may encourage molds and other organics to flourish. Hygrometers need to be calibrated fairly often for accuracy, but the technique is quite simple. For more information contact CMHC.

3.22 Lockers

Lockers can be a significant source of IAQ problems. They need to be cleanable both inside and under and also be ventilated. Raising them on continuous cove bases prevents floor scrubbing to cause water seepage underneath and subsequent mold problems. Student's winter boots drip inside, coats & gym uniforms "cook" in there, juice containers leak or spill, foods are left to mold, food crumbs find their way into the space below, and more. Rodents and insects may visit lockers for food. Wall mounted lockers are easily cleaned below and also allow for identifying dripping from lockers that need cleaning. A locker design was developed for the new Halifax West High School. Lockers are attached away from the wall, allowing for air circulation, and with slanted tops that meet the wall - preventing objects from falling behind. For cleaning and monitoring, they are suspended off the floor using triangular wall supports. Time will tell if space behind would be better eliminated due to creation of a "cavity" that is hard to clean.

3.23 Bunsen Burners

Bunsen burners are a potential source of indoor air pollution from the gas, combustion, and the ingredients being "cooked" in the test tubes. Suggestions for augmented ventilation to counter this: Individual "octopus" fume hood system over lab tables and vented directly outside, or two-speed high capacity exhaust fan that is switch operated by the teacher and with a timed off switch. Vented directly outside.

3.24 Oil tanks/Boilers:

Oil fired furnaces/boilers inherently have leaks, especially during fill-up. In addition, fuel trucks often idle near the tank during fill-up. Aside from the common combustion leaks from boilers, these are further reasons why the tank and boiler room should be separate from the school. (Lee)

3.25 Natural Gas/Propane Gas: minimizing potential for harm.

April 2001

Nova Scotia is in the process of bringing natural gas onshore and piping it into homes and businesses across the province, and bringing with it many perceived benefits to Nova Scotia. As long as the supply lasts, it is a relatively clean burning fuel, therefore causing less combustion pollution. It should be less expensive than the coal & oil fuels we have traditionally burned. Also, propane gas equipment that is currently being used can generally be converted to burn natural gas.

Nothing comes without its challenges, however, and natural gas is not an exception. As with propane gas, it is becoming more commonly recognized that there are potential risks to human health from the use of combustion appliances and furnaces. "...natural gas has been found to be one of the most important sources of indoor air pollution and sensitizing agents..." says Dr. Gerald Ross, MD., founding Director of the Nova Scotia Environmental Medicine Clinic and Past President of the American Academy of Environmental Medicine.

Dr. T.G. Randolph, MD, writes "...for the chemically sensitive individual this gas may be the worst form of fuel." Randolph's clinical studies found that all family members health improved, not just the health of chemically sensitive family members, when gas appliances were removed from the home.

Adds Dr. Bill Rea, MD, Chair of the Environmental Health Center, Dallas, "In both Randolph's and our combined series of 47,000 patients, the most important sources of indoor pollution responsible for generating (environmental) illness were the gas cook stoves, hot water heaters, and furnaces."

The British medical journal, The Lancet, reported in 1996 that the use of domestic gas appliances, especially gas stoves, was linked to increased asthma, respiratory illness, and impaired lung function especially in young women. The same study showed that venting the gas stoves did not reduce adverse effects.

The American Journal of Respiratory and Critical Care Medicine (1998;158:891-895) found ``a significant adverse effect of gas stove exposure on respiratory health in children," more than doubling their risk for respiratory symptoms, including asthma.

By 1994 the Canada Mortgage and Housing Corporation (CMHC) had recommended the replacement of indoor gas appliances and combustion sources with electrical appliances in order to reduce indoor air pollution.

To quote information from the article Gas Attacks, "Natural gas brings harmful chemicals and health hazards into homes through the methane in natural gas itself, as well as with its impurities, contaminants, additives and products of combustion. Natural gas (methane) itself is an asphyxiant

which contains impurities and additives, which typically include radon and other radioactive materials, BTEX (benzene, toluene, ethylbenzene and xylene), organometallic compounds such as methylmercury organoarsenic and organolead, mercaptan odorants and other toxins. When natural gas is burned, as in cooking and heating, the chemicals create nitrogen dioxide, carbon monoxide, fine particulates, polycyclicaromatic hydrocarbons, volatile organic compounds (including formaldehyde) and hundreds of other chemicals. Just imagine what you are breathing when you bend over a gas cook stove to stir your food or when you open the oven door. This stuff sticks to your food too, so you eat it as well. It sticks to clothes in gas dryers so you are covering your skin in it. It is lighter than air so it rises up into your living and sleeping areas, concentrating higher up nearer you head. This is one reason why gas is worse than fuel oil which is heavier than air and thus sinks and which is never used in stoves or driers, etc."

