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R-2000 INDOOR FORMALDEHYDE MONITORING - 1987 UPDATE

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THE R-2000 HOME PROGRAM TECHNICAL REPORT SERIES

The R-2000 Home Program assists in the ongoing development of the various technologies required to build and operate R-2000 homes. This includes support for standards development and the provision of technical information and resources to the building industry. In addition, all R-2000 homes and a control group of conventional homes are being monitored over a two to five year period to gather information on construction techniques, the performance of heating and ventilating systems, indoor air quality and energy consumption. The demographic profile and attitudes of R-2000 homeowners are also being surveyed.

This publication is one of a series of reports documenting technical developments and monitoring activities supported by the R-2000 Home Program and the Canadian housing industry. The program's objective is to assist the housing industry to develop the capability to construct and market quality housing that is both energy-efficient and cost-effective.

For further information on the R-2000 Home Program in general, the series of technical reports, or to obtain additional copies of this document, please contact:

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EXECUTIVE SUMMARY

As part of the R-2000 Home Program, indoor air quality monitoring was conducted Canada-wide for a number of pollutants including formaldehyde. The objective of this report is to review the R-2000 Home Program formaldehyde activities to date.

Urea formaldehyde resin is used in the manufacture of many household products and building materials. Formaldehyde can be released from these materials or products as a result of 'offgassing'. Formaldehyde is also present in cigarette smoke.

In 1984, formaldehyde monitoring was conducted nation-wide in 248 of the initial R-2000 demonstration homes built; while in 1985, formaldehyde was monitored nation-wide in 110 of the initial demonstration homes. The 1986 monitoring was conducted only in Ontario. Formaldehyde was measured in 60 of the initial R-2000 demonstration homes and in 10 of the subsequently built homes. Nation-wide formaldehyde monitoring in 1987 was conducted in 129 of the initial R-2000 demonstration homes and in 125 of the subsequently built homes. During the period of 1984 to 1987, 88 formaldehyde measurements were made in 77 new conventional homes for comparative purposes.

Average formaldehyde levels in both R-2000 homes and in conventional control homes were below the 0.10 ppm short-term action level proposed by the Federal/Provincial Indoor Air Quality Working Group. Furthermore, average levels in R-2000 homes have now decreased to less than the long-term target level of 0.05 ppm. This decrease was from levels greater than 0.06 ppm in 1984 to levels less than 0.05 ppm in 1987. Average levels in the conventional homes monitored remained greater than 0.05 ppm, but still below the short-term action level of 0.10 ppm.

A detailed investigation of a select number of Ontario R-2000 homes identified the following criteria which could create formaldehyde levels greater than 0.05 ppm: indoor temperatures higher than 21^{o}C, relative humidity exceeding 50%, tobacco smoke, new furnishings or building materials containing urea-formaldehyde resin and ventilation systems not meeting the R-2000 requirements.

Monitoring results to date appear to indicate that the implementation of revised R-2000 ventilation guidelines in 1986 has resulted in average indoor formaldehyde levels being reduced to less than 0.05 ppm. Monitoring indicates that when strong formaldehyde sources are present, formaldehyde levels are somewhat greater than 0.05 ppm, but still less than the 0.10 ppm short-term action level

proposed by the Federal/Provincial Indoor Air Quality Working Group. This indicates a need to address the issue of controlling sources of formaldehyde as well as providing good ventilation if levels in all homes are to be reduced below the 0.05 ppm long-term target.

ABREGE

Dans le cadre du Programme de la maison R-2000, un projet de contrôle de la qualité de l'air intérieur a été réalisé dans tout le Canada et a porté sur un certains nombres de substances polluantes, dont le formaldéhyde et le radon. Le présent rapport fait état des activités de mesure du formaldéhyde réalisées jusqu'à présent dans le cadre du Programme de la maison R-2000.

La résine d'urée de formaldéhyde est utilisée dans la fabrication d'un grand nombre de matériaux de construction et de produits d'usage domestique. Ces produits et matériaux peuvent dégager des vapeurs de formaldéhyde, lequel est également present dans la fumée de cigarette.

En 1984, un projet de mesure du formaldéhyde a été réalisé dans tout le Canada et a porté sur 248 des premières maisons de démonstration qui ont été construites dans le cadre du Programme R-2000. En 1985, le formaldéhyde a été mesuré dans 110 des premières maisons de démonstration, et ce, dans tout le Canada. En 1986, le projet de mesure a été mené en Ontario seulement. Le formaldéhyde a été mesuré dans 60 des premieres maisons de demonstration R-2000 et dans 10 des maisons construites ultérieurememement. En 1987, le projet

national de mesure du formaldéhyde a porté sur 129 des premières maisons de démonstration, et sur 125 des maisons construites ultérieurement. Entre 1984 et 1987, 88 mesures du formladéhyde ont été réalisés dans 77 maisons neuves de construction classique, aux fins de comparaison.

Dans les maisons R-2000 et les maisons témoins de construction classique, les concentrations de formaldéhyde ont été inférieures à la concentration de 0,10 ppm nécessitant des mesures à court terme, selon la proposition du groupe de travail fédéral/provincial sur la qualité de l'air ambiant. De plus, la concentration moyenne dans les maisons R-2000 se situe maintenant en deça du seuil de 0,05 ppm nécessitant des mesures à long terme. En effet, la concentration moyenne est passée de 0,06 ppm en 1984 à moins de 0,05 ppm en 1987. La concentration moyenne enregistrée dans les maisons témoins de construction classique est demeurée supérieure à 0,05 ppm, mais inférieure au seuil de 0,10 ppm nécessitant des mesures à court terme.

Une enquête approfondie menée dans un certain nombre de maisons R-2000 en Ontario a permis de dégager les facteurs suivants qui sont à l'origine des concentrations de formaldéhyde supérieures à 0,05 ppm : températures intérieurs supérieures à 21^{o}C, taux d'humidité relative supérieurs à 50%, fumée de tabac, présence de meubles ou de

matériaux de construction neufs contenant de la résine d'urée-formaldéhyde, et systèmes de ventilations non conformes aux exigences du programme R-2000.

