FINAL REPORT NCEMBT-090921

STATISTICAL ANALYSIS AND INTERPRETATION OF BUILDING CHARACTERIZATION, INDOOR ENVIRONMENTAL QUALITY MONITORING AND ENERGY USAGE DATA FROM OFFICE BUILDINGS AND CLASSROOMS IN THE UNITED STATES

SEPTEMBER 2009

Linda D. Stetzenbach, Ph.D. and Lauren Nemnich, M.A.
University of Nevada Las Vegas

Davor Novosel
National Center for Energy Management and Building Technologies

FOR ENERGY MANAGEMENT

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NATIONAL CENTER FOR ENERGY MANAGEMENT AND BUILDING TECHNOLOGIES TASK 08-01: STATISTICAL ANALYSIS AND INTERPRETATION OF BUILDING CHARACTERIZATION, INDOOR ENVIRONMENTAL QUALITY MONITORING AND ENERGY USAGE DATA FROM OFFICE BUILDINGS AND CLASSROOMS IN THE UNITED STATES

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Prepared By:

Linda D. Stetzenbach, Ph.D. and Lauren Nemnich, M.A.
University of Nevada Las Vegas

Davor Novosel
National Center for Energy Management and Building Technologies

Prepared For:

U.S. Department of Energy
Rob Martinez
Project Officer

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NOTICE

UNIVERSITY OF NEVADA, LAS VEGAS, CONTACT

Linda D. Stetzenbach, Ph.D.
Professor, Department of Environmental and Occupational Health
School of Public Health
University of Nevada, Las Vegas
4505 South Maryland Parkway
Las Vegas, NV 89154-4009
(702) 895-5509
linda.stetzenbach@unlv.edu

NATIONAL CENTER FOR ENERGY MANAGEMENT AND BUILDING TECHNOLOGIES CONTACT

Davor Novosel
Chief Technology Officer
National Center for Energy Management and Building Technologies
601 North Fairfax Street, Suite 250
Alexandria VA 22314
703-299-5633
dnovosel@ncembt.org
www.ncembt.org

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EXECUTIVE SUMMARY

Three independent tasks had been performed (Stetzenbach 2008, Stetzenbach 2008b, Stetzenbach 2009) to measure a variety of parameters in normative buildings across the United States. For each of these tasks 10 buildings were selected as normative indoor environments. Task 1 focused on office buildings, Task 13 focused on public schools, and Task 0606 focused on high performance buildings. To perform this task it was necessary to restructure the database for the Indoor Environmental Quality (IEQ) data and the Sound measurement as several issues were identified and resolved prior to and during the transfer of these data sets into SPSS. During overview discussions with the statistician utilized in this task it was determined that because the selection of indoor zones (1-6) was independently selected within each task; zones were not related by location across tasks. Therefore, no comparison would be valid across zones for the 30 buildings so the by location (zone) data were limited to three analysis sets of the buildings within each task. In addition, differences in collection procedures for lighting were used in Task 0606 as compared to Tasks 01 & 13 to improve sample collection. Therefore, these data sets could not be merged and compared so effects by-day data were run separately for Task 0606 and only Task 01 & 13 data were merged.

Results of the statistical analysis of the IEQ parameters show statistically significant differences were found among days and zones for all tasks, although no differences were found by-day for Draft Rate data from Task 0606 ($p>0.05$). Thursday measurements of IEQ parameters were significantly different from Tuesday, and most Wednesday measures for all variables of Tasks 1 & 13. Data for all three days appeared to vary for Operative Temperature, whereas only Tuesday and Thursday differed for Draft Rate 1m. Although no Draft Rate measures within Task 0606 were found to significantly differ by-day, Temperature measurements for Tuesday and Thursday showed variation. Moreover, Wednesday measurements of Relative Humidity within Task 0606 varied significantly from either Tuesday or Thursday. The majority of differences in IEQ measurements by-zone were highly significant ($p<0.001$), with the exception of Relative Humidity in some buildings.

When all task data were combined (30 buildings) neither the airborne culturable fungi nor the airborne non-culturable spore data differed in the concentrations found at any indoor location in terms of day of collection. However, the concentrations of surface-associated fungi varied among the day of collection. Specifically, there was a lower concentration of mold on Tuesday than on Wednesday, for all tasks combined. As expected, variation was found in the concentrations of both airborne culturable fungi and airborne non-culturable fungal spores between indoor zones (1-6) and the outdoor zone (zone 0). No variation was found among the indoor zones of office buildings for Task 1 in the concentrations of airborne culturable fungi. However, airborne non-culturable spores did vary among zones in one building in Task 1 and variation was noted between zones in surface-associated fungi.

Due to the lack of multiple lighting measurements for Tasks 13 and 0606, by-day comparisons were only performed for Task 1. No statistical differences were observed in lighting with respect to the day of collection. There was a wide range of variability by-zone among seven of the office buildings. Although few differences were found for the brightest illumination of the worksurface (IllumWkSfcBrtst) and the darkest illumination of the worksurface (IllumWkSfcDrkst) in Task 1, there was considerable variation for these variables in Task 13 and Task 0606 ($p < 0.001$). Other variables that differed by-zone in Task 13 include CombCCT and AmbCCT1 for S03, S07, and S08. Additionally, AmbChromX1, CombChromY, and CombChromX varied by-zone for school buildings S02, S04, and S05, respectively.

Although all tasks demonstrated significant differences in sound measurements by zone, some of the buildings within each task did not appear to differ in sound quality. Hence, post-hoc tests were not appropriate and individual zones were not compared for these buildings. It is interesting to note that sound measurements in some buildings were widely varied with most zone comparisons and other buildings varied between only a few zones.

1. PROJECT OBJECTIVE

This research effort focused on statistical analysis and interpretation of the previously collected data under NCEMBT Task 1, 13 and 06-06. This task also included compiling information that was not collected during the monitoring of the previous buildings (e.g., additional building characterization and energy usage), and refining the NCEMBT database capabilities to result in a readily searchable/data mining resource for researchers interested in minimizing energy usage while providing quality indoor environments for occupants. The goals of this task included providing statistical interpretation of the existing NCEMBT-sponsored monitoring data to provide new understanding of the relationship of indoor environmental quality parameters to energy usage and building characteristics, and provide additional information from the building managers/facilities personnel regarding energy usage and building characteristics not obtained during the monitoring projects. Comparison and correlation of the data, and interpretation of the results were vetted through an expert advisory board. The results of this project will be made available for downloading from the Building Sciences Database on NCEMBT's website at www.ncembt.org.

2. BACKGROUND

Three previous studies (Task 1, Measurement and Verification of Building Performance Characteristics; Task 13, Building Performance Characterization, Energy Usage, and Indoor Environmental Quality in Educational Facilities; and Task 06-06, Energy Performance and Environmental Characteristics of High Performance Buildings) were sponsored by the National Center for Energy Management and Building Technologies (NCEMBT) under DOE award DE-FC26-03GO13072. These three tasks provided data in typical office buildings, schools, and high performance buildings and some energy consumption data. The data included thermal comfort (i.e., temperature, relative humidity, and draft), carbon dioxide (CO_2), volatile organic compounds (VOCs), sound, lighting, and airborne and surface-associated mold. All buildings were selected based on building design and construction characteristics as determined by a series of screening questions answered by the buildings districts' facilities department personnel. This included the physical characteristics of the building, the age of structure, its geographical location, and type of mechanical air handling system. In each building six indoor areas (zones/locations) were selected that were representative of the building's configuration. Measurement instrumentation was located in each of the six indoor zones. Additionally, an outdoor location at each building was selected as a control site for some of the measurements. Separate reports have been submitted presenting the data from the three independent surveys, but the number of buildings in each survey was limited to 10 by the US DOE. The study objective for this task was to combine data from the 30 buildings which would permit raising the number of measurements and increase the power of the statistical analysis. Therefore, this task was conducted to investigate whether there were differences among days of data collection (Tuesday, Wednesday, or Thursday) and/or differences in the variables of interest among the zones for each building (zones 0-6, with 0 = outdoor measure) within each task.

