#M449

# VENTILATION ALTERNATIVES FOR MARITIME HOUSES - Final Report

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Submitted to:

Canada Mortgage and Housing Corporation

by:

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EXECUTIVE SUMMARY

Buchan, Lawton, Parent Ltd. was engaged by the Canada Mortgage and Housing Corporation (CMHC) to examine the effectiveness of low-cost ventilation systems in reducing moisture problems in houses in Maritime climates. A six unit row house block in Dartmouth, Nova Scotia was the subject of the study. The three different ventilation systems that were installed in separate interior units are:

- a humidistat controlled bathroom exhaust fan,
- a humidistat controlled through-the-wall fan mounted in the kitchen, and
- a whole house fan, also controlled by a humidistat.

Over a one year period, temperature and humidity data in the houses was recorded on a continuous data acquisition system. Monthly readings of fuel, power and water consumption were taken. On a quarterly basis, detailed inspections were carried out by Buchan, Lawton, Parent Ltd. personnel. Structural wood moisture content was measured monthly at two permanently mounted stations in each house and at a number of probe locations checked during the quarterly inspection visits.

All houses had evidence of moisture problems that could be associated with high interior moisture levels. These included mould growth on window frames and in some areas of the ceilings. At the time of selection, none of the units were suspected of having structural problems resulting from moisture collection.

The findings of the project were that all three fan installations were somewhat effective in limiting exposure of the house to high internal humidity levels. There was not a clear link between control of humidity and reduction of those moisture problems evident in the houses.

No areas of severe moisture collection were found in the original structure of the building. In fact, moisture content levels within the measurement range of the instrumentation only noted, at times, that the external humidity levels were very high.

There was one area where moisture collection did seem to be taking place. This was where the original sliding glass doors in the rear of the units had been replaced a number of years prior to the study. In this area, the exterior paneling was painted plywood and it is suspected that moisture is penetrating from the outside rather than the inside.

# 1.0 INTRODUCTION

Canada Mortgage and Housing Corporation (CMHC), with it's mandate to promote improvement in the quality of the internal and external aspects of both new and existing housing, is very interested in the control of moisture related problems in houses. These problems, which range from mould, mildew and water staining to severe structural problems caused by the accumulation of water in structural materials, have been particularly severe in Eastern Maritime climates. Some of these problems have been traced to external moisture sources such as wind-driven rain and others are the result of high levels of internal humidity.

Internal humidity levels can be controlled either by reducing the source or sources of water vapour in the house or by increasing the removal rate, usually through a mechanical ventilation system. One problem associated with the ventilation method is that heating the ventilating air increases the energy requirements of the house. There has also been some concern that, in certain environments, high ambient humidity levels may reduce the drying potential of outdoor air to a point that very high levels of ventilation and therefore energy use, are required or, in the worst case, the reduction of internal humidity by pure ventilation is not possible.

A number of methods exist for reducing the energy penalty of heating ventilating air. One commonly applied is the use of Heat Recovery Ventilators (HRV) which recover a portion of the heat in the outgoing exhaust airstream and transfer it to the incoming ventilation airstream. These systems can be relatively expensive. Another method is to forego the possibility of heat recovery but to ensure that ventilation is only used when necessary. Essentially, this can be done with a ventilating system that is turned on by a humidity controller only when humidity levels go above a preset level. This approach could be as simple as installing a humidity controller on an existing system such as a bathroom exhaust fan or as complex as the installation and application of whole house ventilating systems.

CMHC was interested in determining if such lower cost, humidistat controlled power ventilating systems were an appropriate solution for solving moisture problems in houses in maritime climates. CMHC engaged Buchan, Lawton, Parent Ltd. to carry out the study described in this report. In this study, three ventilation systems were installed in separate units of a row housing development in Dartmouth, Nova Scotia: a humidistat controlled bathroom fan, a humidistat controlled wall fan mounted in the kitchen, and a humidistat controlled whole house fan (Aston

2000) which had exhaust pickup on each of the basement, first and second floors.

In each of these houses plus three control units, temperature, humidity and fan status were monitored over a year long period with a micro-processor controlled data acquisition system. Energy use data was collected on a monthly basis by local personnel. On a quarterly basis, detailed house inspections, including a survey of moisture content in building materials, was carried out by Mark Lawton, P.Eng. of Buchan, Lawton, Parent Ltd.

The approach used in the project had some advantages and disadvantages which were recognized from the beginning of the project. The major advantage is one of economy. By using the six adjacent row units it was possible to install a single data acquisition system and collect continuous data on variables such as humidity and temperature in all units. There were also other economies gained in performing the site visits due to the convenience and flexibility of having the test units in one location.

The units were of identical floor plan providing the opportunity of comparing data on units of similar physical characteristics. Two units were end units and were somewhat different but the four interior units were identical.

While all the houses had some evidence of "moisture problems" none could be classified as severe. This made the test units representative of a larger portion of maritime housing but reduced the likelihood of finding dramatic visible evidence of a reduction of problems due to the effects of the fans.

The project did not incorporate a quantitative measurement technique for evaluating the most common "moisture problem" noted which is biological agents such as mould and fungi. The project relied on qualitative judgements of visible evidence. This reduced the likelihood of establishing a clear link between mould growth and measured data such as humidity.

## 2.0 OBJECTIVES

The objectives of the project described in this report were two-fold.

1. To determine whether the humidistat controlled exhaust fans installed for the study were effective in controlling humidity levels in the houses.

2. To determine whether the controlled humidity had a significant impact on the extent and severity of moisture related problems in the houses.

## 3.0 PROJECT DESCRIPTION

### 3.1 The Test Units

The test units consisted of a block of six attached public housing units in the Victoria Road Project managed by the Dartmouth Housing Authority. These units were selected after an initial screening of three similar housing blocks. The particular block was chosen because the units showed signs of high moisture levels, had occupants which were receptive to the project and were, according to the Housing Authority, a good group of tenants.

These test units, numbered 42 through 52 on Scotia Court, were attached units staggered in pairs down a slight incline (see Figure 3.1). They were identical two storey, three bedroom units with the adjacent units having a reversed layout. Floor plans are shown in Appendix A.

The units were built in the early 1970s and have had some minor renovations since then.

Some additional insulation had been blown into the attics. The units originally had sliding glass patio doors off the living rooms, but these had been removed a number of years prior to the test program. The windows were, effectively, triple glazed. There were newer vinyl double glazed, horizontally sliding pane windows on the interior and older single glazed, horizontally sliding aluminum panes on the outside.

The units were wood frame construction on a full concrete basement with masonry party walls. The interior finish was drywall and the exterior sheathing was gypsum covered by aluminum siding. The wall cavities were insulated with 90 mm paper-backed fibreglass batts. There was no polyethylene air/vapour barrier in the walls. The pitched roof structure was made with Fink trusses. The roof ceiling has a polyethylene air/vapour barrier, 90 mm paper-backed fibreglass insulation batts and was covered by an additional 100 mm of blown loose-fill insulation. The attic space was vented with soffit vents which were cleared free of the loose insulation at every second or third truss. The exterior doors were wood with aluminum storm doors.

The units were heated with forced-air, oil-fired furnaces and had electric hot water systems. None of the units had ventilation fans prior to the test program.


FIGURE 3.1

3.2 The Test Program

Fans were installed in three interior units.

| Unit | Fan Type | Location of Fan | Location of Humidity Controller | Measured Capacity l/s / AC/h |
|---|---|---|---|---|
| 46 | Aston whole house fan | Basement, inlets in basement and in 1st and 2nd floor hallways | 1st floor hall | 42/.4 |
| 48 | Bathroom fan | Bathroom | Bathroom | 20/.2 |
| 50 | Wall fan | Kitchen | 1st floor hall | 53/.5 |

The Aston whole house fan was mounted in the basement. A five inch duct, mounted in the basement header, exhausted the air to the outside. Three five inch diameter inlet ducts draw air from the house. One inlet was located in the basement and covered with a screen for protection. The other two inlets were located in the central hallways of the first and second floors. The ducting to these inlets was run through vertically aligned closets. All hoods and supplies were included in the installation kit and provided for a relatively neat and clean installation.

The bathroom fan was installed in a very conventional manner. The fan itself was mounted in the ceiling of the bathroom and three inch ducting was run through the attic to a soffit exit.

The wall fan, mounted in the kitchen, required a little on-site ingenuity to provide an adequate installation. The fan, approximately eight inches in diameter, was installed in a hole cut in the kitchen wall. The manually operated damper and switch supplied with the fan could not be used in automatic operation. A fabricated flapper-type damper was installed on the outside of the fan in a rectangular duct section. This was goosenecked down to provide some protection from the wind. Even with this damper, cold air leaking through the damper and conductive heat loss through the fan assembly itself lead to complaints from the tenants. To alleviate this problem, an internal, baffled cabinet with a second damper was fabricated and installed during the February site visit. This cabinet met the approval of the tenant, although in very windy conditions, there was still a detectable draft coming from the fan.

All three fans were installed by the same contractor and, therefore, it is somewhat difficult to make a precise split between the installation costs of the three fans. A good estimate would be:

- Aston fan: $ 720
- Kitchen fan: $ 325
- Bathroom fan: $ 550

The three units which did not have fans were used as control units. Two of these were end units, numbers 42 and 52, but one, number 44, was an Interior unit identical to the units with fans.

Four types of data were collected:

1 the results of one-time tests to determine house air leakage rates and chimney backdraft data;

2 on a monthly basis, fuel, power water consumption, and fan run time were recorded, and the moisture content of wall studs were checked at two permanently mounted stations;

3 in-house relative humidity levels, temperatures and fan operating times were monitored on a continuous basis by a data acquisition system;

4 quarterly site visits were carried out to perform house inspections, assess changes in occupancy, locate moisture problems and to check and adjust instrumentation.

The fans and instrumentation were installed in December of 1984 but the fans were not turned on at this time. The intention was to gather data with the systems not operating for one month after the installation. The installation contractor did not install lock boxes on the fan controls as requested. As a consequence, one tenant, in unit 46 with the bathroom fan, did operate the fan during this period.

After mid-January 1985, the humidity controllers were set to turn the fans on when the relative humidity went above a level of approximately forty-five percent. Inaccuracies and drift with the humidity controllers, and some uncertainty with the accuracy of the humidity sensors, created some problems achieving this intention. It was found that one fan, in unit 46, operated for an inordinate length of time while the other two rarely operated. Because of the relatively low relative humidities in the houses during the late winter, a high level of fan operation was not to be expected. In the spring, warmer temperatures and higher exterior absolute humidities were expected to, and did, increase indoor relative humidities and fan operating time.

Over the summer months, the lock boxes were taken off the fan controllers so that tenants could operate the fans manually.

The operation plan for the fall and early winter months was adjusted in order to ensure meaningful data acquisition over this critical period when cold outdoor temperatures and the emmission of moisture stored in the building materials could be expected to create the highest level of moisture problems. The humidistats were re-set and locked in September of 1985. A key to the lock boxes was left with the on-site employee and the period between the changing of the data collection discs was reduced to one week. When a data disc was received by Buchan, Lawton, Parent Ltd., it was reviewed and instructions for adjusting the humidity controllers were relayed back to the on-site employee by telephone. The goal was to get the humidity controllers set to a consistent level in the three houses and to gradually reduce the humidity setpoint as outdoor temperatures dropped.

With this operation plan, all fans operated for a significant amount of time over the fall period allowing analysis on their ability to limit high relative humidity levels in the house.

### 3.2.1 One-Time Tests

#### Fan Depressurization

The main reason for fan depressurization tests was to verify that all units had similar air leakage characteristics.

While all six units were tested in accordance with the CGSB Draft Standard CAN 2-149.10-M85 Determination of Air-Tightness of Buildings by the Fan Depressurization Method, these results should not be compared to other tests by this procedure. No attempt was made to depressurize the units adjacent to the ones being tested. This would be the correct procedure when testing multiple attached units which do not have an air barrier in their common walls. Because of the added time and expense, and because numerical leakage data was not critical to the project, this more elaborate procedure was not proposed in the initial Statement of Work.

The only intentional openings sealed for the test were the oil furnace chimneys.

While the units were depressurized to 30 pascals, the areas of air leakage were located using a smoke pencil.

The fan unit used for the testing was a Retrotec model RDF 501. The calibration of the unit is checked once yearly, and has not required correction.

## Backdraft Tests

Backdrafting testing was performed to determine if the exhaust systems, including the installed fans, were powerful enough to backdraft the furnace chimneys.

Because CMHC's Combustion Ventilation Safety Check procedure was not yet finalized at the time that the backdraft testing was performed, this draft procedure was used only as a guide in formulating the three part test methodology. This methodology is outlined below.

Part 1 - Chimney and Oil Furnace Inspection
Each chimney and appliance was inspected in order to identify any malfunctions caused by wear or poor maintenance which could affect the backdraft test results. Furnace efficiency tests were performed on all furnaces.

Part 2 - Furnace Room Vent/Pressure Test
With the depressurization fan's manometer and four exterior pressure averaging tubes left in place after the fan testing, the indoor/outdoor pressure difference was measured with the house exhaust appliances and furnace blower operating. These differentials were then compared to the CMHC accepted levels or Maximum Allowable Depressurization (MAD) levels. In addition, the depressurization fan was used to produce and measure the pressure required to backdraft flue of the forced-air furnace in both cold and hot conditions.

Part 3 - Furnace Room Spillage Time
A backdraft condition with a cold flue was induced with the house depressurized by the door fan. The furnace was turned on and the time taken to overcome the backdraft condition recorded.

### 3.2.2 Monthly Data Readings

The following data was metered or measured once each month throughout the monitoring period.

To assess the heating, electrical and water requirements of the buildings, fuel, electrical and water meters were read. Kent low flow fuel meters were installed on the fuel oil lines for the test program. Electrical power and water consumption were metered by the existing utility meters.

Fan run-time meters, installed with each of the three fans, were read monthly and served as a cross check with the continuously monitored runtimes obtained by the data acquisition system.

Power psychrometer readings of relative humidity were taken at each of the humidity transmitters of the data acquisition system. These values, and the corresponding times at which they were taken, were used as a check on the values from the continuous recordings.

Two moisture stations containing electrical resistance pins and a thermocouple were placed in the wall studs of each unit (see Figure 3.1) and read with an Delmhorst BD-7 electrical resistance moisture meter and digital thermometer. The stations were placed in the first floor exterior wall beneath the kitchen cupboard (predominant windward side) and the second floor exterior bedroom wall (the leeward side). See Appendix A for locations.

### 3.2.3 Continuous Recording of Data

Temperature and relative humidity were continuously monitored at a central location in each basement and second floor (see Appendix A). The three fan runtimes and the outdoor temperature were also recorded.

The continuous monitoring was done with a Sciemetric 8082/IBM PC data acquisition system which was installed in the basement of unit 50. The Enercorp temperature/relative humidity sensors were scanned about every 30 seconds and their values were averaged and stored hourly for all 403 days of the monitoring period. The system automatically computed daily averages and daily maximum and minimum values. Computer diskettes were changed once monthly for most of the program and returned to Buchan, Lawton, Parent Ltd.'s office for analysis. During the fall and winter of 1985, this frequency was increased to once per week.

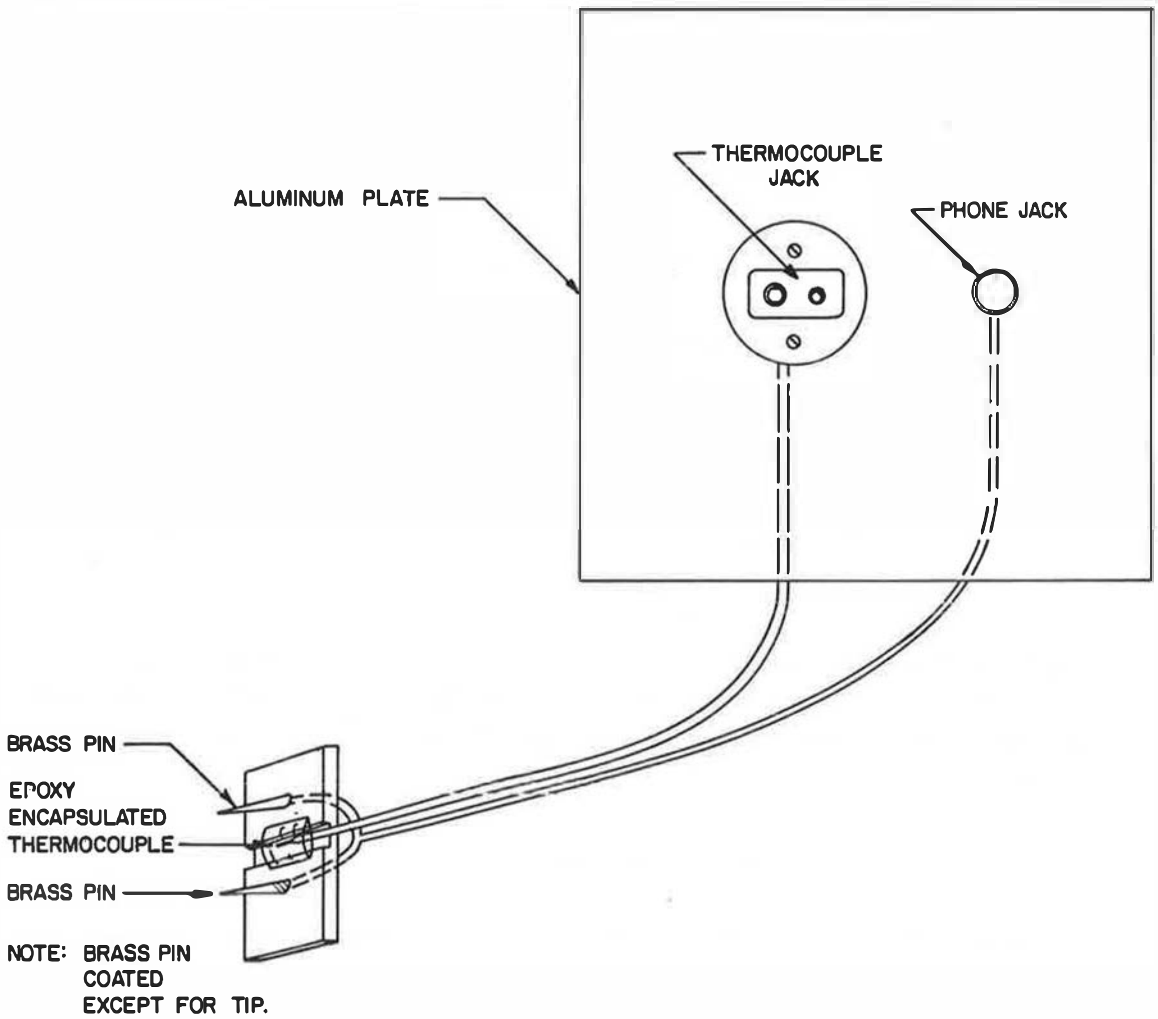



FIGURE 3.1 WALL MOISTURE CONTENT STATION

To ensure the accuracy of the readings, the calibration of the Enercorp sensors was checked at each quarterly site inspection against the readings from the power psychrometer. At the end of the project, the Enercorp sensors were returned to the manufacturer for calibration (see Section 5.0.)

### 3.2.4 Inspections

The units were inspected during each of the five site visits by Buchan, Lawton, Parent Ltd. personnel. The first visit occurred when the monitoring equipment was installed in December 1984 and then at each subsequent three month interval during the ensuing year.

The purpose of the regular inspections was to locate moisture problems and document changes in occupancy or house events which could increase or decrease the house moisture generation or dissipation. The visits also served to identify or correct any discrepencies or problems with meters or instrumentation.

### 3.2.5 Humidity Samplers

One procedure, which was somewhat beyond the true objectives of the program, involved the use of some experimental time-averaged humidity samplers that were manufactured by Buchan, Lawton, Parent Ltd. These samplers were based on others developed at the Lawrence Berkley Labs and were effectively a dosimeter-type sampler measuring time-averaged exposure to absolute humidity. If such samplers have the potential to be reliable and accurate, they could be very useful in the examination of moisture problems in houses. They measure an average humidity level which is, perhaps, more useful than single point measurements and they are relatively inexpensive and simple to fabricate, use and analyze. In many cases, they could be used instead of much more expensive and delicate continuous recording equipment. Because of their simplicity, they could be deployed and handled by homeowners or relatively untrained on-site personnel.

The use of the samplers during this project was primarily undertaken to gain experience with their field use. With this field use, carried out in conjunction with much more detailed lab testing on accuracy and the range of application, the viability of this type of sampling method could be determined.

The samplers were deployed for one week periods each month, corresponding to monthly data collection dates by local personnel. One sampler was deployed near each Enercorp humidity sensor providing a comparison of the two sampling methods. Additional capped control samplers were also deployed to determine if there was any significant weight change in the shipping and handling process which would force the questioning of the analyzed absolute humidity exposure.

After exposure, the samplers were capped by local personnel and shipped back to Buchan, Lawton, Parent Ltd.'s Ottawa office for re-weighing and analysis.

## 4.0 FINDINGS

### 4.1 One-Time Tests

#### 4.1.1 Fan Depressurization Tests

The results of the fan tests are summarized in the following table. Listed are the air change rates per hour (AC/hr) at 50 pascals pressure difference, the equivalent leakage area (ELA) at 10 pascals pressure difference, and the correlation of the data.

Table 4.1.1 Fan Test Results

| Unit No. | AC/hr @ 50 pa | ELA ($m^2$) | Correlation of Data |
|---|---|---|---|
| 42 | 5.65 | 0.074 | .998 |
| 44 | 7.45 | 0.077 | .994 |
| 46 | 7.92 | 0.108 | .999 |
| 48 | 5.83 | 0.172 | .998 |
| 50 | 7.46 | 0.113 | .996 |
| 52 | 5.64 | 0.071 | .998 |

While the interior units, in general, have higher test figures, part of their tested air leakage was coming from the adjacent units through common walls.

The values may be lower in unit 48 because most of the operable windows were sealed over with tape by the tenants. In unit 42, most windows had been sealed with polyethylene and tape.

In general, the air leakage characteristics of all units were similar. The same sources of air leakage were common to all units. These included:

- around doors and operable windows,
- attic hatches,
- sill plates,
- wall penetrations, and
- from the common walls of the adjacent units.

### 4.1.2 Backdraft Tests

Tables 4.1.2 and 4.1.3 list the results from the backdraft tests. Table 4.1.2 shows house depressurization when the furnace blower, the clothes dryer, and the installed exhaust fans were operating.

Table 4.1.2 Depressurization from Ventilation and Exhaust Appliances

| Unit No. | Furnace Blower (Pa) | Clothes Dryer & Installed Exhaust Fan (Pa) |
|---|---|---|
| 42 | 0 | -- |
| 44 | 0 | -- |
| 46 | 0 | 2 |
| 48 | 0 | 1 |
| 50 | 0 | 3.5 |
| 52 | 0 | -- |

In units 42, 44 and 52, there was no noticeable change in house pressures with the exhaust appliances operating. None of these units were equipped with exhaust fans. The clothes dryer in unit 44 vented indoors and the operation of the clothes dryers in units 42 and 52 seemed to contribute little to house depressurization.

In no cases were the cold chimneys backdrafted by the operating exhaust systems, and in no cases were the Maximum Allowable Depressurization (MAD) limits of 4 pa, as outlined by CMHC's Combustion Ventilation Safety Check, exceeded.

Table 4.1.3 shows the level of depressurization that was required to backdraft the cold and hot chimney of the oil furnace and the time taken after furnace start-up to overcome the cold flue backdraft.

Table 4.1.3 Backdraft Pressures and Recovery Times

| Unit No. | Pressure Required to Backdraft Cold Flue (pa) | Warm Flue (pa) | Time to Re-establish Draft (sec) |
|---|---|---|---|
| 42 | 9 | 22 | 10 |
| 44 | 9 | 35 | 5 |
| 46 | 12 | 35 | 25 |
| 48 | 11 | 35 | 20 |
| 50 | 12 | 33 | 5 |
| 52 | 23 | -- | — |

These high pressures substantiate the fact that the exhaust systems are not powerful enough to depressurize the houses and backdraft the cold flues.

The Dartmouth Housing Authority has mentioned sporadic cases of backdrafting and backpuffing upon start-up. It is assumed that these cases were due to wind effects. In four of the units, the barometric dampers on the furnace flue pipes had been secured shut by the furnace service people. The maintenance manager of DHA was notified that this practice is not recommended.

### 4.1.3 Furnace Efficiency

The furnace efficiencies on all six units were measured with a Bacharach furnace efficiency kit. The stack temperatures were measured with a thermocouple and a "Tempmaster" digital thermometer.

All furnaces were Fawcett model OL 106 rated at 106,000 BTU with Fawcett oil burners Model OB3 rated to 1.00 US gph.

An inspection of the heating systems revealed that the flues on all chimneys were free of obstructions, all warm air filters were clean and the fan belt adjustments were acceptable.

There were no test holes in any of the furnace flues to indicate that service personnel were performing furnace efficiency tests.

Barometric dampers were not operational on the furnaces in units 42, 44, 50, and 52. They were wedged shut by sheet metal screws. A discussion with a representative of Fawcett furnaces, Sackville, N.B., revealed that servicemen sometimes resort to this tactic to maintain a strong cool flue draft so as to prevent spillage of smoke into the house upon start-up. The furnace standby or cool flue drafts were measured as being in the range of .10 to .15 inches of water with the barometric dampers free.

All furnaces were tested under fairly high winds.

The results of the furnace efficiency tests are contained in Table 4.1.4.

Table 4.1.4 Efficiencies of Oil-Fired Furnaces

| Unit No. | Furnace Efficiencies (%)<br>Barometric Damper Held Shut | Barometric Damper Free |
|---|---|---|
| 42 | 66 | 75 |
| 44 | 57 | 69 |
| 46 | - | 73 |
| 48 | - | 69 |
| 50 | 65 | 74 |
| 52 | 54 | 70 |

The gun-type burners on these furnaces should have $CO_2$ readings between 7% and 9%, and furnace efficiencies above 75%.

If the barometric damper on a furnace is not operational, wide fluctuations in the combustion air volume and, therefore, the efficiency are to be expected.

## 4.2 Monthly Data

Fuel, electricity and water meters were read once monthly. This metered data was used primarily to verify or corroborate house occupancy data, and to determine if the fan operation was having a noticeable effect on heating fuel consumption.

### 4.2.1 Occupancy Data

Table 4.2.1 lists the occupancy data for all six units. The electrical consumption and water use was metered via the municipal electrical and water meters. Low water and electrical consumption figures for unit 42

Table 4.2.1 Occupancy Data

| Unit No. | No. of Occupants | Electrical Consumption (KWh/day) | Water Consumption (l/day) | Average House Temp.* °C | Notes: |
|---|---|---|---|---|---|
| 42 | 3 | 18.2 | 45.0 | 20.3 | House empty during day; Thermostat low |
| 44 | 4 | 33.4 | 80.0 | 21.8 | Three occupants are students (1 adult, 2 children) and one occupant works |
| 46 | 4 | 36.1 | 74.1 | 22.8 | One adult and baby at home during day |
| 48 | 5 | 27.4 | 65.5 | 24.0 | Both adults home during day and children are school age Thermostat high |
| 50 | 4 | 33.2 | 88.2 | 22.6 | Both adults usually home during day |
| 52 | 4 | 34.7 | 60.9 | 23.7 | Two of three adults home during day; child school age |

* These were second floor temperatures averaged over the six coldest months of the year.

reflect its low occupancy rate. The monthly breakdowns of occupancy data are included in Appendix B.

### 4.2.2 Fuel Consumption

Table 4.2.2 lists the metered fuel consumption for each unit over each of the monitoring periods. It also lists each unit's average second floor temperatures over six of the coldest monitoring periods.

In unit 44, the originally installed oil meter did not function. It was changed half way through the monitoring period. In unit 50, the meter ceased functioning near the end of the program and was not changed. The fuel consumption data for these units was extrapolated from the available data and it is felt that these values are good estimates.

The high fuel consumption in units 48 and 52 coincide with the higher temperatures which are kept inside these units. Unit 52 is also an end unit with the additional exterior wall. Unit 42, the other end unit, has substantially lower fuel consumption figures than unit 52 because it maintains an average inside temperature of 3°C lower.