Selon les résultats enregistrés jusqu'à date, il semble que l'application des directives sur la ventilation, revues en 1986, se soit traduite par la réduction, sous le seuil de 0,05 ppm, de la concentration moyenne de formaldéhyde à l'intérieur des maisons. De plus, les résultats indiquent que lorsqu'il y a présence de fortes sources de formaldéhyde, les concentrations de formaldéhyde sont parfois supérieures à 0,05 ppm, mais inférieures au seuil de 0,10 ppm nécessitant des mesures à court terme, selon la proposition du groupe de travail fédéral/provincial sur la qualité de l'air ambiant. Il semble donc que l'on doive porter une attention particulière à la question des sources de formaldéhyde et d'une ventilation appropriée si l'on veut reduire les concentrations de formaldéhyde en deçà du seuil de 0,05 ppm nécessitant des mesures à long terme.

1.0 INTRODUCTION

As part of the R-2000 Home Program, indoor air quality monitoring in R-2000 homes has been conducted Canada-wide since 1984 for a number of indoor air pollutants including formaldehyde. Conventional new homes were also monitored for comparative purposes.

Formaldehyde is a chemical substance belonging to a group of organic compounds known as 'aldehydes'. Used in the manufacture of many household products and building materials, formaldehyde can be released into the air as a result of 'offgassing' or 'outgassing' from these products. Since the amount of formaldehyde in indoor air is small, measurements are normally given in parts per million (ppm) of formaldehyde gas in the air.

Resins incorporating formaldehyde are used in the manufacture of building materials such as particleboard, panelling and plywood, as well as furnishings, paint and common household products like adhesive tape and glue. Consumer goods such as draperies, carpets and clothing may contain formaldehyde as either a glue component or as a coating on the fibres to reduce wrinkling. After new fabrics are washed, formaldehyde levels are greatly reduced.

Formaldehyde is also released as a by-product of some types of combustion. Cigarette smoke, for example, contains approximately 40 ppm of formaldehyde. Outdoor air contains amounts ranging from 0.005 to 0.05 ppm, which are produced from automobile exhaust, fuel burning and naturally occurring chemical reactions.

The rate at which formaldehyde is released from products depends on: the amount of formaldehyde the products contain, how they are used, the humidity or amount of moisture in the surrounding air and the ambient temperature.

Individuals show varying tolerances to formaldehyde gas; while many experience no negative effects even at high levels, others are sensitive to somewhat lower concentrations. At high levels of exposure, formaldehyde can cause eye, nose, and throat irritation or respiratory problems. These symptoms will vary with the concentration of formaldehyde in the air and the sensitivity of individuals, specifically, their general health, smoking habits and the level of previous exposure to the gas. The Federal/ Provincial Working Group on Indoor Air Quality are recommending two guidelines for residential levels of formaldehyde. An action level (which should not be exceeded in the short-term) is set at 0.10 ppm. The long-term target level is set at 0.05 ppm.

2.0 R-2000 FORMALDEHYDE MONITORING ACTIVITIES

2.1 General Field Monitoring

During the initial phase of monitoring in 1984, Dupont C60 badges were used to measure formaldehyde. The badges were installed in the homes by EMR regional office technicians and were removed by the homeowners and forwarded to a laboratory for analysis.

Three badges were installed in each home: one in a bedroom, one in a central living area location and one remaining unexposed to serve as a laboratory control. Temperature and humidity measurements were taken in the home to determine conditions at the start of exposure. The badges were left in place for seven days.

In 1985 and during subsequent years, monitoring has been conducted using the Air Quality Research Inc. (AQRI PF-1) passive diffusion tube formaldehyde monitors. These PF-1s were also installed in the living and sleeping areas of the R-2000 and control homes. The diffusion tubes were installed by EMR technicians, and removed and forwarded by the homeowners after seven days to the Ontario Research Foundation laboratory for analysis.

Chamber tests indicate that the AQRI PF-1 diffusion tube monitor used in 1985, 1986 and 1987 will normally measure approximately 10 to 20 percent higher than the Dupont badge (AQRI, 1984). Formaldehyde levels taken with the Dupont badge for 1984 have been increased by 15% based on these chamber tests in order to make them comparable to the results of subsequent years.

Indoor air quality monitoring was conducted on the initial R-2000 demonstration homes during 1984 and 1985, and was expanded to additional R-2000 homes in 1986 and 1987. A summary of the 1984, 1985, 1986, and preliminary 1987 formaldehyde results is presented in Table 1.

Average levels of formaldehyde in both R-2000 and conventional homes were below the guideline of 0.10 ppm. In 1984, R-2000 and conventional homes had similar levels, while in 1985, R-2000 homes had lower levels (0.068 ppm vs 0.079 ppm). From Table 1 and Figure 1, formaldehyde levels in R-2000 homes have significantly decreased from 1984 to 1987. Mean national and regional levels have decreased from greater than 0.06 ppm in 1984 to less than 0.05 ppm in 1987. Decreases varied, with Quebec experiencing the greatest decrease (from 0.076 ppm in 1984 to 0.040 ppm in 1987), and B.C. with the least (from 0.059 ppm in 1984 to 0.045 ppm in 1987). The standard

TABLE 1

R-2000 INDOOR AIR QUALITY: FORMALDEHYDE (PPM)

Homes	Year	Number of Homes	Mean	Standard Deviation	Median
R-2000 Homes	1984	248	0.069	0.029	0.061
	1985	110	0.068	0.027	0.064
	1986*	70	0.050	0.020	0.048
	1987**	254	0.045	0.017	0.041
Conventional Homes	1984	63	0.070	0.037	0.066
	1985	16	0.079	0.037	0.067
	1986*	4	0.071	0.024	-
	1987**	5	0.057	0.025	-