3. STATISTICAL ANALYSIS AND RESULTS

This task was focused on sophisticated statistical analysis of the measurement data (i.e., thermal comfort [temperature, relative humidity, and draft], carbon dioxide [CO_2], volatile organic compounds [VOCs], sound, lighting, and airborne and surface-associated mold) from the 30 buildings. Previous analysis was limited to three separate clusters of 10 buildings each. It was envisioned that the results from the 30 buildings would strengthen statistical power of the dataset. Specific statistical methods used for the analysis were determined during the task but were focused on *i*) descriptive statistics used to determine demographic characteristics both within and between the thirty buildings, *ii)* homogeneity between building characteristics tested using the chi-squared test for independence, *iii*) differences in continuous outcome measures such as IEQ measurements and energy usage between buildings using analysis of variance (ANOVA) with post hoc tests where applicable, and *iv*) relationships between continuous measurements using Spearman's and/or Pearson's correlation coefficients proving a measure of agreement. In addition, transformation or nonparametric techniques were applied as needed following testing for normality of the data. No VOC measurements were positive. Therefore, these data were not subjected to statistical analysis

3.1 Enhanced Collection of Energy and Building Characterization Data

During the previous three tasks building characteristic data were collected from the building facilities managers. However, gaps in building information were found by task advisors Dr. James Woods and Mr. Richard Switzer. Therefore, this task included a component to increase the information from some of the 30 monitored buildings concerning building characteristics not included in the original data collection. Additional data submitted by the facilities managers were entered into the database as they were received.

3.2 IEQ

Prior to conducting statistical comparisons, it was noted that differences in collection procedures for some IEQ measurements were used for Task 0606 as compared to Tasks 1 & 13. Therefore, these data sets could not be merged and compared. Therefore, effects by-day data were run separately for Task 0606 but Tasks 1 & 13 data were merged. Additionally, it was determined that IEQ Draft Rates in all tasks were non-normally distributed and required non-parametric testing. Hence, all Draft Rate data were analyzed via rank order for both tests by-day and by-zone. Statistical tests were conducted for each of the following different measures: operative temperature (OpTemp) for Tasks 1 & 13 and room temperature (Temp) for Task 0606; Relative humidity (RelHumidity); and Draft Rates at 0.1m, 0.6m, and 1.1m (DraftRate0_1m, DraftRate0_6m, DraftRate1_1m, respectively).

Univariate analysis of variance (ANOVA) was used to determine the presence or absence of a main effect among the three days or the seven zones. If a main effect was observed, post-hoc analysis was performed to determine which specific days or zones differed through either Bonferroni's test or Dunnett's T3 test for assumption of equal variance or unequal variance, respectively. As shown in the following tables (Table 1-32), significant differences were found among days and zones for all tasks, although no differences ($p \geq 0.05$) were found by-day for Draft Rate data from Task 0606.

Table 1. Explanation of Parameters Used in Tables 2-32

Parameter Name in Tables 2 through 32	Parameter Meaning	Unit
Temp	Dry bulb air temperature at 0.6 m above the floor	°C
OpTemp	Operative Temperature measured at 0.6 m above the floor	°C
RelHumidity	Relative Humidity measured at 0.6 m above the floor	%
DraftRatex_ym	Draft rate measured at three heights, i.e. 0.1 m, 0.6 m and 1.1 m above the floor.	fpm

