RESEARCH REPORT

Attic Ventilation and Moisture Control Strategies

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Attic Ventilation and Moisture Control Strategies
Final Report

Submitted to:
Don Fugler
Research Division
CMHC
700 Montreal Road
Ottawa, Ontario
K1A OP7

Submitted by:
Sheltair Scientific Ltd
#2-3661 West 4th Avenue
Vancouver, B.C.
V6R 2P1

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NOTE: **DISPONIBLE AUSSI EN FRANÇAIS SOUS LE TITRE:**

Stratégies de ventilation et de maîtrise de l'humidité pour les vides sous toit

CONTENTS

1.0 Background

This project is a continuation of research carried out by CMHC into the value of attic ventilation as a strategy for controlling moisture levels in attics. Past research by CMHC has included the development of air tightness and air change test procedures for attics (Sheltair[1] and BLP[2]), a survey of moisture levels in attics (BLP[3]), and the development and application of a computer model (ATTIX) for predicting moisture content of attics (Forest & Berg[4]).

While the national and provincial building codes require attic ventilation in all new houses, there is little understanding of the role played by ventilation in controlling attic moisture levels. Nor is there any flexibility in the code requirements in terms of adjusting ventilation to reflect housing styles, climatic zones, house construction or the presence of alternate moisture control strategies.

The results of the Forest/Berg analysis, based on the computer simulation model *ATTIX*, shows that in extreme climactic zones in Canada such as the prairie region attic ventilation may be prudent and the code specification of 1:300 is generally satisfactory. But in more moderate climates such as coastal climates, it predicts that the same code requirement tends to over ventilate attics resulting in elevated moisture levels.

2.0 Objective

The purpose of this study is to demonstrate the effect on moisture levels in attic spaces resulting from the elimination of all intentional attic roof ventilation in newly constructed houses in the Vancouver Lower Mainland and the Edmonton area.

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[1]Sheltair, **A Procedure for Determining Airtightness Characteristics of Attic Spaces**, for CMHC, 1989
[2]Buchan, Lawton, Parent, Ltd., Attic Air Change Testing: Protocol Development, for CMHC, 1989
[3]Buchan, Lawton, Parent Ltd., **Survey of Moisture Levels in Attics**, for CMHC, 1991
[4]Forest, Berg, **Simulations of Attic Ventilation and Moisture**, for CMHC, 1992

3.0 Methodology

The moisture levels in the attics of four newly constructed houses built with no intentional attic ventilation were monitored and compared to the moisture levels in the attics of four similar houses built with conventionally ventilated attic spaces (control houses). Four of the houses are in the Edmonton area and four are in the Vancouver Lower Mainland. Houses were monitored between the fall of 1996 until the spring of 1997 for attic moisture levels, and indoor and outdoor air temperatures and humidity levels. An air leakage test was performed on each house to measure the leakage rate between the attic and outdoors, between the attic and the house, and between the house and outdoors.

3.1 Moisture Level Measurements

Each of the eight houses was manually monitored once a month from September 1996 until March 1997. The temperature and humidity of the air inside the attic, inside the house, and outside the house was measured with a psychrometer. The moisture levels of the roof sheathing, roof truss members, and gable end walls were measured for north, south, east and west facing roof elevations using a hand held resistance measuring moisture meter. Measurements were taken at two different heights for each orientation, and each measurement was taken at two depths of penetration into the surface of the wood (3mm and 9mm). For each moisture reading, the temperature of the surface of the wood was also recorded using a hand held electronic thermometer. Moisture measurements were then corrected for variances in surface temperature. (Corrected to 22C) Detailed results of air temperatures, humidity levels, wood moisture levels and surface temperatures are listed in Appendix A.

3.2 Air Leakage Measurements

An air leakage test was performed on each attic following the method previously developed for CMHC entitled "A Procedure for Determining Airtightness Characteristics of Attic Spaces"[1]. In this procedure two blower fans are used to vary the pressure of the attic and the house. In the first test the attic is pressurised to +10 Pa and the house is held at 0 Pa by removing air from the house. The second test depressurises the house to 10 Pa and maintains the attic at 0 Pa. Each of the two tests measure the rate of leakage through the interface between the house and the attic. The results of the two tests are then averaged. The procedure also measures the rate of leakage between the attic and outdoors when the attic is pressurised to 10 Pa, as well as the rate of leakage into the house when the house is depressurised to -10 Pa.

3.3 House Descriptions

All houses were newly constructed over the summer of 1996. Each of the houses built with no attic ventilation was paired with a control house built by the same builder and which was as similar as possible in design and location. Control houses were constructed with attic ventilation as normally provided by the individual builders. The following is a short description of each house. Photographs and detailed data on each house is attached in Appendix B.

House V1

Location - Vancouver, BC
Design - Semi-detached, two story, basement, cedar siding and cedar shingle cladding, west facing, two parking garages in basement.
Roof - Each unit has a gable end roof with sections running both east-west and north-south, full attic, asphalt shingles, plywood sheathing. One unit is constructed with no attic venting and the other with soffit vents and roof vents.

House V1 Control

Location - Other half of semi detached house V1
Design - Same as V1
Roof - Same as V1 except built with soffit and roof vents.

House V2

Location - Langely, BC
Design - Single family R2000 house, two story, basement, brick cladding, north facing, double car garage on part of the first floor with living space above. Part of the house is one story plus basement (approximately one third), and the rest is two stories plus basement.
Roof - Hipped roof on four sides with gable end extension on part of north side, cedar shingles on heavy roofing felt and spruce strapping. The attic is separated into two sections, each with its own attic hatch. One attic is above the one story section of the house and the other is above the two story section. The attic above the one storey section butts against the wall of the two storey section and a small (approximately 1 ft^2) opening joins the two attics which has been well sealed with plastic. The attic above the two storey section of house has been constructed with no attic ventilation and the attic above the one storey section has typical soffit and roof vents.

House V2 Control

Location - Langely, BC, second attic of house V2
Design - Same as V2
Roof - Roof above single story section of house V2 with separate attic and constructed with typical soffit and roof vents.

House E1

Location - Edmonton Alberta

Design - Single family R2000 house, square, two story, basement, vinyl siding, attached garage.