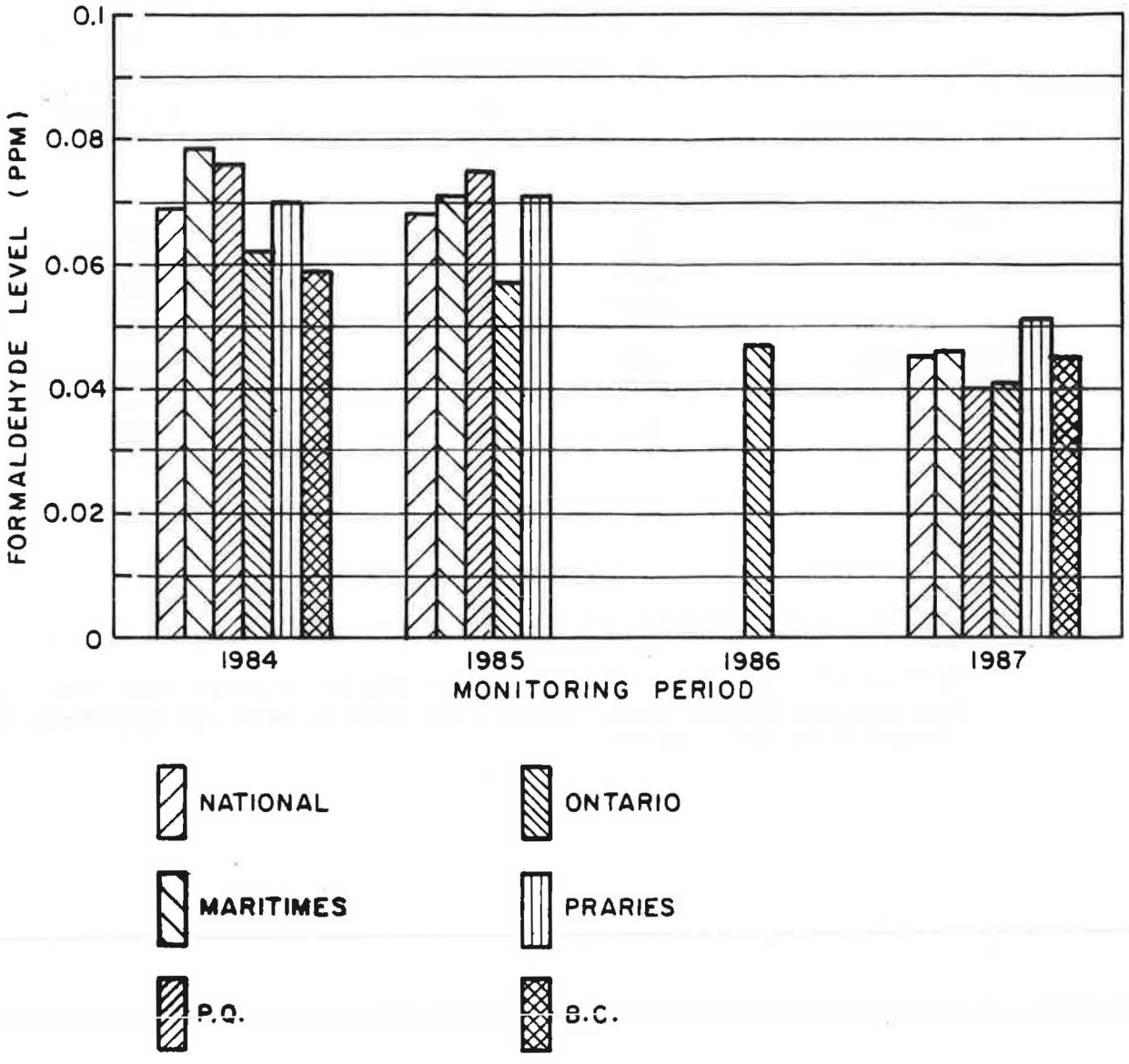
Note:

* Monitoring of formaldehyde in 1986 was conducted only in Ontario

** 1987 results are for monitoring conducted in December 1986 and January, February and March, 1987. April 1987 results were not available for inclusion in this report.

FIGURE 1

R-2000 HOME FORMALDEHYDE LEVELS



deviations of the monitoring results, which are an indication of the scatter of the results, have also decreased from 1984 to 1987.

Frequency distributions for Ontario, for which there are four years of formaldehyde monitoring results, are presented in Figure 2. In 1984 the mean Ontario level was 0.062 ppm with a standard deviation of 0.026 ppm. Approximately six percent of the Ontario R-2000 homes monitored in 1984 had levels greater than 0.10 ppm. These 1984 results are from the initial demonstration R-2000 homes for which monitoring was conducted with the mechanical ventilation systems operating as installed. Corrective adjustments to the mechanical ventilation systems were not made prior to the formaldehyde monitoring. After the 1984 monitoring period, it was determined that only 28% of the mechanical ventilation systems were balanced such that the measured difference between the fresh supply air and the stale exhaust air were within 10%. In addition, in most instances fresh supply air was supplied to only one or two locations in the home and then natural convection or a forced air heating system was relied upon to distribute the fresh air throughout the home (Riley, 1986).

In 1985, measures were undertaken to ensure heat recovery ventilators (HRVs) were balanced properly and were capable of delivering the required airflow capacity. Continuous airflow was

not required in 1985. The 1985 Ontario data includes homes built in 1983 with HRVs operating as installed, and homes built in 1983 and 1984 which had HRVs that were providing the proper airflows and were balanced. In 1985, the mean level for Ontario was 0.057 ppm with a standard deviation of 0.025 ppm. Approximately three percent of the homes had levels greater than 0.10 ppm.

In 1986, measures were completed on all homes to ensure that HRVs were balanced and capable of delivering the required airflow. Revisions made to the ventilation guidelines also required a minimum continuous ventilation rate. The mean Ontario 1986 level decreased to 0.047 ppm with a standard deviation of 0.018 ppm. None of the 70 homes monitored in Ontario in 1986 had levels greater than 0.10 ppm.

Homes monitored in Ontario in 1987 also had properly installed and balanced mechanical ventilation systems which met the revised R-2000 technical ventilation guidelines (R-2000 Home Program, 1986). These R-2000 guidelines stipulate continuous ventilation. In 1987, the preliminary Ontario mean level was 0.041 ppm with a standard deviation of 0.015 ppm. None of the 85 homes monitored in Ontario in 1987 exceeded 0.10 ppm.