The article goes on to say, "At a recent conference on air quality and childrens' health sponsored by the Lung Association, much attention was paid to the extreme problems caused by molds. And natural gas turns out to be a strong contributing factor. One of the principal products of combustion of gas is water vapor. When one cooks with gas or burns gas in any way without perfect venting, considerable amounts of moisture are distributed inside the building, enough to be a significant contributor to molds. And the excess moisture provides better conditions for dust mites. And the water vapor is even an insidiously effective transport mechanism for respirable particulate and volatile organic compounds deep into the lungs and thus into the body.

If You Really Must: Best Practices for Gas

Adverse effects of home and water heating with gas can be lessened considerably by putting the furnace and water heater in a separate building downwind of the house with underground connections. Failing this, putting the furnace and water heater in a separate sealed room with an outside air intake into the room and venting the room itself and all appliances up a chimney that extends above the roof line will result in a substantial lessening of harmful effects. Both furnace and water heater should also be state-of-the-art totally sealed units with separate outside air intakes ducted directly into their combustion chambers and forced exhaust via automatic fans. No side venting should ever be allowed, despite claims of gas purveyors. These practices are recommended as best for all combustion appliances indoors and are likely to increase the health of every individual, even if you are not currently aware of any harmful effects. Still it is safest to not have any combustion at all inside the house."

For generating electricity or as the heating/power supply for large industrial users gas appears a good choice as compared to coal or oil burning. The important thing is to isolate both the fuel storage tanks and the combustion centre (furnace room) from the main building, so there is little chance of leaks entering the living space..

Some schools and other buildings in the province are being built with geothermal and solar heating/air conditioning. Back-up systems of gas-generated electricity are used. This minimizes fossil fuel use, but uses more efficient, cleaner burning fuel when the main system is not enough.

Environment Canada has programs and grants available to encourage use of renewable energy. Ask for information on residential use of solar or geothermal energy. For commercial buildings there are CBIP (Commercial Building Incentive Program) grants for use of solar panels and solar walls and geothermal heatpumps. There are also grants for meeting assessment criteria for sustainable buildings, such as GB-Tool 2000 (Green Building Tool) and the C-2000 program for achieving high performance for commercial buildings.

Nova Scotia made a commitment to reduce greenhouse gas emissions to 3 and a half million metric tons equivalent, which is 16.5% below business as usual, by 2010. Reducing these emissions by using renewable energy will also reduce our dependence on non-renewable petroleum based resources. It will have the added benefits of cleaner air both indoors and outdoors - benefits to both Mother Earth and her inhabitants.

The hazards from possible propane or natural gas explosions still exist, but keeping the combustion process outside the living space by having no combustion appliances and by isolating furnaces, and using other forms of energy as much as possible, we may have found the healthiest combination for now.

-*Citizens for A Safe Learning Environment*

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3.26 Pest Control:

Replace insecticides and herbicides on the site and in landscaping with organic alternatives/Integrated Pest Management (IPM). Texas has mandatory IPM for schools and with full time IPM coordinator. A Maryland school board saved over $90,000.00 in their set-up year.

Use organic fertilizers in landscaping and indigenous flora in place of lawn.

See www.thebestcontrol.com and www.region.halifax.ns.ca for more links and information on alternatives.

3.27 Colours:

The choice of colours of walls, ceilings, floors, and fixtures inside the school can impact on the mood, comfort and overall well-being of occupants.

3.28 Kitchens:

The "Healthy School" Goal in the Cafeteria and Food Labs

March, 2002

The goal in a healthy school is to reduce the opportunity for harm to come to occupants. Choices in the cafeteria and kitchens can impact on this overall goal, but they are complicated by emerging health-related information on materials and their safe use.