Table 2. All tasks IEQ findings by-day

Task 01 & 13					
Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
	(df = 2, 6168)	(df = 2, 6291)	(df = 2, 6135)	(df = 2, 6189)	(df = 2, 5869)
Main Effect	F = 22.409; p<0.001	F = 14.583; p<0.001	F = 7.471; p<0.05	F = 7.854; p<0.001	F = 10.312; p<0.001
Tue vs. Wed	p<0.05	n.s.	n.s.	n.s.	n.s.
Wed vs. Thu	p<0.001	p<0.001	n.s.	p<0.05	p<0.001
Tue vs. Thu	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
*RelHumidity & Draft Rate 1_1m Post-Hoc via Dunnett T3; OpTemp & DraftRate0_1m via Bonferroni					
*Draft Rates ranked prior to analysis for non-parametric measures					
Task 06-06					
Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
	(df = 2, 2796)	(df = 2, 2796)	(df = 2, 2406)	(df = 2, 2297)	(df = 2, 2370)
Main Effect	F = 6.443; p<0.01	F = 9.250; p<0.001	n.s.	n.s.	n.s.
Tue vs. Wed	n.s.	p<0.01			
Wed vs. Thu	n.s.	p<0.001			
Tue vs. Thu	p<0.01	n.s.			
*RelHumidity Post-Hoc via Dunnett T3; Temp via Bonferroni					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 3. Task 01 Bldg 001 IEQ by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 43.504; p<0.001	F = 2.694; p=0.021	F = 213.518; p<0.001	F = 100.472; p<0.001	F = 54.583; p<0.001
1v2	p<0.001		p<0.001		p<0.001
1v3	p<0.001		p<0.001		p<0.001
1v4	p<0.001		p<0.001	p<0.001	p=0.013
1v5	p<0.001		p<0.001	p<0.001	p<0.001
1v6	p=0.028		p<0.001	p<0.001	p<0.001
2v3	p<0.001		p=0.014		
2v4	p<0.001			p<0.001	p<0.001
2v5			p<0.001	p<0.001	
2v6			p<0.001	p<0.001	
3v4				p<0.001	p<0.001
3v5	p<0.001		p<0.001	p<0.001	
3v6	p<0.001		p<0.001	p<0.001	p<0.001
4v5	p<0.001		p<0.001	p<0.001	p<0.001
4v6	p<0.001		p<0.001	p<0.001	p<0.001
5v6			p<0.001		p<0.001
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 4. Task 01 Bldg 002 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 105.332; p<0.001	n.s.	F = 150.267; p<0.001	F = 77.790; p<0.001	F = 113.511; p<0.001
1v2	p<0.001				p<0.001
1v3	p<0.001		p<0.001	p=0.002	p<0.001
1v4			p<0.001	p<0.001	p<0.001
1v5	p=0.002		p=0.012	p=0.046	p<0.001
1v6	p<0.001		p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p<0.001		p=0.001		p<0.001
2v6	p<0.001		p<0.001	p=0.041	
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5			p<0.001	p<0.001	p<0.001
3v6	p<0.001		p<0.001	p<0.001	
4v5	p<0.001		p<0.001	p<0.001	p<0.001
4v6	p<0.001		p<0.001	p<0.001	p<0.001
5v6			p<0.001		p=0.003
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 5. Task 01 Bldg 003 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 451.604; p<0.001	n.s.	F = 98.685; p<0.001	F = 123.225; p<0.001	F = 84.119; p<0.001
1v2	p<0.001		p<0.001	p<0.001	p<0.001
1v3	p<0.001		p<0.001	p<0.001	p<0.001
1v4	p<0.001			p<0.001	p<0.001
1v5	p<0.001		p=0.015	p<0.001	p<0.001
1v6	p<0.001		p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	p<0.001
2v4			p=0.007	p=0.010	
2v5	p<0.001			p<0.001	p<0.001
2v6	p<0.001		p<0.001	p<0.001	p<0.001
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5	p<0.001		p<0.001	p<0.001	p<0.001
3v6	p<0.001				p<0.001
4v5	p<0.001				p<0.001
4v6	p<0.001		p<0.001	p<0.001	p=0.001
5v6	p<0.001		p<0.001	p<0.001	
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 6. Task 01 Bldg 004 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 178.039; p<0.001	F = 6.067; p<0.001	F = 114.979; p<0.001	F = 136.255; p<0.001	F = 70.797; p<0.001
1v2	p<0.001	p=0.001	p<0.001	p<0.001	p<0.001
1v3	p<0.001		p<0.001	p<0.001	p<0.001
1v4	p<0.001			p<0.001	p=0.002
1v5	p<0.001		p=0.011	p=0.006	p=0.001
1v6	p<0.001		p<0.001		
2v3	p<0.001			p<0.001	p<0.001
2v4	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v5	p<0.001		p<0.001	p<0.001	p<0.001
2v6	p<0.001		p<0.001	p<0.001	p<0.001
3v4	p<0.001		p<0.001	p<0.001	
3v5	p=0.002		p<0.001	p<0.001	p<0.001
3v6			p<0.001	p<0.001	p<0.001
4v5	p<0.001	p=0.021		p<0.001	p<0.001
4v6	p=0.001		p=0.004	p<0.001	p=0.006
5v6	p<0.001				
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 7. Task 01 Bldg 005 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 120.036; p<0.001	F = 180.962; p<0.001	F = 112.362; p<0.001	F = 114.662; p<0.001	F = 66.338; p<0.001
1v2	p<0.001	p<0.001	p<0.001	p<0.001	p=0.012
1v3	p<0.001	p<0.001	p<0.001	p<0.001	p=0.006
1v4	p<0.001	p<0.001	p<0.001		p=0.004
1v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v3	p<0.001			p<0.001	p<0.001
2v4	p<0.001	p<0.001			
2v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v4	p<0.001	p<0.001		p<0.001	p<0.001
3v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v6	p<0.001	p<0.001	p<0.001		p=0.031
4v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
4v6			p<0.001	p<0.001	p<0.001
5v6	p<0.001	p=0.001	p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 8. Task 01 Bldg 006 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 18.646; p<0.001	F = 11.340; p<0.001	F = 255.748; p<0.001	F = 317.352; p<0.001	F = 268.340; p<0.001
1v2	p<0.001		p<0.001	p<0.001	p=0.001
1v3	p=0.020	p<0.001	p=0.001	p<0.001	p<0.001
1v4	p<0.001		p<0.001	p<0.001	p<0.001
1v5			p<0.001	p=0.025	p<0.001
1v6		p=0.002	p=0.009	p<0.001	p<0.001
2v3	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v4	p=0.019			p<0.001	p<0.001
2v5	p<0.001		p<0.001	p<0.001	
2v6		p=0.006	p<0.001	p<0.001	p<0.001
3v4	p<0.001	p<0.001	p<0.001	p<0.001	
3v5	p<0.001	p=0.016	p<0.001	p<0.001	p<0.001
3v6				p<0.001	p<0.001
4v5	p<0.001		p<0.001	p<0.001	p<0.001
4v6		p=0.039	p<0.001	p<0.001	p<0.001
5v6			p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 9. Task 01 Bldg 007 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 54.496; p<0.001	F = 14.160; p<0.001	F = 115.061; p<0.001	F = 120.424; p<0.001	F = 129.094; p<0.001
1v2	p<0.001	p=0.031	p<0.001	p<0.001	p<0.001
1v3		p<0.001	p<0.001	p<0.001	p<0.001
1v4	p<0.001		p<0.001	p<0.001	p<0.001
1v5			p<0.001	p<0.001	p<0.001
1v6	p<0.001	p=0.007	p<0.001	p<0.001	p<0.001
2v3	p<0.001	p<0.001		p<0.001	p=0.001
2v4	p=0.014	p=0.006	p<0.001	p<0.001	p<0.001
2v5	p=0.001	p=0.001	p<0.001		p<0.001
2v6		p<0.001		p<0.001	p<0.001
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5		p=0.031	p<0.001	p<0.001	p<0.001
3v6	p<0.001				p<0.001
4v5	p<0.001			p<0.001	
4v6	p<0.001		p<0.001	p<0.001	p<0.001
5v6	p<0.001		p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 10. Task 01 Bldg 008 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 339.069; p<0.001	F = 6.090; p<0.001	F = 79.227; p<0.001	F = 65.801; p<0.001	F = 80.260; p<0.001
1v2	p<0.001			p<0.001	
1v3			excluded		Excluded
1v4			p<0.001	p<0.001	p<0.001
1v5	p<0.001	p=0.023	p<0.001		
1v6	p<0.001		p<0.001	p<0.001	p<0.001
2v3	p<0.001		excluded	p<0.001	Excluded
2v4	p<0.001		p<0.001	p=0.006	p<0.001
2v5	p<0.001	p<0.001	p<0.001	p<0.001	
2v6	p<0.001	p=0.011	p<0.001	p<0.001	p<0.001
3v4			excluded	p<0.001	Excluded
3v5	p<0.001	p=0.008	excluded		Excluded
3v6	p<0.001		excluded	p<0.001	excluded
4v5	p<0.001	p=0.009	p<0.001	p<0.001	p<0.001
4v6	p<0.001				
5v6	p<0.001		p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 11. Task 01 Bldg 009 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 19.530; p<0.001	n.s.	F = 166.519; p<0.001	F = 100.600; p<0.001	F = 57.698; p<0.001
1v2	p<0.001		p<0.001	p<0.001	p<0.001
1v3			p<0.001	p<0.001	excluded
1v4				p<0.001	p<0.001
1v5				p<0.001	p<0.001
1v6	p=0.001		p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	excluded
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p<0.001		p<0.001	p<0.001	p<0.001
2v6				p=0.003	p=0.007
3v4			p<0.001		excluded
3v5			p<0.001		excluded
3v6	p=0.001		p<0.001	p<0.001	excluded
4v5					
4v6	p<0.001		p<0.001	p<0.001	p=0.007
