DATALOGGING - TAKING THE GUESSWORK OUT OF BUILDING DIAGNOSTICS

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ABSTRACT

Periodic or spot check measurements of indoor air quality (IAQ) parameters leave blanks in a building data profile upon which misleading or incomplete conclusions may be made. It is difficult and unwise to make decisions regarding IAQ diagnostics and corrective actions with limited data. Datalogging fills in the blanks left by periodic measurements to complete the profile thus making it a powerful tool for good building diagnostics. This paper will focus on a discussion of the use of datalogging as an integral part of an IAQ program, on the identification of key diagnostic parameters and a discussion of data interpretation for making effective and economic IAQ decisions. Case studies will be presented comparing the differing conclusions which could be drawn from periodic measurements vs. datalogging in a building space.

INTRODUCTION

The quality of the indoor air can be affected by a variety of contaminants which makes the evaluation of IAQ problems a complex and time consuming task. Good evaluation strategies involve data collection for multiple parameters at each sampling location for an extended period of time.

Manual or periodic data collection is limited in collection frequency and number of data points by the manpower available and the time constraints of the workday. These factors tend to create large time gaps in the data collected. Time gaps in the data may influence the interpretation of the data erroneously. In addition, the evaluation strategy may be restricted . For instance, simultaneous data collection to compare complaint and non-complaint areas or multiple ventilation zones is generally not feasible with manual data collection methods.

Automated data collection or datalogging frees the investigator of the these limitations. Without the limitations of manpower or operational hours, a comprehensive data base can be developed economically and efficiently. Datalogging provides a consistent and concise data base which acts as a foundation for good diagnostic decisions. This paper intends to explore the applications for datalogging within an evaluation program and demonstrate the efficiency and economy of building diagnostics.

DIAGNOSTIC PARAMETERS

Most regulatory agencies and cognitive authorities recommend developing a proactive IAQ program to maintain a healthy building and to minimize the occurrence of IAQ problems. As a part of that program it is further recommended to identify a few diagnostic parameters to monitor building conditions. These parameters must be able to identify conditions which may be the source of or contribute to IAQ concerns. Therefore a good diagnostic parameter is one that can be measured with onsite instrumentation which reflects real-time conditions.

Degradation of building air occurs due to the presence of sources and factors that influence the sources. The potential sources of chemicals, microbiological agents and particulate in a building are too numerous to monitor individually and only one or two (carbon monoxide and ozone) can be measured with onsite real-time instrumentation. Sources alone do not degrade the air . It is the combination of sources and the influencing factors that impact building occupants. Oftentimes, understanding these factor- source relationships can help identify the source without costly direct source measurement.

The factors which influence these sources include building and interzonal pressure relationships, ventilation air volume, dilution and exhaust air volumes, thermal conditions, air exchange rates, building envelope leaks/drafts, surface dewpoint and air speed. All of these factors can be measured with direct read real-time instrumentation. Therefore, these factors are good diagnostic parameters. In addition, they are reflective of building ventilation conditions. Two United States agencies, the Environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health (NIOSH) cite poor building ventilation contributes to or is the cause of more than fifty percent of IAQ problems [1,2] .

The influencing factors can be measured and evaluated with a few simple parameters: differential pressure, carbon dioxide, temperature, relative humidity/dewpoint, air speed, carbon monoxide and particulate. Data from measuring these parameters can be used to diagnose many different building conditions which could contribute to IAQ problems. Table 1 summarizes the measurement technology and the diagnostic applications for each parameter.

Table 1 **Summary of Diagnostic Parameters**

Parameter	Sensor Technology	Diagnostic Application
Differential pressure	micromanometer with a pitot tube for some applications*	identify potential pollutant pathways and interzonal influences, leak/draft indication, measure air volume*
Carbon dioxide (CO_2)	non-dispersive infrared or electrochemical	outside mixing, HVAC lead/lag times,air change rates, in/ex filtration, dilution ventilation rate, HVAC adjustments
Temperature	resistance detectors, thermal couples	heat sources, thermal gradients, occupant comfort, HVAC operation
Relative humidity/ dewpoint	thin film capacitor	condensation points, moisture loading, HVAC operation, occupant comfort
Air speed	vane or thermal anemometer	occupant comfort, mixing rates, HVAC operation
Carbon monoxide (CO)	electrochemical	combustion sources, pressure relationships, inadequate flue exhaust, exhaust re-entrainment,
Particulate	optical counter, nephelometric or light scattering	Filtration efficiency, cleaning activities, HVAC operations, renovation activities

APPLICATIONS

Datalogging can be used in a variety of proactive as well as investigative applications. The power in datalogging is 1) the ability to monitor multiple parameters simultaneously for days or weeks at a time and 2) the ability to monitor multiple ventilation zones simultaneously to compare HVAC operation and effectiveness. Both of which are impractical and cost prohibitive to monitor manually.

