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NORTHERN VENTILATION PROJECT:
DATA COLLECTION AND REPORT
FOR IQALUIT, N.W.T.

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Prepared For:

Canada Mortgage & Housing Corporation
Rob Duncan, Project Manager
Ottawa, Ontario

Prepared By:

Ferguson, Simek, Clark
Engineers & Architects
P.O. Box 1777
Yellowknife, N.W.T.
X1A 2P4

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INTRODUCTION

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BACKGROUND AND ISSUES

In the high Arctic enviornment, whiteouts and snow laden winds are a common occurrence. The purpose of the Iqaluit project is to test the performance of several air-to-air heat exchangers from different manufacturers under such conditions.

Air-to-air heat exchangers are not widely accepted in the Arctic because of the typical low temperature operational problems as well as the problems of snow ingestion on the fresh air side. Considering that the new units constructed in the north are of generally tight construction, the apparent tightness of the building results in high humidity levels and condensation on cold surfaces, especially windows. The problem is so severe in some cases that doors freeze to their seals and damage is caused to windows and sills due to the condensation. The evolution of air-to-air heat exchangers is a direct result of the improved building skin technology.

The Iqaluit installation is such an example where the new structure had moisture problems and very high humidity levels during the first winter. The heat exchangers were installed in the project during the second year with the objective of understanding whether the air-to-air exchangers would keep the humidity levels reasonable regardless of other problems which could be encountered with respect to snow drifting and frosting.

The Iqaluit projcct is not designed as a clinical lab test of the exchangers. The intent is to obscrve the HRV's in an actual operating environment with emphasis placcd on how the exchanger behaves in relation to the environment over an extcndcd pcriod.

OBJECTIVES

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The objective is stated as follows:

-To evaluate the long term field performance of various air-to-air heat exchangers in typical housing units above the treeline in high wind and driven snow over a winter season.

DESIGN AND INSTALLATION

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SYSTEM DESCRIPTION

The Iqaluit project consists of a new four-plex with a common mechanical room in Iqaluit on an exposed site. This unit was constructed in 1986 and the experiment has designated the apartments as A, B, C and D. Each of the four-plex units is identical and the layout of the heat exchangers is addressed under the next section, Design Specifications. Intake and exhausts for the units were handled beneath the building and at the leaside walls where penetration through the crawlspace was impractical. The exchangers in the units are listed as follows:

Unit A: Life Breath heat recovery ventilator

Unit B: Van-EE heat recovery ventilator

Unit C: Air changer heat recovery ventilator

Unit D: Van-EE heat recovery ventilator

The existing boiler system for the four-plex consists of two boilers delivering heat via hydronic heating to all units. The only air change to these units besides natural infiltration are the HRV's. In order to establish a relative bench mark for building environment performance per dwelling, we installed humidity sensors in each unit in order to assess the relative performance of each unit over time. This approach is not perfect in that there are the possibilities of life style variations but the relative humidities over time and the rate of change of such humidity is used to determine the benefit of the HRV's.

DESIGN SPECIFICATIONS

The Iqaluit System was installed by a purchase order as a retrofit to an existing building. Local forces in Iqaluit were used, and the units were air freighted to the site from the suppliers. Drawing No. 1 of Appendix A outlines the Iqaluit setup.

MONITORING PACKAGE AND INSTRUMENTATION

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IQALUIT SYSTEM

The monitoring package includes Electronic Measuring Systems (EMS), to convert various transducer outputs to a digital form on an RS232 Bus, suitable for manipulation by a computer.

Output from the Electronic Measuring System is delivered to a modem module with buffer capability. The output is stored on hard disk and archived for the entire test period.

Software was developed to remotely control the Electronic Measuring System which is capable of measuring all types of transducer outputs. Multipliers and constants were incorporated into the program output for direct recording to disks.

To complement the data storage, a data analysis program was developed, which allows manipulation of the output data in any form desired, including statistical averages, instantaneous measurements, graphical output by minute, hour, day, average for month, year, or tabulated data for spreadsheet or database.

Flexibility in analysis of the output is a key element for this style of research as trends over specific periods are best viewed in graphical form initially, with subsequent statistical analysis through spreadsheets or other methods once the patterns are established.

The Iqaluit system also has stand-alone remote control and communications capability. This was done because of the high cost of continuous satellite transmission and the need to back-up the data (in real time) by placing a full time PC on site with the Electronic Measuring System.

The remote system handles all the tasks of data collecting project, and in addition, monitors the telephoe line for incoming calls. The system is set up in such a way to allow pass-word access codes to down-load files, look at data in real time, and to carry out administration and program upgrades on the system remotely. Files are down-loaded directly from Iqaluit and plotted on Auto-CAD to verify proper operation and control of the project in a totally remote context.

A list of the relevant equipment and sensors is included in Appendix No. 8.

SUMMARY OF DATA COLLECTION

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The data collection is summarized in Table 1 for December and January. In general, it can be said that the HRV's kept the relative humidity levels in the units quite low, in spite of the intermittent operation.

The Graphs are collected under the section "Graphs", and form part of the discussion under Engineering Analysis.

DATA ANALYSIS AND FINDINGS

DATA ANALYSIS AND FINDINGS

METHODOLOGY

The HRV's were located as shown in Appendix B. Engineering evaluation consisted of monitoring the units under varying conditions, from December, 1987 to May, 1988. Table 1 lists variables monitored by unit, cross referenced to Drawing No. 1 of Appendix A.

This field evaluation will focus on the physical performance of the ventilation options in moderate and severe Iqaluit conditions. For this purpose, the months of December, 1987 and January, 1988 were used.

ENERGY REQUIREMENTS

The total sensible energy rate requirements for the ventilation systems were calculated for each sampling as follows:

W(total)=K*Q(max)*(T(3)-T(1))

where:

W(total)=Watts (sensible) input required
Q(max)=Greater outflow/inflow from/to dwelling, CMS(Cu. Meters/Sec)
T(3)=Average dwelling temperature, Celsius
T(1)=Outside air temperature, Celsius
K=A dimensioned constant to account for the use of mixed units as recorded and calibrated by the transducers in the ducts.

For the above equation K=1207 Watts/CMS - Degrees Celsius for standard air.

The net sensible dwelling energy input for the four systems were calculated as the difference between recovered (sensible) heat and subsequent makeup by the dwelling to the average space temperature for each sampling as follows:

W(inc)=K*[Q(max)*(T(3)-T(1))-Q(s)*(T(2)-T(1))]

where:

w(inc)=Incremental watts (sensible) input required by dwelling
Q(max)=Greater of outflow/inflow to/from dwelling, CMS
Q(s)=Supply flow to unit, CMS
T(1)=Outside air temperature, Celsius
T(2)=Fresh air supply to dwelling, Celsius
T(3)=Average dwelling temperature, Celsius
K=A dimensioned constant to account for the use of the mixed units as recorded and calibrated by the transducers in the ducts.

For the above equation, K=1207 Watts/CMS - Degrees Celsius

Heat Recovery Performance

The performance of the HRV's were evluated in two ways using equations similar to those derived for laboratory evaluation. These are:

-Sensible Heat-Recovery Efficiency
-Apparent Effectivenss

Sensible Heat-Recovery Efficiency

In laboratory tests, sensible heat recovery is generally used to determine and compare HRV recovery performance. Sensible Heat Recovery Efficiency takes into account the total energy that must be added to the dwelling, including that associated with leakage through the envelope for which there is no heat recovery. Factors such as casing heat gains and cross leakage contamination which can be isolated in the lab, could not or were not measured in the field, and as such, interpretation of field results must take these factors into account. Second, laboratory tests are conducted under controlled constant supply and stale exhaust air temperatures and relative humidities. The temperatures and relative humidities in the field, however, are not constant and application of the standard performance equations then take into account this dynamic behaviour in the environment. Thus, caution must be taken when comparing field performance values to that measured in the lab.

The Sensible Heat-Recovery Efficiency is defined as follows:

$$E = \frac{M(s) * (T(3) - T(2))}{M(max) * (T(3) - T(1))}$$

where:

E is the Sensible Heat-Recovery Efficiency integrated over time.
M(s) is the supply air mass flow rate
T(3) is the average room temperature
T(2) is the supply air temperature after heat recovery
T(1) is the outside air temperature
M(max) is the greater of inflow or outflow mass flow rates.

The value can also be derived directly from the energy requirement analysis as follows:

$$E = \left(1 - \frac{(Winc)}{(Wtotal)}\right) * dt$$

Where Winc and Wtotal are defined.

Apparent Effectiveness

The apparent effectiveness is defined as follows:

> The ratio of actual heat transfer to the thermodynamically limited maximum heat transfer possible in a counter flow unit of infinite transfer area.

This value is generally used to evaluate the heat transfer medium (core) and predict final delivered temperatures.

As for Sensible Heat-Recovery Efficiency, the value measure in the lab is under controlled constant interior and exterior conditions. The results presented in this analysis reflect dynamic conditions, and thus should be interpreted in this context.

The apparent effectiveness is calculated as each measurement of temperature and flow are sampled by the system and converted to a watts rate recovery.

The formula used to calculate the effectiveness is as follows:

$$E = \frac{M(s)*(T1-T2)}{M(min)*(T1-T3)}$$

Where E= apparent heat effectiveness,

and:

T1= Fresh air temperature from outside entering HRV
T2= Fresh air temperature to dwelling leaving HRV
T3= Stale air temperature from dwelling to HRV
M(s)= Air mass flow rate of supply
M(min)= The lesser of supply or exhaust mass flow rate

Cross Leakage

Cross leakage introduces a practical unknown that exceeds the error introduced by sensible versus total effectivenss. Application of the above formula may give an incorrect apparent effectivenss for the unit under such circumstances. This caution is included as flow measurements were based on the fans supply (and/or exhaust) flows to/from the dwelling side due to unreliability of the hall effect flow transducers at low temperatures, and not absolute supply and exhaust quantities to the outside.

Duct Gains

Duct gains is the energy absorbed by the air flowing in the duct from the surrounding air. The greater the temperature difference between the inner and outer air the greater the rate of energy absorbtion by the colder air. The impact of these gains would be that the efficiency of the HRV would appear lower than in actuality.

Flow Volume Corrections

The flow volumes were adjusted for calculation purposes to account for mass/volume (density) variances at the wide temperature ranges of our recorded data. To trend the density effect reasonably for the overall experiment so that standard K (constant density) could be used, the volume flow was corrected to T(3), the warmer temperature. For example, if measured at the temperature T(2), the equation would be:

Qmax (T(3) = Qmax(T2) x T(3)/T(2)

where:

Q(T3)= Volume flow corrected to T(3) (near standard)
Q(T2)= Volume flow recorded at T(2), outside temperature
T(3) = Near standard temperature (house side of system)
T(2) = Temperature at which flow volume Q(T2) is measured

Because the above equation is ration based, any unit group may be used, as long as they are consistent on both sides of the equation.

Comparative Performance

For a final comparative analysis, extrapolation of the calculations and computer derived output was adjusted to a fixed air change in order to assess long term operating costs of the alternatives.

For purposes of comparison, the relationship:

W-Hr net/ac/d = (W*Vol/Mah)/(Tda - Toa)

where:

W-Hr net/ac/d = net Watt-hours/air change added by dwelling based on temperature difference between Toa and Tda
W = Watt average net input by dwelling system for the air change
Vol = Mass of dwelling air volume
Tda = Average dwelling temperature for the air change
Toa = Average outside temperature for the air change
Mah = Average mass of air/hr brought into dwelling for the air change

All of the formula calculations were handled by the computer as part of a global iteration process on the databases. The nth iterative delta-time was calculated as an average lapse of all the sensors measured (for the equation) since the n-1 iteration. This appraoch worked well for the warmer outside temperatures (above -10C), but is less accurate for the lower temperatures as the HRV's cycled at a defrost frequency that was of a lower order than the sampling time for the system to collect all the variables. Graphs 3, 4, 7, and 8 of HRV activity point out the problem. Therefore, the efficiencies as iterated for the lower temperatures may be less reliable than those calculated for the warmer outside air temperatures (above -10C).

ENGINEERING PERFORMANCE

The data summary of Table 1 is included for the months of December and January, which were considered representative of Iqaluit winter conditions. Each sensor and channel is listed for cross reference purposes to Drawing 1 of Appendix A. The data is based on collection done over the period in question.

Graph 1 displays the apparent effectiveness of each unit for December and January. It should be noted that the apparent effectivesness is calculated by the computer over the period under all operating conditions including ice build up, loss of flow through snow ingestion on the fresh air side or very low operating volumes and back flow conditions resulting from high winds. Graphs 2 and 3 indicate the mean supply temperature to each unit by day for December and January respectively. As can be seen, the units indicate a supply temperature varied considerably after mid December when the units were run at either low velocity or were shut off until January 11th, where all units were operating through to the end of January, with the exception of the Air Changer and Life Breath units, which were stopped after January 25th. Both the Life Breath and Air Changer averaged the higher apparent effectiveness over the two months as compared to the Van-EE units. The Van-EE units had sidwall fresh air intakes versus the below soffit intakes of the Air Changer and Life Breath Units, which performed better from a snow ingestion point of view. The Van-EE unit in Unit B did not perform it's defrost cycle as well as in Unit D.