5v6	p=0.002		p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 12. Task 01 Bldg 010 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 120.333; p<0.001	F = 3.939; p=0.002	F = 251.987; p<0.001	F = 238.407; p<0.001	F = 163.735; p<0.001
1v2	p<0.001			p=0.003	
1v3	p<0.001	p=0.009	p<0.001	p<0.001	excluded
1v4	p<0.001	p=0.004	p<0.001	p<0.001	p<0.001
1v5	p<0.001		p<0.001	p<0.001	p<0.001
1v6		p=0.018	p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	excluded
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p<0.001		p<0.001	p<0.001	p<0.001
2v6	p=0.018		p<0.001	p<0.001	p<0.001
3v4	p=0.008		p<0.001	p<0.001	excluded
3v5	p<0.001		p<0.001	p<0.001	excluded
3v6	p<0.001		p<0.001	p=0.017	excluded
4v5			p<0.001	p<0.001	p<0.001
4v6	p<0.001		p=0.003		
5v6	p<0.001		p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 13. Task 13 Bldg S01 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 144.489; p<0.001	n.s.	F = 32.315; p<0.001	F = 127.300; p<0.001	F = 123.314; p<0.001
1v2	p<0.001			p<0.001	p<0.001
1v3	p<0.001		p=0.030	p<0.001	p<0.001
1v4	p<0.001		p<0.001	p<0.001	p<0.001
1v5	p<0.001				
1v6					
2v3	p<0.001				p<0.001
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p<0.001			p<0.001	p<0.001
2v6	p<0.001		p=0.022	p<0.001	p<0.001
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5	p<0.001			p<0.001	p<0.001
3v6	p<0.001		p=0.009	p<0.001	p<0.001
4v5	p=0.019		p<0.001	p<0.001	p<0.001
4v6			p<0.001	p<0.001	p<0.001
5v6	p<0.001				
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 14. Task 13 Bldg S02 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 322.011; p<0.001	F = 10.632; p<0.001	F = 107.348; p<0.001	F = 68.678; p<0.001	F = 35.805; p<0.001
1v2	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v3	p<0.001		p<0.001	p<0.001	
1v4	p<0.001	p=0.004	p<0.001		p<0.001
1v5	p<0.001		p<0.001		p<0.001
1v6	p<0.001	p<0.001	p<0.001	p<0.001	
2v3	p<0.001	p=0.002		p<0.001	p=0.001
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p<0.001	p=0.003	p<0.001	p<0.001	p<0.001
2v6	p<0.001		p<0.001		p<0.001
3v4	p<0.001		p<0.001	p=0.031	p<0.001
3v5	p<0.001		p<0.001	p<0.001	p<0.001
3v6	p<0.001	p=0.012	p<0.001	p<0.001	
4v5	p<0.001		p=0.014		
4v6	p<0.001		p<0.001	p<0.001	p<0.001
5v6	p<0.001	p=0.017	p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 15. Task 13 Bldg S03 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 17.716; p<0.001	F = 53.350; p<0.001	F = 18.270; p<0.001	F = 31.342; p<0.001	F = 15.720; p<0.001
1v2	p<0.001		p=0.001	p<0.001	p<0.001
1v3		p<0.001		excluded	excluded
1v4	p<0.001	p=0.002		p<0.001	p=0.006
1v5	p=0.001	p<0.001	p<0.001		
1v6	p=0.013	p<0.001		p<0.001	p<0.001
2v3	p<0.001	p<0.001	p<0.001	excluded	excluded
2v4		p<0.001	p=0.001		
2v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v6		p<0.001			
3v4	p<0.001	p=0.004		excluded	excluded
3v5		p<0.001	p=0.001	excluded	excluded
3v6				excluded	excluded
4v5	p<0.001	p<0.001	p<0.001	p<0.001	
4v6	p=0.024				
5v6		p<0.001	p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 16. Task 13 Bldg S04 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 32.248; p<0.001	n.s.	F = 24.217; p<0.001	F = 15.077; p<0.001	F = 24.627; p<0.001
1v2					
1v3	p<0.001			p=0.002	p<0.001
1v4	p=0.001		p<0.001		
1v5	p<0.001			p=0.005	p<0.001
1v6	p<0.001		p<0.001		p<0.001
2v3				p=0.018	p<0.001
2v4	p=0.014		p<0.001		
2v5	p<0.001				p<0.001
2v6			p=0.004		p=0.001
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5	p<0.001				
3v6			p<0.001	p<0.001	
4v5	p<0.001		p<0.001	p<0.001	p<0.001
4v6	p<0.001		p=0.001		p<0.001
5v6	p<0.001		p=0.007	p<0.001	
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 17. Task 13 Bldg S05 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 776.266; p<0.001	F = 5.412; p<0.001	F = 62.757; p<0.001	F = 63.178; p<0.001	F = 78.850; p<0.001
1v2				p<0.001	
1v3	p<0.001	p<0.001			p<0.001
1v4	p<0.001		p<0.001	p<0.001	p<0.001
1v5	p<0.001		p<0.001		p<0.001
1v6	p<0.001		p<0.001	p<0.001	
2v3	p<0.001	p<0.001		p<0.001	p<0.001
2v4	p<0.001		p<0.001	p<0.001	p<0.001
2v5	p=0.001		p<0.001	p<0.001	p<0.001
2v6	p<0.001		p<0.001	p=0.003	
3v4	p<0.001	p=0.005	p<0.001	p<0.001	p<0.001
3v5	p<0.001	p=0.005	p<0.001		
3v6	p<0.001		p<0.001	p<0.001	p<0.001
4v5	p<0.001		p<0.001	p<0.001	p<0.001
4v6	p<0.001		p=0.033	p<0.001	p<0.001
5v6	p<0.001			p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3, Except DraftRate1_1m (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 18. Task 13 Bldg S06 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 59.823; p<0.001	F = 49.156; p<0.001	F = 41.469; p<0.001	F = 108.125; p<0.001	F = 38.401; p<0.001
1v2	p<0.001		p<0.001	p=0.005	
1v3	p<0.001			p<0.001	excluded
1v4	p<0.001	p<0.001		p<0.001	p<0.001
1v5	p<0.001	p<0.001			p<0.001
1v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	excluded
2v4		p<0.001	p<0.001	p<0.001	p<0.001
2v5		p=0.001	p<0.001		
2v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v4	p<0.001	p<0.001		p=0.002	excluded
3v5		p<0.001		p<0.001	excluded
3v6	p<0.001	p<0.001	p<0.001	p<0.001	excluded
4v5		p<0.001		p<0.001	
4v6	p<0.001	p=0.042	p<0.001	p<0.001	p<0.001
5v6	p=0.001	p<0.001	p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 19. . Task 13 Bldg S07 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 106.830; p<0.001	F = 29.965; p<0.001	F = 69.810; p<0.001	F = 24.654; p<0.001	F = 13.894; p<0.001
1v2	p<0.001	p<0.001	p<0.001	p=0.001	p<0.001
1v3	p<0.001	p<0.001	excluded	excluded	excluded
1v4	p<0.001	p<0.001	p=0.004		
1v5	p<0.001	p<0.001	p<0.001	p<0.001	p=0.002
1v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v3	p=0.001		excluded	excluded	excluded
2v4	p<0.001	p<0.001	p<0.001	p<0.001	
2v5	p<0.001		p<0.001	p=0.005	
2v6	p<0.001	p=0.022		p<0.001	
3v4	p<0.001	p<0.001	excluded	excluded	excluded
3v5	p<0.001	p=0.006	excluded	excluded	excluded
3v6	p<0.001	p=0.001	excluded	excluded	excluded
4v5	p<0.001		p<0.001	p=0.025	
4v6	p=0.002				p=0.014
5v6			p<0.001		p=0.044
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 20. Task 13 Bldg S08 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 15.197; p<0.001	F = 2.817; p=0.017	F = 69.114; p<0.001	F = 26.845; p<0.001	F = 50.091; p<0.001
1v2	p=0.013		p=0.033		
1v3	p<0.001	p=0.013	p<0.001	p<0.001	excluded
1v4				p=0.001	p<0.001
1v5	p=0.036	p=0.029	p<0.001	p=0.003	
1v6			p=0.011	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p=0.004	excluded
2v4	p<0.001				p<0.001
2v5	p<0.001		p<0.001		
2v6	p=0.020			p<0.001	p<0.001
3v4	p=0.015		p<0.001	p=0.001	excluded
3v5			p<0.001	p=0.015	excluded
3v6	p=0.001		p<0.001	p=0.002	excluded
4v5			p<0.001		p<0.001
4v6				p<0.001	p=0.001
5v6			p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 21. Task 13 Bldg S09 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 12.948; p<0.001	F = 14.452; p<0.001	F = 31.488; p<0.001	F = 33.871; p<0.001	F = 44.322; p<0.001
1v2			p<0.001	p=0.016	p<0.001
1v3	excluded	p=0.002	excluded	p<0.001	excluded
1v4	p<0.001	p<0.001			p=0.009
1v5	p=0.010	p<0.001	p<0.001	p<0.001	p<0.001
1v6	p=0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v3	excluded	p=0.001	excluded		excluded
2v4	p<0.001	p<0.001	p<0.001		
2v5	p=0.003	p<0.001	p<0.001	p<0.001	p<0.001
2v6	p<0.001	p<0.001			
3v4	excluded		excluded	p<0.001	excluded
3v5	excluded		excluded	p<0.001	excluded
3v6	excluded		excluded		excluded
4v5			p<0.001	p<0.001	p<0.001
4v6			p<0.001	p=0.001	
5v6			p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 22. Task 13 Bldg S10 by Zone