National frequency distributions for 1985 and 1987 are presented in Figure 3. In 1985 the mean formaldehyde level was 0.068 ppm with a

FIGURE 2

FREQUENCY DISTRIBUTION OF FORMALDEHYDE IN ONTARIO R-2000 HOMES

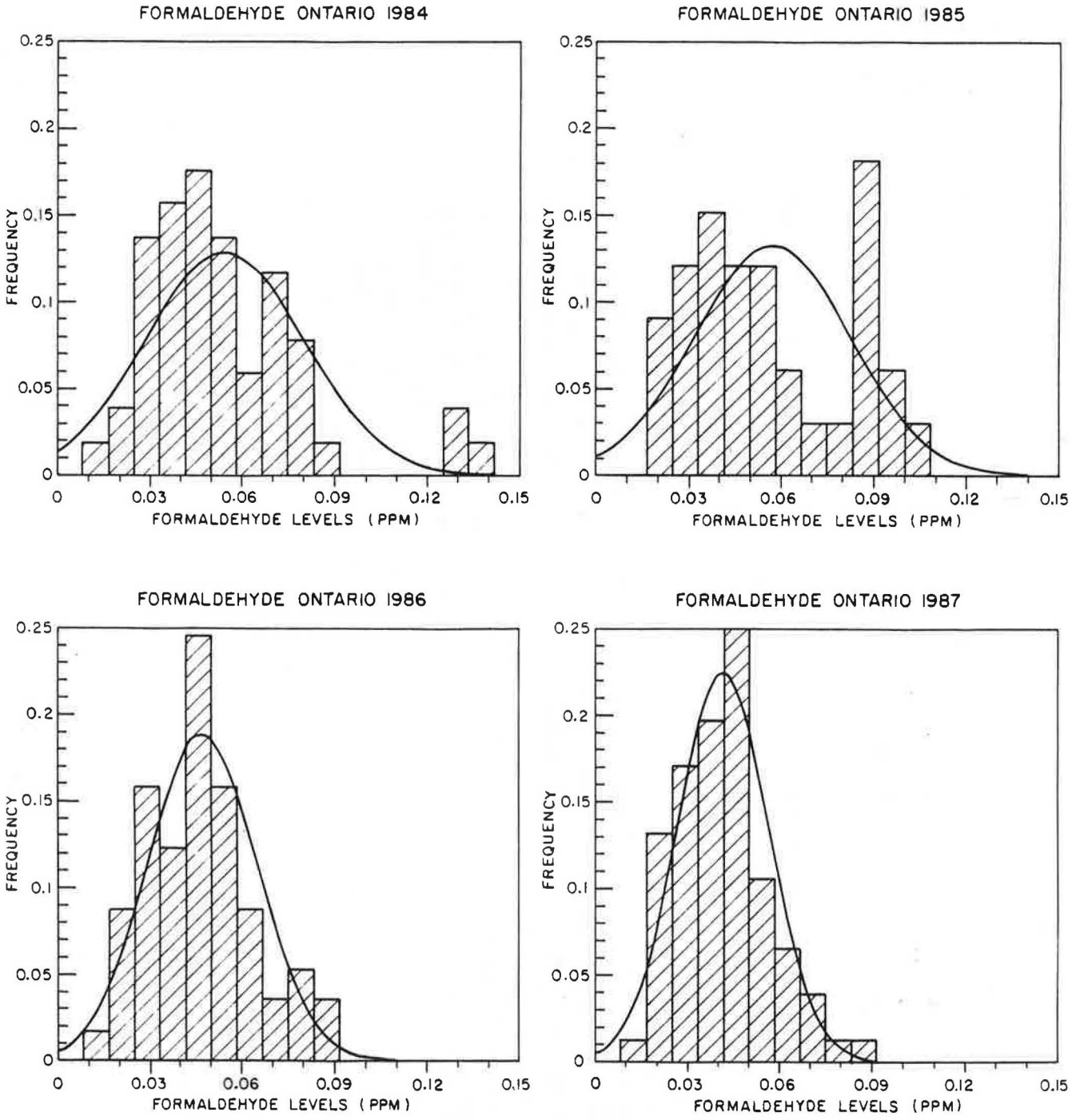
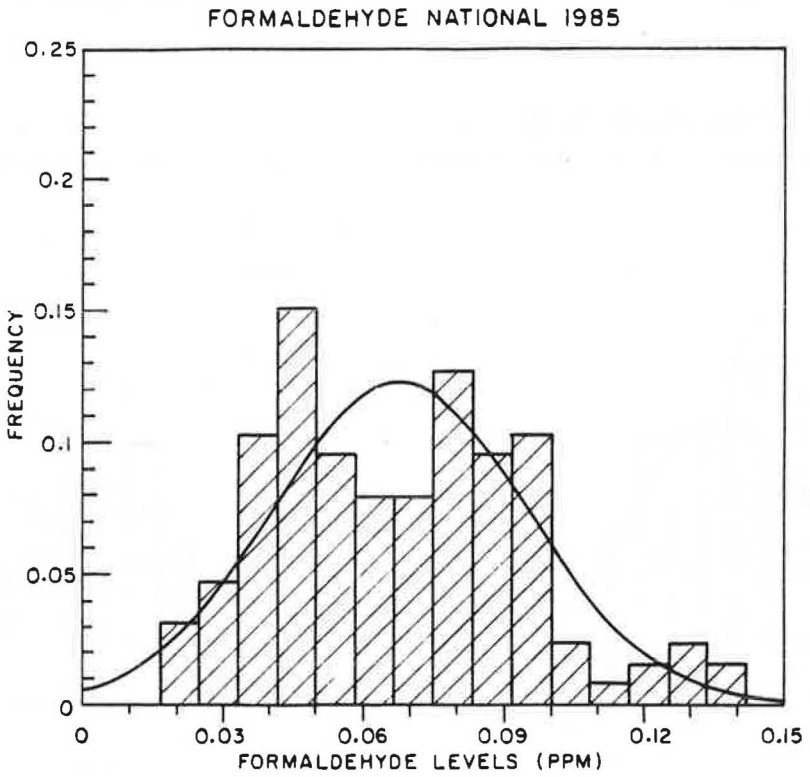
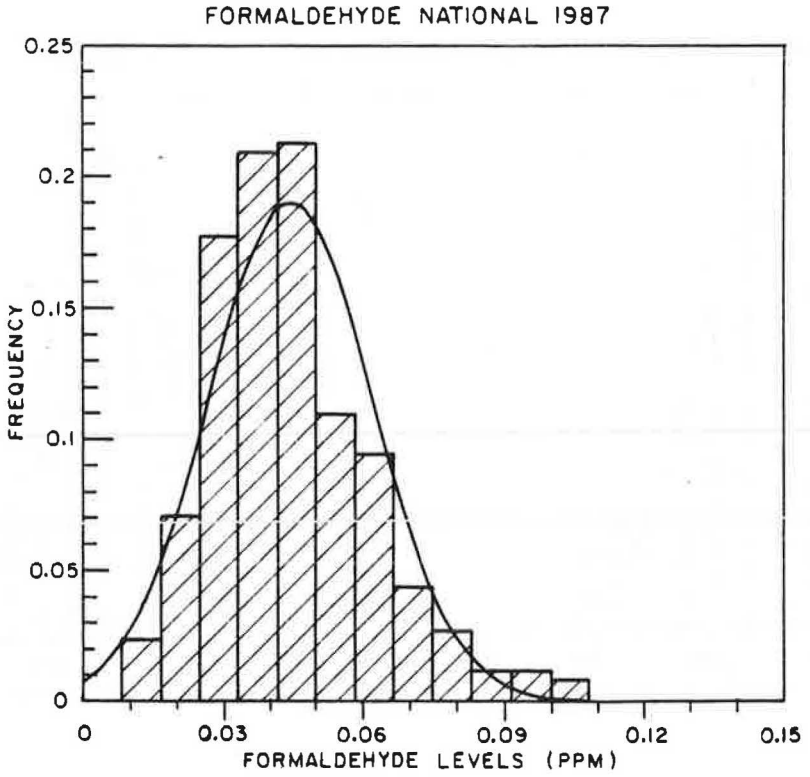