Datalogging can be used to profile a building during the development of a proactive program to evaluate existing building conditions with respect to the influencing factors. This profile serves as a fingerprint for the building. Data collected throughout the program can then be compared to determine if changes in building conditions have occurred. These changes can indicate the source of or the potential for IAQ problems. The profile can also serve to identify existing conditions that contribute to poor IAQ.

For example, a change from positive to negative pressurization in a building after operational hours can cause contaminant infiltration from outside sources such as combustion or industrial processes or moisture from humidity. Datalogging differential pressure will document the time, intensity and duration of the change. The building site can then be inspected to determine if outside sources exist and action can be taken to control the pressurization or remove the source and mitigate problems from developing in the future.

Evaluation of the impact of normal building activities can efficiently be assessed by datalogging before, during and after renovation activities, HVAC adjustments and routine cleaning operations. The data logger will provide a concise picture of the changes or lack thereof due to these activities. Seasonal variations in the operation of the ventilation system as well occupant activities and density can be evaluated by comparing data collected each quarter.

One of the most important aspects of datalogging is that it provides documentation. Documentation that can be used to identify problems as well as demonstrate the existence or maintenance of good indoor air quality.

Considerations

There are some special issues that should be considered before integrating datalogging in a diagnostic program. Selection of the proper sampling instrumentation is critical to meaningful data collection. Some instrument considerations that must be addressed include power source requirements or options (battery and/or direct power), routine calibration requirements, long-term drift due to the electronics or environmental factors and the ability to secure the instrument.

Other general considerations that can affect the quality of the data collected are sampling location and amount of time necessary to obtain sufficient data for diagnostics.

Depending on the application these issues may or may not be important to collecting meaningful data. A clearly defined objective for the data will clarify many of these considerations.

CASE STUDY

The following case studies are presented to demonstrate the diagnostic capabilities of datalogging. The data presented below was collected at 5 minute intervals by a multichannel datalogger (Solomat MPM 4100). The temperature , relative humidity and CO_2 data were collected simultaneously.

Study 1

Figure 1 represents a normal building profile monitoring temperature, relative humidity and CO_2 over a seven hour period. The sensors were centrally located in the study area. The smooth data lines for temperature and relative humidity indicate consistent HVAC operation. The equilibrium CO_2 concentrations reflect an adequate outdoor air (OA) ventilation rate based on the guidelines in the American Society for Heating, Refrigeration, and Air conditioning Engineers (ASHRAE) Standard 62 , Ventilation for Acceptable Indoor Air Quality[(3)]. This guideline recommends a minimum OA ventilation rate of 15 cfm per person. Based on the calculation in Standard 62, at this ventilation rate the equilibrium CO_2 concentration would not exceed 1000 ppm (assumes an outdoor air concentration of 350 ppm) .