Roof - Simple gable roof, asphalt shingles on 9mm OSB sheathing, full attic, constructed with no attic ventilation.

House E1 Control

Location - Edmonton Alberta, same street as E1, four doors down from E1 on the same side of the street, built by the same builder.

Design - Similar to E1 except not R2000.

Roof - Similar to E1 except constructed with typical soffit and roof vents.

House E2

Location - Edmonton, Alberta

Design - Single family house, rectangular, single storey, vaulted ceiling in dining room, basement, west facing, vinyl siding, no garage.

Roof - Simple gable roof, asphalt shingles on 9mm OSB sheathing, full attic, constructed with no attic ventilation.

House E2 Control

Location - Edmonton, Alberta, 3 km away from E2, built by same builder.

Design - Same as E2 except facing south instead of west, 10 sq. meters larger, flat ceiling instead of vaulted.

Roof - Same as E2 except constructed with typical soffit and roof vents.

4.0 Results

Detailed data sheets listing house, attic, and outdoor temperature and humidity levels; wood moisture levels of attic components; and notes on observations of moisture or frost accumulation are listed in Appendix A.

Attic Moisture Levels

As would be expected, the north facing sheathing of each attic was generally found to have the highest wood moisture level. The moisture level of north facing sheathing for Vancouver and Edmonton study houses and their corresponding control houses are plotted in Figure 1 and Figure 2 respectively. In pairs of houses in both Vancouver and Edmonton, one house built with no attic ventilation was found to be dryer than its corresponding control house, and the other was found to be wetter than its corresponding control house. Only the attics of one pair of Vancouver houses (V1 and V1 Control) were found to exhibit high wood moisture levels. North facing roof sheathing of house V1 Control reached a maximum moisture level of 30% moisture content in mid winter. The attic of its partner house V1, built with no attic ventilation, remained slightly dryer but also showed high moisture levels. The attics of all other Vancouver and Edmonton study and control houses remained relatively dry throughout the study period with moisture contents of north facing roof sheathing remaining below 19% moisture content in every case.

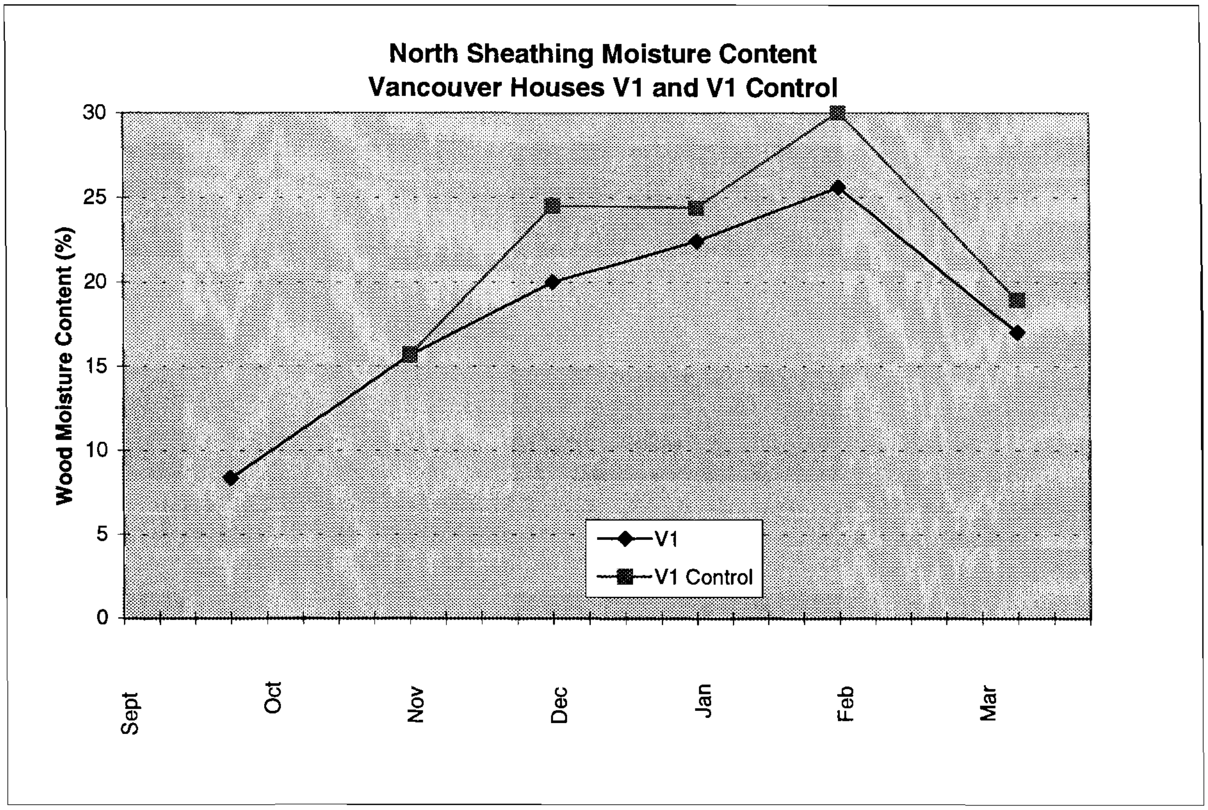
The moisture level of roof truss members in free air for Vancouver and Edmonton houses are plotted in Figure 3 and Figure 4 respectively. These plots show smaller differences in wood moisture levels between study houses and their corresponding control houses. They also show that the moisture content of truss members remained lower than that of north facing roof sheathing for most houses.

Plots of truss and north facing roof sheathing moisture content also show a general trend towards elevated attic moisture levels in mid winter, with this trend being much more pronounced for north facing roof sheathing.

Air Leakage Test Results

Results of air leakage testing for each house are presented in Table 1. The interface leakage results list the quantity of leakage between the attic and the house for each of these two tests in terms of flowrate, equivalent leakage area (ELA) and normalized leakage area (NLA). The NLA is the ELA divided by the area of ceiling between the house and the attic.

The attic leakage is the flow of air out of the attic when the attic is pressurised to +10 Pa and represents leakage due to any intentionally installed attic ventilation and non intentional attic leakage. Attic leakage rates listed do not include leakage through the attic to house interface.



