

Summary of Monitoring Results
USGBC 2003 Greenbuild Conference
Pittsburgh, Pennsylvania

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1.0 Introduction

This document presents a summary of the monitoring results performed by AIRxpert Systems, Inc., in Exhibit Hall A of the David L. Lawrence Convention Center at the Greenbuild Conference in Pittsburgh, Pennsylvania in November of 2003. In accordance with LEED[®] IEQ Credit 1, carbon dioxide (CO₂) monitoring was performed to assess whether indoor concentrations were no more than 530 ppm higher than outdoor concentrations during occupied intervals.

2.0 Procedures

CO₂ measurements were performed in the Exhibit Hall using the shared-sensor monitoring approach. In this approach a network of air sampling lines was installed to transport air from various locations in the hall back to one location at the AIRxpert Systems booth (#310) for analysis with an MSA Model 3600 CO₂ sensor. This sensor was recalibrated at the beginning of this evaluation interval at 6:00 p.m. on the evening of Monday, November 10, 2003. This calibration involved both a span value of 1300 ppm of CO₂ and a zero value for CO₂ using pure nitrogen. A calibration check at 2:00 PM on Thursday, November 13, indicated that the unit had not drifted out of calibration.

The shared-sensor approach to monitoring, which provides increased accuracy and ease of calibration over the monitoring approach using distributed individual sensors, offers the option of monitoring several parameters simultaneously. Monitoring for carbon monoxide (CO) concentrations and dew point temperatures (absolute humidity) was therefore also performed and documented. An Armstrong Monitoring Model AMC-2701 carbon monoxide sensor and an EdgeTech Model 200 chilled-mirror hygrometer were used for this study.

The network of air sampling locations included a grid of nine breathing height locations, two elevated locations, and one outdoor air location. The nine breathing height locations included a north, central, and south location along both the eastern and western sides of the Exhibit Hall as well as three more central locations. The two elevated locations included one at the mezzanine level along the east wall and one at 20 feet above booth #310. The outdoor air location was situated across from the southeast corner of the Exhibit Hall and was situated about eight feet from the Exhibit Hall wall.

3.0 Results from Carbon Dioxide Monitoring

The results from the CO₂ monitoring reflect the activities in the Exhibit Hall as well as the meteorological conditions outdoors. During the early morning hours, the indoor concentrations closely agreed with the outdoor concentrations. This can be seen in Figure 1. These outdoor air CO₂ concentrations were typically read at around 500 ppm, reflective of urban conditions in a valley during low wind conditions. When the outdoor wind speeds increased significantly on Thursday morning, this increased meteorological dispersion reduced the outdoor concentrations closer to 400 ppm. This demonstrated variation in the outdoor air concentration of CO₂ documents the importance of measuring this important value. The ventilation rate is, after all, a function of the difference between the indoor and outdoor concentrations.

