#3624

Technical Report Summary

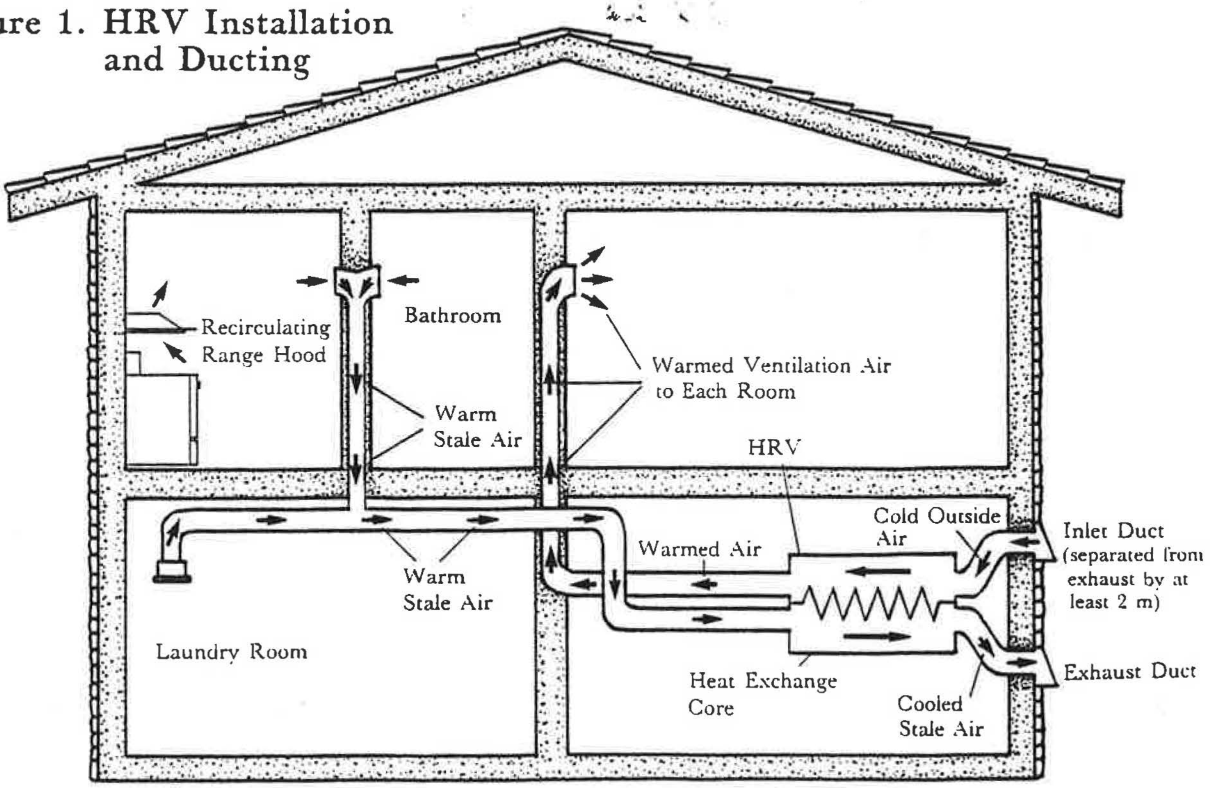
Studies of Mould Growth Potential in Heat Recovery Ventilators

Introduction

The R-2000 Super Energy Efficient Home Program was established in 1980 as a co-operative initiative between government and industry to improve the quality and energy performance of new housing. The program is sponsored by Energy, Mines and Resources Canada (EMR) and delivered by the Canadian Home Builders Association (CHBA); it supports building industry development, research into residential technology and the training of builders to construct and market houses to the R-2000 technical requirements.

These technical requirements stipulate that every R-2000 house must be fitted with a mechanical ventilation system, which replaces stale air with a continuous fresh supply, and which vents household contaminants such as cooking odours, cigarette smoke and excess humidity out of the building. The mechanical system installed in most R-2000 houses is known as a Heat Recovery Ventilator (HRV). As its name implies, the HRV serves two functions; it provides sufficient ventilation throughout the house by means of an air duct system, and it transfers heat from stale outgoing air to colder incoming air by passing both airstreams through a heat exchanger core (see Figure 1). The two airstreams do not mix, but up to 80% of the heat energy from the outgoing air is retained within the house, resulting in substantial heating fuel savings for the homeowner. The HRV system generally provides improved air quality and circulation in an R-2000 house when compared to conventional buildings.