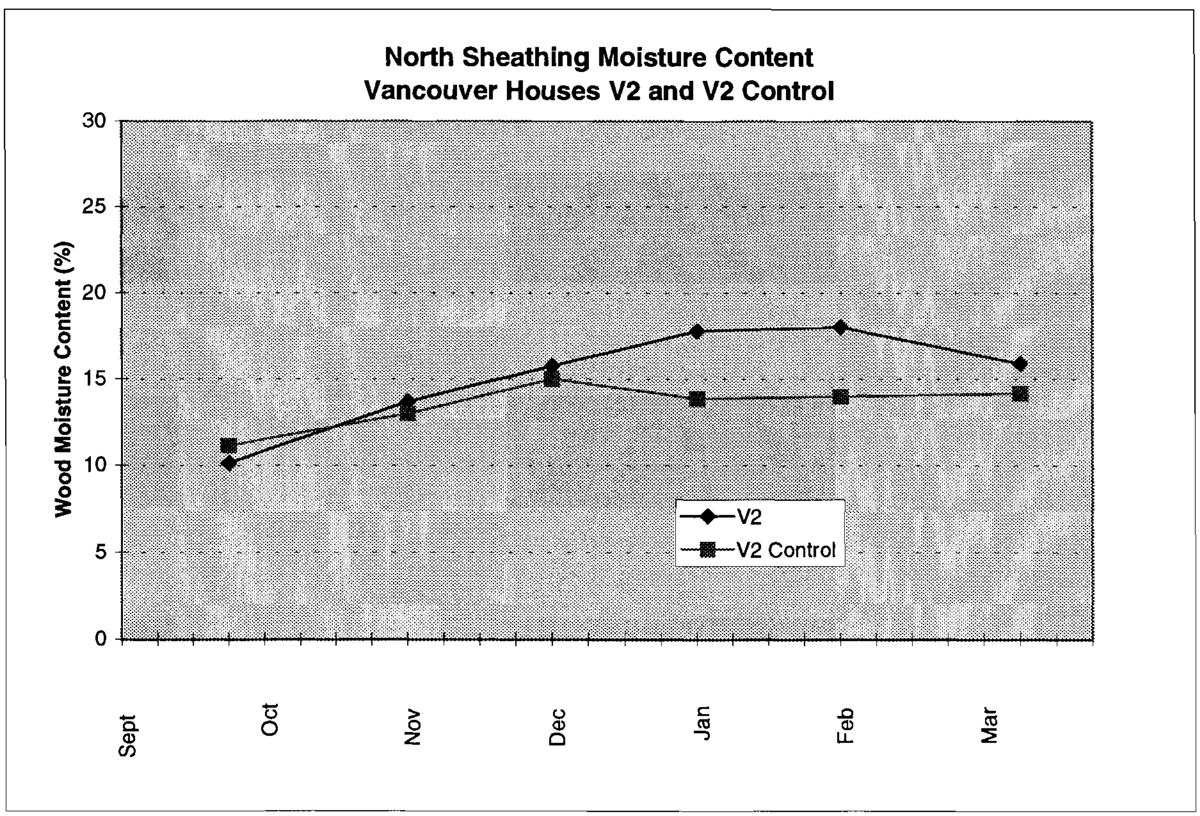
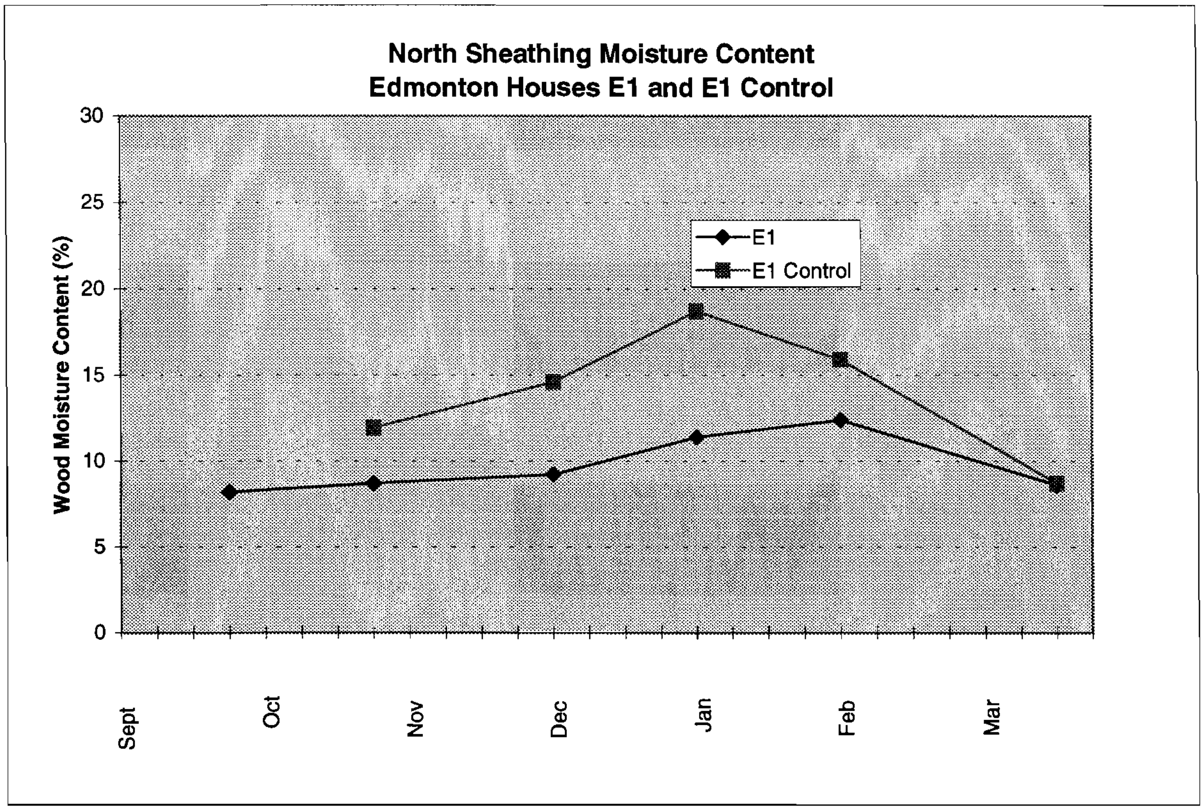


