Evaluation of Pollutant Source Strengths and Control Strategies in an Innovative Residential High-Rise Building

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Executive Summary

The main objectives of this study were to assess the indoor air quality in the Clos St-André through the implementation of a monitoring protocol in three of the building's suites and to examine the relationships between mechanical ventilation, material emissions, occupant lifestyle and indoor air pollutant concentrations.

The monitoring protocol consisted of perfluorocarbon tracer gas, air exchange testing, material emission testing, airtightness testing and the monitoring of temperature, relative humidity, carbon dioxide, carbon monoxide, formaldehyde and total volatile organic compounds (TVOC) in the suites.

Generally, indoor concentrations of TVOC and formaldehyde decreased during the 8 months following construction completion. Formaldehyde emissions of the materials tested in the suites, namely painted gypsum board, carpet, melamine cabinets, vinyl flooring and medium density fibreboard wall moldings, were highest at the pre-occupancy and 5 month post-occupancy periods. In the case of TVOCs, the emissions of the materials tested were highest at the 1 week post-occupancy monitoring period.

Of the materials tested, carpet and vinyl flooring were the main contributors of TVOC emissions. Painted gypsum board and MDF molding samples were the main source of formaldehyde emissions. The trade-off between surface area and pollutant emission rates is evident. Although vinyl flooring and MDF molding have small loading ratios, their impact on the pollutant concentration from material emissions is as important as carpet and painted gypsum board, which have much greater surface areas in the suites.

Formaldehyde levels in only one test suite were above the exposure guideline set by Health Canada during the pre-occupancy and 1 week post-occupancy monitoring periods. TVOC levels were highest at the pre-occupancy and 1 week post occupancy monitoring periods and were above Molhave's recommended guidelines in all suites for all of the monitoring periods.

Mechanical ventilation supply flows are the main sources of fresh air to the suites. In general, ventilation supply flows did not meet CAN/CSA-F326-M91 requirements however increasing supply flows to F326 guidelines during the pre-occupancy and 1 week post-occupancy monitoring periods would probably still not have been sufficient to reduce TVOC levels below recommended limits. TVOC concentrations are controlled most effectively at the source by choosing low-emitting materials and furnishings and educating occupants on these products.

Résumé

Les principaux objectifs de la présente étude consistaient à évaluer la qualité de l'air intérieur du Clos St-André grâce à la mise en oeuvre d'un protocole de contrôle dans trois des appartements du bâtiment et à examiner les relations entre la ventilation mécanique, les émissions des matériaux, le style de vie des occupants et la concentration des polluants de l'air intérieur.

Le protocole de contrôle faisait appel à un gaz traceur d'hydrocarbure perfluoré, à des essais de renouvellement d'air, à des essais d'émissions des matériaux, à des essais d'étanchéité à l'air et au contrôle de la température, du degré d'humidité relative, du gaz carbonique, du monoxyde de carbone, du formaldéhyde et des composés organiques volatils totaux (COVT) dans les appartements.

En règle générale, les concentrations intérieures de COVT et de formaldéhyde ont diminué au cours des 8 mois qui ont suivi la fin des travaux de construction. Les émissions de formaldéhyde des matériaux testés dans les appartements, en l'occurrence les plaques de plâtre, la moquette, les meubles en mélamine, les revêtements de sol vinyliques et les plinthes murales en panneau de fibres de densité moyenne, étaient les plus élevées avant l'occupation des lieux et 5 mois après l'occupation des lieux. Dans le cas des COVT, les émissions des matériaux testés atteignaient leur plus haut niveau lors de la période de contrôle une semaine après l'occupation des lieux.

Parmi les matériaux testés, la moquette et les revêtements de sol vinyliques expliquaient principalement les émissions de COVT. Les plaques de plâtre peintes et les échantillons de plinthes en panneau de fibres de densité moyenne constituaient les principales sources d'émissions de formaldéhyde. Le compromis entre l'aire surfacique et le taux d'émission de polluants est évident. Même si les revêtements de sol vinyliques et les moulures en panneau de fibres de densité moyenne sont assortis d'un ratio de charge faible, leur incidence sur la concentration de polluants provenant des émissions de matériaux est tout aussi importante que la moquette et les plaques de plâtre peintes, qui présentent une aire surfacique beaucoup plus considérable dans les appartements.

Les niveaux de formaldéhyde enregistrés dans un seul appartement testé dépassaient la directive d'exposition établie par Santé Canada au cours des périodes de contrôle précédant l'occupation et une semaine après. Les niveaux de COVT atteignaient leur plus haut niveau lors des périodes de contrôle avant l'occupation et une semaine après l'occupation et dépassaient, dans tous les appartements, les directives recommandées par Molhave lors de toutes les périodes de contrôle.

Les débits d'alimentation de la ventilation mécanique constituent la principale source d'approvisionnement en air des appartements. En général, les débits d'alimentation de la ventilation n'étaient pas conformes aux exigences de la norme CAN/CSA-F326-M91. Peut-être même qu'accroître les débits d'alimentation pour les rendre conformes à la norme F326 au cours des périodes de contrôle avant l'occupation et une semaine après n'auraient pas suffi pour réduire les niveaux de COVT en deçà des limites recommandées. On parvient à éliminer les concentrations de COVT le plus efficacement à la source en choisissant des matériaux et articles d'ameublement qui rejettent peu d'émissions et en sensibilisant les occupants à ces produits.

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Abstract

A research project was undertaken to examine the relationships between indoor air quality, building material pollutant emissions, and occupant activities in a multi-unit residential building. The main objectives of the study were to enhance the understanding of the relative contributions of building-related pollutant sources versus occupant related sources and to characterize the impact of source control and source dilution/venting strategies. The study determined that the concentration of volatile organic compounds (VOC) within the indoor air generally tended to decrease from the time of construction completion through to a period 8 months post-occupancy. Emissions from building materials and finishes dominate the overall emission loading within the apartments only during the pre- and immediate post-occupancy periods. Occupant-related pollutant sources such as furnishing, finishes and activities tend to dominate the overall pollutant concentration levels at later times. VOC concentrations in all apartments were found to exceed accepted guidelines. Formaldehyde emissions from building materials were the dominant source of total formaldehyde concentrations within the apartments for both the pre- and post-occupancy periods. Formaldehyde concentrations were generally below the Health Canada guidelines for new homes. Ventilation rates within the apartments did not appear to have a significant impact on indoor concentrations of volatile organic compounds and formaldehyde indicating that ventilation alone can not be expected to control pollutant levels. Careful selection and use of low or non-polluting building materials would be a more appropriate means of optimizing indoor air quality. Furthermore, occupant education concerning their selection and use of low and non-polluting furnishings, finishes, cleaning compounds and other materials would be required to prevent occupant related sources from continuing to pollute the indoor air as the influence of building related materials decrease over time.

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1. Introduction

The Clos St-André, an 78-unit residential complex in downtown Montréal and the Québec finalist in the CMHC/CANMET IDEAS Challenge competition was the site chosen for assessing the impact of mechanical ventilation, material emissions and occupant lifestyle on indoor air quality.

The main objective of the IDEAS competition was to promote and improve the building envelope durability, energy efficiency, and indoor air quality (IAQ) in multifamily buildings. Occupant comfort, the environment, and resource conservation, as well as building accessibility and adaptability were also important factors addressed by the competition. The building's design represents the cutting-edge in Canadian high-rise residential construction and it is the first building constructed under the banner of the competition. This study aims to transfer the fruits of this research to the building industry.

Figure 1: The Clos St-André

The objectives of this study are to:

- assess the building's indoor air quality through the implementation of a comprehensive indoor air quality monitoring protocol in three test suites;
- characterize the material emissions of five in-place materials namely carpet, painted gypsum board, vinyl flooring, kitchen cabinets and wall moldings;
- evaluate the effectiveness of mechanical ventilation; and
- examine the relationships between mechanical ventilation, material emissions, occupant lifestyle and indoor air pollutant concentrations.

The report is divided into 5 sections. Section 2 presents the methodology used in the selection and the assessment of the test suites, and in the monitoring of the suites' indoor air quality. Section 3 presents the results of airtightness testing, sealing work, and mechanical ventilation measurements. The results of the pre-occupancy and post-occupancy indoor air quality monitoring are discussed in Section 4, and Section 5 provides an analysis of the results. Finally, section 6 makes conclusions with regards to the indoor air quality offered to occupants and the relationships between mechanical ventilation, material emissions, pollutant source strengths, and occupant lifestyle.

2. Methodology

This section describes the methodology used to:

- select the three test suites;
- prepare the test suites , and to
- perform the indoor air quality monitoring.

2.1 Selection of Test Suites

Three test suites were selected for this study to represent typical construction and indoor conditions in the Clos St-André. More consideration was given to suites closer to the mid-height of the building so as to minimize infiltration and exfiltration due to stack effect and to facilitate the compartmentalization of the test suites.

Following the identification of a number of suites to be completed within the same month, the owner of each of these suites was contacted and the purpose of the study, the tests to be performed and their contribution to the study were explained. If further information with regards to the project was needed, SIRICON met with the occupants to answer their questions. Among this group, three owners agreed to participate in the study and each signed a one-year agreement allowing SIRICON to perform the monitoring tests for the duration of the project. A description of the three test suites is given in Section 3.1.

2.2 Preparation of Test Suites

The compartmentalization of test suites was carried out in order to minimize cross-contamination with adjacent suites and the corridor. This task involved the assessment of the background conditions of each of the three test suites prior to occupancy and prior to indoor air quality monitoring and material emission testing. The following three tasks were performed prior to occupancy:

- Airtightness testing and sealing
- Mechanical ventilation measurements
- Air pressure measurements

2.2.1 Airtightness Testing and Sealing

The aim of this task was to maximize the degree of compartmentalization in each test suite in order to minimize the contamination of air within the suite from surrounding areas. This task was performed prior to the pre-occupancy monitoring period. Airtightness tests and sealing works were performed while the construction crew was completing the interior finishing of the suites. A Retrotec Model 910H infiltrometer was used to measure the airtightness of each of the test suites and to guide the SIRICON air sealing crew in identifying and sealing air leakage pathways. Airtightness tests were done following

CAN/CGSB-149.10-M86[1] guidelines and the Retrotec infiltrometer operating manual. An explanation of the sealing work performed in each test suite and the results of the airtightness tests are presented in Section 3.2.

2.2.2 Mechanical Ventilation Measurements

Since one of the principle objectives of the study was to determine the impact of the Clos St-André's mechanical ventilation system on the building's indoor air quality, mechanical ventilation supply and exhaust air flow rates were measured in each test suite for all monitoring periods. For the pre-occupancy and 1 week post-occupancy monitoring periods, mechanical ventilation supply and exhaust air flow rates were measured with the model 1650 air velocity meter by TSI Incorporated, a portable hot-wire, constant temperature anemometer, accurate to within 2% of the reading. The air velocity was determined based on the average of air velocities measured at several points at the grille surface according to ASHRAE[2]. The average airflow velocity was then multiplied by the net cross-sectional area of the grille to determine the air flow rate. For the 5 month and 8 month post-occupancy monitoring periods, mechanical ventilation supply and exhaust flow rates were measured using a cardboard flow-measurement hood and a pressure measuring gauge[3]. This method gives an accuracy of 3% when pressure readings are between 1.5 and 4 Pa.

The measured supply and exhaust flow rates were then compared to CAN/CSA-F326-M91[4] requirements. Although the F-326 standard applies to buildings of 3 storeys or less, one of the Ideas Challenge requirements was that suites be provided with individual balanced ventilation systems as per the standard.

2.2.3 Air Pressure Measurements

Air pressure measurements were taken in each test suite to characterize the air movement under ambient conditions and to investigate if the mechanical ventilation system was creating a positive pressure in the suites, thus minimizing the contamination from adjacent suites or corridors. Pressure differentials were measured with a portable digital micromanometer, model MP6KP by Air Neotronics Ltd. (accuracy of 1% of reading).

2.3 Indoor Air Quality Monitoring

The indoor air quality monitoring protocol consisted of four monitoring periods. They allowed us to assess occupant-related pollutant sources and pollutant source strengths over time.

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1 *Canadian General Standards Board, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method", p.8*

2 *Ashrae Handbook, Fundamentals, 1993. p13-14*

3 *Bower, John. Understanding Ventilation: how to design and install residential ventilation systems. The Healthy House Institute; Bloomington, Indiana; 1995, p264-265*

4 *Canadian Standard Association, "Residential Mechanical Ventilation Systems", Section 5, p.16-21*

The pre-occupancy monitoring period occurred following the completion of each of the test suites. The first post-occupancy monitoring period was scheduled one week following occupancy. The second post-occupancy monitoring period occurred five months after occupancy followed by a final monitoring period eight months after occupancy. The 5 month and 8 month post-occupancy monitoring periods were chosen so that data was obtained at the beginning and end of the winter season, when natural infiltration is low and occupants are less likely to open windows. Table 1 outlines the indoor air quality parameters monitored in the test suites for each monitoring period. Table 2 lists the start date and end date of the four monitoring periods.

Table 1. IAQ parameters monitored

Test	Pre-occupancy	Post-occupancy		
		@ 1 week	@ 5 months	@ 8 months
PFT	✔	✔	✔	n/a
T,RH,CO_2,CO	✔	✔	✔	✔
Formaldehyde	✔	✔	✔	✔
TVOC	✔	✔	✔	✔

n/a = test not performed

Table 2. IAQ Monitoring Schedule

Suite	Pre-occupancy		Post-occupancy					
			1 week		5 months		8 months	
	Start	End	Start	End	Start	End	Start	End
307	22/06/96	04/07/96	10/07/96	24/07/96	26/11/96	08/12/96	12/03/97	24/03/97
400	24/05/96	08/06/96	25/06/96	09/07/96	09/12/96	21/12/96	10/03/97	22/03/97
413*	06/06/96	14/06/96	26/06/96	10/07/96	26/11/96	08/12/96	24/03/97	07/04/97

* The pre-occupancy monitoring period was reduced to 7 days due to a delay in the completion of the test suite.

The methodology followed for the indoor air quality monitoring of the three test suites is described in the subsections below. The monitoring results are presented in section 4.

2.3.1 Perfluorocarbon Tracer Gas Testing

Perfluorocarbon tracer gas (PFT) testing was performed in each test suite simultaneously with material emission testing in order to determine the total air change rate of the suite and to identify any air leakage from surrounding areas to the test suites. The total air change rate of the suite takes into account air entering the suites from outdoors, from the mechanical ventilation system, from adjacent suites and from the corridor. PFT sources were placed in each test suite, in adjacent suites and in the corridor, and capillary absorption tube samplers were placed in each test suite. In order to determine the source of possible contamination from adjacent suites and corridors during the monitoring period, different PFT sources were used. The PFT sources and CATS passive samplers were collected at the end of the monitoring period and sent to the Brookhaven National Laboratory for analysis.

2.3.2 Material Emission Testing

Material emission testing was performed in order to calculate the actual pollutant source strengths of selected materials and to compare these pollutant source strengths to the pollutant emissions measured in the suite in order to evaluate the relative contributions of building-related pollutant sources versus occupant-related pollutant sources over time. The five materials chosen for testing were carpet (no underpad), vinyl tile, medium density fiberboard wall moldings (unpainted), kitchen melamine cabinets and painted gypsum board. The paint brands chosen by the occupants of the test suites are identified in the Environmental Choice Listings from Environment Canada. The carpets installed in suites 400 and 413 were labeled with CRI's Indoor Air Quality label. The vinyl tile brand was not an EcoLogo product.

A total of four samples were obtained from each of the three test suites. Carpet material samples were cut to 28 cm x 28 cm while vinyl flooring and paint (applied to interior gypsum board) samples were cut to 25 cm x 25 cm. Molding samples were cut to 28 cm x 10 cm and cabinet samples were cut to 18 cm x 37 cm. All material samples were cut during the pre-occupancy monitoring period and remained in the test suites until collection at 1 week and 5 month post-occupancy. Upon collection, each sample was placed in a Tedlar sample bag and sealed with a report binder clip. Samples and product information sheets were sent to the Saskatchewan Research Council (SRC) testing facility for analysis.

The product samples were cut to their specified loading ratios by SRC. A material's loading ratio (m^2/m^3) is the ratio of the test specimen area to the chamber volume. The loading ratios of the materials, presented in Table 3, were selected by SRC and based on recommended testing guidelines (see the SRC report included in the appendix). Chamber testing was conducted to ASTM D5116-90 "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products". While awaiting testing in the environmental chamber, sealed samples were stored at 21°C and 50% RH. The samples were kept in an environmental chamber for 7 days. During the course of the 7-day repose in the chamber, 3 air samples were drawn and TVOC and formaldehyde emission rates were determined. The chamber was operated at 0.3 ach to be consistent with typical residential applications. Surface velocities affect a material's emission factor therefore the surface velocities in the chamber approximated those in the suites. The laboratory results from SRC are presented in section 4.2 and the SRC report is included in the Appendix.

Table 3. Material Emission Chamber Test Loading Ratios (m^2/m^3)

Material	Loading Ratio
Painted Gypsum Board	0.45-0.50
Carpet	0.41
Cabinet	0.98
Molding	0.32-0.33
Vinyl flooring	0.38-0.41

Material emission factors were compared to the Finnish Society of Indoor Air Quality and Climate target values for the emissions of finishing materials as well as to the target values recommended by the Carpet and Rug Institute (CRI) and EcoLogo.

Material emission factors (mg/m^2h), determined from chamber testing, were multiplied by the actual material loading areas in the test suites to determine the pollutant source strength (mg/h) from the emissions of the materials tested. The pollutant emission rates were then compared to apparent pollutant emission rates calculated from measured pollutant levels in the test suites, as discussed in section 2.3.4.

2.3.3 Temperature, Relative humidity, Carbon Dioxide, and Carbon Monoxide

Temperature, relative humidity, carbon dioxide (CO_2) and carbon monoxide (CO) concentrations were measured continuously (every 5 minutes) in each of the test suites during each of the four monitoring periods. The monitoring equipment was placed in the living areas of the test suites. Table 4 summarizes the type and accuracy of the monitoring equipment.

Table 4. Testing equipment

IAQ indicator	Equipment	Accuracy
Temp.	ACR Systems RH and Temp sensor EH-02A	±0.7 °C from 0 to 70 °C
RH	ACR Systems RH and Temp sensor EH-02A	±4% from 10-90% rh@25 °C
CO_2	Projeco Tech PL-CO_2	±10%
CO	Projeco Tech PL-CO	±3%

2.3.4 Formaldehyde and Total Volatile Organic Compounds (TVOCs)

In order to compare the pollutant source strengths determined from material emission testing with occupant-related pollutant source strengths and pollutant source strengths from other materials not tested, formaldehyde and TVOC levels were measured in each of the test suites. Passive formaldehyde samplers (Model PF-1) and TVOC samplers (Model 3500 manufactured by 3M) were placed in the living areas of the test suites. By passive diffusion, the sodium bi-sulfate impregnated filter samplers absorbed formaldehyde molecules. The organic compounds in the indoor air entered the TVOC monitors by diffusion and were absorbed by active adsorbent charcoal medium inside the badges. At the end of the monitoring period, the samplers were sent to the ORTECH Corporation Laboratory in Mississauga for analysis.

The apparent pollutant (formaldehyde or TVOC) concentration in the test suite, which represents the total pollutant concentration of all sources present in the air less the sinks was calculated using the following equation:

$$C_i = C_o + N/kV \quad (1)$$

where

C_i = the measured indoor pollutant concentration in the space (mg/m^3) presented in Table 16 in section 4.3;

C_o = the concentration of pollutant at the source of the outside air (mg/m^3);

N = the apparent pollutant source strength (accounting for all sources and sinks) (mg/h);

k = the ventilation effectiveness. An effectiveness of 1.0 representing a well-mixed space was assumed;

V = the volume flow rate into or out of the space determined from mechanical ventilation measurements and perfluorocarbon tracer gas tests (m^3/h).

3. Preparation of Test Suites

This section presents the results of tests characterizing the airtightness of the three test suites and the performance of the mechanical ventilation system.

3.1 Description of Test Suites

The main characteristics of the three test suites are described in Table 5. Figure 1 presents the location of the suites within the general layout of the building. The floor plans of each suite are included in the Appendix.

Table 5. Characteristics of test suites

	Test suite		
	307	400	413
Orientation	SW	SE/NE corner	SW
Volume (m^3)	108.3	171.5	216.0
Total surface area* (m^2)	154	229	277
Exposed surface area** (m^2)	13.3	41.1	25.0
Glazing surface area (m^2)	7.5	13.5	10.6
Floor level***	3	4	4
Floor area (m^2)	45.5	71.5	90.1
Date of completion	June 21,1996	May 22, 1996	June 5, 1996
Date of occupancy	June 29, 1996	June 9, 1996	June 15, 1996
No. of occupants	1	2	1
No. of smokers	1	1	0

* Total surface area represents the area of exterior walls, walls to adjacent suites and corridor, ceiling and floor area
** Exposed surface area represents the area of suite walls exposed to exterior conditions
***The building has a total of 8 floors including the mechanical room and mezzanine on the 7th floor

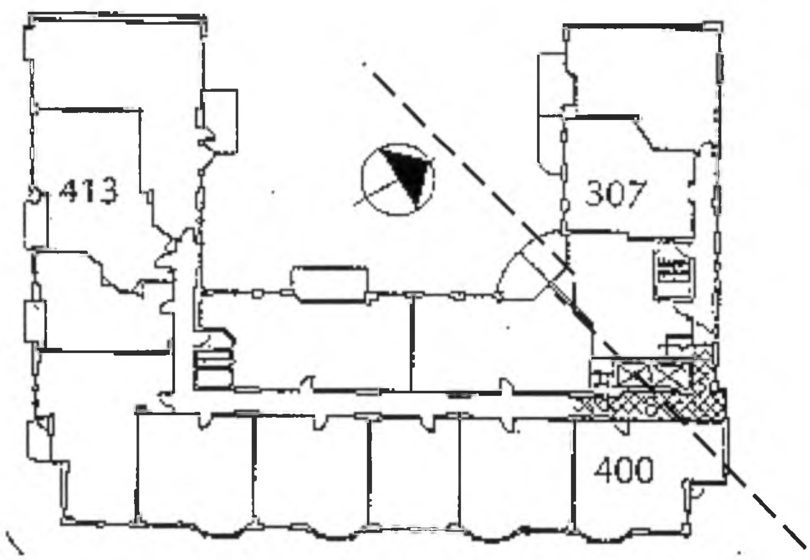


Figure 2. Position of the three test suites

3.2 Airtightness Testing and Sealing

When the owners agreed to participate in the study, the suites were already partially completed. The flooring was unfinished, the drywall was completed, and the counter tops and kitchen cabinets were being installed. Although the SIRICON crew performed sealing work late in the suite preparation schedule, they nonetheless reduced the air leakage in the suites (at 50Pa) by over 60%. Table 6 presents the results of airtightness tests done prior to and after sealing works were completed. The output from the computer program used to calculate the ACH @ 50 Pa is included in the Appendix. The airtightness of test suites at the post-sealing stage represents suite conditions at the pre-occupancy monitoring stage.

Table 6. Airtightness Test Results

Characteristics	Suite 307		Suite 400		Suite 413	
	pre-sealing	post-sealing	pre-sealing	post-sealing	pre-sealing	post-sealing
Floor area (m^2)	45.5		71.5		90.1	
Volume (m^3)	108.3		171.5		216	
Total surface area[1] (m^2)	154		229		277	
Exposed surface area[2] (m^2)	13.3		41.1		25.0	
ACH @ 50 Pa	30.70	6.90	11.51	6.50	14.06	5.44
ELA @ 10 Pa[3] (cm^2)	1300	297	771	436.6	1189	464.5
L/s @ 50 Pa[3]	924	210	548	310	844	326
Air leakage @ 50 Pa (L/s m^2)	6.0	1.4	2.4	1.0	3.0	1.2
Air leakage @ 75 Pa (L/s m^2)[4]	7.8	1.8	3.1	1.3	3.9	1.6

[1] Total surface area represents the area of exterior walls, walls to adjacent suites and corridor, ceiling and floor area.

[2] Exposed surface area represents the area of suite walls exposed to exterior conditions.

[3] Based on total surface area.

[4] Assuming $n = 0.65$.

When performing the airtightness test, all intentional openings such as electrical outlets and switches and TV and telephone jacks were sealed with wall plate foam pads. In test suites with electrical outlets and switches, and dryer exhaust dampers not yet installed, blower door tests were performed with these openings sealed temporarily.

The materials used for sealing were:

- wall plate foam pads
- spray-polyurethane
- aluminum duct tape
- foam backer rods
- silicone
- weather-stripping

In each test suite, all ducts, pipes and electrical wires pass above a dropped ceiling in the kitchen area. Since these dropped ceilings were already finished at the time that sealing works were being carried out, it was not possible to maximize sealing works at the interior wall and ceiling junctions. Nonetheless, sealing work performed in the dropped ceiling area accounted for approximately 40% of the total reduction in air leakage.

Other common air leakage pathways were found to be along the bottom perimeter of interior and exterior walls, underneath the wall moldings and around electrical outlets. Foam backer rods were installed underneath the moldings at the base of the walls. Although the partition walls were designed to include acoustical sealant at their base, the sealant was not properly installed in one of the test suites and no sealant was observed in the other two test suites.

Air leakage pathways were also noticed along the perimeter of the exterior walls underneath the hot-water heating baseboards. However, since all the baseboards were already installed, it was difficult to seal these pathways. The space between the bottom of the baseboards and the slab was not large enough to fit the foam backer rod or to properly spray polyurethane and this space was therefore left partially unsealed.

The openings where the hot-water service pipes pass through the walls were somewhat filled with pipe insulation placed at the time of installation. Any remaining gaps in these areas were sealed with mineral wool and sprayed polyurethane.

Silicone was used to seal joints between window frames that were not properly sealed at the time of installation. Unsealed joints of this type were specifically noted in suite 307 at the frame junctions around the patio door.

A common air leakage pathway observed in each test suite was the gap between the acrylic bathtub side panel and the bathtub's top. The 8" opening through which the drain pipe passes through the flooring underneath the bathtub, left open by the construction crew, allowed air movement from the suites below and was therefore sealed temporarily until it could be sealed permanently by the building contractor. Silicone and polyurethane was then used to reduce the air leakage along the drainpipes and through the gaps between the acrylic bathtub side panel and the bathtub's top.

In the laundry areas of the test suites, the interiors of the access doors to the service valves were weather-stripped and the gaps between the access doorframes and ceiling were sealed using silicone. Silicone was also used to seal around dryer exhaust ducts and dust collector panels.

The followings sealing tasks were also performed in the test suites:

- sprayed-polyurethane foam was injected in openings underneath the window sills where sills were not permanently fixed in place;

- sprayed-polyurethane foam or silicone was injected around all plumbing openings and electrical panel boxes;
- when possible, sprayed-polyurethane foam was injected at the drywall/floor junction of exterior walls and
- the backs of recessed 220-Volt outlets were weather-stripped.

Photographs demonstrating some of the sealing work performed in the test suites are included in the Appendix.

The SIRICON sealing crew maximized the degree of compartmentalization of the test suites without performing major renovations. The crew spent approximately 11 man-hours sealing all of the three test suites.

The compartmentalization of each test suite now depended on a net supply flow from the mechanical ventilation system. Based on the measured airtightness results obtained for each suite, the supply flows required from the mechanical ventilation system to pressurize the suite to 1 Pa were calculated and are presented in Table 7.

Table 7. Required Supply Flows for 1 Pa Pressurization of Test Suites

Suite	ACH @ 50 Pa	Required Net Supply Flow (L/s)	F326 Exhaust Flow (L/s)	Required Supply Flow for 1 Pa pressurization (L/s)
307	6.90	17	40	57
400	6.50	24	40	64
413	5.44	28	40	68

Table 7 presents the theoretical airflows required to ensure compartmentalization in each suite. The actual supply flow rates measured in each test suite are presented in Table 8 of the next subsection.

3.3 Mechanical Ventilation Measurements

The Clos St-André's mechanical ventilation system was designed to meet the Ideas Challenge requirement that each suite be provided with a balanced ventilation system as per the CAN/CSA-F326-M91 standard. The ventilation system is a constant volume system designed to continuously supply fresh air to each suite and exhaust air through kitchen and bathroom vents. Manual dampers at the supply grilles in each suite are adjusted to provide the required flow. The layout of the ventilation system's supply and exhaust ducts can be found in the Appendix.

The purpose of this task was to measure the supply and exhaust flows in each suite and compare the findings with the F326 requirements. Table 8 presents the supply and exhaust flow rates measured during each monitoring period, the air flow rates recommended in section 5 of the standard for each test suite and the supply flows required to pressurize the suite to 1 Pa.

Table 8. Mechanical supply and exhaust flow rates (L/s)

Suite	Req'd supply flow for 1 Pa pressurization	F326 requirement	Pre-occupancy/ 1-week post-occupancy	5 month post-occupancy	8-month post-occupancy
Supply flows					
307	57	30	11.8	5.4	7.1
400	64	30	40.4	39.4	28.9
413	68	35	10.6	23.5	14.8
Exhaust flows					
307	-	40	15	17.4	9.0
400	-	40	17.7	18.2	9.6
413	-	40	2.6	9.2	7.7

As seen in Table 8, the mechanical ventilation system was not operating as designed during any of the monitoring periods and did not comply with the CAN/CSA-F326-M91 standard.

The supply flows required from the mechanical ventilation system to pressurize the suite to 1 Pa were not attained and therefore the test suites were not pressurized so as to prevent any contamination from adjacent suites and corridors.

The manual dampers at the supply grilles were fully open at the time of testing. The HVAC contractor informed us that the mechanical ventilation system would be balanced when the building reached 80% occupancy.

After realizing that the mechanical ventilation system had not yet been balanced, and that it was not likely going to be balanced during the course of the project, the project team decided to proceed with the study because:

- the study would still allow us to examine the impact of the mechanical ventilation system on material emissions and indoor air quality;
- the study would shed light on the degree to which a suite's compartmentalization and mechanical ventilation can improve the indoor air quality at a time when material emissions are at their highest and
- the scenario that presented itself was typical of newly completed high-rise residential buildings.

Between the 5 month and 8 month post-occupancy monitoring periods, work was done on the mechanical system's ductwork and on the balancing of the system. However, at the 8 month post-occupancy monitoring period, at which time the building was 70% occupied, supply flows still did not meet the CAN/CSA-F326-M91 requirements and the system had not yet been balanced.

Pressure differences between test suites and adjacent suites and corridors were measured at the beginning of each monitoring period. However, the results could not be used to determine the pressurization states of the suites due to the low pressure readings recorded and the fluctuation of the measurements. The results of PFT testing, in section 4.1, which identify inter-zonal airflows between adjacent suites and corridors will provide a sufficient indication of the risk of cross-contamination between adjacent suites and corridors.

4. Monitoring Results

This section presents the results of the four monitoring periods. In order to accurately compare the pre-occupancy and post-occupancy indoor air quality in the test suites, it was important that windows be kept closed during each of the monitoring periods. To ensure this, the occupants of the test suites were supplied with air-conditioning units during the one-week post-occupancy monitoring period in June. Test suite 307 was supplied with an Admiral window-mounted 2.5 kW capacity a/c unit, suite 400 with a portable Toyotomi 2.2 kW a/c unit and suite 413 with a Carrier window 1.8 kW capacity a/c unit and a portable Toyotomi 2.2 kW capacity a/c unit. The window-mounted air conditioning units in suites 307 and 400 were operating in re-circulation mode. The occupants were asked to keep their windows closed during the monitoring period but were free to control the temperature and operation of the a/c unit installed in their suite. The results of the indoor air quality monitoring are presented in the subsections below.

4.1 Perfluorocarbon Tracer Gas Testing

The perfluorocarbon tracer gas test results provide information on the total air change in the test suites and are used to correlate measured indoor pollutant source strengths and pollutant emissions from selected materials in section 5. Table 9 presents the results of the PFT testing for three of the four monitoring periods.

Table 9. Total air exchange rate of suites

Suite	Pre-occupancy (May – June 1996)		1 week post-occupancy (June – July 1996)		5 month post-occupancy (Nov – Dec 1996)	
	ACH ±SD	L/s	ACH ±SD	L/s	ACH ±SD	L/s
307	1.12±0.15	33.7	1.08±0.31	32.5	1.07±0.35	32.2
400	1.41±0.21	67.2	1.60±0.26	76.2	1.30±0.61	61.9
413	0.21±0.08	12.6	1.10±0.21	66	0.55±0.07	33.0

The total air change rates measured in suites 307 and 400 remained relatively constant throughout the three monitoring periods. In suite 413, the total air change rate increased quite significantly at the 1 week post-occupancy monitoring period and then decreased at the 5 month post-occupancy monitoring period.

The increase in total air change rate in suites 400 and 413 at the 1 week post-occupancy monitoring period is due to the presence of the portable air conditioning units in these two suites. These units were exhausted to the outdoors.

The percentage of source concentration placed in the adjacent suite and/or corridor and detected in the test suites are presented in Table 10.

Table 10. Percentage of source concentration from adjacent suites and corridors detected in test suites

Source	Percentage (%)		
	Pre-occupancy	1 week post-occupancy	5 month post-occupancy
Suite 307			
Suites 305,309 (unocc)	3	7.5	6.0
Suite 405 (unocc)	1.2	1.0	0.9
Suite 207 (occ)	0.5	0.3	0.1
Corridor	3.4	3.9	9.0
Suite 400			
Suite 402 (unocc)	8.4	1.9	0.3
Suite 500 (occ)	1.5	1.4	1.0
Suite 300 (occ)	0.6	0	0
Corridor	1.4	8.6	7.3
Suite 413			
Suite 415 (unocc)	19.9	15.8	0.7
Suite 411 and corridor (occ)	24.9	3.3	0.5
Suite 513 (unocc)	16.5	6.3	1.0
Suite 313 (occ)	15.7	4.9	9.8

In test suites 307 and 400, there was less than 10% source concentration from adjacent suites and corridors detected in the test suites for the three monitoring periods. In suite 413, up to 25% source concentration from adjacent suite 411 and the corridor was detected in the test suite during the pre-occupancy monitoring period. This may be due to the increased occupancy in the test suite and/or in adjacent suites due to construction activity. During the 1 week and 5 month post-occupancy monitoring periods, source concentrations from adjacent suites and the corridor detected in test suite 413 averaged less than 8% and 3%, respectively.

4.2 Material Emission Testing

Table 11 presents the types of materials selected for emission testing and the date that the selected materials were installed in each suite. Four materials were selected for testing in each suite. The walls in each test suite were originally painted with white latex paint in November 1995. However, as indicated in Table 11, test suite 307 was completely repainted in May 1996 and test suite 413 was partially repainted in May 1996.

Table 11. Type and Installation Date of Selected Materials

Tested materials	Suite		
	307	400	413
Painted drywall	Sico, latex #173-404 May 31, 1996	Sico, latex #872-400 November 95, 1996	Moore, latex #5/243-54 May 10, 1996
Carpet	Club Carpets, #0127 June 21, 1996	Peerless, #6949/CRI rated May 22, 1996	Peerless, #6041/CRI rated June 4, 1996
Cabinets	Melamine, Cognac May 10, 1996	Melamine, Acajou May 10, 1996	Melamine, Acajou May 10, 1996
MDF Molding	Premdor MDF November 95, 1996	n/a*	n/a*
Vinyl flooring	n/a*	Congoleum, #40231 May 22, 1996	Congoleum, #40231 June 4, 1996

* Material not tested

Table 12 presents the surface areas of the selected materials present in the suite.

Table 12. Surface Area (m^2) of Selected Materials

Tested material	Suite		
	307	400	413
Painted gypsum board	39.6	71	145.7
Carpet	22.5	46.8	63.4
Cabinet	12.2	14.6	13.0
MDF Molding	2.42	n/a*	n/a*
Vinyl flooring	n/a*	5.7	5.4

* Material not tested.

The results of the material emission chamber testing are presented in Tables 13 and 14 and illustrated in Figures 3-12. The emission factors of the four materials tested in each suite presented in these tables are those determined from the 144-hr air samples drawn from the SRC test chamber. The tables also show the recommended emission rate limits by the Finnish Society of Indoor Air Quality and Climate, by the Carpet and Rug Institute (CRI) and by Ecologo. The Finnish Society of Indoor Air Quality and Climate established target values for the emissions of finishing materials. Target values are between 0.2 and 0.4 mg/m^2h for TVOC emissions and between 0.05 and 0.125 mg/m^2h for formaldehyde emissions. The Carpet and Rug Institute (CRI) have also established criteria as part of their IAQ Carpet and Testing Program. They specify that TVOC emissions should be below 0.5 mg/m^2h and formaldehyde emissions should be below 0.05 mg/m^2h. Carpets meeting these criteria are labeled with a CRI Indoor Air Quality Testing Program logo. Vinyl flooring materials with TVOC emissions less than 1.0 mg/m^2h are granted the EcoLogo label.