Figure 1. HRV Installation and Ducting



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Research Program

Reports that heating, ventilation and air conditioning systems are potential sources of airborne fungal contamination have led to the concern that HRVs may also be potential sources. In response to these concerns about air quality and as part of a continuing research program to improve housing quality in Canada, EMR has investigated the possible contamination of HRVs by mould fungi and other micro-organisms. This research has been carried out in collaboration with the Department of Health and Welfare, Agriculture Canada and the Canada Mortgage and Housing Corporation (CMHC). The work involved two related projects; a laboratory test to determine whether fungi could be cultivated on any components of an HRV under optimum growth conditions, and a larger-scale study of 74 HRVs installed in R-2000 houses across Canada, which were sampled to determine the types of micro-organism present under conditions of normal use. As part of this project, other research documenting problems with conventional heating, ventilating and air conditioning systems was reviewed.

Mould

Mould is a common name for a group of fungi. It is related to other fungal micro-organisms such as mushrooms and many plant diseases. Like other fungi, all moulds require certain conditions in order to flourish. These conditions are:

- A source of inoculum
- Nutrients
- Suitable temperatures
- Water
- Oxygen

Most of these conditions are met year-round in most Canadian houses. A source of inoculum is provided by the large numbers of fungal spores (seeds) which are found even in clean, well-maintained houses. The majority of these spores originate on leaves and other vegetation outside the house, and are not harmful under normal circumstances. Spores of other species are found in the soil. During summer months the concentration of spores in both outdoor and indoor air may exceed 50,000 per cubic metre. It is the spores which give mould growth its characteristic powdery appearance; they are easily dispersed into the air causing rapid spread. The nutritional requirements of fungi are minimal and can be satisfied, for example, by small amounts of organic matter in house dust. Oxygen is always available and many fungi can flourish under a wide range of temperatures (e.g. 0° to 60°C). This leaves moisture as the usual limiting factor for mould growth inside a house.