Figure 1 - Moisture Content of North Facing Roof Sheathing for Vancouver Houses



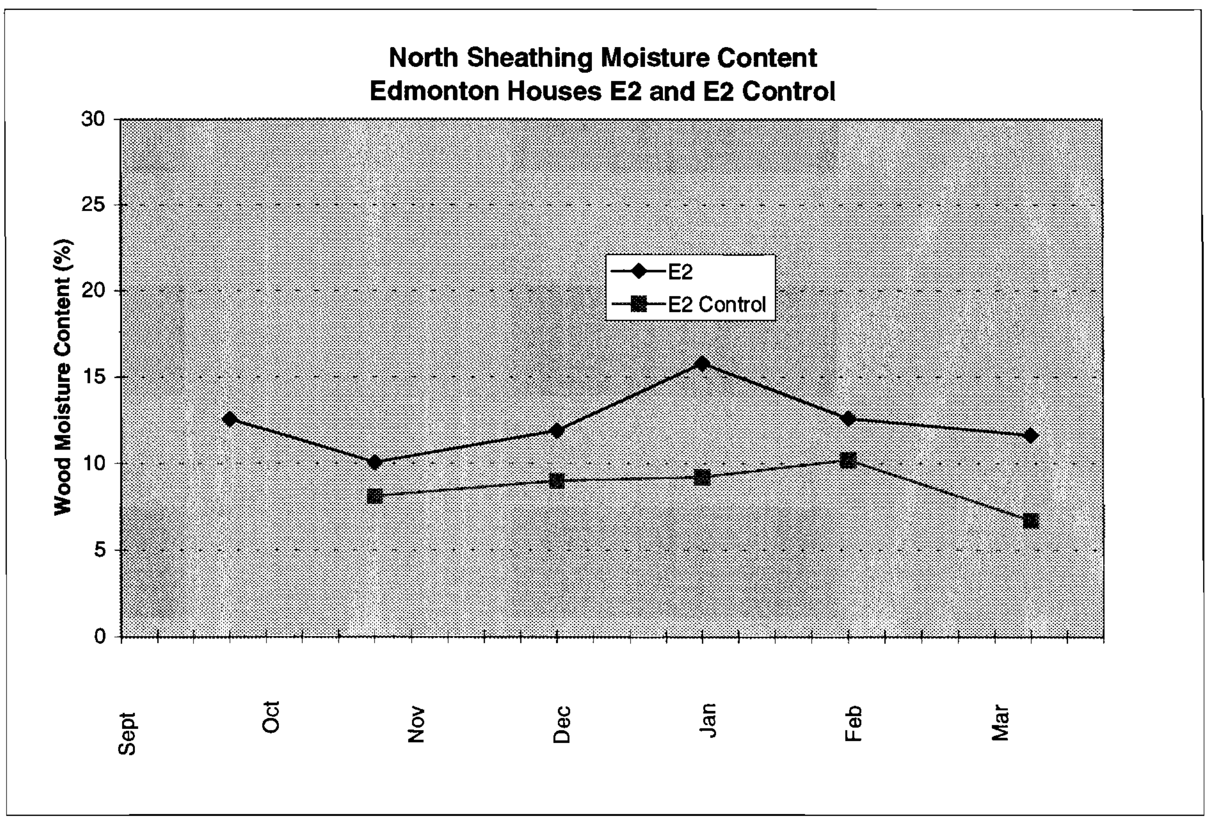
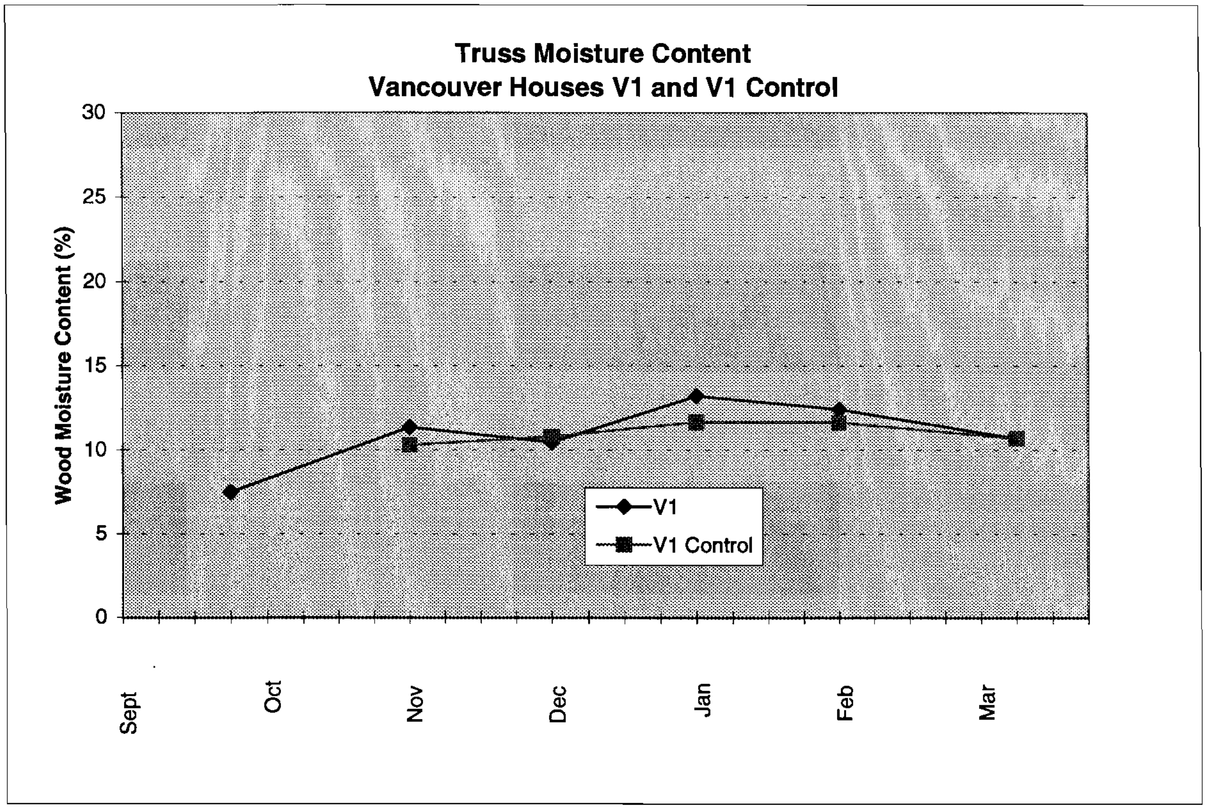