FIGURE 3

FREQUENCY DISTRIBUTION OF FORMALDEHYDE IN R-2000 HOMES, 1985 AND 1987



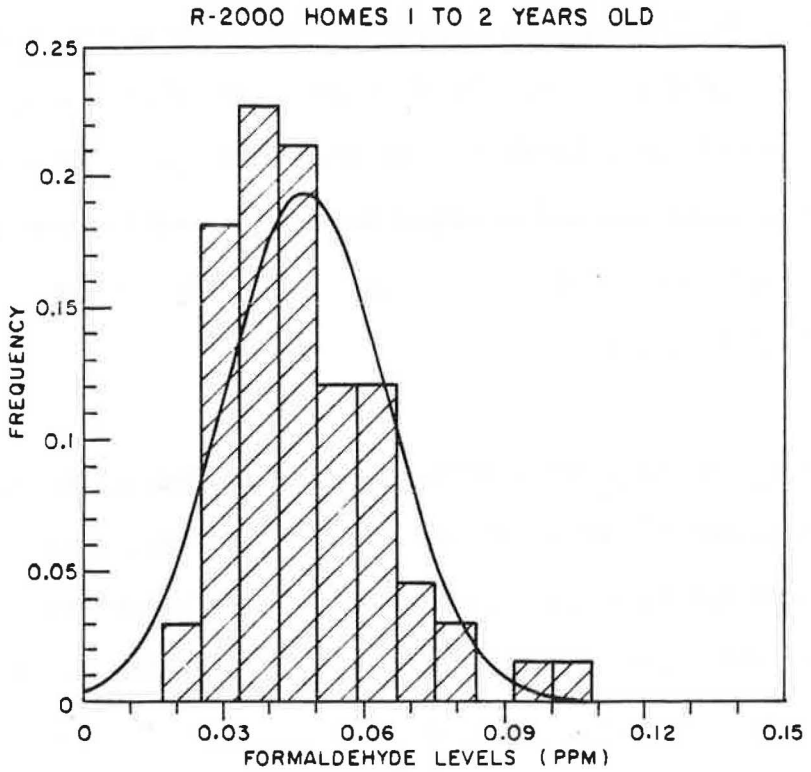


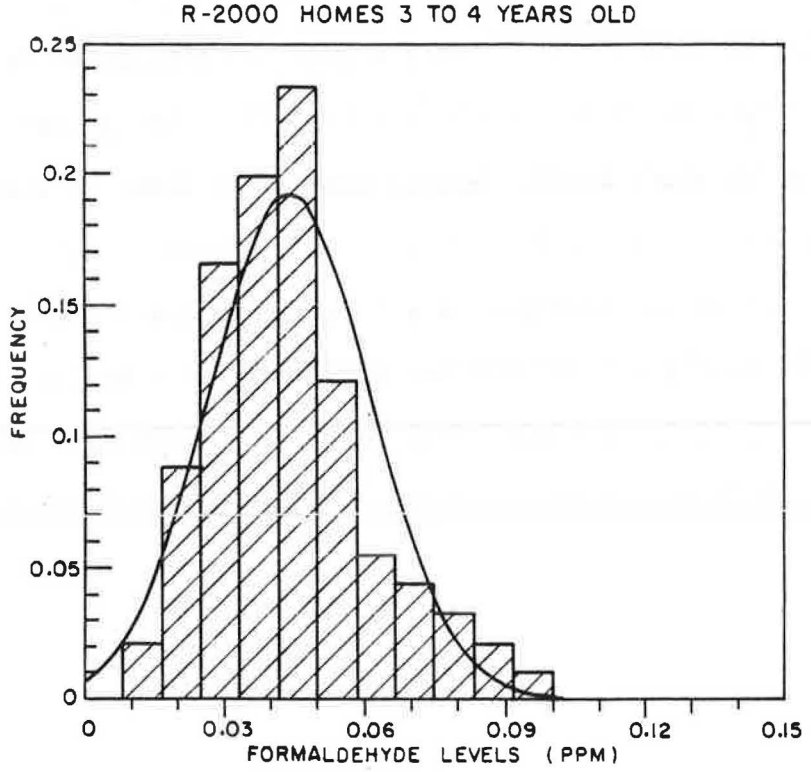
standard deviation of 0.027 ppm. Approximately nine percent of the homes monitored had levels greater than 0.10 ppm. The preliminary national results for 1987 had a mean of 0.045 ppm with a standard deviation of 0.017 ppm. In 1987, only two of 254 homes (less than one percent) had a level greater than 0.10 ppm. These homes had properly installed and balanced mechanical ventilation systems with continuous ventilation in accordance with the revised R-2000 ventilation guidelines.