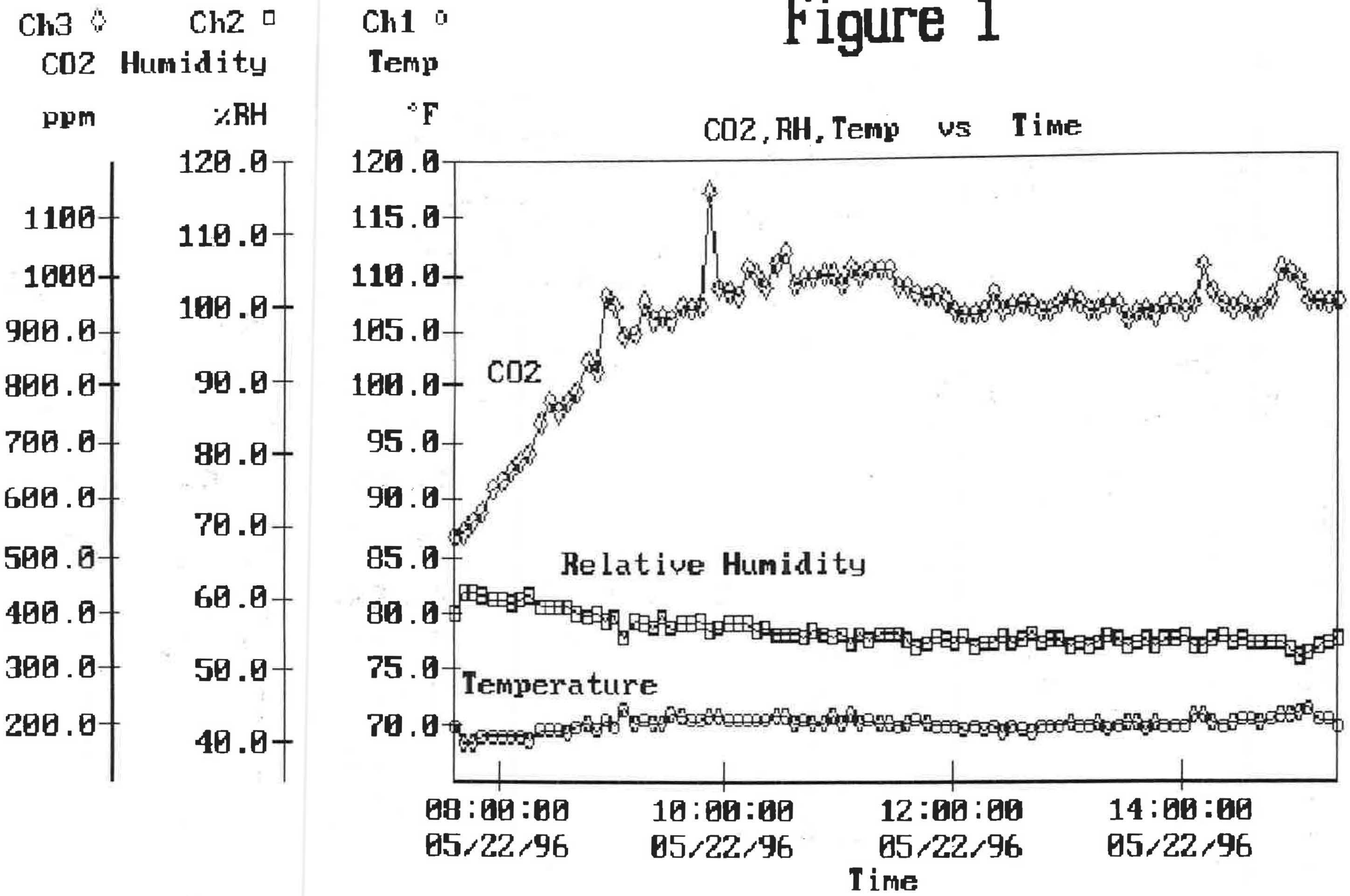
Study 2

In this study temperature, relative humidity and CO_2 were monitored for six hours. Again, the sensors were centrally located in the study area. To demonstrate the diagnostic power of datalogging, the data collected in this study will be presented in two ways, as if collected manually and as it was datalogged.
Manual data collection generally involves recording data from the same location at least every two hours. Table 2 represents the data that would have been collected in this manner. Figure 2 is a graphic representation of the data collected automatically with a datalogger.