The low fuel consumption in unit 50 was originally suspect even though the unit was maintained at temperatures below the two adjacent units and, therefore, could have been "borrowing heat" from them. However, after discussions with the tenant regarding the amount of oil purchased and the furnace operating practice (they usually shut off the furnace at night), it was concluded that the measured values were probably valid.

From the data in Table 4.2.2, one cannot detect a correlation between those units with fans and high fuel consumption. The amount of energy lost through fan operation can be estimated from fan runtime, flow, and the difference between indoor and outdoor temperature by the equation

$$Q = \text{density} \times V \times 3.6 \times C_p \times (T_{house} - T_{amb}) \times \text{status}$$

where

- Q is energy (kJ)
- density is density of air (1.3 kg/m$^3$)
- 3.6 is conversion from l/s to m$^3$/h
- $C_p$ is specific heat of air (1 kJ/kg°C)
- $T_{house}$ - indoor temperature (°C)
- $T_{amb}$ - outdoor temperature (°C)
- status is the ratio of on-time of the fan (hr/hr)

Table 4.2.2. Fuel Consumption

| Monitoring Period | Degree Days in Period | Litres/Period | | | | | | Litres/Degree Days | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 42 | 44 | 46 | 48 | 50 | 52 | 42 | 44 | 46 | 48 | 50 | 52 |
| Dec. 9 - Jan. 8/85 | 590 | 228 | * | 180 | 362 | 221 | 339 | .39 | - | .30 | .61 | .37 | .57 |
| Jan. 8 - Feb. 1/85 | 608 | 237 | * | 278 | 354 | 148 | 363 | .39 | - | .46 | .58 | .24 | .60 |
| Feb. 1 - Feb. 22/85 | 486 | 178 | * | 210 | 266 | 112 | 299 | .37 | - | .43 | .55 | .23 | .61 |
| Feb. 22 - Mar. 10/85 | 339 | 119 | * | 151 | 191 | 46 | 206 | .35 | - | .44 | .56 | .14 | .61 |
| Mar. 10 - Apr. 9/85 | 539 | 180 | * | 242 | 297 | 168 | 353 | .33 | - | .45 | .55 | .31 | .65 |
| Apr. 9 - May. 15/85 | 457 | 132 | * | 135 | 247 | 120 | 335 | .29 | - | .29 | .54 | .26 | .73 |
| May. 15 - June 12/85 | 155 | 31 | * | 4 | 68 | ** | 87 | .20 | - | .03 | .44 | 0 | .56 |
| June 12 - July 17/85 | 96 | 20 | 13 | 0 | 41 | ** | 59 | .21 | .13 | 0 | .42 | 0 | .61 |
| July 17 - Aug. 22/85 | 20 | 2 | 0 | 0 | 0 | ** | 12 | .10 | 0 | 0 | 0 | 0 | .60 |
| Aug. 22 - Sept. 17/85 | 85 | 16 | 0 | 0 | 2 | ** | 44 | .19 | 0 | 0 | 0 | 0 | .52 |
| Sept. 17 - Oct.15/85 | 124 | 43 | 8 | 21 | 48 | * | 82 | .35 | .06 | .17 | .17 | - | .66 |
| Oct. 15 - Nov. 19/85 | 415 | 140 | 127 | 156 | 191 | * | 264 | .34 | .31 | .38 | .46 | - | .64 |
| Nov. 19 - Dec. 16/85 | 537 | 189 | 270 | 205 | 270 | * | 329 | .35 | .50 | .38 | .50 | - | .61 |
| Dec. 16 - Jan. 16/86 | 730 | 272 | 304 | 295 | 342 | * | 333 | .37 | .42 | .40 | .47 | - | .46 |
| Totals | 5181 | 1787 | 1700 | 1676 | 2678 | 1300 | 3106 | .34 | .33 | .32 | .52 | .25 | .60 |

* Fuel meters stopped registering flows and were changed; total fuel consumption figures for units 50 and 44 were from extrapolation of available fuel data.

** Furnace shut off.

This can be converted to equivalent litres of oil by using the conversion factor and assumed efficiencies of 11.25 kwh/litre of oil and 70%.

Table 4.2.3 shows the calculated heat loss through the fans for periods corresponding to fuel meter data. This calculation was done with hourly average data for temperatures and fan operation times. One can see that the percentage of fuel consumption attributable to fan operation is small.

Table 4.2.3 Calculated Energy Loss Through Fans
(Litres Oil Equivalent / % of Oil Consumed)

| House Flow Rate (l/s) | 46 (Aston) | 48 (bathroom) | 50 (kitchen) |
|---|---|---|---|
| Period | | | |
| Dec 9 - Jan 8 | 16.5/9.1 | .1/0 | 0/0 |
| Jan 8 - Feb 1 | 2.4/.9 | .3/.1 | 0/0 |
| Feb 1 - Feb 22 | 2.2/1.1 | 3/1.1 | 0/0 |
| Feb 22 - Mar 10 | 0/0 | 4.5/2.3 | 0/0 |
| Mar 10 - Apr 9 | .1/0 | 12.2/4.1 | .1/0 |
| Apr 9 - May 15 | .1/.1 | 16.3/6.6 | 0/0 |
| Sep 17 - Oct 15 | 2.9/13.8 | 2.3/4.8 | 16.4/* |
| Oct 15 - Nov 19 | 3.7/2.4 | .8/.4 | 5/* |
| Nov 19 - Dec 16 | 3.2/1.5 | 1.2/.5 | .5/* |
| Dec 16 - Jan 16 | 0/0 | 1.6/.5 | .3/* |
| Annual | 31.1/1.9 | 42.3/1.6 | 22.3/* |

*fuel meter defective

## 4.3 Continuous Humidity and Fan Status

The data acquisition system measured the relative humidity and temperature at two points in each unit as well as fan runtimes and outdoor temperature. The system automatically calculated and recorded hourly and daily averages of each reading over the 403 days of the monitoring period. This resulted in a massive amount of raw data. Two analysis programs were written to provide manageable output from this mass of numbers.

The first program classified the frequency distribution of the relative humidities. The second program scanned through the data and printed out hourly information for the period in which fan operating time was recorded and the hour before and the hour after. Examples of the output of these two programs are shown in Appendix C.

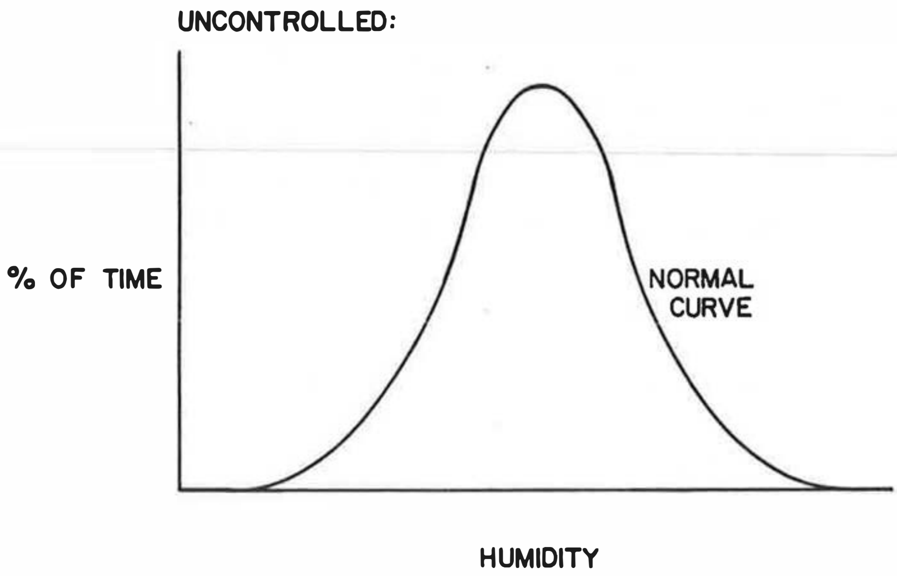
In an ideal case, it would be expected that a humidistat controlled ventilation system would alter the frequency distribution of humidities by reducing or eliminating the number of hours during which the relative humidity was above the control setpoint. It would also be expected that, for a relatively high percentage of the time, the relative humidity would be just below the control setpoint. This is illustrated in Figure 4.3.1.

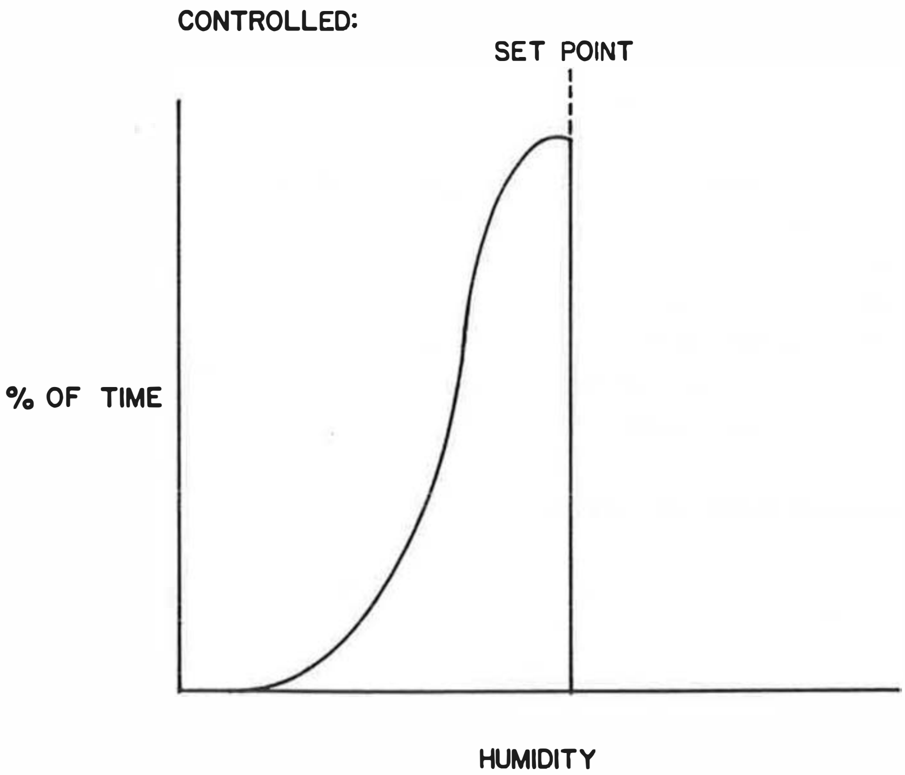
In real life, this idealized result cannot be expected because of factors such as:

- moisture removal capacity being less than that required to stabilize peak moisture generation rates,
- reading error of the humidity sensor caused by drift, hysteresis or slow reaction time,
- control error caused by drift, hysteresis, slow reaction time and the effects of the differential in setpoints to turn the fan on and off,
- local effects; the humidity controllers were not mounted beside the humidity sensors so that it could be expected that one could be sensing a different humidity from the other.

Buchan, Lawton, Parent Ltd. has significant concerns about the accuracy of the relative humidity sensors used in the project. This is detailed in Section 5.0. There is also significant concern with the accuracy and drift characteristics of the simple humidity controllers used to control fan operation. This added concern prompted an increase of effort in the critical fall period of the project (September - December, 1985). Instead of retrieving data on a monthly basis, the schedule was increased to a once per week basis.

FIGURE 4.3.1 THE IDEAL EFFECT OF THE HUMIDITY CONTROLLERS



The humidity controllers were then adjusted based on the results of the weekly data recording. There was usually a lag period of approximately one week for transport and analysis of the data disc.

Figures 4.3.2 through to 4.3.7 show graphical representations of the frequency distribution analysis. Because of the above mentioned factors, the reader should not put too much emphasis on the absolute values of the humidity readings but rather focus on the distribution pattern.

The frequency distributions shown are based on a compilation of data gathering during the critical fall period of October and November. These graphs show the frequency distribution of humidity levels and the percentage of time that the fans were on (i.e., the hours of fan runtime while the upstairs humidity was within the bin range divided by the total number of hours the upstairs humidity was within the bin range). By examining these figures, it can be seen that the operation of the humidistat controlled fans did seem to skew the frequency distribution from a normal distribution.

This effect can be more clearly demonstrated by plotting the results on arithmetic probability paper. In this type of representation, the cumulative percentage of the reading over the X-axis value (humidity) are plotted. In this type of representation, a normal curve will show as a straight line. Figures 4.3.8 and 4.3.9 show the upstairs relative humidity in this format comparing the results for houses with fans with the control houses. These indicate that in the control houses, normal patterns were found and, in the houses with fans operating, the curve was skewed.

This would indicate that the operation of the humidstat controlled fans did have the desired effect of limiting the amount of time that the household humidity was in the higher ranges. The action of the fans did not make a dramatic difference to the average relative humidity in the houses during this period, but rather, controlled the peaks. From the perspective of condensation, the ability to limit the peaks is important since condensation is a step function and is defined by the dewpoint temperature rather than linear function.

Figures 4.3 10 and 4.3.11 show the basement relative humidity plotted on arithmetic probability paper. In these figures, the expected patterns are much less evident. This was not unexpected since there are a number of complicating factors: the basements were isolated from the upstairs portions where the exhaust fans were mounted, the laundry facilities generated high moisture loads at arbitrary times, and the venting action of the furnaces would have a greater effect. This latter factor probably