We have become accustomed to the benefits of using plastics, vinyl, and Teflon coatings in our kitchens. However, research in related fields is showing that caution is warranted, especially when heat is involved, because chemicals from utensils can leach readily into the food. Some of these chemicals are toxic, such as phenol, and some are endocrine disruptors, as DEHP (di[2-ethylhexyl]phthalate) from soft plastics.

A building science engineer in Environmental Building News writes that PVC, poly vinyl chloride, contains "persistent toxic chemicals". The vinyl chloride in PVC is a carcinogen, and the pthalates are carcinogens and endocrine disruptors. Pthalates accumulate in the body because the body has difficulty detoxifying them. Plastics may contain phenol, acetone, diethylene glycol, fluorocarbons and other toxic chemicals. According to this source, burning PVC gives off hydrogen chloride and dioxin, one of the most toxic chemicals known.

In 1998 Health Canada advised parents to throw out soft vinyl toys (Polyvinyl chloride [PVC plastic] or vinyl) because of leaching of toxic plasticizers DINP and DEHP. Also, unacceptable levels of lead and cadmium were found in a range of PVC toys. At the time, latex and silicone were said to be safe alternatives, however a rise in latex allergies in recent years is of note. This January, 2002, a panel of experts advised Health Canada that soft plastics are of particular concern when used as medical devices, even when at room temperature. Plastic/vinyl readily gives off chemicals such as biphenol-2, DEHP and others. The report is cautioning that plastic/vinyl medical equipment be avoided with vulnerable populations such as infants, prepubescent boys, pregnant women and other high risk groups. A Health Canada position paper on this is expected by summer 2002.

Not all plastics are the same. Some do not use any solvents. Teflon is apparently one of these, and should be inert below its decomposition temperature. This is why it is allowed as a cookware coating. However, the concern comes when it is accidentally badly overheated.

About Cooking Pans:

"It seems that the safest ones are the least durable - Pyrex, ceramic, enameled steel - they are breakable or chipable. Several years ago I was sent a copy of a report from Simon Fraser U (or might have been U.B.C.) regarding a lab worker who died after laying a burning cigarette on a Teflon lab table top, then picking it up and inhaling the decomposition fumes from the Teflon. Elapsed time was said to be about four hours.

You should be able to confirm this by referring to a library copy of 'Hazardous Properties of Industrial Materials'. Sax was listed as the author/compiler a decade or two ago but it may have another name on it by now. The last time I priced the current version of 'Sax' it was three volumes and over $400. - and that might have been $US. I haven't been able to find it on-line.

I looked it up in the Departmental copy of HPIM-Sax and read there that Teflon starts to decompose at about 400 deg C, and gives off phosgene gas - which is one of the most deadly gases to be found. As a point of reference, in normal room light the temperature which will be seen as a dull red glow (any stovetop burner turned on high for a few minutes) is at least 600 deg C. For any normal cooking, this temperature would never be reached. However, all it could take is for someone to put a pan on a hot burner, get distracted for five or ten minutes, and...

By the way, stainless steel also has a hazard of its own (as does aluminum). For most foods cooked in water, or fried, there is no problem, but when acidic foods are heated for an extended period of time in stainless steel it can start to dissolve some of the toxic Chromium and Nickel from the stainless steel. For example, mulling apple cider in a stainless steel pot for an evening is not a good idea. (Apple juice is more acidic than orange juice, on average.)"

(Ben Fullerton, retired Dalhousie Physics Department researcher, known for his knowledge of hazardous properties and toxic materials. Also past president, Allergy and Environmental Health Association.)

Alternatives:

In the absence of testing a rule of thumb is "the harder the plastic, the less leaching". However, this all depends on variables such as the acidity of the stored materials, the presence of heat and the age and makeup of the plastic. For example, storing flour in a harder plastic tub would be less of a concern than micro waving soup in the same plastic container.

We can not control what is used at home, but current health issues in the kitchen can be part of what is learned and discussed at school, based on research and without taking alarmist positions. If science is not yet clear, and if we lack relevant testing information on certain materials, is it not better to use

available alternatives? In time society will become more sure of which products are safer and for what purpose, but for now, here are some suggestions.

Food storage:

Avoid contact between plastics and foods, especially when heat is involved.

Glass/high tech ceramic, enamel are best for food storage. Stainless steel for less-acidic materials.