Table 13. Material Emission Test Results: TVOC Emission Factors (mg/m²h)

Material	Testing period	Suite 307	Suite 400	Suite 413	Average
Painted gypsum Board	Pre-occ	0.019	0.043	0.005	*0.022*
	1 week post-occ	0.035	0.213	0.007	*0.085*
	5 month post-occ	0.004	0.027	note 1	*0.016*
	Average	*0.019*	*0.094*	*0.006*	
	Guideline[1]	*0.2-0.4*			
Carpet	Pre-occ	0.234	0.694	0.190	*0.373*
	1 week post-occ	0.037	1.877	1.220	*1.045*
	5 month post-occ	0.300	0.161	0.117	*0.193*
	Average	*0.190*	*0.911*	*0.509*	
	Guideline[2]	*< 0.5*			
Cabinet	Pre-occ	0.012	0.088	0.160	*0.087*
	1 week post-occ	0.006	0.018	0.303	*0.109*
	5 month post-occ	0.037	0.018	0.009	*0.021*
	Average	*0.018*	*0.041*	*0.157*	
	Guideline[1]	*0.2-0.4*			
MDF Molding	Pre-occ	0.376	n/a*	n/a*	*0.376*
	1 week post-occ	0.082	n/a*	n/a*	*0.082*
	5 month post-occ	0.342	n/a*	n/a*	*0.342*
	Average	*0.267*	*n/a*	*n/a*	
	Guideline[1]	*0.2-0.4*			
Vinyl	Pre-occ	n/a*	1.983	7.875	*4.929*
	1 week post-occ	n/a*	2.098	4.376	*3.237*
	5 month post-occ	n/a*	1.142	1.359	*1.251*
	Average	*n/a*	*1.741*	*4.537*	
	Guideline[3]	*< 1.0*			

note 1: No reading available due to GC/MS failure

Guidelines: 1) Finnish Society of indoor Air Quality and Climate

2) CRI

3) Ecologo

* Material not tested.

Table 14. Material Emission Test Results: HCHO Emission Factors (mg/m²h)

Material	Testing period	Suite 307	Suite 400	Suite 413	Average
Painted gypsum Board	Pre-occ	<0.007	0.009	0.011	*0.009*
	1 week post-occ	<0.007	<0.007	0.006	*0.007*
	5 month post-occ	<0.007	0.012	0.013	*0.011*
	Average	*0.007*	*0.009*	*0.010*	
	Guideline[1]	*0.05-0.125*			
Carpet	Pre-occ	<0.007	<0.007	<0.007	*0.007*
	1 week post-occ	<0.007	<0.007	<0.007	*0.007*
	5 month post-occ	note 1	<0.007	note 1	*0.007*
	Average	*0.007*	*0.007*	*0.007*	
	Guideline[2]	*< 0.05*			
Cabinet	Pre-occ	0.005	0.015	0.003	*0.008*
	1 week post-occ	0.004	0.008	0.009	*0.007*
	5 month post-occ	note 1	note 1	note 1	-
	Average	*0.005*	*0.012*	*0.006*	
	Guideline[1]	*0.05-0.125*			
MDF Molding	Pre-occ	0.270	n/a*	n/a*	*0.270*
	1 week post-occ	0.277	n/a*	n/a*	*0.277*
	5 month post-occ	0.201	n/a*	n/a*	*0.201*
	Average	*0.249*	*n/a*	*n/a*	
	Guideline[1]	*0.05-0.125*			
Vinyl	Pre-occ	n/a*	<0.008	<0.007	*0.008*
	1 week post-occ	n/a*	note 1	note 1	-
	5 month post-occ	n/a*	0.016	<0.007	*0.012*
	Average	*n/a*	*0.012*	*0.007*	
	Guideline[1]	*0.05-0.125*			

note 1: HCHO test not conducted

Guidelines: 1) Finnish Society of indoor Air Quality and Climate

2) CRI

* Material not tested.

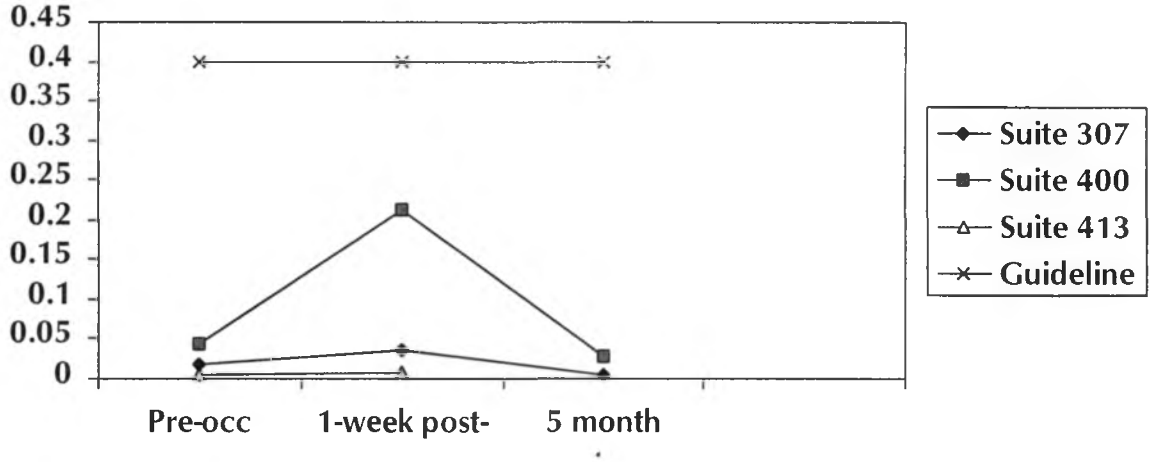


Figure 3. TVOC emission factors (mg/m^{2}h) of painted gypsum board

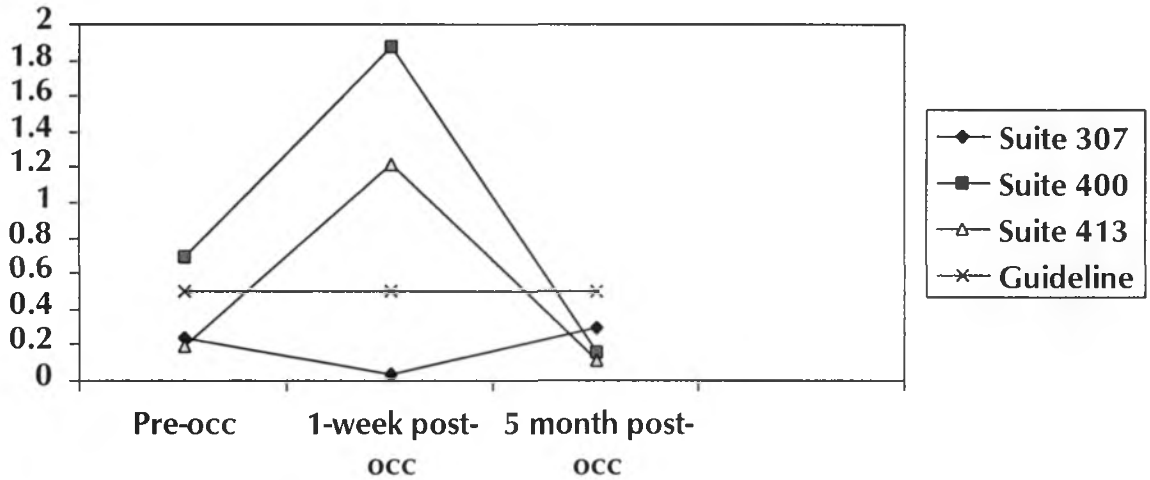


Figure 4. TVOC emission factors (mg/m^{2}h) of carpet

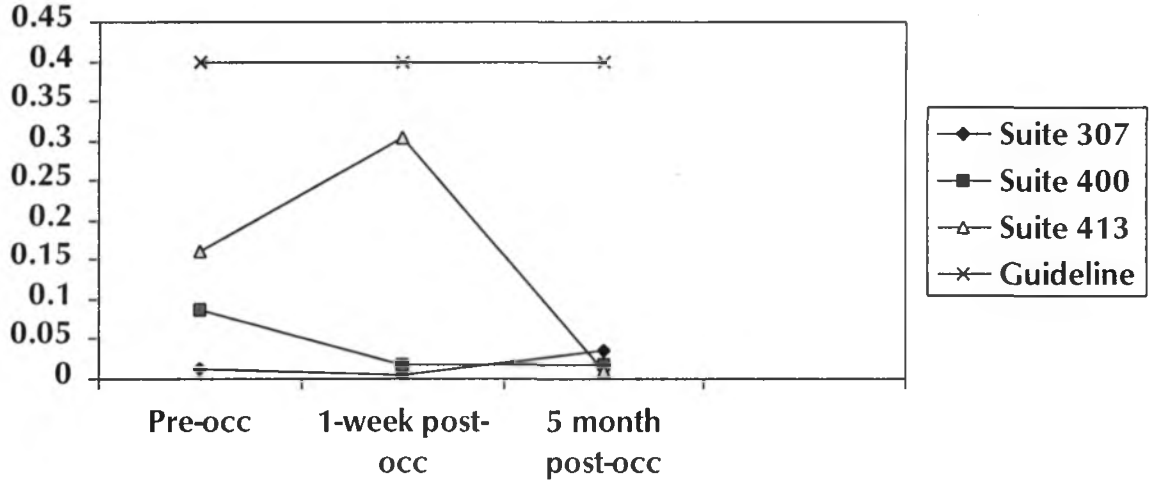


Figure 5. TVOC emission factors (mg/m^{2}h) of cabinet

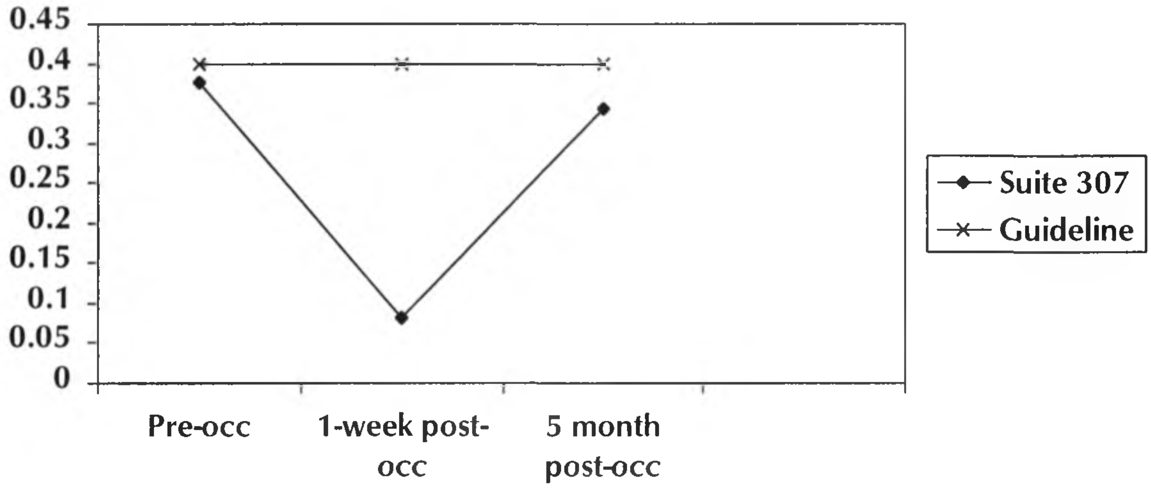


Figure 6. TVOC emission factors (mg/m^{2}h) of MDF molding

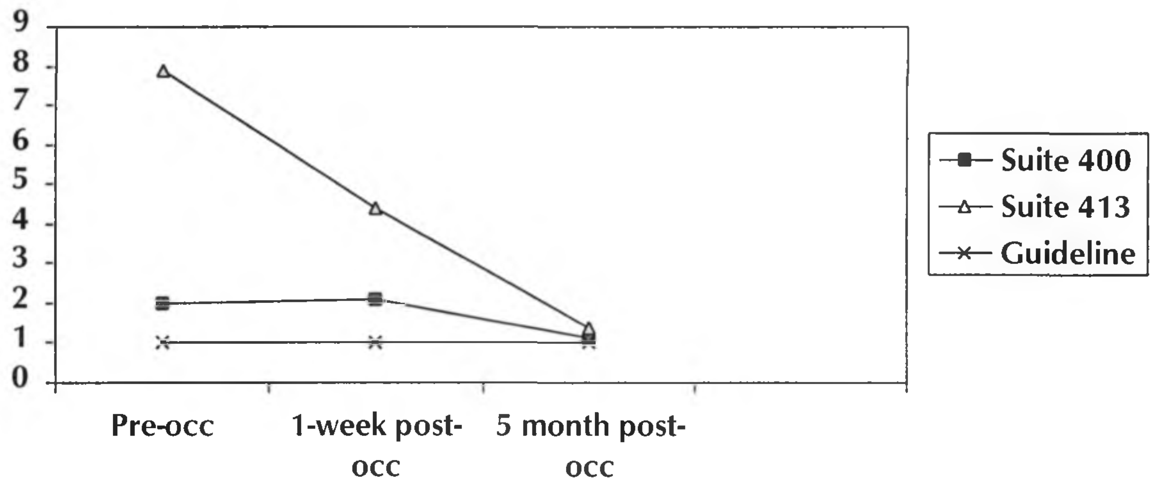


Figure 7. TVOC emission factors (mg/m^{2}h) of vinyl tile

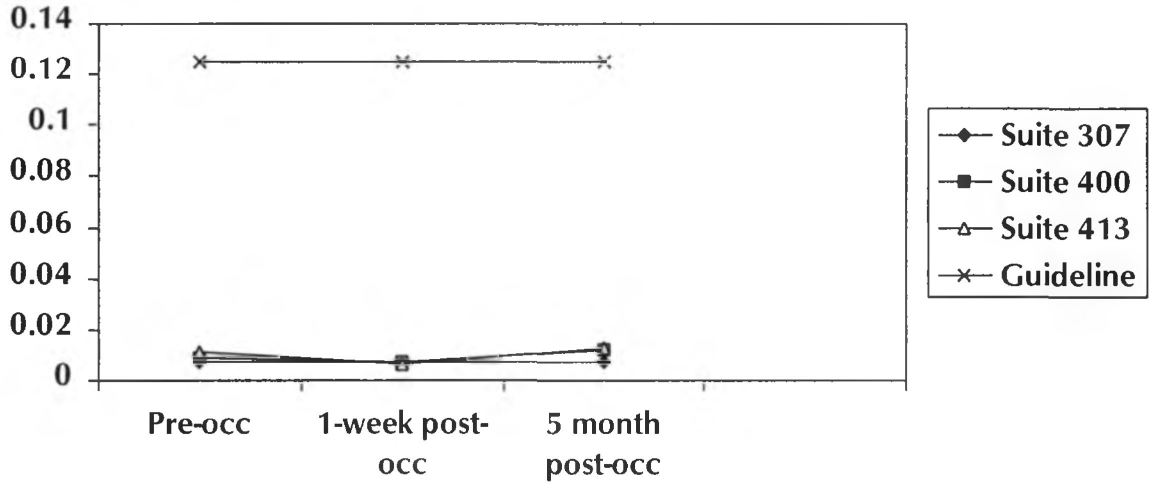


Figure 8. HCHO emission factors (mg/m^{2}h) of painted gypsum board

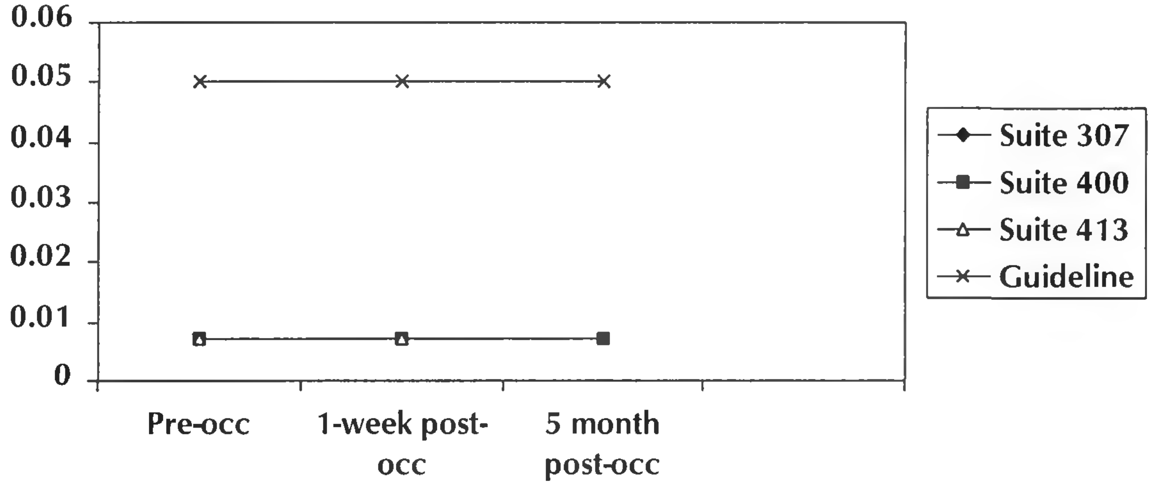


Figure 9. HCHO emission factors (mg/m^{2}h) of carpet

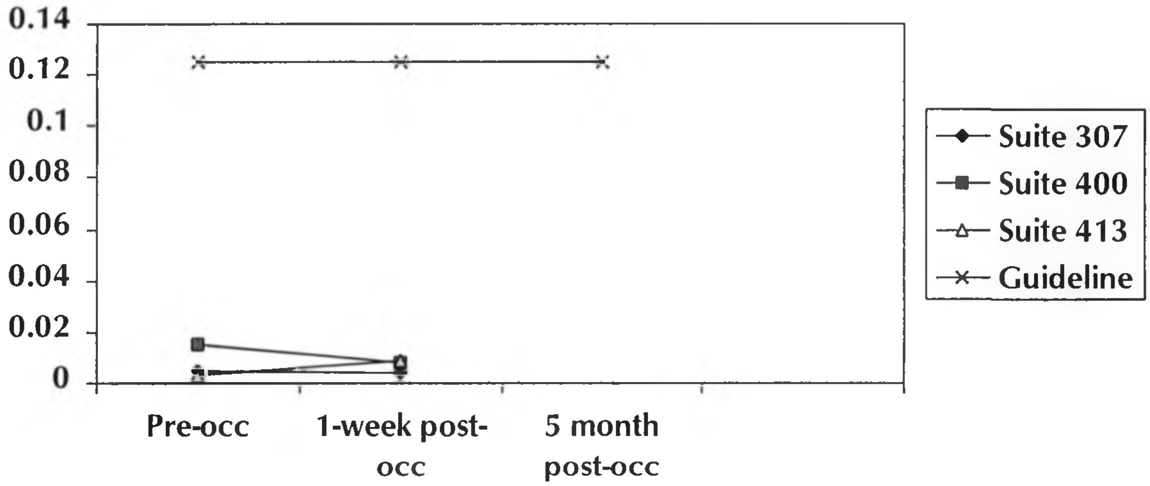


Figure 10. HCHO emissions (mg/m^{2}h) of cabinet

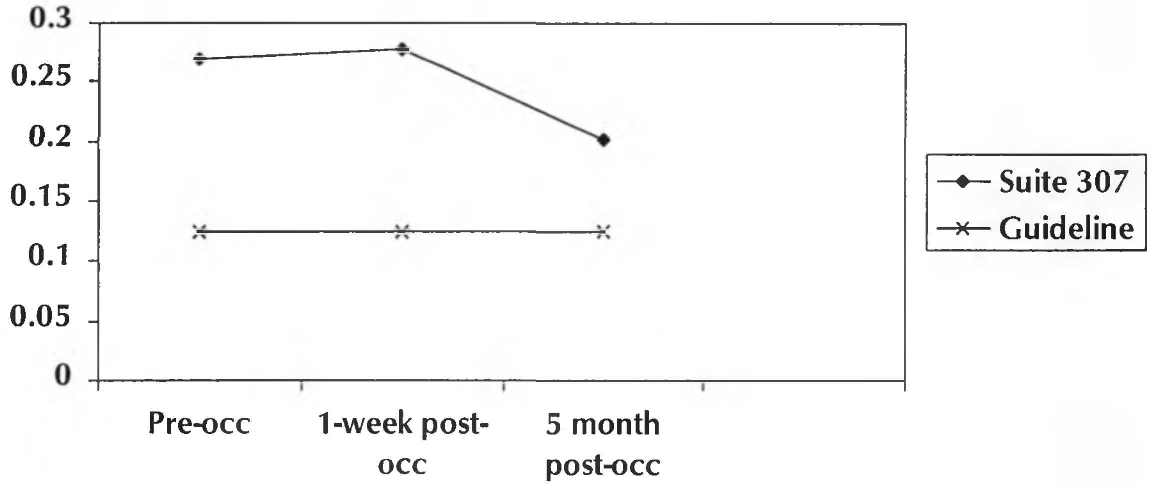


Figure 11. HCHO emissions (mg/m²h) of MDF molding

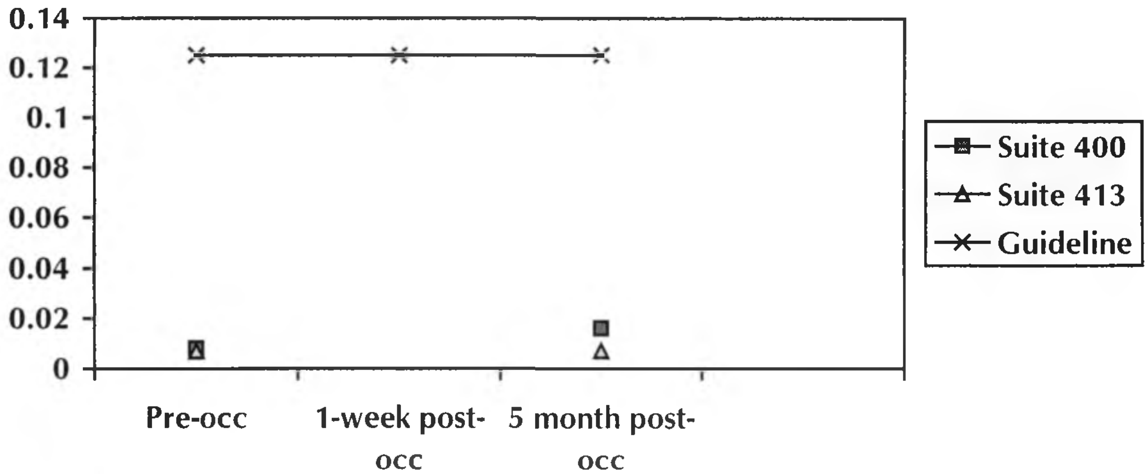


Figure 12. HCHO emissions (mg/m²h) of vinyl tile

Painted gypsum board samples met the TVOC and formaldehyde emission target values established by the Finnish Society of Indoor Air Quality and Climate. The TVOC emission factors were highest at the 1 week post-occupancy monitoring period and decreased below pre-occupancy values at 5 months post-occupancy in suites 307 and 400. This suggests that painted gypsum board acts as a sink for occupant-generated TVOCs and TVOCs emitted from the other materials in the suite at pre-occupancy and 1 week post-occupancy. The TVOC emission factors of painted gypsum board samples in suite 413 remained relatively constant at pre-occupancy and 1 week post-occupancy (the emission factor at 5 months post-occupancy could not be determined due to equipment failure). Formaldehyde emission factors were lowest at the pre-occupancy monitoring period and highest at the 5 month post-occupancy monitoring period. In suite 307 the formaldehyde emission factors of painted gypsum board were below the detection limit.

The carpets installed in suites 400 and 413 were labeled with the CRI's Indoor Air Quality label. The TVOC emission factors of the carpet samples in suite 400 exceeded the CRI 0.5 mg/m^2h criteria for low emitting carpet at the pre-occupancy and 1 week post-occupancy monitoring periods, the carpet sample in suite 413 exceeded the criteria at the 1 week post-occupancy monitoring period only. The TVOC emission factors of carpet samples in suites 400 and 413 were highest at the 1 week post-occupancy monitoring period, decreasing below pre-occupancy values at 5 months post-occupancy. However, in suite 307 the TVOC emission factor decreased at the 1 week post-occupancy monitoring period and increased to its highest value at 5 months post-occupancy. The high TVOC emission factors suggest that carpet is acting as a sink during these periods for occupant generated TVOCs as well as TVOCs emitted from the other materials in the suite. The formaldehyde emission factors of all carpet samples were below formaldehyde detection limits.

Both the TVOC and formaldehyde emission factors of the melamine cabinet samples met the target values established by the Finnish Society of Indoor Air Quality and Climate. The TVOC and formaldehyde emission factors of melamine cabinet samples were not consistent from one suite to another.

MDF molding samples, which were only tested in suite 307, exceeded the formaldehyde emission target values established by the Finnish Society of Indoor Air Quality and Climate at each of the monitoring periods. The TVOC emission factors of the samples were highest at the pre-occupancy monitoring period, decreased significantly at 1 week post-occupancy and increased close to the pre-occupancy value at 5 months post-occupancy. The formaldehyde emission factors of the MDF molding samples remained relatively constant during the pre-occupancy and 1 week post-occupancy monitoring periods and decreased somewhat at 5 months post-occupancy.

Vinyl flooring samples were tested in suites 400 and 413. These samples had the highest TVOC emission factors, exceeding EcoLogo targets. In suite 400, the TVOC emission factors of the vinyl samples remained relatively constant at pre-occupancy and 1 week post-occupancy and decreased by 46% at 5 months post-occupancy. In suite 413, the TVOC emission factors of the vinyl flooring samples decreased significantly at the 1 week and then again at the 5 month post-occupancy monitoring period. Formaldehyde emission factors of vinyl flooring samples were determined at pre-occupancy and 5 months post-occupancy. In suite 400, formaldehyde emission factors doubled at the 5 month post-occupancy monitoring period. In suite 413, formaldehyde emission factors remained constant, below the detection limit for formaldehyde.

A material's emission factor (TVOC and formaldehyde) was combined with the material's surface area in each of the test suites to determine the pollutant source strength of the material. The contributions of each material to the total pollutant source strength from all the materials tested within each test suite and for each monitoring period are presented in Tables 15 and 16.

Table 15: TVOC Emission Rates as % of Total Material Emission Rates of Materials Tested

	Painted gypsum board (%)	Carpet (%)	Cabinet (%)	MDF molding (%)	Vinyl flooring (%)
Pre-occupancy					
Suite 307	11	74	2	13	n/a
Suite 400	6	68	3	n/a	23
Suite 413	1	21	4	n/a	74
Average	6	54	3	n/a	n/a
1 week post-occupancy					
Suite 307	56	33	3	8	n/a
Suite 400	13	77	0	n/a	10
Suite 413	1	73	4	n/a	22
Average	27	61	4	n/a	n/a
5 month post-occupancy					
Suite 307	2	82	6	10	n/a
Suite 400	12	46	2	n/a	40
Suite 413	14	42	1	n/a	43
Average	9	57	3	n/a	n/a

n/a = material not tested

As seen in Table 15, carpet is the main contributor of TVOC emissions during the pre-occupancy monitoring period in suites 307 and 400 of the materials tested. However, in suite 413, vinyl flooring has the most impact although the surface area of this material in the suite is only 5.4 m^2.

At the 1 week post-occupancy monitoring period, carpet is again the main source of TVOC emissions of the materials tested in suites 400 and 413. In suite 307, the painted gypsum board has a greater impact than carpet on TVOC material emissions. Although the two materials have similar TVOC emission factors, painted gypsum board has a greater surface area in suite 307 than carpet.

At the 5 month post-occupancy monitoring period carpet has the greatest influence of the TVOC material emissions tested. In suite 413, the trade-off between surface area and pollutant emission rates is evident. Carpet has a low TVOC emission factor but a greater surface area than vinyl flooring, which has the highest TVOC emission rate of the materials tested and the smallest surface area. Both materials contribute equally to the identified TVOC emissions from the materials tested.

Table 16: HCHO Emission Rates as % of Total Material Emission Rates of Materials Tested

	Painted gypsum board (%)	Carpet (%)	Cabinet (%)	MDF molding (%)	Vinyl flooring (%)
Pre-occupancy					
Suite 307	24	14	5	57	n/a
Suite 400	51	27	18	n/a	4
Suite 413	75	21	2	n/a	2
Average	50	21	8	57	3
1 week post-occupancy					
Suite 307	24	14	4	58	n/a
Suite 400	53	35	12	n/a	n/a
Suite 413	61	31	8	n/a	n/a
Average	46	27	8	58	-
5 month post-occupancy					
Suite 307	36	n/a	n/a	64	n/a
Suite 400	67	26	n/a	n/a	7
Suite 413	98	n/a	n/a	n/a	2
Average	67	26	-	64	5

n/a = material not tested

At all of the monitoring periods, painted gypsum board was the main source of formaldehyde emissions for the materials tested in suites 400 and 413. In suite 307, MDF molding which was not tested in the other two test suites, was the main source of formaldehyde emissions. Although the total surface area of molding in suite 307 is small, this material has a high formaldehyde emission rate relative to the other materials tested.

4.3 IAQ Monitoring

Table 17 presents the results of the pre-occupancy and post-occupancy monitoring of temperature, relative humidity, carbon dioxide and carbon monoxide in the three test suites. Since temperature, relative humidity, carbon dioxide and carbon monoxide concentrations were measured continuously during the monitoring periods, the average values and the range of values (shown in parentheses) are shown in the table. The temperature, relative humidity, and carbon dioxide levels recorded during the monitoring periods are illustrated in the graphs included in the Appendix. The outdoor temperatures in the table are the average daily temperatures during the monitoring period and were obtained from Environment Canada.

Table 17. Indoor Air Quality Monitoring Results

	Outdoor temp (°C)	**Indoor temp (°C)**	**RH (%)**	**CO_2 (ppm)**	**CO (ppm)**
Suite 307					
Pre-occ (June 1996)	18.4	25.0 (23.4-26.6)	40.2 (30.7-52.4)	376 (352-782)	0
1 week post-occ (July 1996)	20.4	24.2 (18.1-27.3)	49.3 (33.7-70.5)	419 (293-997)	0.01 (0-3.9)
5 month post-occ (Nov 1996)	-0.5	22.7 (20.6-25.2)	30.3 (23.2-45.7)	523 (410-880)	0
8 month post-occ (March 1997)	-7.7	20.1 (9.2-23.0)	21.6 (9.1-41.9)	454 (372-940)	0
Suite 400					
Pre-occ (May 1996)	14.6	27.5 (24.1-34.9)	25.8 (8.2-46.5)	456 (352-860)	0
1 week post-occ (June 1996)	19.0	26.6 (23.8-29.5)	37.0 (26.8-51.5)	441 (333-666)	0
5 month post-occ (Dec 1996)	-0.2	23.1 (22.3-24.8)	30.6 (19.1-36.2)	644 (430-1192)	0.4 (0-13.2)
8 month post-occ (March 1997)	-6.4	24.4 (20.9-28.1)	22.0 (13.4-28.6)	529 (332-860)	0.6 (0-8.8)
Suite 413					
Pre-occ (June 1996)	19.0	(a)	(a)	437 (371-897)	0
1 week post-occ (June 1996)	19.0	26.3 (24.1-29.2)	(a)	537 (429-917)	0
5 month post-occ (Nov 1996)	-0.5	24.3 (21.6-26.6)	25.9 (18.3-28.9)	603 (450-646)	0
8 month post-occ (March 1997)	2.2	26.6 (24.8-32.9)	24.7 (14.5-33.4)	531 (352-821)	0.2 (0-7.4)
Guidelines		-	30-80[4] 25-60*	1000[5]	11[4]

Note: The range of measurements is shown in parentheses
(a) Defective equipment
Sources: [5]Exposure Guidelines for Residential Indoor Air Quality, Health Canada
[6]ASHRAE 62-1989 Standard
*IDEAS Challenge requirement

5 *Exposure Guidelines for Residential Indoor Air Quality, Department of National Health and Welfare, April 1987 (revised July 1989)*

6 *Ventilation for Acceptable Indoor Air Quality, ASHRAE Standard 62-1989.*

Table 18 presents the average formaldehyde and TVOC concentrations measured in the test suites during the pre-occupancy and post-occupancy monitoring periods and the average outdoor formaldehyde and TVOC concentrations in downtown Montréal during the monitoring periods, obtained from Environment Canada.

Table 18. Indoor and Outdoor Formaldehyde and TVOC concentrations

	HCHO		TVOC	
	Indoor (ppm)	**Outdoor (ppm)**	**Indoor (mg/m^3)**	**Outdoor (mg/m^3)**
Suite 307				
Pre-occ (June 1996)	0.011	0.002	5.39	0.11
1 week post-occ (July 1996)	0.040	0.0007	2.67	0.07
5 month post-occ (Nov 1996)	0.01	n/a	0.52	0.15
8 month post-occ (March 1997)	0.01	n/a	0.61	0.08
Suite 400				
Pre-occ (June 1996)	0.013	0.0009	0.69	0.14
1 week post-occ (July 1996)	0.020	0.001	0.33	0.11
5 month post-occ (Nov 1996)	0.01	n/a	0.32	0.13
8 month post-occ (March 1997)	0.01	n/a	0.28	0.08
Suite 413				
Pre-occ (June 1996)	0.064	0.001	3.37	0.14
1 week post-occ (July 1996)	0.060	0.001	1.11	0.11
5 month post-occ (Nov 1996)	0.03	n/a	0.41	0.15
8 month post-occ (March 1997)	0.02	n/a	0.32	0.17
Guidelines	0.05[1]		<0.20	

Sources: [1] Exposure Guidelines for Residential Indoor Air Quality, Health Canada
[2] Molhave

Note: Pollutant levels are averaged over the monitoring period.
n/a = not available

4.3.1 Temperature and Relative Humidity

Average relative humidities varied between 26% and 31% during the 5 month post-occupancy monitoring period (November, 1996) and between 22% and 25% during the 8 month post-occupancy monitoring period (March 1997).

During the post-occupancy monitoring periods, temperatures and relative humidities in the test suites were within the comfort range defined by ASHRAE.[7] All of the test suites reported average relative humidity levels within the stipulated range of 25-60% set by the Ideas Challenge competition for the 1 week and 5 month post-occupancy monitoring periods. However, at the end of the season, relative humidity readings taken at the 8 month post-occupancy monitoring period (<25%) suggest the need for additional humidification. The central humidifier was in operation during the winter monitoring periods.

[7] *ASHRAE Standard 55-1992; Thermal Environmental Conditions for Human Occupancy; 1992.*

4.3.2 Carbon Dioxide and Carbon Monoxide

The average carbon dioxide levels in the test suites varied between:

- 376 and 456 ppm at pre-occupancy (June 1996);
- 419 and 537 ppm at 1 week post-occupancy (July 1996);
- 523 and 644 at 5 month post-occupancy (November 1996) and
- 454 and 531 ppm at the 8 month post-occupancy monitoring period (March 1997).

Average carbon dioxide levels remained below the ASHRAE 1989 guideline (1000 ppm) for all the test suites and during all monitoring periods. Carbon dioxide levels above the ASHRAE guideline were only measured in test suite 400 sporadically for short periods of time (total time < 1.5 hours) and may correspond to increased occupancy and/or respiration near the monitoring instrument.

The average carbon monoxide levels detected remained well below the limit of 11 ppm recommended by Health Canada.

4.3.3 Formaldehyde

Formaldehyde levels varied between:

- 0.011 ppm and 0.064 ppm at pre-occupancy (June 1996);
- 0.02 ppm and 0.06 ppm at 1 week post-occupancy (July 1996);
- 0.01 ppm and 0.03 ppm at 5 month post-occupancy (November 1996) and
- 0.01 ppm and 0.02 ppm at the 8 month post-occupancy monitoring period (March 1997).

Levels above the exposure guideline set by Health Canada (0.05 ppm) were recorded only in suite 413 during the pre-occupancy and 1 week post-occupancy monitoring periods.

Formaldehyde levels generally increased from the pre-occupancy to the 1 week post-occupancy monitoring period and then decreased at the 5 month and 8 month post-occupancy monitoring periods.

4.3.4 Total Volatile Organic Compounds

Total volatile organic compound concentrations varied between:

- 0.69 mg/m^3 and 5.39 mg/m^3 at pre-occupancy (June 1996);
- 0.33 mg/m^3 and 2.67 mg/m^3 at 1 week post-occupancy (July 1996);
- 0.32 mg/m^3 and 0.52 mg/m^3 at 5 months post-occupancy (November 1996) and
- 0.28 mg/m^3 and 0.61 mg/m^3 at the 8 month post-occupancy monitoring period (March 1997).

Molhave[8] states that TVOC levels between 0.2 and 3.0 mg/m^3 may cause irritation and discomfort if other exposures interact and that at levels between 3 and 25 mg/m^3 headaches are probable. TVOC levels were above 0.2 mg/m^3 in all suites for all of the monitoring periods. TVOC levels above 3 mg/m^3 were noted during the pre-occupancy monitoring periods only.