Graph 1 also displays the mean relative humidities by unit for December and January. All units appeared to have low relative humidities during the January period with only Unit B displaying an average relative humidity of 30% in December. This unit was off for the latter part of December and the relative humidity reflects that fact. In all cases, the HRV's were able to maintain very low relative humidities even with the varying volume states of operation and the shutting off of the units. In conjunction with the unit operation were the icing up of the units on the exhaust sides below -20 Degrees Celsius, and the problem of solid snow blockage of the fresh air filters and intake side of the system. Graphs 4 and 5 show the day by day relative humidity fluctuation by unit. It should be noted that each of these units at high volumes were capable at producing 0.8 air changes per hour at maximum setting and running continuously.

The units used for this experiment suffered the previous year from excess humidity levels and it is clear that the HRV's are capable of controlling such humidity levels in spite of the problems of frosting and snow ingestion.

Energy Requirements

The energy requirements of these units are based on watt hours per air change per degree. For the Iqaluit project, these values were interpolated from mean operating conditions of the units and extrapolated defrost cycles. Due to the fact that the operation was not coninuous, it was necessary to evaluate the data in this way. The Van-EE units were calculated to use 34 and 27 watt hours per air change per degree against the Life Breath, which appeared to use 22 watt hours per air change per degree.

To glimpse a compiled operation comparison of the units, we have included Graphs 6, 7, 8 and 9 for each of the units. The graphs have been deliberately split low/high for a comparison of operation under different outside air conditions. Recognize that this is a compiled chart and that the frequencies are not as rapid as those which occur in real time. For a real time view of such cycling, the Northern Ventilation Project Data Collection Report of Yellowknife should read.

CONSTRUCTABLILITY

All of the units involved in the Iqaluit project proved to be straightforward to install. Considering that a retrofit was required to accommodate the units, we see no problem in including such units technically in typical housing as constructed above grade in the Arctic. All installation were carried out by local forces, and there were no problems encountered in the retrofit.

COST ANALYSIS

The cost to install the air-to-air heat exchangers did not vary significantly from manufacturer to manufacturer. Considering the logistical components required to construct in Iqaluit, the installation price per unit was $2,300.00 based on typical trades prices one finds in Iqaluit.

RELIABILITY

Units performed reasonably up to -15 Degrees Celsius. At this point, the units spent more time in defrost cycles.

During a two day blizzard whiteout in Iqaluit, the wall mounted intakes were blocked on the fresh air side of the exchanger. THese HRV's were not able to defrost themselves and were blocked three days after the storm (see photos of typical blockage). The intakes for the units located on the under side of the building worked better and were not observed to have been fully blocked.

The reliability of the units in a whiteout environment where entrained snow is highly concentrated is a problem.

MARKET ANALYSIS

The final value of the air-to-air heat exchanger tested in the eastern Arctic with respect to marketability is not a simple one to answer. While it is apparent that the units kept the humidity low in each apartment, (regardless of the brand) the problem of blocked intakes is of concern.

The HRV's did keep the environment acceptable in units that had a previously poor history of condensation. Considering the low level of maintenance in many communities, it is doubtful whether people would operate the units on the proper speeds using the proper adjustments for seasonal consideration. Such an approach requires enthusiasm and dedication. In addition, the frost and defrost cycle lowers the efficiency of the units at the lower temperatures encountered, although the units still managed to carry out the role of dehumidification for the unit (see Graphs 6 through 9).

For problems in the eastern Arctic which relate to condensation and tight buildings, the unit HRV's have a marketability subject to further research on intakes which can act as self purging filters or particle separators. To demonstrate the wind blown snow considerations, we have included some photographs of Iqaluit.

OTHER RELEVANT FINDINGS

It was noted throughout the sampling period that the occupants of this particular four-plex continually opened their windows. This may have been a carry over from their previous year's experience with condensation. On the other hand, all tenants complainted at one point or another that the units were nosiy and drafty, and requested that they be shut off. In many cases we tried reducing volumes, but the correlation was not definitive between volumes and complaints.

With the units shut down, there were no real short term differences in the relative humidity averages over time. This was somewhat puzzling and invites further investigation. The building and furnishigs have a certain capacitance to absorb moisture once the relative humidity has been forced low.

One element identified (the open window syndrome) was no doublt a contributing factor, while other potential explanations come to mind:

We investigated other projects where condensation occurred during the first year of construction and in subsequent years did not reoccur. Investigation revealted that the wood fram building components tended to dry and shrink somewaht thereby "lossening up" the structure for subsequent years. In such cases, there had been recommendations to install air-to-air heat exchanger during that first living cycle. Whe this did not occur, the problem appears to have receded (from the occupants point of view).

There may be a correlation between new construction, moist drywall mud, green lumber and tight building which results in high humidity in the first part of the life cycle. If the structure does loosen up over time, then the required 0.3 to 0.5 air changes may come about naturally. In the Arctic context, it appears that high wind chill factors, cold temperatures and stack effect contribute to increased air changes. As wll, the dryer climate may contribute over time to the loosening of the structure.

In the case of units which have high condensation levels in winter, coupled with the higher humidities of southern summer, the structure may not be capable of drying out on its own. However, once the process has comenced in the winter season, it may be self starting from a natural cycle point of view. As the data shows for Iqaluit, there is no real difference in the humidity levels in the environment over time regardless of the flow rates or cycling of the heat exchanger, or whether the units are off or on.

RECOMMENDATIONS AND CONCLUSIONS

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RECOMMENDATIONS

1. It is recommended that a competent research agency address the problem of self cleaning partical separators for the intakes to air-to-air heat exchanger if they are to be used in an eastern Arctic environment.
2. It is recommended that a season by season alternate study be carried out on the Iqaluit four-plex to assess the long term effects of mechanical HRV's versus infiltration in buildings as they age. Since Iqaluit is operational, it would be possible to continue that operation for minor costs given that there are no equipment failures which would result in logistical trips to the site.

3. It is recommended that research be done into the aging of wood dwellings from a tightness point of view.

CONCLUSIONS

It is concluded that all HRV"s currently manufactured and tested under this project deteriorate in performance beyond -20 Degrees Celsius.

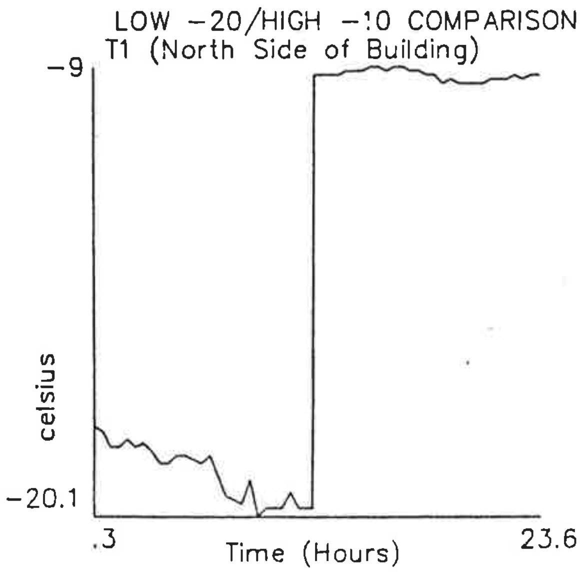
It is concluded that work must be done on the fresh air intakes of HRV's to be used in the eastern Arctic to separate snow particles in a self cleaning fashion if the units are to be widely applied in a consumer market.

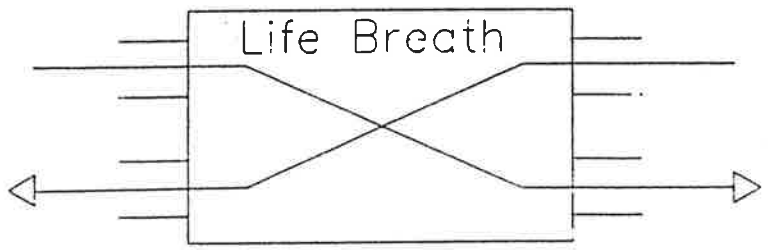
It is concluded that HRV's in a high Arctic environment do reduce the levels of relative humidity in dwellings, regardless of the operational problems.