Cover with aluminum foil with the shiny side toward the food (the non-shiny side usually has a waxy coating.)

Cellophane bags can be used in place of plastic “baggies”. (Cellophane is made from plants.)

Products labeled "rubber" are sometimes plastics instead and may or may not be stable.

Caution: Some imported or older North American ceramic glazes may leach harmful minerals such as lead, cadmium and barium.

Suggested order of preference:

1.glass, Pyrex, high tech ceramic, enamel

2.stainless steel

Cooking pans/pots:

Suggested order of preference:

1.Enamel, Pyrex, high tech ceramic

2.stainless steel

3.cast iron

Avoid Teflon, other teflon-like surface, and aluminum

Alternatives:

Greased muffin tins/baking pans

Avoid pressurized lubricant sprays. Use shortening, cooking oil...

Paper liners (cooking oil coated?)but not waxed paper, as the wax is commonly a petrochemical.

Cooking utensils:

Avoid plastic utensils, especially for cooking.

Use wooden or stainless steel stirring/serving spoons, and

stainless steel ladles and lifters.

Plates/bowls/cups:

Suggested order of preference:

1. glass, enamel or ceramic preferred.
2. Heavy paper plates and cups are better than Styrofoam, but some do have a waxy coating. Styrofoam should be avoided, especially for heated foods. Styrene is a suspected carcinogen.

Anti-microbial cutting boards:

Some research has found hardwood cutting boards washed with soap and hot water to be just as good and possibly safer than the plastic ones that are commonly used. "Anti-microbial" cutting boards have a pesticide or poison in them to kill bacteria. Perhaps phenol, as it is a commonly used micro poison for liquid injectables these days. Some "advancements" are not necessarily improvements.

Cleaning:

Less hazardous cleaning materials are also available for school kitchen use. Chlorine bleach and citrus based cleaners have toxic chemicals as their main ingredients. Hydrogen peroxide bleaches are alternatives to chlorine for washing school tea towels, but note that hydrogen peroxide can corrode steel. Research indicates ordinary washing with surfactant "soap" and hot water will disinfect, even in a hospital setting. Many advertisements lead us to believe that to be clean we need to use a disinfectant, but this is not the case. In addition, research is indicating the overuse of disinfectants may be leading to the development of resistant "superbug" viruses and bacteria. See www.chebucto.ns.ca/Education/CASLE for information on cleaning materials. In particular, the article "Maintenance Chemicals in Schools".

Gas appliances:

Also avoid the use of gas appliances such as gas food warmers, clothes dryers and stoves or other combustion appliances often found in kitchens and cafeterias. See the Task Lists for Healthy School Design and Construction and its appendix.

This article has been prepared not as a "directive" but to assist with responsible decision-making.

- *Citizens for A Safe Learning Environment*

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4.0 RECOMMENDATIONS FOR P-3 (Private/Public Partnership) SCHOOLS

by School Board Occupational Health & Safety Program Administrators

These are general recommendations on school design which directly or indirectly impact on Health and Safety. They are not described or discussed in detail. If those reviewing these items request further detail, justification or rationalization, the administrators will meet with or respond to those making requests.

These concerns have not been dealt with well by those who have designed and built schools in the last few years. They currently are major causes of problems which school boards are trying to deal with now.

(1) The roof will as much as possible shall be a continuous membrane at one level with moderately sloped insulation for draining. Two floors of classrooms and a two story high gym would make the roof one level and continuous. *Nearly all school built recently have had significant and chronic leaks at membrane seams and edges from day one. Some of the leaks are caused by snow drifting on multi-level roofs leads to water damning which allows water to spill over flashing roofs. Chronic roof leaks cause major mold related air quality costs and concerns.*

(2) Complete gymnasium first when building the school. The pressure to open the school forces occupancy as soon as the classrooms are completed. Serious air quality problems have occurred in new schools because of off gassing of chemicals used in completing the gymnasium.

(3) For every P3 school, the prime contractor shall be responsible for designating an individual to be continuously on site during all construction activities who is responsible for health and safety for all those involved in construction. If this individual must temporarily leave the site, that individual must designate a replacement in writing. This will be done in order that there is one individual at the site during all construction who has overall responsibility for compliance with all health and safety legislation and related regulations.