Figure 2 - Moisture Content of North Facing Roof Sheathing for Edmonton Houses



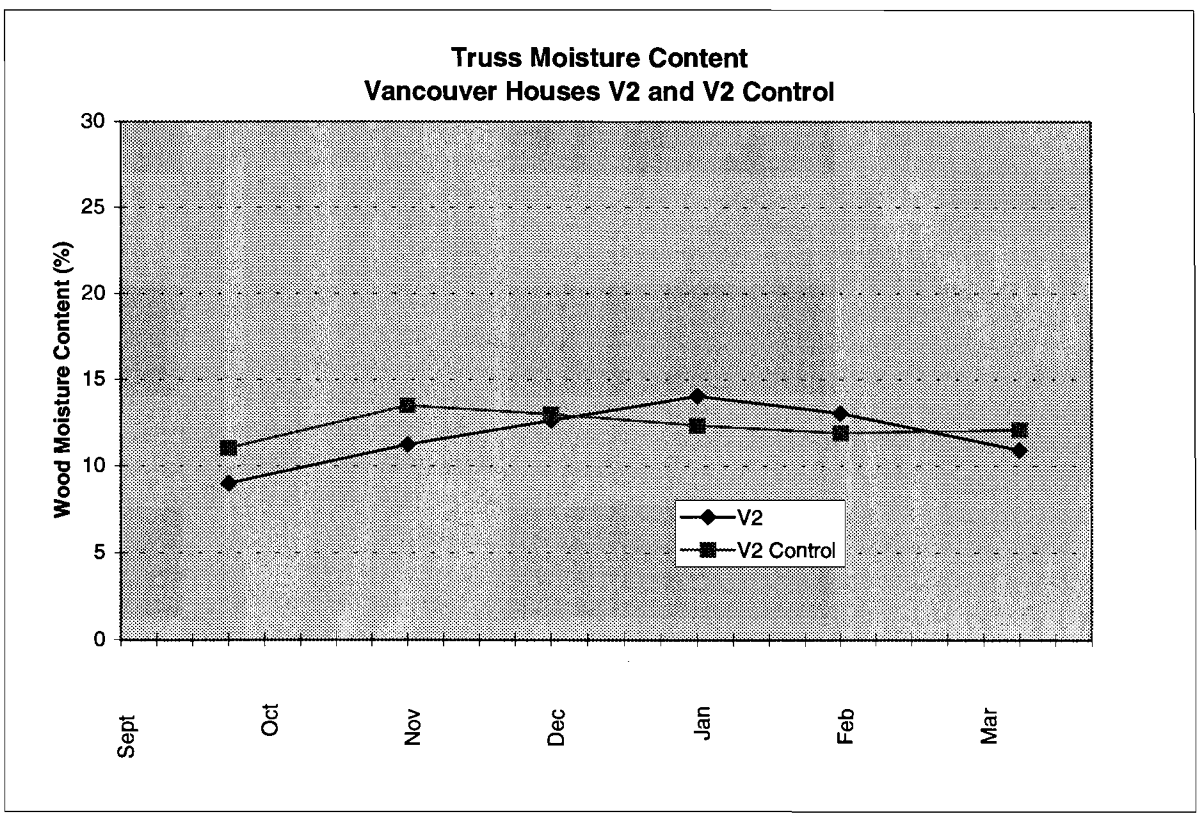
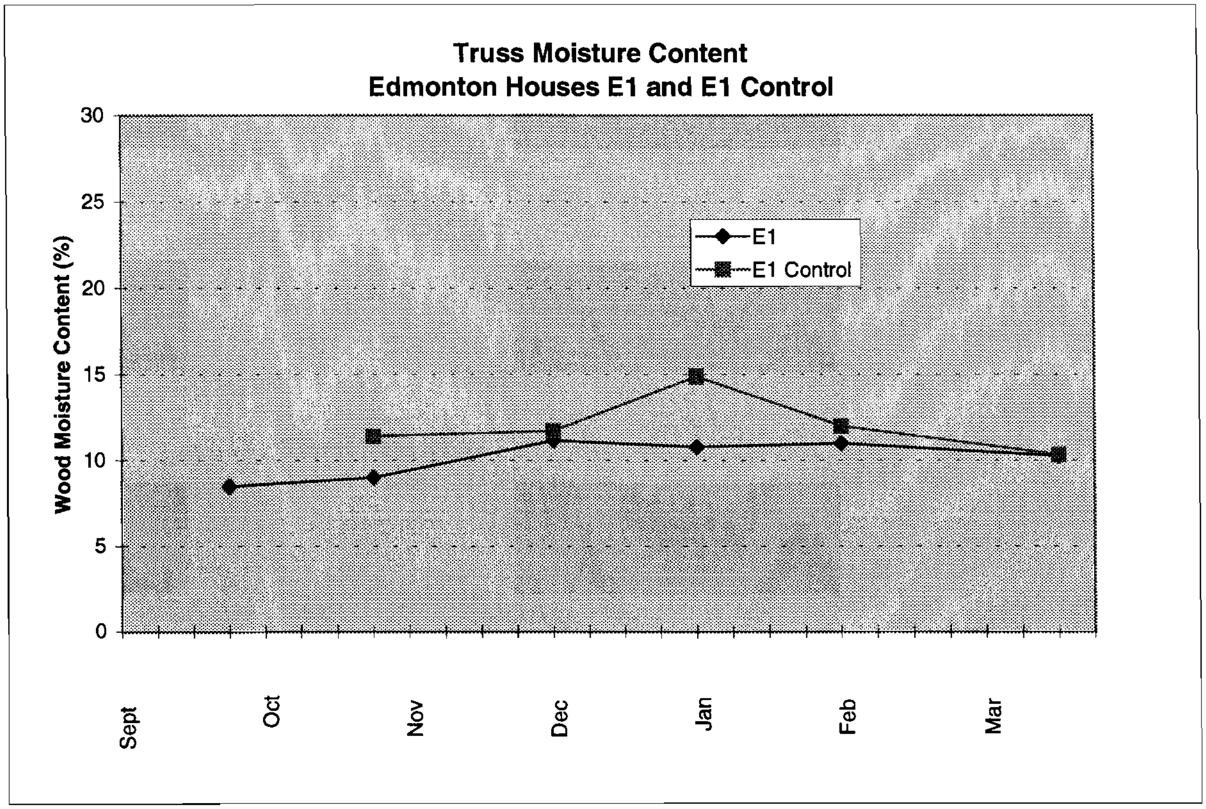