4.3.5 Occupant Questionnaires

The occupant of suite 307 is an occasional smoker who estimated smoking 1-2 cigarettes daily. She rated the air quality in her suite as dry but had no other complaints as to indoor temperature or the presence of odors from other suites. The relative humidity levels in suite 307 were not lower than those monitored in the other two test suites. General purpose cleaning products were used once or twice a week. Hairspray was used in suite 307 daily.

Two adults occupy suite 400. One of the two occupants is a smoker who smokes approximately 15 cigarettes daily. Both occupants found the temperature in their suite to be too high. They often kept their thermostat at the minimum setting. The occupants were happy with the fresh air supply to their suite. Old Dutch and Hertel cleaning products were used daily.

The occupant of suite 413 is a non-smoker. He was occasionally disturbed with kitchen odors in his suite from adjacent suites. It should be noted that the highest percentages of source concentration from adjacent suites and corridors were detected in test suite 413. No symptoms such as headaches or fatigue were reported. Cleaning products were used once or twice a week.

The occupant questionnaires completed during the 5 month post-occupancy monitoring period are included in the Appendix.

8 *Molhave, L. "The Use of the TVOC-Concept in Source Characterization and Regulation of IAQ", Indoor Air Quality, Ventilation and Energy Conservation in Buildings, 2nd International Conference, Montreal, May 9-12, 1995, Volume 1, pp. 1-29.*

5. Analysis

Given the number of variables which affect the indoor air quality of a space and the inherent cross effects of a multi-zone building, the analysis presented herein is an engineering attempt to understand the relationships between material emissions, indoor air pollutant concentrations, mechanical ventilation and occupant lifestyle.

In order to facilitate the reader's analysis of the results presented in the preceding section, results are summarized in a fold-out table (Table 22) at the end of this section.

Each subsection below addresses one of the five indoor air quality performance criteria addressed by the study, namely:

- formaldehyde;
- TVOCs;
- fresh air change;
- CO_2 ;
- CO and
- temperature and relative humidity.

5.1 Formaldehyde

The results of formaldehyde testing during the 5 month and 8 month post-occupancy monitoring periods indicate that concentrations have stabilized and are well below Health Canada's guidelines. Only the occupant of suite 413 was exposed to formaldehyde concentrations exceeding the recommended limits during the 1 week post-occupancy monitoring period.

Table 19 compares the apparent formaldehyde source strengths calculated from measured concentrations in the test suite with the formaldehyde source strengths in the space from the emissions of the materials tested in the suite. A range is provided for the apparent formaldehyde source strengths in the suites, based on the maximum and the minimum outdoor air change rates. The percentage of the total apparent formaldehyde source strength due to the emissions of the materials tested is also provided. The lower end value was calculated using mechanical ventilation supply flows as the volume flow rate into and out of the space in equation (1), presented in section 2.3.4, and represents a minimum apparent formaldehyde source strength. The high end value was calculated using the total air change rate, as determined from PFT testing, as the volume flow rate in the equation. Since the total air change rate includes fresh air from the ventilation system and outdoors and air entering the suite from adjacent suites and the corridor, this is the maximum apparent formaldehyde source strength possible.

The average outdoor concentrations of formaldehyde in downtown Montréal during the monitoring periods, presented in Table 18 in section 4.3, were used in equation (1).

Outdoor formaldehyde concentrations for the 5 month post-occupancy monitoring period were not available.

Table 19. HCHO Emissions of Materials Tested vs. Apparent HCHO Emission Rates

Suite	Monitoring period	Formaldehyde Source Strengths (mg/h)		% from material tested
		material emissions tested	Apparent	
307	Pre-occupancy	1.149	0.461-1.317	>100-87
	1 week post-occ	1.154	2.013-5.545	57-21
	5 month post-occ	0.764	0.234-1.398	>100-55
400	Pre-occupancy	1.231	2.122-3.530	58-35
	1 week post-occ	0.941	3.333-6.286	28-15
	5 month post-occ	1.271	1.711-2.687	74-47
413	Pre-occupancy	2.123	2.899-3.446	73-62
	1 week post-occ	1.435	2.715-16.906	53-8
	5 month post-occ	1.932	3.061-4.298	63-45

The percentage of formaldehyde in the indoor air due to the formaldehyde emissions of the materials tested in the suite decreased from the pre-occupancy to the 1 week post-occupancy monitoring period and then increased at the 5 month post-occupancy monitoring period in all of the test suites. This pattern indicates that material emissions continue to be important after construction completion, when formaldehyde emissions are expected to be high, and also at a later date when "sink" materials re-emit formaldehyde to the indoor air. At the 1 week post-occupancy monitoring period, emissions from other sources including occupant activities, from materials and furnishings not tested, and from any cross-contamination with adjacent suites and the corridor accounted for an average of 54% (minimum value) of the indoor formaldehyde emissions.

In suite 307, at the pre-occupancy and 5 month post-occupancy monitoring period, the formaldehyde emissions of the materials tested is greater then the apparent formaldehyde emission rate (when using the mechanical ventilation supply flow rate as the volume flow rate into and out of the suite). This suggests that materials are acting as sinks during these monitoring periods and reducing indoor formaldehyde concentrations or that the exchange rate experienced in the suite was actually greater than the mechanical ventilation rate, i.e closer to the total air change rate as determined from PFT testing.

The materials selected for emission testing to determine the impact of formaldehyde material emissions on indoor formaldehyde source strengths are representative of the main sources of formaldehyde due to material emissions. The percentage of ambient formaldehyde due to material emissions was found to be as high as 87% (minimum non 100% value) of the overall emissions in the apartments.

The results indicated that mechanical ventilation had a small but noticeable influence on measured formaldehyde concentrations. Suite 400 had marginally lower formaldehyde concentrations than suite 413 which had less ventilation and similar indoor formaldehyde concentrations as suite 307 though apparent source strengths were greater in suite 400.

Measured formaldehyde levels in suite 413 were, on average, 2.6 times greater than those monitored in the other two test suites at each of the monitoring periods. The wooden color-treated blinds in this suite, combined with the lower air change rate might have caused this difference.

5.2 Total Volatile Organic Compounds

As cited in section 4.3.4, Molhave states that TVOC levels between 0.2 and 3.0 mg/m^3 may cause irritation and discomfort if other exposures interact. At levels between 3 and 25 mg/m^3, he states that headaches are possible. TVOC levels above 3 mg/m^3 were noted only during the pre-occupancy monitoring periods. Average TVOC levels between 0.2 and 3.0 mg/m^3 were monitored in all the test suites during the post-occupancy monitoring periods.

The average TVOC level of 0.41 mg/m^3 monitored during the 5 month and 8 month post-occupancy monitoring periods were lower than the average levels monitored in other indoor air quality studies performed in residential buildings as may be expected given the absence of wood frame construction. Wallace et al. reported a mean TVOC concentration for a sample of 200 homes in the U.S. at 0.7 mg/m^3 and Brown et al reported 1.13 mg/m^3 as a weighted averaged geometric mean for 1081 residences measured in several countries[9].

Table 20 compares the TVOC emissions in the suites due to the materials tested and the apparent TVOC emissions calculated with the measured indoor concentrations. As for formaldehyde, apparent TVOC emissions were calculated using equation (1) presented in section 2.3.4 using both the mechanical ventilation supply flow and the total air change to provide a range of values. The average outdoor concentrations of TVOCs in downtown Montréal for the three monitoring periods, presented in section 4.3 were used.

Table 20. TVOC Emissions of Materials Tested vs. Apparent TVOC Emission Rates

Suite	Monitoring period	TVOC Concentration (mg/h)		% from material tested
		material emissions tested	Apparent	
307	Pre-occupancy	7.071	224-641	3-1
	1 week post-occ	2.490	110-304	2-1
	5 month post-occ	8.187	7-43	>100-19
400	Pre-occupancy	48.120	81-134	60-36
	1 week post-occ	115.188	32-60	>100
	5 month post-occ	16.224	27-43	59-38
413	Pre-occupancy	57.380	123-147	47-39
	1 week post-occ	105.937	38-237	>100-45
	5 month post-occ*	17.205	22-31	79-56

* The average emission factor determined for painted gypsum board at 5 months post-occupancy was used to determine the pollutant generation rate of the painted gypsum board during this monitoring period since the emission factor of this sample could not be obtained due to equipment failure during chamber tests.

9 Levin, Hal. "VOCs:Sources, Emissions, Concentrations, and Design Calculations", Indoor Air Bulletin, Vol 3, No.5

In suite 307, at the pre-occupancy monitoring period and 1 week post-occupancy monitoring periods, the percentage of indoor TVOC emissions due to the materials tested in the suite is only 3% (maximum value). The sources of TVOCs during this monitoring period may be building materials which were not part of the material emission testing such as the adhesives used in the installation of the carpet (adhesives were not used to apply the carpet in the other test suites) and the ceramic tiles in this suite, furnishings, cigarette smoking, air from adjacent suites and corridors carrying in TVOCs and occupant activity.

In suite 400, at the 1 week post-occupancy monitoring period, the TVOC emissions due to the materials tested exceed the apparent TVOC emissions. This result suggests that during this monitoring period, the materials tested and/or other materials were acting as sinks and thus reducing indoor TVOC levels. Another key reason why the emissions from the materials tested exceeded the apparent TVOC emission rate is the fact that the fresh air change rate in the suite was approximately three times the air change rate used in the material emission test chamber. This higher air change rate lowers the concentration in the indoor air and hence lowers the apparent emission rates.

The results of material emission tests suggest that occupant behavior, emissions from materials, products and/or furnishings in the suite not tested, TVOCs entering the suite from adjacent suites and the corridor have an impact on indoor TVOC concentrations. Common TVOC sources include particle board furniture, furnishings, household and janitorial cleaning, hobby and art materials, food preparation, smoking, and consumer products used for personal hygiene.

Though the percentages of indoor TVOC emissions due to the materials tested were generally lower than those of formaldehyde, the materials selected for emission testing were representative of materials used in residential high rise buildings which are common TVOC sources.

Suite 400, which had the highest ventilation supply and exhaust flows and was the only suite whose supply flow met the CAN/CSA-F326-M91 requirements, had the lowest measured indoor TVOC levels at each of the monitoring periods. This suggests that the mechanical ventilation did have an impact on the indoor TVOC levels in the test suite. The impact of mechanical ventilation on indoor TVOC levels however is not proportional. Although suite 400 had three times the fresh air change rate as the other suites, it did not have a corresponding improvement in the quality of the indoor air with respect to indoor TVOC levels (i.e. the indoor TVOC levels were not three times lower than levels in the other suites).

It seems that high fresh air flows are required following construction completion to counter the effects of high TVOC levels. The study revealed that during the pre-occupancy monitoring period, TVOC levels measured in suites 307 and 413, where ventilation flows were well below the CAN/CSA-F326-M91 recommended flows, were above 3.0 mg/m^3. However, mechanical ventilation flows according to F326 would probably not have been sufficient to bring the TVOC levels below the recommended limits. High indoor TVOC levels and other pollutant concentrations are best controlled during the first few months following a suite's completion at the source by the choice of low-emitting materials and furnishings and occupant education on these products. The oversizing of a mechanical ventilation system, and its associated cost, to provide high enough fresh air flows to reduce indoor TVOC concentrations following construction completion is not recommended.

5.3 Fresh Air Change

The fresh air change rate in a dwelling is the number of times in an hour that the volumetric quantity of air is replaced completely by outdoor air. The fresh air change rate is useful in evaluating potential occupant comfort and indoor air quality. The results of PFT testing and the mechanical ventilation measurements showed that the mechanical ventilation supply flows accounted for, on average, 48% of the total air change rate in the suites, i.e. an average fresh air change rate of 0.47 ach. This value represents the minimum average fresh air change rate of the test suites.

To that amount of 0.47 ach, should be added the fresh air change due to infiltration. The calculation of infiltration is a complex task. It involves a dynamic analysis of several factors including airtightness, stack effect, wind, temperature, etc. However, the amount of infiltration was approximated based on the percentage of the suite's exposed surface areas. The fresh air entering the suites from the exposed walls was calculated using the following equation:

$$FA_{inf} = [SA_{exposed}/SA_{total}] \times (ACR_{total} - SF)$$

where:

FA	=	the estimated fresh air change rate from infiltration, L/s;
$SA_{exposed}$	=	the exposed surface area of the suite which represents the area of suite walls exposed to exterior conditions, m^2;
SA_{total}	=	the total surface area of the suite which represents the area of exterior walls, walls to adjacent suites and corridor, ceiling and floor area, m^2;
ACR_{total}	=	the total air exchange rate determined from PFT testing, L/s;
SF	=	the mechanical ventilation supply flow rate, L/s.

This approximation is valid since the exposed surface area in the test suites is small (the exposed surface area in the test suites represent only 12% of the total surface area) compared to the total surface area.

The estimated fresh air from infiltration was then added to the mechanical ventilation system's supply flow to obtain the estimated fresh air change for the test suites assuming that air flows into rather than out of the suites due to stack, wind, and mechanical system effects. Thus the estimated fresh air change rate represents a maximum outdoor air change rate. Results are presented in Table 21.

Table 21. Estimated fresh air change rate

	Estimated fresh air from infiltration (L/s)	Mech. ventilation supply flow (L/s)	Estimated fresh air change rate (L/s)	Estimated fresh air change rate (ACH)	% Fresh air/ total air change	Estimated % fresh air from mech. ventilation
Suite 307						
Pre-occ	1.9	11.8	13.7	0.46	41	86
1 week post-occ	1.8	11.8	13.6	0.45	42	87
5 month post-occ	2.3	5.4	7.7	0.26	24	70
Suite 400						
Pre-occ	4.8	40.4	45.2	0.95	67	89
1 week post-occ	6.4	40.4	49.0	1.03	64	82
5 month post-occ	4.0	39.4	43.4	0.91	70	91
Suite 413						
Pre-occ	0.2	10.6	10.8	0.18	86	98
1 week post-occ	5.0	10.6	15.6	0.26	24	68
5 month post-occ	0.9	23.5	24.4	0.41	74	96

Based on this simplification, the added fresh air change rate due to infiltration was 0.08 ach and the average fresh air change in the suites was 0.55, of which 85% was due to mechanical ventilation.

These results stress the importance of directly supplying outdoor air to suites in multifamily residential buildings, especially buildings that are built as airtight as the Clos St-André, because they cannot rely on fresh air entering the suites from infiltration alone to meet fresh air requirements.

ASHRAE 62-89 specifies an outdoor air requirement of 0.35 ach in residential dwellings. According to the estimates shown in Table 21, only fresh air change rates in suite 307 at 5 month post-occupancy and suite 413 at pre-occupancy and 1 week post-occupancy did not meet these requirements.

Although mechanical ventilation rates did not meet the CAN/CSA-F326-M91 requirements, the occupants of the three test suites made no complaints as to their indoor air quality and rated their air quality as "average". The occupants of suite 400, the only suite whose supply flows met F326 requirements liked the fresh air supply to their suite.

5.4 Carbon dioxide

The carbon dioxide levels monitored in the test suites were well below ASHRAE limits. Average carbon dioxide levels monitored in the test suites were highest at the 5 month post-occupancy monitoring period in December. Average levels decreased at the 8 month post-occupancy monitoring period in March although average outdoor temperatures during this time were lower.

Higher average carbon dioxide levels were not recorded in suite 400, which had two occupants, relative to the other two test suites, which were single occupancy. However, supply ventilation flows in this test suite were, on average, 2.7 times greater than supply flows in the other test suites.

A qualitative analysis of the continuous carbon dioxide levels monitored in the test suites, graphed and included in the Appendix, show that peak carbon dioxide levels occurred in the morning and evening during weekdays. During weekends, carbon dioxide levels show fewer peaks. Unoccupied periods were noted in December in suites 307 and 413 and again in March in suite 307.

5.5 Carbon Monoxide

As mentioned in section 4.3.2, the average carbon monoxide levels detected in the test suites were below the limit of 11 ppm recommended by Health Canada.

Carbon monoxide was only detected in suite 307 at the 1 week post-occupancy monitoring period, in suite 400 at the 5 month and 8 month post-occupancy monitoring periods, and in suite 413 at the 8 month post-occupancy monitoring period. A qualitative analysis of the carbon monoxide levels monitored in these test suites during these monitoring periods, graphed and included in the Appendix, show that in suite 307, carbon monoxide was detected during one day of the 1 week post-occupancy period in the morning. In suite 400, at the 5 month post-occupancy monitoring period, carbon monoxide levels peaked in the evening at 10pm. During the 8 month post-occupancy monitoring period, however, the carbon monoxide levels in this test suite peaked in the mornings, between 7am and 8 am, and in the evenings, to higher levels, at 8pm. In suite 413, at the 8 month post-occupancy monitoring period, carbon monoxide levels peaked in the mornings, at approximately 10am.

5.6 Temperature and Relative Humidity

As mentioned in section 4.3.1, the temperatures and relative humidities monitored in the test suites were within the comfort range defined by ASHRAE. However, the occupant of suite 307 rated the air quality in her suite as dry and the occupants of suite 400 found the temperatures in their suite too high.

A qualitative analysis of the continuous temperatures measured in each of the test suites, graphed and included in the Appendix, reveals that sharp temperature increases correspond to hours of greatest solar gain. The occupants of suite 400, which is located at the southeast/northeast corner of the building and has the greatest glazing surface area, complained of high indoor temperatures. To offset these high temperatures, the occupants of suite 400 closed window blinds and curtains during the day.

Although an air conditioning system was not provided for in the building's design, a cooling coil has recently been installed in the building's central ventilation system following complaints by building occupants of high indoor temperatures.

Table 22. Summary of Results

Suite	Mon. period	Floor area (m^2)	Vol. (m^3)	Surface area (m^2)	Exposed surface area (m^2)	No. occ.	Smokers	Airtight-ness (ACH @ 50Pa)	Mechanical ventilation (L/s) Supply	Mechanical ventilation (L/s) Exhaust	Total AC rate (L/s)	Estim fresh AC rate (L/s)	Avg Cross-conta-mina-tion (%)	TVOC emissions due to materials tested (mg/h)	Apparent TVOC emissions (mg/h)	Indoor TVOC conc. (mg/m^3)	HCHO emissions due to materials tested (mg/h)	Apparent HCHO emissions (mg/h)	Indoor HCHO conc. (ppm)	Temp. °C	RH (%)	CO_2 (ppm)	CO (ppm)
	Pre-occ								11.8	15.0	33.7	13.7	2.0	7.071	229-654	5.39	1.149	0.564-1.609	0.011	25.0	40.2	376	0
307	1 week	45.5	108.3	154	13.3	1	1	6.90	11.8	15.0	32.5	13.6	3.2	2.490	113-312	2.67	1.154	2.049-5.644	0.040	24.2	49.3	419	0.01
	5 month								5.4	17.4	32.2	7.7	4.0	8.187	10-60	0.52	0.764	0.234-1.398	0.01	22.7	30.3	523	0
	8 month								7.1	9.0	n/a	n/a	n/a	n/a	n/a	0.61	n/a	n/a	0.01	20.1	21.6	454	0
	Pre-occ								40.4	17.7	67.2	45.2	3.0	48.120	100-167	0.69	1.231	2.280-3.793	0.013	27.5	25.8	456	0
400	1 week	71.5	171.5	229	14.1	2	1	6.50	40.4	17.7	76.2	49.0	3.0	115.188	48-90	0.33	0.941	3.508-6.617	0.020	26.6	37.0	441	0
	5 month								39.4	18.2	61.9	43.4	2.2	16.224	45-71	0.32	1.271	1.711-2.687	0.01	23.1	30.6	644	0.4
	8 month								28.9	9.6	n/a	n/a	n/a	n/a	n/a	0.28	n/a	n/a	0.01	24.4	22.0	529	0.6
	Pre-occ								10.6	2.6	12.6	10.8	19.3	57.380	129-153	3.37	2.123	2.945-3.501	0.064			437	0
413	1 week	90.1	216	277	25.0	1	0	5.44	10.6	2.6	66.0	15.6	7.6	105.937	42-263	1.11	1.435	2.761-17.193	0.060	26.3		537	0
	5 month								23.5	9.2	33.0	24.4	3.0	17.205	35-49	0.41	1.932	3.061-4.298	0.03	24.3	25.9	603	0
	8 month								14.8	7.7	n/a	n/a	n/a	n/a	n/a	0.32	n/a	n/a	0.02	26.6	24.7	531	0.2
Guidelines									30	40						0.2			0.05		30-80	1000	11

6. Conclusions

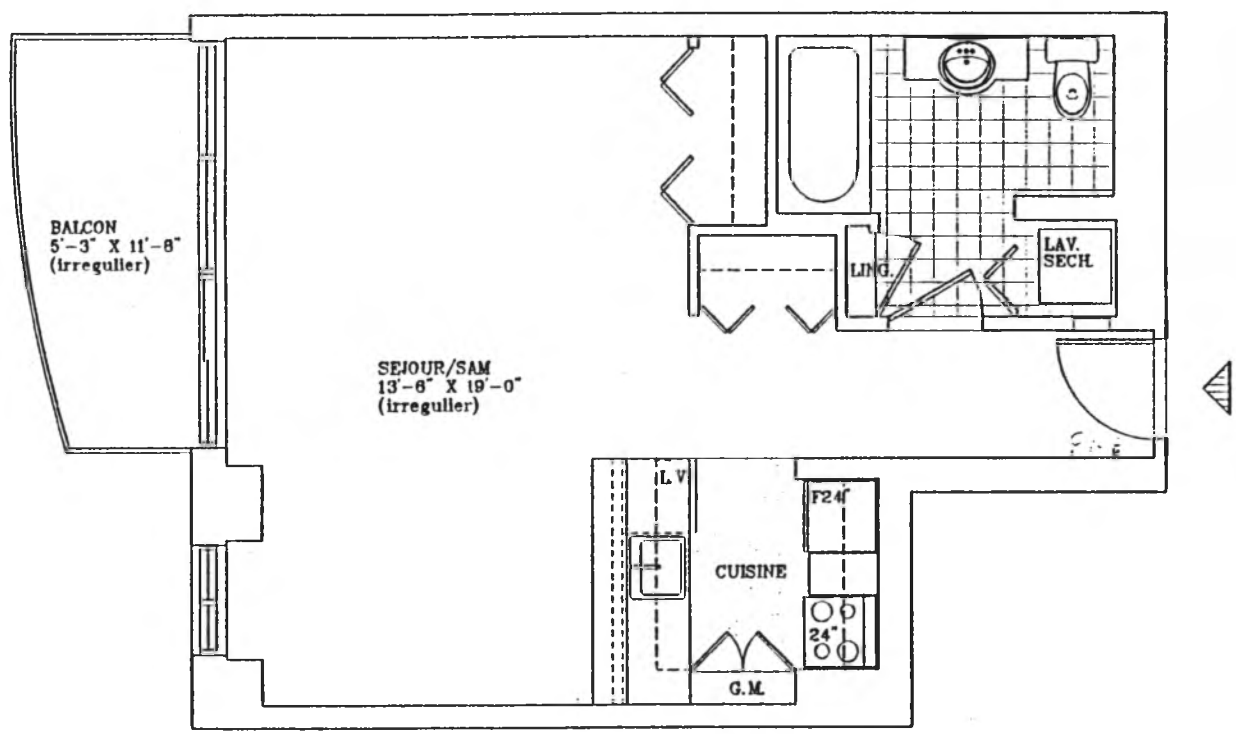
This research project greatly increases the understanding of the pollutant emission characteristics of common construction and finishing materials used in multi-unit residential buildings at key points in time: immediately following the completion of construction, immediately after occupancy and five months post-occupancy. It also increases the understanding of the relative contributions of pollutant emission from building-related materials and finishes versus those from occupant-related furnishing, finishes, personal affects and activities over the first eight months of occupancy of a newly completed building.

Based on the results of the chamber testing, the TVOC emissions of vinyl flooring and the formaldehyde emissions from medium density fibreboard moldings exceeded recommended limits. Although the surface area of these materials was small compared to the surface areas of other materials and finishes studied, their high emission rates made them major contributors to the overall emissions within the suites. An increase in the pollutant emission rates of painted gypsum board and carpet indicates that these materials act as "sinks" for pollutants generated by other materials, finishes, and occupant-related furnishings and activities.

Pollutant emissions from the materials tested accounted for as much as 87% of the total apparent pollutant concentrations within the suites immediately after the occupants moved in. These trends tend to indicate a decline in the amount of pollutants being emitted by the construction materials while occupant-related pollutant emissions remain stable or increase.

While ventilation rates can contribute to the control of pollutant concentrations within dwellings, the relationships between the ventilation rates in the suites and the indoor concentrations of VOCs and formaldehyde were not so clear. It was apparent that a substantial increase in fresh air change rate was not necessarily accompanied by a corresponding decrease in indoor pollutant concentrations. This finding indicates that the magnitude of ventilation supplied to the suites is not conducive to the control of indoor pollutants. Indoor pollutant levels would be better controlled through source control by selection and use of non- or low polluting materials and finishes. This applies to both the materials and finishes used in the construction of the building and the furnishings, fittings, possessions and activities of the occupants of the building.

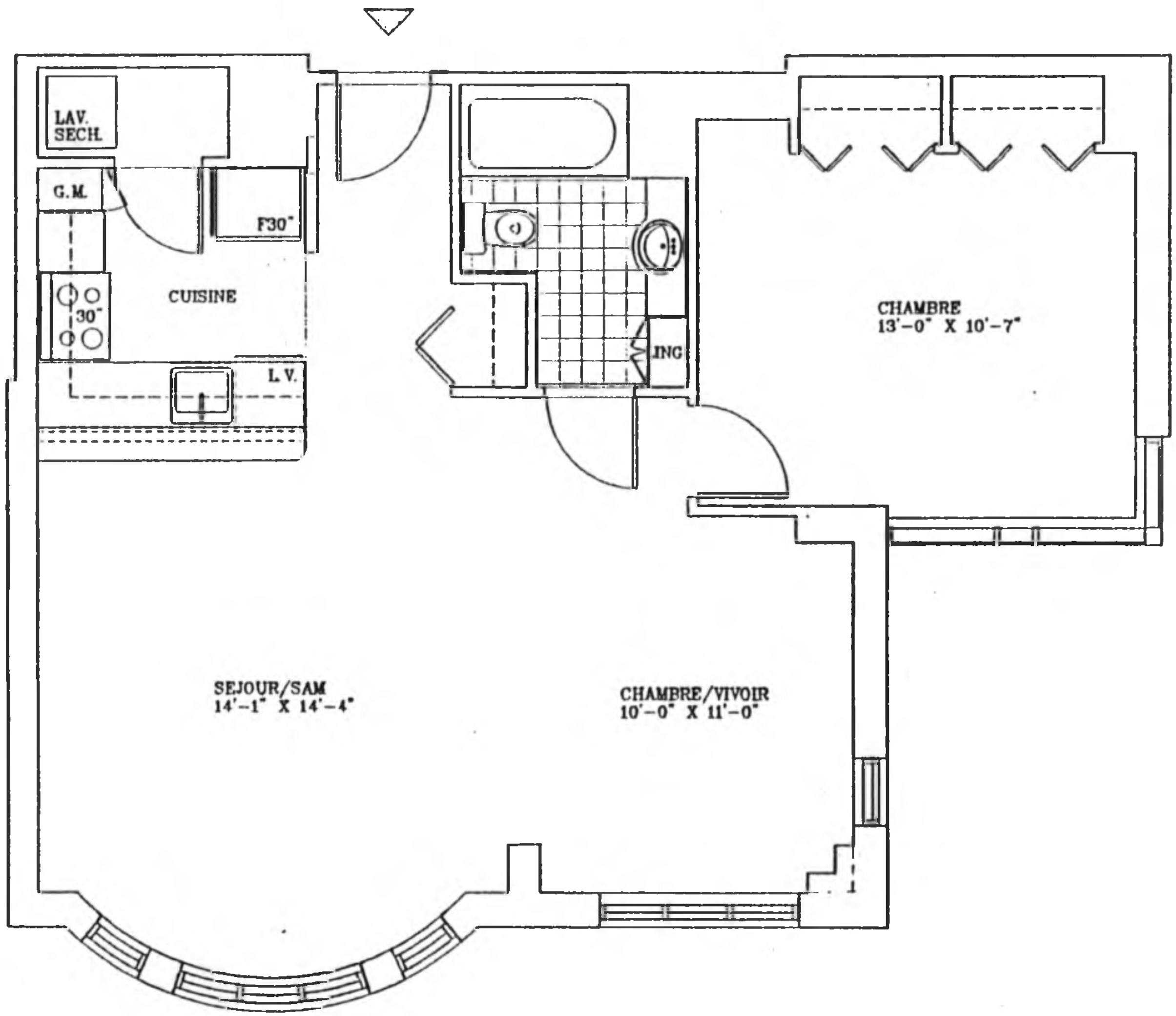
Appendix



* LES PLANS SONT SUJETS A DES MODIFICATIONS MINEURES SANS PREAVIS. TOUTES LES DIMENSIONS SONT APPROXIMATIVES ET A VERIFIER SUR LE SITE.
LA SUPERFICIE EXPRIME LA SURFACE BRUTE DE L'UNITE ET NON LE PLAN CADASTRAL.

ECHELLE: 1/4
23-08-95

MODELE H

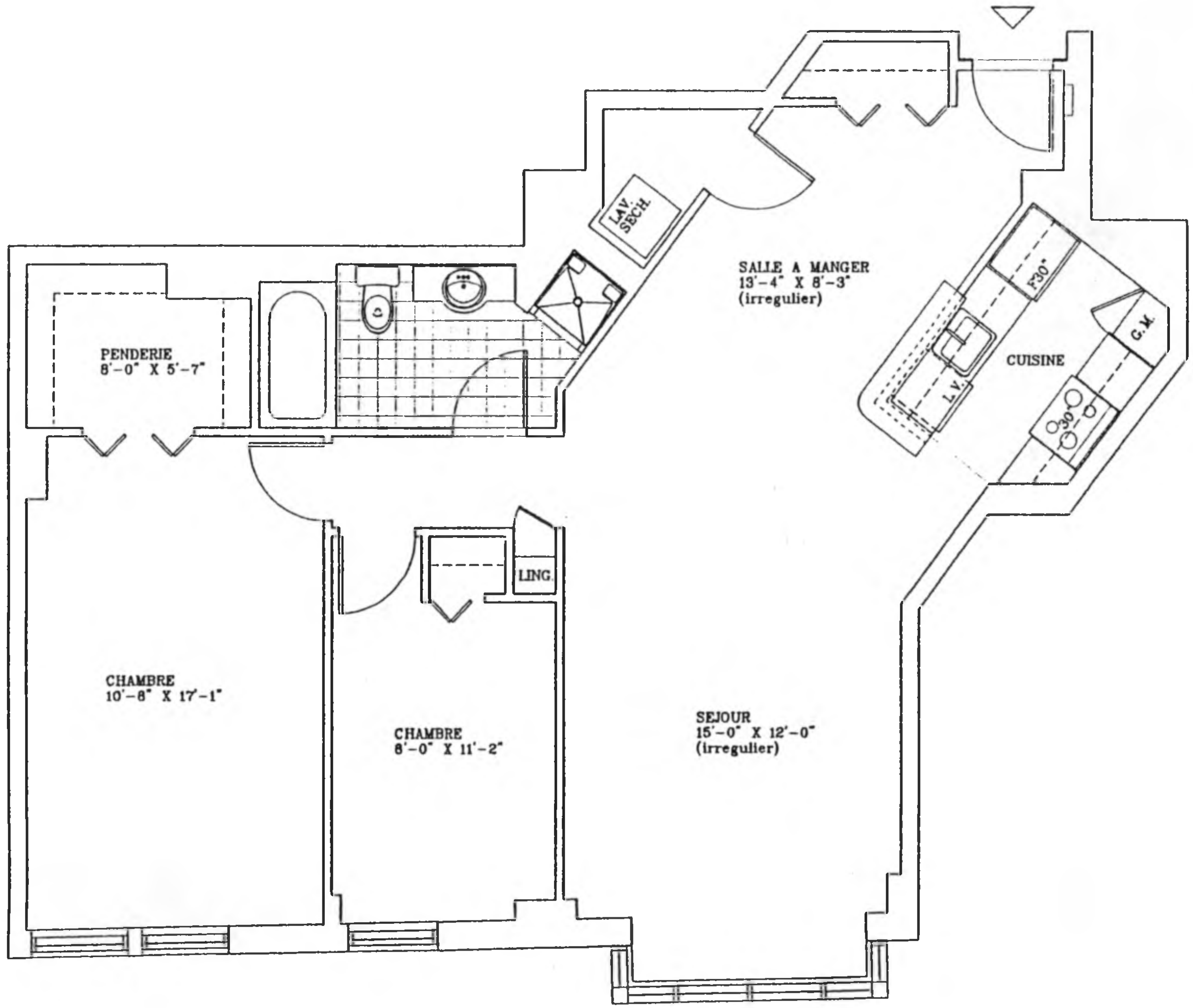


* LES PLANS SONT SUJETS A DES MODIFICATIONS MINEURES SANS PREAVIS. TOUTES LES DIMENSIONS SONT APPROXIMATIVES ET A VERIFIER SUR LE SITE
LA SUPERFICIE EXPRIME LA SURFACE BRUTE DE L'UNITE ET NON LE PLAN CADASTRAL

ECHELLE: 1/4
7-09-95

MODELE DB

400



* LES PLANS SONT SUJETS A DES MODIFICATIONS MINEURES SANS PREAVIS. TOUTES LES DIMENSIONS SONT APPROXIMATIVES ET A VERIFIER SUR LE SITE.
LA SUPERFICIE EXPRIME LA SURFACE BRUTE DE L'UNITE ET NON LE PLAN CADASTRAL.