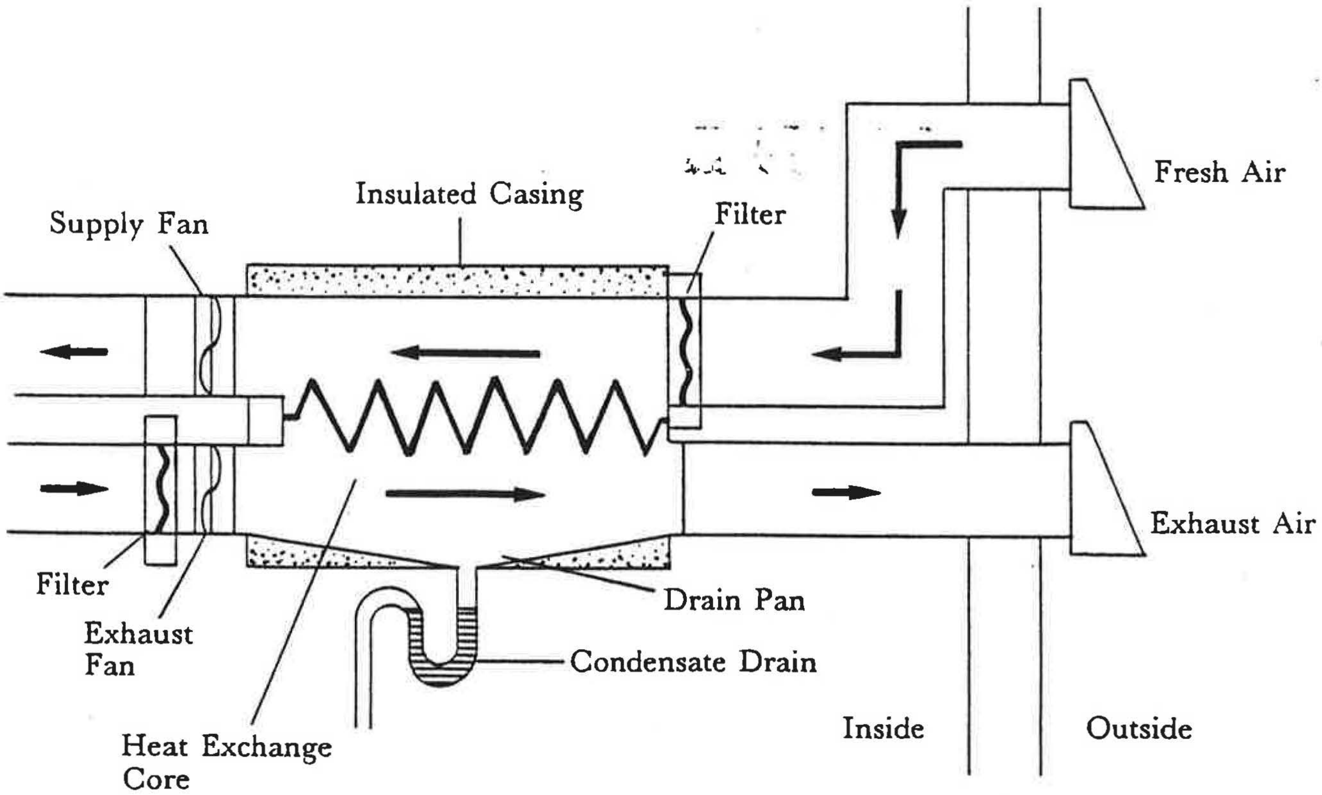
Health Implications of Fungi in Air

Research into fungal contamination of buildings has shown that exposure to certain fungi can cause a variety of symptoms among inhabitants, ranging from discomfort or mild allergic reactions to acute respiratory illness. These symptoms may result from exposure to large numbers of non-toxic fungal spores or from lighter exposure to pathogenic fungal species. Some moulds produce toxic chemicals during their life cycles which have also been implicated as potential health hazards. Due to both the diversity of species inside most houses, and the number and chemical complexity of their by-products, no safe exposure level for fungi has yet been determined. The Department of Health and Welfare has classified fungi and fungal products as potential health hazards, and Federal-Provincial guidelines on indoor air quality recommend that exposure to both be minimized.*

Inside an HRV

Figure 2 illustrates the operation and components of an HRV. During winter, cold dry air passes into the unit via the supply duct and is heated, while stale air is cooled and expelled from the exhaust duct. In summer, the incoming warm air will be cooled by the outgoing exhaust air. Suitable conditions for mould growth will only occur if there is excessive leakage of moist, stale air from the exhaust side to the supply side of the HRV, or, in air conditioned houses, if incoming warm, moist air is cooled enough to produce condensation on the supply side of the heat exchange core. Normally, however, conditions inside the HRV will not encourage mould growth.

Figure 2. Inside an HRV



Fungal Resistance Testing of HRV Components

Different materials vary in their susceptibility to fungal growth. Generally, this reflects the availability of moisture and nutrition on the surface of the material. The smooth surface of a glass window pane, for example, will rarely sustain mould growth whereas a dirty piece of carpet under appropriate conditions of temperature and humidity will quickly become contaminated by moulds.

As part of the research program to investigate potential fungal contamination of HRVs, EMR commissioned the Ontario Research Foundation to test a number of commercial brands. Under standard laboratory conditions,** components taken from 4 different HRV units were studied to determine their potential for fungal growth. These components included insulation materials, air filters and heat exchange cores; each was inoculated with a controlled fungal mixture and exposed to warm, moist conditions for 28 days. Results showed that metal and plastic HRV components resist fungal attack. No mould growth was observed on any of the metal or plastic parts, including aluminum core material, wire dust filters, metal filter frames and aluminum insulation backing. Fibreglass insulation materials also resisted mould growth. The only HRV components found to be clearly susceptible were disposable air filters made from either paper or cardboard, both of which showed moderate mould growth after the incubation period.

The implications of these tests are clear: there is little potential for mould growth contamination inside an HRV when the unit is properly maintained and when the air filters are replaced regularly.

Fungal Contamination Testing of Installed HRVs

During the winter months of 1987/88, swab samples were taken from 74 HRVs installed in houses across Canada. This housing sample included many older HRV units, rather than new installations, and it was felt that if contamination of HRVs by fungi or bacteria was occurring, then these units would represent the worst known cases.

Collection of the field samples was carried out by EMR technicians and all were sent to a federal government laboratory for analysis. Swab samples were taken at a number of locations within each HRV unit, including the drain pan, air supply outlet, heat exchange core and air filters. These places were thought to be the most likely to sustain fungal growth and cause contamination of the HRV air supply. Swab samples were also taken from any humidifier in the house, since these can be sources of contamination.