Figure 3 - Moisture Content of Attic Roof Truss Members for Vancouver Houses



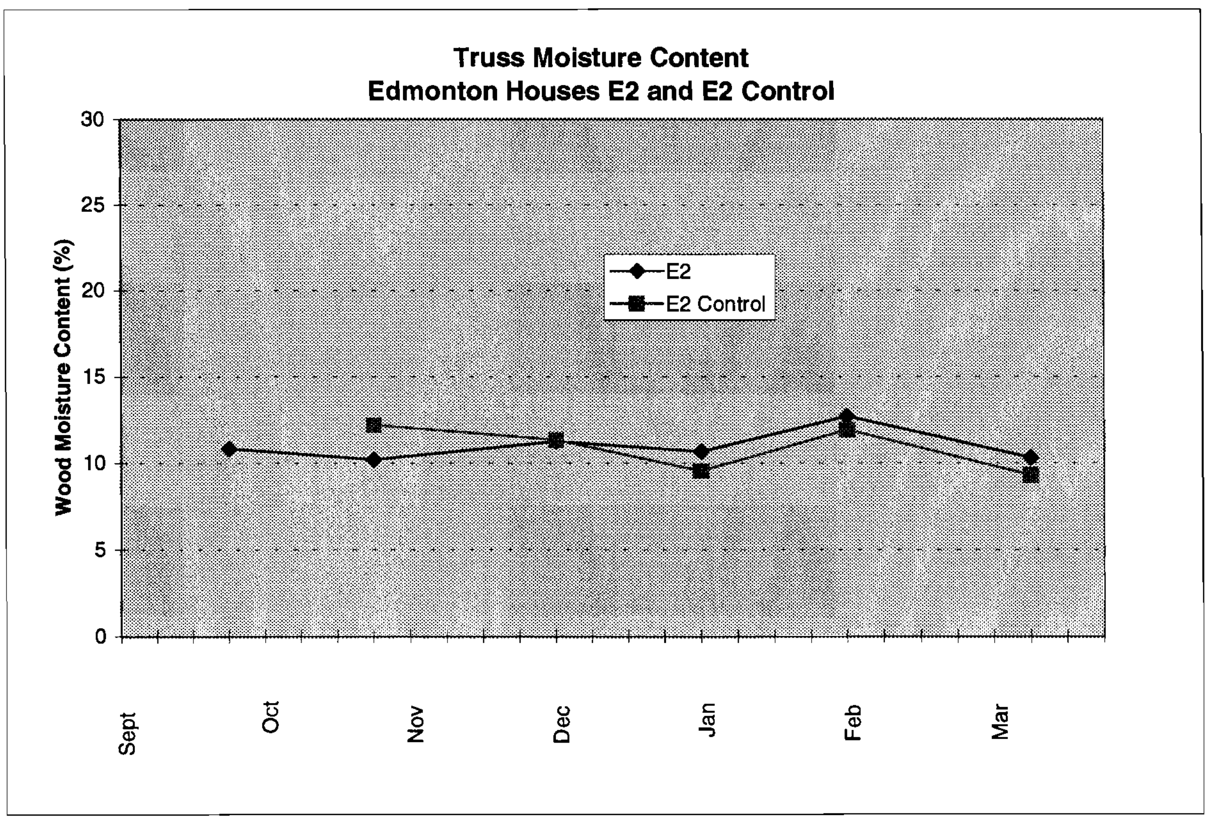


Figure 4 - Moisture Content of Attic Roof Truss Members for Edmonton Houses

House	Interface Leakage			Attic Leakage		House Leakage	
	Flow (L/s)	ELA (cm^2)	NLA (cm^2/m^2)	Flow (L/s)	Attic ACH	Flow (L/s)	House ACH
V1 Test #1	61	244.0	5.98	**158.8**	**11.10**		
V1 Test #2	63.4	253.6	6.22			**316.1**	**3.44**
Average	**62.2**	**248.8**	**6.10**				
V1 Control Test #1	47.5	190.0	4.66	**256.0**	**17.80**		
V1 Control Test #2	63.4	253.6	6.22			**312.5**	**3.37**
Average	**55.5**	**222.0**	**5.44**				
V2 Test #1	57.2	228.8	1.91	**800.6**	**14.35**		
V2 Test #2	121.8	487.2	4.07			**209.7**	**0.73**
Average	**89.5**	**358.0**	**2.99**				
V2 Control Test #1	34.8	139.2	3.34	**395.1**	**30.56**		
V2 Control Test #2	58.3	233.2	5.60			**207.8**	**0.72**
Average	**46.6**	**186.2**	**4.47**				
E1 Test #1	49.1	196.4	2.07	**551.8**	**16.10**		
E1 Test #2	88.5	354.0	3.72			**120.4**	**0.66**
Average	**68.8**	**275.2**	**2.89**				
E1 Control Test #1	37.8	151.2	1.69	**786.0**	**25.20**		
E1 Control Test #2	36.6	146.4	1.64			**203.0**	**1.03**
Average	**37.2**	**148.8**	**1.67**				
E2 Test #1	44.8	179.2	2.20	**351.0**	**18.60**		
E2 Test #2	29.9	119.6	1.47			**154.2**	**1.34**
Average	**37.4**	**149.4**	**1.84**				
E2 Control Test #1	**117.2**	**468.6**	**5.44**	**2410.0**	**88.70**		
E2 Control Test #2	(1)	(1)	(1)			(1)	(1)

(1) - Test #2 not completed. Attic was too leaky to notice any effect on attic pressure due to a change in house pressure.