(4) The Department of Education shall appoint a full time site inspector at each P3 school construction site with regular access to all those involved with the project to review school plans and contractor Occupational Health and Safety procedures, to assure that Department and Board interests and these recommendations are being addressed.

(5) No part of the building occupied space should be below grade. Foundations do not retain their integrity over more than twenty years in our winters. Most schools remain in service for thirty to fifty years or more, and basement areas become damp spawning grounds for mold.

(6) To alleviate problems of getting onto the roof, the following should be provided; stairs and a vertical door entering the roof area at a point more than five feet from the roof edge rather than

vertical ladder and horizontal hatch entrance. Getting onto a roof for maintenance and inspection can be a constant inconvenience and safety problem.

(7) HVAC intake/exhaust shall be located so that there is no re-entrainment and consideration of other sources of entrainment be considered such as the location of school buses, kitchen and plumbing vents. filters shall be located far enough from the intake to prevent snow and rain from sucking or blowing in to wet filters. *We are all dealing with recent poor designs in this area.*
(8) HVAC/energy management systems shall have its final commissioning during the winter.

(9) Maximum HVAC noise level in the classroom shall be specified and a check shall be part of the commissioning process. Needs of hearing impaired children shall be considered in the specifications and design. *Currently staff thank the principal when the noisy HVAC system is turned off for servicing. It is difficult to instruct and causes voice problems when the teacher has to project their voice above the system noise*.

(10) HEPA FILTER after a prefilter for all air supplied to classrooms.

(11) The designs shall separate vehicular traffic (including parent drop off, buses and service vehicles) from pedestrian traffic and make a rational analysis of building entrance by those arriving by various means.

(12) Openable windows (top and bottom) suitable for providing adequate independent ventilation.

(13) All windows must have interior screens (due to increased number of students and staff allergic to bee stings).

(14) Sun screens should be horizontal, metal blinds (no drapes or plastic).

(15) By far the most common injury cause in schools is slip and falls. These are fundamentally caused by the unexpected loss of traction. Consideration should be given to textured flooring (no carpets) in areas of greatest hazard: entrances, cafeterias, stairs, areas where monitors watch the playground activity.

(16) Location and height of display boards should be such that they can be reached without a ladder. *A lot of teachers fall off chairs while putting, pinning or taping educational materials on display boards above "blackboards.*

(17) All hallway and stairwell doors shall be normally open and connected to the fire alarm system. When they are not, users typically wedge them open. Areas accessed for public functions (gyms, cafetoriums, AV theatres, etc.) can be isolated from the rest of the school and have a separate security system.

(18) Boiler room isolated, ideally in a separate building. External access only. Provision for adequate external air supply for boilers.

(19) No oil, propane or natural gas fired water heaters, spirit duplicators or laminations (unless independently vented.)

(20) Adequate storage for school program related materials and custodial supplies.

(21) Provision of an internal communication system for those working alone in the building.

(22) Labs: separate CSA or ULC approved cabinets for strong acids, alkalis, flammable; separate exhausts for fume hoods, chemical storage rooms and classroom.

(23) List and MSDS's for all materials used in the construction of the building provided to the board at the time of commissioning.

(24) Electric heat source to replace "Bunsen burners" for labs.

(25) Lab table designed for adequate supervision of all experiments.

(26) All parts of the building to be wheel chair accessible for students, teachers and public.

(27) Custodial storage with CSA approved cabinets for flammable materials cabinets for storage of paints and solvents. Sufficient number of custodial closets with exhausted negative air. Custodial closet with sink close to main entrance to allow for moping of tracked-in water. Adequate number of closets with a good locking system with independent key.

(28) No carpets

(29) Adequate storage with separate bins in appropriate location to support the garbage separation and recycling system.

(30) External shed for storing grounds maintenance equipment.

(31) All fuel storage above ground.

(32) In all cases ground slopes away from building for a minimum distance of 100 feet.

(33) Separate pedestrian, bus and public vehicular entrances.

(34) All schools must have a least three week gas off period and base line testing for formaldehyde, VOC, noise and lighting levels prior to occupancy. gym floor coating is never to be applied or drying while the building is used by students.

(35) Music room and performance areas (gymnasiums, cafetoriums, AV rooms) should be designed for acoustic compatibility for activities.