Zone Comparison	Variable				
	OpTemp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 48.496; p<0.001	F = 10.119; p<0.001	F = 81.085; p<0.001	F = 13.788; p<0.001	F = 10.859; p<0.001
1v2				p=0.006	
1v3					p=0.006
1v4	p=0.003		p<0.001		
1v5	p<0.001	p=0.003	p<0.001	p=0.011	
1v6	p<0.001	p=0.001	p<0.001	p<0.001	
2v3	p=0.001		p<0.001	p=0.001	p<0.001
2v4	p<0.001		p<0.001		
2v5	p<0.001	p<0.001	p<0.001		
2v6	p<0.001	p<0.001	p<0.001		
3v4				p=0.046	p=0.004
3v5	p<0.001	p=0.004	p<0.001	p=0.003	p=0.004
3v6	p<0.001	p=0.001	p=0.004	p<0.001	p<0.001
4v5	p<0.001	p=0.006	p<0.001		
4v6	p<0.001	p=0.001		p<0.001	
5v6			p<0.001	p=0.007	
*All Post-Hoc via Dunnett's T3, Except RelHumidity (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 23. Task 06-06 Bldg HPB01 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 594.237; p<0.001	F = 183.504; p<0.001	F = 46.175; p<0.001	F = 71.486; p<0.001	F = 63.311; p<0.001
0v1	p<0.001	p<0.001	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2	p<0.001		p<0.001	p<0.001	p<0.001
1v3	p=0.024				p=0.024
1v4	p<0.001			p<0.001	p<0.001
1v5	p<0.001		p=0.009	p=0.005	p=0.001
1v6			p<0.001	p<0.001	p<0.001
2v3	p<0.001		p<0.001	p<0.001	p<0.001
2v4	p<0.001		p<0.001	p=0.044	
2v5	p<0.001		p<0.001	p<0.001	p<0.001
2v6	p<0.001		p=0.009		
3v4	p<0.001			p<0.001	p<0.001
3v5	p<0.001		p=0.009	p=0.043	
3v6	p<0.001		p<0.001	p<0.001	p<0.001
4v5			p<0.001	p<0.001	p<0.001
4v6			p<0.001	p<0.001	p=0.021
5v6			p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3; Except DraftRate1_1m (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 24. Task 06-06 Bldg HPB02 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 650.932; p<0.001	F = 388.828; p<0.001	F = 28.460; p<0.001	F = 75.318; p<0.001	F = 175.963; p<0.001
0v1	excluded	excluded	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2	excluded	excluded	excluded	excluded	excluded
1v3	excluded	excluded	excluded	excluded	excluded
1v4	excluded	excluded	excluded	excluded	excluded
1v5	excluded	excluded	excluded	excluded	excluded
1v6	excluded	excluded	excluded	excluded	excluded
2v3		p<0.001		p<0.001	p<0.001
2v4				p<0.001	p<0.001
2v5			p<0.001		p=0.027
2v6	p<0.001		p<0.001		p<0.001
3v4	p=0.002	p<0.001		p=0.001	p<0.001
3v5		p<0.001	p<0.001	p<0.001	p<0.001
3v6	p<0.001	p<0.001		p<0.001	p<0.001
4v5	p=0.001		p<0.001	p<0.001	p<0.001
4v6	p<0.001		p=0.013	p<0.001	p<0.001
5v6	p=0.001		p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3; Except DraftRate0_6m (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 25. Task 06-06 Bldg HPB03 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 68.317; p<0.001	F = 38.522; p<0.001	F = 114.101; p<0.001	F = 54.885; p<0.001	F = 36.215; p<0.001
0v1	p<0.001	p<0.001	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2	p<0.001				
1v3	p<0.001		p<0.001	p<0.001	p<0.001
1v4	p<0.001		p<0.001		p=0.027
1v5	p<0.001		p=0.001		
1v6	p<0.001		p<0.001	p<0.001	p<0.001
2v3			p<0.001	p<0.001	p<0.001
2v4	p<0.001		p<0.001		p<0.001
2v5			p<0.001		
2v6	p=0.008		p<0.001	p<0.001	p<0.001
3v4			p<0.001	p<0.001	p<0.001
3v5	p=0.002			p<0.001	p<0.001
3v6			p<0.001		p<0.001
4v5	p<0.001		p<0.001		
4v6			p<0.001	p<0.001	
5v6	p<0.001		p<0.001	p<0.001	p=0.013
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 26. Task 06-06 Bldg HPB04 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 3.788; p=0.001	F = 71.615; p<0.001	F = 35.802; p<0.001	F = 100.384; p<0.001	F = 87.252; p<0.001
0v1		p<0.001	excluded	excluded	excluded
0v2		p<0.001	excluded	excluded	excluded
0v3		p<0.001	excluded	excluded	excluded
0v4		p<0.001	excluded	excluded	excluded
0v5		p<0.001	excluded	excluded	excluded
0v6		p<0.001	excluded	excluded	excluded
1v2	p=0.047	p<0.001	p=0.020		p<0.001
1v3		p<0.001		p=0.001	
1v4	p<0.001	p<0.001	p<0.001	p<0.001	p=0.003
1v5	p=0.002	p<0.001		p<0.001	p<0.001
1v6	p<0.001	p<0.001		p<0.001	p=0.008
2v3		p<0.001	p=0.001	p<0.001	p<0.001
2v4	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v5		p<0.001	p=0.006	p<0.001	p<0.001
2v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v4	p<0.001	p<0.001	p<0.001	p<0.001	p=0.006
3v5	p=0.004	p<0.001		p<0.001	p<0.001
3v6	p<0.001	p<0.001		p=0.005	p=0.010
4v5			p<0.001		p<0.001
4v6	p<0.001	p<0.001	p<0.001	p=0.001	
5v6	p<0.001	p<0.001			p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 27. Task 06-06 Bldg HPB05 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 98.913; p<0.001	n.s.	F = 8.089; p<0.001	F = 12.438; p<0.001	F = 5.429; p<0.001
0v1	p<0.001		excluded	excluded	excluded
0v2	p<0.001		excluded	excluded	excluded
0v3	p<0.001		excluded	excluded	excluded
0v4	p<0.001		excluded	excluded	excluded
0v5	excluded		excluded	excluded	excluded
0v6	p<0.001		excluded	excluded	excluded
1v2	p<0.001		p=0.049	p<0.001	
1v3	p=0.007				
1v4	p=0.022				
1v5	excluded		p=0.002	p<0.001	
1v6	p<0.001			p<0.001	
2v3	p<0.001			p<0.001	p<0.001
2v4	p<0.001		p=0.023	p=0.011	
2v5	excluded				
2v6	p<0.001		p=0.008		
3v4					p=0.005
3v5	excluded		p=0.005	p=0.002	
3v6	p<0.001			p<0.001	p<0.001
4v5	excluded		p=0.001		
4v6	p=0.025				
5v6	excluded		p<0.001		
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 28. Task 06-06 Bldg HPB06 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 393.845; p<0.001	F = 165.078; p<0.001	F = 96.366; p<0.001	F = 56.382; p<0.001	F = 68.829; p<0.001
0v1	p<0.001	p<0.001	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2		p<0.001		p<0.001	p<0.001
1v3	p<0.001	p=0.005	p=0.001		p<0.001
1v4	p<0.001	p<0.001	p<0.001	p<0.001	
1v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v6	p<0.001	p<0.001	p<0.001	p=0.020	
2v3				p<0.001	p<0.001
2v4	p=0.014		p<0.001	p<0.001	
2v5	p<0.001	p<0.001	p<0.001		p<0.001
2v6	p<0.001	p<0.001		p<0.001	p=0.001
3v4			p<0.001	p<0.001	p=0.001
3v5	p<0.001	p=0.009	p<0.001	p<0.001	p=0.016
3v6	p<0.001	p<0.001			p<0.001
4v5	p<0.001		p<0.001	p=0.001	p<0.001
4v6	p<0.001	p<0.001	p<0.001		
5v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 29. Task 06-06 Bldg HPB07 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 314.834; p<0.001	F = 330.545; p<0.001	F = 67.067; p<0.001	F = 100.246; p<0.001	F = 88.516; p<0.001
0v1	p<0.001	p<0.001	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2		p<0.001		p<0.001	p=0.004
1v3	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v4	p<0.001	p<0.001	p<0.001		p<0.001
1v5	p<0.001	p<0.001	p=0.007	p<0.001	p<0.001
1v6	p<0.001	p<0.001			p<0.001
2v3		p<0.001	p<0.001	p<0.001	p<0.001
2v4	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v5	p<0.001	p<0.001	p=0.001	p<0.001	p<0.001
2v6	p<0.001			p=0.012	p<0.001
3v4	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v5	p<0.001				
3v6	p=0.041	p<0.001	p<0.001	p=0.004	p<0.001
4v5	p<0.001	p<0.001	p<0.001	p<0.001	p=0.012
4v6	p<0.001	p<0.001	p<0.001		
5v6	p<0.001	p<0.001	p=0.004	p<0.001	
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 30. Task 06-06 Bldg HPB08 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 105.356; p<0.001	F = 14.540; p<0.001	F = 51.753; p<0.001	F = 134.952; p<0.001	F = 121.179; p<0.001
0v1	p<0.001	p=0.040	excluded	excluded	excluded
0v2	p<0.001	p=0.034	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p=0.001	excluded	excluded	excluded
0v5	p<0.001		excluded	excluded	excluded
0v6	p<0.001		excluded	excluded	excluded
1v2			p<0.001	p<0.001	p<0.001
1v3		p<0.001	p<0.001	p<0.001	
1v4	p<0.001	p=0.001	p<0.001	p=0.034	p<0.001
1v5			p<0.001		
1v6				p<0.001	p<0.001
2v3		p<0.001	p=0.027	p<0.001	p=0.006
2v4	p<0.001	p=0.001		p<0.001	p<0.001
2v5			p<0.001	p<0.001	p<0.001
2v6			p<0.001	p<0.001	p<0.001
3v4	p<0.001			p<0.001	p<0.001
3v5		p<0.001		p<0.001	p=0.035
3v6		p<0.001	p<0.001	p<0.001	p<0.001
4v5	p<0.001	p<0.001	p=0.033	p<0.001	p<0.001
4v6	p<0.001	p<0.001	p<0.001	p<0.001	p=0.023
5v6			p<0.001	p<0.001	p<0.001
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 31. Task 06-06 Bldg HPB09 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 166.314; p<0.001	F = 125.504; p<0.001	F = 242.549; p<0.001	F = 431.348; p<0.001	F = 338.979; p<0.001
0v1	p<0.001	p<0.001	excluded	excluded	excluded
0v2	p<0.001	p<0.001	excluded	excluded	excluded
0v3	p<0.001	p<0.001	excluded	excluded	excluded
0v4	p<0.001	p<0.001	excluded	excluded	excluded
0v5	p<0.001	p<0.001	excluded	excluded	excluded
0v6	p<0.001	p<0.001	excluded	excluded	excluded
1v2	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v3		p=0.042	p<0.001		p<0.001
1v4	p<0.001		p<0.001	p<0.001	p<0.001
1v5	p<0.001		p=0.001	p<0.001	p<0.001
1v6			p<0.001	p<0.001	p<0.001
2v3	p<0.001	p=0.010	p<0.001	p<0.001	p<0.001
2v4	p<0.001	p<0.001	p<0.001		p<0.001
2v5	p<0.001	p<0.001	p<0.001	p<0.001	
2v6	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
3v4	p<0.001		p<0.001	p<0.001	p<0.001
3v5	p<0.001		p=0.008	p<0.001	p<0.001
3v6	p=0.001	p<0.001	p<0.001	p<0.001	p<0.001
4v5			p<0.001	p<0.001	p<0.001
4v6	p<0.001	p=0.038	p<0.001	p<0.001	p<0.001
5v6	p<0.001		p<0.001		p<0.001
*All Post-Hoc via Dunnett's T3; Except DraftRate0_6m (equal variance: Bonferroni)					
*Draft Rates ranked prior to analysis for non-parametric measures					