Initially, a new product containing urea formaldehyde resin will emit somewhat higher levels of formaldehyde gas. The emission rate will decrease to a lower level over time. Comparisons were made between older and newer R-2000 homes to determine whether lower formaldehyde emisson levels were a result of such a time-related decrease, or whether this reflected the impact of the revised ventilation guidelines. Figure 4 presents histograms for formaldehyde monitoring conducted in 1987 in two groups of homes built a few years apart. Ninety homes were three to four years old and 66 homes were one to two years old. There is not a significant difference in formaldehyde levels between those homes which are three to four years old and those which are one to two years old. Therefore, it is concluded that revisions to the ventilation requirements were a major factor in lowering the formaldehyde levels.

FIGURE 4

FORMALDEHYDE IN R-2000 HOMES OF DIFFERENT AGES



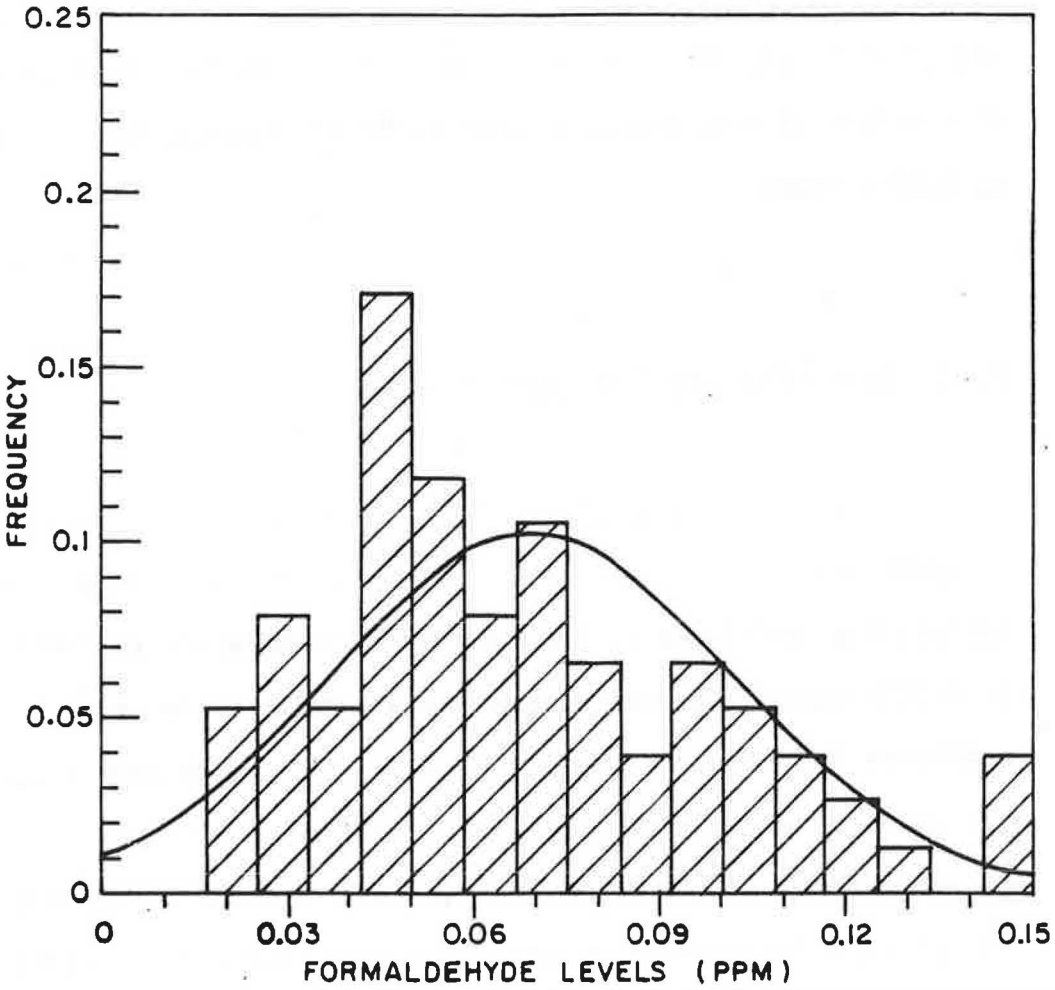


During the monitoring program, 77 new, conventional control homes were also monitored for formaldehyde. The majority of the measurements were made in 1984 and 1985, and some of these control homes were monitored more than once. A frequency distribution of the control home results is presented in Figure 5. The mean national level (0.069 ppm), and the standard deviation (0.033 ppm), are greater than those of the R-2000 homes. The frequency of homes with values of 0.10 ppm or greater (17%) is also greater than that of R-2000 homes.