(36) Facility health and safety considerations for hearing and visually impaired individuals shall be addressed in the design of the school.

5.0 Draft Building Readiness Guidelines for New School Buildings

Prepared for the Nova Scotia Department of Education

by

The Healthy Schools Construction Committee

November 20, 2002

Introduction:

There is tremendous pressure to open schools once they have reached substantial completion, a point where they are contractually finished but often still being worked on. This situation has led to students and staff reporting marked health and learning difficulties from the offgassing of new building materials, equipment, furniture, paints and more. Direct and indirect costs from this situation have included assessment and remedial work, and medical, insurance and productivity losses for affected building occupants. By making sure that new and renovated school buildings are ready for occupancy, the risk of these short term and long term costs can be reduced.

The Elements of Occupancy Review:

The legally recognized provincial standards for Indoor Air Quality (IAQ) for workers are the ACGIH standards, however these industrial standards may not be adequate for protection of the developing bodies of children. To achieve more appropriate guideline we are using a combination of controls and standards, including: (1) Source control in several forms (including elimination, substitution and dilution) (2) traditional commissioning processes (including performance testing and with some adjustments), (3) observations and recommendations of an evaluation team and (4) testing according to Health Canada's Exposure Guidelines for Residential Indoor Air Quality and ALARA (As Low As Reasonably Achievable) principles.

The broad approach to preoccupancy guidelines also includes warranty period follow-up and a user's manual, management and occupant training and a general preventive maintenance plan, including maintenance logs, frequent filter replacement, equipment maintenance and more.

(1) **Source Control** as covered in the Healthy School Design and Construction task lists is central to achieving a healthy building on opening day as well as for years to come.

Also require a Flush Out Procedure with building heat on for a minimum of (six to eight) weeks, but possibly longer if the Guideline levels are not reached, and continued flushing at 100% fresh air at a high rate for at least one year after opening.

(2) **Evaluation Team**:

This committee would be formed by the Department of Education, but would be a non-technical team. That is, the architects, Dept. of Transportation and Public Works (TPW), air handling team etc. would be present to answer questions, but not serving on the committee itself.

This committee would be formed early in the process to overview the healthy schools aspects of the project, oversee the elements of the Building Readiness Guidelines throughout and evaluate and advise the Department of Education on the success of the elements. At the end of the project their role would be to review the commissioning and performance tests, and the IAQ evaluation (according to this document), and walk through the building and grounds before recommending readiness to the Department of Education.

As mentioned, this readiness recommendation would include the TPW readiness decisions, but would be a separate recommendation specifically on whether the building is ready in terms of occupant health risks.

This evaluation team's participation as an advisory committee needs to be included in contracts and agreements to ensure the committee has access to information as the project develops, although authority for decisions remains with the Department of Education.

(ASHRAE 62-1999, Appendix C suggests "the air can be considered acceptably free of annoying contaminants if 80% of a panel of at least 20 untrained observers deems the air to be not objectionable under representative conditions of use and occupancy. An observer should enter the space in the manner of a normal visitor and should render a judgement of acceptability within 15 seconds. Each observer should make the evaluation independently of other observers and without influence from a panel leader. Users of this method are cautioned that the method is only a test for odours. Many harmful contaminants will not be detected by this test. Carbon Monoxide and radon are two examples of odourless contaminants." P.17)

(3) **Commissioning and performance testing**

Including review of

- Ventilation re: Ventilation Requirements from ASHRAE 62-1999 - air quality for human occupancy.
- An Air Balancing Report
- TPW's already-detailed existing process

(4) **IAQ testing**. Testing has value despite inherent limitations. (1) It is applicable only to the exact location and time where testing was done, (2) It is only as accurate as the equipment and technician's interpretation, (low levels that have produced symptoms are sometimes not picked up by testing equipment), (3) There is a risk that the numbers will be given attention not afforded other evidence that could provide obvious clues, and (4) It can be costly and time consuming.

The following is a suggested wording for specifications and contracts, however we recommend the Department's lawyers review and adjust it as the situation requires:

An Air Quality Report will be prepared by an Indoor Air Quality (IAQ) Environmental Consultant, to be specified by the Department of Education, and reporting directly to the Department of Education, and meeting the guidelines specified in this document. Unless there is reason to indicate other tests are needed, the recommended levels specified in this guide will be met for:

Before Occupancy:

1. **TVOCs:** current Health Canada's Exposure Guidelines for Residential Indoor Air Quality (HC Res.)