Table 32. Task 06-06 Bldg HPB10 by Zone

Zone Comparison	Variable				
	Temp	RelHumidity	DraftRate0_1m	DraftRate0_6m	DraftRate1_1m
Main Effect	F = 33.683; p<0.001	F = 15.261; p<0.001	F = 76.078; p<0.001	F = 128.145; p<0.001	F = 83.478; p<0.001
0v1			excluded	excluded	excluded
0v2			excluded	excluded	excluded
0v3	p=0.009		excluded	excluded	excluded
0v4	p=0.003		excluded	excluded	excluded
0v5	p<0.001		excluded	excluded	excluded
0v6			excluded	excluded	excluded
1v2	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1v3	p=0.025	p<0.001	p<0.001	p<0.001	p<0.001
1v4	p<0.001	p<0.001	p<0.001	p<0.001	p=0.030
1v5	p<0.001	p<0.001			
1v6			p<0.001	p<0.001	
2v3	p<0.001	p<0.001	p<0.001		
2v4	p<0.001	p<0.001		p<0.001	p<0.001
2v5	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
2v6	p<0.001	p<0.001	p<0.001		p<0.001
3v4		p<0.001	p<0.001	p<0.001	p<0.001
3v5	p<0.001		p<0.001	p<0.001	p<0.001
3v6		p=0.002			p<0.001
4v5	p<0.001	p<0.001	p<0.001	p<0.001	
4v6	p=0.002		p=0.003	p<0.001	
5v6	p<0.001	p=0.001	p<0.001	p<0.001	
*All Post-Hoc via Dunnett's T3					
*Draft Rates ranked prior to analysis for non-parametric measures					

3.3 AIRBORNE AND SURFACE-ASSOCIATED MOLD

For more salient interpretation, mold variables were log10-transformed prior to examination. Statistical tests were conducted for each of the three different measures: airborne culturable fungi, microscopically examined non-culturable airborne fungal spores, and vacuum-collected surface dust. Univariate analysis of variance (ANOVA) was used to determine the presence or absence of a main effect among the three days or the six indoor zones. If a main effect was observed, post-hoc analysis was performed to determine which specific days or zones differed through either Bonferroni's test or Dunnett's T3 test for assumption of equal variance or unequal variance, respectively.

The statistical findings are summarized in the following tables. No statistical differences ($p \geq 0.05$) were found by day for airborne culturable fungi or for airborne non-culturable spores. However, some differences ($p < 0.05$) were found by day (for Tuesday vs. Wednesday; p=0.o13) for the surface-associated fungi (Table 33).

Table 33. . Statistical Results by Day for All Tasks for Airborne Culturable Fungi, Airborne Non-culturable Spores, and Surface-associated Fungi

Comparison	Mold Parameter		
	Airborne Culturable Fungi	Airborne Non-Culturable Spores	Surface-associated Fungi
	(df = 2, 1964)	(df = 2, 2558)	(df = 2, 3154)
Main Effect	n.s.	n.s.	F = 4.12, p = .016
Tue vs. Wed			P = 0.013
Wed vs. Thu			n.s.
Tue vs. Thu			n.s.
*Post-Hoc via Bonferroni			

Selection of indoor zones (1-6) was independently selected within each task; zones were not related by location across tasks. Therefore, no comparison would be valid across zones for the 30 buildings and statistical analysis by zone was only conducted within each task. No statistically significant differences ($p \geq 0.05$) were found by-zone for Task 1 airborne culturable data. Statistically significant differences ($p < 0.05$) were found between outdoor locations (zone 0) and indoor zones 1-6 for Task 1 airborne non-culturable spores (Table 34), but these differences ($p = 0.043$) were only noted for one indoor location comparison (zone 1 vs. 4) for Task 1 airborne non-culturable fungi.