ECHELLE: 1/4
7-09-95

MODELE K

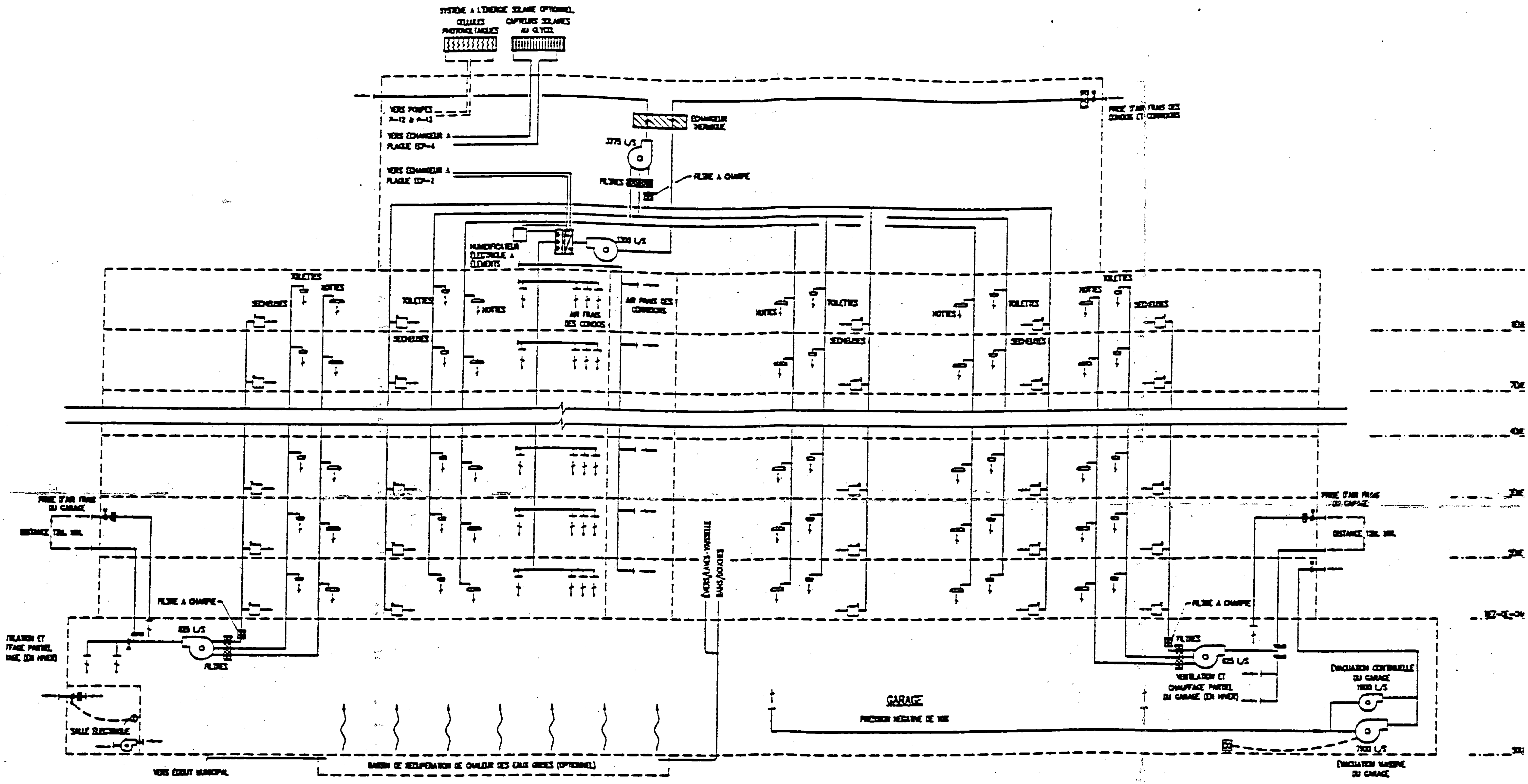
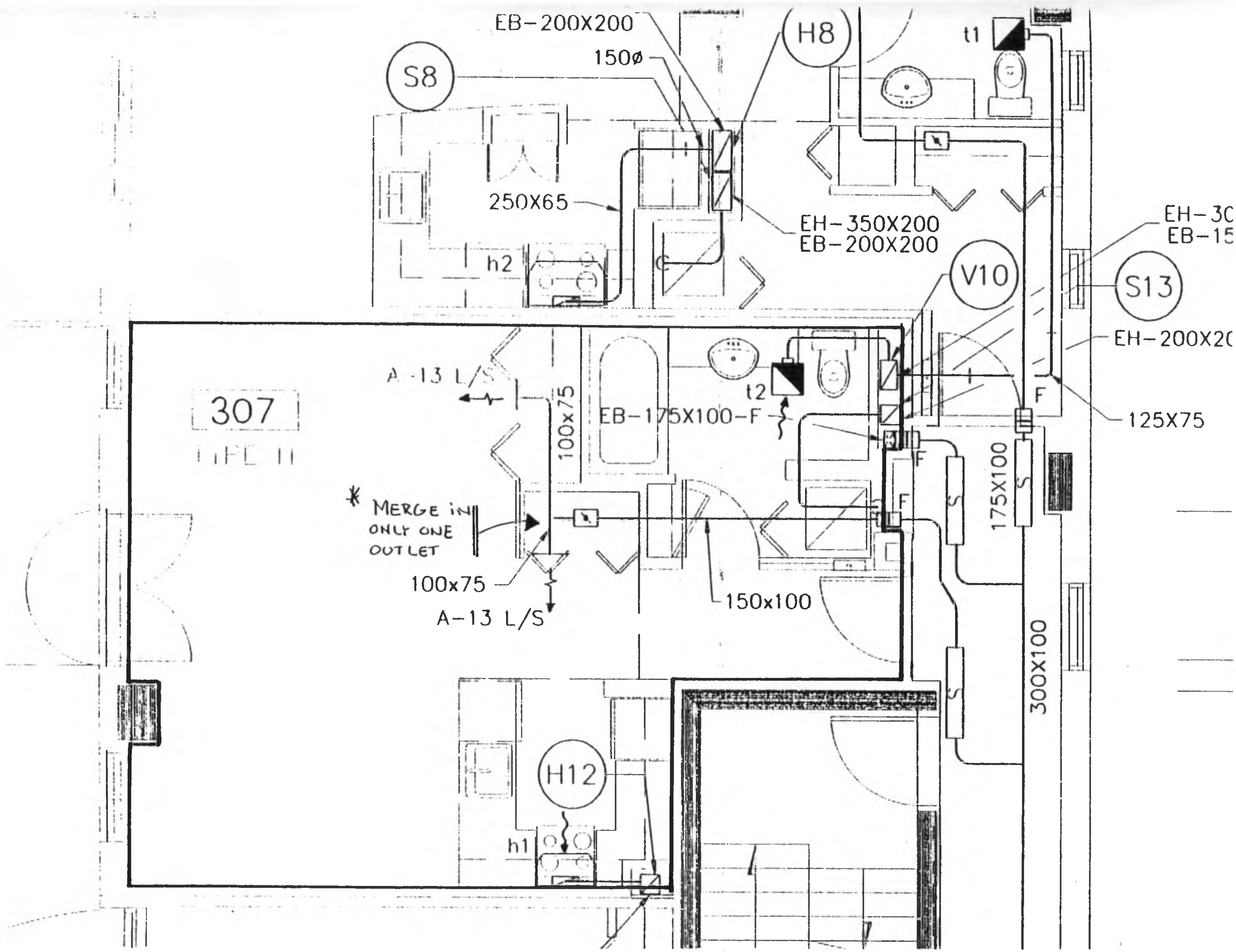
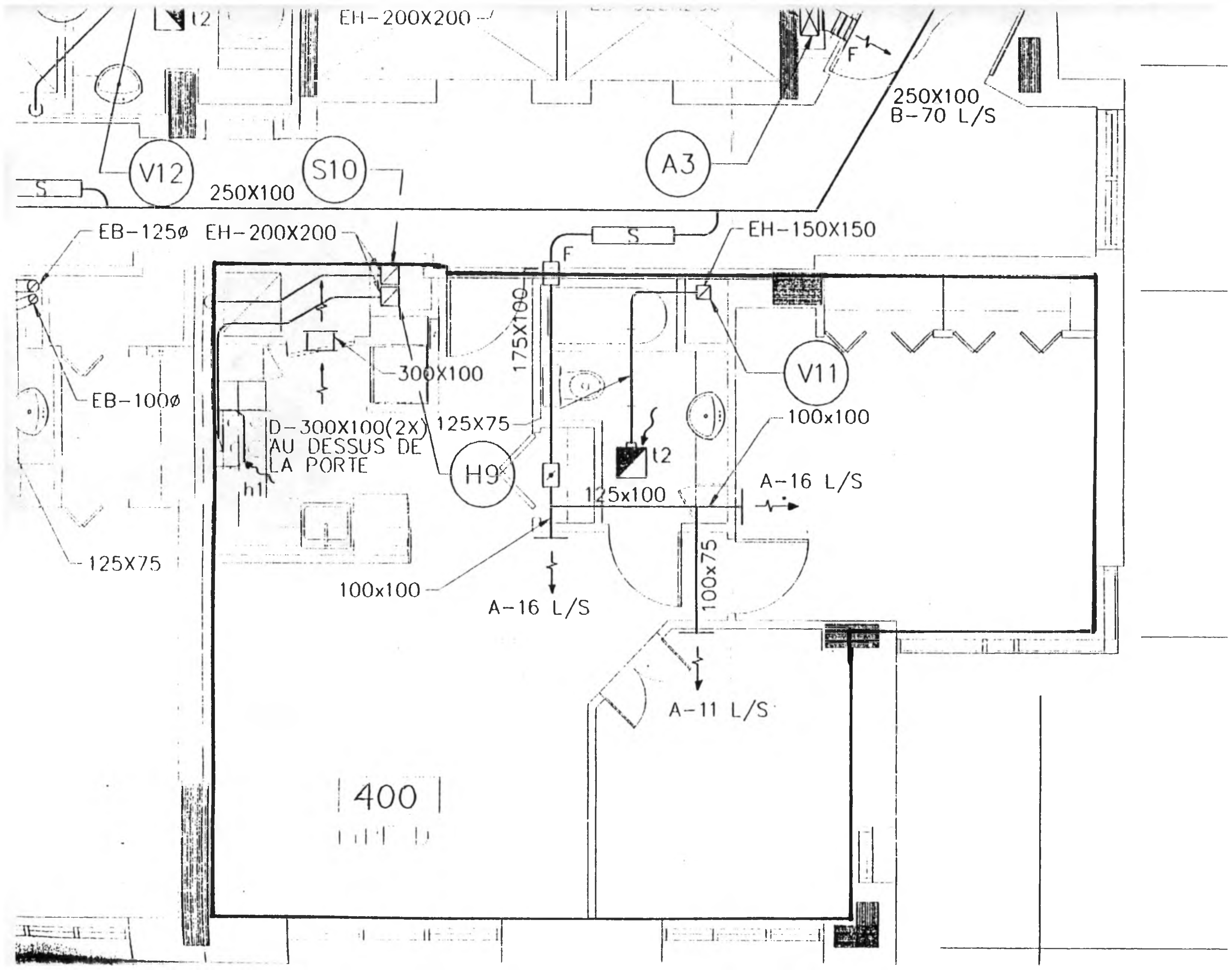


DIAGRAMME DE VENTILATION



EB-200X200
150ø
H8
t1
S8
250X65
EH-350X200
EB-200X200
EH-3C
EB-15
h2
V10
S13
EH-200X2C
307
A-13 L/S
100x75
t2
EB-175X100-F
F
125X75
175X100
* MERGE IN ONLY ONE OUTLET
100x75
A-13 L/S
150x100
300X100
H12
h1



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t2
F
250X100
B-70 L/S
V12
S10
A3
S
250X100
EB-125ø
EH-200X200
S
F
EH-150X150
175X100
300X100
V11
EB-100ø
D-300X100(2X)
AU DESSUS DE
LA PORTE
125X75
100x100
H9
t2
h1
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100x75
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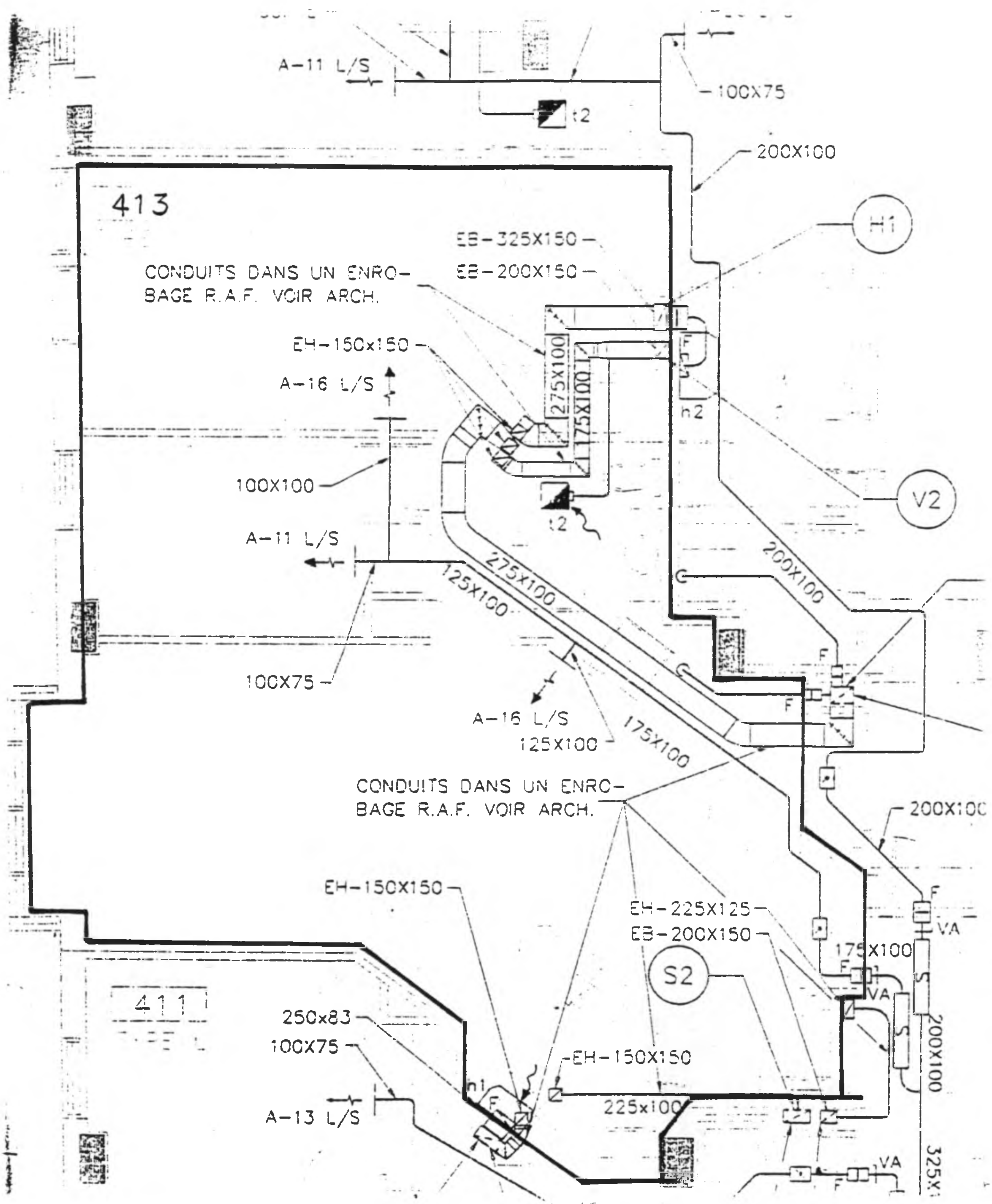
100x100
A-16 L/S
A-11 L/S
400



A-11 L/S
100X75
t2
200X100
413
H1
EB-325X150
EB-200X150
CONDUITS DANS UN ENROBAGE R.A.F. VOIR ARCH.
EH-150x150
A-16 L/S
275X100
175X100
h2
100X100
V2
t2
A-11 L/S
275X100
125X100
200X100
100X75
A-16 L/S
125X100
175X100
F
CONDUITS DANS UN ENROBAGE R.A.F. VOIR ARCH.
200X100
EH-150X150
EH-225X125
EB-200X150
VA
175X100
S2
VA
411
250x83
100X75
200X100
EH-150X150
A-13 L/S
h1
225x100
VA
325X

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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VERSION ELA 3.2 COPYRIGHT RETROTEC 1994

Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	Suite 307
Address:	Clos St. Andre, Montreal
Date:	May 16 1996
Volume:	3822 Cubic Feet
Surface Area	490 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2
Test #	Comfort Checkup
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	73.0
Outdoor Temperature:	72.0
Static Pressure:	0.0
Blower Range:	9.0
Ending Range:	9.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
50	170	1956	0.0

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Equivalent Leakage Area: 1.40 Square Feet
202.04 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 39.62

Estimated Winter Manual J Air Change Rate per Hour: 1.90
Estimated Summer Manual J Air Change Rate per Hour: 1.40

CFM @ 50 pa: 1956
ACH @ 50 pa: 30.71
LBL ELA @ 4 pa 107 In2
LR 4 pa 21.9 In2/100Ft2
NLA= 41.2 In2/100Ft2

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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VERSION ELA 3.2 COPYRIGHT RETROTEC 1994

Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	Suite 307
Address:	Clos St. Andre, Montreal
Date:	June 22 1996

Volume:	3822 Cubic Feet
Surface Area	490 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2

Test #	Pre-monitoring #2
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	74.5
Outdoor Temperature:	62.5
Blower Range:	3.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
45	93	415	0.0

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=

Equivalent Leakage Area: 0.32 Square Feet
45.88 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 9.00

Estimated Winter Manual J Air Change Rate per Hour: 0.43
Estimated Summer Manual J Air Change Rate per Hour: 0.32

CFM @ 50 pa: 444
ACH @ 50 pa: 6.97
CFM @ 25 Pa 283
LBL ELA @ 4 pa 24 In2
LR 4 pa 5.0 In2/100Ft2
NLA= 9.4 In2/100Ft2

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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VERSION ELA 3.2 COPYRIGHT RETROTEC 1994

Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	Suite 400
Address:	Clos St. Andre, Montreal
Date:	May 15 1996
Volume:	6052 Cubic Feet
Surface Area	770 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2
Test #	Pre-sealing
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	75.0
Outdoor Temperature:	67.0
Blower Range:	9.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
50	65	1161	0.0

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Equivalent Leakage Area: 0.83 Square Feet
119.94 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 14.85

Estimated Winter Manual J Air Change Rate per Hour: 0.71
Estimated Summer Manual J Air Change Rate per Hour: 0.53

CFM @ 50 pa:	1161
ACH @ 50 pa:	11.51
CFM @ 25 Pa	740
LBL ELA @ 4 pa	64 In2
LR 4 pa	8.3 In2/100Ft2
NLA=	15.6 In2/100Ft2

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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VERSION ELA 3.2 COPYRIGHT RETROTEC 1994

Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	Suite 400
Address:	Clos St. Andre, Montreal
Date:	May 29 1996
Volume:	6052 Cubic Feet
Surface Area	770 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2
Test #	After sealing/carpet installed/Final ELA
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	79.9
Outdoor Temperature:	55.0
Blower Range:	5.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
50	80	655	0.0

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Equivalent Leakage Area: 0.47 Square Feet
67.67 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 8.38

Estimated Winter Manual J Air Change Rate per Hour: 0.40
Estimated Summer Manual J Air Change Rate per Hour: 0.30

CFM @ 50 pa:	655
ACH @ 50 pa:	6.50
CFM @ 25 Pa	418
LBL ELA @ 4 pa	36 In2
LR 4 pa	4.7 In2/100Ft2
NLA=	8.8 In2/100Ft2

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	Suite 413
Address:	Clos St. Andre, Montreal
Date:	May 28 1996
Volume:	7624 Cubic Feet
Surface Area	970 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2
Test #	Pre-sealing
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	76.2
Outdoor Temperature:	64.4
Blower Range:	9.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
50	147	1787	0.0

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Equivalent Leakage Area: 1.28 Square Feet
184.60 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 18.15

Estimated Winter Manual J Air Change Rate per Hour: 0.87
Estimated Summer Manual J Air Change Rate per Hour: 0.64

CFM @ 50 pa: 1787
ACH @ 50 pa: 14.07
CFM @ 25 Pa 1139
LBL ELA @ 4 pa 98 In2
LR 4 pa 10.1 In2/100Ft2
NLA= 19.0 In2/100Ft2

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HOUSE CHARACTERISTICS AND INFILTROMETER TEST DATA

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VERSION ELA 3.2 COPYRIGHT RETROTEC 1994

Testing Company:	RETROTEC INC.
Tester:	Enrico
Client:	suite 413
Address:	Clos St. Andre, Montreal
Date:	May 28 1996
Volume:	7624 Cubic Feet
Surface Area	970 Square Feet
LBL Climate Factor:	1
Wind Shielding:	1.2
Test #	After sealing/Final ELA
Ducts:	As Is
Test Direction:	D
Operator & Gauges:	IN
Indoor Temperature:	76.0
Outdoor Temperature:	75.0
Blower Range:	5.0

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House Pressure (pa)	Flow Pressure (pa)	Airflow (CFM)	Error %
50	85	691	0.0

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Equivalent Leakage Area: 0.50 Square Feet
71.35 Square Inches
Optimum Leakage Area: 0.78 Square Feet

Estimated Annual Average Air Change Rate per Day: 7.02

Estimated Winter Manual J Air Change Rate per Hour: 0.34
Estimated Summer Manual J Air Change Rate per Hour: 0.25

CFM @ 50 pa: 691
ACH @ 50 pa: 5.44
CFM @ 25 Pa 440
LBL ELA @ 4 pa 38 In2
LR 4 pa 3.9 In2/100Ft2
NLA= 7.4 In2/100Ft2

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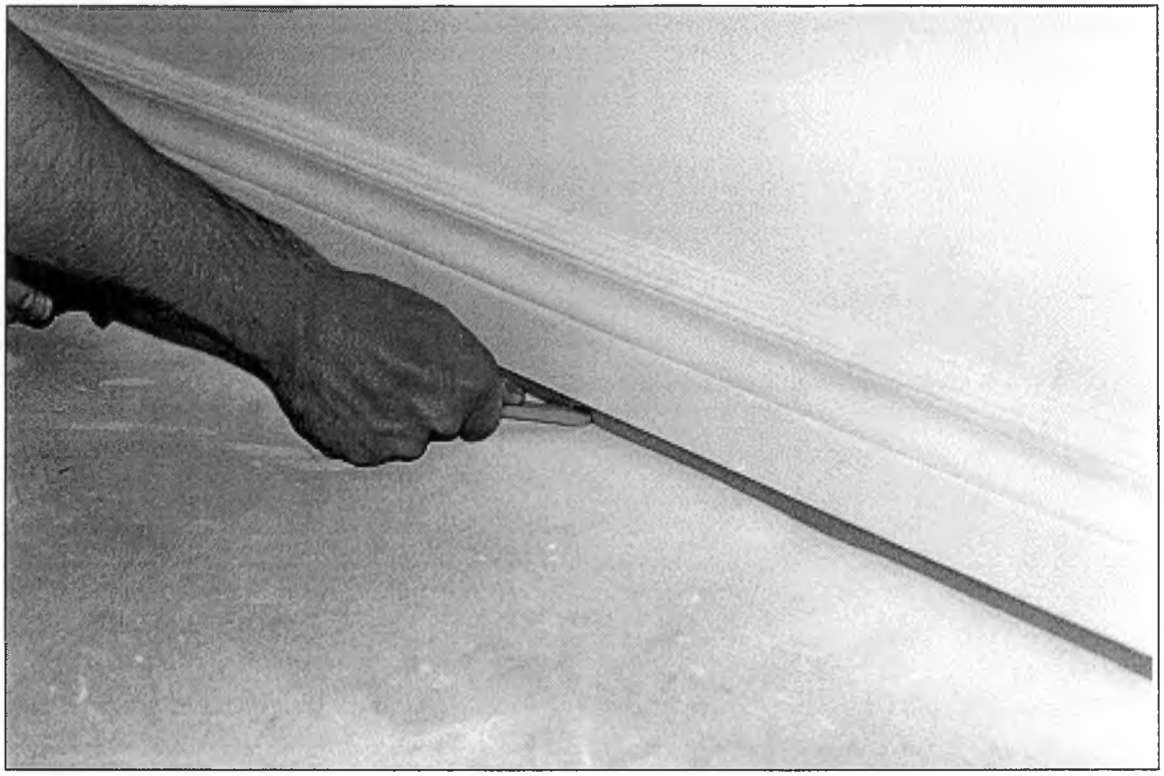
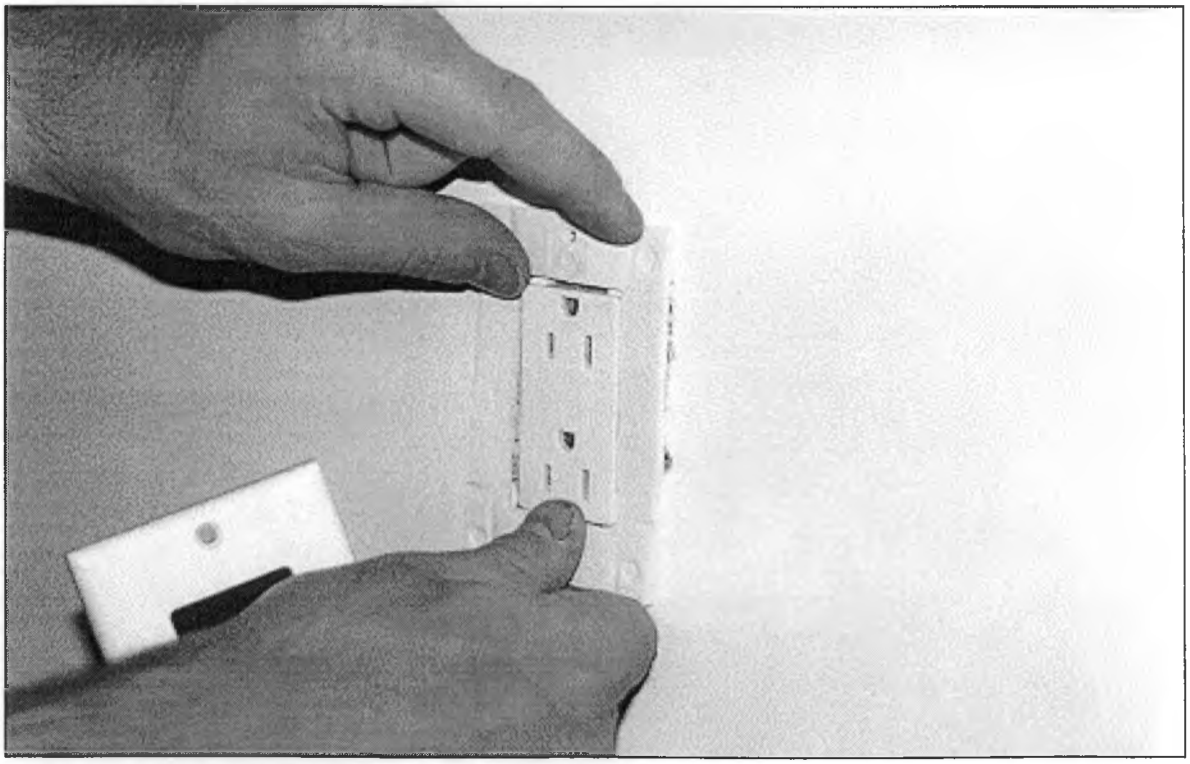
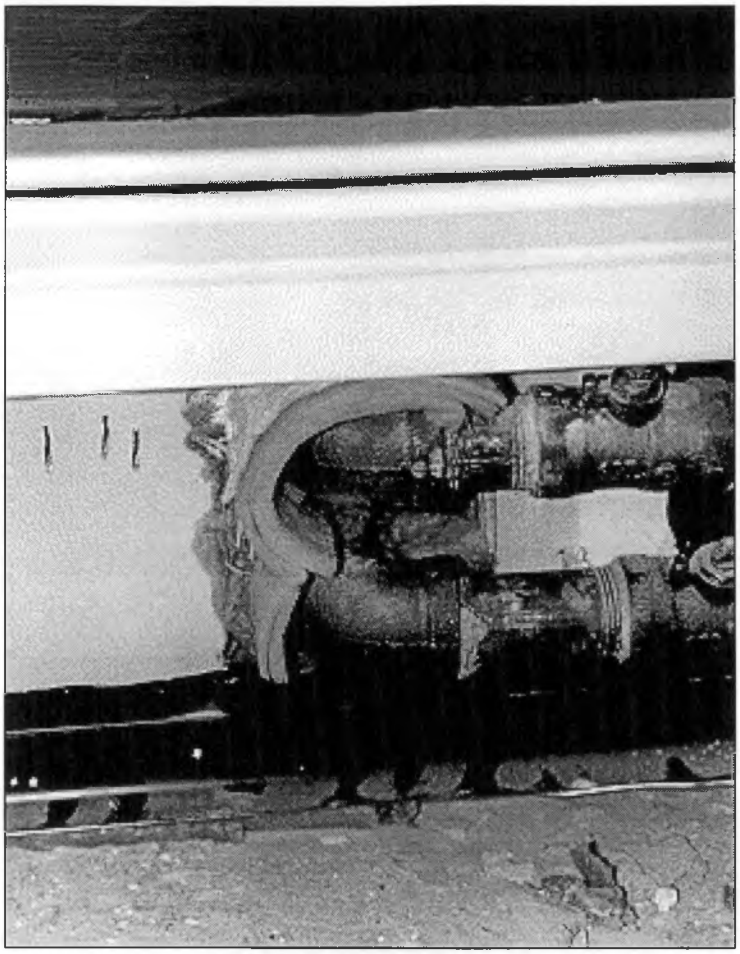


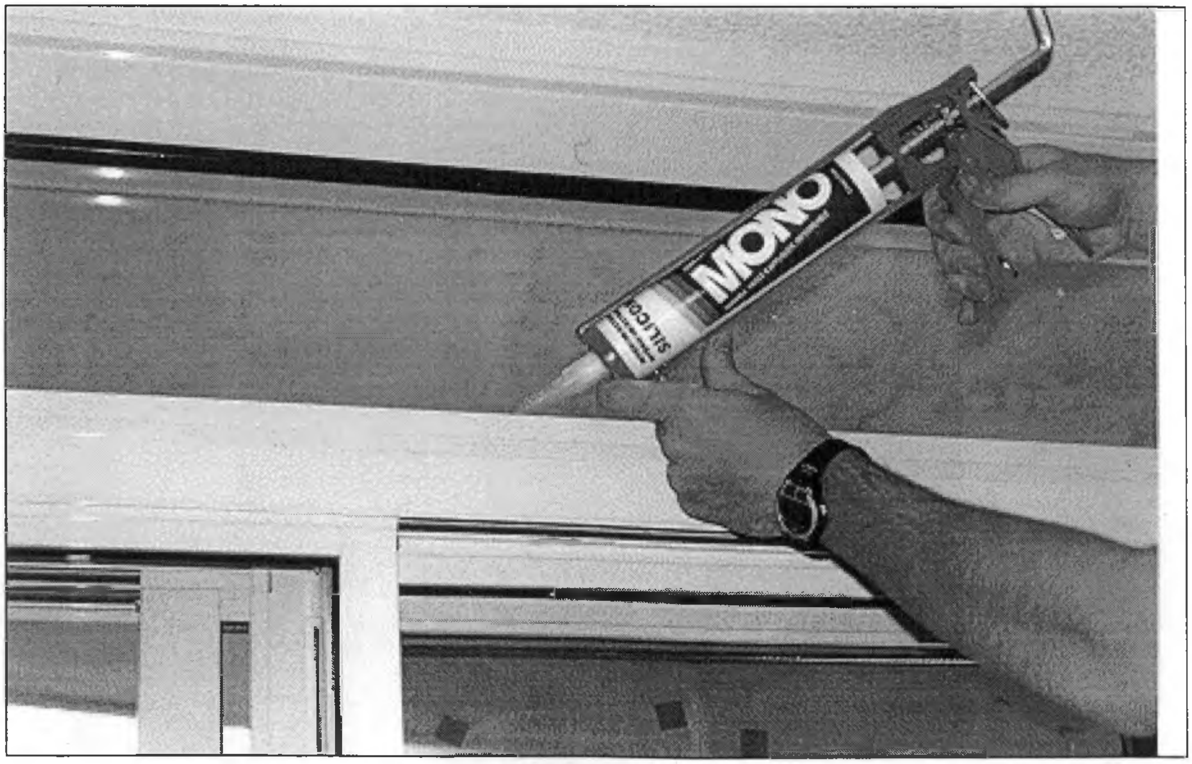
Installation of foam backer rod behind mouldings



Installation of wall plate foam pads

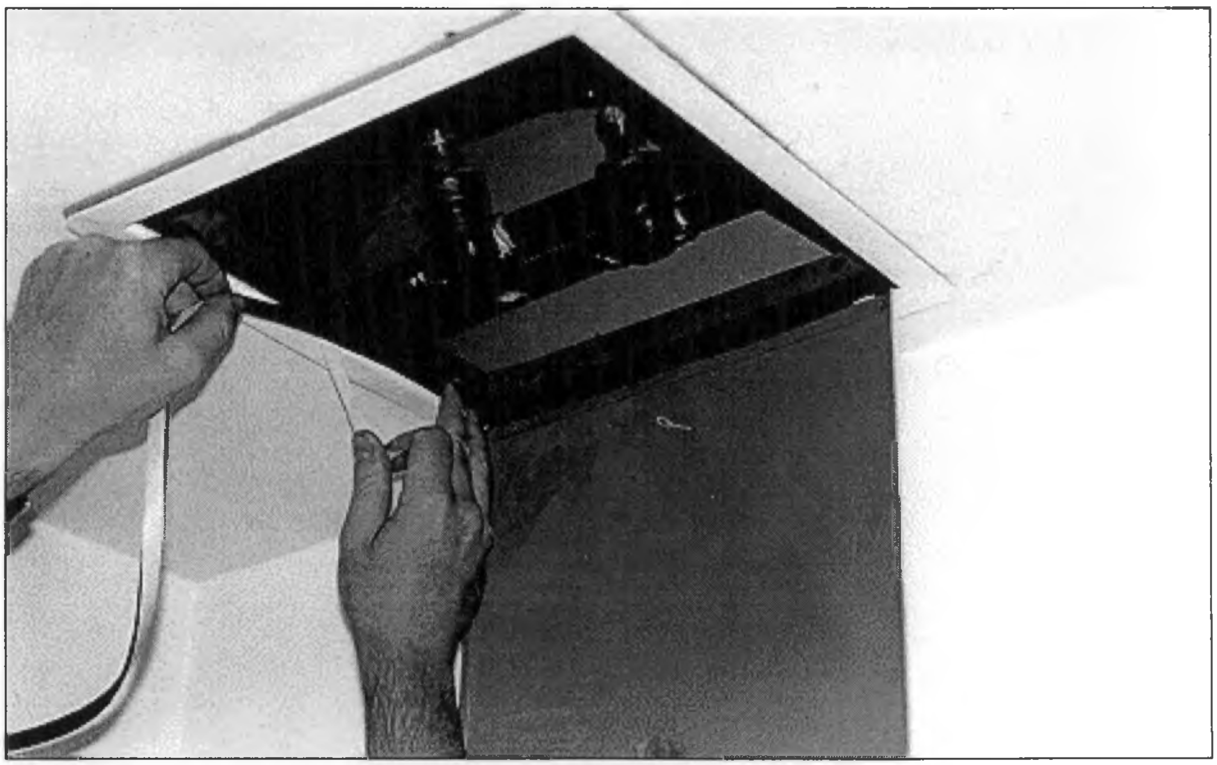


Baseboard Openings

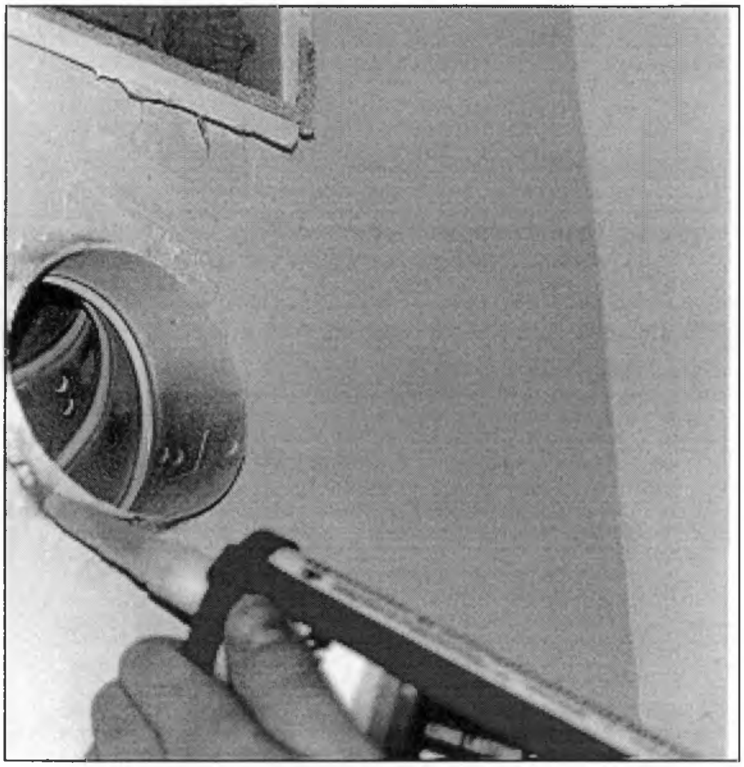


Window frame sealing

Bathtub sealing



Access door sealing



Dryer ducts

CONFIDENTIAL REPORT

VOLATILE ORGANIC CHEMICAL EMISSION CHARACTERIZATION OF BUILDING MATERIAL SAMPLES FROM A RESIDENTIAL HIGH-RISE BUILDING

for

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Montreal, Quebec

by

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October, 1997

technology is our business

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- Mr. Luis DeMiguel, SIRICON
- Mr. Duncan Hill, CMHC
- Dr. Wo Yuen and Mr. Pat Moser of the SRC Analytical Chemistry Laboratory

EXECUTIVE SUMMARY

This report presents the results of a project for characterizing the volatile organic chemical emissions from building material samples from an innovative high-rise residential building in Montreal, Quebec. The building was built as one of the winners in the Ideas Challenge Program of the Canada Mortgage and Housing Corporation and Natural Resources Canada CANMET. The name of the building is Le Clos St-Andre.

Building material samples were collected on-site by Siricon staff at three designated times periods - preoccupancy, one week postoccupancy, and six months postoccupancy. Four different types of materials were collected in each of three apartments and sent to the Saskatchewan Research Council, Building Performance Section laboratory in Saskatoon, SK for environmental chamber testing.

The environmental chamber testing was conducted according to ASTM D 5116-90 "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions From Indoor/Material/Products". Materials selected included carpet, painted drywall, kitchen cupboard doors, vinyl flooring, and wood moldings.

The focus of the testing was to gather engineering data on the emissions from these products over a one week decay period in the environmental chamber. Sampling was performed one day, two days, and six days following the placement of the sample in the chamber. Prior to the start of the testing, in collaboration with the clients, a determination was made which sample material would have both volatile organic chemical and formaldehyde sampling performed and at which time period. In total, 36 samples were tested (12 from each apartment) with 100 volatile organic chemical tests and 89 formaldehyde tests completed.

The results of the material emission characterization testing indicate a wide range among material classifications and within a material type. For instance, for the carpet samples tested, the total volatile organic chemical emission factors varied from a low of 0.036 milligrams per square metre per hour (mg/m^2-h) to a high of 1.88 mg/m^2-h for measurements taken at the six day decay time. Similarly, the range for vinyl flooring samples was 1.14 mg/m^2-h to 7.88 mg/m^2-h.

The results of the material testing indicate that specific materials can be problematic and that the total emissions source was distributed amongst the variety of the commonly used construction materials.

1 INTRODUCTION

The Saskatchewan Research Council (SRC), Building Performance Section (BPS) was contracted by Siricon to conduct environmental chamber testing on building material samples from Le Clos St-Andre building in Montreal, Quebec. Volatile organic chemicals (VOCs) and formaldehyde (HCHO) measurements were conducted on a variety of commonly used construction material samples over a seven day decay period. Samples were collected from three apartments at three time periods - preoccupancy, one week postoccupancy, and six months postoccupancy.