FIGURE 4.3.2

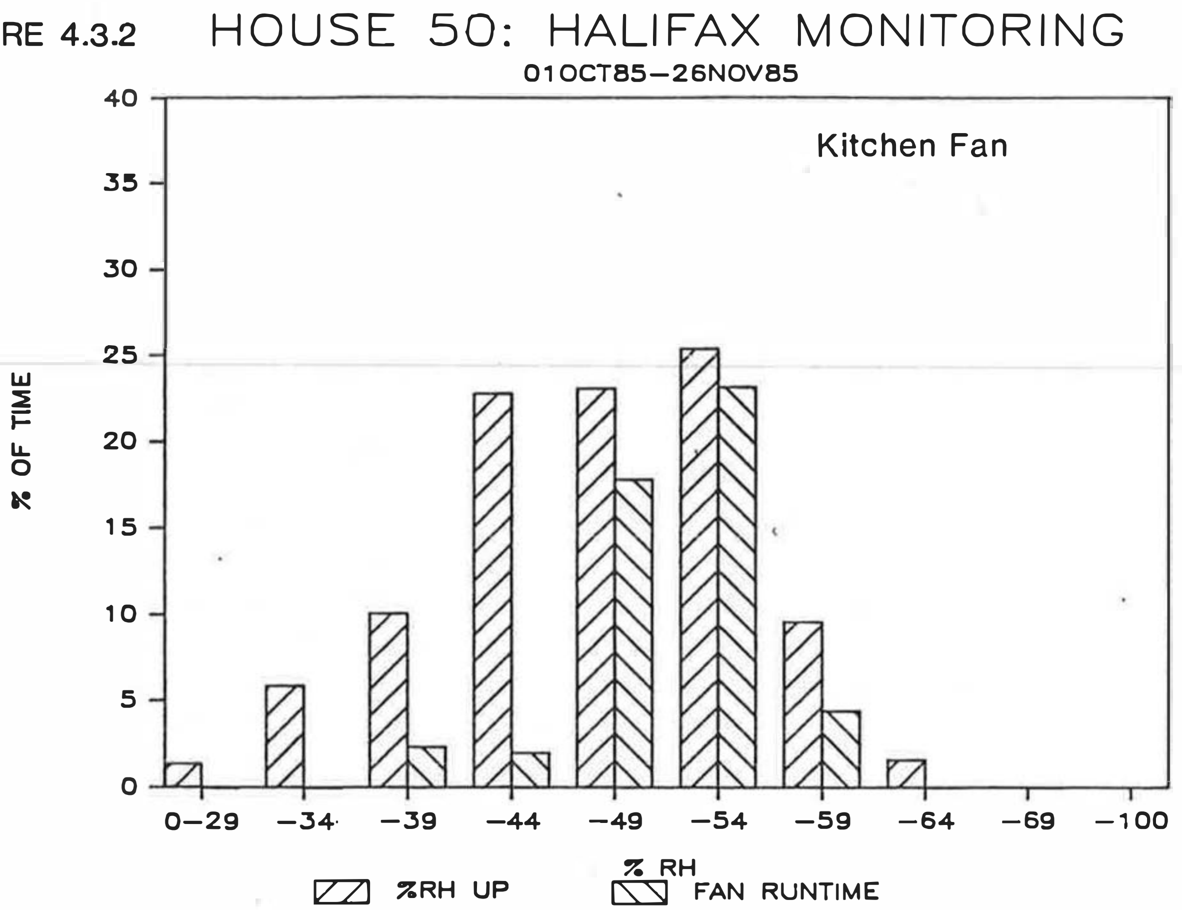



FIGURE 4.3.3

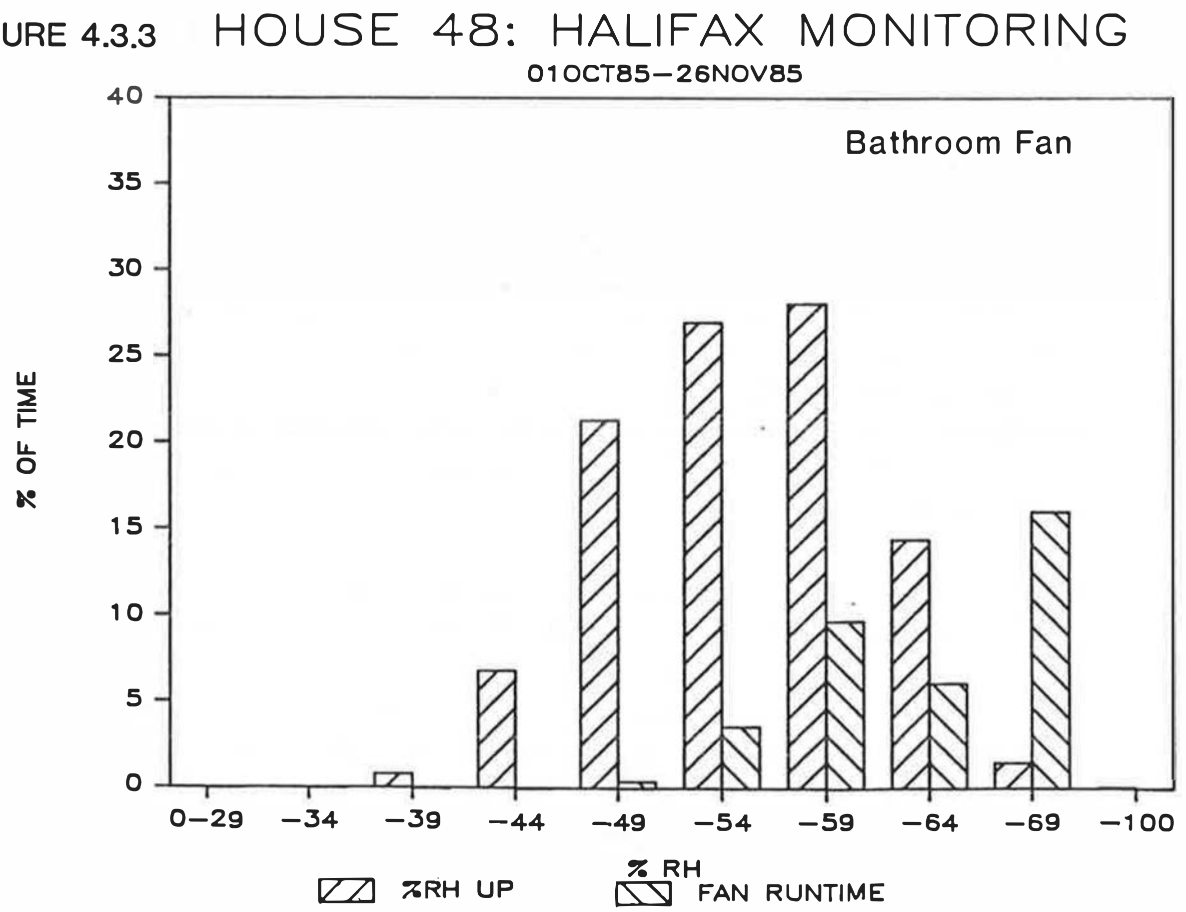


FIGURE 4.3.4

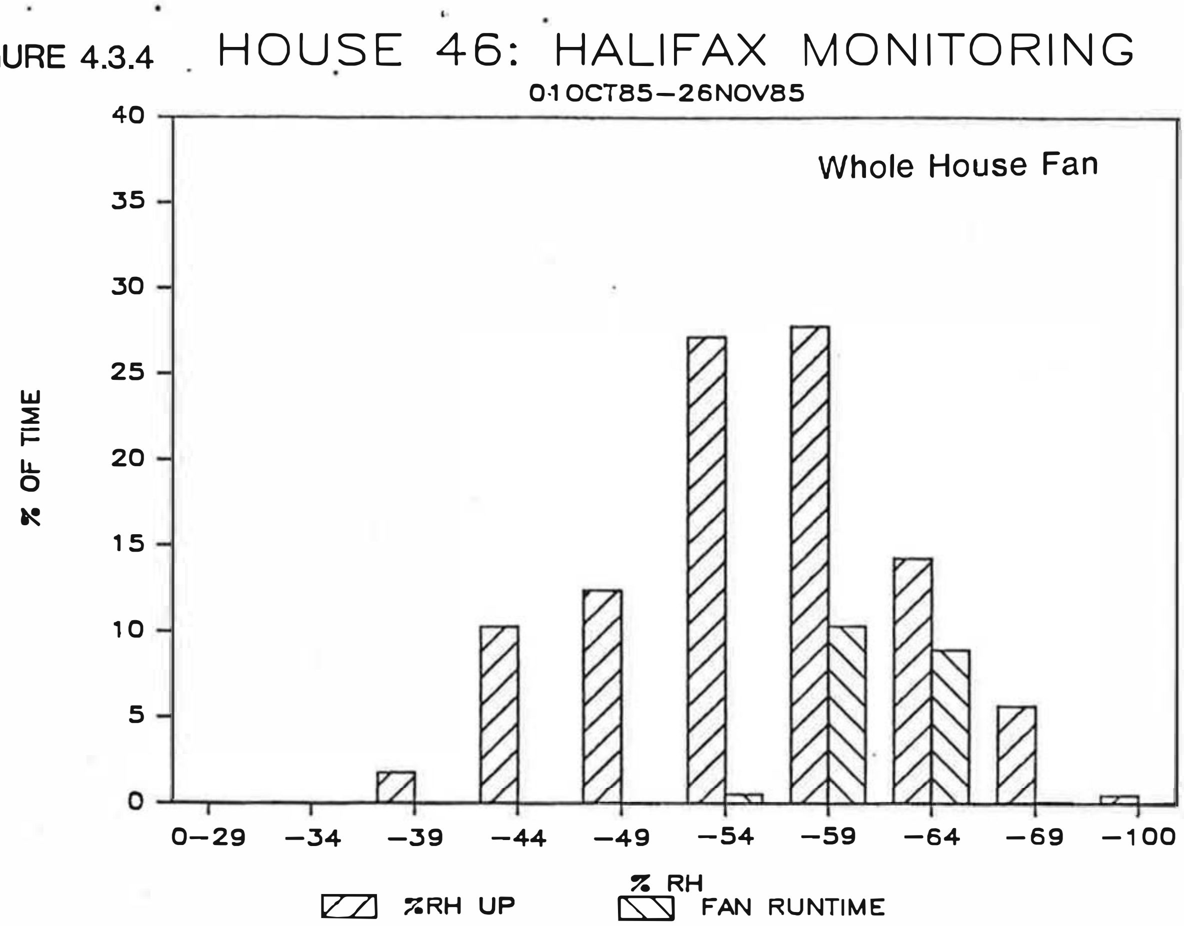



FIGURE 4.3.5

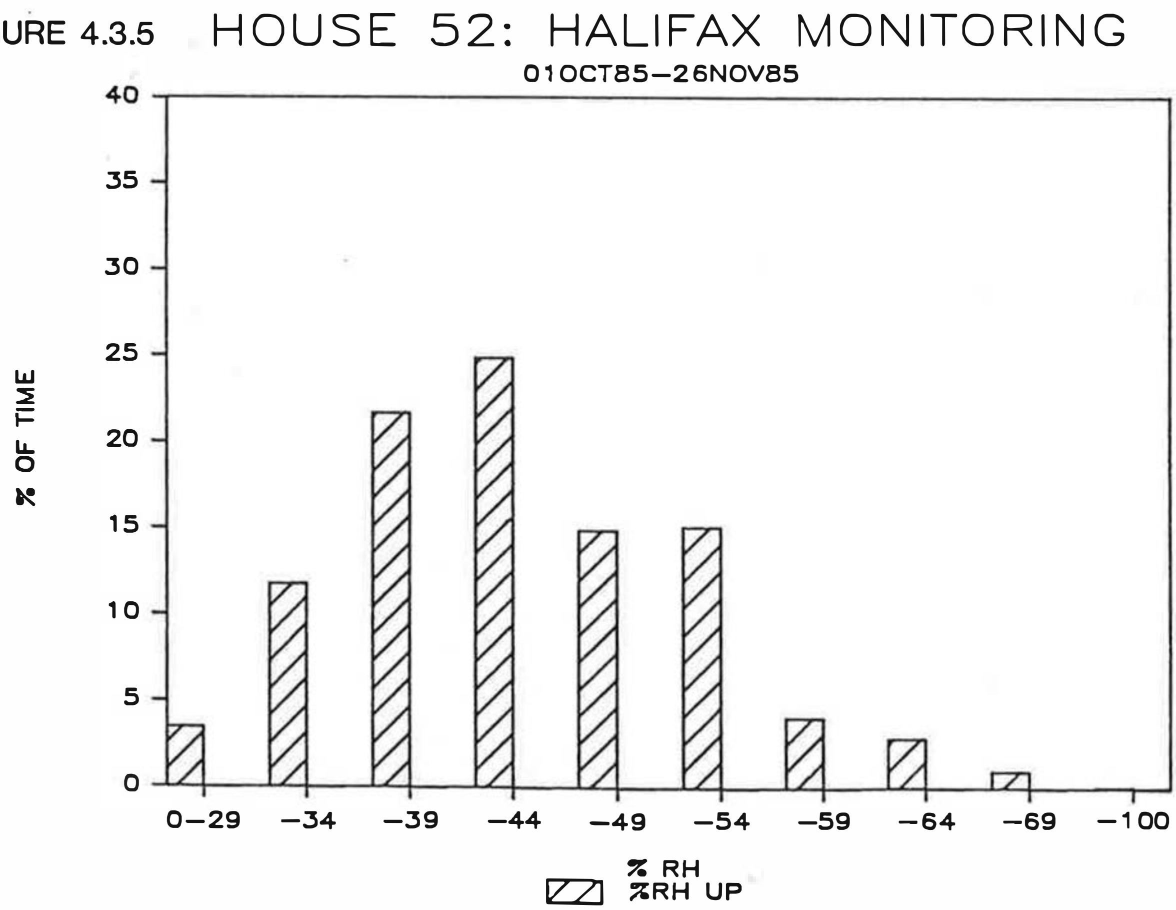


FIGURE 4.3.6

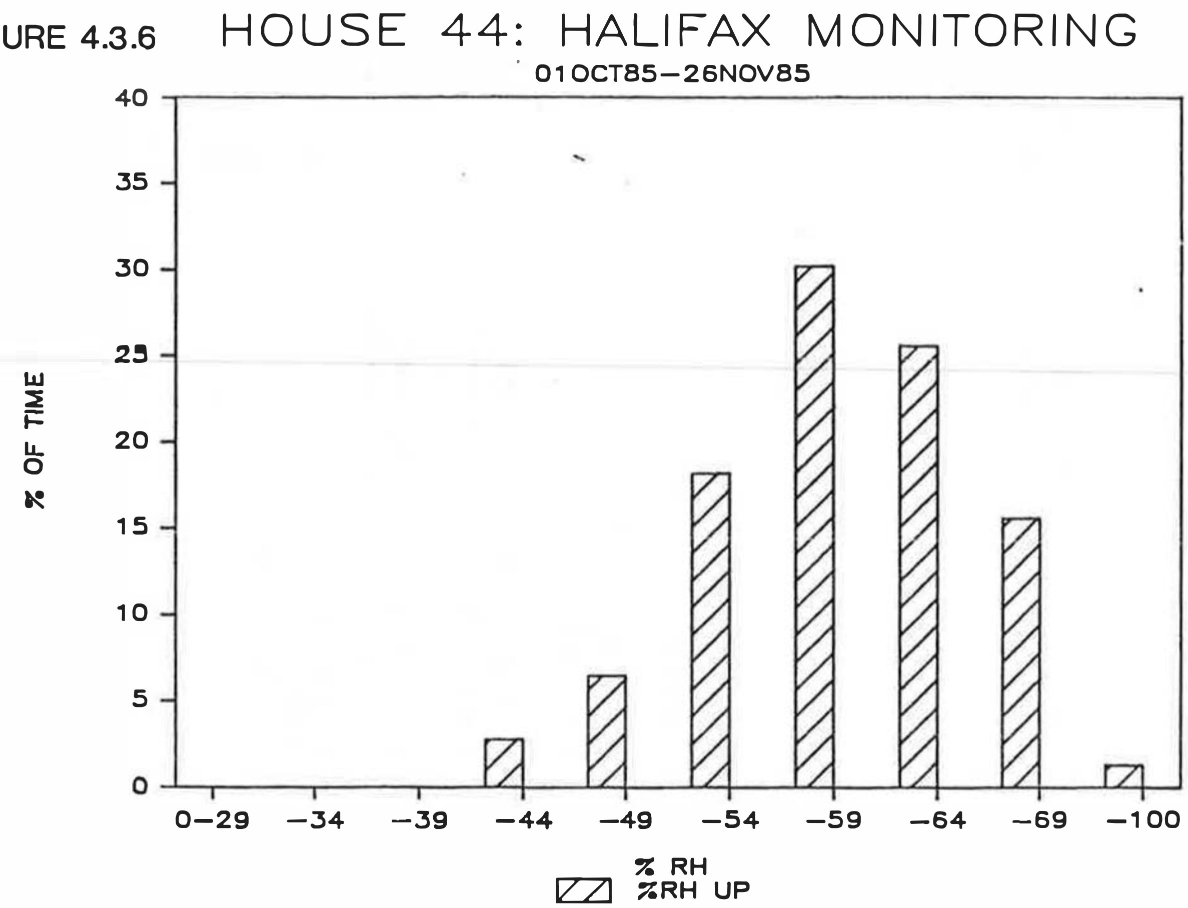



FIGURE 4.3.7

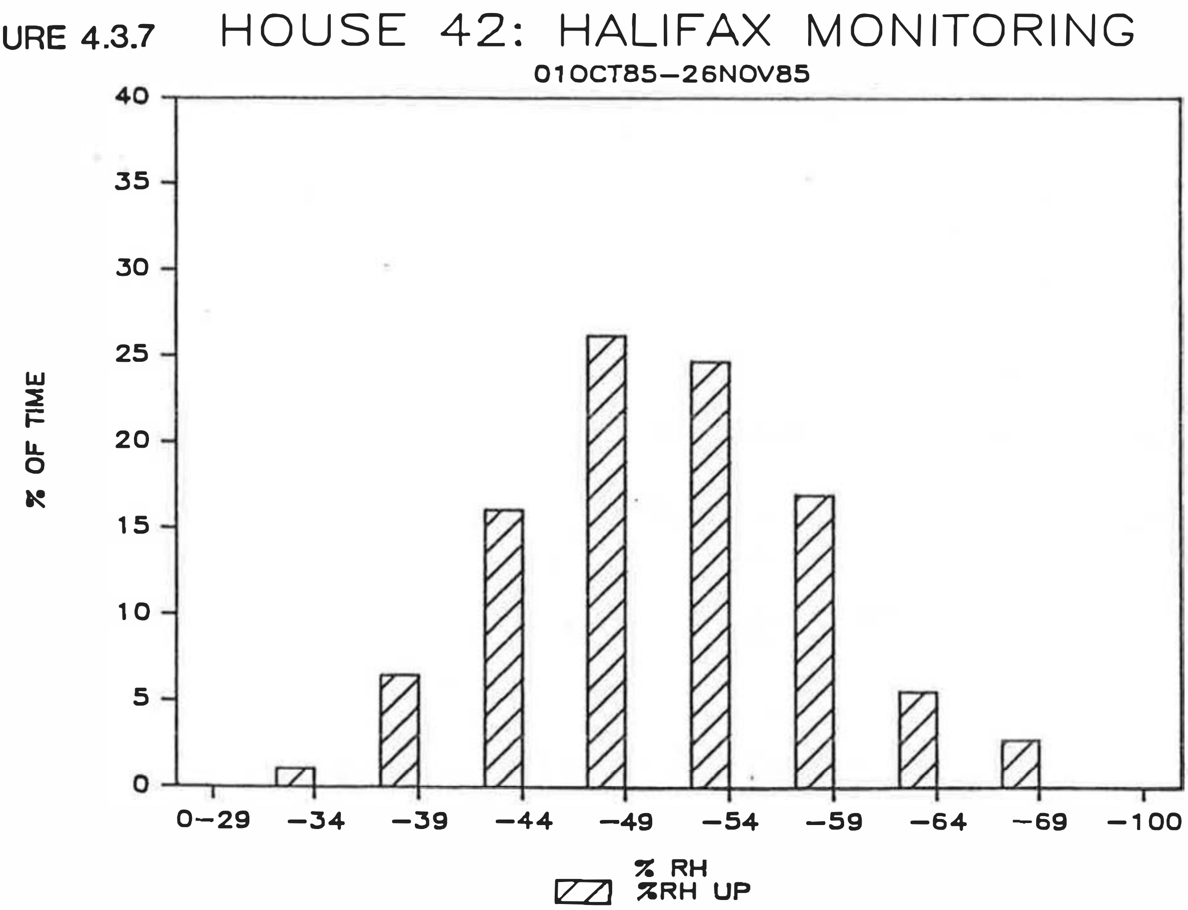


FIGURE NO. 4.3.8 HOUSES WITH FANS

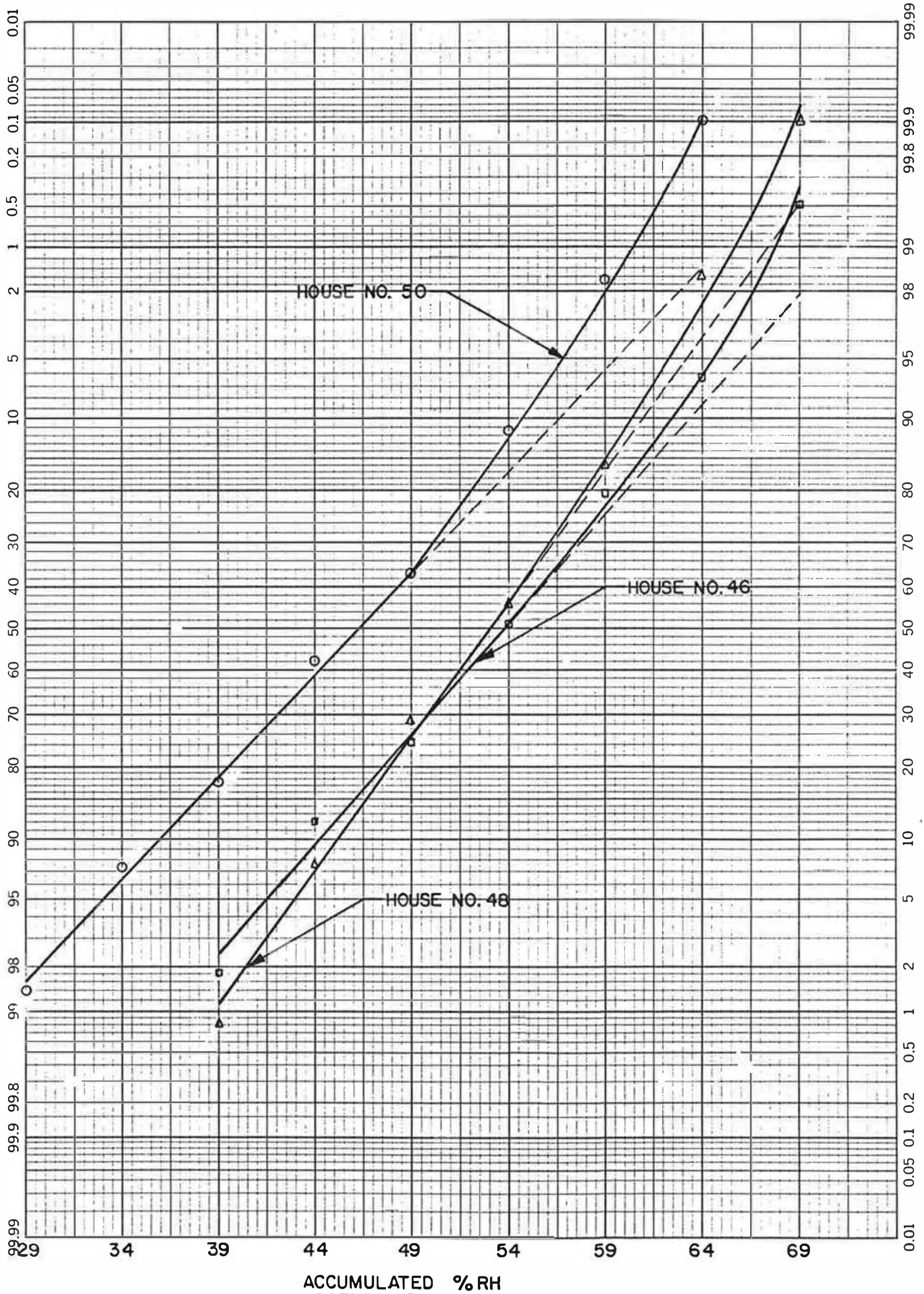
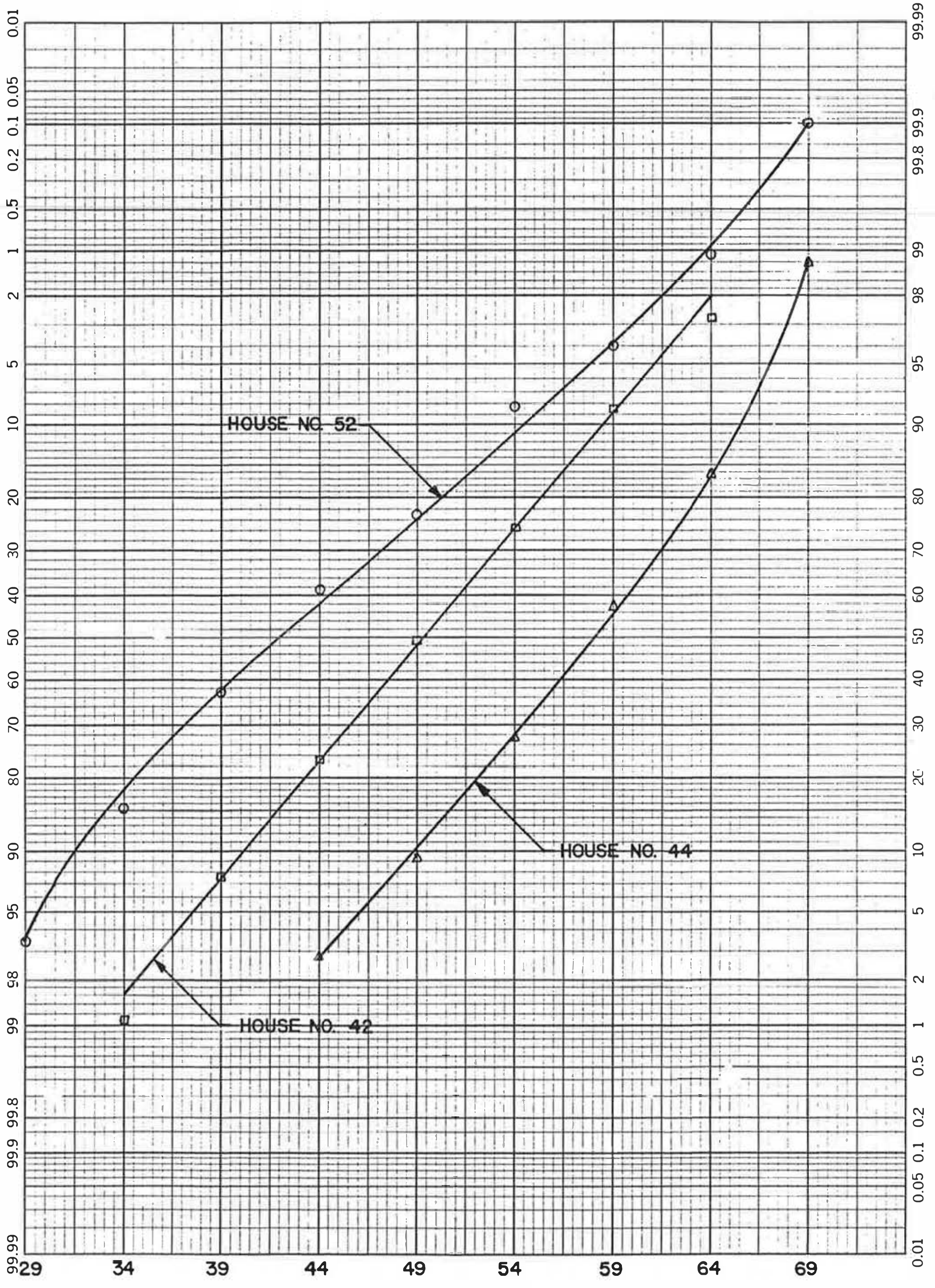


FIGURE NO. 4·3·9 HOUSES WITHOUT FANS




ACCUMULATED % RH
UPSTAIRS — FALL PERIOD

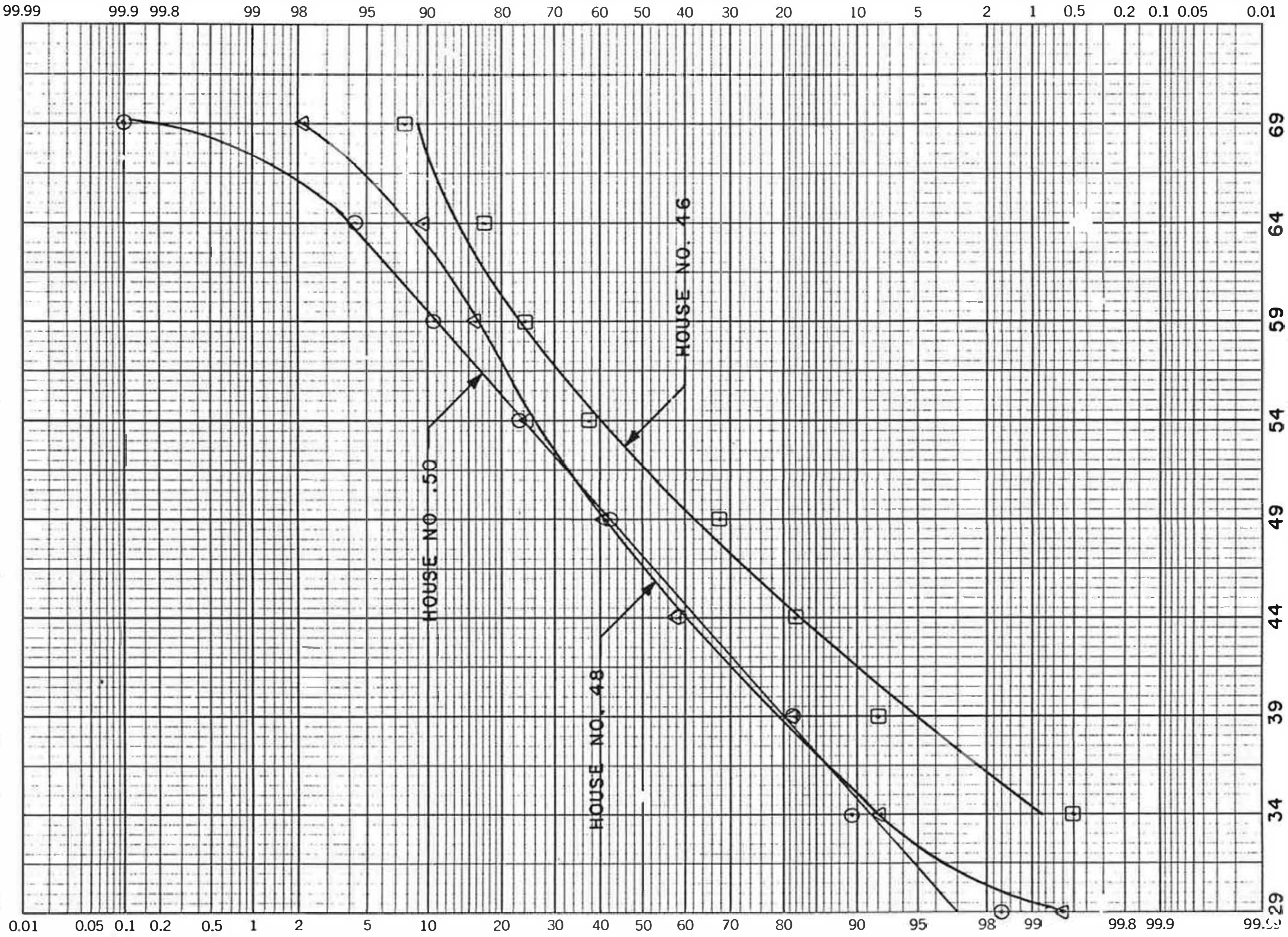
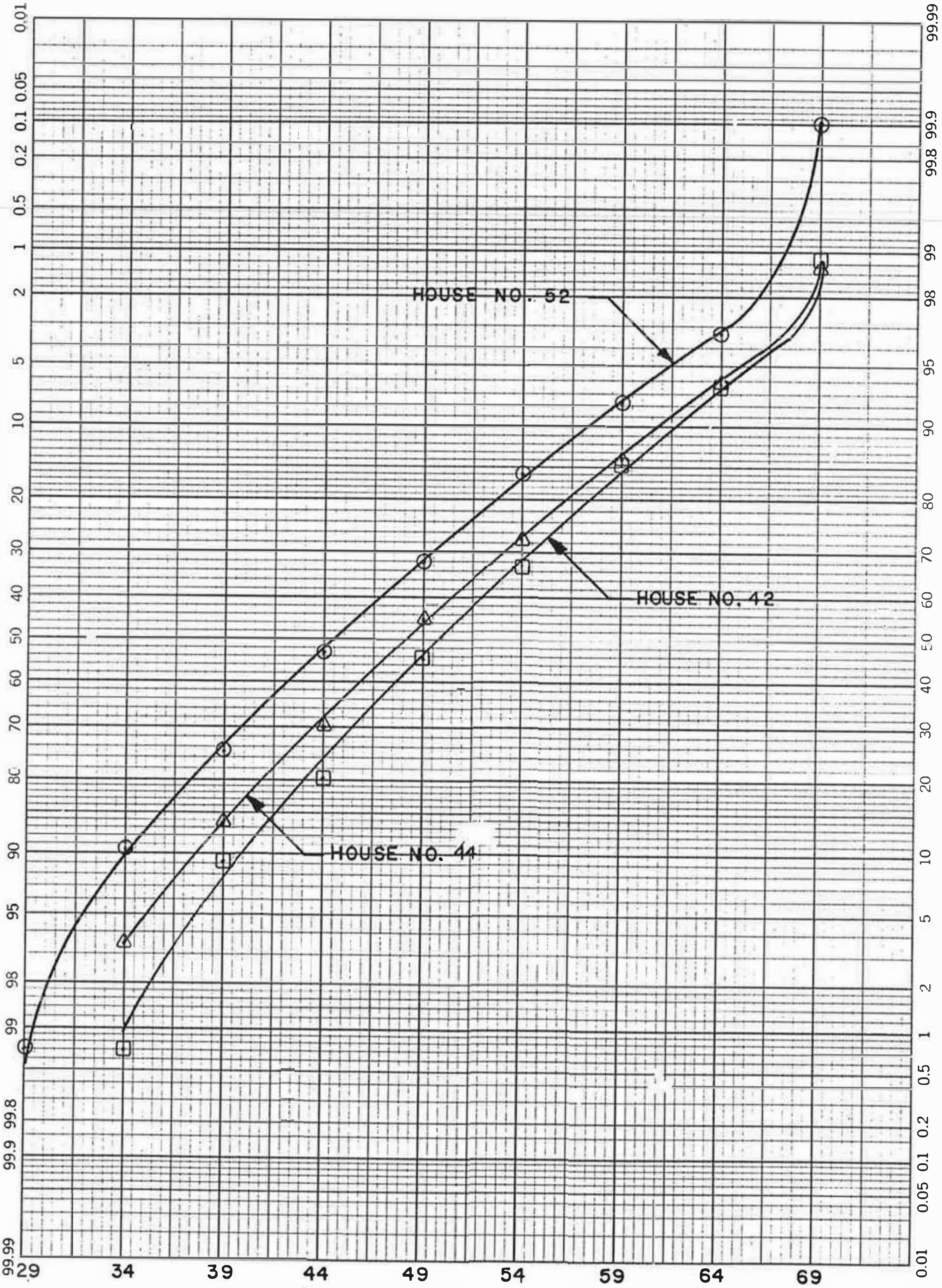



FIGURE NO. 4.3.10 HOUSES WITH FANS- DOWNSTAIRS

FIGURE NO. 4.3.II HOUSES WITHOUT FANS - DOWNSTAIRS



explains the downward curve at low humidity ranges evident in Figures 4.3.10 and 4.3.11.

The frequency distribution of humidities through other periods of the program are included in Appendix C. These are the periods in which fan operation was not particularly significant. During the winter, relative humdities in the houses were generally low and during the summer the controls were left unlocked so that tenants could use the ventilation at will.

The next most obvious question relates to the effectiveness of the different fan configurations in controlling humidity levels. It is interesting to note that, in Figure 4.3.8, the amount that the frequency distribution is skewed off normal by the fans does vary. The highest capacity fan (i.e., unit 50, wall fan) has the greatest apparent skew and the lowest capacity fan (i.e., unit 48, bathroom fan) has the lowest. However, taking into consideration all factors such as runtime, moisture generation values, etc., this is questionable proof of actual effectiveness.

Although it is difficult to rate the effectiveness of the various fans, it is possible to assess the capability of the fans to adequately control moisture generation in the homes under examination. Inadequate drying capability for the moisture genereration rate of the houses would be characterized by three operation characteristics:

- long periods of fan operation,
- fans operating at close to one hundred percent of the time in each hour as opposed to cycling on and off within that time frame,
- even when the fan was operating, the measured humidities would tend to drift upwards.

If none of these characteristics were evident, it could be assumed that the fan configuration was adequate for controlling the moisture generation rates in the houses. If any one or two of these characteristics was evident but not the third, it could be assumed that local effects could be responsible (i.e., difference in the humidity at the humidistat and the sensing location).

In examining the data for the primary fall period, the are very few incidences of this pattern of long periods of operation at high percentage of fan operation time per hour. An example of this in the fan operation output included in Appendix C on October 15, unit 46, from hour 18:00 through 14:00 the next day.

This day, and all other periods with incidences of this pattern, are associated with unseasonably warm temperatures and high outdoor humidity levels (14-17°C, 85-100% R.H.). In these cases, the drying potential of pure ventilation without some form of dehumidification is low. The variety of this pattern indicates that all three fans were of a sufficient capacity to control the peak moisture generation rates occuring in the houses.

## 4.4 Inspection Results

Personnel from Buchan, Lawton, Parent Ltd. visited the site on a quarterly basis to inspect the test units. The prime purpose of the inspections was to document moisture related problems in the houses and to make note of any changes in the occupancy or operation of the houses which could significantly affect the readings or conclusions drawn from the testing program.

The inspection involved a visual survey of the units and the measurement of the structural wood moisture content using a Delmhorst moisture meter. The moisture content was measured at two permanently mounted moisture stations in each unit and at a number of other locations where the moisture content was determined by using extended probes placed through small holes drilled through the drywall.

Three basic categories of moisture problems were found:

- Temporary situations in which the actual condition at the time of the inspection could play a major role in whether they were noticed. This category would include such items as condensation or frosting on windows and condensation on basement walls resulting from a high moisture generating activity such as the laundry and leakage or flooding in the basement. These temporary situations were noted by or reported to the inspection personnel.

- Situations which were evident for a longer time period but could still be expected to vary on a cycle. This would include the moisture content of structural materials and the growth of mould colonies on window frames and moisture trapped in insulation.

- The third type could be considered "fossil" evidence and consisted primarily of damage or noticeable signs of previous moisture problems which may or may not have been evident at the time of inspection. This could include paint damage due to water condensing off windows, staining of walls and ceiling finishes due to mould growth and water staining of building materials.

Before discussing the units individually, it is worth noting a number of common areas of the third category of moisture problems. In all units, it was observed that, on the underside of the floor as viewed from the basement at an area near the rear wall, there was a white efflorescence on the plywood flooring. This was in the area in which the units had originally had sliding glass doors. These doors had been removed a number of years before the test program and it could be speculated that they were the prime source of this fossil artifact. Whether the moisture collection was from condensation or the tracking in of snow during the winter cannot be determined at this stage. Either or both mechanisms are very likely.

During the first site visit, it was observed that in many of the units there was noticeable staining in a restricted area of the walls and ceilings near the wall/ceiling joints at the exterior walls. This is an area where a higher incidence of condensation due to the coolness of the surface would be expected. This evidence was most noticeable in bathrooms where higher peaks in humidity levels would be expected. Subsequent to the initial visit, many of these areas were either cleaned or painted over by the tenants and the problem was much less evident through the winter of 1985/86. There are two factors which could have had an effect in reducing the significance of this evidence:

- In a pre-program inspection carried out in October, 1984, it was noted that the blown-in insulation which had been added to the attics was not distributed evenly. It tended to be heaped in the middle and spread relatively thinly at the outer edges. This was pointed out to the Dartmouth Housing Association personnel. It was explained that, as long as the soffit vents were kept clear, it would be desirable to spread the insulation out to the edges to eliminate cold surfaces and possible condensation around the edges. This was done by DHA personnel prior to the installation site visit and it is very likely that the mechanism creating the condensation along these areas was reduced.

- A number of the homeowners were somewhat perturbed when, in discussions with the monitoring personnel, it was noted that these stains were probably a result of mould growth. This may have contributed to the cleaning of a long term accumulation of mould staining.

With respect to more the variable evidence of moisture problems, the most commonly noted problem was the growth of mould colonies on and around the windows in most units. While there were variations to the volume and "lushness" of these colonies in the particular units and in particular locations in units, it was evident in all units. This mould growth was particularly evident on the elastomer holding the windows into the vinyl window frames, was commonly noted on the vinyl window frames themselves and, to a lesser extent, on the wood sills of the window. During the summer, these mould colonies tended to be dry and flaky and in the winter when there was evidence of condensation on the window panes, they would become healthy and vibrant.

Wood moisture content readings were taken at the locations shown in the site plans included in Appendix A. At most locations, the moisture content levels required for rot (above twenty percent) were not evident. In fact, in most locations, the minimum reading attainable on an instrument, ten percent, was not obtained. In locations where measurable readings of moisture content were obtained, it was directly related to weather conditions. Readable levels were generally associated with wet, rainy conditions outside on the day of or the day previous to measurement. This would indicate that the wood moisture content of the structural walls was primarily related to water or humidity entry through the exterior cladding rather than due to condensation resulting from high levels of interior humidity. Of course, it cannot be assumed that there were no structural moisture problems related to interior humidity condensation effects. This type of problem can be very localized and to actually find it with a moisture probe involves a heavy element of chance.

None of the units showed any sign of moisture damage or collection in the attics which would be the most common area of moisture damage related to internal humidity levels.

There was one area where there was cause for concern. In a number of units, the area at or around the location of the previously existing sliding glass doors had probe measurements which indicated high levels of wood moisture content and damp insulation. The glass doors had been replaced with a wall section containing a window and an exterior surface of painted plywood.

The paint was showing evidence of weathering and chipping. The consultant suspects that the moisture gathering in this area came from outside rather than from inside.