Table 2 Summary of Data Collected at Two Hour Intervals

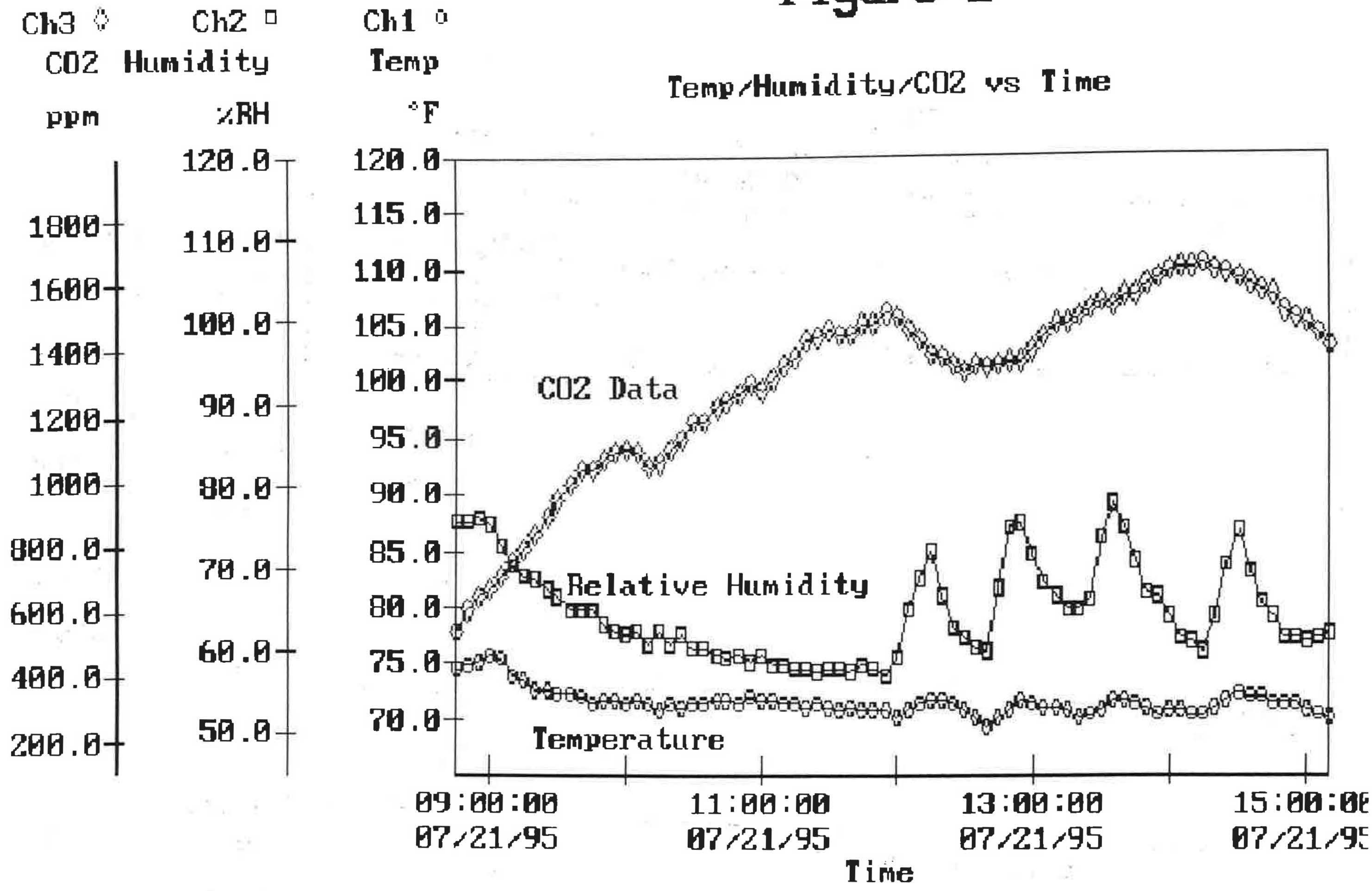
Time, hrs	0900	1100	1300	1500
Temperature, °F	75	71	71	71
Relative humidity, %	76	62	72	62
Carbon dioxide, ppm	660	1300	1435	1485

Figure 1



Ch3 ◊ CO2 ppm
Ch2 □ Humidity %RH
Ch1 ○ Temp °F
CO2,RH,Temp vs Time
1100
1000
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
85.0
80.0
75.0
70.0
CO2
Relative Humidity
Temperature
08:00:00 05/22/96
10:00:00 05/22/96
12:00:00 05/22/96
14:00:00 05/22/96
Time

Figure 2


Ch3 ◊
CO2
ppm
Ch2 □
Humidity
%RH
Ch1 ○
Temp
°F
Temp/Humidity/CO2 vs Time
1800
1600
1400
1200
1000
800.0
600.0
400.0
200.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
85.0
80.0
75.0
70.0
CO2 Data
Relative Humidity
Temperature
09:00:00
07/21/95
11:00:00
07/21/95
13:00:00
07/21/95
Time

Interpretation of Table 2 Based on the data in the table, it appears that the HVAC system is controlling temperature consistently. Twice the relative humidity exceeded the ASHRAE recommended guidelines for occupant comfort and the minimization for microbiological growth [4,5].The inconsistency in the relative humidity data may be due to an instrument or sensor out of calibration, instrument response error, user error, or a condition exists in the study space that needs further evaluation to determine the reason. The CO_2 data indicates that equilibrium was achieved in the space by 1300 hrs (accuracy of the sensor is $\pm$ 50 ppm). According to Standard 62, this equilibrium level indicates that the OA ventilation rate is a less than recommended 15 cfm per person.

Interpretation of Figure 2 The temperature data again indicates that the HVAC system is controlling on and maintaining temperature consistently. The fluctuations in the relative humidity data are easily diagnosed in this data set. The large changes in relative humidity correspond to the small changes in temperature. From this data, it is clear that the HVAC system is short- cycling, turning on and off frequently. This commonly occurs when a system has been oversized for a space. The result is under ventilation of the space. The CO_2 data also supports this conclusion. The CO_2 data clearly shows that equilibrium was not achieved in the space before the occupants began to leave. Not reaching equilibrium indicates that a space is *significantly* underventilated.

The data representing manual collection (Table 2) is inconclusive and requires further study before diagnosis can be made. However, a good diagnosis can be made with the data collected in the same period of time by the datalogger.

CONCLUSIONS

Datalogging can be an cost effective, efficient tool for building diagnostics. It allows the simultaneous data collection of multiple parameters which provides a more complete data picture of building dynamics than is practical for manual data collection. A comprehensive database takes the guesswork out of building diagnostics.

REFERENCES

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