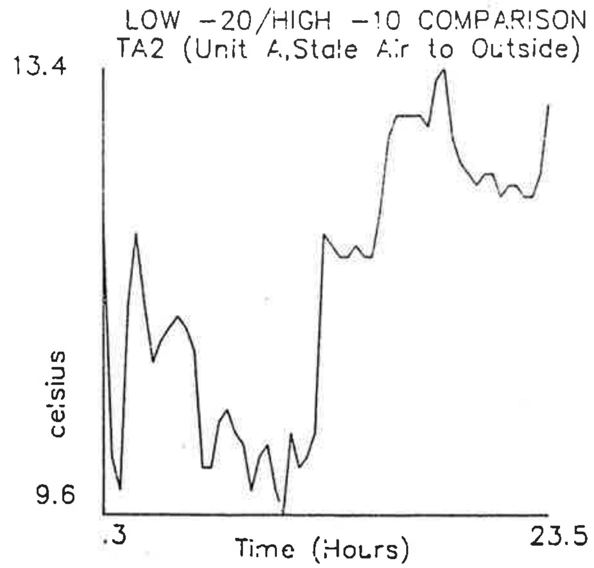
GRAPHS

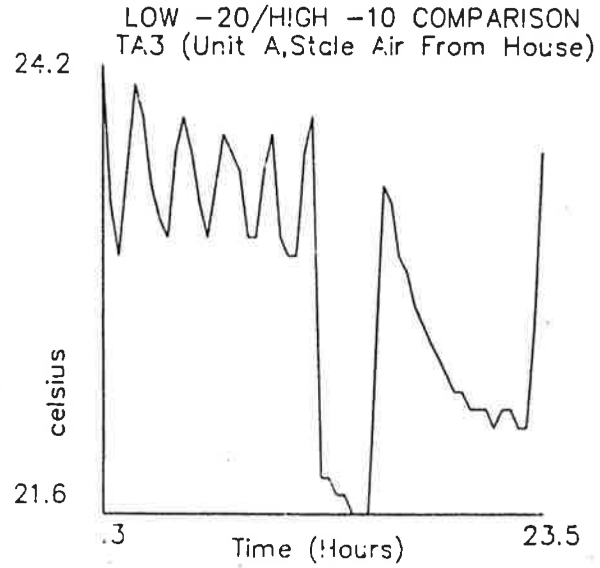
ATTACHMENTS

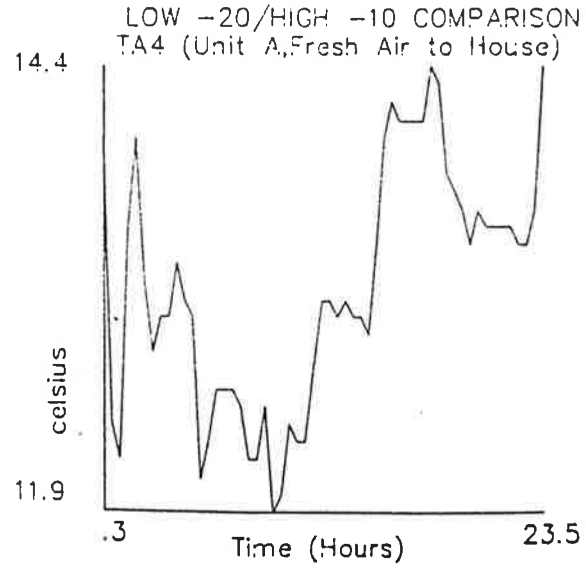
LOW -20/HIGH -10 COMPARISON

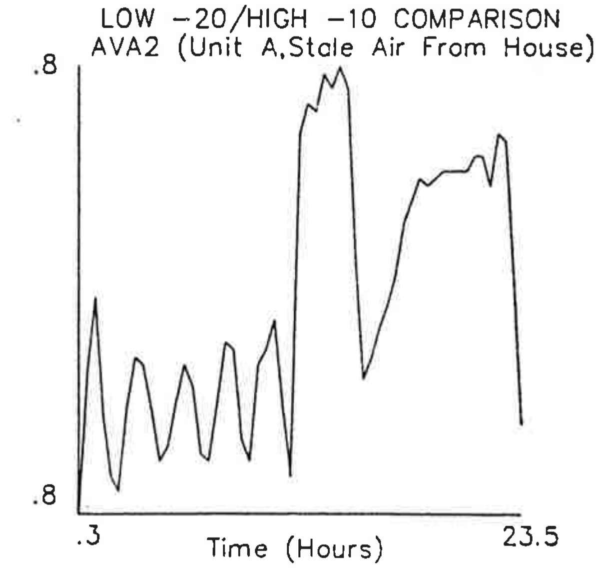


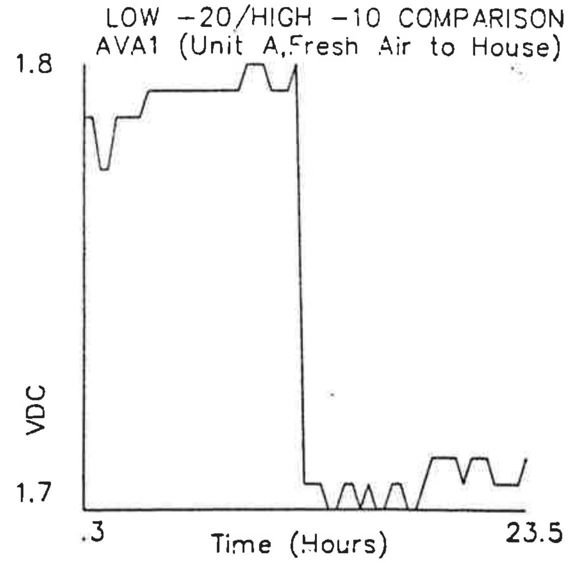






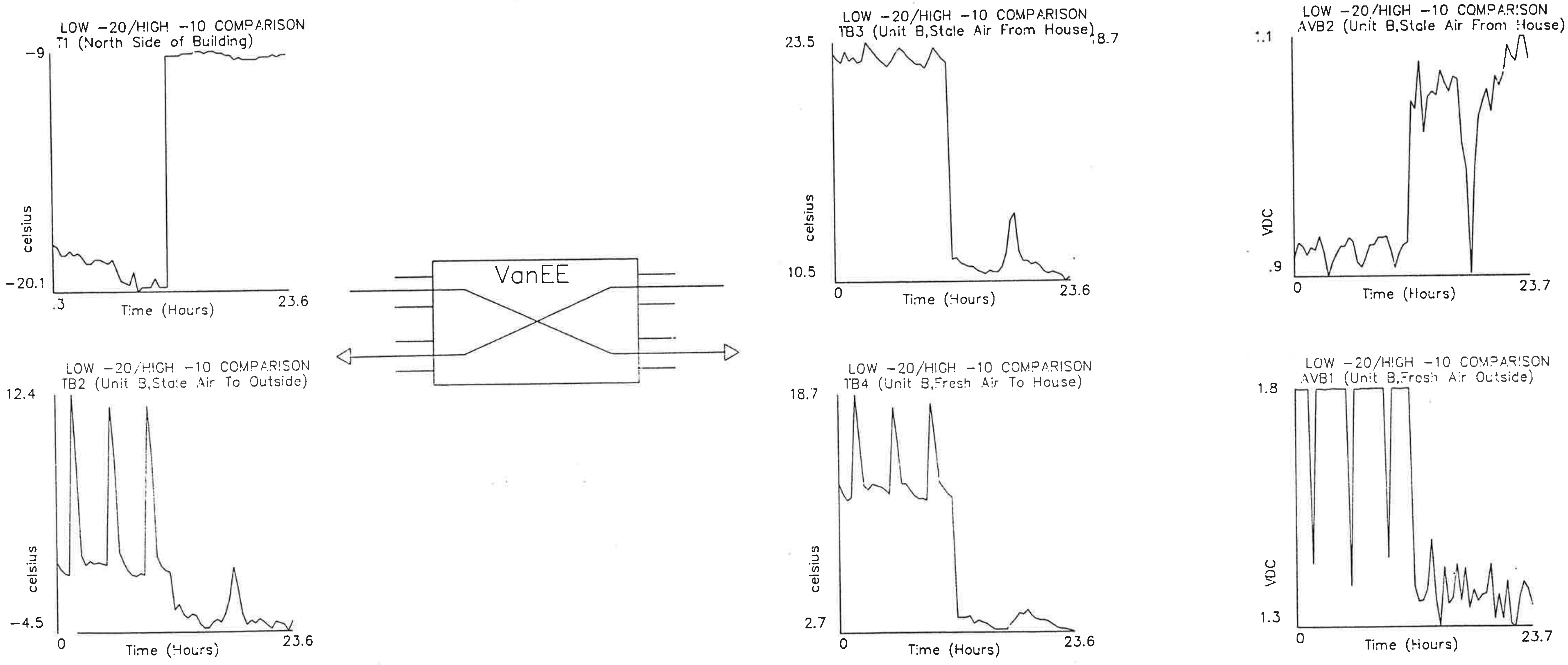






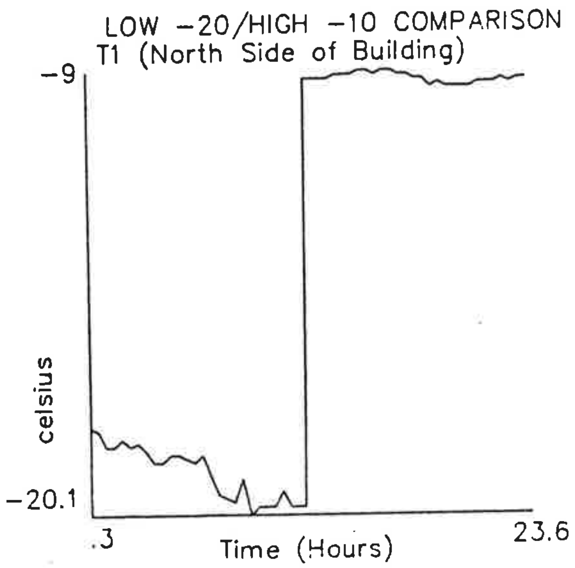
Graph 6

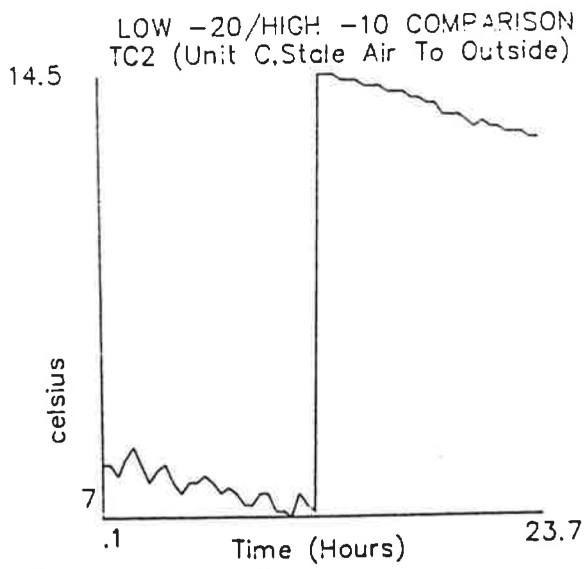
LOW -20/HIGH -10 COMPARISON

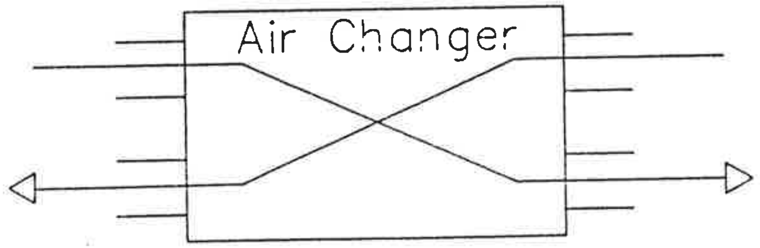


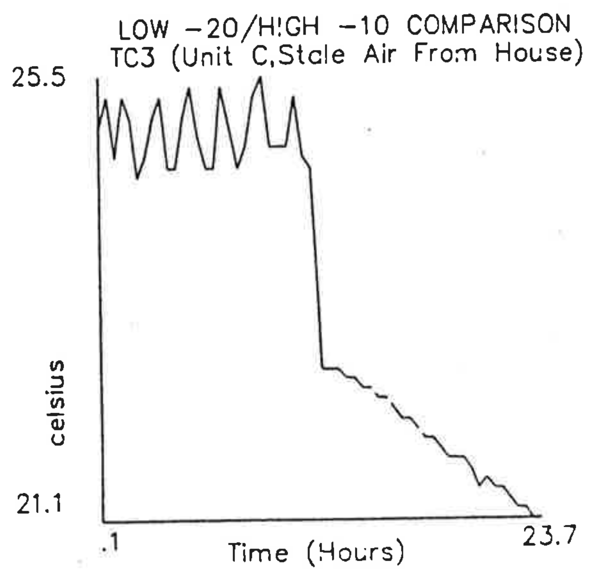
Graph 7

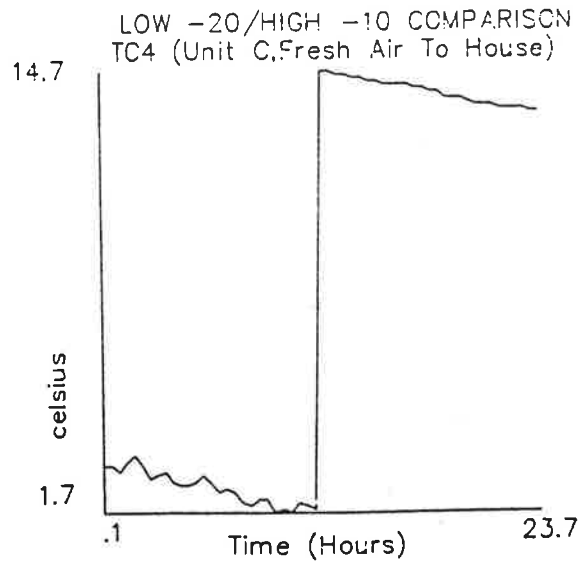
LOW −20/HIGH −10 COMPARISON

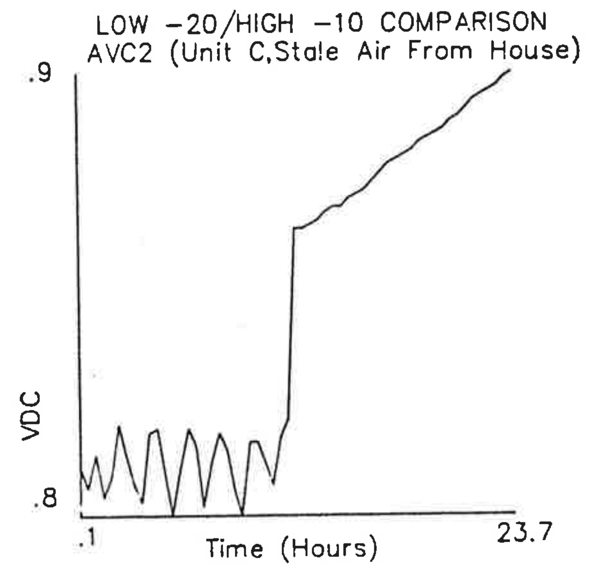


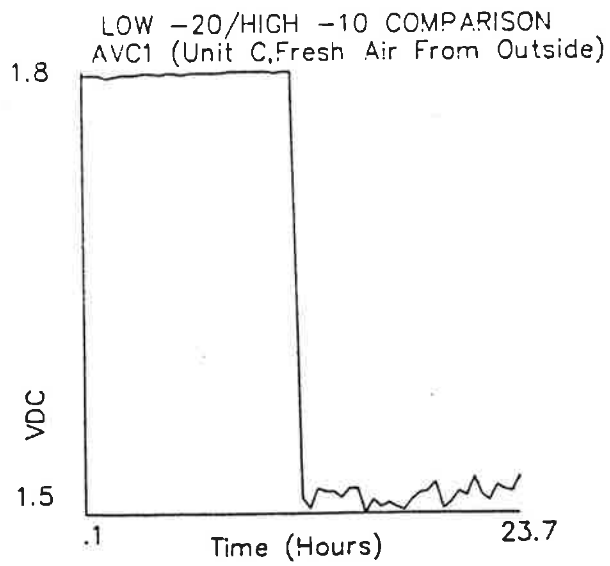