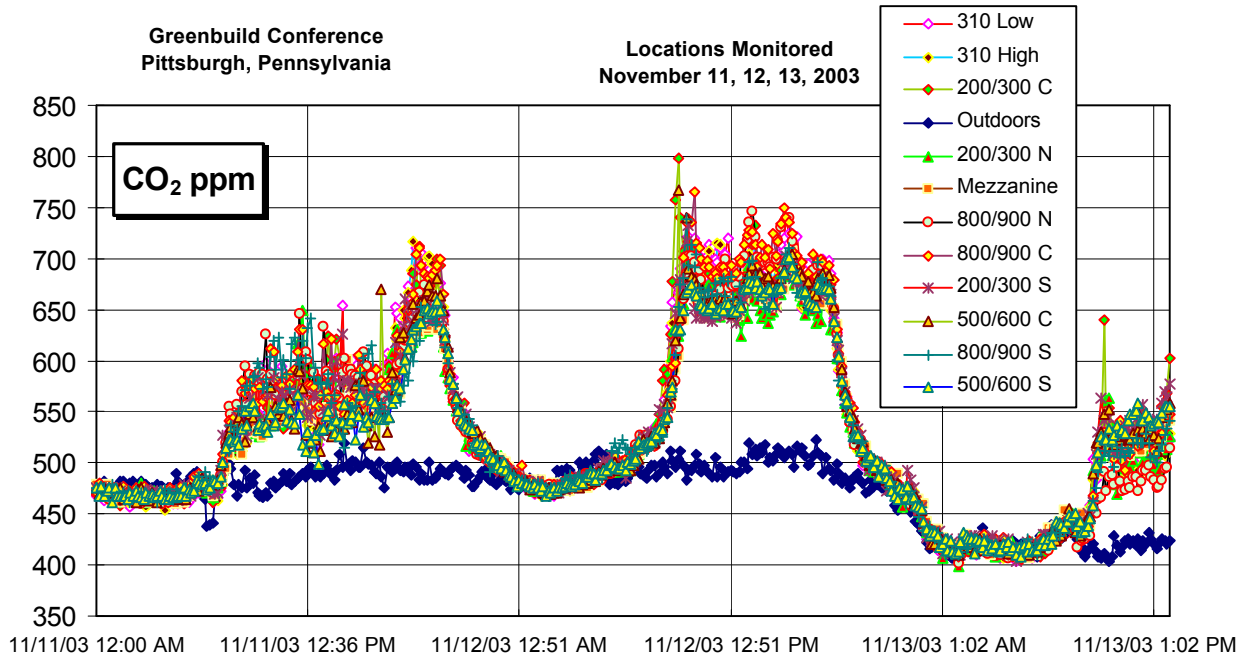


Figure 1. Carbon Dioxide Monitoring Results

Increases in the indoor CO₂ concentrations can be observed on the morning of Tuesday, November 11, 2003 during the set-up of the hall. Sources of CO₂ included both the combustion-powered equipment in use in the hall (i.e., fork-lift trucks) and the exhibitors themselves. The ventilation provided by the operating air handling units (AHUs) were supplemented during this interval by the natural ventilation occurring due to the opened overhead doors to the loading dock, which was open to the outdoors

The Exhibit Hall CO₂ concentrations increased further during the Opening Reception beginning at 5:30 p.m. on Tuesday, November 11. Here the indoor levels, at about 700 ppm, achieved a differential of about 200 ppm over the outdoor concentration of about 500 ppm. This differential of 200 ppm corresponds to a ventilation rate of around 50 cubic feet per minute (cfm) per person.

On Wednesday, the results were similar to those of the Tuesday night Opening Reception, with an effective ventilation rate of about 50 cfm per person during the occupied intervals through the day.

On Thursday, the results indicated a significant increase in the amount of ventilation, which rose to around 75 cfm per person. While this result could have been attributed to a decrease in the number of people in the Exhibit Hall, it is more likely attributed to the increase in the amount of natural ventilation occurring. This was also the morning when the 2004 Toyota Prius was awarded and therefore a lot of people were present.

The decrease in the outdoor air temperature, coupled with the increase in the local wind speed, very likely affected the natural ventilation in this hall. This uncontrolled natural ventilation would also be a function of the fact that the building envelope has yet to be sealed, especially along the top edge of the east wall. Since the area of the top opening is fixed, the amount of natural ventilation occurring would be a function of the indoor to outdoor temperature difference, the wind speed and direction, and the lower level openings between the Exhibit Hall and the outdoors. On Thursday, the indoor to

outdoor temperature difference and the wind speed significantly increased over the conditions present on Wednesday.

The significant increase in the local wind speeds that began on Wednesday evening also diluted outdoor CO₂ levels. On Wednesday afternoon, the outdoor CO₂ concentrations were in excess of 500 ppm and on Thursday they were noticeably lower at around 420 ppm.