Table 34. Task 1 Office Buildings by Zone Statistical Results for Airborne Non-culturable Spores

Zone Comparison	Building ID									
	001	002	003	004	005	006	007	008	009	010
Main Effect	n.s.	F = 5.801 p = 0.000	F = 4.970 p = 0.000	F = 3.047 p = 0.012	F = 5.273 p = 0.000	F = 8.429 p = 0.000	F = 12.569 p = 0.000	F = 12.678 p = 0.000	F = 3.873 p= 0.004	n.s.
0v1						0.000	0.000	0.000		
0v2		0.000	0.000		0.000	0.000	0.000	0.001	0.000	
0v3		0.010	0.000		0.002	0.000	0.000	0.000	0.000	
0v4		0.000	0.000		0.031	0.000	0.000	0.000	0.003	
0v5		0.000	0.003		0.003	0.000	0.000	0.000	0.000	
0v6		0.002	0.000		0.000	0.000	0.000	0.000	0.000	
1v2										
1v3										
1v4						0.043				
1v5										
1v6										
2v3										
2v4										
2v5										
2v6										
3v4										
3v5										
3v6										
4v5										
4v6										
5v6										

*All Post-Hoc via Dunnett's T3, Except Bldg 04 (equal variance: Bonferroni)

Statistically significant differences ($p<0.05$) were found during analysis by indoor zone for the Task 1 surface-associated fungal data for 6 of the 10 buildings (Table 35).

Table 35. Task 1 Office Buildings by Zone Statistical Results for Surface-associated Fungi.

Zone Comparison	Building									
	001	002	003	004	005	006	007	008	009	010
Main Effect	F = 2.321 p = 0.048	n.s.	n.s.	F = 13.266 p = 0.000	F = 5.107; p = 0.000	F = 7.463 p = 0.000	F = 2.618 p = 0.028	n.s.	F = 11.521 p = 0.000	n.s.
1v2					0.001		0.023			
1v3				0.001	0.019					
1v4										
1v5				0.020	0.002					
1v6						0.001				
2v3				0.001					0.000	
2v4									0.000	
2v5				0.009					0.000	
2v6						0.008				
3v4	0.023			0.000						
3v5										
3v6				0.000		0.001			0.000	
4v5				0.000						
4v6						0.004			0.000	
5v6				0.007					0.001	

*All Post-Hoc via Dunnett's T3; Except Bldg 05, 07, and 09 (equal variance: Bonferroni)

Statistically significant differences ($p<0.05$) at indoor zones in airborne culturable fungi were noted for Task 13 data in two of the 10 buildings. The differences were found when comparing zone 1 vs 4 in one school building (Building S5), and in two indoor zone comparisons (zones 2 vs 5 and 2 vs 6) in another school building (Building S2) (Table 36). Differences were also found when comparing ourdoor (zone 0) and indoor zones in several of the buildings.

Table 36. Task 13 Schools by Zone Results for Airborne Culturable Fungi

Zone Comparison	Building									
	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Main Effect	F = 2.992; p = 0.011	F = 27.494; p = 0.000	n.s.	n.s.	F = 7.021; p = 0.000	n.s.	F = 2.553; p = 0.030	n.s.	F = 2.755; p = 0.019	(Table 5), and surface-ass0cn.s.
0v1	0.036									
0v2										
0v3	0.023									
0v4					0.000		0.005			
0v5		0.000								
0v6		0.000				0.000				
1v2										
1v3										
1v4					0.006					
1v5										
1v6										
2v3										
2v4					MD					
2v5		0.002								
2v6		0.002								
3v4										
3v5										
3v6						MD				
4v5		0.000								
4v6		0.000								
5v6		MD								

*Post-Hoc via Dunnett's T3 ; MD = missing data

While differences were found for indoor vs. outdoors, no statistically significant differences ($p \geq 0.05$) were found for airborne non-culturable spores in the Task 13 indoor zones (1-6) (Table 37).

Table 37. Task 13 Schools by Zone Results for Airborne Non-culturable Spores

Zone Comparison	Building									
	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Main Effect	F = 10.556 p = 0.000	F = 5.308 p = 0.000	F = 3.956 p = 0.002	F = 2.754 p = 0.014	F = 5.045 p = 0.000	F = 3.536 p = 0.017	F = 7.391 p = 0.000	F = 3.456 p = 0.003	F = 4.273 p = 0.001	F = 8.289 p = 0.000
0v1	0.000				0.006					
0v2	0.000	0.022	0.000				0.000	0.003		0.043
0v3				0.043	0.005		0.004		0.004	0.016
0v4	0.000					0.000	0.000			0.000
0v5	0.000		0.009		0.000		0.000			0.000
0v6	0.000						0.000		0.018	0.028
1v2										
1v3										
1v4										
1v5										
1v6										
2v3										
2v4										
2v5										
2v6										
3v4										
3v5										
3v6										
4v5						MD				
4v6										
5v6										

*All Post-Hoc via Dunnett's T3; Except Bldg 9 (equal variances: Bonferroni); MD = missing data

Statistically significant differences ($p < 0.05$) were found for surface-associated fungi for Task 13 indoors zones in four of the school buildings (Building S01, S02, S07, and S09) (Table 38).

Table 38. Task 13 Schools by Zone Findings for Surface-associated Fungi

Zone Comparison	Building									
	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Main Effect	F = 4.077 p = 0.002	F = 9.080 p = 0.000	n.s.	n.s.	n.s.	n.s.	F = 3.519 p = 0.005	n.s.	F = 2.786 p = 0.020	n.s.
1v2										
1v3							0.015			
1v4										
1v5										
1v6		0.002					0.018			
2v3	0.022									
2v4										
2v5	0.001									
2v6		0.000							0.012	
3v4										
3v5										
3v6										
4v5		0.001								
4v6										
5v6		0.000								

*All Post-Hoc via Bonferroni

Although differences were found when comparing outdoor (zone 0) airborne culturable fungi to that found in indoor zones (1-6), no statistically significant differences ($p \geq 0.05$) were found by indoor zone (1-6) (Table 39) or for airborne non-culturable spores (Table 40) in the high performance buildings of Task 0606.

Table 39. Task 0606 High Performance Buildings by Zone Results for Airborne Culturable Fungi

Zone Comparison	Building									
	HPB01	HPB02	HPB03	HPB04	HPB05	HPB06	HPB07	HPB08	HPB09	HPB010
Main Effect	F = 4.115 p = 0.001	F = 20.151 p = 0.000	F = 4.979 p = 0.001	F = 7.264 p = 0.000	n.s.	n.s.	F = 5.954 p = 0.000	F = 3.198 p = 0.007	n.s.	n.s.
0v1	0.050	0.000		0.001						
0v2	0.048		0.002	0.000						
0v3	0.035									
0v4	0.033			0.000			0.050			
0v5	0.041			0.000			0.002	0.039		
0v6										
1v2										
1v3										
1v4										
1v5										
1v6										
2v3										
2v4										
2v5										
2v6										
3v4										
3v5										
3v6										
4v5										
4v6										
5v6										

*Post-Hoc via Dunnett's T3; Except Buildings HPB03 and HPB06 (equal variance: Bonferroni)

Table 40. Task 0606 High Performance Buildings by Zone Results for Airborne Non-culturable Spores

Zone Comparison	Building									
	HPB01	HPB02	HPB03	HPB04	HPB05	HPB06	HPB07	HPB08	HPB09	HPB010
Main Effect	F = 4.917 p = 0.000	F = 7.565 p = 0.000	F = 7.121 p = 0.000	F = 9.478 p = 0.000	F = 11.081 p = 0.000	F = 5.272 p = 0.000	F = 13.190 p = 0.000	F = 11.441 p = 0.000	F = 6.635 p = 0.000	F = 20.841 p = 0.000
0v1	0.005			0.000	0.000	0.002		0.018		0.000
0v2	0.000			0.000		0.015		0.000		0.000
0v3					0.001	0.019	0.000	0.001		0.000
0v4		0.000		0.000	0.000	0.004	0.000	0.000		0.000
0v5	0.001			0.000	0.000		0.000	0.000	0.000	0.000
0v6	0.000			0.000	0.001		0.000	0.001		0.000
1v2										
1v3										
1v4										
1v5										
1v6										
2v3										
2v4										
2v5										
2v6										
3v4										
3v5										
3v6										
4v5										
4v6										
5v6										

*All Post-Hoc via Dunnett's T3; Except Building HPB06 (equal variances: Bonferroni)

Statistically significant differences ($p<0.05$) were found for surface-associated fungi in three of the 10 high performance buildings of Task 0606 (Table 41).