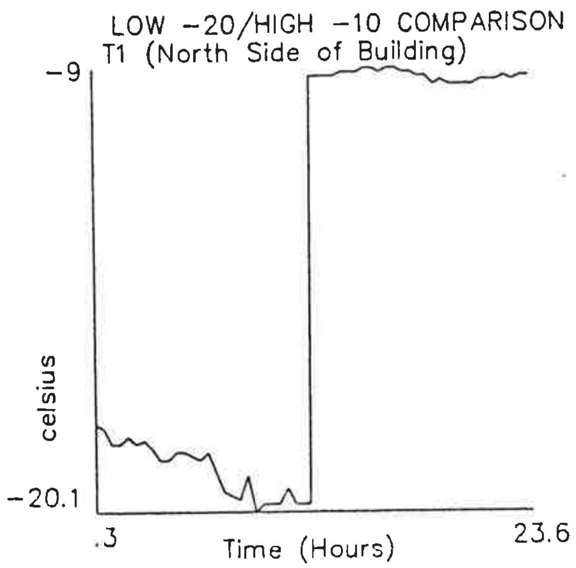


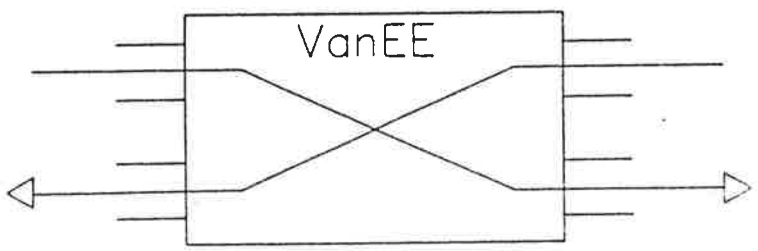


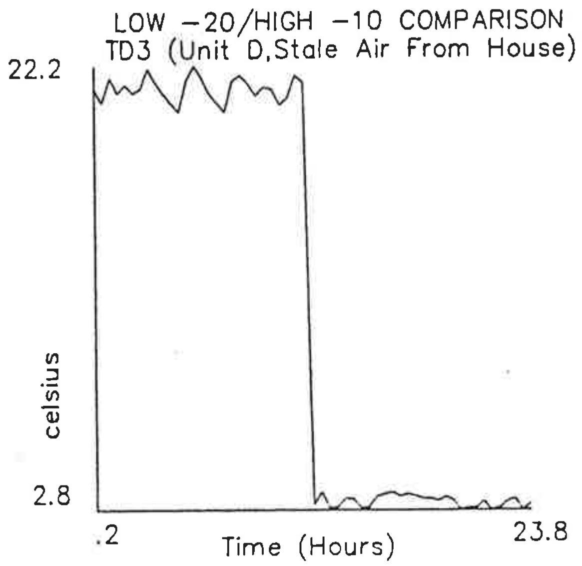


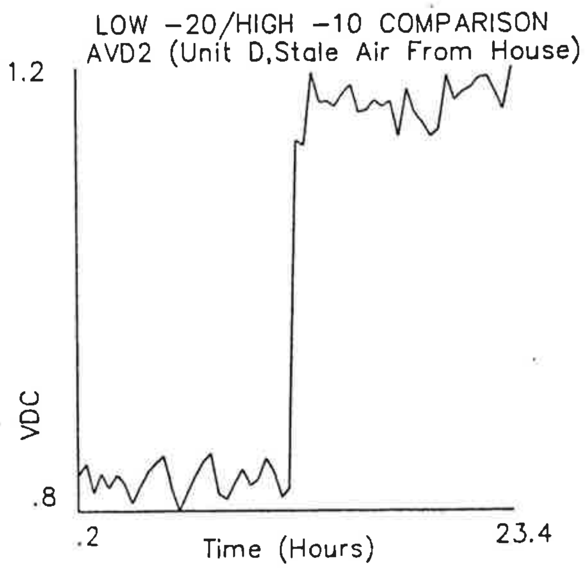
Graph 8

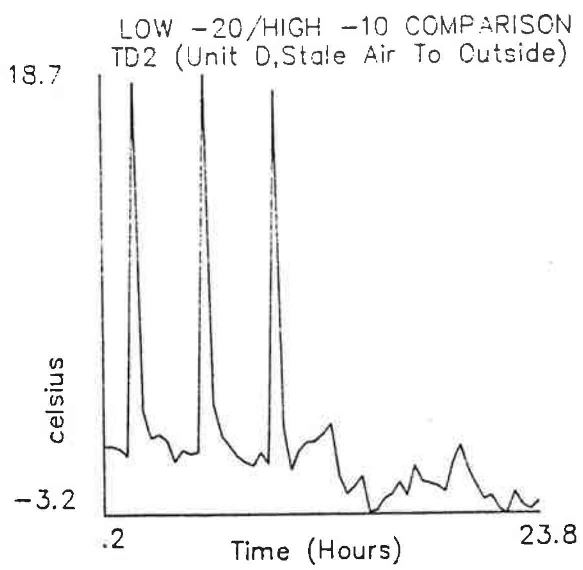
LOW -20/HIGH -10 COMPARISON

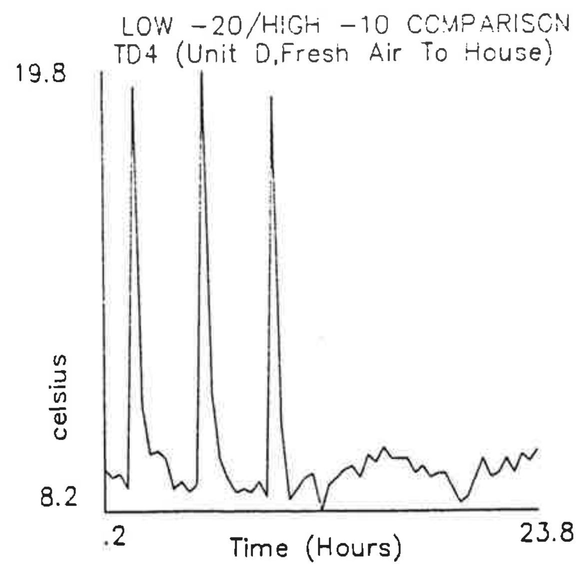


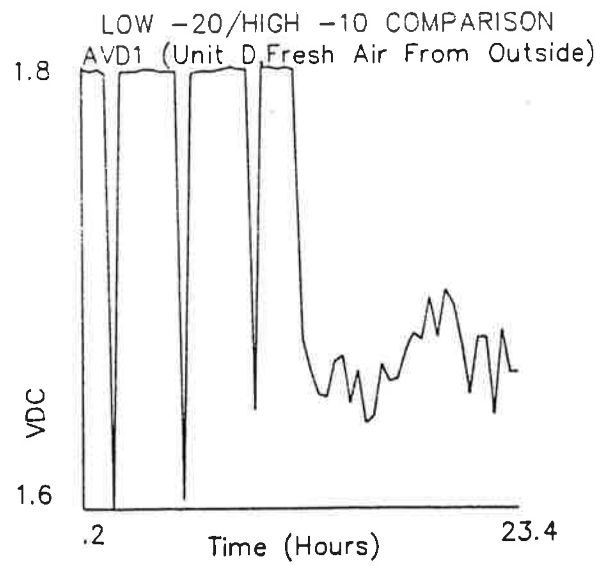




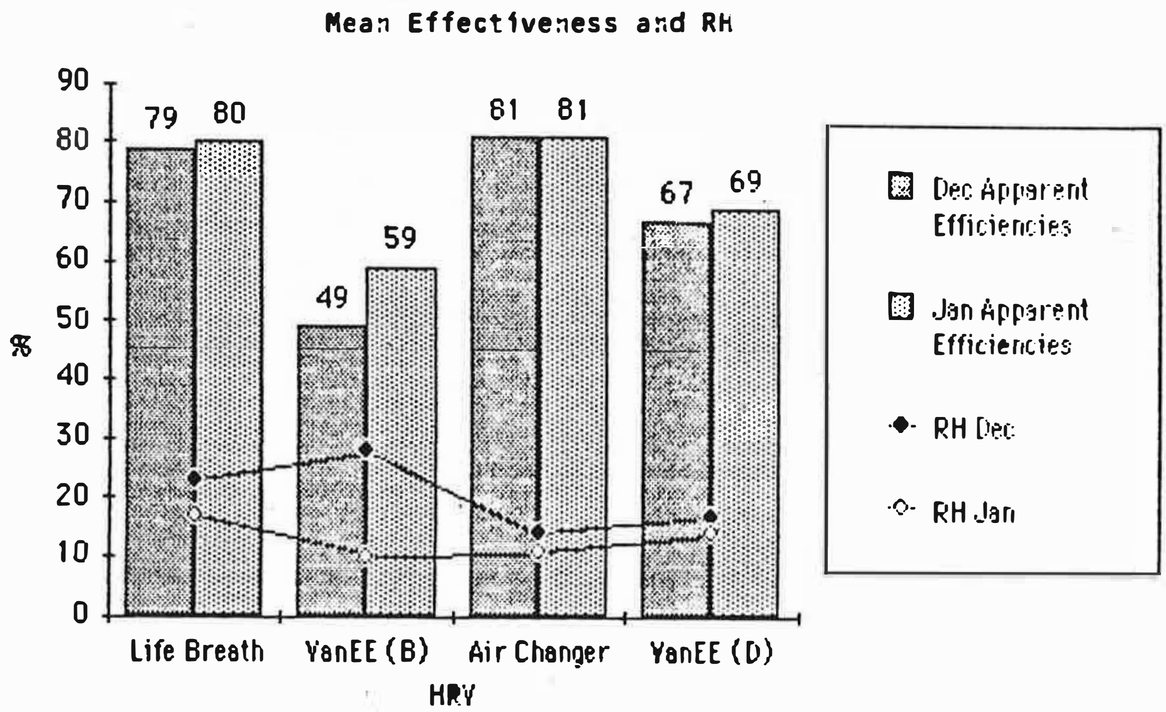






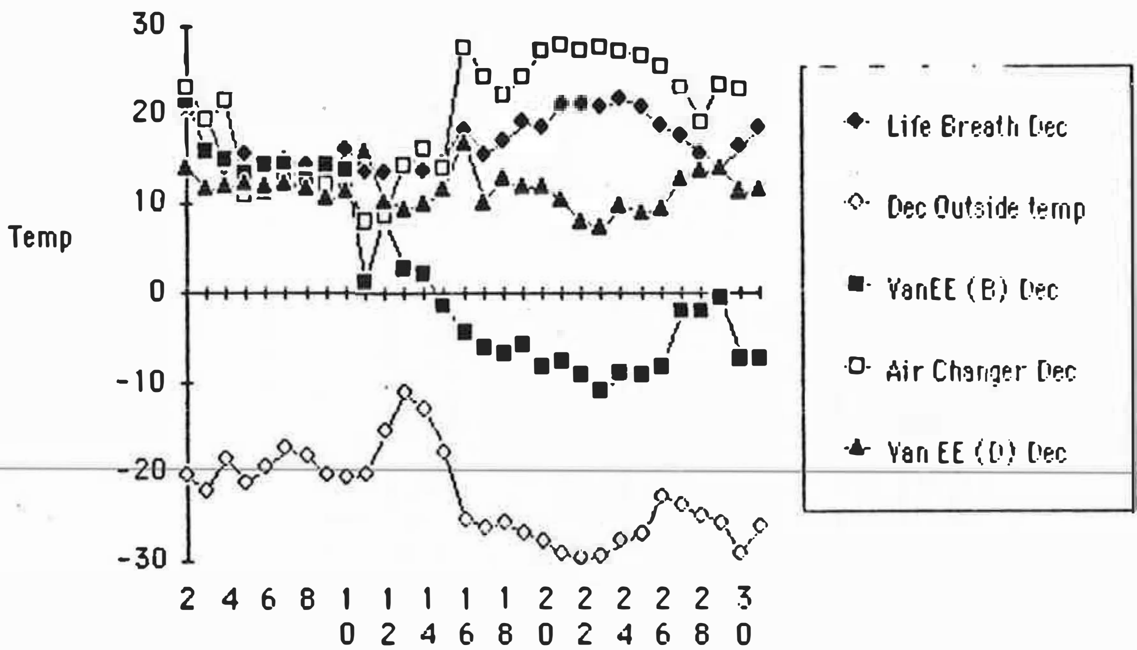


Graph 9

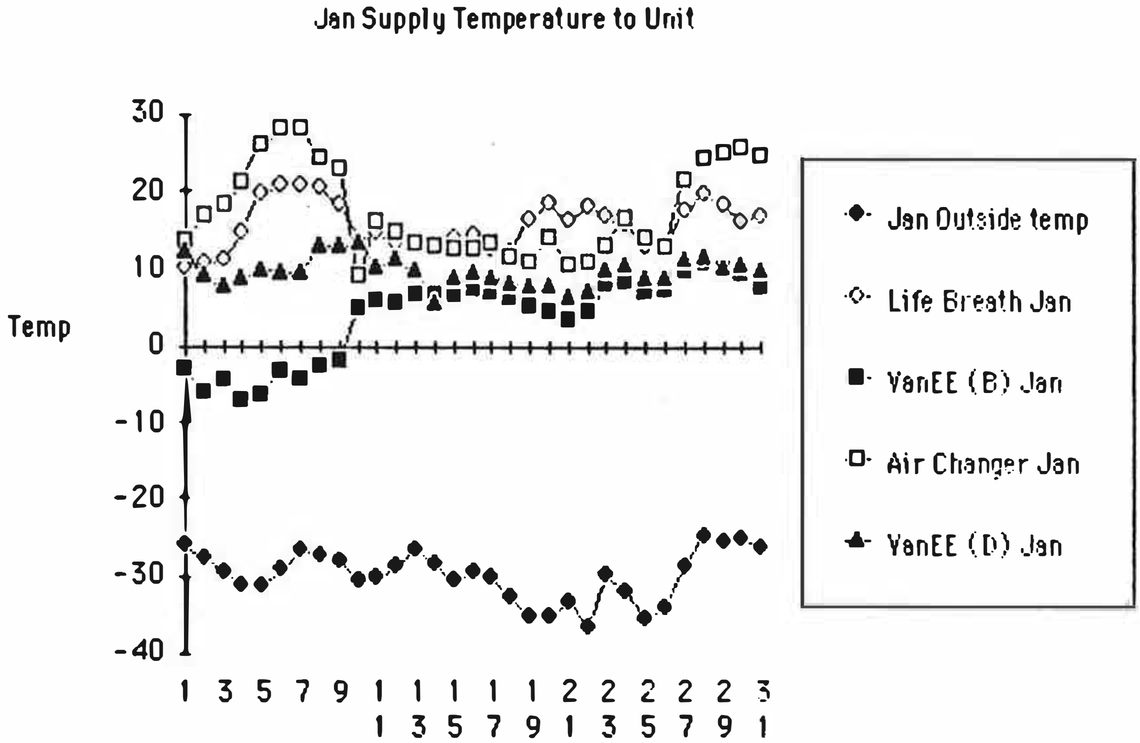

Mean Effectiveness and RH
90
80
70
60
50
40
30
20
10
0
%
79
80
49
59
81
81
67
69
Life Breath
VanEE (B)
Air Changer
VanEE (D)
HRV
Dec Apparent Efficiencies
Jan Apparent Efficiencies
RH Dec
RH Jan