4.0 Additional Monitoring Results

Taking advantage of the shared-sensor option for measuring other IAQ parameters besides CO₂, this monitoring effort also documented the levels of CO and absolute humidity in the Exhibit Hall and outdoors.

The only time the CO indoor measurements were consistently above zero was during the setup of the Exhibit Hall on Tuesday. This can be explained by the presence of the numerous combustion-powered equipment that included forklift trucks and aerial lifts. While peaks of CO were measured, as can be observed in Figure 2, these concentrations were rapidly reduced by the generous amounts of ventilation provided at this time. There were also short-term peaks in CO measured in the outdoor air, presumably from passing diesel engines on the nearby trains.

This monitoring effort could be interpreted to relate to LEED IEQ Credit 5: Indoor Chemical Pollutant Source Control. That is, combustion powered forklifts which generate CO have the potential to expose the building occupants to a potentially hazardous chemical that could negatively impact indoor air quality. While the generous ventilation rates prevented the accumulation of CO in this instance, future consideration might be given to electric forklifts that do not generate CO.

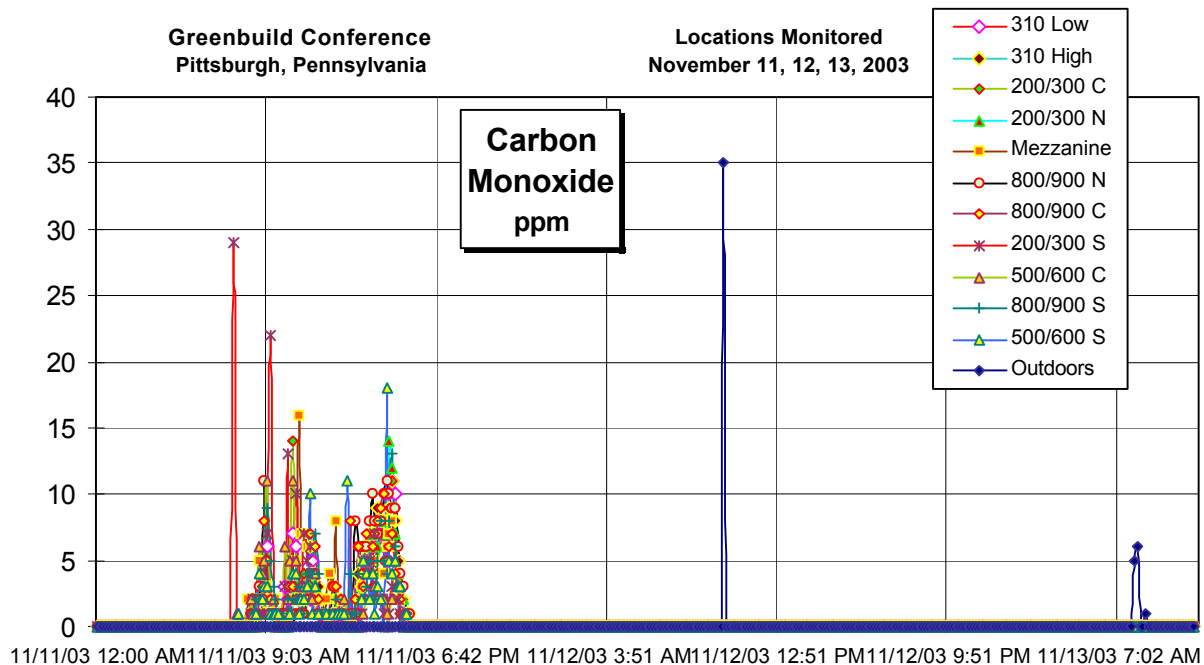


Figure 2. Carbon monoxide monitoring results

The absolute humidity monitoring results display how the rapidly changing outdoor humidity was quickly reflected indoors. This rapid communication with the outdoors reflects the fact that the

building envelope is unfinished and numerous openings still exist between the indoors and outdoors, especially along the top of the east wall. Weather conditions varied tremendously over this short monitoring interval. Cold temperatures and a dew point of 31°F were recorded overnight between Monday and Tuesday. Outdoors conditions increased to a dew point of 57°F while temperatures rose above 60°F by Wednesday afternoon. Cold conditions returned dramatically Wednesday night, resulting in dew point temperatures below as 25°F on Thursday. These changes in outdoor and indoor dew points are displayed in Figure 3.