2 METHODOLOGY

2.1 Chamber Test Method

The chamber testing was conducted to the American Society for Testing and Materials (ASTM) test standard ASTM D 5116-90 *Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products.* Environmental chamber tests currently represent the most established method for evaluating VOC emissions from products.

The ASTM general test method, along with a similar test method developed by SRC used for a project for Natural Resources Canada, was used to describe the chamber operating criteria, building product collection and storage method, chamber chemical sampling and analysis protocols, and data analysis methodology that would be common to all of the building materials tested.

For each building material type, a test parameter and methodology sheet was used to record product-specific information. This document ensured that each product sample within a product type was tested in a standardized way. Where available, recommended product loading ratios were used for the chamber tests. Where published loading ratios were not available, past experience and consideration of the intended use of the product in a real building was used.

The products tested were vinyl flooring, carpet, cupboard doors, and painted drywall. The samples were tested "as is" or "as received" from Siricon. What is unknown is how long the products sat in storage, etc. before being used in the building. Many of these materials have emission characteristics which change relatively slowly with time.

VOC testing was conducted on all of the samples at three specific test times over a seven day period that the specimen was in the chamber. Due to budget restraints, some specimens (as predetermined in consultation with CMHC) had only two VOC measurements made. Similarly, formaldehyde (HCHO) was also tested over the same seven day period. A multisorbent sampling tube and gas chromatograph/mass spectrometer (GC/MS) detector was used to measure for a broad spectrum of VOCs commonly emitted from building materials. While this analysis is widely accepted as being the most appropriate technique for screening material emissions, it does not identify every known VOC, including formaldehyde. For that reason, formaldehyde was tested using a midget impinger with deionized, distilled water test method. NIOSH Method 3500 is used to analyze the collected sample.

For factory finished building material samples (i.e. prefinished cupboard doors), the assembly was tested as supplied and the actual product loading ratio noted in the test results.

2.2 Building Material Emission Characterization

The samples were collected by Siricon personnel from the building in Montreal. The samples were collected at three distinct time periods of construction and occupancy. Those time periods were:

- one week before occupancy
- one week following occupancy
- six months following occupancy

Each sample was cut approximately to the product loading ratio for chamber testing and sealed in a Tedlar bag for shipping to the SRC laboratory. Product information sheets were completed for each sample. Once packaged in the Tedlar bag, the material sample emissions would be minimized, thereby reducing the effect of product aging due to offgassing. When received in Saskatoon, each sample was assigned a product sample test number and a code for the type of test to be performed. The samples in their Tedlar bags were stored in a conditioned space at 23 degrees C and 50% relative humidity until testing. The matrices of product samples received are given in Table 1, 2, and 3. Samples were numbered from 1 to 36. For preoccupancy samples, code A was used, code B for one week postoccupancy, and code C for six month postoccupancy samples. The apartment number was used for each sample. Product samples tests are indicated with a V for VOC testing and F for formaldehyde testing following the apartment code and sample numbers. For example, B-307-7-VF represents a sample from apartment 307 collected one week postoccupancy with VOC and formaldehyde testing to be conducted. A total of 36 samples were collected. Samples were collected from three apartments: 307, 400, and 413.

Each sample was checked upon receipt in Saskatoon for confirmation of its physical integrity, adequacy of packaging for shipping, and completeness of the required documentation. None of the 36 samples were rejected for testing.

Table 1: Apartment 307 Samples Numbers

Preoccupancy*	1 week postoccupancy	6 month postoccupancy
A-307-1-VF Painted drywall	B-307-5-V Painted drywall	C-307-9-V Painted drywall
A-307-2-VF Carpet	B-307-6-V Carpet	C-307-10-V Carpet
A-307-3-VF Cupboard door	B-307-7-VF Cupboard door	C-307-11-VF Cupboard door
A-307-4-VF Molding (MDF)	B-307-8-VF Molding (MDF)	C-307-12-VF Molding (MDF)

Table 2: Apartment 400 Samples Numbers

Preoccupancy*	1 week postoccupancy	6 month postoccupancy
A-400-13-VF Painted drywall	B-400-17-V Painted drywall	C-400-21-V Painted drywall
A-400-14-VF Carpet	B-400-18-V Carpet	C-400-22-V Carpet
A-400-15-VF Cupboard door	B-400-19-VF Cupboard door	C-400-23-VF Cupboard door
A-400-16-VF Vinyl flooring	B-400-20-V Vinyl flooring	C-400-24-V Vinyl flooring

Table 3: Apartment 413 Samples Numbers

Preoccupancy*	1 week postoccupancy	6 month postoccupancy
A-413-25-VF Painted drywall	B-413-29-V Painted drywall	C-413-33-V Painted drywall
A-413-26-VF Carpet	B-413-30-V Carpet	C-413-34-V Carpet
A-413-27-VF Cupboard door	B-413-31-VF Cupboard door	C-413-35-VF Cupboard door
A-913-28-VF Vinyl flooring	B-413-32-V Vinyl flooring	C-413-36-V Vinyl flooring

Code **A** - Preoccupancy *All preoccupancy samples will have both VOC and HCHO tests
B - 1 week postoccupancy
C - 6 month postoccupancy
V - VOC test
F - Formaldehyde test

2.3 Data Collection and Analysis

The environmental chamber test procedure provided for the measurement of the chamber airflow and resulting indoor air concentration for specific chemicals under defined operating parameters. The same 171 litre stainless steel chamber was used for all testing. Chamber background measurements were taken before the testing began and during the test program at various intervals to ensure that background contamination levels did not exceed recommended values.

For most samples, three measurements were taken over a seven day period. Before being placed in the chamber, a specimen would be cut (if necessary) to the correct loading ratio fir its building product class type. The specimen would be preconditioned in its Tedlar bag for 24 hours and then placed in the environmental chamber. The same conditioned air source used in the chamber was used for the preconditioning. The conditioned air passes through a dryer, catalytic oxidizer, and two charcoal filters before entering the chamber or Tedlar bag. Following 24 hours of conditioning in the chamber, the first sample would be collected. The second sample was collected following 48 hours in the chamber with the third sample collected at 144 hours (six days).

For the equilibrium test, the data was analyzed to calculate chemical emission factors using equation 1.

$$EF = C \times N/L \tag{1}$$

where:

EF = emission factor, milligrams/m^2 x hour
C = equilibrium chamber concentration, milligrams/m^3
N = chamber air exchange rate, ach^{-1}
L = product loading ratio, m^2/m^3

The product loading is calculated by dividing the entire exposed surface area of the product specimen by the chamber volume.

For results reported as TVOC, EF represents the emission factor for the total of all volatile organic compounds identified in the chemical analysis. The TVOC concentration was calculated using the sum of the masses of the individual chemicals identified in the analysis. The analyst reviewing the GC/MS output for the analysis would identify and quantify all of the significant peaks. Small peaks (below the mass detection level) were not reported. This analysis method reports greater than 95% of all of the volatile mass recovered from the sample.

3 RESULTS

The calculated emission factors for TVOC are presented in Table 4.

The calculated emission factors for formaldehyde are presented in Table 5.

4 DISCUSSION

All 36 samples received were tested. Two TVOC analyses failed due to problems in the SRC Analytical Chemistry Laboratory during analysis (i.e. power failure during analysis and glass tube broke).

1. Twenty-eight of the thirty-six samples showed declines in emission factors (EF) with time. For example, specimen A-307-4-VF had an EF reading of 1.34 at 24 hours, declining to 0.78 at 48 hours, and 0.38 at 144 hours.

2. At the 144 hour time interval, nine specimens out of 35 successfully tested had EF values greater than the 0.5mg/m2-hr standard of the Carpet and Rug Institute. Of those nine specimens, six were vinyl flooring with the remaining three being carpet.

3. The highest offgassing product at 144 hours was A-413-28-VF, a vinyl flooring material, at 7.87 mg/m^2-hr for the preoccupancy specimen. The "B" value was 4.38 and the "C" value was 1.36 mg/m^2-hr at 144 hours.

4. The group averages for TVOC EF values for the 144 hour tests for the four types of products (which included more than one sample) are presented in Table 6.

5. The group averages for HCHO EF values for the 144 hour tests for the five types of products are presented in Table 7. Wood molding results are for one specimen.

As can be seen from Table 6, the TVOC EF values declined from preoccupancy to the 6 months postoccupancy tests. Painted drywall and carpet EF values rose for the one week postoccupancy tests. An explanation for this is that these two materials are the "soft or fleecy" materials in the suites and thus are "sinks" for the occupant generated TVOCs. The cupboard door 6 months postoccupancy value is up slightly from the one week postoccupancy value.

The formaldehyde EF values shown in Table 7 follow a similar pattern as the TVOC EF values. Many of the tests were near or below the detection limit for formaldehyde.

Table 4: Calculated TVOC Emission Factors

Specimen number	Exposed surface area mm²	Exposed surface area m²	Chamber volume m³	Product loading ratio m²/m³	Chamber air exchange rate, ac/h	TVOC, mg/m³			TVOC Emission Factor, mg/m²·h		
						24hr.	48hr.	144hr.	24hr.	48hr.	144hr.
A-307-1-VF	78120	0.0781	0.171	0.46	0.3	0.042	0.038	0.029	0.028	0.025	0.019
A-307-2-VF	70225	0.0702	0.171	0.41	0.3	0.99	0.66	0.32	0.723	0.482	0.234
A-307-3-VF	168394	0.1684	0.171	0.98	0.3	0.06	0.1	0.04	0.018	0.030	0.012
A-307-4-VF	55102	0.0551	0.171	0.32	0.3	1.44	0.838	0.404	1.341	0.780	0.376
B-307-5-V	78400	0.0784	0.171	0.46	0.3	0.078	0.077	0.053	0.051	0.050	0.035
B-307-6-V	70225	0.0702	0.171	0.41	0.3	0.17	0.11	0.05	0.124	0.080	0.037
B-307-7-VF	168394	0.1684	0.171	0.98	0.3	0.05	note b	0.02	0.015		0.006
B-307-8-VF	55628	0.0556	0.171	0.33	0.3	0.35	0.128	0.089	0.323	0.118	0.082
C-307-9-V	77840	0.0778	0.171	0.46	0.3	0.23	0.03	0.006	0.152	0.020	0.004
C-307-10-V	70225	0.0702	0.171	0.41	0.3	1.5	1	0.41	1.096	0.731	0.300
C-307-11-VF	168394	0.1684	0.171	0.98	0.3	0.173	note b	0.121	0.053		0.037
C-307-12-VF	56052	0.0561	0.171	0.33	0.3	0.709	0.372	0.374	0.649	0.340	0.342
A-400-13-VF	78400	0.0784	0.171	0.46	0.3	0.105	0.095	0.066	0.069	0.062	0.043
A-400-14-VF	70225	0.0702	0.171	0.41	0.3	2.69	2.37	0.95	1.965	1.731	0.694
A-400-15-VF	168394	0.1684	0.171	0.98	0.3	0.43	0.35	0.29	0.131	0.107	0.088
A-400-16-VF	65025	0.0650	0.171	0.38	0.3	3.166	2.816	2.514	2.498	2.222	1.983
B-400-17-V	77006	0.0770	0.171	0.45	0.3	1.13	0.87	0.32	0.753	0.580	0.213
B-400-18-V	70225	0.0702	0.171	0.41	0.3	5.899	4.37	2.57	4.309	3.192	1.877
B-400-19-VF	168394	0.1684	0.171	0.98	0.3	0.07	note b	0.06	0.021		0.018
B-400-20-V	65025	0.0650	0.171	0.38	0.3	4.11	4.304	2.659	3.242	3.396	2.098
C-400-21-V	85728	0.0857	0.171	0.50	0.3	0.421	0.204	0.045	0.252	0.122	0.027
C-400-22-V	70225	0.0702	0.171	0.41	0.3	1.89	1.61	0.22	1.381	1.176	0.161
C-400-23-VF	168394	0.1684	0.171	0.98	0.3	0.119	note b	0.06	0.036		0.018
C-400-24-V	64262	0.0643	0.171	0.38	0.3	2.13	1.096	1.43	1.700	0.875	1.142
A-413-25-VF	77284	0.0773	0.171	0.45	0.3	0	0.022	0.008	0.000	0.015	0.005
A-413-26-VF	70225	0.0702	0.171	0.41	0.3	1.03	0.69	0.26	0.752	0.504	0.190
A-413-27-VF	168394	0.1684	0.171	0.98	0.3	0.649	0.619	0.524	0.198	0.189	0.160
A-413-28-VF	70225	0.0702	0.171	0.41	0.3	11.64	10	10.78	8.503	7.305	7.875
B-413-29-V	78400	0.0784	0.171	0.46	0.3	0.04	0.05	0.01	0.026	0.033	0.007
B-413-30-V	70225	0.0702	0.171	0.41	0.3	1.75	1.52	1.67	1.278	1.110	1.220
B-413-31-VF	168394	0.1684	0.171	0.98	0.3	0.1	note b	0.1	0.030		0.303
B-413-32-V	70225	0.0702	0.171	0.41	0.3	7.04	note a	5.99	5.143		4.376
C-413-33-V	77562	0.0776	0.171	0.45	0.3	0.14	0.047	note c	0.093	0.031	
C-413-34-V	70225	0.0702	0.171	0.41	0.3	0.264	0.191	0.16	0.193	0.140	0.117
C-413-35-VF	168394	0.1684	0.171	0.98	0.3	0.097	note b	0.029	0.030		0.009
C-413-36-V	70225	0.0702	0.171	0.41	0.3	2.758	2.37	1.86	2.105	1.731	1.359

note a - Carbotrap tube broke in GC/MS during analysis

note b - VOC test not conducted because of project scope

note c - GC/MS failure

Table 5: Calculated Formaldehyde Emission Factors

Specimen number	Exposed surface area mm²	Exposed surface area m²	Chamber volume m³	Product loading ratio m²/m³	Chamber air exchange rate, ac/h	HCHO, mg/m³			HCHO, Emission Factor, mg/m²·h		
						24hr.	48hr.	144hr.	24hr.	48hr.	144hr.
A-307-1-VF	78120	0.0781	0.171	0.46	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
A-307-2-VF	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
A-307-3-VF	168394	0.1684	0.171	0.98	0.3	0.01	0.035	0.018	0.003	0.011	0.005
A-307-4-VF	55102	0.0551	0.171	0.32	0.3	0.26	0.31	0.29	0.242	0.289	0.270
B-307-5-V	78400	0.0784	0.171	0.46	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-307-6-V	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-307-7-VF	168394	0.1684	0.171	0.98	0.3	0.014	note a	0.014	0.004		0.004
B-307-8-VF	55628	0.0556	0.171	0.33	0.3	0.33	0.3	0.3	0.304	0.277	0.277
C-307-9-V	77840	0.0778	0.171	0.46	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
C-307-10-V	70225	0.0702	0.171	0.41	0.3	<0.01	note a	note a	<0.007		
C-307-11-VF	168394	0.1684	0.171	0.98	0.3	0.03	note a	note a	0.009		
C-307-12-VF	56052	0.0561	0.171	0.33	0.3	0.27	0.23	0.22	0.247	0.211	0.201
A-400-13-VF	78400	0.0784	0.171	0.46	0.3	0.01	0.014	0.013	0.007	0.009	0.009
A-400-14-VF	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
A-400-15-VF	168394	0.1684	0.171	0.98	0.3	0.04	0.03	0.05	0.012	0.009	0.015
A-400-16-VF	65025	0.0650	0.171	0.38	0.3	<0.01	<0.01	<0.01	<0.008	<0.008	<0.008
B-400-17-V	77006	0.0770	0.171	0.45	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-400-18-V	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-400-19-VF	168394	0.1684	0.171	0.98	0.3	0.030	note a	0.025	0.009		0.008
B-400-20-V	65025	0.0650	0.171	0.38	0.3	note a	note a	note a			
C-400-21-V	85728	0.0857	0.171	0.50	0.3	<0.01	0.02	0.02	<0.006	0.012	0.012
C-400-22-V	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
C-400-23-VF	168394	0.1684	0.171	0.98	0.3	0.04	note a	note a	0.912		
C-400-24-V	64262	0.0643	0.171	0.38	0.3	0.01	<0.01	0.02	0.008	0.000	0.016
A-413-25-VF	77284	0.0773	0.171	0.45	0.3	0.01	0.016	0.017	0.007	0.011	0.011
A-413-26-VF	70225	0.0702	0.171	0.41	0.3	<0.001	<0.01	<0.01	<0.007	<0.007	<0.007
A-413-27-VF	168394	0.1684	0.171	0.98	0.3	0.017	0.024	0.011	0.005	0.007	0.003
A-413-28-VF	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-413-29-V	78400	0.0784	0.171	0.46	0.3	0.009	0.008	0.009	0.006	0.005	0.006
B-413-30-V	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007
B-413-31-VF	168394	0.1684	0.171	0.98	0.3	0.06	note a	0.03	0.018		0.009
B-413-32-V	70225	0.0702	0.171	0.41	0.3	note a	note a	note a			
C-413-33-V	77562	0.0776	0.171	0.45	0.3	0.03	0.06	0.02	0.020	0.040	0.013
C-413-34-V	70225	0.0702	0.171	0.41	0.3	0.01	note a	note a	0.007		
C-413-35-VF	168394	0.1684	0.171	0.98	0.3	0.03	note a	note a	0.009		
C-413-36-V	70225	0.0702	0.171	0.41	0.3	<0.01	<0.01	<0.01	<0.007	<0.007	<0.007

note a - HCHO test not conducted

Table 6: TVOC Emission Factors For Building Material Types - Averages For 144 Hour Tests

Product (number of samples)	TVOC EF, mg/m²-hr		
	Preoccupancy	1 week postoccupancy	6 months postoccupancy
Painted drywall (4)	0.023	0.085	0.016
Carpet (4)	0.373	1.045	0.192
Cupboard door (4)	0.087	0.018	0.021
Vinyl flooring (3)	4.929	3.237	1.250

Table 7: HCHO Emission Factors For Building Material Types - Averages For 144 Hour Tests

Product (number of samples)	HCHO EF, mg/m²-hr		
	Preoccupancy	1 week postoccupancy	6 months postoccupancy
Painted drywall (3)	0.01	0.006	0.013
Carpet (3)	<0.007	<0.007	<0.007
Cupboard door (4)	0.008	0.007	no tests
Vinyl flooring (2)	<0.007	no tests	0.16
Wood molding (1)	0.27	0.277	0.201

5 SUMMARY

The results from this extensive testing program provide the building industry with basic data on the chemical emissions from some common building materials. Data on long term offgassing and sink effects are attainable. A rational process for selecting materials is available through the use of a similar testing program. Specific prescriptive measures may in the future be detailed for homeowners, designers, builders, and regulators.

The test methodology used in this project can be used to structure test programs to evaluate other materials and components. Working from the test method, application-specific procedures can be developed which best represent the in-situ performance of the material or meet the needs of the testing program.

APPENDIX A

Product Information Sheet
Test Parameters and Methodology

PRODUCT INFORMATION SHEET

Name of House ______________________________

Date ________________________

Person filling in information ______________________________

Manufacturer(s) (also enclose any available product literature)

____

____

Date of Manufacture (if known) ______________________________

Previous storage history (temperature, RH, location if known)

____

____

Date of Installation/Preparation ______________________________

Comments or Additional Information ______________________________

____

____

____

SPECIFIC TEST PARAMETERS AND METHODOLOGY SHEET

PRODUCT: *Paint*

SUPPORT TYPE: ☑ PAN ☐ OPEN

PRODUCT LOADING RATIO: 1.0 m^2/m^3

SPECIMEN PREPARATION:

Use aluminum foil to seal gypsum board edges and bottom surface.

CHEMICAL SAMPLING REQUIRED: (*check/complete as required*)

1) VOC (multi-sorbent tube) ☑

2) HCHO (midget impinger) ☑

3) Other (*specify*) ☐ ____________________

Rationale

The paint product loading ratio was developed by estimating the typical painted wall surface area/volume ratio for bungalow, split level and two storey houses. An average value was arbitrarily selected. Ceiling areas were not considered due to the variation in finishes used.

SPECIFIC TEST PARAMETERS AND METHODOLOGY SHEET

PRODUCT: ***Carpet and vinyl***

SUPPORT TYPE: ☑ PAN ☐ OPEN

PRODUCT LOADING RATIO: 0.41 m^2/m^3

SPECIMEN PREPARATION:

- carpet only - no underlay or substrate
- aluminum foil formed into pan to match sample sizes

CHEMICAL SAMPLING REQUIRED: *(check/complete as required)*

1) VOC (multi-sorbent tube) ☑

2) HCHO (midget impinger) ☑

3) Other *(specify)* ☐ ______________________

<u>Rationale</u>

The carpet product loading ratio was selected to match the value recommended in the US EPA carpet test protocol and draft ASTM carpet test guide.

The pan type specimen holder was selected to be consistent with field use (emission from the top surface only) and the draft ASTM carpet test guide.

The draft ASTM guide specifies a chamber air exchange rate of 1.0 ach^{-1}, however, it focuses on commercial applications. For these tests, the chamber was operated at 0.3 ach^{-1} to be consistent with typical residential applications.

SPECIFIC TEST PARAMETERS AND METHODOLOGY SHEET

PRODUCT: ***Wood Products - Particleboard, MDF, Cabinet Components***

SUPPORT TYPE: ☐ PAN ☑ OPEN

PRODUCT LOADING RATIO: 0.43 m^2/m^3

SPECIMEN PREPARATION:

- product sample only (as supplied) if area less than or equal to specified product loading ratio
- test specimen cut from product sample if sample size greater than specified loading ratio
- if pre-finished edges, test entire sample and note loading ratio

CHEMICAL SAMPLING REQUIRED: (*check/complete as required*)

1) VOC (multi-sorbent tube) ☑

2) HCHO (midget impinger) ☑

3) Other (*specify*) ☐ ____________________

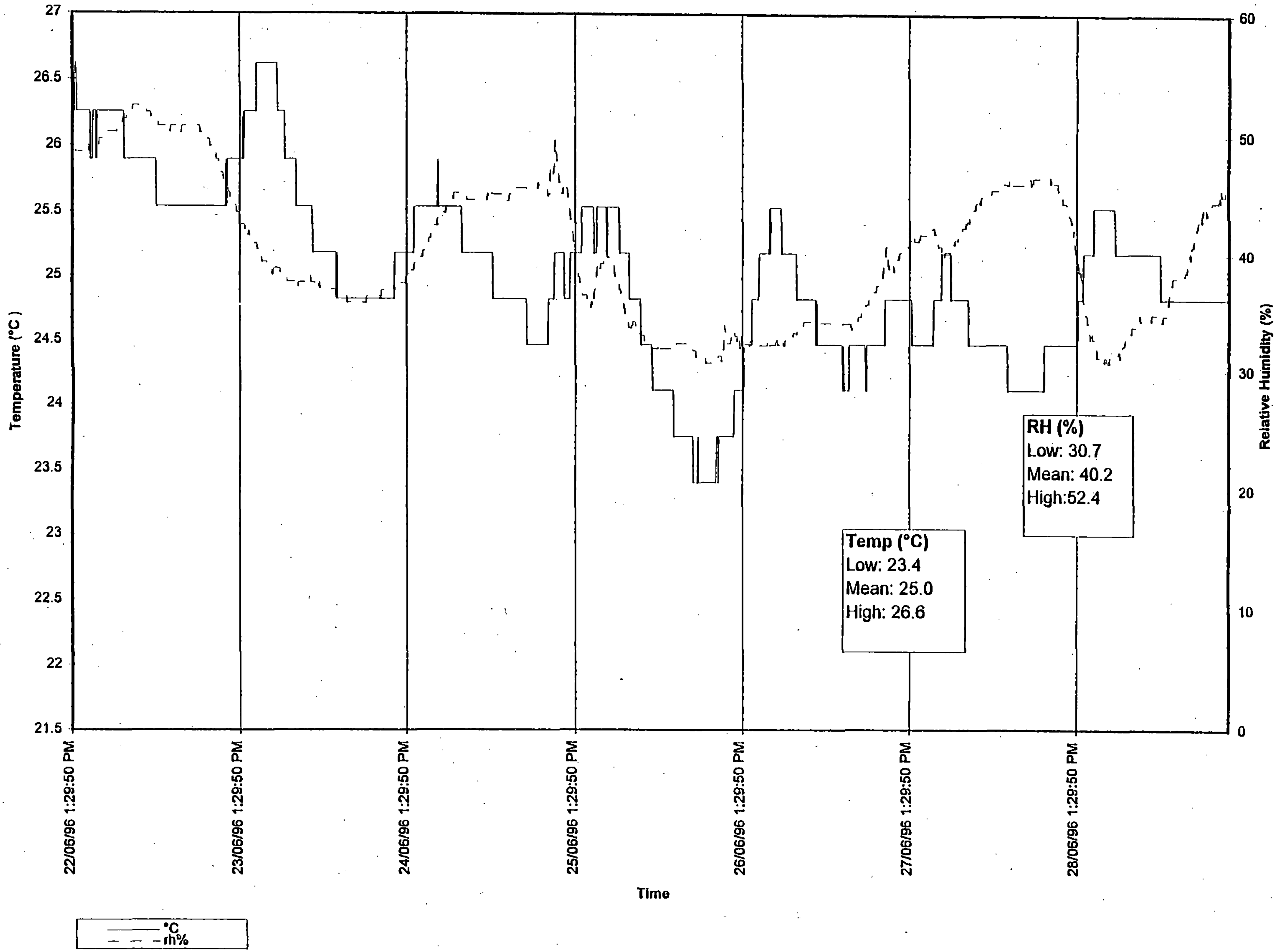
Rationale

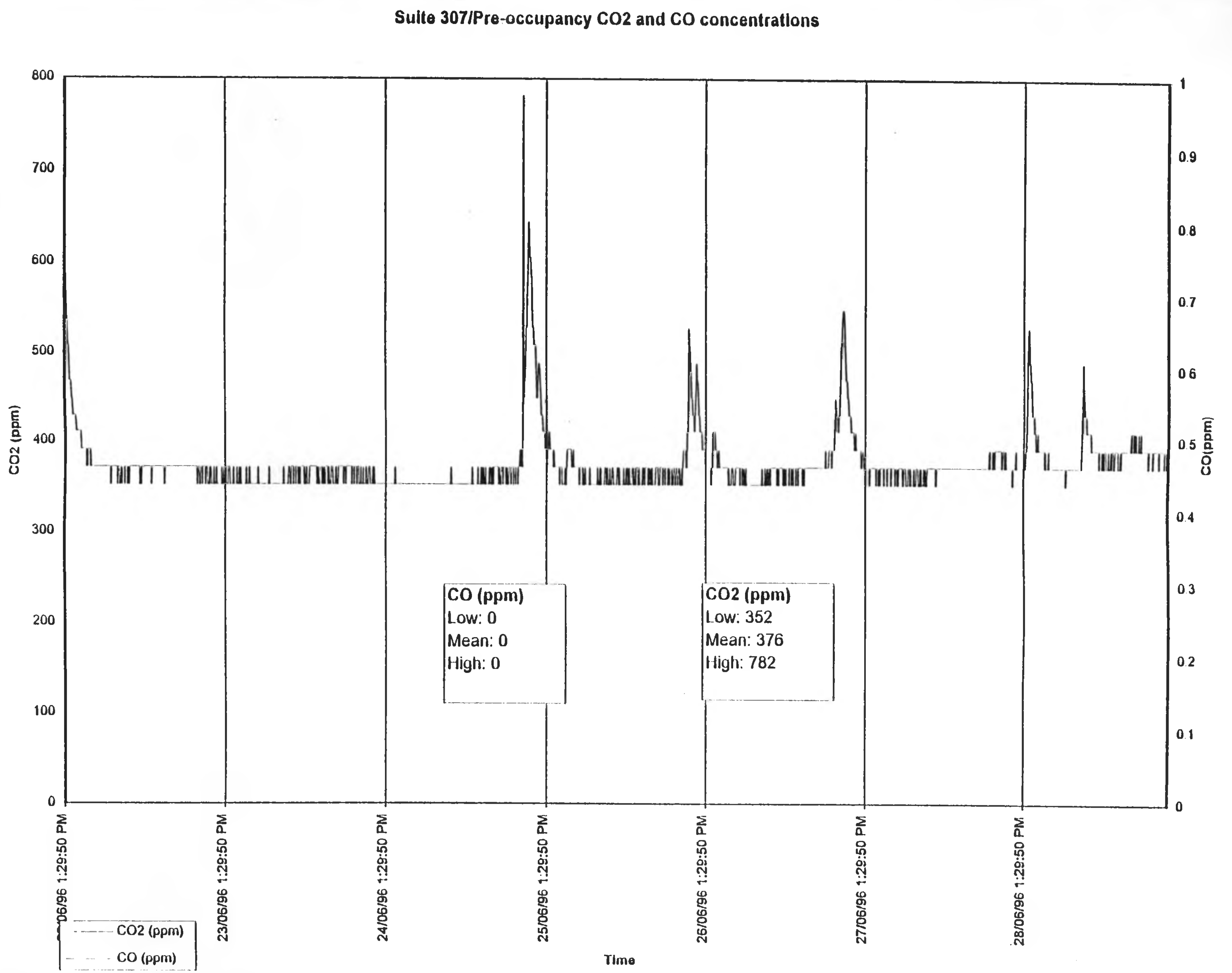
The composite wood product loading ratio was selected to match the value recommended in ASTM 1333-90 for large chamber testing of sheet materials. An open type specimen holder was selected to expose the entire surface area of the specimen.

BUILDING PRODUCT EMISSION TESTING TEST PARAMETERS AND METHODOLOGY	
PRODUCT	
Name	
Manufacturer	
Date manufactured	
Other manufacturer identifiers	
SAMPLE SUPPLIER	
Sample received from	
Method of selection	
Method of use within the intended building	
On-site storage conditions prior to shipping	(°C, % RH)
SRC sample number/identifier	
TESTING	
Test to be performed	(VOC, HCHO)
Storage conditions upon receipt of sample	(°C, % RH)
Date received for testing	
Method used to enclose sample	
PRE-CONDITIONING	
Method used to cut sample	(knife, saw, etc.)
Date of specimen preparation	
Pre-conditioning method	
Pre-conditioning conditions	(°C, % RH, ach^{-1})
Start of pre-conditioning	(date & time)
End of pre-conditioning	(date & time)
Physical size of specimen	(mm x mm x mm)

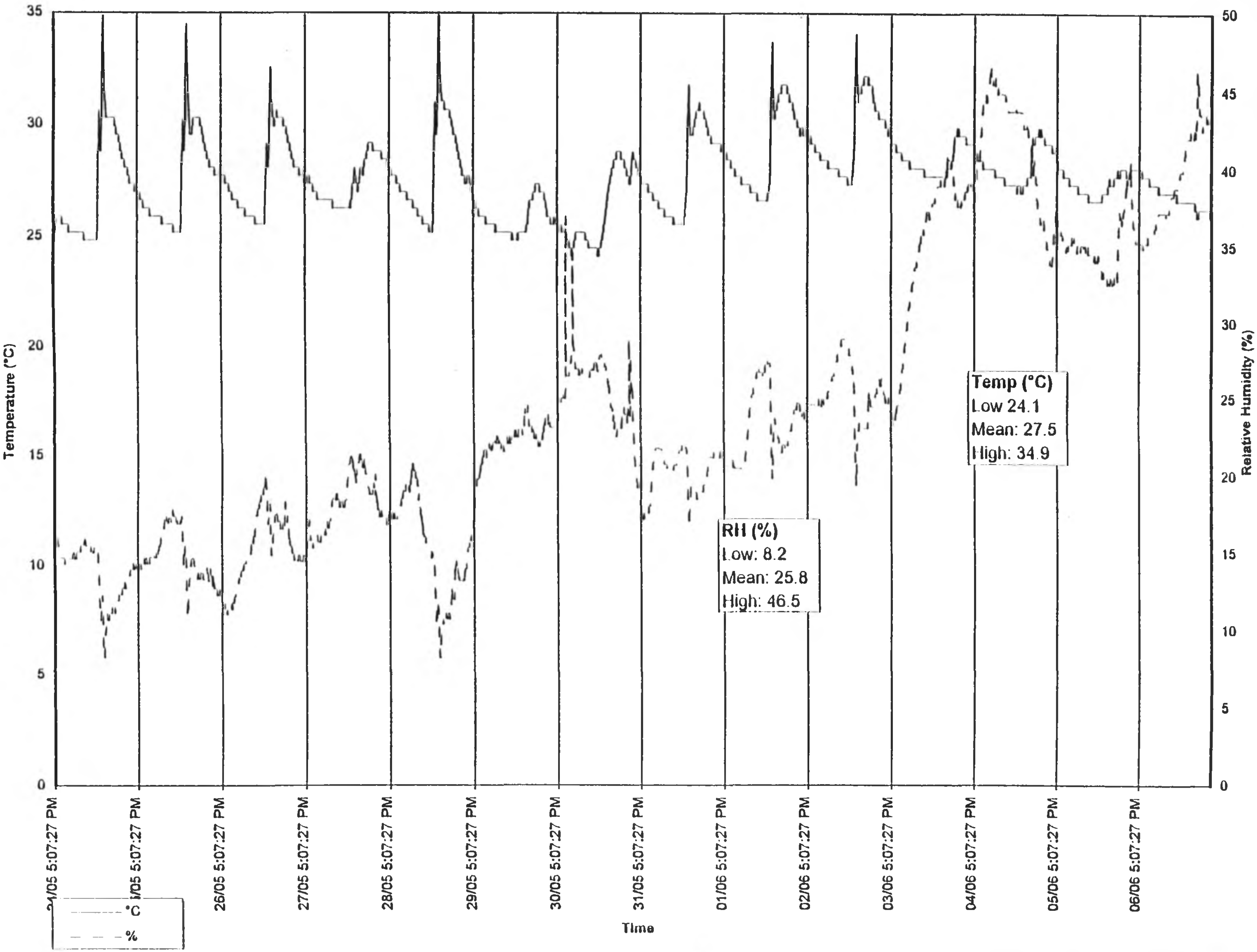
BUILDING PRODUCT EMISSION TESTING TEST PARAMETERS AND METHODOLOGY	
LABORATORY TESTING	
Date and time specimen placed in chamber	
Date and time test started	
Date and time test ended	
Specimen holder type	
Chamber conditions	(°C, % RH, ach^{-1})
Chamber air exchange rate	
Collection method	(Supelco tube, etc.)
Air flow rate for sampling	
Environmental enclosure conditions	(°C, % RH)
Material loading rate	(m^2/m^3)
Chamber volume	
Name of person performing testing	
TEST LABORATORY	
Name	
Address	
Telephone/fax numbers	
Contact person	
Air sample analyst name	
Analysis system description	
COMMENTS:	

Suite 307/ Pre-occupancy Temperature and Relative Humidity

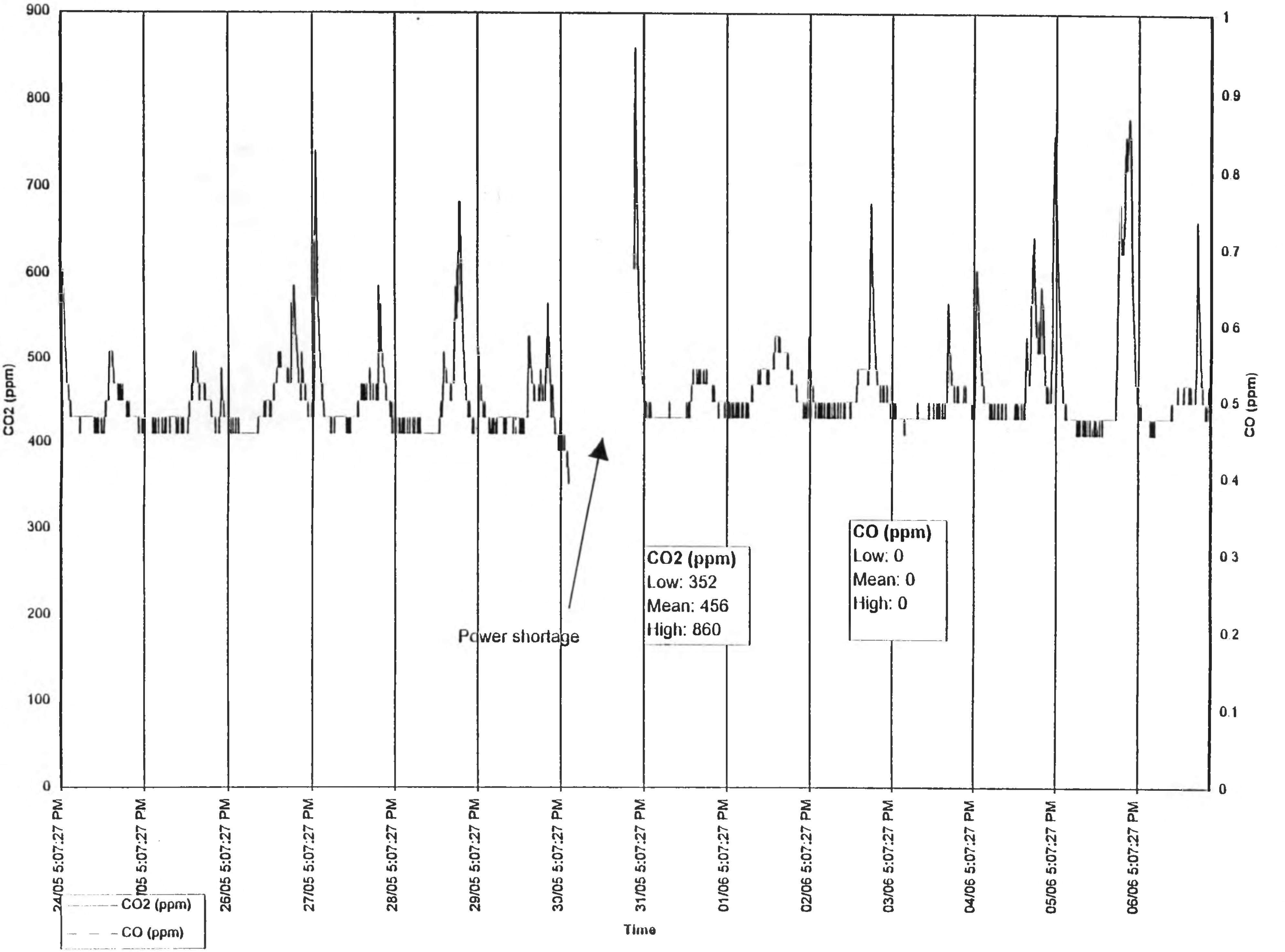



Suite 307/Pre-occupancy CO2 and CO concentrations
CO2 (ppm)
CO(ppm)
Time
CO (ppm)
Low: 0
Mean: 0
High: 0
CO2 (ppm)
Low: 352
Mean: 376
High: 782
23/06/96 1:29:50 PM
24/06/96 1:29:50 PM
25/06/96 1:29:50 PM
26/06/96 1:29:50 PM
27/06/96 1:29:50 PM
28/06/96 1:29:50 PM
CO2 (ppm)
CO (ppm)