Graph 1

Dec Supply Temperature to Unit

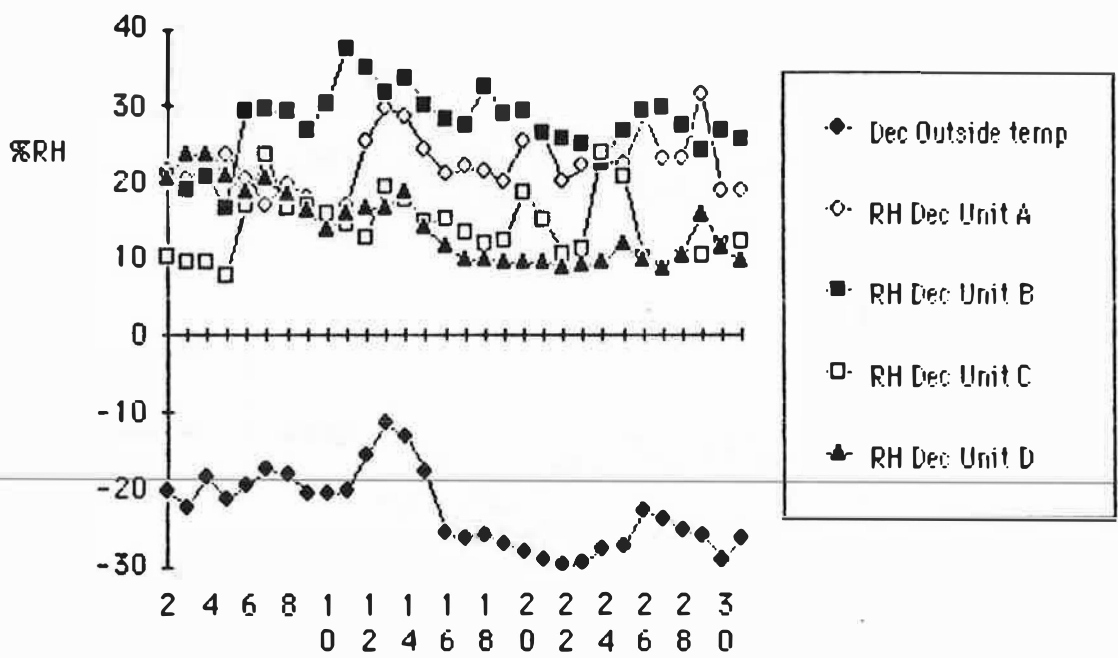


Graph 2


Jan Supply Temperature to Unit
Temp
30
20
10
0
-10
-20
-30
-40
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
Jan Outside temp
Life Breath Jan
VanEE (B) Jan
Air Changer Jan
VanEE (D) Jan

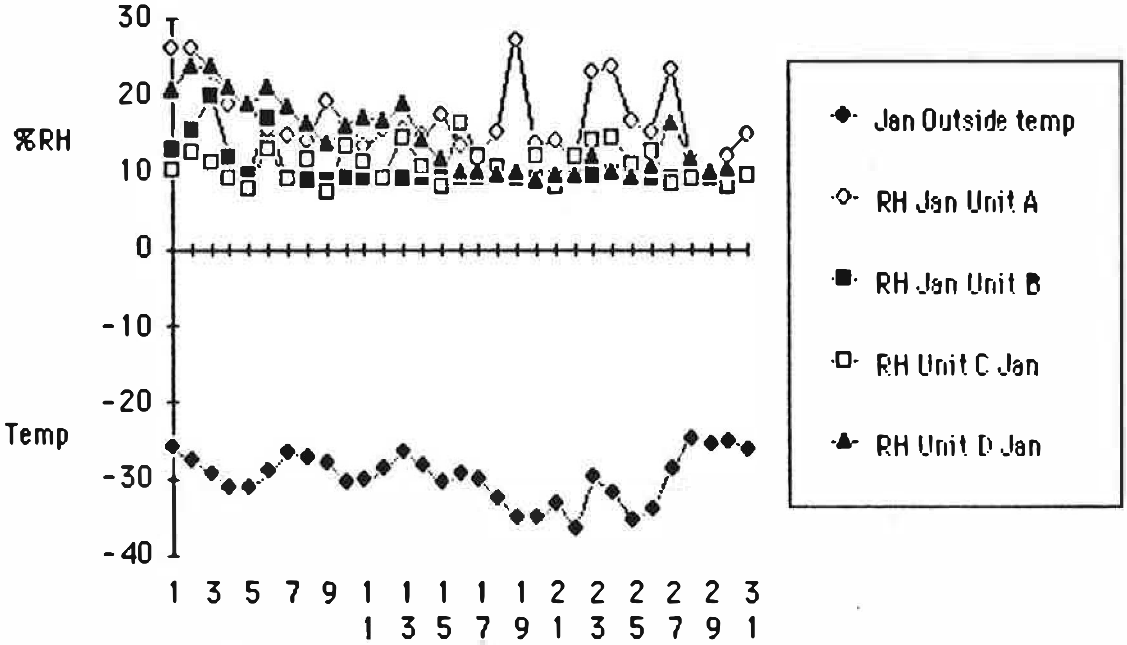
Graph 3

Relative Humidity by Unit December



Graph 4

RH January by Unit



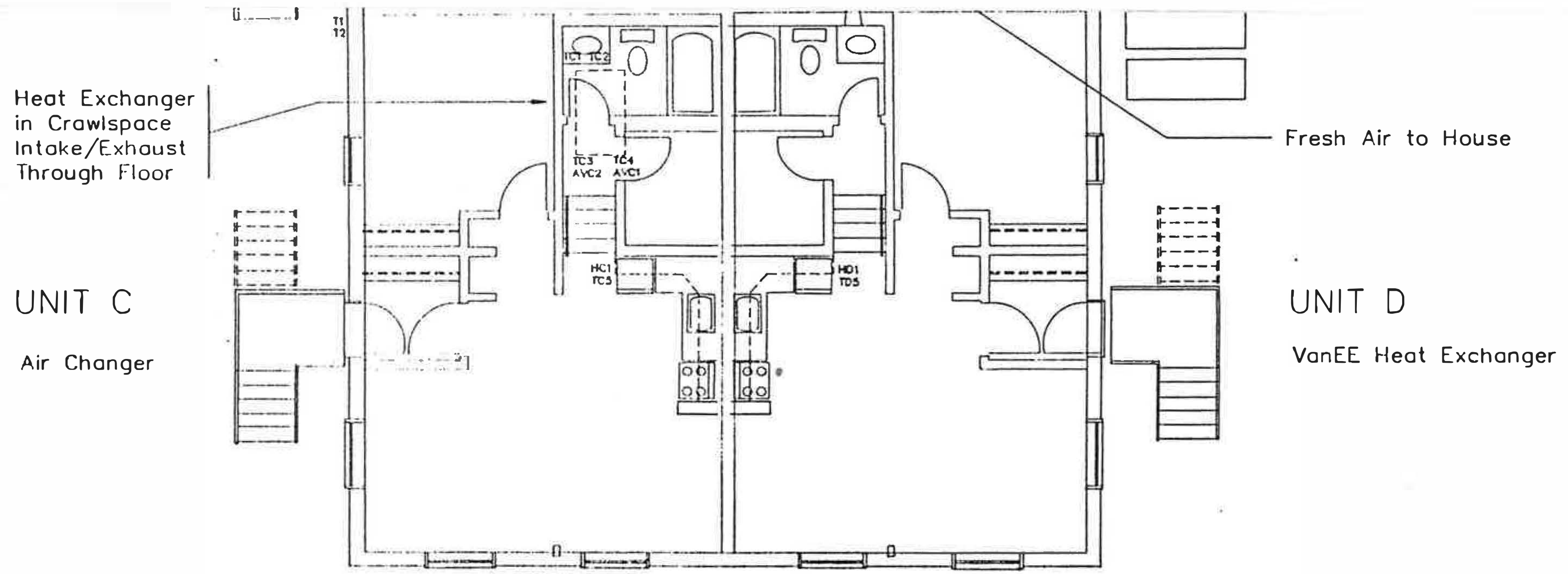
Graph 5

CMHC DataLog Summary (default)

Unit	Ch.	Description	Month	Sensor	Minimum	Maximum	Average	# Records
	11	OAT	Dec	T2	-30.75	-10.65	-22.77	1,692
			Jan	T2	-36.16	-15.86	-28.38	2,025
A	1	Life Breath fresh air outside	Jan	TA1	-32.25	1.53	-24.2	2,013
			Dec	TA1	-25.37	-8.36	-17.26	1,700
	2	Life Breath stale air outside	Jan	TA2	6.44	24.95	15.75	2,021
			Dec	TA2	9.64	24.25	16.39	1,705
	3	Life Breath stale air house	Jan	TA3	19.85	28.45	24.46	2,021
			Dec	TA3	19.85	29.62	23.96	1,705
	4	Life Breath fresh air house	Dec	TA4	11.55	22.62	16.82	1,705
			Jan	TA4	7.44	23.62	15.64	2,022
	5	Life Breath fresh flow house	Dec	AVA1	1.23	1.8	1.73	1,706
			Jan	AVA1	1.11	1.8	1.77	2,022
	6	Life breath stale flow house	Jan	AVA2	0.7	0.93	0.81	2,028
			Dec	AVA2	0.72	0.93	0.83	1,711
	8	Living room temp	Dec	TA5	23.85	31.25	26.7	1,711
			Jan	TA5	23.12	29.85	26.91	2,026
	9	Living room RH	Dec	HA1	11.89	51.7	22.57	1,710
			Jan	HA1	8.6	44.9	16.95	2,026
B	16	VenEE fresh air outside	Jan	TB1	-36.16	4.05	-26.11	2,009
		VenEE fresh ier outside	Dec	TB1	-27.87	4.13	-17.78	1,689
	17	VenEE stale air outside	Dec	TB2	-24.65	21.75	-9.64	1,686
			Dec	TB2	-24.96	21.04	-10.06	2,004
	18	VenEE stale air house	Jan	TB3	-2.07	25.04	16.45	2,015
			Dec	TB3	-5.87	26.85	10.27	1,701
	19	VenEE fresh air house	Dec	TB4	-16.46	24.95	1.4	1,702
			Jan	TB4	-14.95	24.04	3.69	1,702
	20	VenEE fresh air outside	Jan	AVB1	1.13	1.85	1.83	2,014
			Dec	AVB1	1.07	1.85	1.75	1,700
	25	Living room RH	Dec	HB1	10.68	51	27.62	1,699
			Jan	HB1	9	30.79	10.1	2,010
	26	VenEE stale air house	Jan	AVB2	0.86	1.58	1.05	2,008
			Dec	AVB2	0.79	1.7	1.18	1,699
	27	VenEE Living room temp	Dec	TB5	24.33	27.85	25.97	1,699
			Jan	TB5	20.45	26.95	25.09	2,008
	31	VenEE fresh flow outside (Fpm)	Jan	FB1	7	1,190	611	1,743
			Dec	FB1	0	105	382	1,401
C	32	Air Changer fresh outside	Jan	TC1	-32.25	-12.36	-23.78	2,003
			Dec	TC1	-24.55	-3.75	-16.12	1,693
	33	Air Changer stale outside	Dec	TC2	4.13	23.35	12.57	1,700
			Dec	TC2	1.12	22.04	12.12	2,009
	34	Air Changer stale house	Jan	TC3	22.45	29.12	26.07	2,010
			Dec	TC3	20.12	29.25	25.26	1,700
	35	Air Changer fresh air house	Dec	TC4	1.75	29.62	19.75	1,700
			Jan	TC4	3.83	29.45	17.46	2,009
	36	Air Changer fresh flow outside	Jan	AVC1	1.58	1.8	1.79	2,009
			Dec	AVC1	1.36	1.8	1.71	1,699
	37	Air Changer stale air house	Dec	AVC2	0.75	0.95	0.83	1,697
			Jan	AVC2	0.75	0.87	0.8	2,009
	40	Living area temp	Jan	TC5	24.54	33.63	27.35	2,007
			Dec	TC5	22.95	29.35	26.75	1,695
	41	Living area RH	Dec	HC1	6.9	69.3	14.15	1,695
			Jan	HC1	7.09	54.9	10.78	2,007
D	48	VenEE fresh air outside	Jan	TD1	-36.16	4.63	-25.65	2,001
			Dec	TD1	-28.15	13.05	-16.87	1,685
	49	VenEE stale air outside	Dec	TD2	-25.05	21.95	-8.82	1,681
			Jan	TD2	-25.96	18.12	-11.13	1,994
	50	VenEE stale air house	Jan	TD3	-13.45	25.85	10.68	2,005
			Dec	TD3	-10.86	25.45	5.66	1,693
	51	VenEE fresh air house	Dec	TD4	0.62	26.25	11.41	1,693
			Dec	TD4	-1.47	26.95	9.61	2,006
	52	VenEE fresh flow outside	Dec	AVD1	1.07	1.85	1.79	1,695
			Jan	AVD1	1.26	1.85	1.84	2,005
	53	VenEE stale flow house	Jan	AVD2	0.76	1.71	1.1	2,004
			Dec	AVD2	0.73	1.66	1.21	1,694
	56	Living area temp	Dec	TD5	24.85	31.85	27.47	1,693
			Jan	TD5	24.85	30.85	27	2,001
	57	Living area RH	Dec	HD1	9	29.6	17.25	1,693
			Jan	HD1	8.8	37	14.04	2,001
							Total	125,224