### 4.4.1 Individual Inspection Findings

#### Unit 42

Unit 42 was an end unit and did not have a fan installed. During the day, the unit was empty usually empty since the tenant worked and her children were in school. In the winter of 1984/85, this unit had most of its windows covered with multiple layers of polyethylene that had been taped over the interior frame. This probably accounted for the low incidence of mould growth on the windows. There was some paint chipping which could be attributed to water damage prior to the start of the monitoring program.

In the December/84 visit, it was noted that at the time when the tenant was doing laundry, all three exterior basement concrete walls were "sweating" due to condensation even though the dryer was vented to the outside. During periods when the laundry wasn't being done, this was not evident. In the December site visit, there was also some minor puddling of water on the basement floor which could be attributed to water running off the walls. The tenant also reported that in the past and again in the spring of 1985, there was flooding in the basement due to water leaking in. This was not seen by BLP personnel but had been reported to the Dartmouth Housing Authority.

The unit had a relatively low incidence of moisture related evidence upstairs compared to other units and had a relatively low heating requirement even though it was an end unit. These were probably attributable to the low occupancy levels as much as anything else.

#### Unit 44

Unit 44 was one of four interior units studied under the project. Because it was the only interior unit without a fan, it was the most appropriate control of the three control units. The dryer, which apparently had been obtained just previous to the December/84 site visit, was not vented to the outside until sometime after the June/85 site visit. During the February/85 site visit, condensation was noted on the exterior concrete basement wall in the laundry area when the dryer was operating. Mould growth on the windows in relation to the other units could be considered to be below average but it was still significant.

Unit 46

Unit 46 was the unit in which the Aston whole house fan was installed for the test program. The housekeeping in this unit was, generally, very poor and in the first three site visits, an unpleasant odour was detectable while in the house. During the summer months and during the fall, the Aston fan had a significant level of operation time and, on site visits in September/85 and January/86, it was noted that this problem was significantly reduced.

During the installation visit in December/84, it was noted that Unit 46 had the highest levels of mould growth around windows and some staining attributable to mould was noted in the corners and at exterior wall/ceiling joints. This was particularly obvious for the bathroom, and to a lesser extent, in the bedrooms. The window growth, which was not cleaned during the program, dried up during the summer but re-grew with the moisture from condensation on the window in the winter months. At the time of the December/86 visit, the level of growth was judged to be slightly less than the winter of 1984/85 but not by a dramatic extent.

Much of the unit was finished with wallpaper and there were areas in the basement and in the livingroom where the wallpaper was lifting. An examination and moisture probing of these areas did not give any reason to believe that this was due to moisture. The problem got progressively worse over the program.

Unit 48

A humidistat controlled bathroom fan was installed in Unit 48 for the test program. The tenants of this unit kept the temperature at a relatively high level and there were two adults at home during the day. During the winter months, the tenants sealed most operating windows with masking tape to eliminate drafts and heat loss.

The housekeeping in this unit was very good and, over the course of the program, the tenant repainted most of the house, one or two rooms at a time. During the December/84 site visit, some staining of the bathroom ceiling that could be attributed to mould and the characteristic mould growth on the windows were noted. The accessible portions of these were cleaned during "spring cleaning" and did not recover to the levels noted in the installation visit. In those areas where it was inaccessible (between window panes), the dark mould colonies remained and flourished during the winter.

Unit 50

Unit 50 contained the data acquisition system and was supplied with a humidistat controlled wall fan in the kitchen for the test program. There was some mould growth on windows and minor staining of exterior wall/ceiling joint areas, particularly in the bathroom. The tenant was somewhat taken aback when this was pointed out and cleaned the bathroom ceiling in the evening hours during the installation site visit. The mould on the window sills was kept relatively clean on accessible surfaces but was noticeable throughout the program on inaccessible surfaces.

Unit 52

Unit 52 was an end unit which did not have a fan installed. During the installation site visit, this unit was being fully repainted by the Dartmouth Housing Association. After this, no particular moisture problems were noted aside from the characteristic mould growth on windows which followed the regular pattern of drying and flaking in the summer and re-growing in the winter.

In summary, it could be said that none of the units exhibited moisture problems which would threaten the integrity of the building. By the standards of most Canadians, the mould growth found was certainly not aesthetic and was unusual but by East Coast standards, it was common. The linkage between the control of the exhibited moisture problems and the operation of the humidstat controlled fans was not definitive. The somewhat subjective opinion from the inspection personnel was that the levels of mould growth during the second winter, when fan operation was a factor, was lower than the first winter, but this could be attributed to many factors other than the operation of the fans.

## 4.5 Humidity Samplers

The use of the passive time-averaged humidity samplers in this program, as stated in Section 3.2.5, was primarily as a field evaluation of the technique rather than of direct benefit to the program itself.

On the whole, the performance of 'ıe samplers provided some optimism but also pointed out the need for future development. Most importantly, it was found, in the field program and the corresponding lab trials that were undertaken, that the actual weight gain of the samplers was significantly less than their theoretical weight gain as outlined by Lawrence Berkley Labs. The samplers did, however, show a high degree of consistency and, in most cases, any inconsistencies were attributable to other factors. The indication was that, with appropriate adjustments to the handling and proper emperical calibration, the sensors could provide a good, low-cost method of determining time-averaged exposure to absolute humidity.

A summary of the results of the humidity sampler tests has been included in Appendix D. They indicate that, within the range of temperatures and humidities encountered in this field trial, the weight gain was approximately twenty percent less than that accounted for by theory. This is corrobarated by other trials carried out in Buchan, Lawton, Parent Ltd.'s lab facilities. In order to emperically calibrate the samplers, the firm is undertaking some detailed calibration exercises with the intention of being able to offer the supply and analysis of the samplers as a service for anyone desiring to use the samplers.

## 5.0 EQUIPMENT LIMITATIONS

A Sciemetric 8082 scanner interfaced with an IBM PC formed the basis of the data acquisition system used for the monitoring program. Because the equipment was fairly sophisticated and relatively untried, the program included a significant amount of testing and cross-checking of the data to ensure that the readings taken by the equipment were credible or that the potential sources of error could, at least, be identified.

The data acquisition system proved to be very reliable. One important feature was it's ability to self-boot. After a power failure, the system would re-boot, reference it's internal time clock and continue to acquire data. Except for the period during the power failure, the system would continue to calculate and store the hourly and daily averages. There were situations which could and did "fox" this system. If the power failure was of very short duration or was a "brownout" rather than a "blackout", the system could get "hung up" and would not re-boot. This was a function of the IBM operation. When this happened, the corrective action involved shutting off the system and re-booting it and the monitoring would continue.

During the course of the monitoring program, Buchan, Lawton, Parent Ltd. was fortunate to have a high school student in the house where the system was located who was very interested in computers and their operation. A key to the box in which the data acquisition was stored was provided for him and the system was checked about once a week to make sure there were no problems. In general, the program was remarkably free of data interruptions. There was one occasion where approximately one week of data was lost due to a brownout situation. Taking into consideration the duration of the project, this was a remarkable level of reliability.

Four types of sensors were used with the data acquisition system. Temperatures were taken with thin film RTDs and on no occasion was there reason to suspect the operation of any of the thirteen used. Fan status was monitored by using relays which provided a closed circuit when the fan was operating and an open circuit when it was off. Because there was some concern over the reliability o˘ the relays and status channels, runtime meters were installed on each of the fans to provide a backup and cross-reference. The fan runtime, as measured with the meters and the status monitoring system, were identical.

The two types of humidity sensors used in the monitoring program were another issue. While not specified in the contract, Buchan, Lawton, Parent

Ltd. did install an exterior humidity sensor in the weather station. This sensor, a Vaisala HMP 14U sensor, did not provide reliable readings of outdoor humidities. During wet or below freezing conditions, the output from these sensors was some multiple above the value for 100% RH. In conditions where the sensor was above freezing and would have had a chance to dry out from any moisture that had been drawn into the weather station, the readings were more believable but not to the level that any significant confidence could be put in the data. As far as the analysis of the data in this project was concerned, exterior humidities were taken from AES weather data.

The interior humidities were sensed with Enercorp Humidity Transmitters. The units, which were based on the Philips capacitance-type humidity sensor, were judged at the beginning of the program to be the most appropriate for the project. The cost of the units was well below some of the more sophisticated possibilities and it's specifications and reputation for stability and accuracy seemed entirely appropriate for the project.

Three types of calibration procedures were pre-planned into the program. The humidity sensors were supplied in an aged and calibrated condition by the manufacturer and, at the end of the program, the sensors were re-calibrated and any differences noted. During the program, calibration was checked by taking power psychrometer readings and comparing these to the signal output of the sensors. It was hoped that by following this procedure, the errors in absolute accuracy, comprised of offset and span errors and the instrument's drift characteristics, could be identified and compensated for in the data analysis.

On installation, the output of the sensors was compared with a power psychrometer and it was found that, in general, the sensed humidity levels were significantly less than that registered by the power psychrometer. One sensor, in fact, didn't work (although it had been previously checked in Buchan, Lawton, Parent Ltd.'s office) and was returned to the manufacturer with a request to find the problem, repair it, re-calibrate the sensor and determine the difference in the sensed humidity level. The manufacturer found and repaired a loose wire. Re-calibration determined that there was an offset error of roughly 10% RH. This may be attributable to an error on the part of the technician who did the original calibrations.

The manufacturer undertook that, at the end of the program, he would re-calibrate the sensors free of charge so that the data could be adjusted if necessary.

At each quarterly visit, the sensor outputs were compared with the power psychrometer readings. It was observed that the amount of difference between the sensor output and power psychrometer readings did vary with different site visits. At the time, the portion of this change that was attributable to drift and that which could be attributed to a span error (different error of different humidity levels) could not be determined. At the end of the program all sensors were sent back to the manufacturer for re-calibration. A three point calibration was requested at levels of approximately 25%, 50% and 75% RH. For all but two sensors, the same basic pattern of calibration difference was noted. The calibration difference involved offset and span error with the size of the error being larger at low humidity levels and smaller at high humidity levels. This could be corrected with a correction equation of the form:

$$H_c = x\,H_r + y$$

where:

$H_c$ is the corrected humidity level
$H_r$ is the recorded humidity level
x and y are coefficients taken from a linear approximation of the calibration curve corresponding to the slope and offset difference.

By comparing the corrected data with the power psychrometer readings taken in the same period, some measurable level of confidence in the corrected data could be gained. While remembering that the reading of a power psychrometer has it's own potential error, some significant scatter was found when making this comparison. It was found that the power psychrometer readings at particular sensor location were sometimes consistently lower, sometimes consistently higher and sometimes on both sides of the corrected output of the humidity sensors. This indicated that cyclic drift could, in fact, be a problem, but it was not consistent and, therefore could not be factored into the analysis.

All the data used in this report was based on humidity readings recorded by the data acquisition system and was corrected using the curve determined by the manufacturer's calibration at the end of the program. Based on the intermediate readings, it is felt that the corrected values have a reliability of +/- 6-7% RH. This is roughly double the +/- 3% quoted by the manufacturer. In terms of humidity measurement, this is fairly good but when drawing conclusions from the data it is important to consider this potential error.

Another piece of equipment which caused some problem during the program was the simple household humidistats used to control fan operation. It was well known before entering the program that the absolute accuracy of these instruments was notoriously bad. It was hoped that, by comparing their setpoint to the power psychrometer readings, the humidstats could be set within the reasonable range of 45 to 50% RH desired in the program. Experience during the program indicated that this was possible but that the instruments also had high levels of setpoint drift. To control the fan at a pre-set level required "playing" with the dial setting on a periodic basis. In a situation where the occupant of a house had access to and sufficient knowledge and interest to maintain the level of fan operation at an appropriate level for the outdoor temperature, internal moisture generation rate and such factors, this is perhaps not very significant. For the test program where it was desirable to set and lock the humidstats to operate at a consistent level, this did prove to be a problem. It prompted the decision to increase the frequency of data analysis to a weekly basis during the critical fall period and to phone instructions to local personnel to adjust the humidistats to a level that provided an appropriate level of fan operation for outdoor temperature and interior humidity level.

It is also worth commenting on the potential effects of the location of the humidity sensors and the humidity controllers themselves. The humidity sensors were located in a central location in the basement and the second floor of each unit providing a consistent average humidity for all six units. The humidity controller locations varied. For the Aston whole house fan and the kitchen wall fan (units 46 and 50), the humidstat was located in the main floor hallway, a location chosen to provide an average for the house. The controller for the bathroom fan in unit 48 was placed in the bathroom where it could sense one high moisture generation area before moisture diffused to a more central location. The potential local humidity levels effecting either the sensors or the controller and not the other was recognized and accepted in order to gain consistent sensor locations in all six units.

## 6.0 CONCLUSIONS AND COMMENTS

There are two basic groups of conclusions relating to the monitoring program. The first deals with the effectiveness of humidistat controlled fans in reducing moisture related problems in housing and the second group deals with the mechanisms of the monitoring program itself.

### 6.1 Conclusions

1. The monitored data indicated that dehumidistat controlled exhaust fans could significantly reduce both the peak humidity levels and the time that the house was exposed to high internal humidity levels.

2. All three fan configurations monitored under this program were reasonably effective in accomplishing the above mentioned reductions. There was some indication that the effectiveness of the fans in accomplishing these objectives was related to their exhaust capacity but even the smallest fan was capable of adequately dealing with the moisture generation rate of these particular houses.

3. The lack of reliabililty of the simple household humidity controllers used for this program could have an effect on the value of the fan. The drift characteristics experienced could lead to excessive runtime or inadequate moisture control.

4. The link between the control of peak humidity levels and reduced moisture problems was not clearly established.

5. The moisture content in the structural wood of the houses seemed much more related to external humidity and/or water penetration than internal humidity levels.

6. Any increase in the energy consumption of the unit attributable to the operation of the fans could not be isolated from the regular variance in energy consumption resulting from occupant activities.

## 6.2 Conclusions with Respect to the Monitoring Program

1. The moisture problems in the houses selected for the monitoring program were, to a large extent, surface problems related to mould growth in high condensation areas such as windows and cool areas on interior surfaces. The moisture problems located were not, at that stage, a threat to the building structure itself. This was true even though these units were identified by the local authorities as "moisture troubled houses".

2. From the point of view of aesthetics and practicality, the wall-mounted kitchen fan used in the program was probably less desirable than either the Aston fan or the bathroom fan. The drafts coming through the dual dampers installed in this unit were significant and proved uncomfortable in what was perhaps the most lived-in room in this house.

   The basement mounted Aston fan was quiet and provided a relatively neat installation. In the units tested there was a relatively easy path to run ducts through vertically aligned closets in a central location on the first and second floors. Retrofitting these fans in other houses could prove to be more difficult and costly.

   The bathroom fan originally installed in the program was a Broan 660. This proved to be noisy and it was later replaced with a 60 CFM Nutone unit which provided a much more acceptable noise level. The installation was relatively conventional and easy.

3. With one exception, the data acquisition hardware used in this program provided very reliable service. The exception was the humidity sensors. The difficulties encountered with the calibration of these sensors were significant but well in line with both Buchan, Lawton, Parent Ltd.'s experience and experiences documented by other researchers in measuring humidity levels over the long term.

4. The time-averaged humidity samplers tested in this program proved to be reasonably good indicators of average humidity levels. Their weight gain per concentration hour was less than the theoretical value assumed by the Lawrence Berkley Lab, from which pattern they were adapted, but their consistency indicates that, with proper emperical calibration, they could be a very useful tool for projects dealing with long-term humidity levels.

## 6.3 Comments

The results of this project lead to some comments that are very important in dealing with the subject of moisture troubled houses in the Maritime environment.

1. The results suggest that in most cases, structural moisture damage to houses, as is reasonably common in a number of Maritime environments, is probably less related to internal humidity levels than it is to moisture transfer into wall and ceiling areas from outside the building envelope. There are, certainly, problems created by high internal moisture levels but many of these are surface problems and do not necessarily result in building threatening damage. This is not to say that high internal moisture levels cannot create major problems but that ventilation systems should not be considered a global solution to the problems of "moisture troubled houses in the Maritime climate".

2. While none of the six units covered in this study had major moisture problems, there are houses in other locations, in fact, in the same housing project, which do have relatively major problems caused by high interior humidity levels. In these houses the installation of a humidity controlled ventilation system should have a positive benefit.

3. The use of exhaust-only systems, such as those studied in this project, is appropriate in houses which have envelopes which are leaky enough that the potential of causing high negative pressures in the house is minimal. In "tight houses", the higher negative pressures from an exhaust-only system could increase the potential for backdrafting of combustion appliances and, in areas of high radon concentrations in soil gas, result in increased interior levels of radon gas.

4. In the houses under study in this project, even the simplest and cheapest installation (humidistat controlled bathroom fan) was capable of limiting high humidity levels in the houses under study. None of the houses appeared to have excessive moisture generation rates. The results did indicate, if not prove conclusively, the seemingly obvious concept that higher capacity fans were more effective in reducing humidity than lower capacity fans.

5. Part 9 of the National Building Code now incorporates a requirement that each dwelling unit be provided with a mechanical ventilation system capable of providing a capacity of one-half air changes per hour either on manual or automatic controls. This requirement has not been incorporated into provincial building codes as of yet. A ventilation system of this capacity would have been more than adequate to handle the humidity generation rates of all houses covered in this test program.

6. The humidity controllers used in the program (two Honeywell H46C1000 and the one supplied with the Aston fan) proved to be very inaccurate and displayed significant setpoint drift. This probably would not create a major problem with a knowledgable resident who periodically checked to see that the fan system was operating when there was evidence of high interior humidities (i.e., condensation on windows) but could decrease the effectiveness of ventilation for humidity control with a resident who was less than knowledgable. Ideally, the fans should be controlled by a humidity controller which took into account outdoor temperature or absolute humidity as well as indoor humidity and did so with a reliablility that allowed setting the control once and leaving it in that position. The development of a low cost device to accomplish this would be a well worthwhile endeavor.