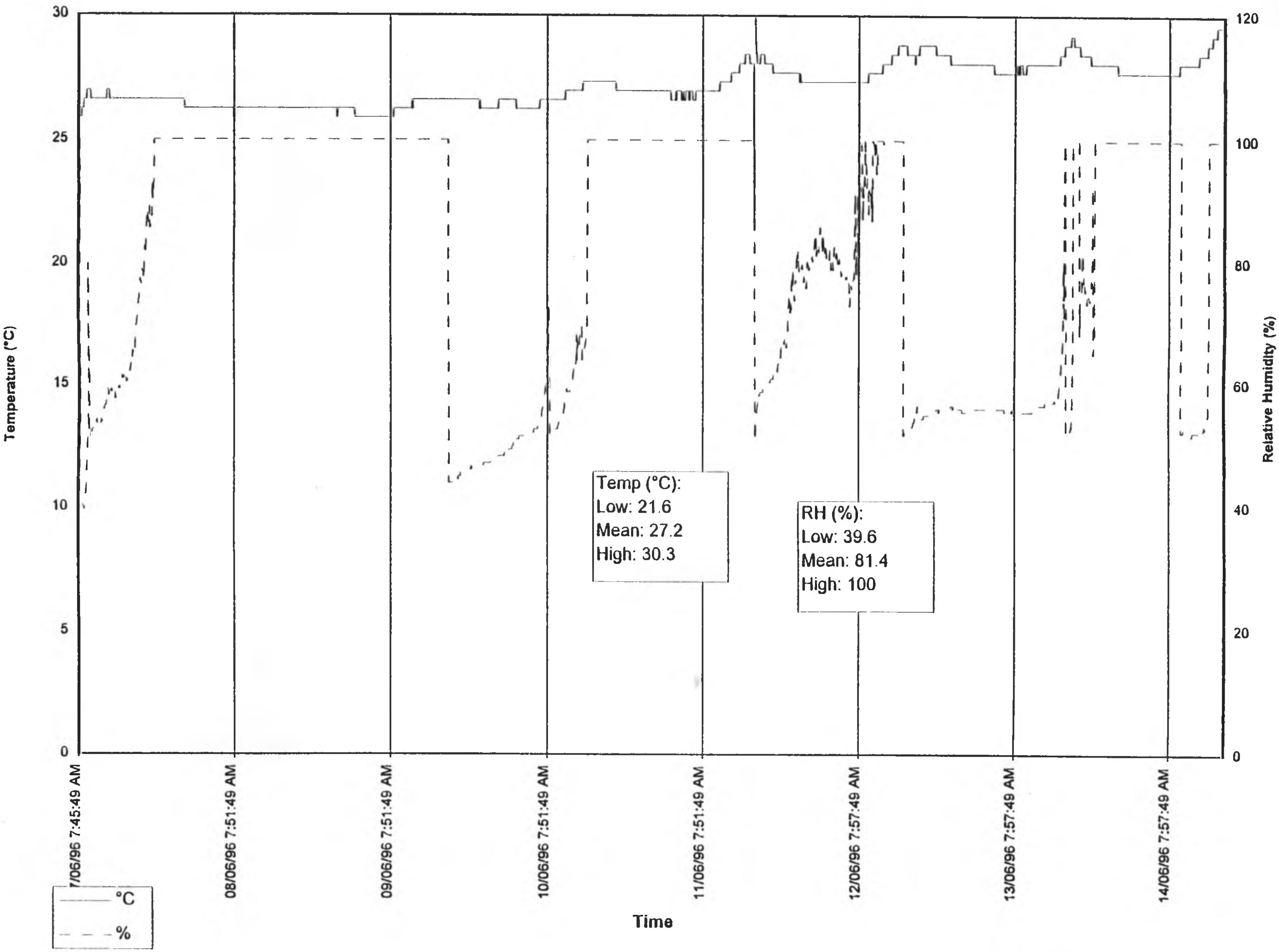
Suite 400/Pre-occupancy Temperature and Relative Humidity



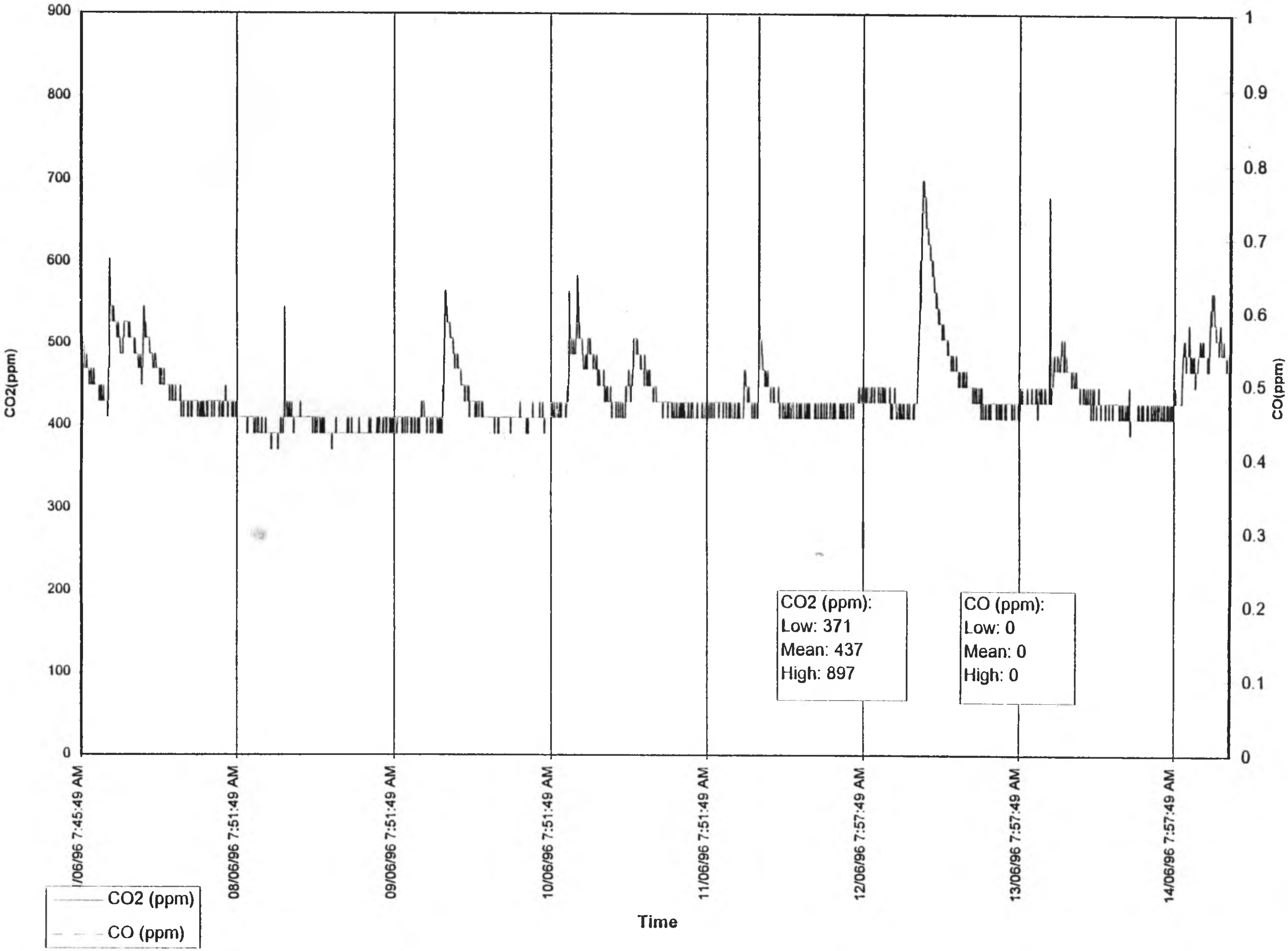
Suite 400/ Pre-occupancy CO2 and CO Concentrations

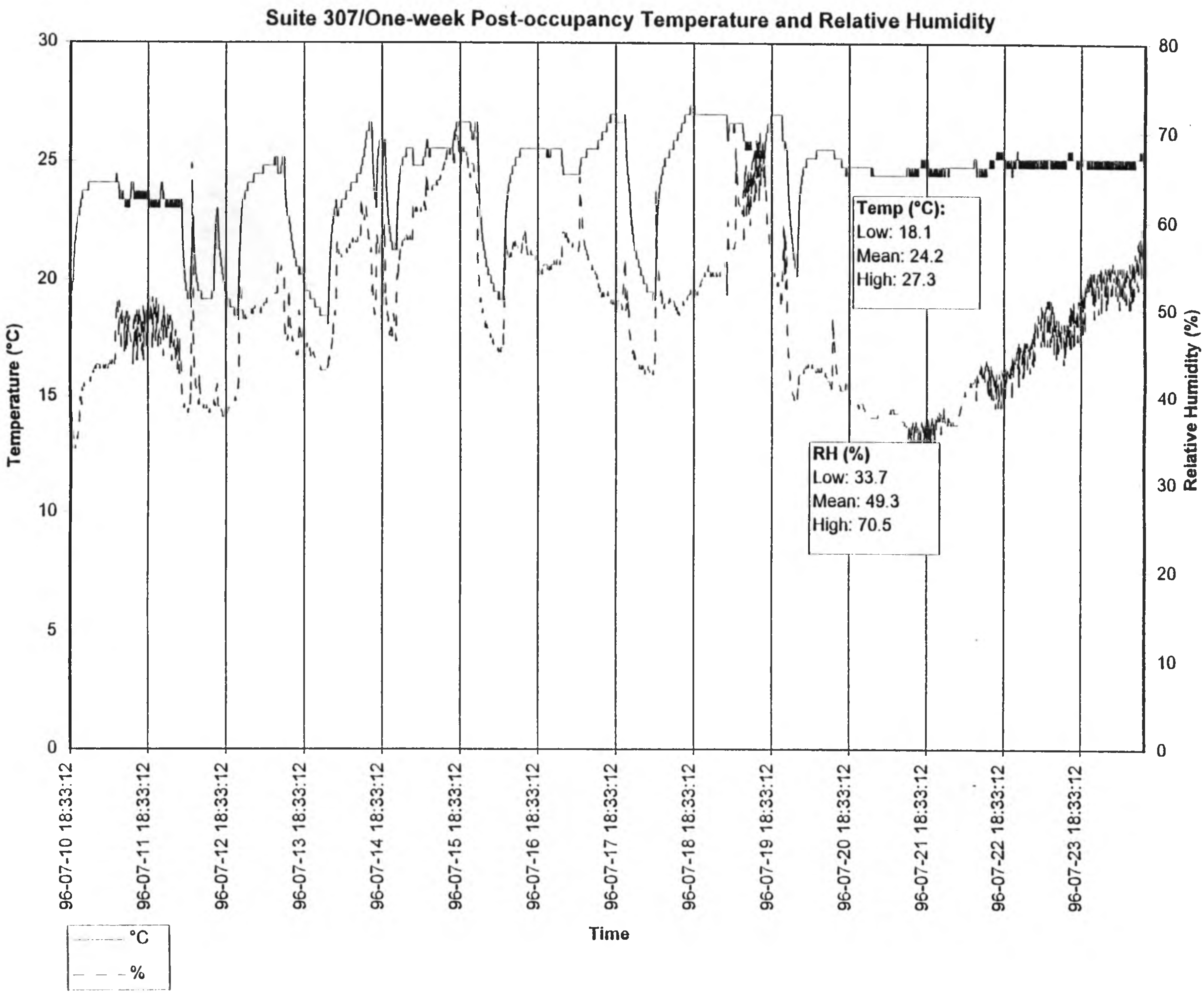


Suite 413/Pre-occupancy Temperature and Relative Humidity

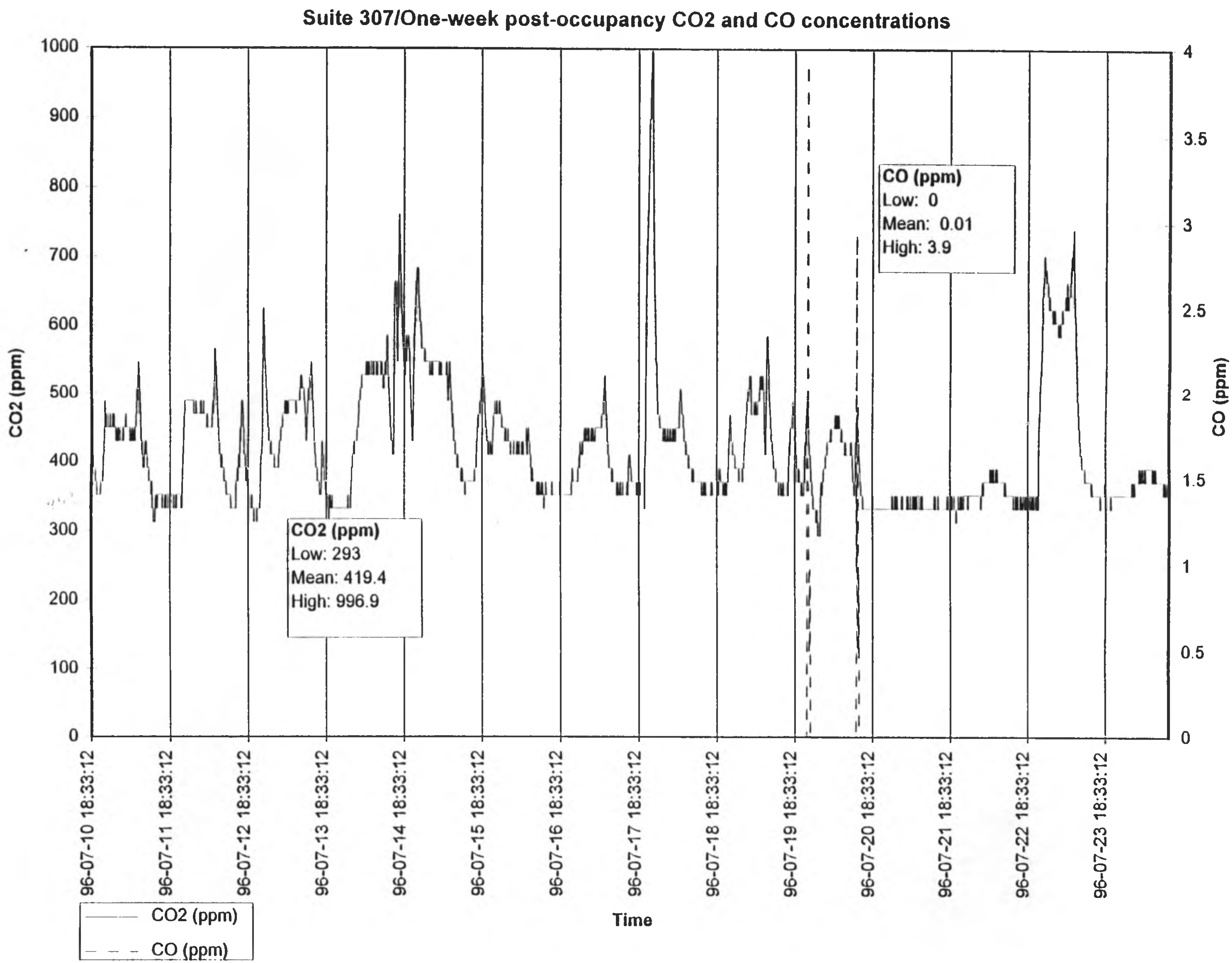


Suite 413/Pre-occupancy CO and CO2 Concentrations



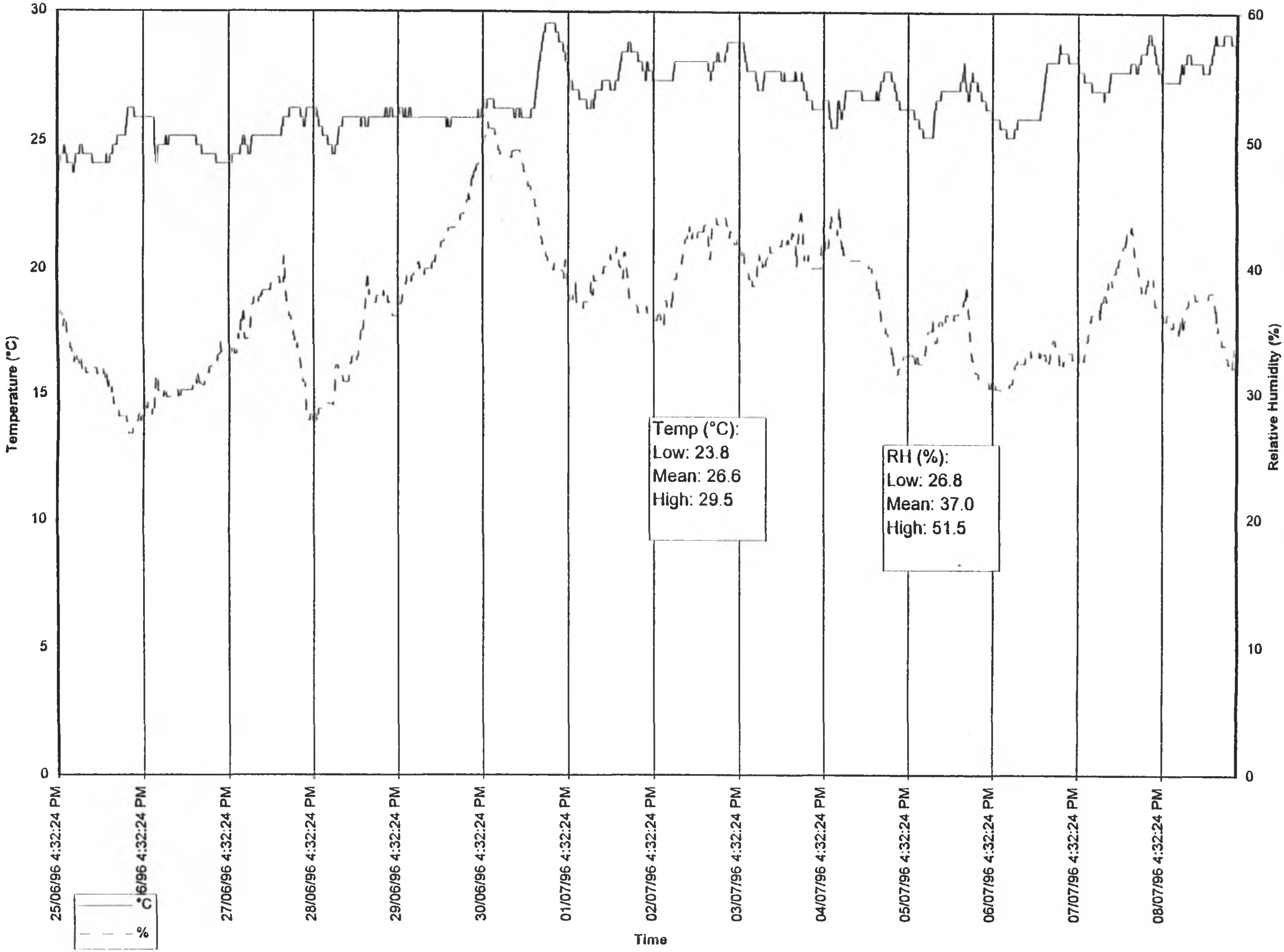


Suite 307/One-week Post-occupancy Temperature and Relative Humidity
Temperature (°C)
Relative Humidity (%)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
Temp (°C):
Low: 18.1
Mean: 24.2
High: 27.3
RH (%)
Low: 33.7
Mean: 49.3
High: 70.5
96-07-10 18:33:12
96-07-11 18:33:12
96-07-12 18:33:12
96-07-13 18:33:12
96-07-14 18:33:12
96-07-15 18:33:12
96-07-16 18:33:12
96-07-17 18:33:12
96-07-18 18:33:12
96-07-19 18:33:12
96-07-20 18:33:12
96-07-21 18:33:12
96-07-22 18:33:12
96-07-23 18:33:12
Time
°C
%

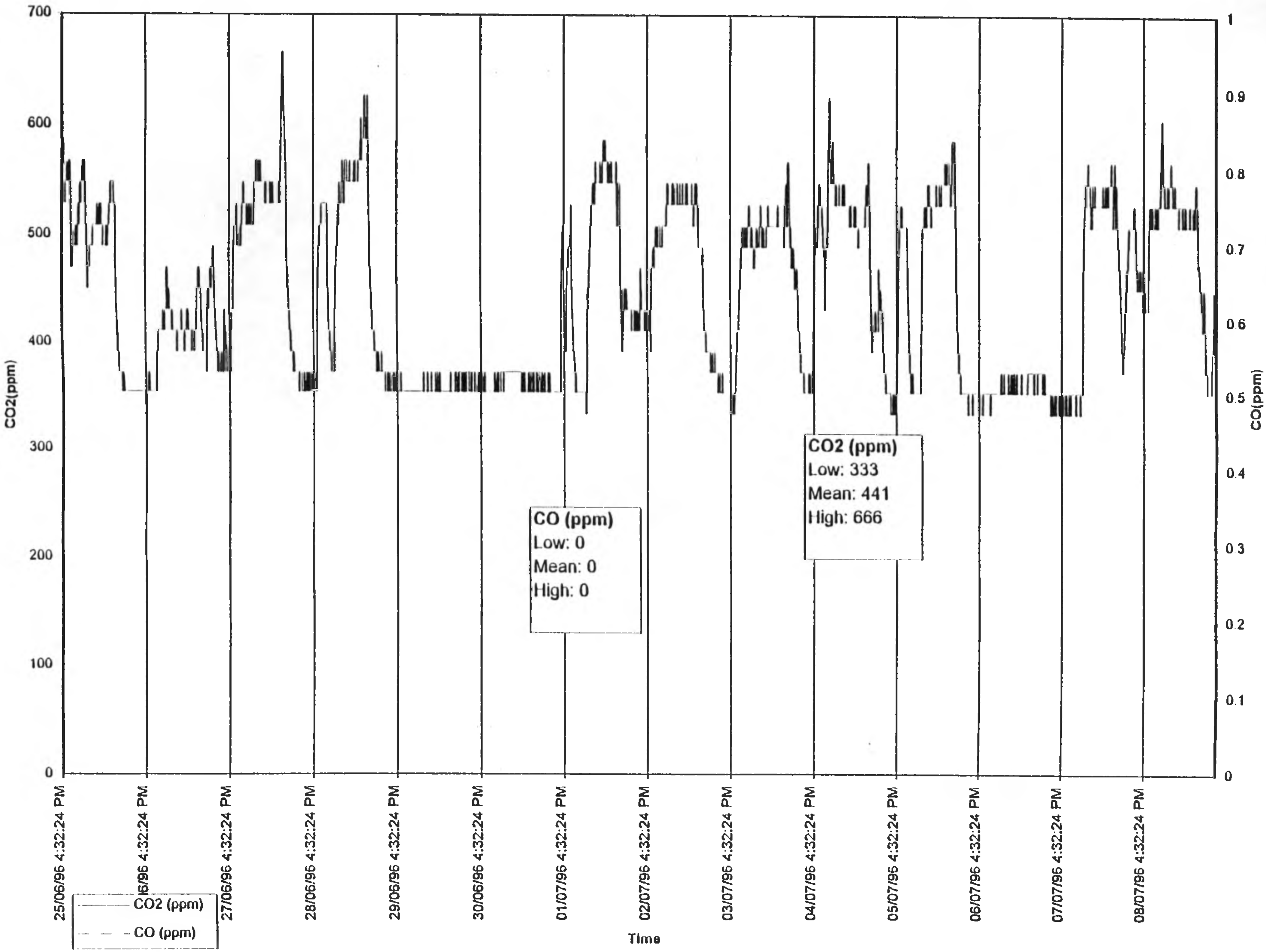


Suite 307/One-week post-occupancy CO2 and CO concentrations
1000
900
800
700
600
500
400
300
200
100
0
CO2 (ppm)
4
3.5
3
2.5
2
1.5
1
0.5
0
CO (ppm)
CO2 (ppm)
Low: 293
Mean: 419.4
High: 996.9
CO (ppm)
Low: 0
Mean: 0.01
High: 3.9
96-07-10 18:33:12
96-07-11 18:33:12
96-07-12 18:33:12
96-07-13 18:33:12
96-07-14 18:33:12
96-07-15 18:33:12
96-07-16 18:33:12
96-07-17 18:33:12
96-07-18 18:33:12
96-07-19 18:33:12
96-07-20 18:33:12
96-07-21 18:33:12
96-07-22 18:33:12
96-07-23 18:33:12
Time
CO2 (ppm)
CO (ppm)

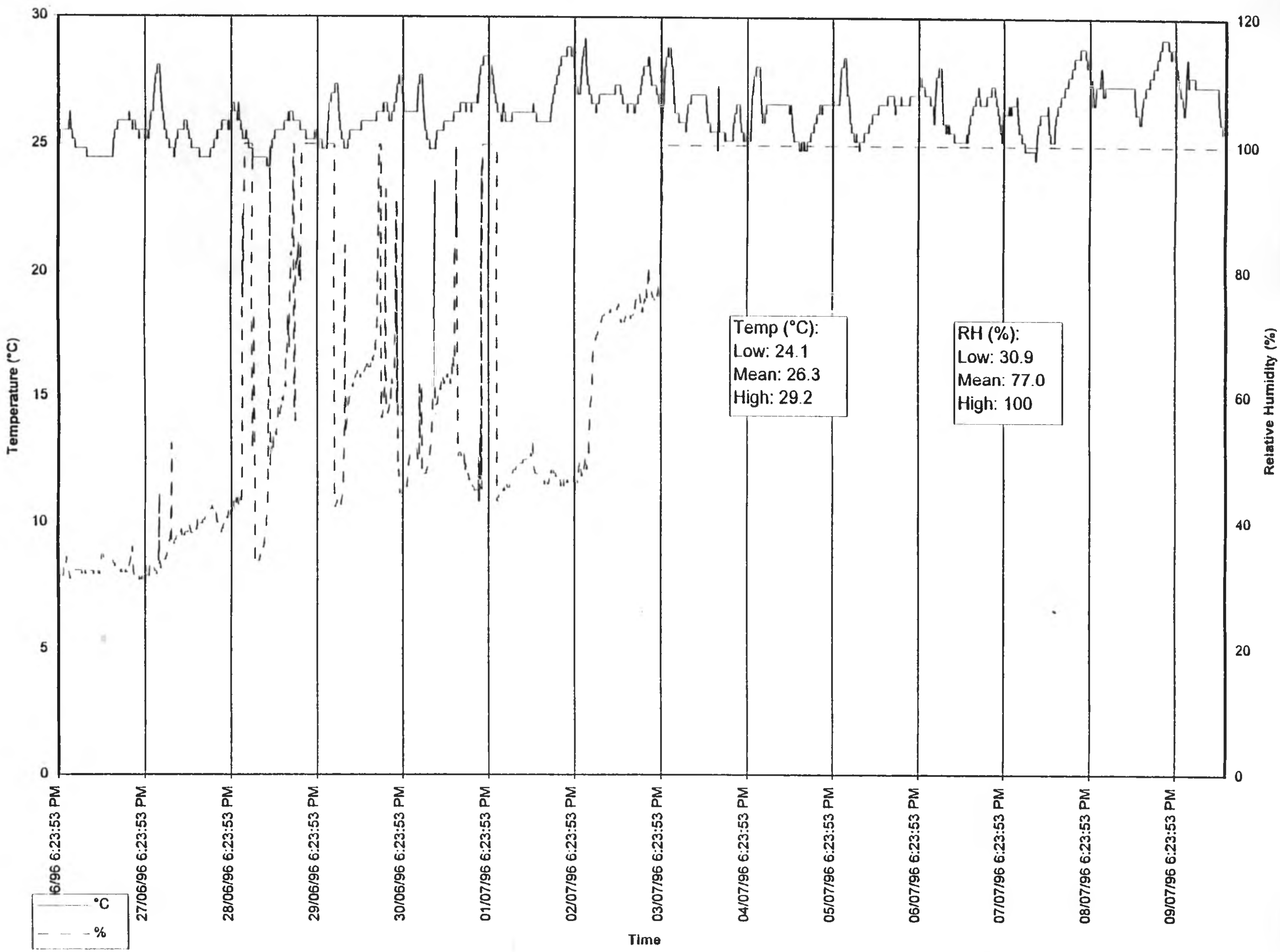
Suite 400/ One Week Post Occupancy Temperature and Relative Humidity



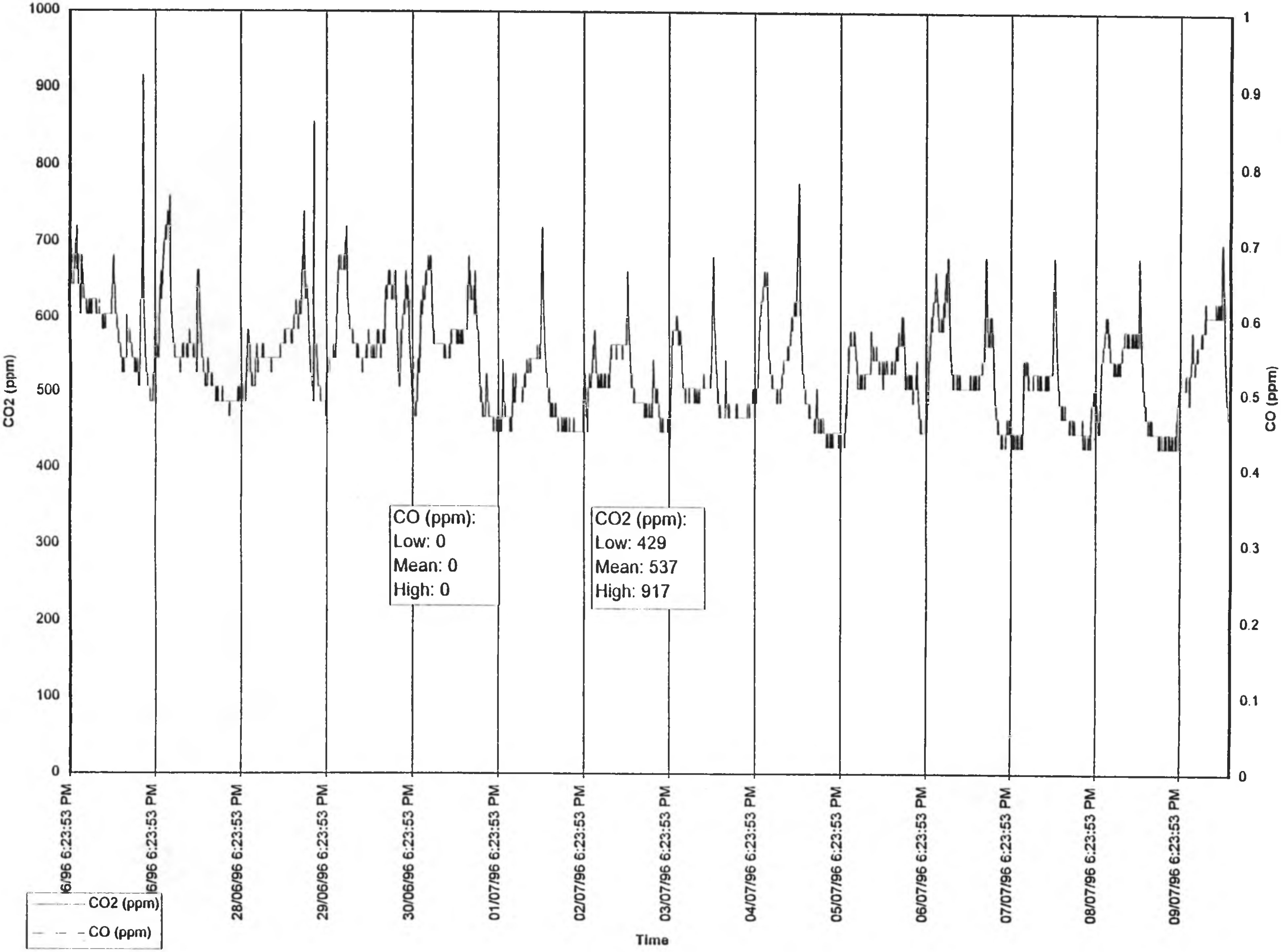
Suite 400/One Week Post-Occupancy CO2 and CO Concentrations



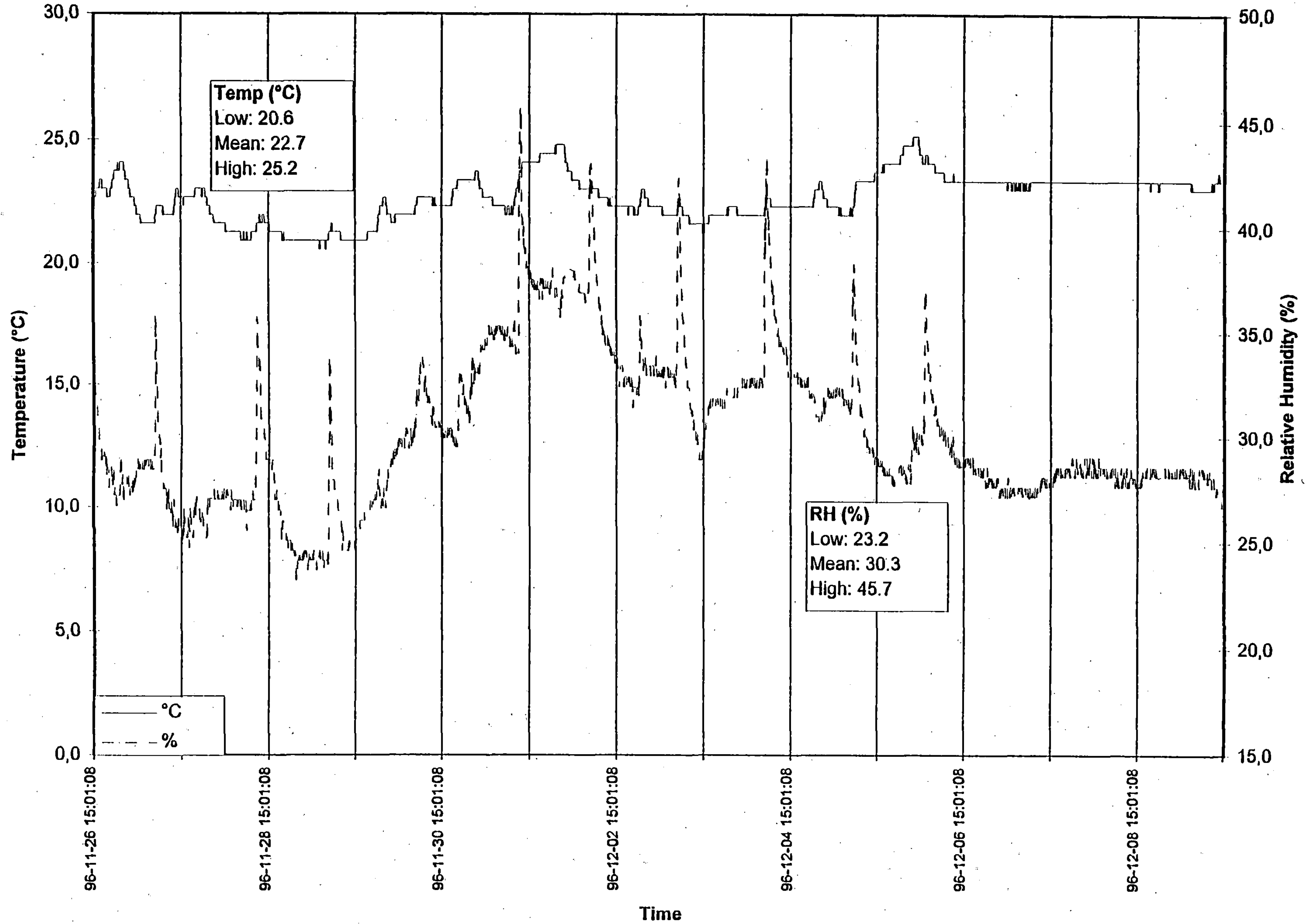
Suite 413/One Week Post-occupancy Temperature and Relative Humidity