Table 1 - Air Leakage Test Results

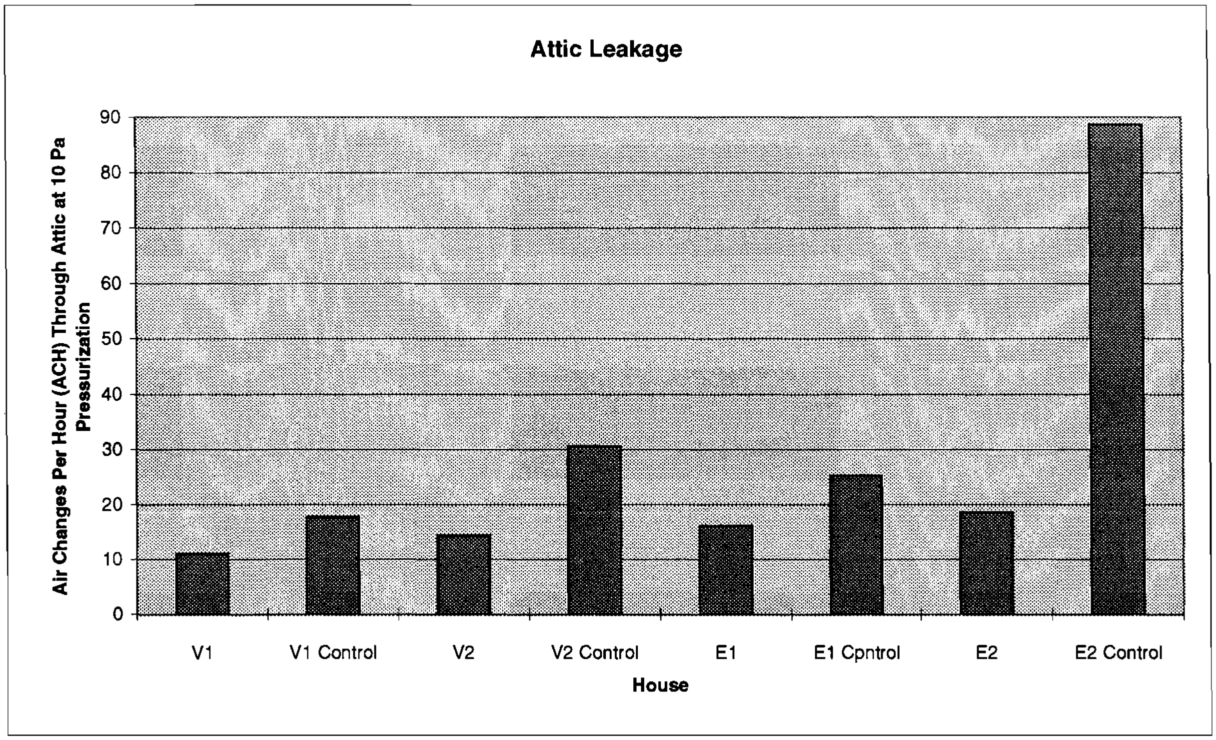


Figure 5 - Comparison of Attic Leakage Rates

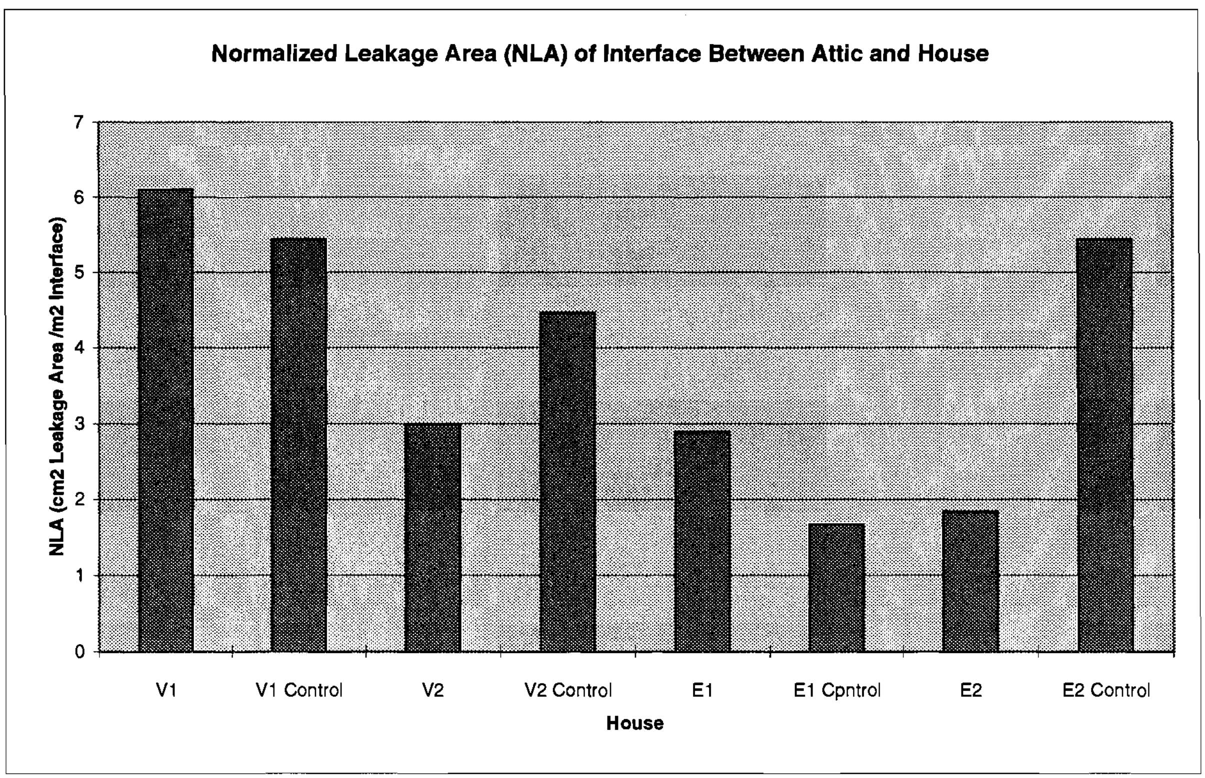


Figure 6 - Comparison of Interface Leakage Areas

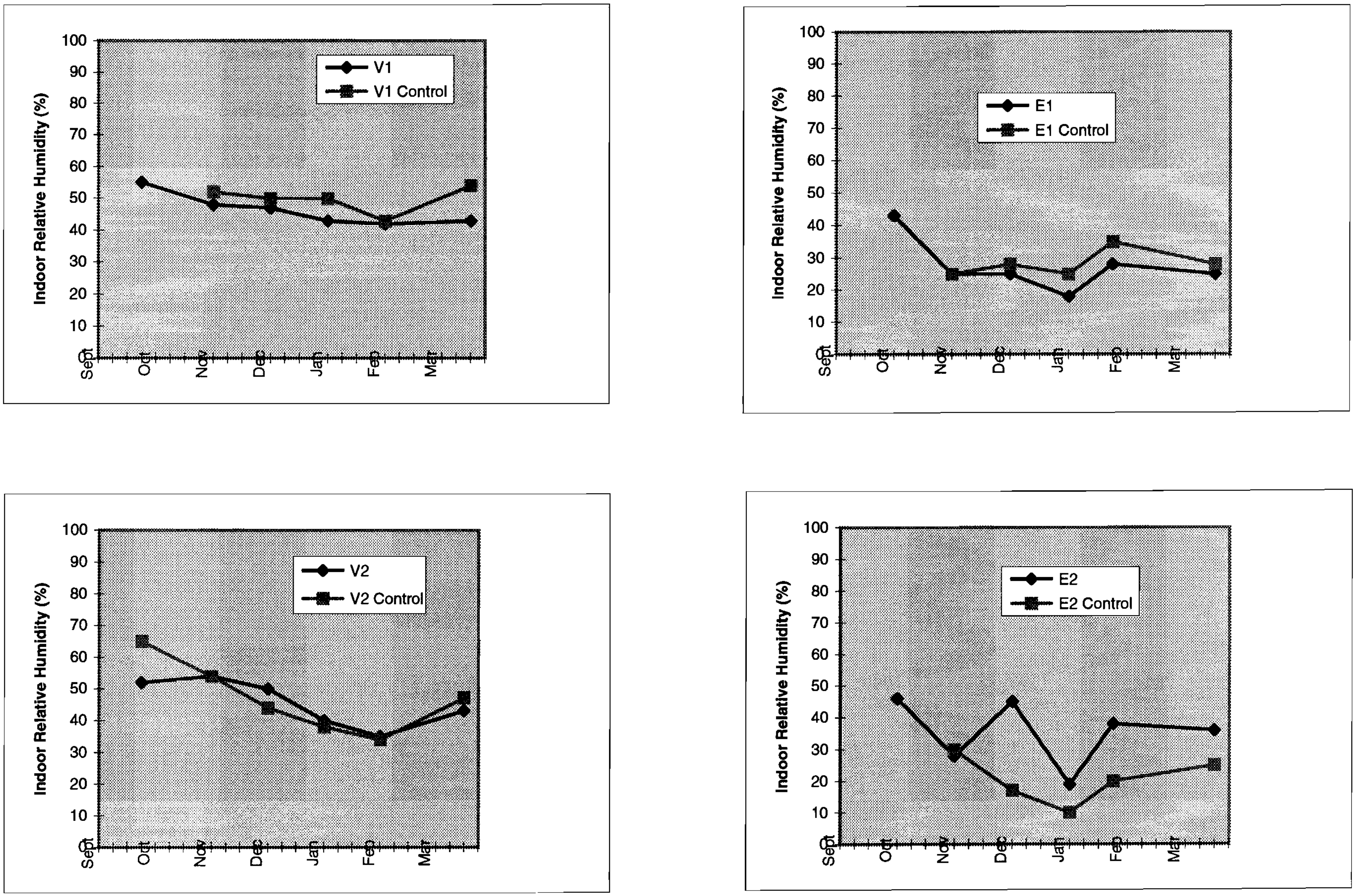


Figure 7 - House Indoor Relative Humidity

The house leakage is the quantity of air leaking into the house when the house is depressurized to -10 Pa and includes leakage through the attic to house interface. The number of air changes per hour (ACH) are calculated for both the attic and house leakage based on attic and house volumes respectively.

Attic Leakage

A comparison of attic leakage rates between houses is shown in Figure 5. The effect of the elimination of intentional attic ventilation reduces the attic leakage rate at 10 Pa pressurisation by from 36% to 79% for each pair of houses. As was discussed above, no definite trends were observed between attics with and without intentional attic ventilation and attic moisture levels.

Interface Leakage

A comparison of the interface leakage area for each house is shown in Figure 6. When interface NLA is compared to attic moisture levels in Figures 1 and 2 it can be seen that, for each pair of houses, the house which exhibited higher north sheathing moisture levels also had the tighter house to attic interface. However, a comparison of interface leakage to attic moisture levels for all eight houses does not indicate any general trend towards wetter or dryer attics.

Indoor Relative Humidity