# APPENDIX A

## House Floor Plans and Sensor Locations

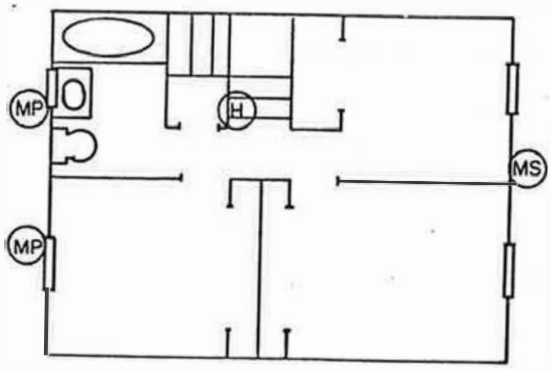
Legend

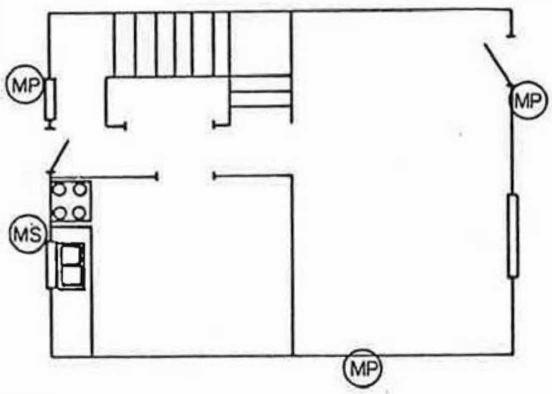
(H) - Temperature/Humidity Transmitter

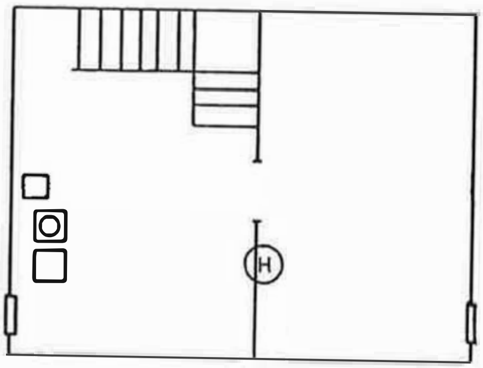
(MS) - Moisture Station

(MP) - Moisture Probe Location

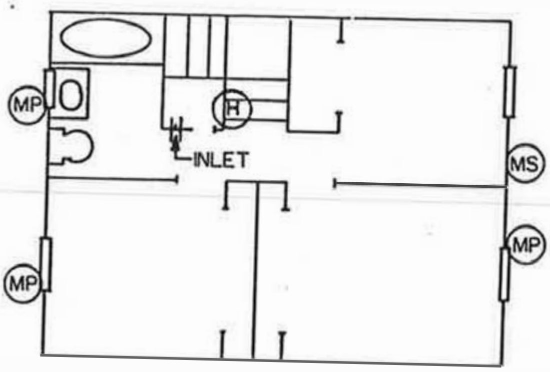
UNIT 42 / CONTROL

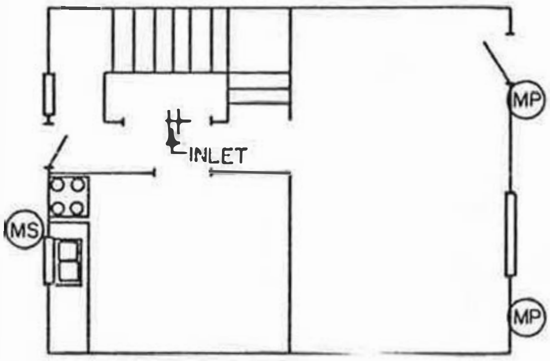


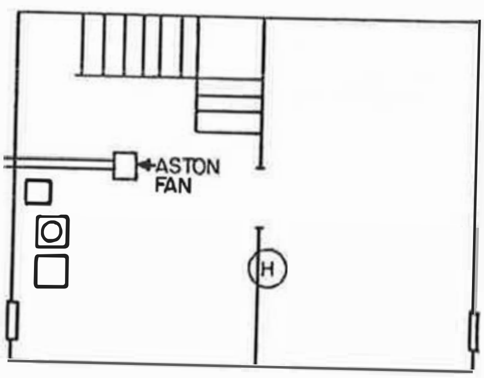



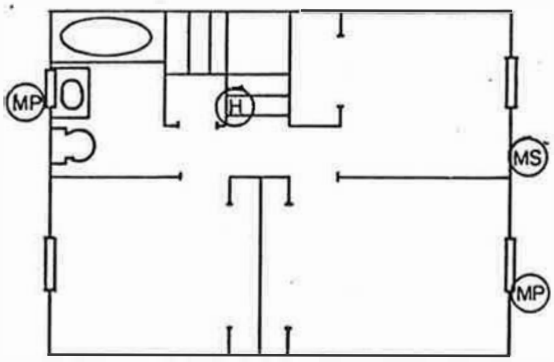
# UNIT 46 / ASTON

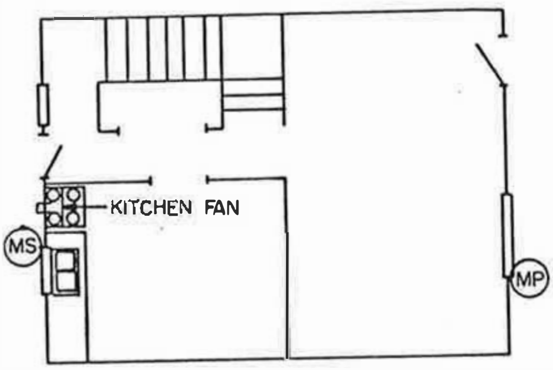


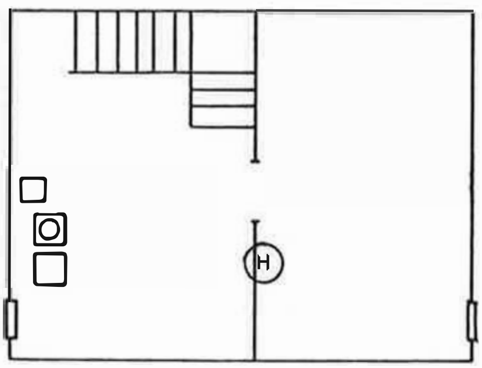



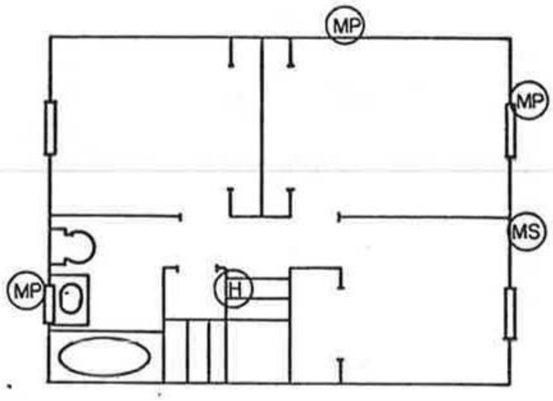
# UNIT 50 / KITCHEN FAN

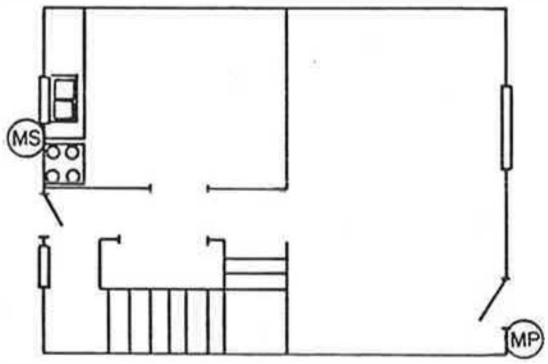


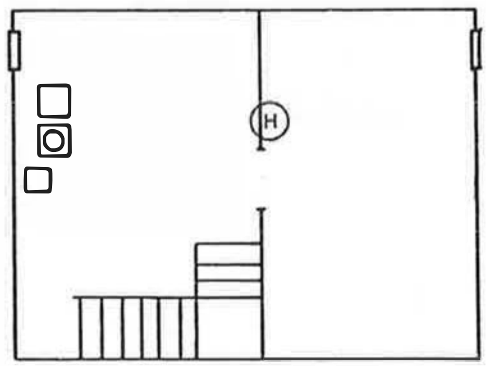



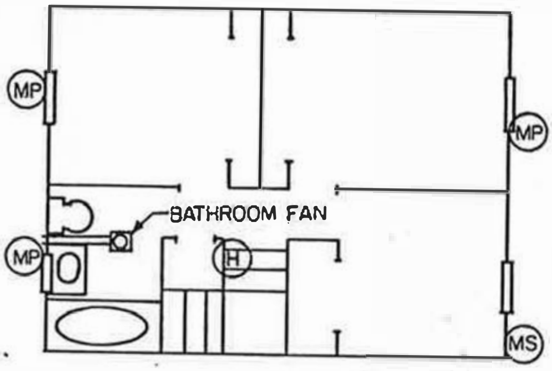
## UNIT 52 / CONTROL

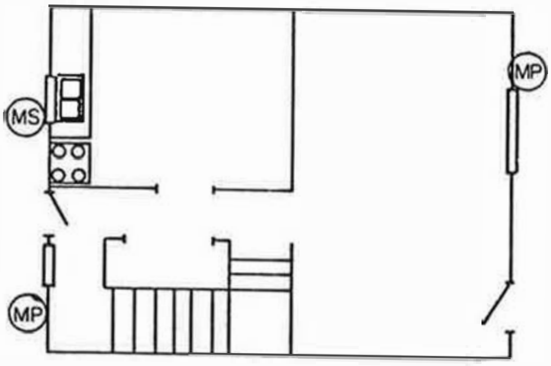


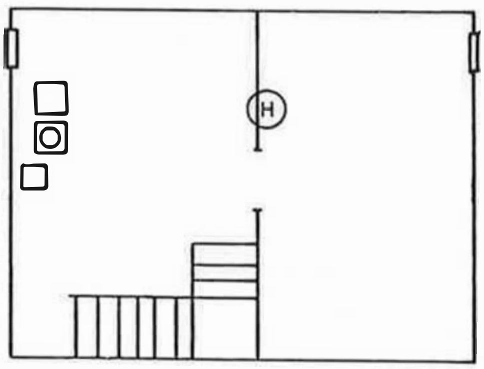



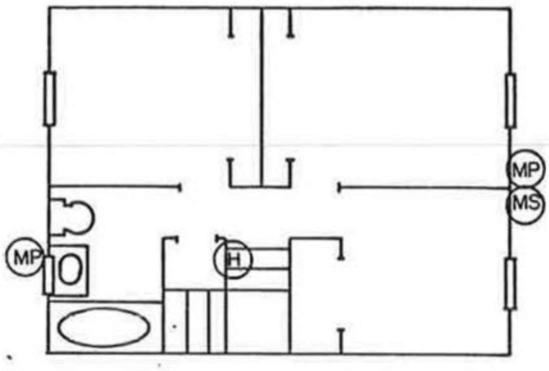
# UNIT 48 / BATHROOM FAN

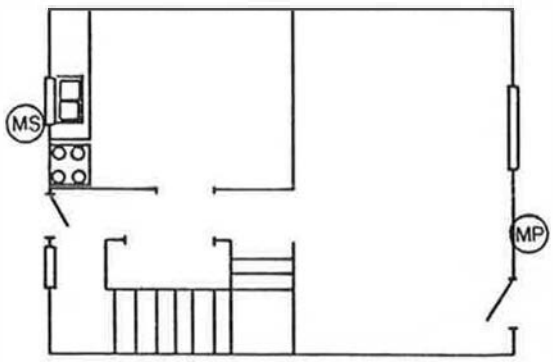


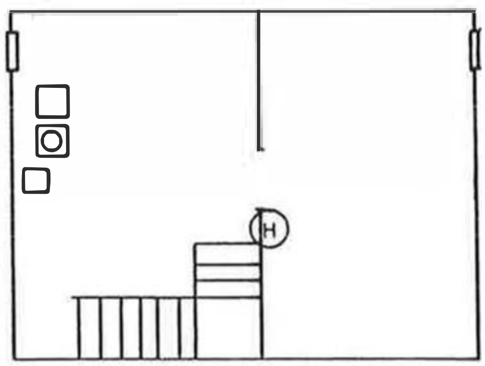



# UNIT 44 / CONTROL



## APPENDIX B ELECTRICAL AND WATER CONSPUMPTION

| Monitoring Period | Electrical Consumption (KWh/day) | | | | | | Water Consumption (l/day) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 42 | 44 | 46 | 48 | 50 | 52 | 42 | 44 | 46 | 48 | 50 | 52 |
| Dec. 9-Jan. 8/85 | 21.2 | 38.6 | 39.9 | 27.6 | 33.2 | 41.6 | 44.5 | 84.9 | 70.4 | 56.7 | 94.9 | 59.9 |
| Jan. 8-Feb. 1/85 | 26.5 | 33.4 | 39.9 | 30.2 | 45.4 | 45.2 | 43.6 | 63.6 | 59.9 | 71.7 | 101.2 | 55.4 |
| Feb. 1-Feb. 22/85 | 15.8 | 30.5 | 32.8 | 29.1 | 38.6 | 35.4 | 40.9 | 67.6 | 71.3 | 59.9 | 107.1 | 54.0 |
| Feb. 22-Mar. 10/85 | | 39.7 | 41.5 | 30.1 | 46.8 | 38.7 | 55.8 | 74.0 | 74.9 | 69.9 | 95.8 | 44.9 |
| Mar. 10-Apr. 9/85 | 21.7 | 31.0 | 23.2 | 29.6 | 30.7 | 37.2 | 51.3 | 63.6 | 74.4 | 64.0 | 93.1 | 56.7 |
| Apr. 9-Mar. 15/85 | 18.2 | 31.2 | 37.9 | 28.4 | 29.2 | 37.8 | 49.0 | 72.2 | 75.8 | 66.3 | - | 57.2 |
| Mar. 15-June 12/85 | 16.1 | 27.6 | 34.1 | 26.5 | 34.1 | 32.7 | 43.1 | 69.5 | 76.7 | 63.1 | 84.9 | 73.5 |
| June 12-July 17/85 | 16.4 | 29.1 | 35.8 | 28.3 | 28.2 | 33.5 | 45.8 | 77.6 | 80.3 | 74.4 | 76.7 | 65.8 |
| July 17-Aug. 22/85 | 15 | 31.3 | 29.6 | 22.9 | 22.5 | 31.3 | 49.0 | 03.5 | 62.6 | 76.3 | 68.5 | 71.2 |
| Aug. 22-Sept 17/85 | 13.5 | 34.2 | 30.8 | 24.0 | 32.6 | 30.7 | 39.0 | 98.' | 86.3 | 64.0 | 62.6 | 54.9 |
| Sept 17-Oct. 15/85 | 15.1 | 32.1 | 35.8 | 23.9 | 31.5 | 30.5 | 39.5 | 78.1 | 76.3 | 57.2 | 90.3 | 47.6 |
| Oct. 15-Nov. 19/85 | 16.6 | 32.1 | 34.5 | 28.9 | 36.1 | - | 39.0 | 77.6 | 73.1 | 65.4 | 93.1 | 51.7 |
| Nov. 19-Dec. 16/85 | 17.8 | 38.3 | 39.6 | 32.7 | 34.6 | - | 38.3 | 84.0 | 71.3 | 59.5 | 98.5 | 88.1 |
| Dec. 16-Jan. 16/86 | 20.7 | 40.0 | 37.9 | 29.2 | 33.2 | - | 48.6 | 83.1 | 69.9 | 61.3 | 97.6 | 48.6 |

# APPENDIX C

## Sample Outputs from Data Analysis Programs

Table 1 Weekly Averages

Month: OCT/3

| | Week 1 Day 1- 7 | Week 2 Day 8- 8 |
|---|---|---|
| **House 50** | | |
| Up RH | 47.71 | 41.09 |
| Up temp | 24.40 | 22.90 |
| Down RH | 51.97 | 41.11 |
| Down Temp | 22.52 | 21.40 |
| Fan Rtm | 2.3 | 0.0 |
| **House 48** | | |
| Up RH | 55.45 | 51.35 |
| Up temp | 24.39 | 24.00 |
| Down RH | 53.11 | 41.25 |
| Down Temp | 22.56 | 24.00 |
| Fan Rtm | 2.5 | 0.0 |
| **House 46** | | |
| Up RH | 55.14 | 48.24 |
| Up temp | 23.54 | 23.40 |
| Down RH | 54.92 | 46.56 |
| Down Temp | 22.15 | 22.70 |
| Fan Rtm | 21.5 | 0.0 |
| **House 52** | | |
| Up RH | 44.84 | 39.74 |
| Up temp | 23.81 | 22.60 |
| Down RH | 48.99 | 40.40 |
| Down Temp | 22.69 | 22.90 |
| **House 44** | | |
| Up RH | 60.79 | 54.01 |
| Up temp | 21.79 | 21.50 |
| Down RH | 52.91 | 44.33 |
| Down Temp | 19.87 | 19.10 |
| **House 42** | | |
| Up RH | 51.29 | 46.71 |
| Up temp | 21.27 | 20.90 |
| Down RH | 54.68 | 46.84 |
| Down Temp | 20.94 | 20.10 |
| | | |
| Amb Temp | 8.46 | 2.40 |
| Amb RH | 0.00 | 0.00 |

Table 2a RH Histogram (total counts)

Month OCT/3
Start day 15OCT85
End day 22OCT85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| Up RH | 0 | 1 | 22 | 48 | 32 | 41 | 18 | 5 | 0 | 0 |
| Down RH | 0 | 0 | 4 | 43 | 36 | 20 | 27 | 37 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.5 | 0.3 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 2.61 | 5.20 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 1 | 12 | 58 | 77 | 19 | 0 | 0 |
| Down RH | 0 | 0 | 1 | 24 | 47 | 45 | 15 | 17 | 18 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.6 | 1.2 | 0.5 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.58 | 1.00 | 1.58 | 2.74 | 0.00 | 0.00 |
| **House 46** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 7 | 23 | 48 | 60 | 27 | 2 | 0 |
| Down RH | 0 | 0 | 0 | 2 | 37 | 56 | 41 | 31 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | 12.4 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.22 | 45.85 | 0.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| Up RH | 0 | 13 | 40 | 50 | 24 | 23 | 10 | 7 | 0 | 0 |
| Down RH | 0 | 0 | 19 | 38 | 42 | 37 | 30 | 1 | 0 | 0 |
| **House 44** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 0 | 1 | 34 | 54 | 38 | 31 | 9 |
| Down RH | 0 | 0 | 0 | 12 | 60 | 41 | 27 | 20 | 7 | 0 |
| **House 42** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 16 | 73 | 32 | 32 | 13 | 1 | 0 |
| Down RH | 0 | 0 | 0 | 2 | 54 | 32 | 45 | 29 | 2 | 3 |

Table 2b RH Histogram (% counts)

Month OCT/3
Start day 15OCT85
End day 22OCT85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10… |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| % Up RH | 0.0 | 0.6 | 13.2 | 28.7 | 19.2 | 24.6 | 10.8 | 3.0 | 0.0 | 0.0 |
| % Down RH | 0.0 | 0.0 | 2.4 | 25.7 | 21.6 | 12.0 | 16.2 | 22.2 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.5 | 0.3 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 2.61 | 5.20 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.6 | 7.2 | 34.7 | 46.1 | 11.4 | 0.0 | 0.0 |
| % Down RH | 0.0 | 0.0 | 0.6 | 14.4 | 28.1 | 26.9 | 9.0 | 10.2 | 10.3 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.6 | 1.2 | 0.5 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.58 | 1.00 | 1.58 | 2.74 | 0.00 | 0.00 |
| **House 46** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 4.2 | 13.8 | 28.7 | 35.9 | 16.2 | 1.2 | 0.0 |
| % Down RH | 0.0 | 0.0 | 0.0 | 1.2 | 22.2 | 33.5 | 24.6 | 18.6 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | 12.4 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.22 | 45.85 | 0.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| % Up RH | 0.0 | 7.8 | 24.0 | 29.9 | 14.4 | 13.8 | 6.0 | 4.2 | 0.0 | 0.0 |
| % Down RH | 0.0 | 0.0 | 11.4 | 22.8 | 25.1 | 22.2 | 18.0 | 0.6 | 0.0 | 0.0 |
| **House 44** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 20.4 | 32.3 | 22.8 | 18.6 | 5.4 |
| % Down RH | 0.0 | 0.0 | 0.0 | 7.2 | 35.9 | 24.6 | 16.2 | 12.0 | 4.2 | 0.0 |
| **House 42** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 9.6 | 43.7 | 19.2 | 19.2 | 7.8 | 0.6 | 0.0 |
| % Down RH | 0.0 | 0.0 | 0.0 | 1.2 | 32.3 | 19.2 | 26.9 | 17.4 | 1.2 | 1.8 |

Fan Runtime Schedule
Month: OCT/3
House 50

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 15 | 15 | 21:00 | 22:00 | 0.23 | 0.8 | 53.65 | 54.11 |
| 16 | 16 | 4:00 | 4:00 | 0.11 | 0.0 | 59.57 | 59.57 |
| 16 | 16 | 6:00 | 7:00 | 0.23 | 4.6 | 59.57 | 62.30 |
| 16 | 16 | 9:00 | 10:00 | 0.39 | -9.6 | 61.39 | 55.47 |
| 19 | 19 | 14:00 | 18:00 | 0.76 | 1.7 | 52.20 | 53.20 |
| 19 | 20 | 23:00 | 1:00 | 0.57 | 5.3 | 51.83 | 54.56 |

Fan Runtime Schedule
Month: OCT/3
House 48

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 15 | 15 | 18:00 | 19:00 | 0.98 | 2.2 | 60.34 | 61.68 |
| 16 | 16 | 18:00 | 19:00 | 0.22 | 9.1 | 48.77 | 53.22 |
| 17 | 17 | 14:00 | 14:00 | 0.13 | -2.4 | 56.34 | 55.00 |
| 17 | 17 | 18:00 | 18:00 | 0.29 | 1.7 | 52.78 | 53.67 |
| 18 | 18 | 18:00 | 18:00 | 0.30 | -7.6 | 58.56 | 54.11 |
| 20 | 20 | 17:00 | 18:00 | 0.33 | -2.3 | 57.23 | 55.89 |
| 21 | 21 | 18:00 | 19:00 | 0.26 | -2.5 | 53.22 | 51.89 |

Fan Runtime Schedule

Month: OCT/3

House 46

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 15 | 16 | 18:00 | 14:00 | 16.24 | -11.2 | 66.66 | 59.22 |
| 16 | 16 | 18:00 | 20:00 | 1.86 | -3.1 | 59.22 | 57.36 |
| 18 | 18 | 18:00 | 18:00 | 0.26 | 6.8 | 54.57 | 58.29 |
| 19 | 19 | 9:00 | 13:00 | 1.47 | 6.6 | 55.96 | 59.68 |
| 19 | 19 | 15:00 | 21:00 | 1.68 | -5.4 | 60.15 | 56.89 |

Fan Runtime Schedule
Month: OCT/3
House 50

First day is 15

| | Before | | | After |
|---|---|---|---|---|
| Hr | 20:00 | 21:00 | 22:00 | 23:00 |
| RunT | 0.00 | 0.12 | 0.11 | 0.00 |
| RHup | 53.7 | 53.7 | 53.7 | 53.7 |
| RHdn | 58.2 | 60.0 | 60.9 | 60.9 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 16

| | Before | | After |
|---|---|---|---|
| Hr | 3:00 | 4:00 | 5:00 |
| RunT | 0.00 | 0.11 | 0.00 |
| RHup | 60.0 | 59.1 | 60.0 |
| RHdn | 62.7 | 63.6 | 63.6 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 16

| | Before | | | After |
|---|---|---|---|---|
| Hr | 5:00 | 6:00 | 7:00 | 8:00 |
| RunT | 0.00 | 0.09 | 0.14 | 0.00 |
| RHup | 60.0 | 59.1 | 60.0 | 62.8 |
| RHdn | 63.6 | 63.6 | 63.6 | 63.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 16

| | Before | | | After |
|---|---|---|---|---|
| Hr | 8:00 | 9:00 | 10:00 | 11:00 |
| RunT | 0.00 | 0.12 | 0.27 | 0.00 |
| RHup | 62.8 | 61.8 | 59.1 | 56.4 |
| RHdn | 63.6 | 63.6 | 63.6 | 62.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 19

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.04 | 0.15 | 0.17 | 0.19 | 0.21 | 0.00 |
| RHup | 53.7 | 54.6 | 51.8 | 52.7 | 52.7 | 52.7 | 53.7 |
| RHdn | 60.9 | 60.0 | 61.8 | 60.9 | 60.9 | 60.0 | 57.3 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 19

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 |
| RunT | 0.00 | 0.17 | 0.18 | 0.22 | 0.00 |
| RHup | 51.8 | 50.9 | 50.0 | 51.8 | 53.7 |
| RHdn | 60.0 | 60.0 | 60.0 | 59.1 | 59.1 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule
Month: OCT/3
House 48

First day is 15

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.46 | 0.52 | 0.00 |
| RHup | 61.2 | 59.5 | 60.3 | 62.1 |
| RHdn | 61.1 | 62.0 | 62.0 | 63.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 16

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.11 | 0.11 | 0.00 |
| RHup | 47.0 | 49.7 | 51.4 | 52.3 |
| RHdn | 63.0 | 63.0 | 63.9 | 63.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | After |
|---|---|---|---|
| Hr | 13:00 | 14:00 | 15:00 |
| RunT | 0.00 | 0.13 | 0.00 |
| RHup | 56.8 | 55.9 | 55.9 |
| RHdn | 55.6 | 54.7 | 54.7 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.29 | 0.00 |
| RHup | 51.4 | 50.6 | 52.3 |
| RHdn | 53.8 | 52.8 | 52.8 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 18

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.30 | 0.00 |
| RHup | 58.6 | 55.9 | 54.1 |
| RHdn | 47.3 | 48.2 | 48.2 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 20

| | Before | | | After |
|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.06 | 0.27 | 0.00 |
| RHup | 57.7 | 56.8 | 57.7 | 55.9 |
| RHdn | 46.4 | 47.3 | 47.3 | 44.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 21

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.08 | 0.18 | 0.00 |
| RHup | 51.4 | 49.7 | 53.2 | 52.3 |
| RHdn | 46.4 | 45.5 | 45.5 | 45.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule
Month: OCT/3
House 46

First day is 15

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | |
| RunT | 0.00 | 0.90 | 0.96 | 0.69 | 0.87 | 0.90 | 1.00 | 0.78 | 0.72 | 0.65 | 0.67 | |
| RHup | 69.9 | 62.5 | 61.5 | 61.5 | 60.6 | 60.6 | 59.7 | 59.7 | 60.6 | 60.6 | 60.6 | |
| RHdn | 58.4 | 60.2 | 60.2 | 60.2 | 60.2 | 61.1 | 61.1 | 62.0 | 62.0 | 62.0 | 62.0 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | | 4:00 | 5:00 | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | |
| RunT | | 0.68 | 0.69 | 0.66 | 0.72 | 0.90 | 0.85 | 0.62 | 0.79 | 1.00 | 1.00 | |
| RHup | | 60.6 | 59.7 | 59.7 | 61.5 | 60.6 | 59.7 | 59.7 | 59.7 | 60.6 | 59.7 | |
| RHdn | | 62.0 | 62.0 | 62.0 | 62.9 | 62.9 | 62.9 | 62.9 | 62.9 | 62.9 | 62.9 | |
| RHam | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | After |
|---|---|---|---|
| Hr | | 14:00 | 15:00 |
| RunT | | 0.19 | 0.00 |
| RHup | | 61.5 | 59.7 |
| RHdn | | 63.9 | 63.9 |
| RHam | | 100.0 | 100.0 |

First day is 16

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.82 | 1.00 | 0.04 | 0.00 |
| RHup | 59.7 | 59.7 | 59.7 | 56.9 | 56.9 |
| RHdn | 62.9 | 62.9 | 62.9 | 62.9 | 62.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 18

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.26 | 0.00 |
| RHup | 56.9 | 61.5 | 59.7 |
| RHdn | 52.9 | 52.0 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 19

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 |
| RunT | 0.00 | 0.19 | 0.34 | 0.15 | 0.48 | 0.31 | 0.00 |
| RHup | 56.0 | 57.8 | 56.9 | 62.5 | 61.5 | 60.6 | 59.7 |
| RHdn | 55.7 | 56.6 | 56.6 | 54.7 | 55.7 | 56.6 | 57.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

. First day is 19

| | Before | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|
| Hr | 14:00 | 15:0● | 16:00 | 17:00 | 18:00 | 19:00 | 20:●● | 21:00 | 22:00 |
| RunT | 0.00 | 0.22 | 0.14 | ●.24 | 0.16 | 0.28 | 0.51 | 0.13 | 0.00 |
| RHup | 59.7 | 59.7 | 61.5 | 60.6 | 60.6 | 61.5 | 61.5 | 58.8 | 56.9 |
| RHdn | 57.5 | 55.7 | 55.7 | 56.6 | 57.5 | 57.5 | 58.4 | 58.4 | 58.4 |
| RHam | 100.0 | 100.0 | 100.● | 100.● | 100.● | 100.● | 1●●.● | 1●●.● | 100.0 |

Table 1 Weekly Averages

Month: OCT/4

| | Week 1 Day 1- 7 | Week 2 Day 8- 8 |
|---|---|---|
| **House 50** | | |
| Up RH | 47.78 | 39.61 |
| Up temp | 24.11 | 20.29 |
| Down RH | 49.20 | 39.44 |
| Down Temp | 21.98 | 19.43 |
| Fan Rtm | 9.3 | 0.0 |
| **House 48** | | |
| Up RH | 54.45 | 49.41 |
| Up temp | 24.31 | 24.00 |
| Down RH | 48.71 | 38.12 |
| Down Temp | 22.70 | 25.29 |
| Fan Rtm | 3.4 | 0.0 |
| **House 46** | | |
| Up RH | 53.45 | 44.27 |
| Up temp | 23.37 | 22.86 |
| Down RH | 51.12 | 43.70 |
| Down Temp | 21.86 | 23.86 |
| Fan Rtm | 2.0 | 0.0 |
| **House 52** | | |
| Up RH | 43.67 | 35.44 |
| Up temp | 23.53 | 22.00 |
| Down RH | 45.91 | 33.11 |
| Down Temp | 22.61 | 24.00 |
| **House 44** | | |
| Up RH | 62.17 | 58.70 |
| Up temp | 21.63 | 20.29 |
| Down RH | 50.85 | 40.30 |
| Down Temp | 19.63 | 19.00 |
| **House 42** | | |
| Up RH | 50.52 | 39.25 |
| Up temp | 20.69 | 20.43 |
| Down RH | 50.62 | 43.48 |
| Down Temp | 20.08 | 20.86 |
| | | |
| Amb Temp | 8.35 | 0.14 |
| Amb RH | 0.00 | 0.00 |

Table 2a                    RH Histogram (total counts)

Month      OCT/4
Start day  22OCT85
End day    29OCT85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-100 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| Up RH | 0 | 0 | 8 | 40 | 58 | 55 | 2 | 2 | 0 | 0 |
| Down RH | 0 | 0 | 5 | 26 | 68 | 52 | 14 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 7.3 | 0.0 | 1.9 | 0.0 | 0.2 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 18.28 | 0.00 | 3.40 | 0.00 | 8.00 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| Up RH | 0 | 0 | 2 | 4 | 28 | 73 | 24 | 28 | 4 | 2 |
| Down RH | 0 | 0 | 8 | 38 | 46 | 59 | 14 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.8 | 1.2 | 0.7 | 0.3 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.54 | 1.14 | 4.79 | 2.39 | 7.75 | 0.00 |
| **House 46** | | | | | | | | | | |
| Up RH | 0 | 0 | 2 | 5 | 36 | 64 | 40 | 17 | 1 | 0 |
| Down RH | 0 | 0 | 0 | 7 | 46 | 99 | 13 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.5 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | 8.53 | 7.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| Up RH | 3 | 7 | 28 | 74 | 33 | 15 | 3 | 2 | 0 | 0 |
| Down RH | 0 | 7 | 10 | 41 | 92 | 15 | 0 | 0 | 0 | 0 |
| **House 44** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 0 | 0 | 6 | 33 | 95 | 26 | 5 |
| Down RH | 0 | 0 | 0 | 10 | 77 | 56 | 22 | 0 | 0 | 0 |
| **House 42** | | | | | | | | | | |
| Up RH | 0 | 0 | 5 | 6 | 61 | 78 | 9 | 6 | 0 | 0 |
| Down RH | 0 | 0 | 0 | 10 | 68 | 74 | 13 | 0 | 0 | 0 |

Table 2b RH Histogram (% counts)

Month OCT/4
Start day 22OCT85
End day 29OCT85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 4.8 | 24.2 | 35.2 | 33.3 | 1.2 | 1.2 | 0.0 | 0. |
| % Down RH | 0.0 | 0.0 | 3.0 | 15.8 | 41.2 | 31.5 | 8.5 | 0.0 | 0.0 | 0. |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 7.3 | 0.0 | 1.9 | 0.0 | 0.2 | 0.0 | 0. |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 18.28 | 0.00 | 3.40 | 0.00 | 8.00 | 0.00 | 0.0 |
| **House 48** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 1.2 | 2.4 | 17.0 | 44.2 | 14.5 | 17.0 | 2.4 | 1. |
| % Down RH | 0.0 | 0.0 | 4.8 | 23.0 | 27.9 | 35.8 | 8.5 | 0.0 | 0.0 | 0. |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.8 | 1.2 | 0.7 | 0.3 | 0. |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.54 | 1.14 | 4.79 | 2.39 | 7.75 | 0.0 |
| **House 46** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 1.2 | 3.0 | 21.8 | 38.8 | 24.2 | 10.3 | 0.6 | 0. |
| % Down RH | 0.0 | 0.0 | 0.0 | 4.2 | 27.9 | 60.0 | 7.9 | 0.0 | 0.0 | 0. |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.5 | 0.0 | 0. |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | 8.53 | 7.00 | 0.0 |
| **House 52** | | | | | | | | | | |
| % Up RH | 1.8 | 4.2 | 17.0 | 44.8 | 20.0 | 9.1 | 1.8 | 1.2 | 0.0 | 0. |
| % Down RH | 0.0 | 4.2 | 6.1 | 24.8 | 55.8 | 9.1 | 0.0 | 0.0 | 0.0 | 0. |
| **House 44** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 | 20.0 | 57.6 | 15.8 | 3 |
| % Down RH | 0.0 | 0.0 | 0.0 | 6.1 | 46.7 | 33.9 | 13.3 | 0.0 | 0.0 | 0 |
| **House 42** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 3.0 | 3.6 | 37.0 | 47.3 | 5.5 | 3.6 | 0.0 | 0 |
| % Down RH | 0.0 | 0.0 | 0.0 | 6.1 | 41.2 | 44.8 | 7.9 | 0.0 | 0.0 | 0 |

Fan Runtime Schedule

Month: OCT/4

House 50

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 22 | 22 | 15:00 | 22:00 | 7.31 | 0.0 | 42.28 | 42.28 |
| 25 | 25 | 17:00 | 21:00 | 1.64 | -18.0 | 58.20 | 47.74 |
| 26 | 26 | 15:00 | 16:00 | 0.22 | 11.7 | 42.73 | 47.74 |
| 27 | 27 | 18:00 | 18:00 | 0.17 | -1.8 | 51.83 | 50.92 |

Fan Runtime Schedule

Month: OCT/4

House 48

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 22 | 22 | 17:00 | 18:00 | 0.46 | 9.1 | 48.77 | 53.22 |
| 23 | 23 | 17:00 | 17:00 | 0.43 | 3.7 | 47.88 | 49.66 |
| 23 | 23 | 19:00 | 19:00 | 0.37 | 9.2 | 48.32 | 52.78 |
| 25 | 25 | 18:00 | 19:00 | 0.94 | -9.5 | 70.13 | 63.46 |
| 27 | 27 | 18:00 | 20:00 | 1.19 | 7.8 | 56.78 | 61.23 |

Fan Runtime Schedule
Month: OCT/4
House 46

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 24 | 24 | 14:00 | 15:00 | 0.57 | -11.3 | 57.82 | 51.31 |
| 25 | 25 | 10:00 | 11:00 | 0.48 | 1.6 | 57.36 | 58.29 |
| 25 | 25 | 17:00 | 17:00 | 0.07 | -6.6 | 62.94 | 58.75 |
| 27 | 27 | 12:00 | 12:00 | 0.05 | 13.4 | 52.24 | 59.22 |
| 27 | 27 | 17:00 | 19:00 | 0.64 | 3.9 | 59.22 | 61.54 |
| 27 | 27 | 21:00 | 22:00 | 0.13 | -5.2 | 62.01 | 58.75 |
| 28 | 28 | 18:00 | 18:00 | 0.08 | -3.4 | 54.57 | 52.71 |

# Fan Runtime Schedule

Month: OCT/4
House 50

First day is 22

| | Before | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 |
| RunT | 0.00 | 0.93 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.38 | 0.00 |
| RHup | 43.6 | 41.8 | 42.7 | 42.7 | 42.7 | 42.7 | 41.8 | 41.8 | 40.9 | 40.9 |
| RHdn | 43.8 | 46.5 | 45.6 | 44.7 | 44.7 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 25

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 |
| RunT | 0.00 | 0.16 | 0.49 | 0.47 | 0.20 | 0.32 | 0.00 |
| RHup | 61.8 | 60.9 | 54.6 | 52.7 | 50.9 | 50.0 | 48.2 |
| RHdn | 55.5 | 56.4 | 56.4 | 56.4 | 56.4 | 56.4 | 55.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 26

| | Before | | | After |
|---|---|---|---|---|
| Hr | 14:00 | 15:00 | 16:00 | 17:00 |
| RunT | 0.00 | 0.02 | 0.20 | 0.00 |
| RHup | 41.8 | 54.6 | 50.0 | 50.9 |
| RHdn | 45.6 | 46.5 | 47.4 | 47.4 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 27

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.17 | 0.00 |
| RHup | 52.7 | 52.7 | 51.8 |
| RHdn | 52.8 | 52.8 | 52.8 |
| RHam | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule
Month: OCT/4
House 48