Table 1

APPENDIX A - DRAWINGS


Heat Exchanger
in Crawlspace
Intake/Exhaust
Through Floor
Fresh Air to House
UNIT C
Air Changer
UNIT D
VanEE Heat Exchanger
TC1 TC2
TC3 TC4
AVC2 AVC1
HC1
TC5
HD1
TD5
T1
T2

APPENDIX B - MONITORING EQUIPMENT

Honeywell

Comfort Control Systems

H7506A/H7508A

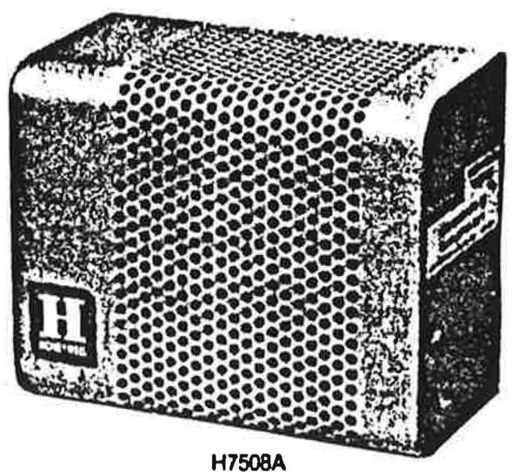
Specifications

Humidity Sensor
Humidity-Temperature Sensor

APPLICATION

The H7506A is a capacitance type relative humidity space sensor for control and indication of relative humidity in commercial or industrial installations.
The H7506A humidity sensor mounted in a duct sampling chamber 14002362-001 can be used for duct humidity sensing, i.e. as high limit control.
The H7508A Humidity-Temperature sensor combines a capacitance type relative humidity sensor and a Balco 500 Ohm temperature sensor for outside air sensing, both mounted in one case. The sensors are shielded by a perforated, wrap-around cover for maximum air circulation and protection from physical damage.
These sensors must be used in conjunction with suitable electronic controllers (i.e. MicroniK 100 or Excel), and automation systems. The temperature compensation feature, built into the humidity sensors, maintains the sensor accuracy through the ambient temperature range.

H7506A



H7508A

SPECIFICATIONS

Power supply	: 24 Volts $^{+10\%}_{-15\%}$ 50/60 Hz
Power consumption	: 400 mW
Sensing element	: Capacitance element
Sensing range	: 10...90% RH
Output signal	: 0...1 V/0...100% RH
Sensitivity	: 10 mV/% RH
Accuracy	: ± 1% RH
Temperature coefficient	: < 0.2%/K
Response time	: < 3 min.
Ambient temperature	: 0...50°C
Storage temperature	: −20... + 80°C
Relative humidity	: 5...95% RH

Sensors are calibrated at 21°C

WIRING

From sensor to ...	Type of wire	Length max. up to 100 m	Length max. up to 150 m
Controller	Local standard	18 AWG	14 AWG

ORDERING INFORMATION

1) Space humidity sensor	H7506A
2) Duct humidity sensor	H7506A + 14002362-001
3) Outside air humidity-temperature sensor	H7508A

NOTE

The relative humidity sensors should not be used in an atmosphere containing ketones.

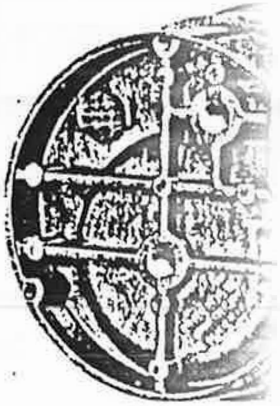
12/82
R.F.T.

MLF II.G.2.

Honeywell 740 Ellesmere Road, Scarborough, Ontario M1P 2V9. Offices across Canada.

Form Number 95C-10274

SERIES 600 DIFFERENTIAL PRESS



V

SERIES 600 TRANSMITTER MODELS & RANG

MODEL NUMBER	RANGES IN INCHES OF	
	AS STOCKED	MIN. RANGE
602-0	0- 0.25	0- 0.20
602-1	0- 0.50	0- 0.40
602-2	0- 2.0	0- 1.1
602-3	0- 5.0	0- 5.0
602-4	0-15.0	0-13.0
	RANGE IN PSI	
602-5	0-20	0-2.0

Span can be adjusted to any range between minimums and maximums listed above.

How to Order: See price list, Bulletin S-26

) mA Strain Gage Transmitter

...nble, ...sive gases

...or 18 to ...or 15 VDC ...led ...A DC, 3 or 4 ...ited at 30 mA) ...ohms at 15 ...wire) ...1200 ohms at 30 ...wire) ...ohms at ...VDC (4 wire ...sourcing) ...inutes ...(min.) ...(max.)

...oz

...d potentiom- ...externally ...ble ...NPT female

PERFORMANCE AT ROOM TEMPERATURE

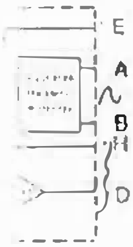
Zero Output:	4 mA
Full Scale Span:	16 mA
Static Accuracy:	± 2% Span
Span & Zero:	Adjustable to 0.05
Repeatability:	0.5% Span
Resolution:	Infinitesimal

ENVIRONMENTAL

Operating Temperature: -20 to 120
Compensated Temperature: 20 to 120
Thermal Errors: ... 50

STANDARD ACCESSORIES

- 5 ft cable assembly
- Span and zero adjustment tool
- Mounting hardware kit including screws and washers plus two each tubing adapters and pipe plugs.



E INTERNAL VOLTAGE SUPPLY + 15 VDC

A, B POWER INPUT 20 to 30 VDC OR 18 to 26 VAC

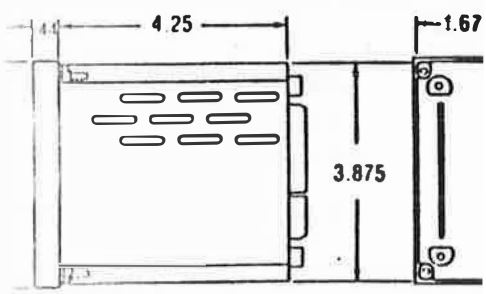
H CURRENT SOURCING CONTROL TERMINAL

D CURRENT SINKING CONTROL TERMINAL 4-20 mA LIMITED AT 30 mA

A-701 Digital Readout

Light emitting diode display reads required engineering units to 1999 current loop input. Provides operat to the Series 600 Transmitter.

The A-701 Digital Readout provides local of pressures monitored by the Series 600 standard unit is supplied to read 0-100.0 to age of transmitter pressure range. Howe also be field adjusted to read out in the ran ing units specified for your application wi decimal point locations (1.999, 19.99, 199.9 22 VAC, 180 ma output is provided for oper 600 Transmitter, this device and the transm complete digital pressure indicating syste include automatic polarity and over ran high LED digits, ± 0.5% accuracy, and pa all necessary hardware supplied. Opera VAC (± 15%) line voltage with all ele made by means of a 30 pin edge connecto A-701. Draws only 3.5 watt and weighs



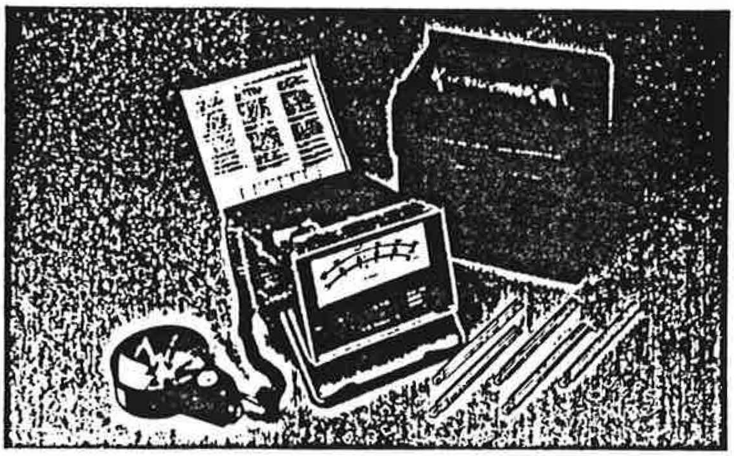
EDRA 5 Electronic Direct Reading Anemometer

Description
The EDRA 5 is an electronic instrument which provides direct readout of air velocity. Models are available in either analogue form, equipped with a high quality taut-band moving coil meter, or with digital readout (metric only) featuring a low power consumption liquid crystal display.
The 100 mm (4 in) diameter rotating vane measuring head is supplied with a handle and extension rods for use where access is limited. The instrument is powered by rechargeable batteries but can also be operated from the mains supply.
The electronic output socket gives 0-1 mA forced current on each velocity range. This facility may be used for a variety of purposes such as recorder-driving, remote display via a duplicate readout, alarm triggering or to initiate control functions.
EDRA 5 is built into a substantial aluminium case with welded seams which provides storage space for the accessories supplied with the instrument. A soft carrying case is also available.

Applications
The EDRA 5 is primarily designed for measurement of velocity at supply and extract grilles in air conditioning systems and is used throughout the H & V industry for proportional system balancing. It is also suitable for permanent monitoring and in this application the rechargeable battery will automatically function as a standby power supply in the event of mains power failure. The low velocity model is particularly suitable for use in fume cupboards and laminar flow cabinets.

Operation
Full operating instructions are provided with each instrument.

Accuracy and Calibration
Normal accuracy is shown in the table. Where higher accuracy is required, Airflow offer a certified calibration service for individual instruments. It is good practice to return the instrument to Airflow for a calibration check at least once a year and also if it has been accidentally mishandled. Airflow operate an instrument hire service for the convenience of U.K. customers having equipment repaired or recalibrated.



Specification

Parameter	Edra Five & Edra Five LV	Edra Five Digital
Measuring Range	Edra 5: 0.25-5 m/s (50-1000 l/min); 3.5-25 m/s (700-5000 l/min) Edra 5LV: 0.25-1 m/s (50-200 l/min); 0.7-5 m/s (150-1000 l/min)	0.25-30 m/s (Exceeding this velocity may cause damage to the measuring head)
Accuracy at 20°C and 1013 mbar	Calibrated to better than ± 1% FSD	Calibrated to better than ± 1.5% FSD
Operating Environment (Indicator Unit)	Barometric pressure 500 mbar to 2 bar Temperature −10°C to +50°C	500 mbar to 2 bar −5° to +50°C
Operating Environment (Measuring Head)	Barometric pressure 500 mbar to 2 bar Temperature −10°C to +70°C (short periods to −30°C)	As Edra Five
Power Supply	Mains: Nominal 110-240V/1 phase/ 50-60 Hz Power consumption approx. 3 watts. Fuse rating 3A Battery: Rechargeable nickel-cadmium type. 15 hrs operation per charge	As Edra Five
Readout	Taut-band moving coil meter 1 mA FSD. Scale length: 125mm	Liquid crystal display Digit height 17.7 mm update period approx 1.5 s
Recorder output	0-1 mA on each range Load 5k ohm maximum	0-1 mA. Load 5k ohm maximum
Standard Accessories	1 Mains cable 2 Screw-in handle for head. 3 Set of 5 extension rods for measuring head 5 x 169 mm long. 4 Plug for recorder output socket.	As Edra Five
Optional Accessories	1 Adjustable shoulder/neck strap 2 Head/Indicator extension cables Max. length 100 metres 3 All angle swivel bracket for head/ extension rod joint. 4 Carrying case	As Edra Five
Overall Dimensions	220 mm x 130 mm x 210mm	As Edra Five
Total Weight with standard accessories	2.5 kg	As Edra Five

AIRFLOW

AIRFLOW DEVELOPMENTS LIMITED
Lancaster Road, High Wycombe
Buckinghamshire HP12 3QP England
Telephone High Wycombe (0494) 25252/443821
Telex 83288

MODEL 641 ELECTRONIC MEASUREMENT SYSTEM

ANALOG INPUTS

Number of channels	: 64 multifunction*/differential [Note 1]
A/D converter	: 12 bit-plus-sign, dual slope, integrating
Conversion rate	: Typically: 10 channels per second Worst case: 7.5
Measurable signal types	: Volts — DC; Resistance — Ω; Current — mA; Frequency — Hz

*any channel, any order, any range, totally software selectable

DC VOLTAGE

Channel types	: All channels fully differential. Single-ended measurements made by connecting channel Low input to analog common.		
Input impedance	: single-ended: 5 MΩ, differential: 10 MΩ		
Ranges (built-in)	: **Gain**	**Full-Scale**	**Resolution**
	1	± 4.096 V	1.0 mV
	10	±0.4096 V	0.1 mV
	100	±40.96 mV	10 µV
	500	±8.192 mV	2.0 µV
Accuracy	: 0.1% + 2 digits		