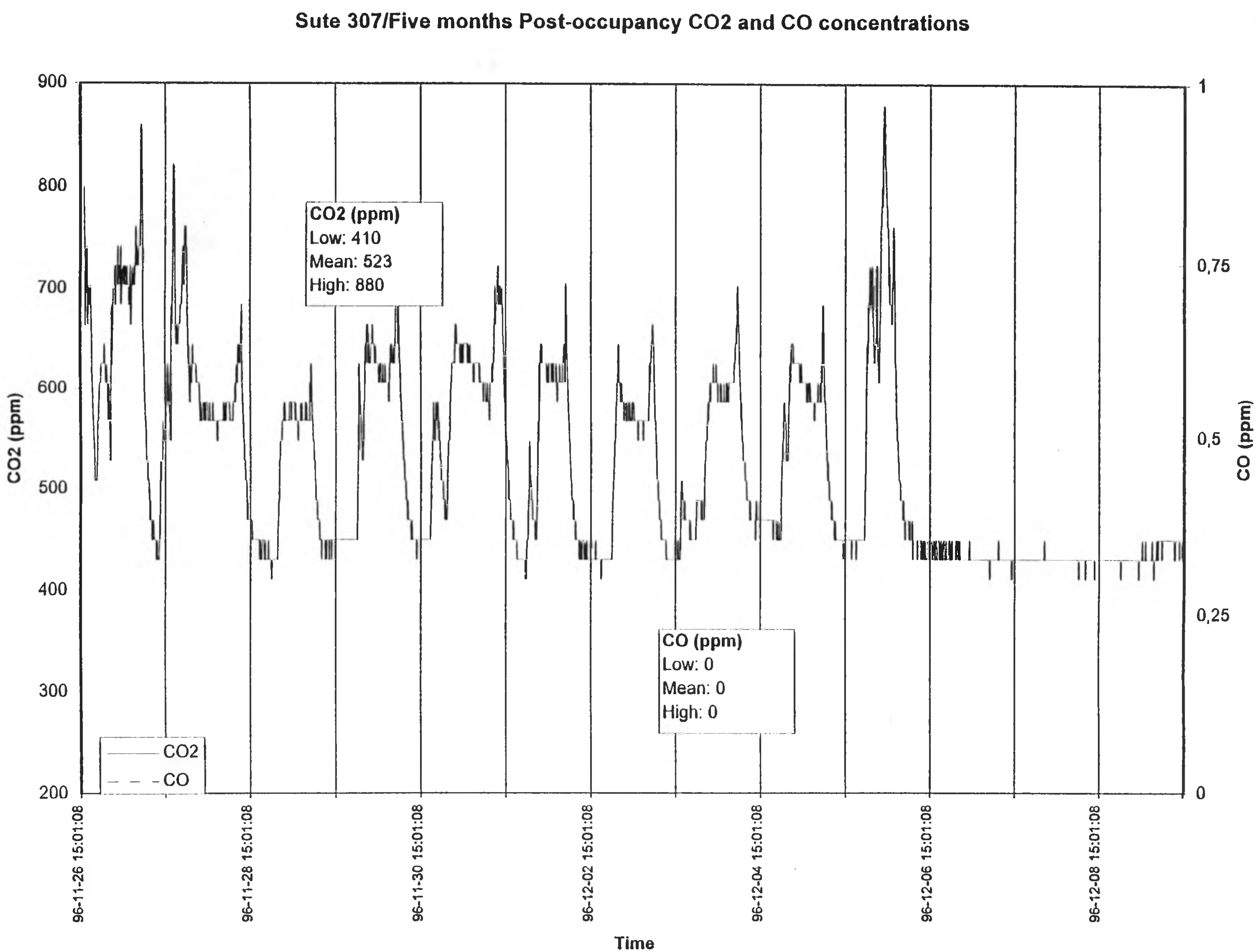


Suite 413/Post-occupancy CO and CO2 Concentrations

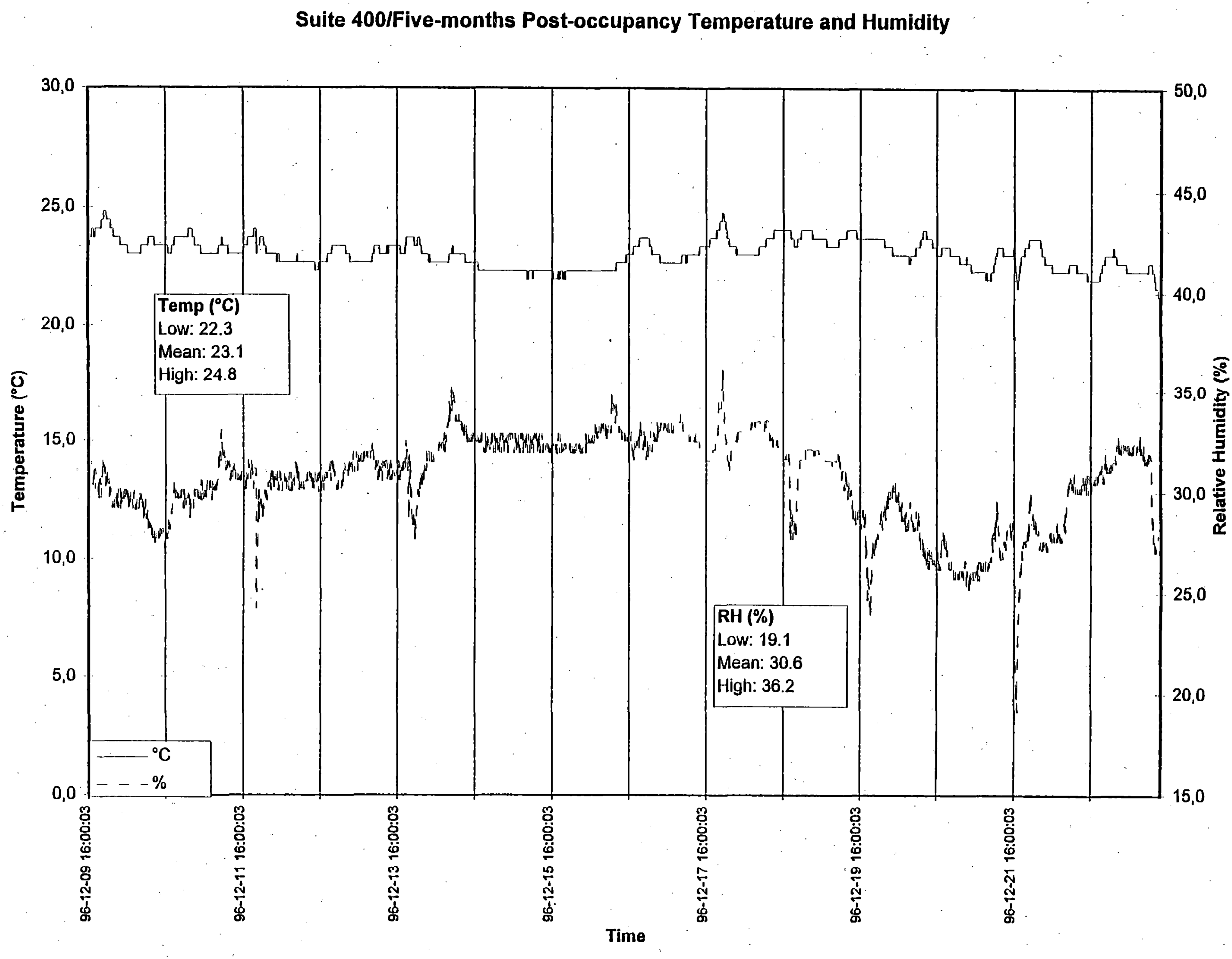


Suite 307/Five-months Post-occupancy Temperature and Humidity

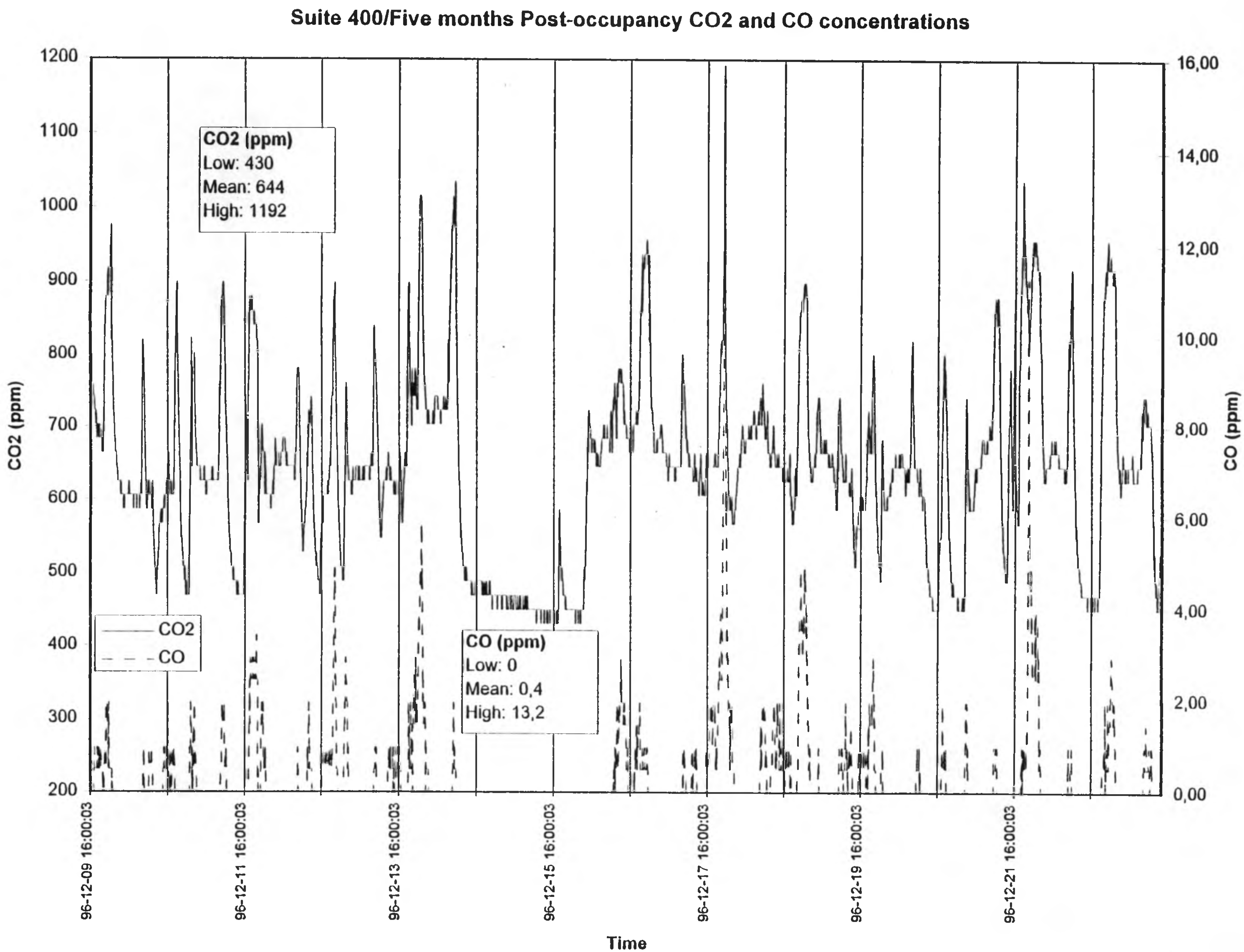




Sute 307/Five months Post-occupancy CO2 and CO concentrations
CO2 (ppm)
Low: 410
Mean: 523
High: 880
CO (ppm)
Low: 0
Mean: 0
High: 0
CO2
CO
900
800
700
600
500
400
300
200
1
0,75
0,5
0,25
0
CO2 (ppm)
CO (ppm)
96-11-26 15:01:08
96-11-28 15:01:08
96-11-30 15:01:08
96-12-02 15:01:08
96-12-04 15:01:08
96-12-06 15:01:08
96-12-08 15:01:08
Time

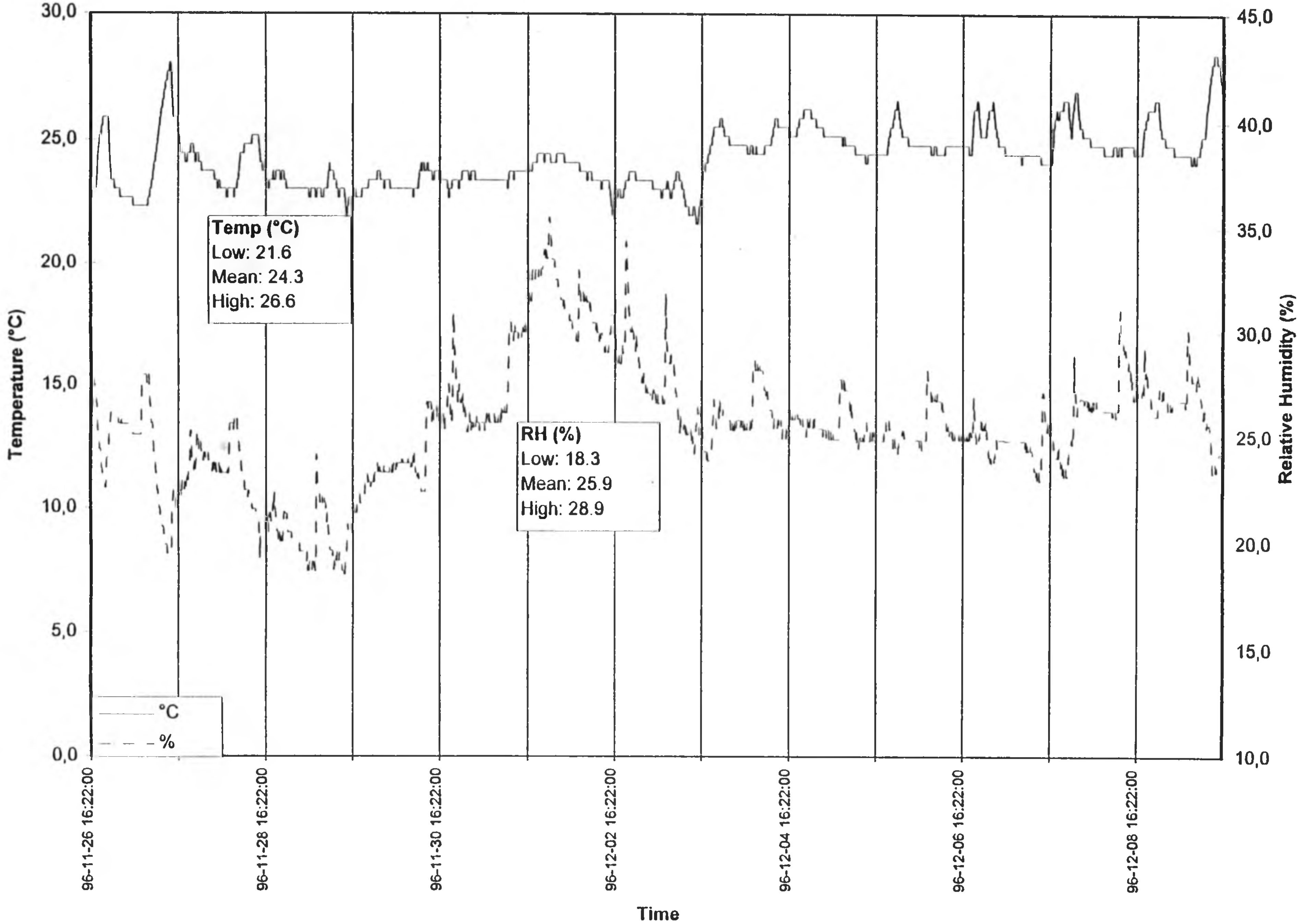


Suite 400/Five-months Post-occupancy Temperature and Humidity
Temp (°C)
Low: 22.3
Mean: 23.1
High: 24.8
RH (%)
Low: 19.1
Mean: 30.6
High: 36.2
°C
%
Temperature (°C)
Relative Humidity (%)
30,0
25,0
20,0
15,0
10,0
5,0
0,0
50,0
45,0
40,0
35,0
30,0
25,0
20,0
15,0
96-12-09 16:00:03
96-12-11 16:00:03
96-12-13 16:00:03
96-12-15 16:00:03
96-12-17 16:00:03
96-12-19 16:00:03
96-12-21 16:00:03
Time

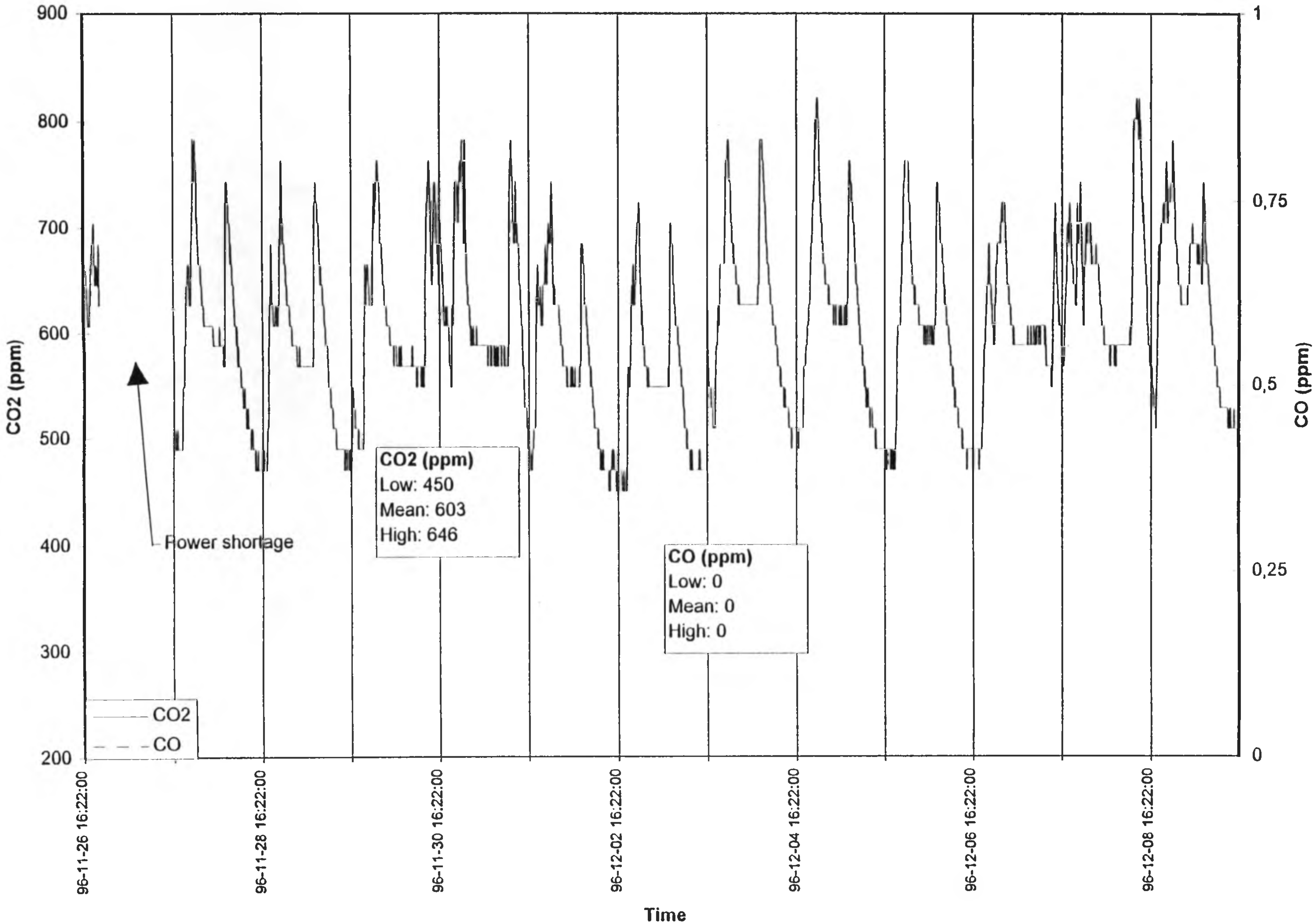


Suite 400/Five months Post-occupancy CO2 and CO concentrations
CO2 (ppm)
Low: 430
Mean: 644
High: 1192
CO (ppm)
Low: 0
Mean: 0,4
High: 13,2
CO2
CO
CO2 (ppm)
CO (ppm)
1200
1100
1000
900
800
700
600
500
400
300
200
16,00
14,00
12,00
10,00
8,00
6,00
4,00
2,00
0,00
96-12-09 16:00:03
96-12-11 16:00:03
96-12-13 16:00:03
96-12-15 16:00:03
96-12-17 16:00:03
96-12-19 16:00:03
96-12-21 16:00:03
Time

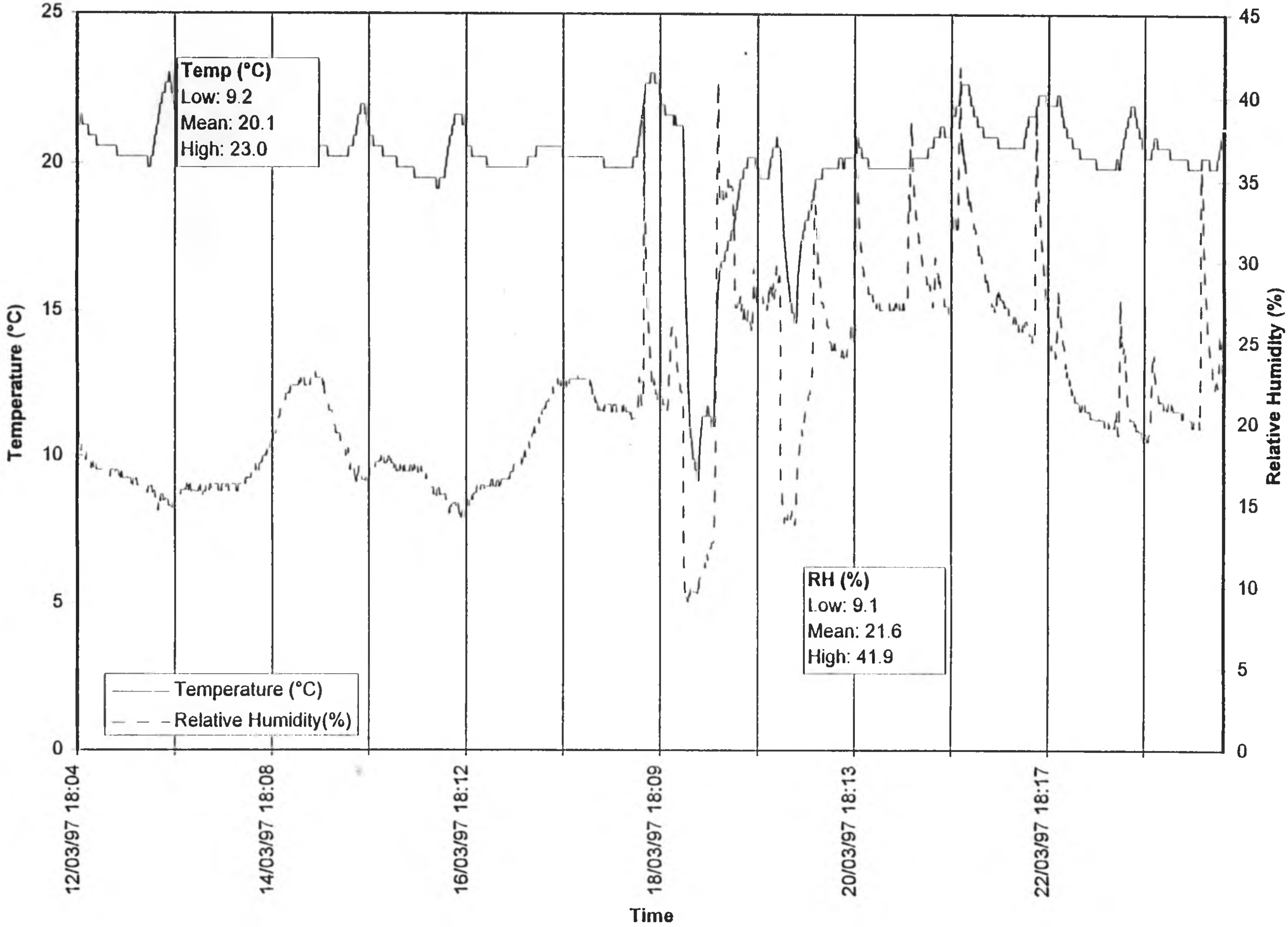
Suite 413/Five-months Post-occupancy Temperature and Humidity



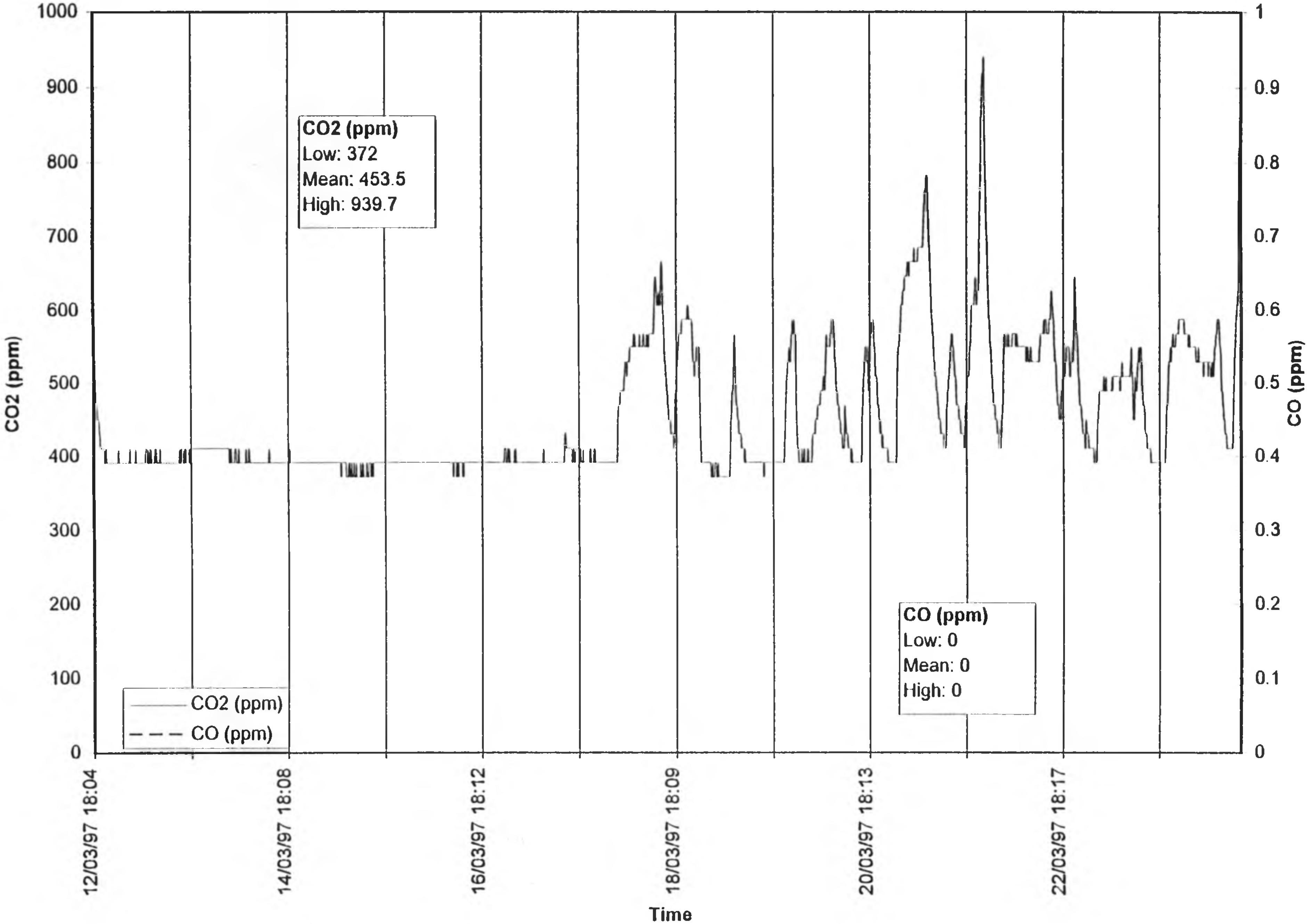
Suite 413/Five-months Post-occupancy CO2 and CO concentrations