First day is 22

| | Before | | | After |
|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.08 | 0.38 | 0.00 |
| RHup | 50.6 | 54.1 | 53.2 | 53.2 |
| RHdn | 44.6 | 44.6 | 45.5 | 45.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 23

| | Before | | After |
|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 |
| RunT | 0.00 | 0.43 | 0.00 |
| RHup | 53.2 | 48.8 | 47.9 |
| RHdn | 45.5 | 46.4 | 46.4 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 23

| | Before | | After |
|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.37 | 0.00 |
| RHup | 47.9 | 51.4 | 52.3 |
| RHdn | 46.4 | 47.3 | 46.4 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 25

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.31 | 0.63 | 0.00 |
| RHup | 70.1 | 68.4 | 64.8 | 63.9 |
| RHdn | 57.4 | 57.4 | 56.5 | 55.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 27

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.54 | 0.61 | 0.04 | 0.00 |
| RHup | 60.3 | 59.5 | 59.5 | 61.2 | 61.2 |
| RHdn | 49.2 | 50.1 | 49.2 | 49.2 | 50.1 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule
Month: OCT/4
House 46

First day is 24

| | Before | | | After |
|---|---|---|---|---|
| Hr | 13:00 | 14:00 | 15:00 | 16:00 |
| RunT | 0.00 | 0.13 | 0.44 | 0.00 |
| RHup | 57.8 | 63.4 | 64.3 | 53.2 |
| RHdn | 52.0 | 52.9 | 52.9 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 25

| | Before | | | After |
|---|---|---|---|---|
| Hr | 9:00 | 10:00 | 11:00 | 12:00 |
| RunT | 0.00 | 0.16 | 0.32 | 0.00 |
| RHup | 56.9 | 56.9 | 57.8 | 54.1 |
| RHdn | 55.7 | 55.7 | 55.7 | 54.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 25

| | Before | | After |
|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 |
| RunT | 0.00 | 0.07 | 0.00 |
| RHup | 63.4 | 66.2 | 60.6 |
| RHdn | 56.6 | 56.6 | 57.5 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 27

| | Before | | After |
|---|---|---|---|
| Hr | 11:00 | 12:00 | 13:00 |
| RunT | 0.00 | 0.05 | 0.00 |
| RHup | 57.8 | 60.6 | 60.6 |
| RHdn | 46.6 | 48.4 | 49.3 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 27

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.26 | 0.31 | 0.07 | 0.00 |
| RHup | 58.8 | 62.5 | 61.5 | 62.5 | 61.5 |
| RHdn | 50.2 | 50.2 | 52.9 | 52.0 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 27

| | Before | | | After |
|---|---|---|---|---|
| Hr | 20:00 | 21:00 | 22:00 | 23:00 |
| RunT | 0.00 | 0.11 | 0.02 | 0.00 |
| RHup | 61.5 | 61.5 | 59.7 | 57.8 |
| RHdn | 52.0 | 52.9 | 52.9 | 53.8 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 28

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.08 | 0.00 |
| RHup | 54.1 | 60.6 | 55.0 |
| RHdn | 51.1 | 51.1 | 50.2 |
| RHam | 100.0 | 100.0 | 100.0 |

Table 1 Weekly Averages

Month: NOV/2

| | Week 1 Day 1- 7 | Week 2 Day 8- 8 |
|---|---|---|
| **House 50** | | |
| Up RH | 50.30 | 49.33 |
| Up temp | 24.08 | 22.33 |
| Down RH | 52.02 | 45.99 |
| Down Temp | 21.22 | 18.25 |
| Fan Rtm | 22.0 | 0.0 |
| **House 48** | | |
| Up RH | 56.37 | 54.93 |
| Up temp | 24.53 | 24.00 |
| Down RH | 51.77 | 44.87 |
| Down Temp | 22.84 | 23.25 |
| Fan Rtm | 3.5 | 0.0 |
| **House 46** | | |
| Up RH | 56.82 | 53.64 |
| Up temp | 23.99 | 22.58 |
| Down RH | 53.61 | 52.78 |
| Down Temp | 21.88 | 21.33 |
| Fan Rtm | 3.7 | 0.0 |
| **House 52** | | |
| Up RH | 47.62 | 43.41 |
| Up temp | 24.08 | 21.75 |
| Down RH | 48.59 | 43.87 |
| Down Temp | 22.31 | 21.42 |
| **House 44** | | |
| Up RH | 62.22 | 58.18 |
| Up temp | 23.07 | 23.00 |
| Down RH | 50.99 | 45.33 |
| Down Temp | 21.58 | 22.75 |
| **House 42** | | |
| Up RH | 52.90 | 50.94 |
| Up temp | 21.46 | 20.67 |
| Down RH | 53.44 | 47.09 |
| Down Temp | 20.38 | 18.50 |
| | | |
| Amb Temp | 7.83 | -0.58 |
| Amb RH | 100.00 | 94.73 |

Table 2a RH Histogram (total counts)

Month NOV/2
Start day 05NOV85
End day 12NOV85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10( |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 19 | 41 | 89 | 15 | 1 | 0 | 0 |
| Down RH | 0 | 0 | 0 | 15 | 38 | 71 | 41 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 16.6 | 3.0 | 0.0 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 18.66 | 19.73 | 0.00 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 0 | 18 | 39 | 73 | 35 | 0 | 0 |
| Down RH | 0 | 0 | 0 | 28 | 50 | 40 | 29 | 18 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 1.3 | 1.9 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 | 1.82 | 5.37 | 0.00 | 0.00 |
| **House 46** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 0 | 2 | 45 | 94 | 24 | 0 | 0 |
| Down RH | 0 | 0 | 0 | 0 | 20 | 84 | 61 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 2.4 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 9.92 | 0.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| Up RH | 0 | 1 | 18 | 55 | 31 | 45 | 6 | 8 | 0 | 1 |
| Down RH | 0 | 0 | 1 | 40 | 55 | 69 | 0 | 0 | 0 | 0 |
| **House 44** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 0 | 0 | 15 | 45 | 47 | 58 | 0 |
| Down RH | 0 | 0 | 0 | 23 | 53 | 49 | 40 | 0 | 0 | 0 |
| **House 42** | | | | | | | | | | |
| Up RH | 0 | 0 | 1 | 8 | 22 | 77 | 51 | 6 | 0 | 0 |
| Down RH | 0 | 0 | 0 | 3 | 36 | 68 | 55 | 3 | 0 | 0 |

Table 2b RH Histogram (% counts)

Month NOV/2
Start day 05NOV85
End day 12NOV85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 11.5 | 24.8 | 53.9 | 9.1 | 0.6 | 0.0 | 0.0 |
| % Down RH | 0.0 | 0.0 | 0.0 | 9.1 | 23.0 | 43.0 | 24.8 | 0.0 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 16.6 | 3.0 | 0.0 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 5.95 | 18.66 | 19.73 | 0.00 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.0 | 10.9 | 23.6 | 44.2 | 21.2 | 0.0 | 0. |
| % Down RH | 0.0 | 0.0 | 0.0 | 17.0 | 30.3 | 24.2 | 17.6 | 10.9 | 0.0 | 0. |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 1.3 | 1.9 | 0.0 | 0. |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 | 1.82 | 5.37 | 0.00 | 0.0 |
| **House 46** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 27.3 | 57.0 | 14.5 | 0.0 | 0. |
| % Down RH | 0.0 | 0.0 | 0.0 | 0.0 | 12.1 | 50.9 | 37.0 | 0.0 | 0.0 | 0. |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 2.4 | 0.0 | 0. |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 9.92 | 0.00 | 0.0 |
| **House 52** | | | | | | | | | | |
| % Up RH | 0.0 | 0.6 | 10.9 | 33.3 | 18.8 | 27.3 | 3.6 | 4.8 | 0.0 | 0. |
| % Down RH | 0.0 | 0.0 | 0.6 | 24.2 | 33.3 | 41.8 | 0.0 | 0.0 | 0.0 | 0. |
| **House 44** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | 27.3 | 28.5 | 35.2 | 0. |
| % Down RH | 0.0 | 0.0 | 0.0 | 13.9 | 32.1 | 29.7 | 24.2 | 0.0 | 0.0 | 0. |
| **House 42** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.6 | 4.8 | 13.3 | 46.7 | 30.9 | 3.6 | 0.0 | 0. |
| % Down RH | 0.0 | 0.0 | 0.0 | 1.8 | 21.8 | 41.2 | 33.3 | 1.8 | 0.0 | 0. |

Fan Runtime Schedule

Month: NOV/2

House 50

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 5 | 5 | 21:00 | 22:00 | 0.29 | -2.8 | 49.10 | 47.74 |
| 5 | 6 | 0:00 | 1:00 | 0.29 | 2.8 | 48.65 | 50.01 |
| 6 | 6 | 3:00 | 3:00 | 0.13 | 0.9 | 49.10 | 49.56 |
| 6 | 6 | 5:00 | 19:00 | 3.11 | 5.5 | 50.01 | 52.74 |
| 6 | 8 | 22:00 | 6:00 | 9.40 | 13.8 | 52.74 | 60.02 |
| 8 | 8 | 8:00 | 21:00 | 5.17 | -20.5 | 60.02 | 47.74 |
| 10 | 10 | 11:00 | 11:00 | 0.27 | -0.9 | 52.28 | 51.83 |
| 10 | 10 | 14:00 | 15:00 | 0.36 | -0.9 | 51.83 | 51.38 |
| 10 | 11 | 17:00 | 2:00 | 2.99 | 6.3 | 50.92 | 54.11 |

Fan Runtime Schedule

Month: NOV/2

House 48

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 5 | 5 | 19:00 | 20:00 | 0.65 | 0.8 | 56.34 | 56.78 |
| 7 | 7 | 18:00 | 19:00 | 0.85 | 3.0 | 59.90 | 61.68 |
| 8 | 8 | 11:00 | 12:00 | 0.18 | -0.7 | 60.79 | 60.34 |
| 8 | 8 | 19:00 | 19:00 | 0.37 | -3.5 | 63.01 | 60.79 |
| 9 | 9 | 18:00 | 18:00 | 0.29 | 0.0 | 49.22 | 49.22 |
| 10 | 10 | 18:00 | 19:00 | 0.68 | 4.0 | 55.89 | 58.12 |
| 11 | 11 | 19:00 | 20:00 | 0.48 | -4.2 | 63.01 | 60.34 |

Fan Runtime Schedule
Month: NOV/2
House 46

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 6 | 7 | 23:00 | 3:00 | 0.49 | -0.8 | 58.29 | 57.82 |
| 7 | 7 | 8:00 | 10:00 | 0.40 | 6.5 | 57.36 | 61.08 |
| 7 | 7 | 12:00 | 14:00 | 0.23 | -1.6 | 59.22 | 58.29 |
| 8 | 8 | 11:00 | 17:00 | 1.39 | 2.4 | 59.22 | 60.61 |
| 10 | 10 | 18:00 | 19:00 | 0.16 | 4.9 | 56.43 | 59.22 |
| 10 | 11 | 23:00 | 4:00 | 0.82 | -3.9 | 59.22 | 56.89 |
| 11 | 11 | 12:00 | 12:00 | 0.11 | 2.5 | 56.43 | 57.82 |
| 11 | 11 | 18:00 | 18:00 | 0.12 | -0.8 | 58.75 | 58.29 |

Fan Runtime Schedule
Month: NOV/2
House 50

First day is 5

| | Before | | | After |
|---|---|---|---|---|
| Hr | 20:00 | 21:00 | 22:00 | 23:00 |
| RunT | 0.00 | 0.16 | 0.13 | 0.00 |
| RHup | 49.1 | 50.0 | 49.1 | 48.2 |
| RHdn | 47.4 | 47.4 | 48.3 | 48.3 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 5

| | Before | | | After |
|---|---|---|---|---|
| Hr | 23:00 | 0:00 | 1:00 | 2:00 |
| RunT | 0.00 | 0.14 | 0.15 | 0.00 |
| RHup | 48.2 | 47.3 | 48.2 | 50.0 |
| RHdn | 48.3 | 49.2 | 49.2 | 49.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 6

| | Before | | After |
|---|---|---|---|
| Hr | 2:00 | 3:00 | 4:00 |
| RunT | 0.00 | 0.13 | 0.00 |
| RHup | 50.0 | 50.0 | 50.0 |
| RHdn | 49.2 | 50.1 | 50.1 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 6

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 4:00 | 5:00 | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | |
| RunT | 0.00 | 0.13 | 0.14 | 0.28 | 0.17 | 0.15 | 0.34 | 0.33 | 0.16 | 0.33 | 0.14 | |
| RHup | 50.0 | 49.1 | 50.9 | 50.0 | 50.0 | 50.0 | 49.1 | 50.0 | 50.9 | 50.0 | 50.9 | |
| RHdn | 50.1 | 51.0 | 51.9 | 51.9 | 52.8 | 52.8 | 51.9 | 53.7 | 55.5 | 55.5 | 54.6 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | | 0.20 | 0.18 | 0.19 | 0.19 | 0.18 | 0.00 |
| RHup | | 50.9 | 51.8 | 53.7 | 51.8 | 50.9 | 51.8 |
| RHdn | | 50.1 | 52.8 | 54.6 | 56.4 | 56.4 | 53.7 |
| RHam | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 6

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 | 5:00 | 6:00 | 7:00 | |
| RunT | 0.00 | 0.17 | 0.44 | 0.32 | 0.17 | 0.16 | 0.30 | 0.15 | 0.15 | 0.25 | 0.21 | |
| RHup | 53.7 | 52.7 | 50.9 | 52.7 | 54.6 | 54.6 | 54.6 | 55.5 | 55.5 | 55.5 | 55.5 | |
| RHdn | 55.5 | 55.5 | 53.7 | 54.6 | 54.6 | 55.5 | 55.5 | 55.5 | 55.5 | 55.5 | 55.5 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | |
| RunT | 0.32 | 0.22 | 0.57 | 0.41 | 0.44 | 0.23 | 0.37 | 0.37 | 0.25 | 0.35 | |
| RHup | 55.5 | 55.5 | 52.7 | 52.7 | 52.7 | 52.7 | 52.7 | 51.8 | 52.7 | 51.8 | |
| RHdn | 55.5 | 54.6 | 52.8 | 54.6 | 55.5 | 56.4 | 56.4 | 56.4 | 56.4 | 56.4 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | |
| RunT | 0.34 | 0.33 | 0.28 | 0.33 | 0.33 | 0.35 | 0.38 | 0.37 | 0.16 | 0.16 | |
| RHup | 50.9 | 50.9 | 50.0 | 50.0 | 49.1 | 50.9 | 51.8 | 55.5 | 57.3 | 58.2 | |
| RHdn | 57.3 | 56.4 | 56.4 | 56.4 | 53.7 | 54.6 | 55.5 | 55.5 | 55.5 | 55.5 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | After |
|---|---|---|---|---|
| Hr | 4:00 | 5:00 | 6:00 | 7:00 |
| RunT | 0.17 | 0.17 | 0.18 | 0.00 |
| RHup | 58.2 | 58.2 | 59.1 | 60.9 |
| RHdn | 55.5 | 55.5 | 55.5 | 55.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 8

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | |
| RunT | 0.00 | 0.18 | 0.27 | 0.58 | 0.33 | 0.17 | 0.43 | 0.40 | 0.43 | 0.43 | 0.23 | |
| RHup | 60.9 | 59.1 | 59.1 | 53.7 | 52.7 | 52.7 | 52.7 | 51.8 | 51.8 | 51.8 | 51.8 | |
| RHdn | 55.5 | 55.5 | 55.5 | 55.5 | 54.6 | 55.5 | 55.5 | 55.5 | 56.4 | 56.4 | 56.4 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 |
| RunT | 0.64 | 0.50 | 0.35 | 0.23 | 0.00 |
| RHup | 50.9 | 50.9 | 49.1 | 49.1 | 47.3 |
| RHdn | 53.7 | 54.6 | 54.6 | 55.5 | 54.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | After |
|---|---|---|---|
| Hr | 10:00 | 11:00 | 12:00 |
| RunT | 0.00 | 0.27 | 0.00 |
| RHup | 51.8 | 49.1 | 50.9 |
| RHdn | 49.2 | 46.5 | 47.4 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | | After |
|---|---|---|---|---|
| Hr | 13:00 | 14:00 | 15:00 | 16:00 |
| RunT | 0.00 | 0.20 | 0.16 | 0.00 |
| RHup | 52.7 | 52.7 | 50.9 | 50.9 |
| RHdn | 48.3 | 49.2 | 51.0 | 51.9 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | |
| RunT | 0.00 | 0.44 | 0.29 | 0.37 | 0.19 | 0.19 | 0.32 | 0.39 | 0.28 | 0.20 | 0.32 | |
| RHup | 50.9 | 51.8 | 50.9 | 49.1 | 50.0 | 50.0 | 50.0 | 50.9 | 50.0 | 50.9 | 51.8 | |
| RHdn | 51.9 | 51.9 | 51.0 | 49.2 | 51.0 | 51.9 | 52.8 | 53.7 | 53.7 | 54.6 | 54.6 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | After |
|---|---|---|
| Hr | | 3:00 |
| RunT | | 0.00 |
| RHup | | 54.6 |
| RHdn | | 54.6 |
| RHam | | 100.0 |

Fan Runtime Schedule

Month: NOV/2

House 48

First day is 5

| | Before | | | After |
|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.35 | 0.30 | 0.00 |
| RHup | 56.8 | 55.9 | 55.9 | 56.8 |
| RHdn | 44.6 | 45.5 | 44.6 | 45.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 7

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.34 | 0.51 | 0.00 |
| RHup | 61.2 | 62.1 | 61.2 | 62.1 |
| RHdn | 63.9 | 64.8 | 63.0 | 63.9 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 8

| | Before | | | After |
|---|---|---|---|---|
| Hr | 10:00 | 11:00 | 12:00 | 13:00 |
| RunT | 0.00 | 0.12 | 0.06 | 0.00 |
| RHup | 60.3 | 62.1 | 63.0 | 61.2 |
| RHdn | 58.4 | 57.4 | 57.4 | 58.4 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 8

| | Before | | After |
|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.37 | 0.00 |
| RHup | 63.0 | 62.1 | 62.1 |
| RHdn | 58.4 | 58.4 | 56.5 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 9

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.29 | 0.00 |
| RHup | 48.8 | 50.6 | 49.7 |
| RHdn | 44.6 | 45.5 | 44.6 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.43 | 0.25 | 0.00 |
| RHup | 57.7 | 56.8 | 57.7 | 58.6 |
| RHdn | 48.2 | 50.1 | 49.2 | 50.1 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 11

| | Before | | | After |
|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.29 | 0.19 | 0.00 |
| RHup | 63.0 | 60.3 | 61.2 | 61.2 |
| RHdn | 48.2 | 49.2 | 48.2 | 48.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule

Month: NOV/2

House 46

First day is 6

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 |
| RunT | 0.00 | 0.04 | 0.07 | 0.22 | 0.08 | 0.08 | 0.00 |
| RHup | 57.8 | 58.8 | 59.7 | 62.5 | 59.7 | 58.8 | 57.8 |
| RHdn | 56.6 | 56.6 | 55.7 | 56.6 | 55.7 | 55.7 | 55.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 7

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 |
| RunT | 0.00 | 0.22 | 0.14 | 0.04 | 0.00 |
| RHup | 56.9 | 59.7 | 58.8 | 57.8 | 60.6 |
| RHdn | 55.7 | 56.6 | 56.6 | 56.6 | 56.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 7

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 |
| RunT | 0.00 | 0.04 | 0.04 | 0.15 | 0.00 |
| RHup | 60.6 | 61.5 | 60.6 | 59.7 | 56.9 |
| RHdn | 56.6 | 56.6 | 56.6 | 56.6 | 56.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 8

| | Before | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|
| Hr | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 |
| RunT | 0.00 | 0.01 | 0.25 | 0.21 | 0.28 | 0.41 | 0.15 | 0.08 | 0.00 |
| RHup | 58.8 | 59.7 | 59.7 | 59.7 | 60.6 | 60.6 | 61.5 | 61.5 | 60.6 |
| RHdn | 55.7 | 56.6 | 56.6 | 56.6 | 56.6 | 58.4 | 58.4 | 58.4 | 59.3 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.12 | 0.04 | 0.00 |
| RHup | 58.8 | 61.5 | 60.6 | 59.7 |
| RHdn | 53.8 | 54.7 | 54.7 | 54.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 10

| | Before | | | | | | | After |
|---|---|---|---|---|---|---|---|---|
| Hr | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 | 5:00 |
| RunT | 0.00 | 0.08 | 0.15 | 0.13 | 0.23 | 0.18 | 0.05 | 0.00 |
| RHup | 59.7 | 60.6 | 61.5 | 62.5 | 61.5 | 60.6 | 58.8 | 57.8 |
| RHdn | 55.7 | 55.7 | 55.7 | 56.6 | 56.6 | 56.6 | 56.6 | 56.6 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 11

| | Before | | After |
|---|---|---|---|
| Hr | 11:00 | 12:00 | 13:00 |
| RunT | 0.00 | 0.11 | 0.00 |
| RHup | 57.8 | 60.6 | 58.8 |
| RHdn | 54.7 | 53.8 | 53.8 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is . 11

| | Before | | After |
|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.12 | 0.00 |
| RHup | 58.8 | 60.6 | 59.7 |
| RHdn | 54.7 | 54.7 | 52.9 |
| RHam | 100.0 | 100.0 | 100.0 |

Table 1 Weekly Averages

Month: NOV/3

| | Week 1<br>Day 1- 7 | Week 2<br>Day 8- 8 |
|---|---|---|
| **House 50** | | |
| Up RH | 43.76 | 45.69 |
| Up temp | 23.63 | 23.33 |
| Down RH | 41.08 | 40.73 |
| Down Temp | 21.79 | 20.83 |
| Fan Rtm | 8.4 | 0.0 |
| **House 48** | | |
| Up RH | 49.88 | 50.70 |
| Up temp | 24.25 | 24.83 |
| Down RH | 42.02 | 40.80 |
| Down Temp | 23.75 | 23.83 |
| Fan Rtm | 5.2 | 0.0 |
| **House 46** | | |
| Up RH | 51.47 | 49.37 |
| Up temp | 23.07 | 23.00 |
| Down RH | 48.65 | 47.32 |
| Down Temp | 22.14 | 21.67 |
| Fan Rtm | 15.8 | 0.0 |
| **House 52** | | |
| Up RH | 40.29 | 36.59 |
| Up temp | 22.83 | 23.67 |
| Down RH | 41.30 | 40.96 |
| Down Temp | 21.96 | 21.75 |
| **House 44** | | |
| Up RH | 52.76 | 52.29 |
| Up temp | 22.78 | 23.58 |
| Down RH | 42.14 | 40.81 |
| Down Temp | 22.73 | 22.83 |
| **House 42** | | |
| Up RH | 46.13 | 46.42 |
| Up temp | 20.58 | 19.83 |
| Down RH | 46.77 | 47.25 |
| Down Temp | 19.99 | 18.25 |
| | | |
| Amb Temp | 2.92 | 1.83 |
| Amb RH | 95.82 | 0.00 |

Table 3a RH Histogram (total counts)

Month NOV/3
Start day 12NOV85
End day 19NOV85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| Up RH | 1 | 15 | 26 | 47 | 46 | 28 | 5 | 0 | 0 | 0 |
| ~~Down RH~~ | ~~3~~ | ~~40~~ | ~~24~~ | 61 | ~~14~~ | ~~26~~ | 0 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 6.4 | 0.3 | 0.0 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 3.57 | 23.00 | 5.60 | 0.00 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| Up RH | 0 | 0 | 6 | 37 | 38 | 46 | 33 | 7 | 1 | 0 |
| Down RH | 1 | 35 | 24 | 59 | 22 | 26 | 1 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 1.5 | 1.2 | 1.0 | 0.9 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.55 | 3.20 | 3.73 | 14.14 | 89.00 | 0.00 |
| **House 46** | | | | | | | | | | |
| Up RH | 0 | 0 | 2 | 23 | 30 | 62 | 48 | 3 | 0 | 0 |
| Down RH | 0 | 0 | 14 | 35 | 29 | 74 | 16 | 0 | 0 | 0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 14.1 | 0.1 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.58 | 29.38 | 3.33 | 0.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| Up RH | 3 | 47 | 48 | 28 | 23 | 15 | 3 | 1 | 0 | 0 |
| Down RH | 0 | 32 | 40 | 46 | 34 | 16 | 0 | 0 | 0 | 0 |
| **House 44** | | | | | | | | | | |
| Up RH | 0 | 0 | 0 | 20 | 30 | 59 | 40 | 19 | 0 | 0 |
| Down RH | 0 | 26 | 22 | 68 | 35 | 17 | 0 | 0 | 0 | 0 |
| **House 42** | | | | | | | | | | |
| Up RH | 0 | 7 | 22 | 40 | 62 | 24 | 10 | 3 | 0 | 0 |
| Down RH | 0 | 2 | 32 | 18 | 73 | 24 | 15 | 3 | 1 | 0 |

Table 2b. RH Histogram (% counts)

Month NOV/3
Start day 12NOV85
End day 19NOV85

| | 0-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **House 50** | | | | | | | | | | |
| % Up RH | 0.6 | 8.9 | 15.5 | 28.0 | 27.4 | 16.7 | 3.0 | 0.0 | 0.0 | 0.0 |
| % Down RH | 1.8 | 23.8 | 14.3 | 36.3 | 8.3 | 15.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 6.4 | 0.3 | 0.0 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 3.57 | 23.00 | 5.60 | 0.00 | 0.00 | 0.00 |
| **House 48** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 3.6 | 22.0 | 22.6 | 27.4 | 19.6 | 4.2 | 0.6 | 0.0 |
| % Down RH | 0.6 | 20.8 | 14.3 | 35.1 | 13.1 | 15.5 | 0.6 | 0.0 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 1.5 | 1.2 | 1.0 | 0.9 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 1.55 | 3.20 | 3.73 | 14.14 | 89.00 | 0.00 |
| **House 46** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 1.2 | 13.7 | 17.9 | 36.9 | 28.6 | 1.8 | 0.0 | 0.0 |
| % Down RH | 0.0 | 0.0 | 8.3 | 20.8 | 17.3 | 44.0 | 9.5 | 0.0 | 0.0 | 0.0 |
| Fan Rtm | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 14.1 | 0.1 | 0.0 | 0.0 |
| RT fact (X100) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.58 | 29.38 | 3.33 | 0.00 | 0.00 |
| **House 52** | | | | | | | | | | |
| % Up RH | 1.8 | 28.0 | 28.6 | 16.7 | 13.7 | 8.9 | 1.8 | 0.6 | 0.0 | 0.0 |
| % Down RH | 0.0 | 19.0 | 23.8 | 27.4 | 20.2 | 9.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **House 44** | | | | | | | | | | |
| % Up RH | 0.0 | 0.0 | 0.0 | 11.9 | 17.9 | 35.1 | 23.8 | 11.3 | 0.0 | 0.0 |
| % Down RH | 0.0 | 15.5 | 13.1 | 40.5 | 20.8 | 10.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **House 42** | | | | | | | | | | |
| % Up RH | 0.0 | 4.2 | 13.1 | 23.8 | 36.9 | 14.3 | 6.0 | 1.8 | 0.0 | 0.0 |
| % Down RH | 0.0 | 1.2 | 19.0 | 10.7 | 43.5 | 14.3 | 8.9 | 1.8 | 0.6 | 0.0 |

Fan Runtime Schedule
Month: NOV/3
House 50

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 12 | 12 | 18:00 | 19:00 | 0.42 | -4.5 | 50.01 | 47.74 |
| 12 | 12 | 23:00 | 0:00 | 0.14 | 10.8 | 46.37 | 51.38 |
| 13 | 14 | 7:00 | 1:00 | 7.68 | -7.9 | 57.29 | 52.74 |
| 17 | 17 | 17:00 | 17:00 | 0.12 | 2.9 | 46.37 | 47.74 |

Fan Runtime Schedule
Month: NOV/3
House 48

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 12 | 12 | 19:00 | 19:00 | 0.21 | -5.4 | 57.67 | 54.56 |
| 13 | 13 | 11:00 | 12:00 | 0.63 | -0.8 | 58.12 | 57.67 |
| 13 | 13 | 17:00 | 20:00 | 2.23 | 7.0 | 57.23 | 61.23 |
| 14 | 14 | 19:00 | 19:00 | 0.59 | 8.8 | 45.66 | 49.66 |
| 17 | 17 | 18:00 | 20:00 | 0.83 | -6.1 | 58.12 | 54.56 |
| 18 | 18 | 19:00 | 21:00 | 0.68 | -11.7 | 60.79 | 53.67 |