2. **Formaldehyde**: 0.10 ppm action level and .05ppm target level (1995 HC Res. Plus combination limit of three main aldehydes. See formula page 8 of HC Res.)

3. **Particulate:**

- dust in ducts/air handling units is first priority. Use current NADCA method.
- respirable dust ALTER (acceptable long term exposure range) $\leq$ 40ug/m3 and ASTER(acceptable short term exposure range) $\leq$ 100ug/m3 one-hour average, or better. (HC Res. 1995)

4. **Ozone:** Control: smoke pencil to confirm negative air and air is going out.
ASHRAE 100ug/m3 or .05ppm (copiers, fax, printer areas when in operation)

5. **Radon:** (1)Test before system is in operation, and (2) when in operation. 800Bq/m3 recommended as an average concentration in normal living area. (HC Res. 1995)

6. **Noise/acoustics**: Check all areas for mechanical system noise. (ASHRAE 62-1989)

7. **Magnetic fields and Electric fields**: Review current information.

8. **Nitrogen Dioxide:** ALTER $\leq$ 100ug/m3 or $\leq$ 0.05ppm detection limit and ASTER $\leq$480ug/m3 or $\leq$0.25ppm one hour average. (HC Res. 1995) (with fuel burning systems)

9. **Sulphur Dioxide**: ALTER $\leq$ 50ug/m3 or 0.019ppm, ASTER $\leq$ 1000ug/m3 or <0.38ppm five-minute average. (HC Res. 1995) (with fuel burning systems)

10. **Mold**: for baseline, indoor and outdoor comparison.

11. **Lighting**: According to NS Design Requirements Manual DC350.

12. If use of other toxic materials such as isocyanates are unavoidable, test for presence.

After Occupancy:

1. **CO2**: baseline 850ppm (HC Office) ASHRAE: an indoor to outdoor concentration differential not greater than about 700ppm. (When school is in use, take outdoor readings to compare.) (HC Res. calls for <3500ppm)

2. **CO**: baseline Do not exceed 9ppm (ASHRAE) (also, once busses and cars come.) (HC Res. calls for 11ppm over 8 hours.)

3. **Temperature**: 25 degrees in winter to 50 degrees in summer (HC Res 1995) (ASHRAE 25 to 60)

4. **Relative Humidity**: summer: 30-80% and winter: 30-55% (unless constrained by condensation) (HC Res 1995)

5. **Noise/acoustics**: (ASHRAE 62-1989) Minimum:

Classroom and library 35-45 db

Labs/Shops 40-50 db

Gyms/multipurpose 40-55 db

Kitchens 45-55 db

The above would be the minimum acceptable level of testing and reporting. The report would go to the Department of Education, TPW, the school board and the school.

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6.0 Appendix Reference Key:

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*(*Culver*) - Your Guide to Understanding Electric and Magnetic Fields*, Culver Co, USA, 1991

(Cutter) – *Materials Specification Guide.* By Cutter Information Corporation, USA.

(Di Franco and Labrecque) - Mario Di Franco and Simon Labrecque, respirologist, MicronAir, Laurier, Quebec, Canada

(DST Consulting) - Vince Catalli and Ed Lowans, Ottawa, Canada

(HSH) – *The Healthy Schools Handbook.* Miller ed., US National Education Association. 1995

(Lee) - Professor Tang Lee, University of Calgary, Canada.

(McLaughlin) - Art McLaughlin, Environmental Specialist, OCL Group - Environmental Management Consultants, Halifax, Canada.

(Oberg) - personal communication with Dr. Gary Oberg, author of Ch.16, *The Healthy School Handbook*, NEA, USA.

(Oetzel) – personal communication with M. Oetzel or taken from *Right from the Start: Constructing a Healthy School. Austin, Texas, USA.*

(Salares) - Dr. Virginia Salares, Canada Mortgage and Housing Corporation, Research Division, Ottawa, Canada.

(Small) - Bruce Small, P.Eng., Director, Envirodesic Certification Program, Toronto, Canada.

(Sorensen) Mr. Sam Sorensen, Chemcraft, Dartmouth, Nova Scotia