Analysis of the swab samples produced consistent results in almost every case. The fungal species found inside most HRV units corresponded closely with those commonly found elsewhere in Canadian houses, as reported in larger scale studies of indoor air quality.

These fungi included species such as *Cladosporium* and *Alternaria*, which are not considered hazardous under conditions of normal exposure. Only 3 of the 74 HRVs showed fungal growth which deviated significantly from typical species patterns. Additional measurements were taken in the three houses which deviated from the norm. In one case the problem was believed to originate from accumulated debris at the air supply inlet on the outside wall. In the second case, tests showed unusual fungal growth in the ductwork downstream of an in-duct humidifier, and also at the grille of an exhaust duct leading from the kitchen to the HRV. Additional testing in the third house identified contamination in a kitchen exhaust duct. However, this contamination was not affecting the supply air or the air quality in the house.

Conclusions

These studies of fungal growth inside HRVs have led EMR to conclude that the domestic HRV is not a source of fungi in indoor air, and that it poses no health hazard to house occupants. Nevertheless, the research program has demonstrated the potential for mould growth problems in badly designed, improperly installed or poorly maintained HRVs.

Of 74 'worst case' houses across Canada, only 3 were found to have potentially harmful mould growth inside the HRV, and in each of these 3 cases, contamination seemed to originate from poor maintenance of vents, exhaust ducts and humidifiers. EMR therefore makes the following recommendations:

Recommendations to Owners

- All HRV owners are encouraged to follow a maintenance schedule and to keep a log of cleaning and servicing operations for their units.
- Detailed maintenance instructions should be provided by the HRV manufacturer; owners can also refer to the EMR R-2000 publication 'How to Operate a Heat Recovery Ventilator' for additional information.
- Check regularly for sources of contamination near the exterior air supply vent (e.g. birds or leaves). Arrange to have the vent moved if a clean air supply cannot be maintained. If contamination does occur, clean the vent.
- It is important that all interior components of the HRV be kept clean; accumulation of dust, dirt or water should be avoided. Interior surfaces of the HRV may be washed with a mild bleach solution (1 part bleach, 20 parts water) and air filters should be replaced at regular intervals.
- In winter, owners should operate HRVs to maintain humidity levels which prevent surface condensation in the home. Recommended levels are 30% to 40% RH.
- Owners should be aware of the need to periodically clean and maintain other parts of the air supply system, such as ducts, interior vents and humidifiers. A growing number of businesses specialise in air duct cleaning or offer the service as a component of furnace maintenance.

Recommendations to Manufacturers, Installers and Purchasers

- HRV units must be designed to allow easy access to all working parts and components. At least one of the side panels and all air filters should be removable to permit routine maintenance by the owner.
- Drain pans and sub-floors inside the HRV should be sloped and well-drained, so that water pooling is prevented at all times. Installers must ensure the unit is mounted properly, and that there is a water trap in the drain pipe.
- HRVs should be designed to perform with minimal cross-contamination of fresh supply air by stale exhaust air (exhaust air transfer), as tested in accordance with CAN/CSA C439-88 "Standard Methods for Rating the Performance of HRVs." Purchasers should check the HRV specification sheet for this information.
- Manufacturers should provide all new HRV purchasers with a comprehensive owner's manual which details service and maintenance requirements for their unit.
- All interior surfaces of the unit should be smooth to avoid the accumulation of dirt and debris. Porous insulation materials should not be open to air within the HRV, but should be covered with metal or plastic sheeting.
- Installers should ensure that the exterior air supply vent is well clear of any potential source of contamination, such as combustion vents, dryer vents, pet houses, firewood, garbage containers and compost heaps.

References

* "Exposure Guidelines for Residential Indoor Air Quality", Federal/Provincial Advisory Committee on Environmental and Occupational Health, 1987.

"Significance of Fungi on Indoor Air Quality", Report of the Health and Welfare Working Group on Fungi, 1987. (Reprinted in the Canadian Journal of Public Health, Vol. 78 #2).

** The U.S. Military Standard 810 D (1985) was used to determine the susceptibility of materials to fungal attack. Unlike the more common ASTM G-21 method, this test requires temperature cycling every 24 hours, and is therefore more representative of conditions inside an HRV.

Acknowledgement:

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