RESISTANCE

Measurement mode	: 3-wire for single channel measurements 4-wire using 2 channels	
Ranges :	**Full-Scale**	**Resolution**
	200 Ω	0.048 Ω
	20000 Ω	4.8 Ω
	200000 Ω	48 Ω
Accuracy	: 0.3% + 2 digits	

DC CURRENT

Ranges [Note 2] :	**Full-Scale**	**Resolution**
	0.409 mA	0.1 µA
	4.096 mA	1.0 µA
Accuracy	: 0.5% + 2 digits	

FREQUENCY

Waveform Types	: any shape, internal amplication and squaring
Measurement method	: pulse-period measured with binary counters and computer clock signal
Trigger-point	: Zero-crossing detector
Ranges	: DC to 10000 Hz, 255 ranges, 16-bit counter
Resolution	: 4 µS per bit on 0.26 sec maximum period range [Note 3]

DIGITAL INPUTS

Number of inputs	: 16, TTL compatible
Conditioning	: Internal pull-up resistors
Logic "0" voltage	: -0.5 to 0.8 V
Logic "1" voltage	: 2.0 to 5.0 V

DIRECTLY COMPATIBLE SENSORS

- Thermocouples, types E, T, J, K, R, S
- IC temperature sensors (AD590, MTS102, LM3911, LM135)
- Displacement transducers
- Pyranometers
- Anemometers
- Hall effect transducers
- Thermistors
- Pressure sensors
- Humidity sensors
- Liquid flow meters
- KWH meters
- Liquid level sensors

COMPUTER INTERFACE

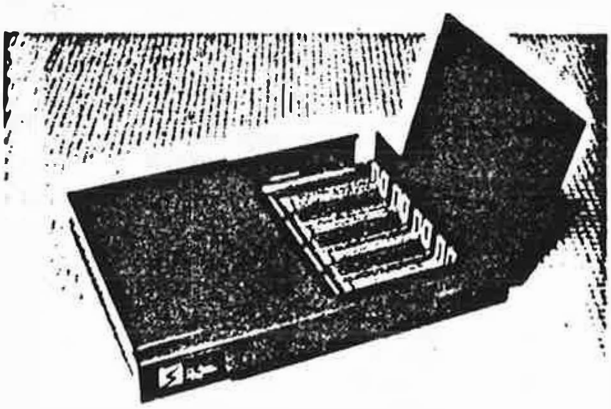
Base unit	: memory-mapped/dedicated bus interface with switch-selectable address
Interface Cards	: Optional computer interface cards available for IBM PC, APPLE II+/IIe, and Commodore PET/C64/C128. Card installs in any slot and connects to unit via interface cable. Multiple EMS units may be connected to a single interface card
Serial Interface	: Optional RS-232C interface card can be installed internal to EMS unit for operation with most common computers
CPU Card	: Optional CPU card available with on-board program EPROM, CMOS RAM, battery-backed real-time clock, serial interface port and built-in operating system software for stand-alone applications

SOFTWARE

Optional software packages are available for the IBM PC (MS-DOS), APPLE II+/IIe, Commodore 64/128/PET, and other computers. Sophistication ranges from Level 1 software, a complete library of Model 641 subroutines to fully automated, menu-driven data acquisition packages.

GENERAL SPECIFICATIONS

Power requirements	: 12-14 VDC input power @ 0.5A maximum		
Connection method	: Screw terminals included with base unit		
Operating temperature range	: 5°C to 40°C		
Relative humidity	: 8 to 80%		
Storage temperature	: -30°C to 60°C		
Size	: **Height**	**Width**	**Depth**
	60mm	450 mm	365 mm
	2.4 inches	17.7 inches	14.4 inches
Base unit weight	: 3.5 kg		



Notes

1. When thermocouples are measured, one of the 32 analog channels is used by the system for software auto-zeroing and cold junction compensation.
2. Higher currents (e.g. 4..20 mA) are measured using precision shunts and the DCV function
3. Specifications based on 1 MHz clock frequency.

MANUFACTURED BY
SCIEMETRIC INSTRUMENTS INC
P O BOX 1048 MANOTICK, ONTARIO, CANADA, K0A 2N0
(613) 692-3506

SCIEMETRIC INSTRUMENTS

HARDWARE PRODUCTS FOR DATA ACQUISITION AND CONTROL

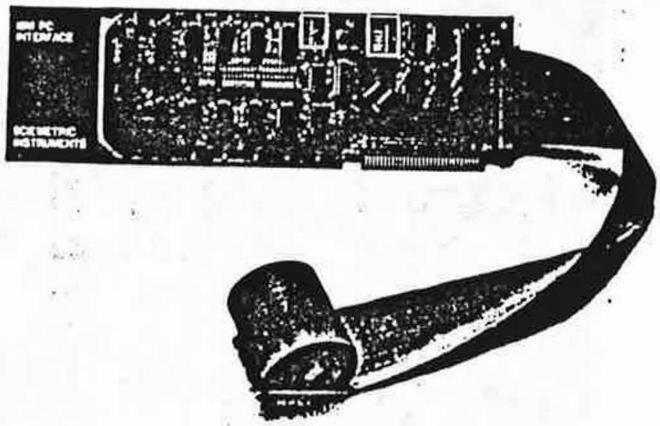
INTERFACES

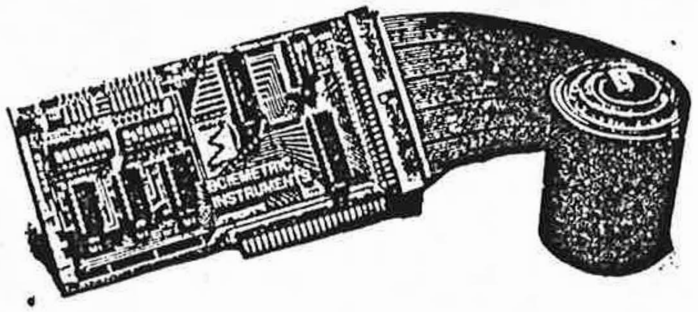
IBM PC* INTERFACE: SERIES 801

Interface card for connecting up to four (4) model 8082A's or up to sixteen (16) PDC 848's (or combinations) to the IBM PC or compatible computers. Multiple units connected to the interface card via daisy-chained cable.

* Uses any full length PC slot
* Switches select memory vs. port address and location
* Single slot supports multiple units
* Complete documentation included
* 2 m connecting cable included

* Trademark of IBM Ltd.





APPLE** INTERFACE: SERIES 701B

Interface card for connecting up to eight (8) model 8082A's or up to thirty-two (32) PDC 848's (or combinations) to APPLE compatible computers. Multiple units connected to the interface card via daisy-chained cable.

* APPLE II, II+, IIe, compatibles
* Uses any APPLE slot
* Switch selectable card address
* Single slot supports multiple units
* Complete documentation included
* 2 m connecting cable included

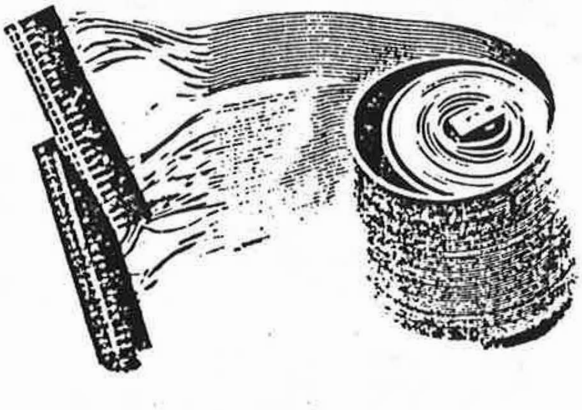
** Trademark of Apple Computers, Inc.

COMMODORE PET*** INTERFACE: SERIES 601

Interface for connecting multiple 8082A's and PDC 848's to Commodore PET series computers. Cable attaches between PET memory expansion port and 8082A/PDC. Multiple units connected via daisy-chained cable.

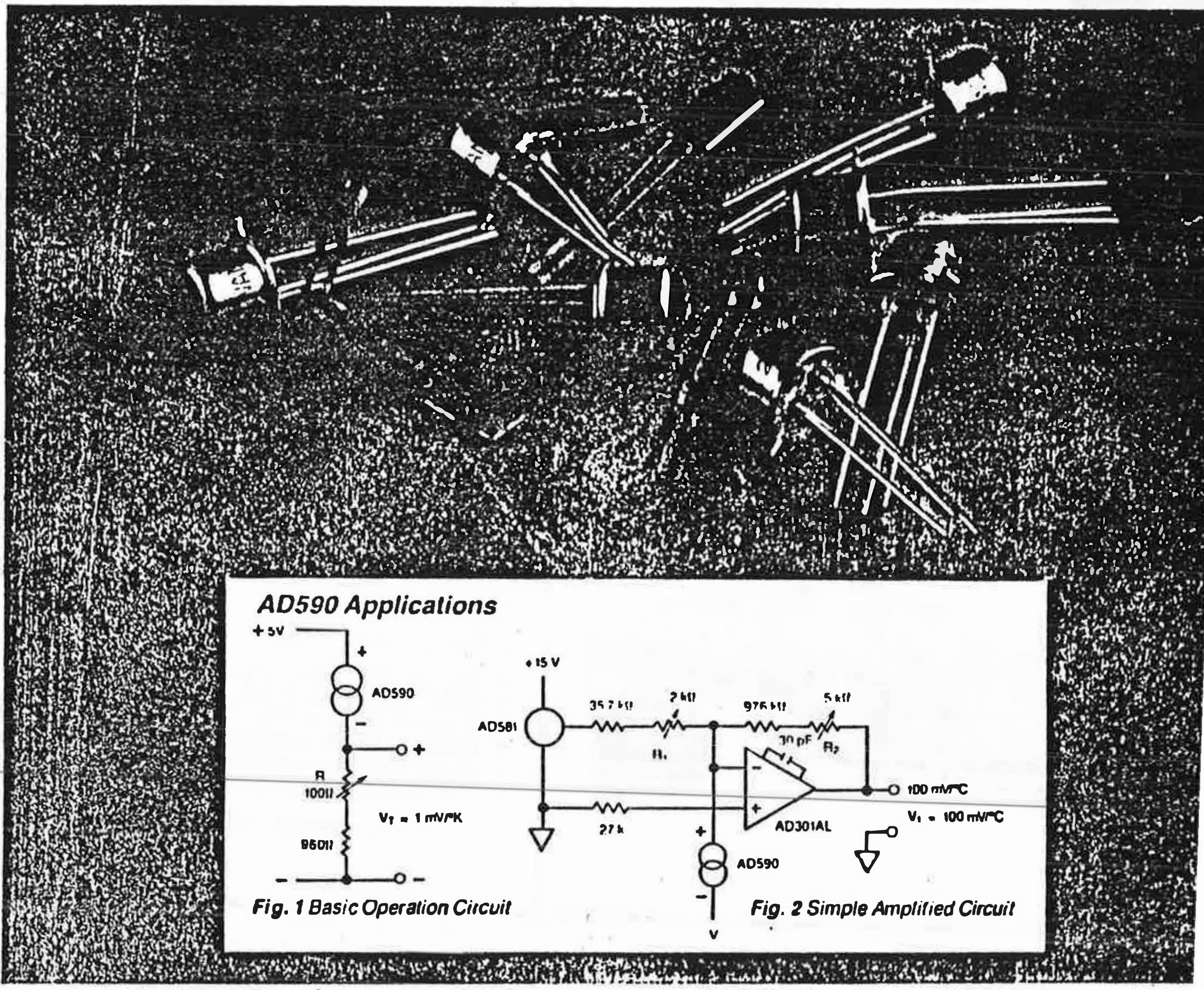
* PET series 2001, 4016, 4032, 8032, etc.
* Switch selectable address via 8082A internal switches
* Number of units limited only by free PET memory
* Complete documentation included

*** Trademark of Commodore Business Machines Ltd



SCIEMETRIC INSTRUMENTS P.O. BOX 1048, MANOTICK, ONTARIO, CANADA K0A 2N0 (613) 692-3507

Solid State Temperature Sensor
AD590 Series
Linear 1 Microamp per Kelvin Output (-273)



AD590 Applications

Fig. 1 Basic Operation Circuit

Fig. 2 Simple Amplified Circuit

- **Linear Current Output**
- **Broad Range –55 to 150°C**
- **No Linearization Circuitry Required**
- **Versatile and Economical**
- **Fast Response**

The AD590 is a small temperature transducer that converts a temperature input into a proportional current output.

The advanced technology in the AD590 is especially suited for special temperature measurement and control applications between –55 and 150°C when solid state reliability, linearity and accuracy are required. The AD590 can be used to determine minimum, average, and differential temperatures, in addition to being used for thermocouple cold junction compensation and temperature control applications. The size and responsiveness of the AD590 make it perfect for uses where size is a consideration, such as on PC boards or heat sinks.

Just power up—and measure the absolute temperature (Kelvin). No linearization, amplification or cold junction compensation is required (fig. 1). To convert reading to °C, subtract 273.15.