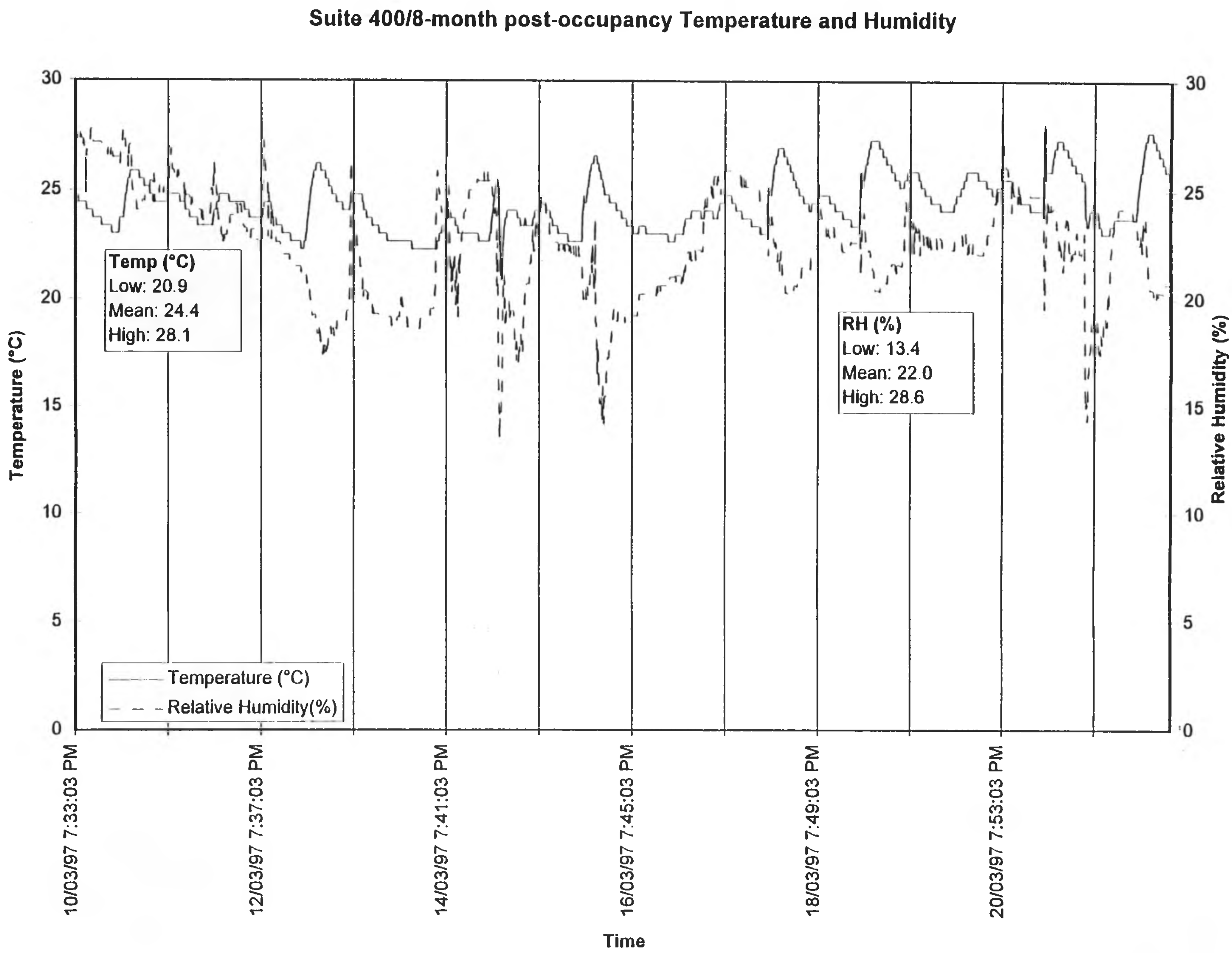


Suite 307/8-month post-occupancy Temperature and Humidity

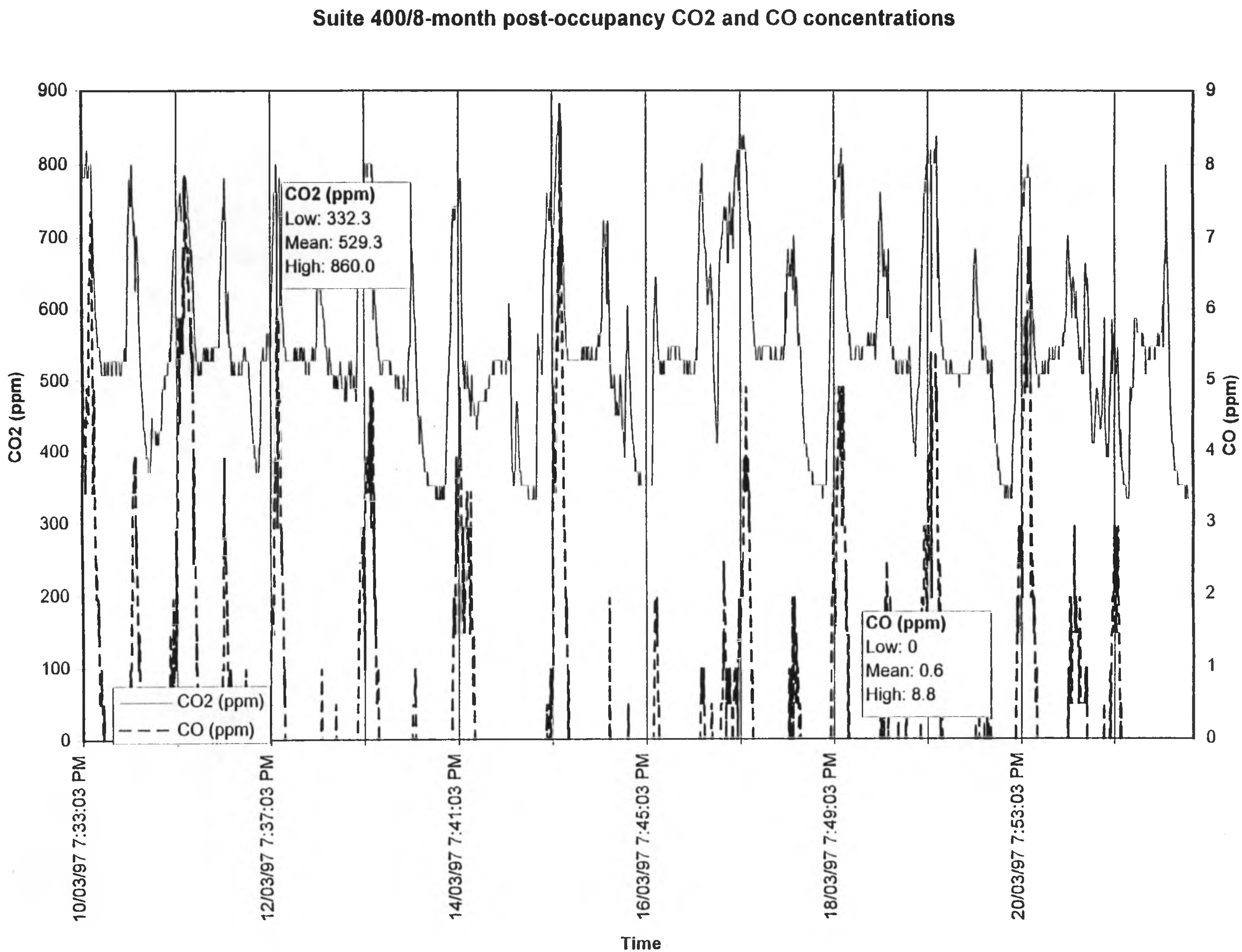


Suite 307/8-month post-occupancy CO2 and CO concentrations



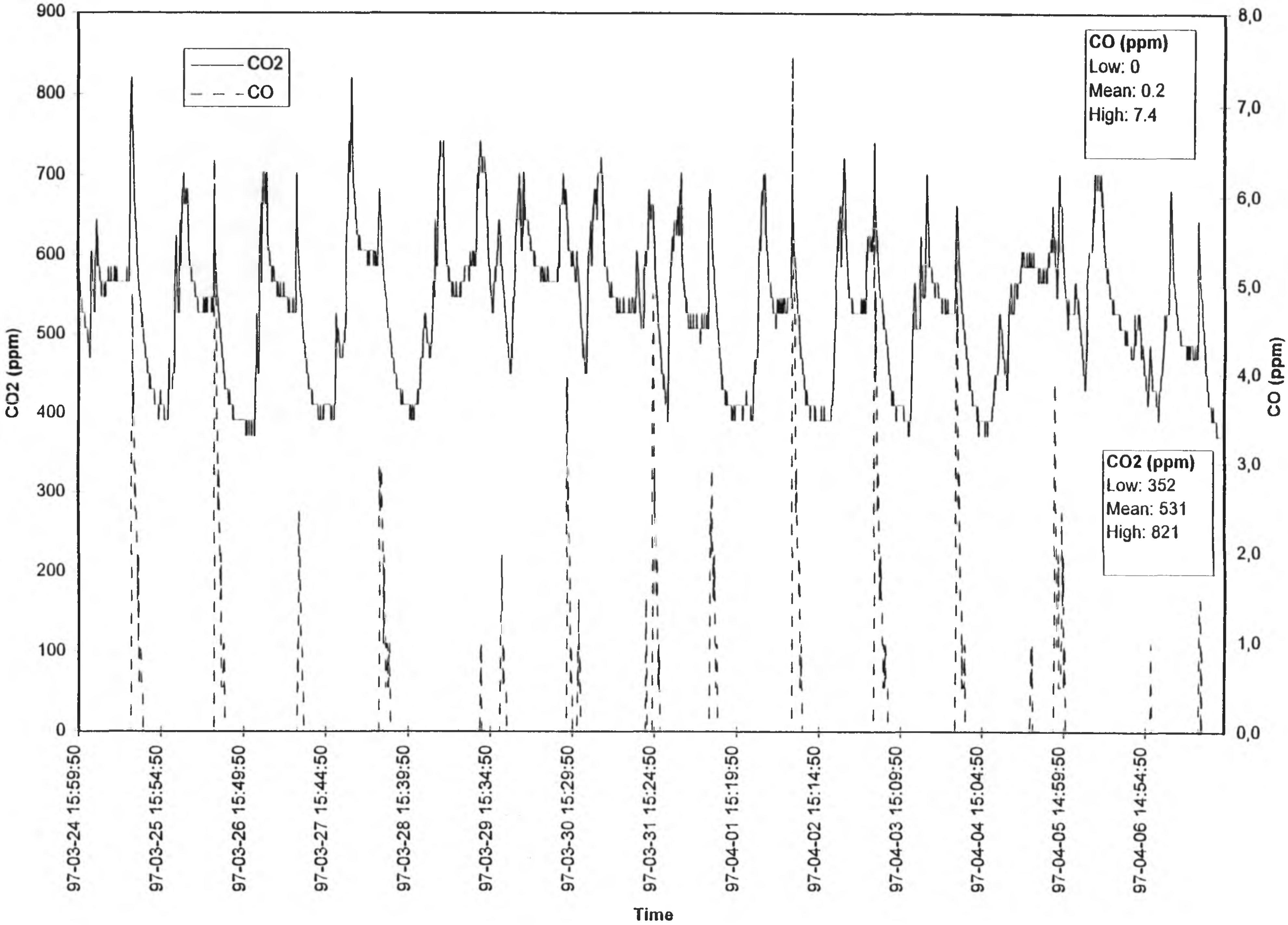


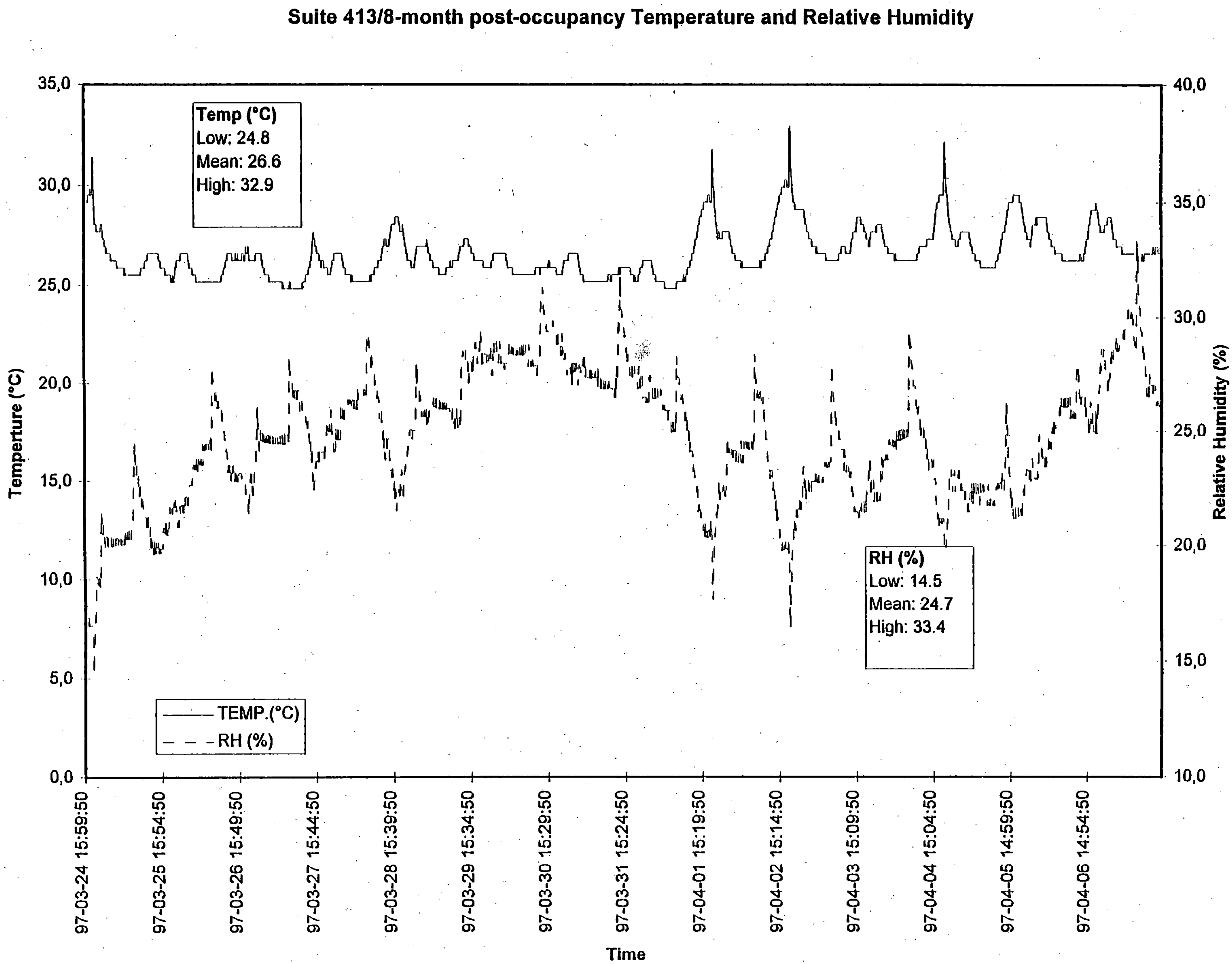
Suite 400/8-month post-occupancy Temperature and Humidity
Temp (°C)
Low: 20.9
Mean: 24.4
High: 28.1
RH (%)
Low: 13.4
Mean: 22.0
High: 28.6
Temperature (°C)
Relative Humidity(%)
Temperature (°C)
Relative Humidity (%)
0
5
10
15
20
25
30
10/03/97 7:33:03 PM
12/03/97 7:37:03 PM
14/03/97 7:41:03 PM
16/03/97 7:45:03 PM
18/03/97 7:49:03 PM
20/03/97 7:53:03 PM
Time



Suite 400/8-month post-occupancy CO2 and CO concentrations
CO2 (ppm)
Low: 332.3
Mean: 529.3
High: 860.0
CO (ppm)
Low: 0
Mean: 0.6
High: 8.8
CO2 (ppm)
CO (ppm)
900
800
700
600
500
400
300
200
100
0
9
8
7
6
5
4
3
2
1
0
10/03/97 7:33:03 PM
12/03/97 7:37:03 PM
14/03/97 7:41:03 PM
16/03/97 7:45:03 PM
18/03/97 7:49:03 PM
20/03/97 7:53:03 PM
Time

Suite 413/8-month post-occupancy CO2 and CO concentrations





Suite 413/8-month post-occupancy Temperature and Relative Humidity
Temp (°C)
Low: 24.8
Mean: 26.6
High: 32.9
RH (%)
Low: 14.5
Mean: 24.7
High: 33.4
TEMP.(°C)
RH (%)
Temperture (°C)
Relative Humidity (%)
Time
35,0
30,0
25,0
20,0
15,0
10,0
5,0
0,0
40,0
35,0
30,0
25,0
20,0
15,0
10,0
97-03-24 15:59:50
97-03-25 15:54:50
97-03-26 15:49:50
97-03-27 15:44:50
97-03-28 15:39:50
97-03-29 15:34:50
97-03-30 15:29:50
97-03-31 15:24:50
97-04-01 15:19:50
97-04-02 15:14:50
97-04-03 15:09:50
97-04-04 15:04:50
97-04-05 14:59:50
97-04-06 14:54:50

VOC HOUSE QUESTIONNAIRE (Note: this questionnaire is to be filled out by the person testing the house. Answer all questions; if the answer is unknown, please state "Don't know".)

Name of House Owner or Occupier Julie-Édith Lafortune

Address 925 René-Levesque #407

City Montreal

Postal Code ____________

Telephone ____________

House information:

1. Date that the house was completed (Year and Month) June 996
   Date that the house was first occupied (Year and Month) June 996

2. House floor area including basement (m^2) 45.5

3. Type of house

   - 1 story ☐
   - 1 & 1/2 story ☐
   - 2 story ☐
   - split level ☐
   - bilevel ☐
   - other (please specify) Condo

4. Type of foundation

   - slab on grade ☐
   - crawl space ☐
   - cast concrete basement ☒
   - concrete block basement ☐
   - preserved wood foundation ☐
   - other (please specify) ____________

Type of exterior finish.

- brick ☒
- aluminum siding ☐
- vinyl siding ☐
- wood siding ☐
- stucco ☐
- other (please specify) ______________________

6. Are there any unusual pollution sources within 1 kilometre of the house? (For instance, a paint factory, furniture plant, chemical factory, oil refinery, animal feed lot, etc.) Please specify.

Molson brewery

7. Do the house occupants notice any odours entering the house from exterior pollution sources? (For instance, wood smoke, exhaust from automobiles and trucks, chemical smells from factories, etc?) Please specify the type of odour, and the frequency and duration.

Type of odour ______________________

____

Frequency ______________________

Duration ______________________

8. What was the use of the land before the house was built on it?

- Agricultural ☐
- Forest ☐
- Another house ☒
- Factory site ☐
- Other (Please specify.) ______________________
- Don't know ☐

9. What was the main wood framing material used in the walls of the house?

- Spruce ☐
- Fir ☐
- Pine ☐
- Other (Please specify) Metal Stud
- Don't know ☐

10. What was the main wood framing material used for the floor joists in the house?

- Spruce ☐
- Fir ☐
- Pine ☐
- Hemlock ☐
- Other (Please specify) N/A
- Don't know ☐

11. What type of wood or plywood was used as the subfloor?
(Note: Removal of a floor register will allow access to the subfloor and the underlay.)

- Spruce ☐
- Fir ☐
- Pine ☐
- Waferboard ☐
- Other (Please specify) N/A
- Don't know ☐

2. What type of material was used as the underlay?

- Particle board ☐
- Spruce plywood ☐
- Fir plywood ☐
- Waferboard ☐
- None ☐
- Other (Please specify) N/A

13. For each of the following rooms, specify the type of floor, ill and ceiling finish. (Please use the following code;

FLOOR:
1 synthetic carpet with separate foam rubber underlay
2 synthetic carpet with integral foam rubber underlay
3 wool carpet
4 vinyl flooring
5 wood flooring
6 unpainted concrete floor
7 painted concrete floor
8 ceramic tile or marble
9 other

WALL:
10 painted gypsum board
11 wallpaper on gypsum board
12 interior grade plywood (birch, mahogany, oak etc)
13 painted particle board
14 wood boards
15 other

CEILING:
20 painted gypsum board
21 stippled gypsum board
22 unfinished (floor joists exposed)
23 acoustic ceiling using glass-fibre based tiles
24 acoustic ceiling using wood fibre based tiles
25 other

	Floor	Wall	Ceiling
Living Room	1	10	20
Dining Room	1	10	20
Master Bedroom	1	10	20
Bedroom 2			
Bedroom 3			
Bedroom 4			
Bathroom 1	2	10	20
Bathroom 2			
Kitchen	4	10	20
Family room			
Re-reation room			
Laundry	4	10	20
Basement			

14. What is the material used for the structural part of the kitchen cabinets?

- Particle board [X]
- Plywood [ ]
- Other(Please specify) ________________

15. What is the material used for the doors of the kitchen cabinets?

- Painted particle board [ ]
- Melamine covered particle board [X]
- Solid wood [ ]
- Mixture of solid wood and plywood [ ]
- Other ________________

16. Is the ventilation system or ventilation components run continuously?

- Yes [X]
- No [ ]
- Partial (State no of hours per day.)________

17. What type of humidifier does the house have?

- Central humidifier on a warm air furnace [X]
- Individual room humidifiers [ ]
- No humidifier [ ]
- Other (Please specify)

18. What was the humidity in the house on the two occasions you were in the house? (Measure in the living room.) (See monitored data)

First visit Relative Humidity = ________

Date = ________________

Second visit Relative Humidity = ________

Date = ________________

19. What was the temperature in the house on the two occasions you were in the house? (Measure in the living room.) (see monitored data)

First visit Temperature = ______________

Second visit Temperature = ______________

20. Do the occupants store the following in the house? No.

Paint ☐

Solvents ☐

Insecticides ☐

Fertilizer ☐

Paint stripper ☐

Other high volatile materials (Please specify)

____

21. Have the occupants used any of the following in the 30 day period prior to the placement of the VOC badges? No

Paint inside the house ☐

Floor wax ☐

Paint stripper ☐

Insecticides ☐

Furniture polish ☐

Rug shampoo ☐

Other high volatile materials (Please specify) ______________________________

____

22. Do any of the occupants in the house smoke?

Please specify the number and the amount smoked.

Number of smokers __x__ occasional

Total number of cigarettes smoked each day in the house ________ ~ 1-2

23. Is there a wood stove or fireplace in the house?

Yes ☐

No ☒

If the answer is Yes, please specify the number of times per week the wood stove or fireplace is used.

Number of times ______

24. Were there any significant renovations in the house since the house was originally completed?

Please specify ____

____

____

25. How do you (the interviewer) rate the air quality in this house?

Much worse than average ☐

Worse than average ☐

Average ☒

Better than average ☐

Much better than average ☐

Comments: ____

26. Do the occupants have any comments about the air quality in their home?

____

____

____

____

27. Are there any unique air quality aspects of the house that should be mentioned? (For instance, unusual odours, condensation stains on windows or walls, exceptionally good or bad housekeeping, hobby activities, etc.)

____

____

____

____

28. What is the brand name and frequency of use of the following products used inside the house?

	Brand Name	Number of times used per week
Dishwasher detergent	Sunlight	2
Floor wax		
Laundry Detergent	Sunlight	5
General purpose cleaner Mr. Clean, etc.)	Vim / Pledge	1-2
Hair spray	Salon Selectives	1/day
Perfume		

****

QUESTIONNAIRE PORTANT SUR LES PLAINTES DES OCCUPANTS

Quelle section de l'immeuble est l'objet du plus grand nombre de plaintes? Indiquer le numéro d'étage, de pièce ou d'appartement ou alors décrire brièvement (exemple : rez-de-chaussée, problème généralisé, etc.).

____

____

Les réponses que vous donnerez aux questions ci-dessous s'appliqueront à cet endroit. Lorsqu'un choix est proposé, encercler la réponse convenant le mieux. Inscrire votre propre réponse aux endroits indiqués. L'espace nécessaire est fourni.

1. Quelle est la température habituelle de ce lieu?
   correcte / trop élevée / trop basse / parfois trop chaud, parfois trop froid

2. Décrire la qualité habituelle de l'air dans cette pièce.
   correct / courants d'air / stagnant / renfermé / vicié / sec

3. Y a-t-il des odeurs qui vous dérangent à cet endroit? oui/non
   Si OUI, à quelle fréquence sentez-vous ces odeurs?
   rarement / à l'occasion / souvent / constamment
   Laquelle des odeurs suivantes y correspond le mieux?
   gaz d'échappement / fumée de diesel / chaufferie / appareil de chauffage / odeurs corporelles / moisi / produit chimique / solvant / ciment ou plâtre (humide) / poussière ou craie
   Selon-vous, qu'est-ce qui est à l'origine de l'odeur?

   ____

4. Pouvez-vous régler l'un ou l'autre des problèmes susmentionnés? Comment? oui/non

5. Y a-t-il déjà eu un «dégât d'eau» comme une inondation ou un débordement dans cette partie de l'immeuble, à cet étage ou au-dessus de celui-ci? oui/non

6. Avez-vous des antécédents d'allergies? oui/non
   Dans l'affirmative, de quel genre d'allergie s'agit-il?
   respiratoire / cutanée / alimentaire / autre
   Vos allergies empirent-elles lorsque vous vous trouvez dans cet immeuble? oui/non

7. Parmi les symptômes suivants, lesquels sont selon vous sont causés par ce bâtiment?
   maux de tête / fatigue / étourdissements / vertiges / nausées / problèmes gastriques / irritation de la peau / sécheresse des yeux / démangeaisons oculaires / larmoiements / vue brouillée / embarras de la respiration nasale / écoulement nasal / éternuements / maux de gorge / sécheresse de la gorge / problèmes thoraciques / toux / asthme

[redacted] À quel moment de la journée les symptômes se manifestent-ils avec le plus de force?

matin / après-midi / soir / nuit / tout le temps pareil

Durant quels jours de la semaine vous plaignez-vous le plus?

la semaine / la fin de semaine / tout le temps pareil

[redacted] Les symptômes coïncident-ils avec les activités de nettoyage ou d'entretien ou les suivent-ils? oui/non

Si OUI, décrire l'activité.

____

Commentaires :

VOC HOUSE QUESTIONNAIRE (Note: this questionnaire is to be filled out by the person testing the house. Answer all questions; if the answer is unknown, please state "Don't know".)

Name of House Owner or Occupier MARYSE DERRIEN

Address 925 René Lévesque #400

City MONTREAL

Postal Code ____________

Telephone 344-

House information:

1. Date that the house was completed (Year and Month) May 1996
   Date that the house was first occupied (Year and Month) [illegible]

2. House floor area including basement (m^2) 71.5

3. Type of house

   - 1 story ☐
   - 1 & 1/2 story ☐
   - 2 story ☐
   - split level ☐
   - bilevel ☐
   - other (please specify) Condo complex

4. Type of foundation

   - slab on grade ☐
   - crawl space ☐
   - cast concrete basement ☒
   - concrete block basement ☐
   - preserved wood foundation ☐
   - other (please specify) ____________

Type of exterior finish.

- brick ☒
- aluminum siding ☐
- vinyl siding ☐
- wood siding ☐
- stucco ☐
- other (please specify) ______________

6. Are there any unusual pollution sources within 1 kilometre of the house? (For instance, a paint factory, furniture plant, chemical factory, oil refinery, animal feed lot, etc.) Please specify.

Molson Brewry

7. Do the house occupants notice any odours entering the house from exterior pollution sources? (For instance, wood smoke, exhaust from automobiles and trucks, chemical smells from factories, etc?) Please specify the type of odour, and the frequency and duration.

Type of odour ______________

____

Frequency ______________

Duration ______________

8. What was the use of the land before the house was built on it?

- Agricultural ☐
- Forest ☐
- Another house ☒
- Factory site ☐
- Other (Please specify.) ______________
- Don't know ☐

9. What was the main wood framing material used in the walls of the house?

Spruce ☐

Fir ☐

Pine ☐

Other (Please specify) Metal stud

Don't know ☐

10. What was the main wood framing material used for the floor joists in the house?

Spruce ☐

Fir ☐

Pine ☐

Hemlock ☐

Other (Please specify) N/A

Don't know ☐

11. What type of wood or plywood was used as the subfloor?
(Note: Removal of a floor register will allow access to the subfloor and the underlay.)

Spruce ☐

Fir ☐

Pine ☐

Waferboard ☐

Other (Please specify) N/A

Don't know ☐

2. What type of material was used as the underlay?

Particle board ☐

Spruce plywood ☐

Fir plywood ☐

Waferboard ☐

None ☐

Other (Please specify) N/A

13. For each of the following rooms, specify the type of floor, (all and ceiling finish. (Please use the following code;

FLOOR:
- 1 synthetic carpet with separate foam rubber underlay
- 2 synthetic carpet with integral foam rubber underlay
- 3 wool carpet
- 4 vinyl flooring
- 5 wood flooring
- 6 unpainted concrete floor
- 7 painted concrete floor
- 8 ceramic tile or marble
- 9 other

WALL:
- 10 painted gypsum board
- 11 wallpaper on gypsum board
- 12 interior grade plywood (birch, mahogany, oak etc)
- 13 painted particle board
- 14 wood boards
- 15 other

CEILING:
- 20 painted gypsum board
- 21 stippled gypsum board
- 22 unfinished (floor joists exposed)
- 23 acoustic ceiling using glass-fibre based tiles
- 24 acoustic ceiling using wood fibre based tiles
- 25 other

	Floor	Wall	Ceiling
Living Room ✓	1	10	20
Dining Room ✓	1	10	20
Master Bedroom ✓	1	10	20
Bedroom 2			
Bedroom 3			
Bedroom 4			
Bathroom 1 ✓	8	10	20
Bathroom 2			
Kitchen ✓	4	10	20
Family room			
Recreation room			
Laundry ✓	4	10	20
Basement			

14. What is the material used for the structural part of the kitchen cabinets?

- Particle board ☒
- Plywood ☐
- Other(Please specify) ______________________

15. What is the material used for the doors of the kitchen cabinets?

- Painted particle board ☐
- Melamine covered particle board ☒
- Solid wood ☐
- Mixture of solid wood and plywood ☐
- Other ______________________

16. Is the ventilation system or ventilation components run continuously?

- Yes ☒
- No ☐
- Partial (State no of hours per day.) ________

17. What type of humidifier does the house have?

- Central humidifier on a warm air furnace ☒
- Individual room humidifiers ☐
- No humidifier ☐
- Other (Please specify)

18. What was the humidity in the house on the two occasions you were in the house? (Measure in the living room.)

(see monitored data)

First visit Relative Humidity = ________

Date = ______________________

Second visit Relative Humidity = ________

Date = ______________________

19. What was the temperature in the house on the two occasions you were in the house? (Measure in the living room.)

First visit Temperature = ________________ (see monitored data)

Second visit Temperature = ________________

20. Do the occupants store the following in the house? No.

Paint ☐

Solvents ☐

Insecticides ☐

Fertilizer ☐

Paint stripper ☐

Other high volatile materials (Please specify)

____

21. Have the occupants used any of the following in the 30 day period prior to the placement of the VOC badges? No

Paint inside the house ☐

Floor wax ☐

Paint stripper ☐

Insecticides ☐

Furniture polish ☐

Rug shampoo ☐

Other high volatile materials (Please specify)

____

____

22. Do any of the occupants in the house smoke?

Please specify the number and the amount smoked.

Number of smokers 1

Total number of cigarettes smoked each day in the house ≈15

23. Is there a wood stove or fireplace in the house?

- Yes ☐
- No ☒

If the answer is Yes, please specify the number of times per week the wood stove or fireplace is used.

Number of times ______

24. Were there any significant renovations in the house since the house was originally completed?

Please specify ______________________________

____

____

25. How do you (the interviewer) rate the air quality in this house?

- Much worse than average ☐
- Worse than average ☐
- Average ☐
- Better than average ☒
- Much better than average ☐

Comments: ______________________________

26. Do the occupants have any comments about the air quality in their home?

Warm they keep the thermostat at min.

they like the fresh air supply

____

____

27. Are there any unique air quality aspects of the house that should be mentioned? (For instance, unusual odours, condensation stains on windows or walls, exceptionally good or bad housekeeping, hobby activities, etc.)

____

____

____

____

28. What is the brand name and frequency of use of the following products used inside the house?

	Brand Name	Number of times used per week
Dishwasher detergent	Calgonite	2-3
Floor wax		
Laundry Detergent	Tide	1
General purpose cleaner Mr. Clean, etc.)	old Dutch Hertel	[illegible]
Hair spray		
Perfume		

****

QUESTIONNAIRE PORTANT SUR LES PLAINTES DES OCCUPANTS

Quelle section de l'immeuble est l'objet du plus grand nombre de plaintes? Indiquer le numéro d'étage, de pièce ou d'appartement ou alors décrire brièvement (exemple : rez-de-chaussée, problème généralisé, etc.).

____

____

Les réponses que vous donnerez aux questions ci-dessous s'appliqueront à cet endroit. Lorsqu'un choix est proposé, encercler la réponse convenant le mieux. Inscrire votre propre réponse aux endroits indiqués. L'espace nécessaire est fourni.

1. Quelle est la température habituelle de ce lieu?
   correcte / trop élevée / trop basse / parfois trop chaud, parfois trop froid   21°C

2. Décrire la qualité habituelle de l'air dans cette pièce.
   correct / courants d'air / stagnant / renfermé / vicié / sec

3. Y a-t-il des odeurs qui vous dérangent à cet endroit? oui/non
   Si OUI, à quelle fréquence sentez-vous ces odeurs?
   rarement / à l'occasion / souvent / constamment
   Laquelle des odeurs suivantes y correspond le mieux?
   gaz d'échappement / fumée de diesel / chaufferie / appareil de chauffage / odeurs corporelles / moisi / produit chimique / solvant / ciment ou plâtre (humide) / poussière ou craie
   Selon-vous, qu'est-ce qui est à l'origine de l'odeur?
   ____

4. Pouvez-vous régler l'un ou l'autre des problèmes susmentionnés? Comment? oui/non

5. Y a-t-il déjà eu un «dégât d'eau» comme une inondation ou un débordement dans cette partie de l'immeuble, à cet étage ou au-dessus de celui-ci? oui/non

6. Avez-vous des antécédents d'allergies? oui/non
   Dans l'affirmative, de quel genre d'allergie s'agit-il?
   respiratoire / cutanée / alimentaire / autre
   Vos allergies empirent-elles lorsque vous vous trouvez dans cet immeuble? oui/non

7. Parmi les symptômes suivants, lesquels sont selon vous sont causés par ce bâtiment?
   maux de tête / fatigue / étourdissements / vertiges / nausées / problèmes gastriques / irritation de la peau / sécheresse des yeux / démangeaisons oculaires / larmoiements / vue brouillée / embarras de la respiration nasale / écoulement nasal / éternuements / maux de gorge / sécheresse de la gorge / problèmes thoraciques / toux / asthme

8. À quel moment de la journée les symptômes se manifestent-ils avec le plus de force?
matin / après-midi / soir / nuit / tout le temps pareil
Durant quels jours de la semaine vous plaignez-vous le plus?
la semaine / la fin de semaine / tout le temps pareil

9. Les symptômes coïncident-ils avec les activités de nettoyage ou d'entretien ou les suivent-ils? oui/non
Si OUI, décrire l'activité.

____
____
____
____

Commentaires :

____
____
____
____
____
____
____
____
____
____
____
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* Note Questionnaire to be completed during next monitoring period 1 upon return of occupant (out of the country)

VOC HOUSE QUESTIONNAIRE (Note: this questionnaire is to be filled out by the person testing the house. Answer all questions; if the answer is unknown, please state "Don't know".)

Name of House Owner or Occupier Driss El-Khatouri

Address 925 René Levesque #413

City Montreal

Postal Code ____________

Telephone ______________

House information:

1. Date that the house was completed (Year and Month) June 1996
   Date that the house was first occupied (Year and Month) June 1996

2. House floor area including basement (m^2) 90.1

3. Type of house

   - 1 story ☐
   - 1 & 1/2 story ☐
   - 2 story ☐
   - split level ☐
   - bilevel ☐
   - other (please specify) Condo

4. Type of foundation

   - slab on grade ☐
   - crawl space ☐
   - cast concrete basement ☒
   - concrete block basement ☐
   - preserved wood foundation ☐
   - other (please specify) ______________

Type of exterior finish.

- brick ☒
- aluminum siding ☐
- vinyl siding ☐
- wood siding ☐
- stucco ☐
- other (please specify) ____________________

6. Are there any unusual pollution sources within 1 kilometre of the house? (For instance, a paint factory, furniture plant, chemical factory, oil refinery, animal feed lot, etc.) Please specify.

Molson brewery

7. Do the house occupants notice any odours entering the house from exterior pollution sources? (For instance, wood smoke, exhaust from automobiles and trucks, chemical smells from factories, etc?) Please specify the type of odour, and the frequency and duration.

Type of odour ____________________

____

Frequency ____________________

Duration ____________________

8. What was the use of the land before the house was built on it?

- Agricultural ☐
- Forest ☐
- Another house ☒
- Factory site ☐
- Other (Please specify.) ____________________
- Don't know ☐

9. What was the main wood framing material used in the walls of the house?

Spruce ☐

Fir ☐

Pine ☐

Other (Please specify) Metal Stud

Don't know ☐

10. What was the main wood framing material used for the floor joists in the house?

Spruce ☐

Fir ☐

Pine ☐

Hemlock ☐

Other (Please specify) N/A

Don't know ☐

11. What type of wood or plywood was used as the subfloor?
(Note: Removal of a floor register will allow access to the subfloor and the underlay.)

Spruce ☐

Fir ☐

Pine ☐

Waferboard ☐

Other (Please specify) N/A

Don't know ☐

2. What type of material was used as the underlay?

- Particle board ☐
- Spruce plywood ☐
- Fir plywood ☐
- Waferboard ☐
- None ☐
- Other (Please specify) N/A

13. For each of the following rooms, specify the type of floor, [w]all and ceiling finish. (Please use the following code;

FLOOR:
- 1 synthetic carpet with separate foam rubber underlay
- 2 synthetic carpet with integral foam rubber underlay
- 3 wool carpet
- 4 vinyl flooring
- 5 wood flooring
- 6 unpainted concrete floor
- 7 painted concrete floor
- 8 ceramic tile or marble
- 9 other

WALL:
- 10 painted gypsum board
- 11 wallpaper on gypsum board
- 12 interior grade plywood (birch, mahogany, oak etc)
- 13 painted particle board
- 14 wood boards
- 15 other

CEILING:
- 20 painted gypsum board
- 21 stippled gypsum board
- 22 unfinished (floor joists exposed)
- 23 acoustic ceiling using glass-fibre based tiles
- 24 acoustic ceiling using wood fibre based tiles
- 25 other

	Floor	Wall	Ceiling
Living Room	1	10	20
Dining Room	1	10	20
Master Bedroom	1	10	20
Bedroom 2			
Bedroom 3			
Bedroom 4			
Bathroom 1	2	10	20
Bathroom 2			
Kitchen	4	10	20
Family room			
Recreation room	1	10	20
Laundry	4	10	20
Basement			

14. What is the material used for the structural part of the kitchen cabinets?

- Particle board ☒
- Plywood ☐
- Other(Please specify) ____________

15. What is the material used for the doors of the kitchen cabinets?

- Painted particle board ☐
- Melamine covered particle board ☒
- Solid wood ☐
- Mixture of solid wood and plywood ☐
- Other ____________

16. Is the ventilation system or ventilation components run continuously?

- Yes ☒
- No ☐
- Partial (State no of hours per day.) ________

17. What type of humidifier does the house have?

- Central humidifier on a warm air furnace ☒
- Individual room humidifiers ☐
- No humidifier ☐
- Other (Please specify)

18. What was the humidity in the house on the two occasions you were in the house? (Measure in the living room.)

(see monitored data)

First visit Relative Humidity = ________

Date = ____________

Second visit Relative Humidity = ________

Date = ____________

19. What was the temperature in the house on the two occasions you were in the house? (Measure in the living room.) (see monitored data)

First visit Temperature = ________________

Second visit Temperature = ________________

20. Do the occupants store the following in the house?

Paint ☐

Solvents ☐

Insecticides ☐

Fertilizer ☐

Paint stripper ☐

Other high volatile materials (Please specify)

____

21. Have the occupants used any of the following in the 30 day period prior to the placement of the VOC badges?

Paint inside the house ☐

Floor wax ☐

Paint stripper ☐

Insecticides ☐

Furniture polish ☐

Rug shampoo ☐

Other high volatile materials (Please specify)

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____

22. Do any of the occupants in the house smoke?

Please specify the number and the amount smoked.

Number of smokers ________

Total number of cigarettes smoked each day in the house ________

23. Is there a wood stove or fireplace in the house?

Yes ☐

No ☒

If the answer is Yes, please specify the number of times per week the wood stove or fireplace is used.
Number of times ______

24. Were there any significant renovations in the house since the house was originally completed?

Please specify ______________________________

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25. How do you (the interviewer) rate the air quality in this house?

Much worse than average ☐

Worse than average ☐

Average ☒

Better than average ☐

Much better than average ☐

Comments: ______________________________

26. Do the occupants have any comments about the air quality in their home?

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27. Are there any unique air quality aspects of the house that should be mentioned? (For instance, unusual odours, condensation stains on windows or walls, exceptionally good or bad housekeeping, hobby activities, etc.)

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28. What is the brand name and frequency of use of the following products used inside the house?

	Brand Name	Number of times used per week
Dishwasher detergent		
Floor wax		
Laundry Detergent	Tide	2
General purpose cleaner Mr. Clean, etc.)	Old Dutch / Fantastik	1-2
Hair spray		
Perfume		

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QUESTIONNAIRE PORTANT SUR LES PLAINTES DES OCCUPANTS

Quelle section de l'immeuble est l'objet du plus grand nombre de plaintes? Indiquer le numéro d'étage, de pièce ou d'appartement ou alors décrire brièvement (exemple : rez-de-chaussée, problème généralisé, etc.).

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Les réponses que vous donnerez aux questions ci-dessous s'appliqueront à cet endroit. Lorsqu'un choix est proposé, encercler la réponse convenant le mieux. Inscrire votre propre réponse aux endroits indiqués. L'espace nécessaire est fourni.

1. Quelle est la température habituelle de ce lieu?
   correcte / trop élevée / trop basse / parfois trop chaud, parfois trop froid

2. Décrire la qualité habituelle de l'air dans cette pièce.
   correct / courants d'air / stagnant / renfermé / vicié / sec

3. Y a-t-il des odeurs qui vous dérangent à cet endroit? oui/non
   Si OUI, à quelle fréquence sentez-vous ces odeurs?
   rarement / à l'occasion / souvent / constamment
   Laquelle des odeurs suivantes y correspond le mieux?
   gaz d'échappement / fumée de diesel / chaufferie / appareil de chauffage / odeurs corporelles / moisi / produit chimique / solvant / ciment ou plâtre (humide) / poussière ou craie
   Selon-vous, qu'est-ce qui est à l'origine de l'odeur?
   ____

4. Pouvez-vous régler l'un ou l'autre des problèmes susmentionnés? Comment? oui/non

5. Y a-t-il déjà eu un «dégât d'eau» comme une inondation ou un débordement dans cette partie de l'immeuble, à cet étage ou au-dessus de celui-ci? oui/non

6. Avez-vous des antécédents d'allergies? oui/non
   Dans l'affirmative, de quel genre d'allergie s'agit-il?
   respiratoire / cutanée / alimentaire / autre
   Vos allergies empirent-elles lorsque vous vous trouvez dans cet immeuble? oui/non

7. Parmi les symptômes suivants, lesquels sont selon vous sont causés par ce bâtiment?
   maux de tête / fatigue / étourdissements / vertiges / nausées / problèmes gastriques / irritation de la peau / sécheresse des yeux / démangeaisons oculaires / larmoiements / vue brouillée / embarras de la respiration nasale / écoulement nasal / éternuements / maux de gorge / sécheresse de la gorge / problèmes thoraciques / toux / asthme

8. À quel moment de la journée les symptômes se manifestent-ils avec le plus de force?
matin / après-midi / soir / nuit / tout le temps pareil
Durant quels jours de la semaine vous plaignez-vous le plus?
la semaine / la fin de semaine / tout le temps pareil

9. Les symptômes coïncident-ils avec les activités de nettoyage ou d'entretien ou les suivent-ils? oui/non
Si OUI, décrire l'activité.

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Commentaires :

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