2.2 Factors Affecting Formaldehyde Levels

A more detailed analyses of the formaldehyde monitoring results, was performed on a sample of R-2000 homes in Ontario to determine which factors may contribute to differences in formaldehyde concentrations in R-2000 homes. The formaldehyde in a sample of the homes monitored in 1986 was measured in living room and bedroom areas and averaged. The sample consisted of 16 homes with average formaldehyde levels less than 0.05 ppm and 19 homes with average formaldehyde levels of 0.05 ppm or greater. Average formaldehyde levels for these homes are presented in Table 2. Average concentrations in the homes ranged from 0.023 to 0.088 ppm

FIGURE 5
FORMALDEHYDE LEVELS IN CONTROL HOMES,
1984 TO 1987



formaldehyde. There were no homes with levels greater than 0.10 ppm available for this evaluation. Information on the homes was obtained from three seasons of formaldehyde monitoring results (1984, 1985 and 1986) and from the questionnaires which were completed as part of the R-2000 monitoring program home visits. The value of 0.05 ppm that was chosen as the point to separate the data into two different groups for analysis was based on one-half of the formaldehyde guideline action level of 0.10 ppm. The 0.05 ppm level is also the proposed long-term target level.

In order to determine factors which contribute to differences in formaldehyde levels, the following parameters were investigated:

Ventilation System Factors:

The R-2000 program ventilation guidelines require a capability to provide a minimum continuous supply of ventilation air of 5 litres per second (ℓ/s) (10 cubic feet per minute (cfm)) to each habitable room, bathroom and kitchen and 10 ℓ/s (20 cfm) to basement areas and utility rooms.

- The measured airflows of the HRVs were compared to the R-2000 technical ventilation guidelines. If the flow was greater than 80% of the requirement, the flow was considered adequate.

- The continuous operation of the HRV was noted. If the HRV and associated mechanical equipment such as a forced air furnace provided a minimum continuous airflow, the system was considered a continuous operation.

- The maintenance of the HRV was noted. If the homeowner performed routine maintenance of the HRV as suggested in the manufacturer's literature, the HRV was considered maintained.

House/Occupant Factors:

- New furnishings and/or recent renovations were noted. New furnishings and recent renovations included new furniture purchased, and decorating and renovations performed in the last twelve months.

- The existence of fireplaces, woodstoves and gas ranges was noted, i.e., if the home-owner used these features on an ongoing basis, and not just during the formaldehyde sampling period.

- The presence of tobacco smokers was noted, i.e., if the home occupants smoked or if the home-owner considered the impact of visiting smokers important.

TABLE 2

FORMALDEHYDE LEVELS IN ONTARIO R-2000 HOMES EVALUATED

Homes with Levels Greater than 0.05 ppm		Homes with Levels Less than 0.05 ppm	
Home Number	Average Formaldehyde (ppm)	Home Number	Average Formaldehyde (ppm)
1	0.069	1	0.030
2	0.065	2	0.032
3	0.063	3	0.049
4	0.059	4	0.031
5	0.082	5	0.043
6	0.075	6	0.050
7	0.069	7	0.023
8	0.082	8	0.032
9	0.086	9	0.041
10	0.082	10	0.045
11	0.088	11	0.050
12	0.060	12	0.042
13	0.054	13	0.049
14	0.057	14	0.039
15	0.062	15	0.033
16	0.061	16	0.040
17	0.072		
18	0.069		
19	0.050		
Mean	0.069	Mean	0.039
Std. Dev.	0.011	Std. Dev	0.008

- The presence of wall-to-wall carpeting was noted.

- The average temperature of the bedroom and living area was noted. These temperatures were taken by the technicians when the formaldehyde samplers were installed.

- The average percent relative humidity was noted. As with the temperature, this average was based on measurements taken in the living area and bedroom when the formaldehyde samplers were installed.

An additional analysis involved characterizing the homes according to the ventilation system and house/occupant factors in order to compare the relative effects of the characteristics to indoor formaldehyde levels. Average formaldehyde levels were determined for the following groups:

- Meets Ventilation Guidelines and Minor Sources of Formaldehyde: This group includes homes with ventilation systems which meet the revised R-2000 ventilation guidelines and have no new furnishings/renovations, no smokers and indoor temperatures of 21^{o}C or less.

- Does Not Meet Ventilation Guidelines and Minor Sources of Formaldehyde: This group includes homes with ventilation systems which do not meet the revised R-2000 ventilation guidelines and have no new furnishings/renovations, no smokers and indoor temperature of 21°C or less.

- Meets Ventilation Guidelines and New Furnishings and/or Elevated Temperature: This group includes homes with ventilation systems which meet the revised R-2000 ventilation guidelines and have new furnishings and/or renovations and/or indoor temperature greater than 21°C.

- Meets Ventilation Guidelines and Smokers and/or Elevated Temperature: This group includes homes with ventilation systems which meet the revised R-2000 ventilation guidelines and have smokers and/or indoor temperature greater than 21°C.

- Does Not Meet Ventilation Guidelines and New Furnishings and/or Elevated Temperature: This group includes homes with ventilation systems which do not meet the revised R-2000 ventilation guidelines and have new furnishings and/or recent renovations and/or indoor temperature greater than 21°C.

- Does Not Meet Ventilation Guidelines and Smokers and/or Elevated Temperature: This group includes homes with ventilation systems which do not meet the revised R-2000 ventilation guidelines and have smokers and/or indoor temperature greater than 21^{o}C.

Based on the results of these two evaluations of formaldehyde levels (ventilation systems and house/occupant factors), it appears that a combination of source related factors will result in formaldehyde levels greater than 0.05 ppm. These factors are: indoor temperatures greater than 21^{o}C, new furnishings/recent renovations, tobacco smokers and mechanical ventilation systems which do not meet the R-2000 ventilation guidelines. The results are summarized and presented in Table 3.

The group of homes with formaldehyde levels greater than 0.05 ppm had a significantly greater proportion of homes with smokers and significantly higher indoor temperatures and relative humidity than the homes with levels less than 0.05 ppm. In addition, the group of homes with levels less than 0.05 ppm had a significantly greater number of homes with maintained HRVs.

Wall-to-wall carpets could not be considered a contributing factor because they were found in all homes but one. Fireplaces/

woodstoves/gas ranges also existed in homes of both groups and could not be considered a contributing factor.

A relative ranking by indoor formaldehyde levels for six ventilation-source-related groupings is presented in Figure 6. The categories with the lowest indoor formaldehyde levels were those with only background or minor formaldehyde sources. These homes did not have new furnishings/recent renovations, smokers or indoor temperatures greater than 21^{o}C. Levels in these homes averaged approximately 0.04 ppm.