A comparison of the indoor relative humidity for each study house and its corresponding control over the period of the study are plotted in Figure 7. When indoor relative humidity levels of houses are compared to plots of attic sheathing moisture levels it can be seen that for each pair of houses the house with wetter attic north sheathing levels also generally had higher indoor house relative humidity levels.

Frost and Condensation Observations

No condensation or frost was observed in any of the Vancouver houses. Three of the four Edmonton houses (E1, E1 Control, and E2) showed accumulation of frost on the inside of attic sheathing in midwinter but sheathing moisture levels were not greatly elevated.

5.0 Conclusions

The moisture levels in the attics of four houses built with no intentional attic ventilation were compared to the moisture levels in the attics of four similar control houses built with normal attic ventilation over one winter season. It was found that:

- The elimination of all intentional attic ventilation in the houses studied did not result in a trend towards either large reductions or elevations in wood moisture content of attic members in either Vancouver or Edmonton.
- Wood moisture content in attics generally peaked in January/February for both Vancouver and Edmonton.
- The moisture level in truss members was generally found to be lower than sheathing moisture levels.
- Houses with higher indoor relative humidity levels showed higher attic moisture levels irrespective of attic ventilation or of interface leakage rates.
- Differences in wood moisture content in attics was not found to relate directly to differences in interface leakage between the houses and attics.
- Frost accumulation was observed in some of the Edmonton houses. Wood moisture levels were found to remain low in these areas even with the presence of frost.