Fan Runtime Schedule

Month: NOV/3

House 46

| Days | | Hours | | Total | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| Start | End | Start | End | Fan Rntm | %Change | Before | After |
| 12 | 12 | 18:00 | 19:00 | 0.91 | -3.4 | 55.50 | 53.64 |
| 12 | 13 | 23:00 | 3:00 | 1.46 | 2.6 | 53.64 | 55.03 |
| 13 | 13 | 5:00 | 6:00 | 0.41 | 0.8 | 55.50 | 55.96 |
| 13 | 14 | 8:00 | 1:00 | 9.74 | -3.4 | 55.03 | 53.17 |
| 14 | 14 | 17:00 | 18:00 | 0.89 | 4.6 | 50.85 | 53.17 |
| 15 | 15 | 2:00 | 3:00 | 0.30 | -1.7 | 53.64 | 52.71 |
| 15 | 15 | 8:00 | 9:00 | 0.31 | 8.2 | 51.31 | 55.50 |
| 16 | 16 | 15:00 | 15:00 | 0.07 | -5.3 | 52.24 | 49.45 |
| 17 | 17 | 16:00 | 17:00 | 0.20 | 6.5 | 50.38 | 53.64 |
| 17 | 17 | 19:00 | 20:00 | 0.24 | 3.4 | 54.10 | 55.96 |
| 17 | 18 | 22:00 | 2:00 | 0.93 | 2.7 | 52.24 | 53.64 |
| 18 | 18 | 8:00 | 9:00 | 0.11 | 2.7 | 52.24 | 53.64 |
| 18 | 18 | 13:00 | 14:00 | 0.23 | -1.7 | 53.64 | 52.71 |

Fan Runtime Schedule.
Month: NOV/3
House 50

First day is 12

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.14 | 0.28 | 0.00 |
| RHup | 51.8 | 51.8 | 49.1 | 48.2 |
| RHdn | 43.8 | 43.8 | 44.7 | 44.7 |
| RHam | 90.0 | 90.0 | 93.0 | 95.0 |

First day is 12

| | Before | | | After |
|---|---|---|---|---|
| Hr | 22:00 | 23:00 | 0:00 | 1:00 |
| RunT | 0.00 | 0.08 | 0.06 | 0.00 |
| RHup | 45.5 | 48.2 | 48.2 | 50.0 |
| RHdn | 46.5 | 46.5 | 47.4 | 49.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 13

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | |
| RunT | 0.00 | 0.11 | 0.17 | 0.69 | 0.51 | 0.29 | 0.43 | 0.32 | 0.16 | 0.57 | 0.47 | |
| RHup | 57.3 | 56.4 | 56.4 | 50.0 | 50.0 | 50.9 | 50.0 | 50.9 | 51.8 | 50.0 | 50.9 | |
| RHdn | 51.0 | 51.0 | 51.9 | 51.9 | 52.8 | 52.8 | 53.7 | 53.7 | 51.9 | 45.6 | 47.4 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 |
| RunT | 0.52 | 0.46 | 0.57 | 0.27 | 0.83 | 0.30 | 0.40 | 0.35 | 0.26 | 0.00 |
| RHup | 51.8 | 50.9 | 50.0 | 49.1 | 49.1 | 50.0 | 50.0 | 50.0 | 51.8 | 52.7 |
| RHdn | 47.4 | 50.1 | 51.0 | 51.9 | 52.8 | 53.7 | 53.7 | 53.7 | 53.7 | 53.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | After |
|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 |
| RunT | 0.00 | 0.12 | 0.00 |
| RHup | 45.5 | 49.1 | 47.3 |
| RHdn | 42.9 | 44.7 | 45.6 |
| RHam | 100.0 | 100.0 | 100.0 |

# Fan Runtime Schedule

Month: NOV/3

House 48

First day is 12

| | Before | | After |
|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.21 | 0.00 |
| RHup | 56.8 | 54.1 | 53.2 |
| RHdn | 43.6 | 44.6 | 43.6 |
| RHam | 90.0 | 93.0 | 95.0 |

First day is 13

| | Before | | | After |
|---|---|---|---|---|
| Hr | 10:00 | 11:00 | 12:00 | 13:00 |
| RunT | 0.00 | 0.17 | 0.46 | 0.00 |
| RHup | 58.6 | 58.6 | 56.8 | 58.6 |
| RHdn | 52.8 | 52.8 | 52.8 | 52.8 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 13

| | Before | | | | | After |
|---|---|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.89 | 0.48 | 0.51 | 0.35 | 0.00 |
| RHup | 58.6 | 67.5 | 60.3 | 60.3 | 59.5 | 61.2 |
| RHdn | 52.8 | 52.8 | 51.9 | 52.8 | 51.9 | 52.8 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 14

| | Before | | After |
|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.59 | 0.00 |
| RHup | 47.9 | 49.7 | 49.7 |
| RHdn | 42.7 | 41.8 | 40.9 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.29 | 0.15 | 0.39 | 0.00 |
| RHup | 56.8 | 51.4 | 52.3 | 53.2 | 54.1 |
| RHdn | 44.6 | 45.5 | 47.3 | 46.4 | 47.3 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 18

| | Before | | | | After |
|---|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 |
| RunT | 0.00 | 0.25 | 0.38 | 0.05 | 0.00 |
| RHup | 58.6 | 55.0 | 54.1 | 53.2 | 55.0 |
| RHdn | 44.6 | 44.6 | 45.5 | 42.7 | 42.7 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Fan Runtime Schedule
Month: NOV/3
House 46

First day is 12

| | Before | | | After |
|---|---|---|---|---|
| Hr | 17:00 | 18:00 | 19:00 | 20:00 |
| RunT | 0.00 | 0.04 | 0.87 | 0.00 |
| RHup | 56.0 | 60.6 | 54.1 | 54.1 |
| RHdn | 51.1 | 52.0 | 52.9 | 52.9 |
| RHam | 90.0 | 90.0 | 93.0 | 95.0 |

First day is 12

| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 |
| RunT | 0.00 | 0.37 | 0.28 | 0.18 | 0.34 | 0.29 | 0.00 |
| RHup | 54.1 | 56.9 | 55.0 | 56.0 | 56.9 | 56.0 | 55.0 |
| RHdn | 50.2 | 51.1 | 52.9 | 50.2 | 52.0 | 52.9 | 52.9 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 13

| | Before | | | After |
|---|---|---|---|---|
| Hr | 4:00 | 5:00 | 6:00 | 7:00 |
| RunT | 0.00 | 0.14 | 0.27 | 0.00 |
| RHup | 55.0 | 55.0 | 55.0 | 55.0 |
| RHdn | 52.9 | 52.0 | 52.9 | 52.9 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 13

| | Before | | | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hr | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | |
| RunT | 0.00 | 0.30 | 0.53 | 0.63 | 0.75 | 0.77 | 0.74 | 0.73 | 0.41 | 0.50 | 0.33 | |
| RHup | 55.0 | 56.9 | 57.8 | 57.8 | 57.8 | 56.9 | 56.9 | 56.9 | 56.0 | 56.0 | 56.0 | |
| RHdn | 52.9 | 52.0 | 53.8 | 54.7 | 54.7 | 55.7 | 55.7 | 56.6 | 56.6 | 54.7 | 55.7 | |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |

| | Before | | | | | | | | | After |
|---|---|---|---|---|---|---|---|---|---|---|
| Hr | | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 |
| RunT | | 0.79 | 0.71 | 0.47 | 0.35 | 0.43 | 0.37 | 0.65 | 0.28 | 0.00 |
| RHup | | 56.9 | 56.9 | 56.9 | 56.0 | 56.0 | 56.0 | 56.0 | 56.0 | 55.0 |
| RHdn | | 52.9 | 55.7 | 56.6 | 58.4 | 58.4 | 59.3 | 57.5 | 57.5 | 57.5 |
| RHam | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 14

| | Before | | | After |
|---|---|---|---|---|
| Hr | 16:00 | 17:00 | 18:00 | 19:00 |
| RunT | 0.00 | 0.31 | 0.58 | 0.00 |
| RHup | 51.3 | 55.0 | 55.0 | 54.1 |
| RHdn | 50.2 | 50.2 | 50.2 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 15

| | Before | | | After |
|---|---|---|---|---|
| Hr | 1:00 | 2:00 | 3:00 | 4:00 |
| RunT | 0.00 | 0.15 | 0.15 | 0.00 |
| RHup | 53.2 | 54.1 | 55.0 | 53.2 |
| RHdn | 53.8 | 53.8 | 53.8 | 53.8 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 15

| | Before | | | After |
|---|---|---|---|---|
| Hr | 7:00 | 8:00 | 9:00 | 10:00 |
| RunT | 0.00 | 0.15 | 0.16 | 0.00 |
| RHup | 51.3 | 53.2 | 53.2 | 54.1 |
| RHdn | 53.8 | 52.0 | 51.1 | 47.5 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 16

| | Before | | After |
|---|---|---|---|
| Hr | 14:00 | 15:00 | 16:00 |
| RunT | 0.00 | 0.07 | 0.00 |
| RHup | 53.2 | 55.0 | 51.3 |
| RHdn | 40.2 | 41.1 | 42.0 |
| RHam | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | | After |
|---|---|---|---|---|
| Hr | 15:00 | 16:00 | 17:00 | 18:00 |
| RunT | 0.00 | 0.03 | 0.17 | 0.00 |
| RHup | 50.4 | 56.9 | 55.0 | 53.2 |
| RHdn | 44.7 | 46.6 | 48.4 | 50.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 17

| | Before | | | After |
|---|---|---|---|---|
| Hr | 18:00 | 19:00 | 20:00 | 21:00 |
| RunT | 0.00 | 0.09 | 0.15 | 0.00 |
| RHup | 53.2 | 54.1 | 53.2 | 51.3 |
| RHdn | 50.2 | 52.0 | 52.0 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 17

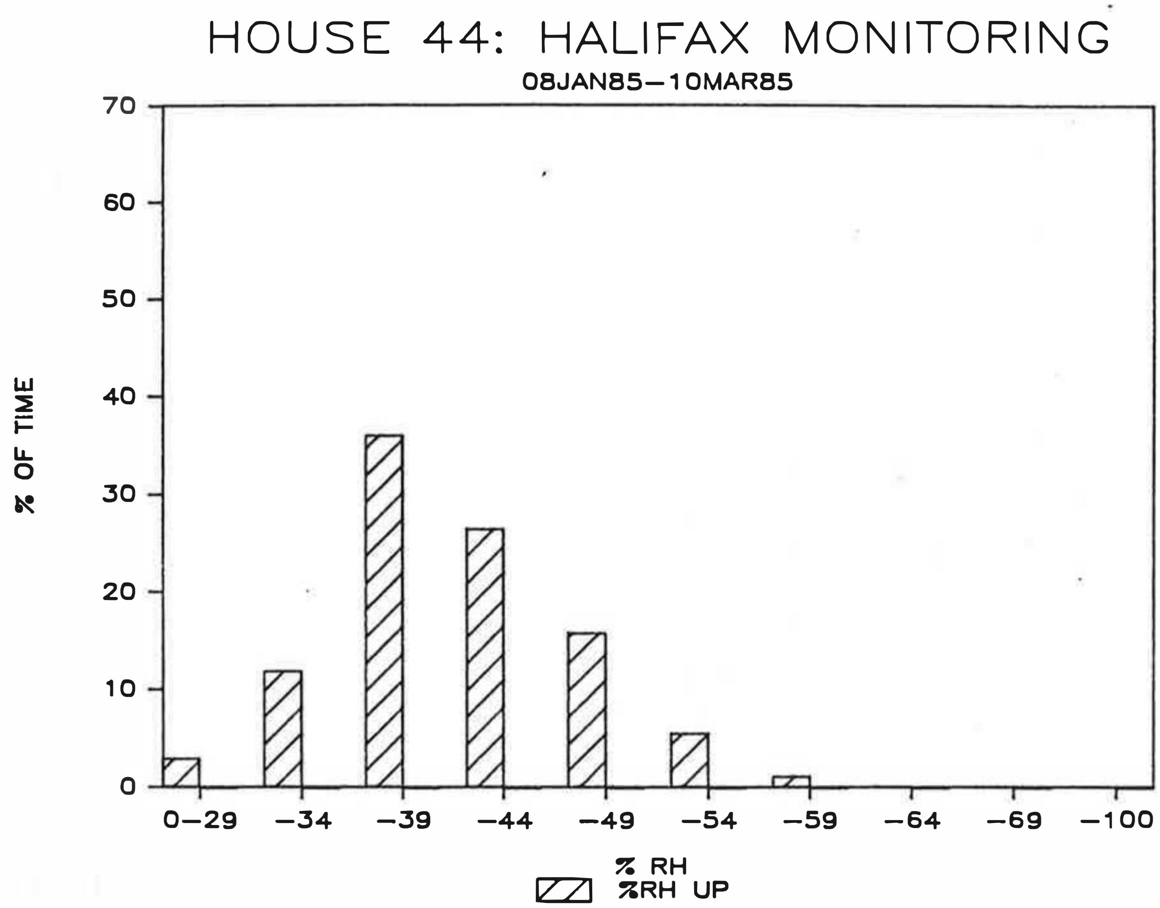
| | Before | | | | | | After |
|---|---|---|---|---|---|---|---|
| Hr | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 |
| RunT | 0.00 | 0.06 | 0.32 | 0.29 | 0.07 | 0.19 | 0.00 |
| RHup | 51.7 | 60.6 | 59.7 | 57.8 | 56.0 | 56.0 | 54.1 |
| RHdn | 52.0 | 51.1 | 52.9 | 52.9 | 52.9 | 52.0 | 52.0 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

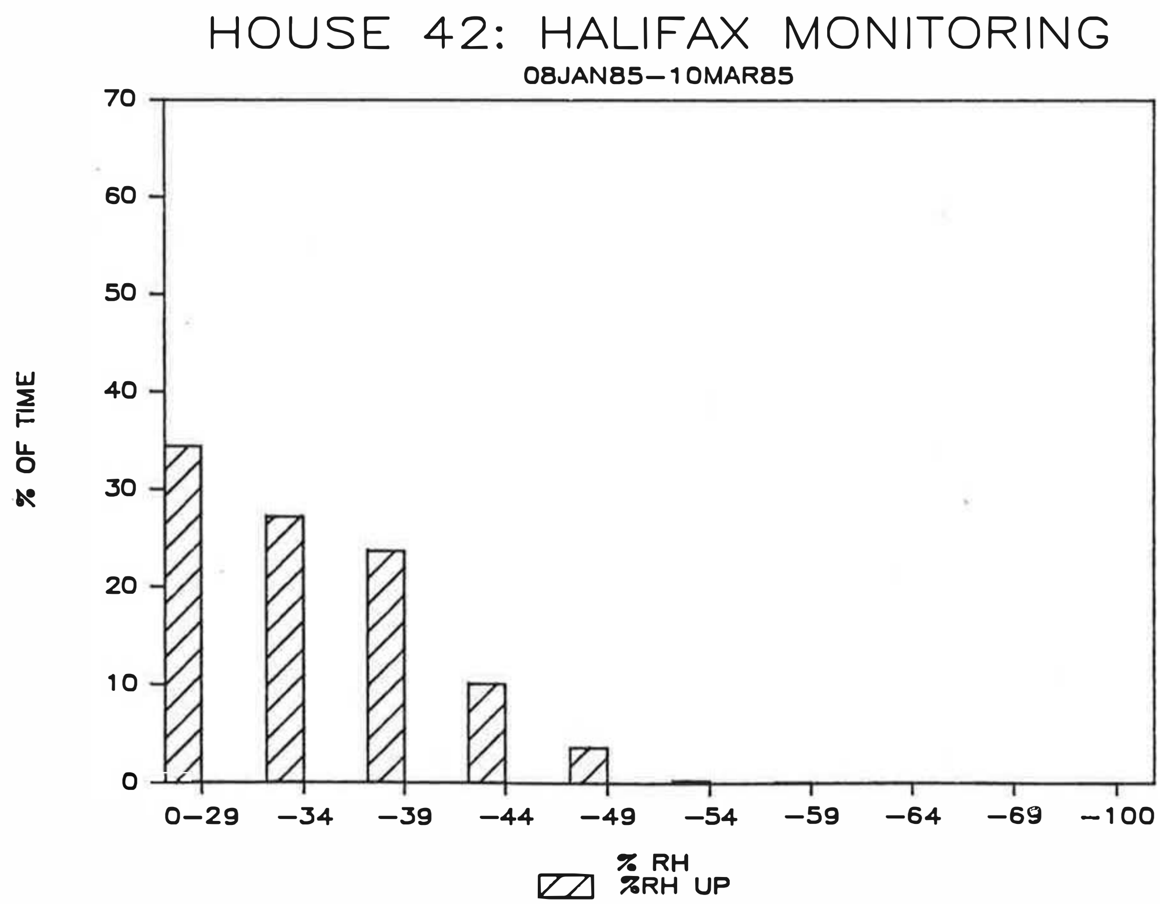
First day is 18

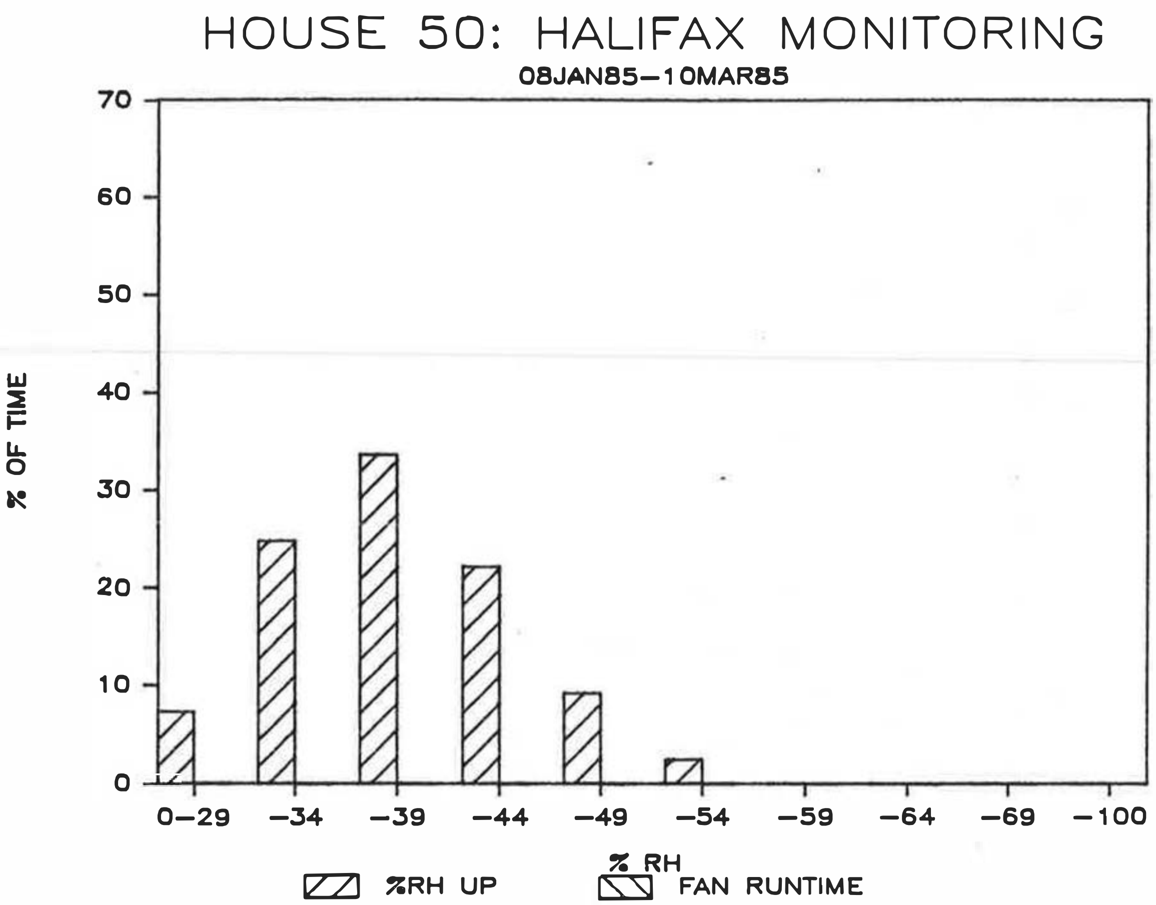
| | Before | | | After |
|---|---|---|---|---|
| Hr | 7:00 | 8:00 | 9:00 | 10:00 |
| RunT | 0.00 | 0.05 | 0.06 | 0.00 |
| RHup | 52.2 | 56.0 | 56.0 | 54.1 |
| RHdn | 51.1 | 51.1 | 49.3 | 50.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |

First day is 18

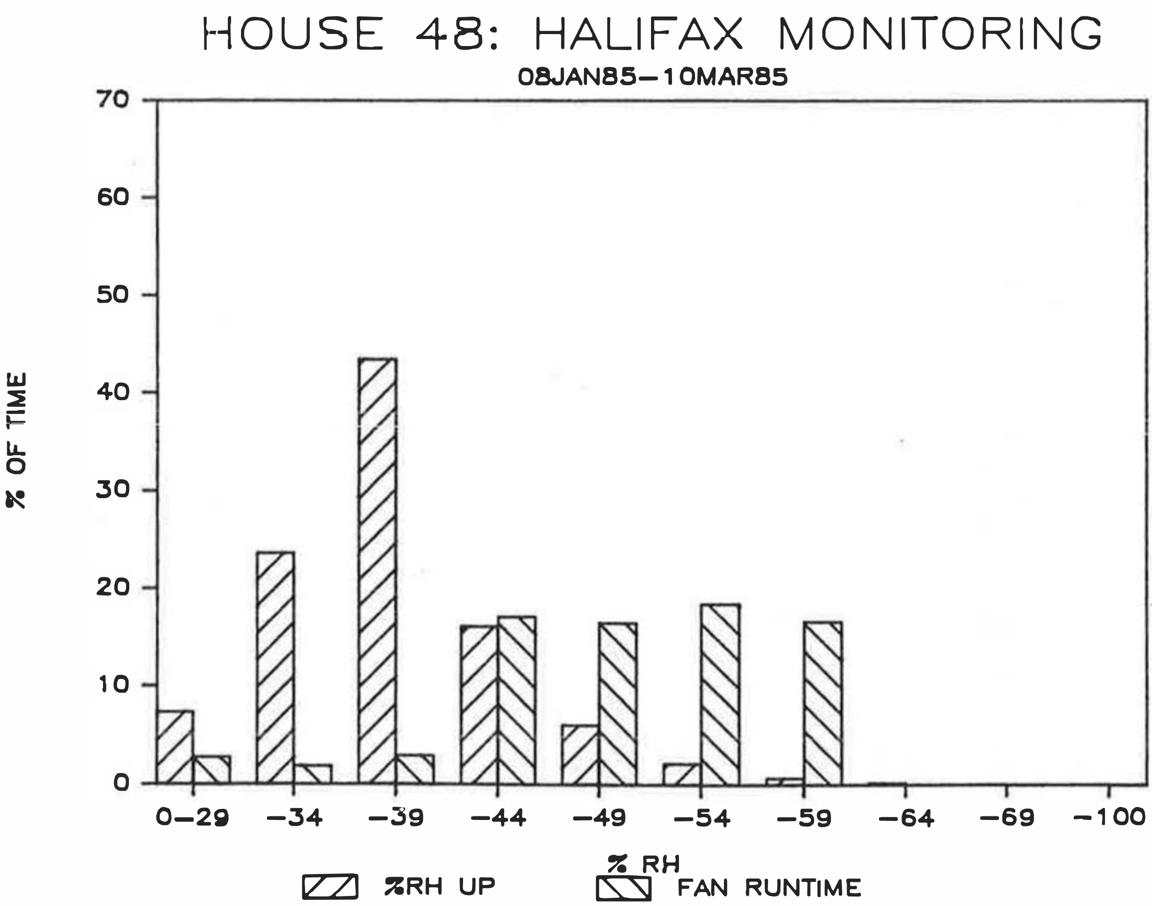
| | Before | | | After |
|---|---|---|---|---|
| Hr | 12:00 | 13:00 | 14:00 | 15:00 |
| RunT | 0.00 | 0.20 | 0.03 | 0.00 |
| RHup | 54.1 | 56.9 | 54.1 | 53.2 |
| RHdn | 49.3 | 49.3 | 50.2 | 50.2 |
| RHam | 100.0 | 100.0 | 100.0 | 100.0 |


HOUSE 44: HALIFAX MONITORING
08JAN85–10MAR85
% OF TIME
0
10
20
30
40
50
60
70
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP

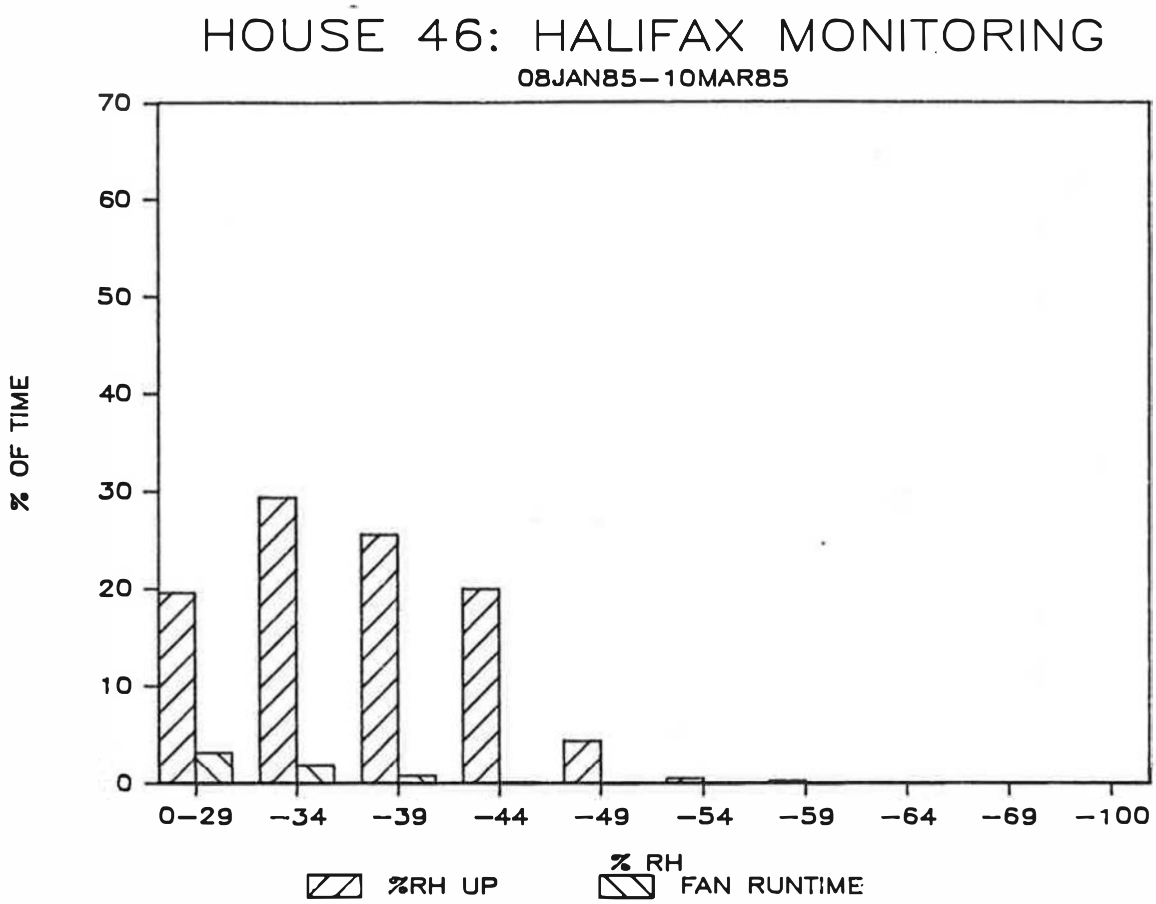

HOUSE 42: HALIFAX MONITORING
08JAN85–10MAR85
% OF TIME
0
10
20
30
40
50
60
70
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP

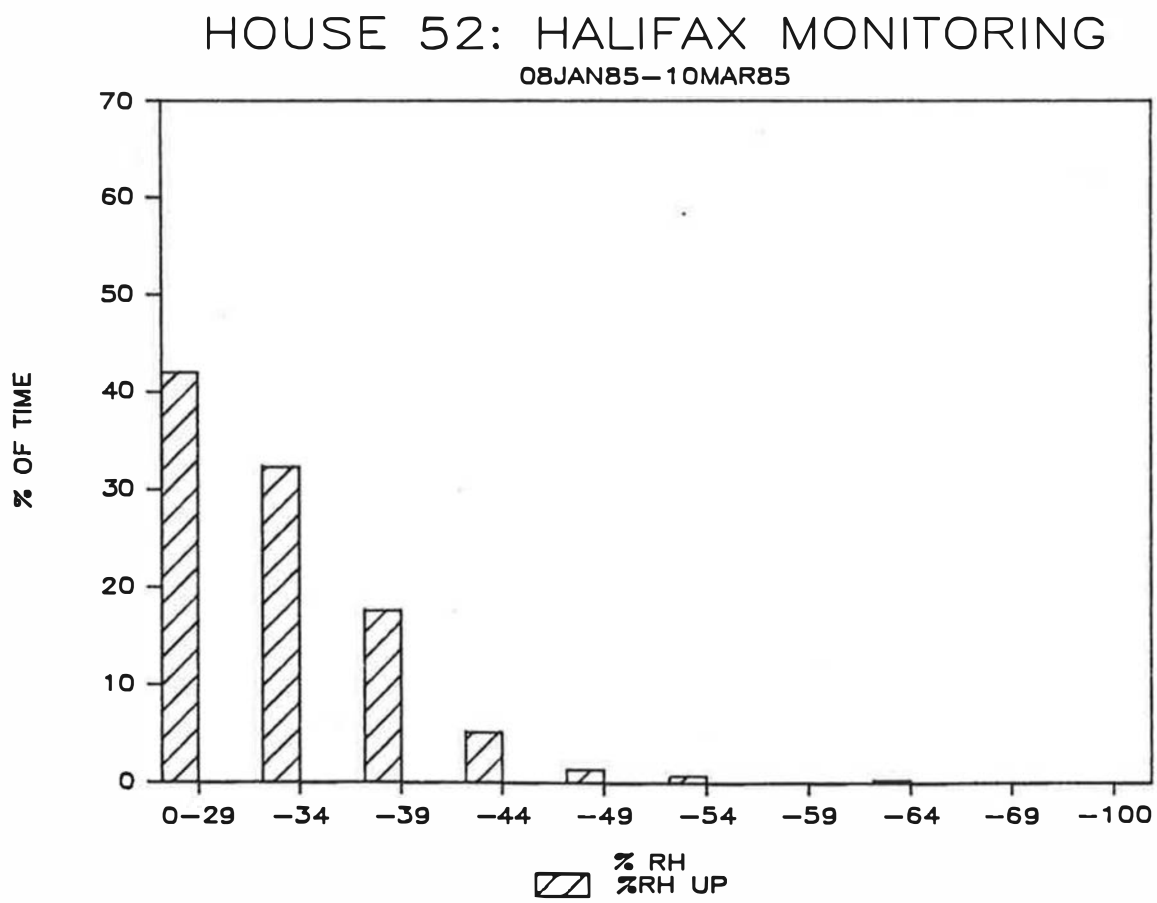


HOUSE 50: HALIFAX MONITORING
08JAN85-10MAR85
70
60
50
40
30
20
10
0
% OF TIME
0-29
-34
-39
-44
-49
-54
-59
-64
-69
-100
% RH
%RH UP
FAN RUNTIME

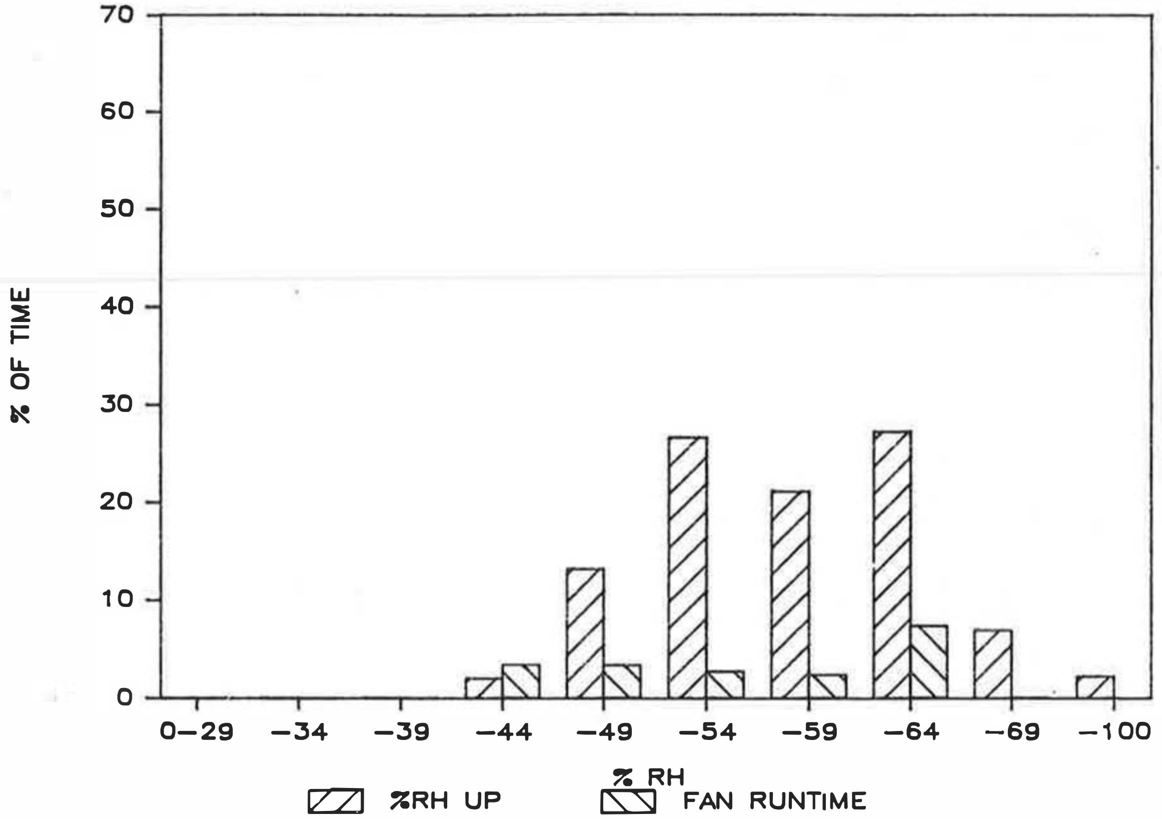
HOUSE 48: HALIFAX MONITORING
08JAN85-10MAR85
70
60
50
40
30
20
10
0
% OF TIME
0-29
-34
-39
-44
-49
-54
-59
-64
-69
-100
% RH
%RH UP
FAN RUNTIME


HOUSE 46: HALIFAX MONITORING
08JAN85—10MAR85
70
60
50
40
30
20
10
0
% OF TIME
0—29
—34
—39
—44
—49
—54
—59
—64
—69
—100
% RH
%RH UP
FAN RUNTIME


HOUSE 52: HALIFAX MONITORING
08JAN85—10MAR85
70
60
50
40
30
20
10
0
% OF TIME
0—29
—34
—39
—44
—49
—54
—59
—64
—69
—100
% RH
%RH UP

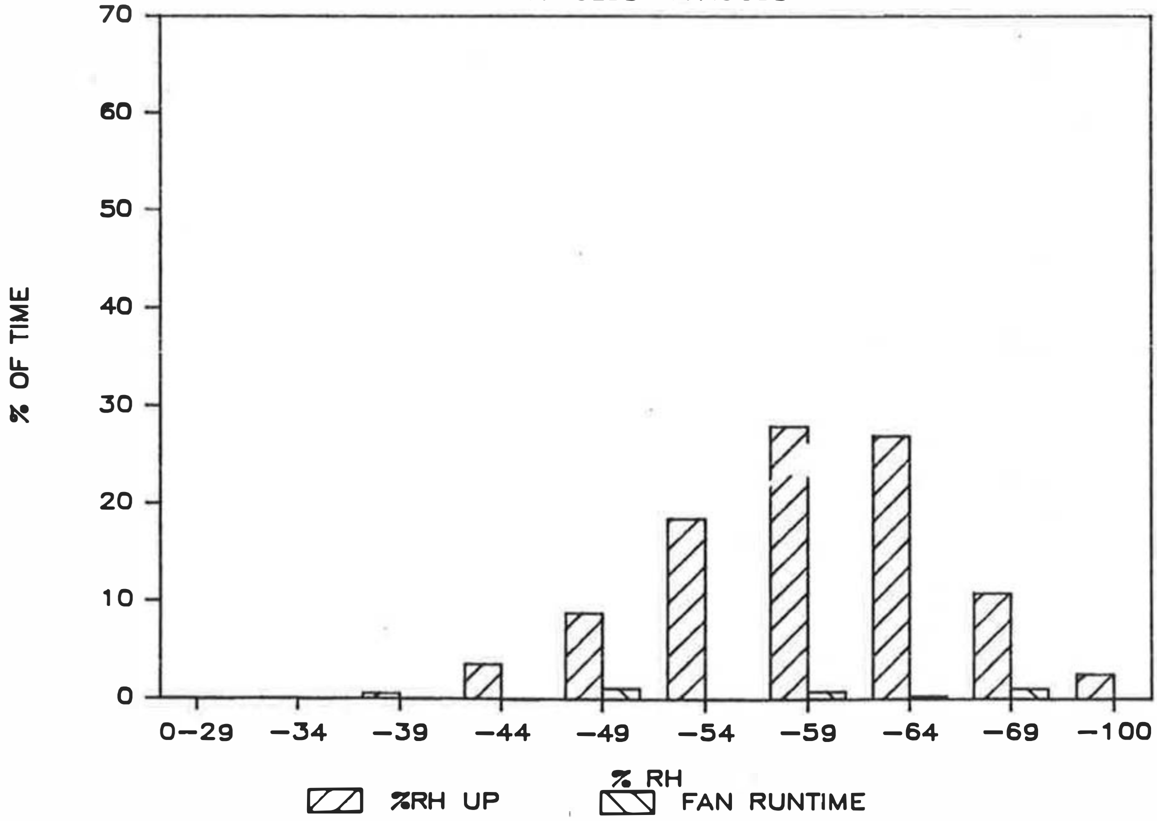
# HOUSE 50: HALIFAX MONITORING

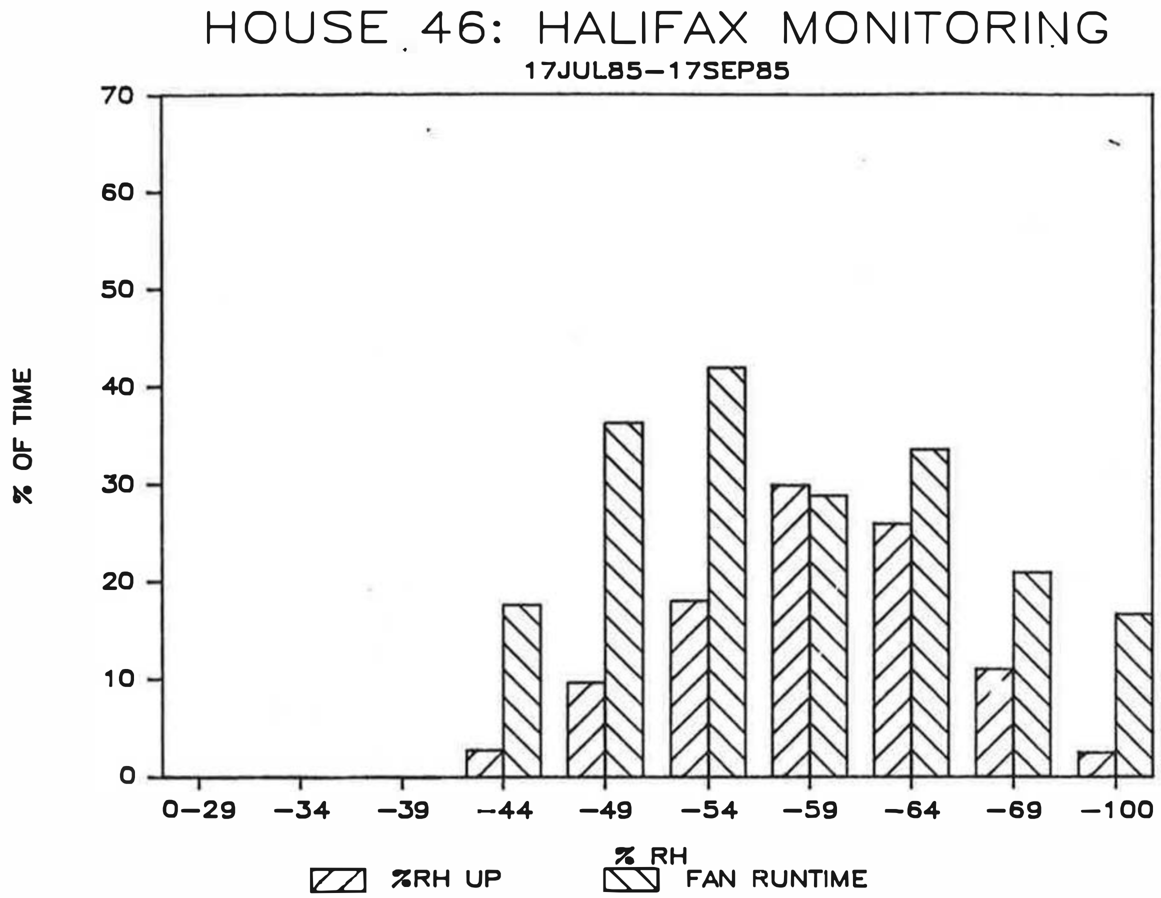
17JUL85–17SEP85

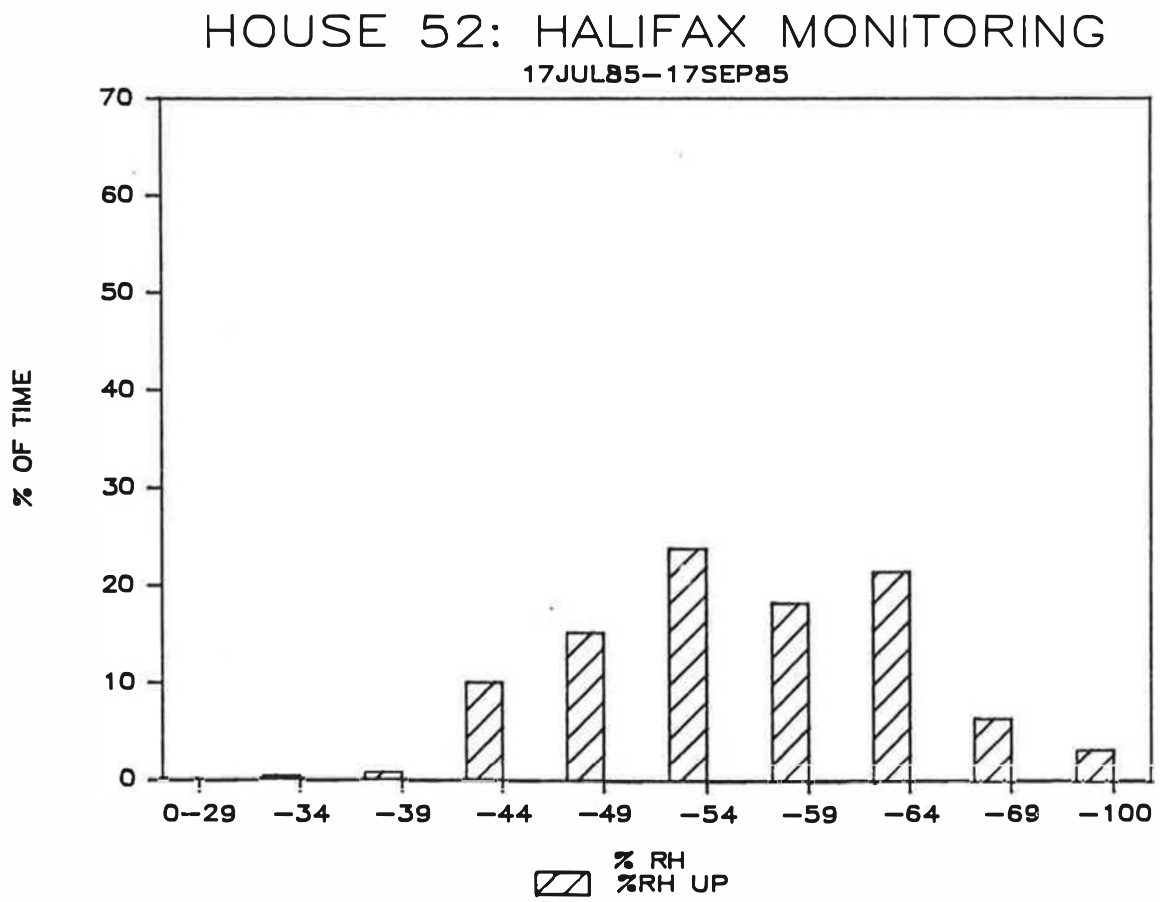


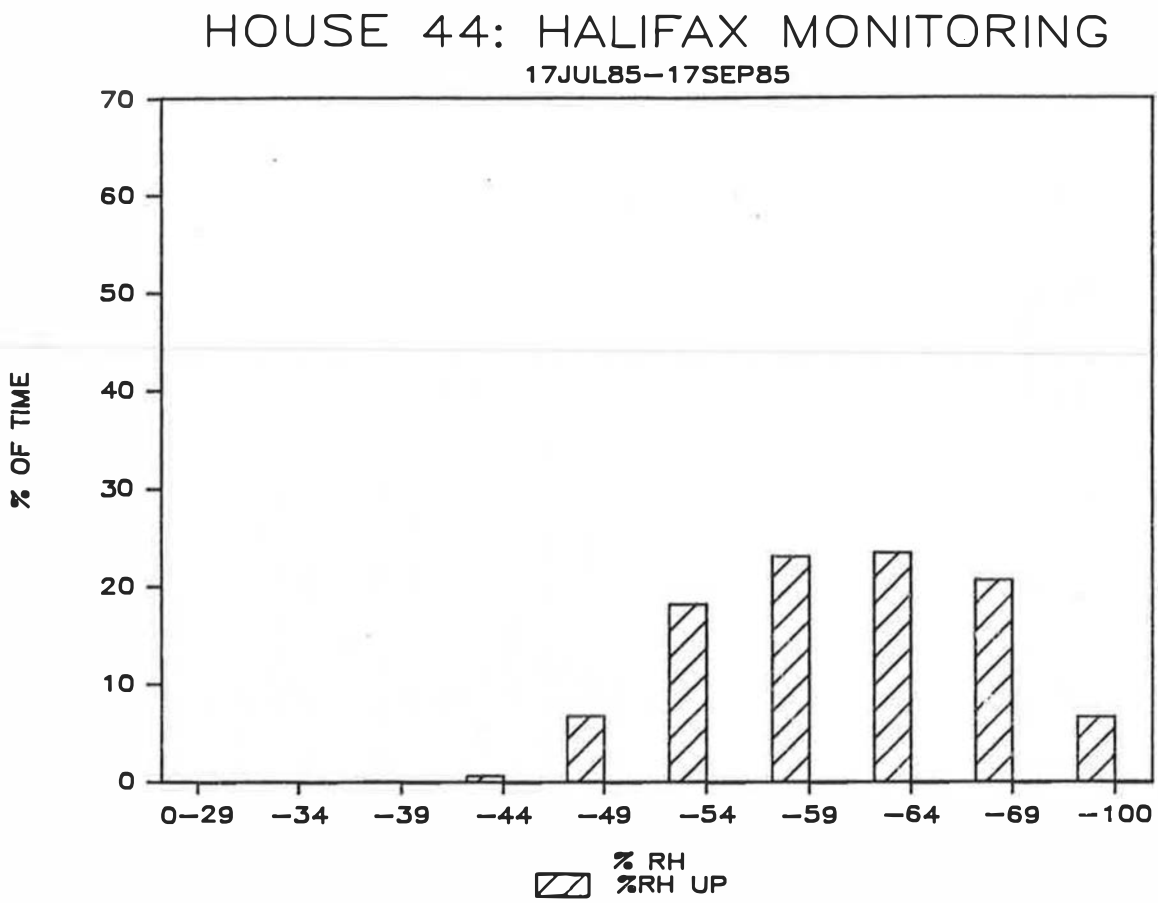

# HOUSE 48: HALIFAX MONITORING

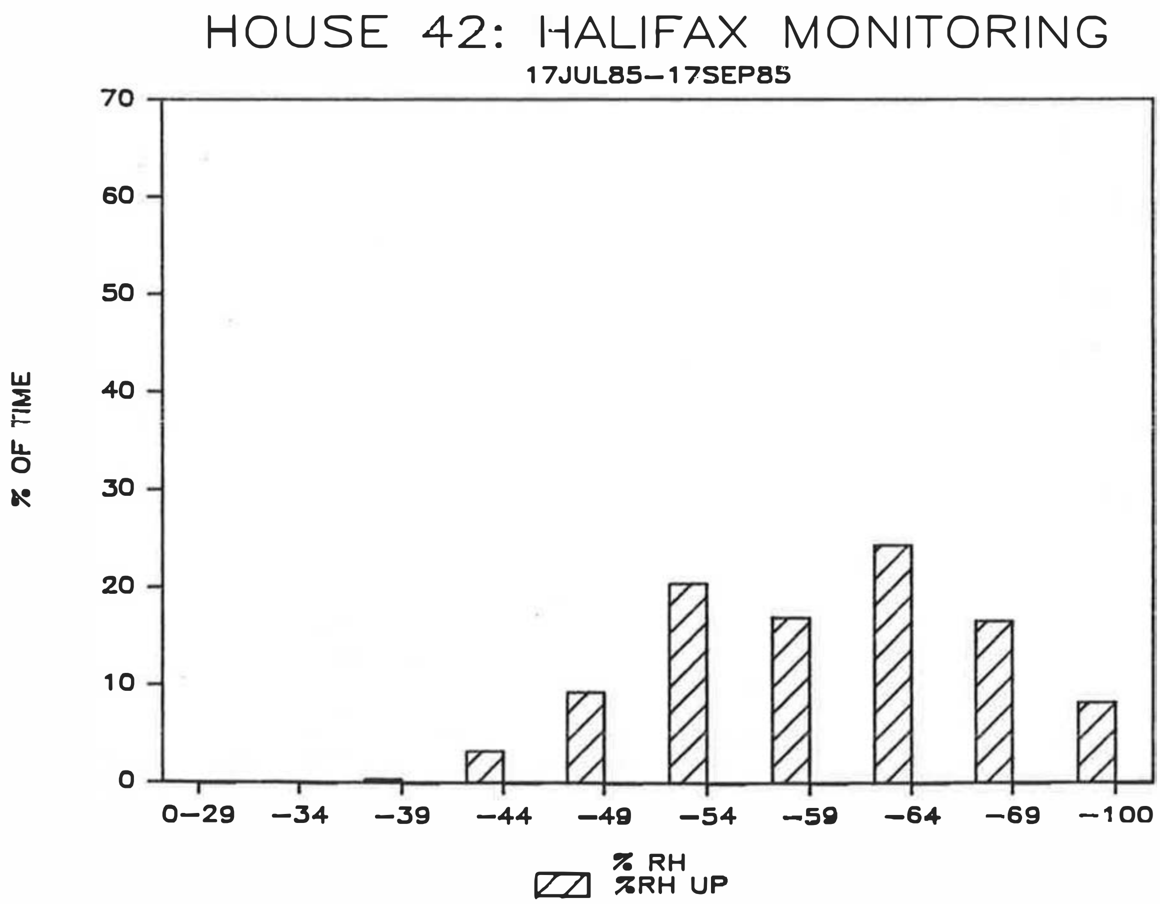
17JUL85–17AUG85




HOUSE 46: HALIFAX MONITORING
17JUL85–17SEP85
70
60
50
40
30
20
10
0
% OF TIME
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP
FAN RUNTIME


HOUSE 52: HALIFAX MONITORING
17JUL85–17SEP85
70
60
50
40
30
20
10
0
% OF TIME
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP


HOUSE 44: HALIFAX MONITORING
17JUL85–17SEP85
70
60
50
40
30
20
10
0
% OF TIME
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP


HOUSE 42: HALIFAX MONITORING
17JUL85–17SEP85
70
60
50
40
30
20
10
0
% OF TIME
0–29
–34
–39
–44
–49
–54
–59
–64
–69
–100
% RH
%RH UP

APPENDIX D ENERCORP VS. PASSIVE SAMPLER HUMIDITY READINGS

UNIT 42

| Period | BASEMENT Absolute Humidity | T | Sampler R.H. | Enercorp R.H. | % Diff. * | SECOND FLOOR Absolute Humidity | T | Sampler R.H. | Enercorp R.H. | % Diff. * |
|---|---|---|---|---|---|---|---|---|---|---|
| Apr. 2-9 | .00508 | 18.1 | 39 | 42 | -7 | .00682 | 20.6 | 44 | 43 | +2 |
| May 8-15 | .00684 | 19.0 | 49 | 42.6 | +15 | .00640 | 21.3 | 40 | 43.3 | -7 |
| June 12-19 | .00710 | 19.4 | 50 | 59.6 | -16 | .00732 | 21.0 | 47 | 53.2 | -12 |
| Aug. 15-22 | .00939 | 22.4 | 55 | 68.5 | -20 | .00931 | 23.8 | 50 | 60.5 | -17 |
| Sept. 10-17 | .00735 | 21.4 | 45 | 59.7 | -25 | .00707 | 21.6 | 43 | 52.1 | -17 |
| Oct. 22-28 | .00585 | 20.0 | 40 | 50.6 | -21 | .00637 | 20.7 | 41 | 50.5 | -19 |
| Nov. 12-19 | .00559 | 20.0 | 38 | 46.8 | -19 | .00609 | 20.6 | 40 | 46.1 | -13 |
| Dec. 9-16 | .00388 | 18.6 | 29 | 34.0 | -15 | .00448 | 19.3 | 32 | 35.9 | -11 |

UNIT 44

| Period | BASEMENT Absolute Humidity | T | Sampler R.H. | Enercorp R.H. | % Diff. * | SECOND FLOOR Absolute Humidity | T | Sampler R.H. | Enercorp R.H. | % Diff * |
|---|---|---|---|---|---|---|---|---|---|---|
| Apr. 2-9 | .00544 | 21.0 | 35 | 39.5 | -11 | .00672 | 22.1 | 40 | 45.6 | -12 |
| May 8-15 | .00565 | 20.1 | 38 | 45.4 | -16 | .00721 | 22.2 | 42 | 50.1 | -16 |
| June 12-19 | .00809 | 20.1 | 55 | 63.6 | -13.5 | .00799 | 22.7 | 46 | 55.8 | -17 |
| Aug. 15-22 | .00916 | 22.3 | 54 | 67.9 | -20 | .00938 | 24.8 | 47 | 61.5 | -23 |
| Sept. 10-17 | .00694 | 20.3 | 46 | 58.5 | -21 | .00802 | 22.7 | 46 | 56.8 | -19 |
| Oct. 22-28 | .00593 | 19.6 | 41 | 50.8 | -19 | .00813 | 21.6 | 50 | 62.2 | -19 |
| Nov. 12-19 | .00606 | 22.7 | 35 | 42.1 | -17 | .00832 | 22.8 | 47 | 52.8 | -11 |
| Dec. 9-16 | .00449 | 23.1 | 25 | 31.2 | -19 | .00596 | 22.4 | 35 | 42.6 | -18 |

* $\frac{\text{P.S. - E}}{\text{E}} \times 100\%$