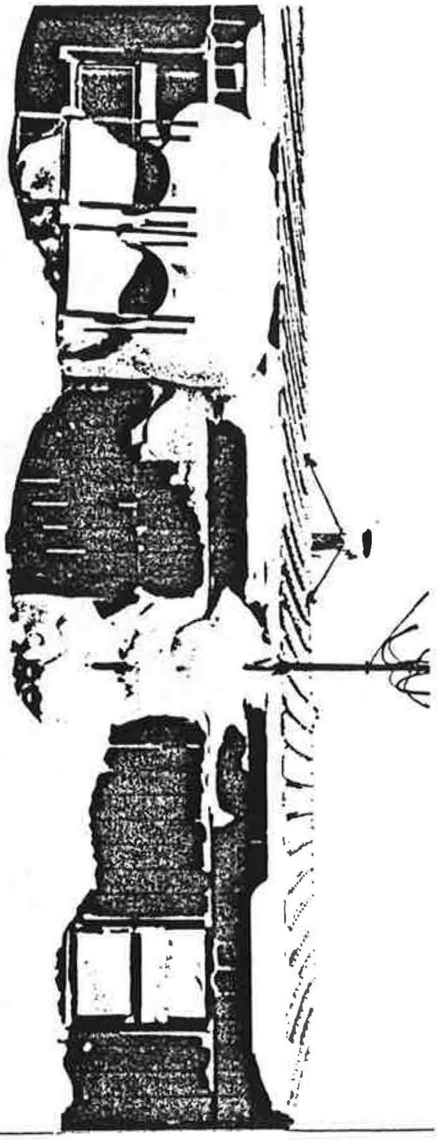
AD590 Applications

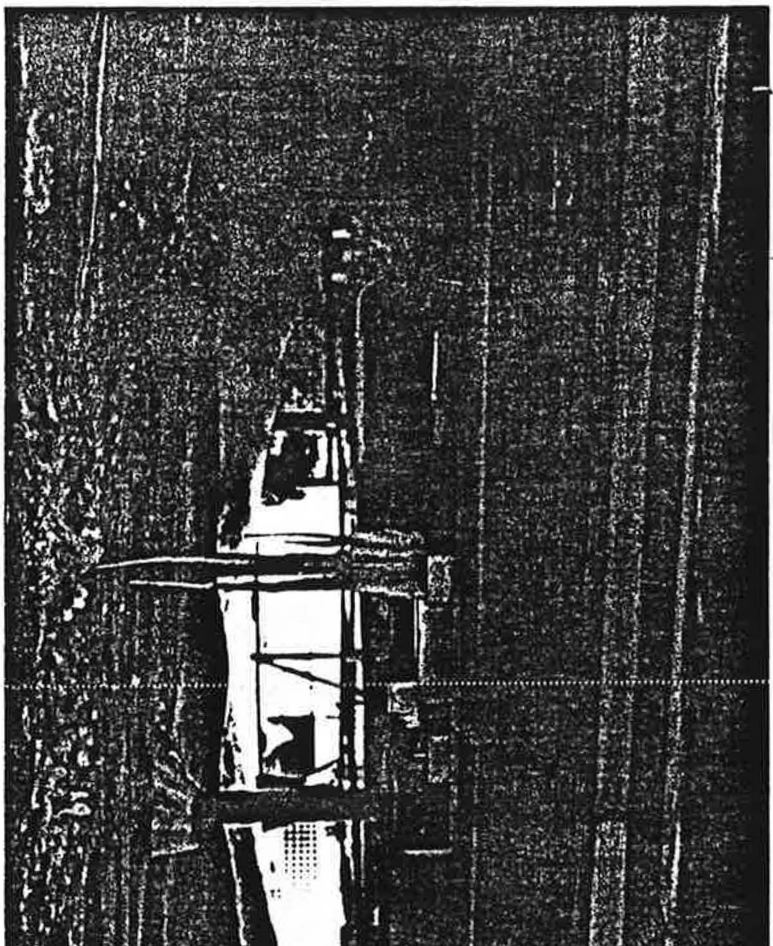
- ✓ *Ideal for Fast Respo. Surface Measureme*
- ✓ *Sensors for Controll and Meters*
- ✓ *Use In Custom Made Probes*
- ✓ *Use on PC Boards f Accurate Measurem*

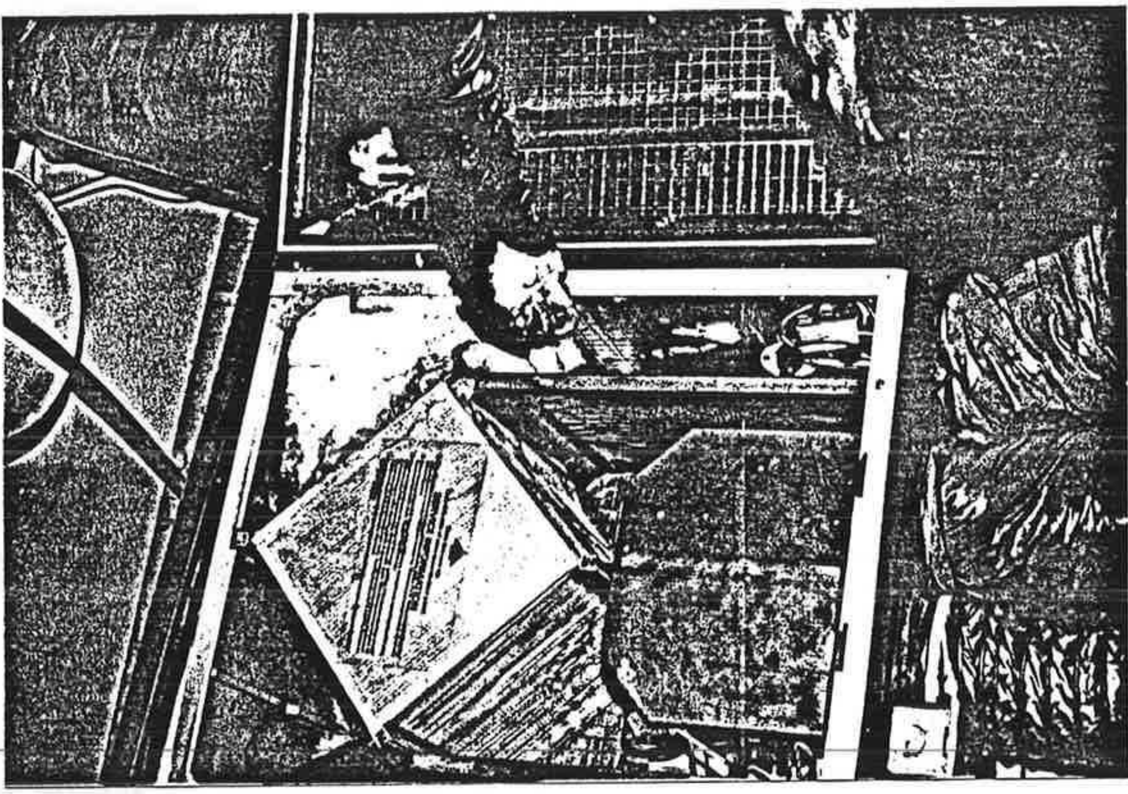
PRICED AS LOW AS

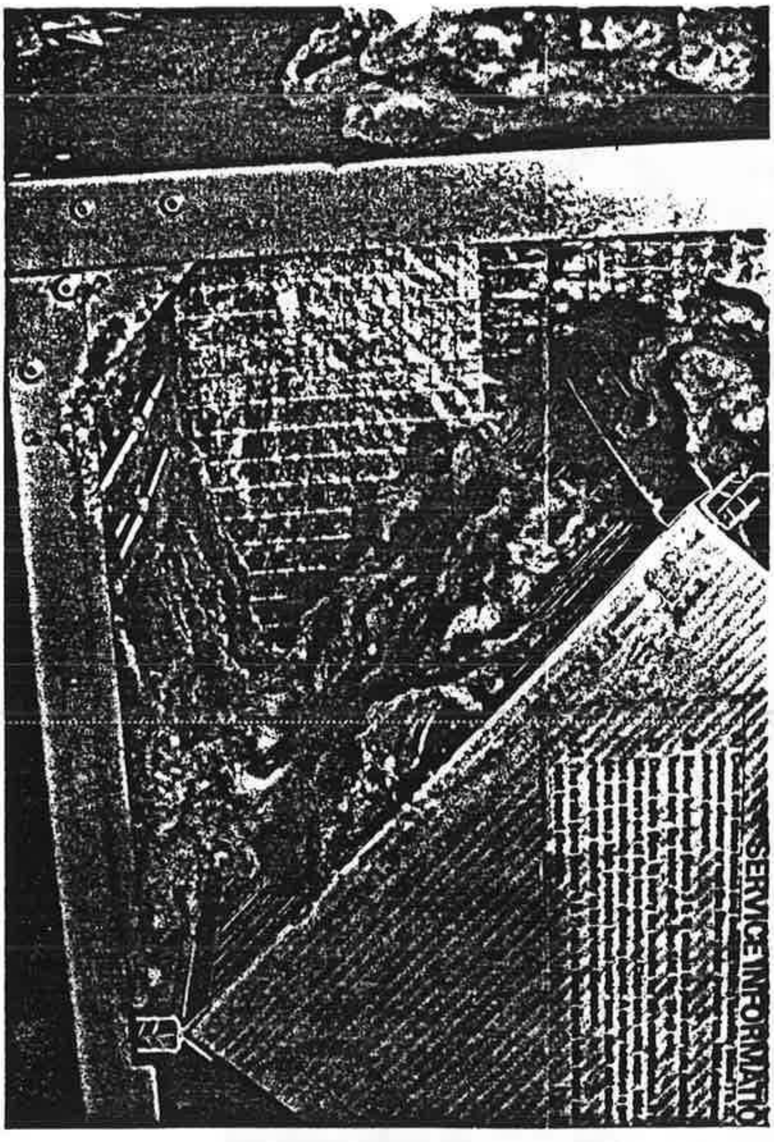
$4.50 EACH

APPENDIX C - PHOTOGRAPHS








SERVICE INFORMATIO

APPENDIX D - CONSTRUCTION SPECIFICATIONS

FERGUSON
SIMEK
CLARK
ENGINEERS & ARCHITECTS
4910 - 53rd STREET
YELLOWKNIFE NWT
(403) 920-2882
PO BOX 1777
X1A-2P4
TELEX 034-45619

Our File: 86-131

October 31, 1986

NWT Housing Corporation
Yellowknife District Office
P.O. Box 2732
Yellowknife, N.W.T.
X1A 2R1

Att: Ralph Meikle

Dear Ralph:

Re: Northern Ventilation Study Duplex Housing Latham Island, Units A,B,C & D

Please process a Contemplated Change Order for the following changes to the original contract.

Quotes are to be submitted with a material labour and freight breakdown including number of man hours, room and board if applicable, and subtrades original specification guidlines shall govern.

ITEM #1

Extra passive ventilation piping installation Unit C.

A. Provide and install all necessary piping, grilles, insulation and sheet metal for a complete system as per sketches SKM # 8,9,10 & 11.

ITEM #2

Install extra (Air changer) heat recovery unit as a complete functioning system The air changer unit only is supplied by Ferguson, Simek, Clark Ltd. This shall be installed in Housing Unit D.

A. Contractor to pick unit up at trucking depot upon arrival and assume responsibility for handling and storage.

B. Provide and install all related ducting, grilles, controls and wiring required for complete system operation.

C. Cut and or frame holes as required to allow for duct routing and securing.

D. Insulate all ducting from exterior to unit and 6' down stream wherever practical with 2" vapour seal insulation making good all joints.

E. Provide and install wiring to 120V duplex receptical using an individual 15 amp circuit from main power panel and clearly mark panel in type written letters. Also supply from separate circuit 24 volt remote control for timers and switches. To control high speed.

. . ./2

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ITEM #3

Install using the same perameters as item #2 a Nutech and Kantherm heat recovery unit also supplied by Ferguson, Simek, Clark.

Items No. 2.A,.B,.C,.D, and .E shall also imply for installing these units in housing unit A and D. Kantherm installed in Unit A. Nutech installed in Unit B.

Following is a specification guidline for all equipment and/or components required for Items 2 and 3:

1.1	Flex Duct	.1	6" dia insulated for cold end and warm end ducting. Catalogue # 1FD625.
1.2	Outside Vent Hoods	.1	6" dia c/w fresh air filters. Catalogue # OVH6. Provide four extra filters for each system.
1.3	24V Wire	.1	Catalogue # V133. Class II 24V doorbell wire.
1.4	Exhaust Grilles	.1	Swing up exhaust grille face c/w GFM4 filters 45 - 75 CFM air flow. Provide six extra filters for each system.
1.5	Supply Grilles	.1	Provide 12 x 8 vertical bar double deflection grilles equal to Titus.
1.6	Insulation	.1	1" thick flex wrap complete RFK medium foil wrap vapour barrier. Use contact cement or equal on all joints and tape overlapping min of 2".
1.7	Crank Timers	.1	Provide three remote 30 min switch timers in each unit location to be determined on site. One for kitchen, bathroom and laundry. Catalogue # CT30. Allow for 10 total switches.
1.8	Note	.1	Catalogue numbers were taken from the Air Changer catalogue. All components specified are available locally through Bartle & Gibson. Other components may be used if of equal or better quality. Six copies of shop drawings of all components must be provided.
1.9	Drawings	.1	Shop drawing of heat recovery units are included in this CCO for information only.

Yours truly,

FERGUSON, SIMEK, CLARK

B Feodoroff

Bernie Feodoroff