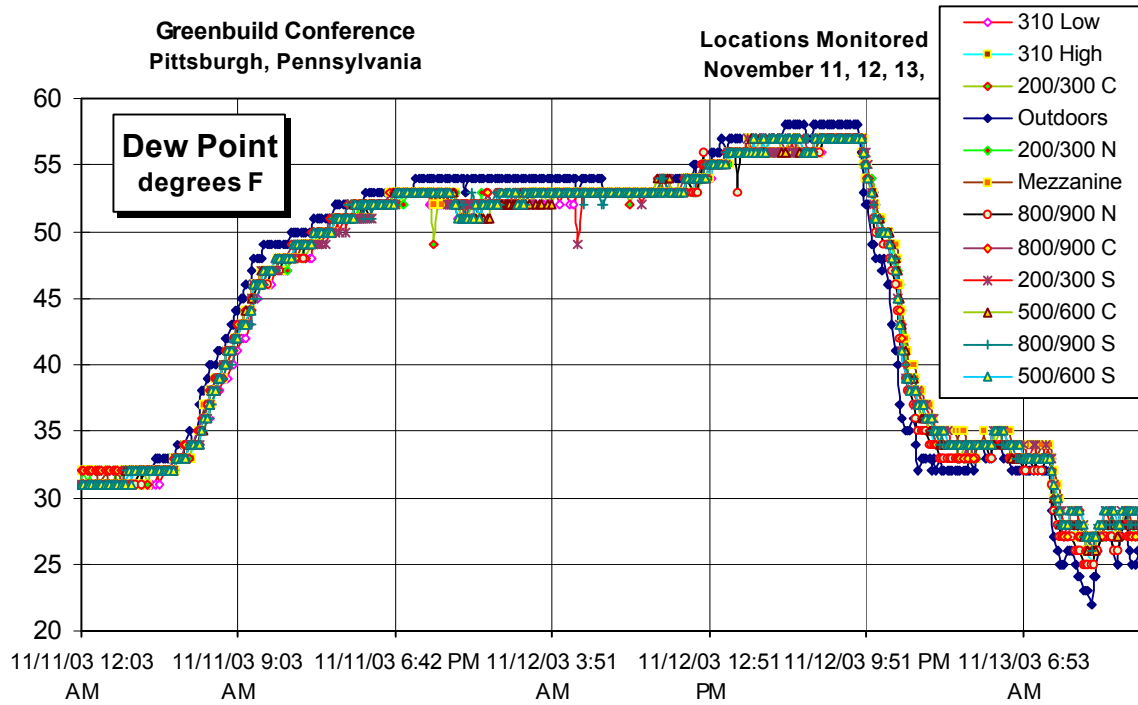


Figure 3. Absolute humidity (dew point) monitoring results

5.0 Conclusions

Based on the maximum difference between indoor and outdoor CO₂ concentrations, a ventilation rate of approximately 50 cubic feet per minute (cfm) per person of outdoor air was provided during intervals of peak occupancy in this Exhibit Hall. This ventilation rate is significantly in excess of the 20 cfm per person minimum recommended in ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality. While a specific category of exhibit halls was not listed, this minimum of 20 cfm per person is listed for the conference rooms, office spaces, and lobbies of theaters.

6.0 Recommendations

In view of the fact that the generous ventilation rate documented partially depended on the unfinished building envelope around the exhibit hall, it is suggested that the carbon dioxide concentrations in this exhibit hall be reviewed during this hall's use during the winter a year from now when the building envelope details have been completed.