The next group were those homes with sources of formaldehyde, but with ventilation systems which met the R-2000 ventilation guidelines. Levels of formaldehyde in these homes averaged approximately 0.05 ppm. Levels in individual homes ranged from 0.030 to 0.088 ppm.

The groups which had highest indoor formaldehyde levels were those homes with major formaldehyde sources and with HRV systems which did not meet the R-2000 ventilation guidelines. Average levels in homes of these categories were 0.07 ppm. Levels in individual homes ranged from 0.05 to 0.086 ppm.

TABLE 3

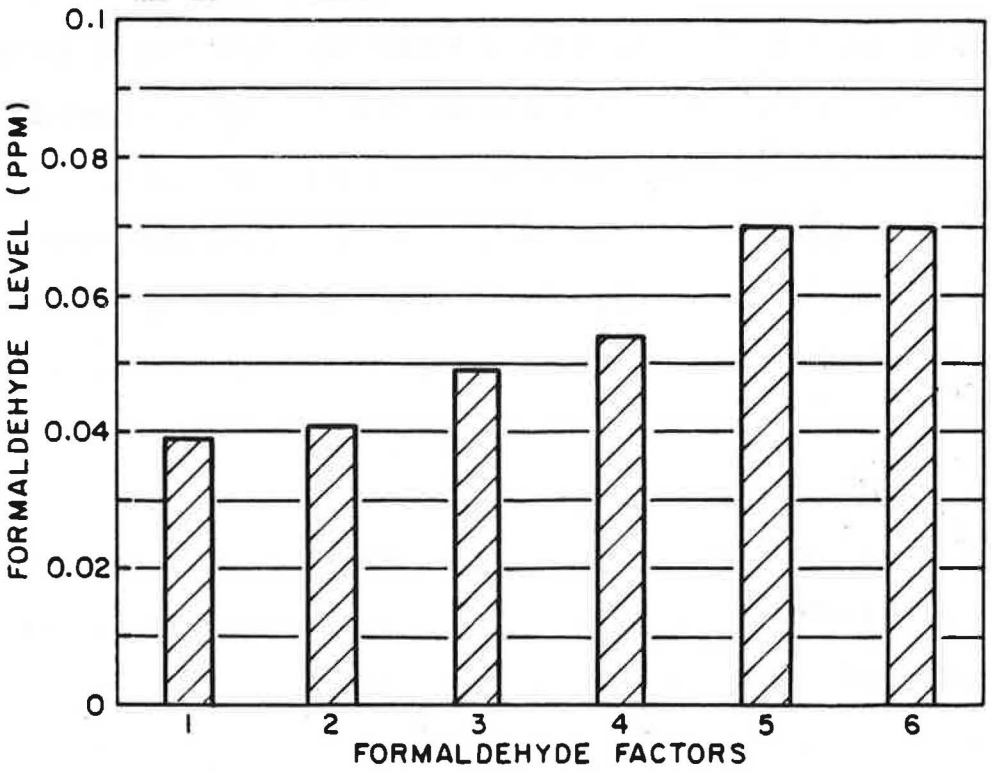
VENTILATION: SOURCE EVALUATION

Parameter	Distribution of Homes According to Formaldehyde Concentration	
	<0.05 ppm	>0.05 ppm
Ventilation Systems		
Airflow >80% of technical requirement	57%	44%
Continuous system Operation	100%	67%
Airflow >80% of technical requirement and continuous system operation*	57%	22%
Maintenance performed	64%	0%
Formaldehyde Sources		
Smokers	7%	46%
Indoor temperature > 21°C	14%	69%
Indoor humidity > 50% Relative Humidity	21%	85%
New furnishings and/ or renovations	7%	31%

* Conforms with R-2000 Program Guidelines.

FIGURE 6

FORMALDEHYDE PARAMETERS vs FORMALDEHYDE LEVELS



CODE 1 HRV MEETS VENTILATION GUIDELINES AND NO MAJOR SOURCES.

2 HRV DOES NOT MEET VENTILATION GUIDELINES AND NO MAJOR SOURCES.

3 HRV MEETS VENTILATION GUIDELINES AND SMOKERS AND TEMPERATURE GREATER THAN 21°C .

4 HRV MEETS GUIDELINES AND NEW FURNISHINGS AND TEMPERATURE GREATER THAN 21°C .

5 HRV DOES NOT MEET VENTILATION GUIDELINES AND SMOKERS AND TEMPERATURE GREATER THAN 21°C .

6 HRV DOES NOT MEET VENTILATION GUIDELINES AND NEW FURNISHINGS AND TEMPERATURE GREATER THAN 21°C .

3.0 CONCLUSIONS

Mean national and regional levels of formaldehyde in the R-2000 homes monitored, decreased from greater than 0.06 ppm in 1984 to less than 0.05 ppm in 1987. Homes monitored in 1984 and 1985 had mechanical systems which operated as installed, resulting in various instances of airflows that were too low or not balanced. Revisions to the guidelines were made in 1986 to ensure proper system installation and a minimum continuous airflow. These revisions likely contributed to the significant decrease in average formaldehyde levels and reduction in the standard deviations of the measurements.

In addition to this decreasing trend for homes monitored nationally, a more detailed investigation of a select number of Ontario homes also indicated a decrease in formaldehyde levels as a result of implementation of the revised guidelines.

The detailed investigation also indicated that elevated formaldehyde levels from strong sources may not be reduced as effectively with ventilation alone. When strong sources were present and the ventilation guidelines were met, formaldehyde levels were higher than average. Strong sources could result from a combination of indoor temperatures greater than 21^{o}C, relative humidity greater

than 50%, and tobacco smoke and new furnishings or renovations which involved building materials containing urea formaldehyde resin.

R-2000 homes now, on average, have formaldehyde levels less than the long-term target level of 0.05 ppm proposed by the Federal/ Provincial Indoor Air Quality Working Group, while conventional homes monitored to date, on average, exceed this level.

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