Table 41. Task 0606 High Performance Buildings by Zone Results for Surface-associated Fungi

Zone Comparison	Building									
	HPB01	HPB02	HPB03	HPB04	HPB05	HPB06	HPB07	HPB08	HPB09	HPB010
Main Effect	F = 4.399 p = 0.001	n.s.	F = 7.605 p = 0.000	n.s.	n.s.	F = 4.105 p = 0.002	n.s.	F = 2.898 p = 0.023	n.s.	n.s.
1v2										
1v3	0.043									
1v4										
1v5										
1v6						0.023				
2v3	0.001		0.028							
2v4			0.036							
2v5										
2v6										
3v4										
3v5										
3v6	0.009		0.008							
4v5										
4v6			0.008							
5v6										

*All Post-Hoc via Bonferroni; Except Building HPB3 (unequal variance: Dunnett's T3)

3.4 LIGHTING

Multiple measures of each lighting variable within a single day were only performed during Task 1. Therefore, by-day comparisons were only analyzed for that task. In the case of normally distributed variables, ANOVA was used to determine the presence or absence of a main effect among the three days or the seven zones. These variables were CombChromX, CombCCT, CombCRI, AmbChromY1, and IllumWkSfcDrkst. All remaining variables were found to be non-normally distributed, thus nonparametric Kruskal-Wallis (K-W) tests were performed for: CombChromY, AmbChromX1, AmbCCT1, AmbCRI1, and IllumWkSfcBrtst. If a main effect was observed, post-hoc analysis was performed to determine which specific days or zones differed through either Tukey's Honest Significant Difference (HSD) test or Dunnett's T3 test for assumption of equal variance or unequal variance, respectively.

There were no significant differences ($p\geq0.05$) among the days of collection for all Task 1 office. The statistical results for by-zone comparisons for Task 1 are summarized below, where each table represents either main effect or K-W statistic (Table 42-49). Fields denoted by "+++" indicate that all zones for a particular building were non-homogenous subsets with equivalent values for each case in all zones, thus

preventing comparison by ANOVA. These tables show the results from all post-hoc tests if a difference was observed. There were no significant differences by-zone in any variables for Buildings O03, O06, and O10. Therefore, post-hoc analysis was not performed. Fields denoted by "---" indicate that the measures for both zones were equivalent, thus preventing comparison of variance.

By-zone comparisons were analyzed differently for Task 1 as compared to Task 13 and Task 0606. Due to Task 13 and Task 0606 only having a single measurement of each variable for each zone, Chi-square (χ^2) tests of uniformity were used for variables with values >1 and Kolmogorov-Smirnov (K-S) for variables with values <1. By-zone comparisons for Tasks 13 and 0606 are listed in Tables 50-51, respectively. Note that Task 0606 only has analysis for illumination, because all other variables of interest were not collected.

Table 42. Task 1 Office Buildings Lighting by Zone: All Buildings

ANOVA					
Office Bldg ID	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
001	26.914; 0.000	32.597; 0.000	49.978; 0.000	66.242; 0.000	4.708; .0013
002	0.800; 0.571	0.882; 0.522	0.771; 0.588	4.044; 0.022	2.501; 0.090
003	0.535; 0.746	0.561; 0.728	2.533; 0.087	0.924; 0.498	1.161; 0.382
004	1.816; 0.184	1.653; 0.220	4.218; 0.019	423.755; 0.000	0.621; 0.687
005	+++	3.850; 0.026	0.412; 0.832	+++	1.979; 0.154
006	1.544; 0.249	1.688; 0.212	0.114; 0.987	+++	0.746; 0.604
007	1.037; 0.440	0.925; 0.498	1.366; 0.304	+++	1.790; 0.189
008	3.941; 0.024	19.402; 0.000	8.846; 0.001	+++	1.305; 0.325
009	1.718; 0.205	1.444; 0.278	1.895; 0.169	+++	1.201; 0.366
010	1.937; 0.161	1.664; 0.217	1.667; 0.217	+++	2.934; 0.059
Nonparametric Measures					
Office Bldg ID	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
001	13.638; 0.018	15.896; 0.007	15.489; 0.008	14.781; 0.011	16.158; 0.006
002	1.234; 0.942	11.896; 0.036	11.826; 0.037	8.149; 0.148	3.830; 0.574
003	3.032; 0.695	1.112; 0.953	2.099; 0.835	4.565; 0.471	10.006; 0.075
004	7.232; 0.204	16.516; 0.006	16.516; 0.006	17.000; 0.004	10.778; 0.056
005	17.000; 0.004	17.000; 0.004	0.000; 1.000	0.000; 1.000	9.023; 0.108
006	3.214; 0.667	0.000; 1.000	0.000; 1.000	0.000; 1.000	8.953; 0.111
007	4.414; 0.491	17.000; 0.004	0.000; 1.000	0.000; 1.000	11.152; 0.048
008	9.047; 0.107	0.000; 1.000	0.000; 1.000	0.000; 1.000	13.757; 0.017
009	7.745; 0.171	17.000; 0.004	17.000; 0.004	17.000; 0.004	6.591; 0.253
010	9.618; 0.087	0.000; 1.000	0.000; 1.000	0.000; 1.000	5.842; 0.322

Table 43. Task 1 Office Buildings Lighting by Zone: Building 001

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	26.914; 0.000	32.597; 0.000	49.978; 0.000	66.242; 0.000	4.708; 0.013
1 v 2			0.030		
1 v 3			0.009	0.004	
1 v 4			---		
1 v 5				0.022	
1 v 6			0.009		
2 v 3					
2 v 4					0.005
2 v 5				0.001	
2 v 6					0.000
3 v 4					0.007
3 v 5				0.006	
3 v 6	0.038	0.019			0.000
4 v 5				0.002	
4 v 6	0.009				0.019
5 v 6					0.037

Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	13.638; 0.018	15.896; 0.007	15.489; 0.008	14.781; 0.011	16.158; 0.006
1 v 2					0.015
1 v 3		0.002	0.001	---	
1 v 4			0.028		
1 v 5		0.002	0.001		0.047
1 v 6			0.020		
2 v 3					
2 v 4					
2 v 5		0.011	0.009		
2 v 6	0.043				
3 v 4		0.049			
3 v 5	0.039	0.000	0.000		
3 v 6		0.009	0.009		
4 v 5		0.000	0.000	0.024	
4 v 6		0.000			
5 v 6			0.000		

Table 44. Task 1 Office Buildings Lighting by Zone: Building 002

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	n.s.	n.s.	n.s.	4.044; 0.022	n.s.
1 v 2					
1 v 3					
1 v 4					
1 v 5					
1 v 6					
2 v 3					
2 v 4					
2 v 5					
2 v 6					
3 v 4					
3 v 5					
3 v 6				0.041	
4 v 5					
4 v 6					
5 v 6					

Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	n.s.	11.896; 0.036	11.826; 0.037	n.s.	n.s.
1 v 2					
1 v 3					
1 v 4					
1 v 5					
1 v 6					
2 v 3					
2 v 4					
2 v 5					
2 v 6					
3 v 4		0.031	0.049		
3 v 5					
3 v 6		0.011	0.014		
4 v 5					
4 v 6					
5 v 6					

Table 45. Task 1 Office Buildings Lighting by Zone: Building 004

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	n.s.	n.s.	4.218; 0.019	423.755; 0.000	n.s.
1 v 2					
1 v 3				---	
1 v 4				---	
1 v 5			0.028	---	
1 v 6				---	
2 v 3					
2 v 4				0.040	
2 v 5				0.015	
2 v 6					
3 v 4				---	
3 v 5				---	
3 v 6				---	
4 v 5				---	
4 v 6				---	
5 v 6				---	

Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	n.s.	16.516; 0.006	16.516; 0.006	17.000; 0.004	n.s.
1 v 2				+++	
1 v 3		---	---	+++	
1 v 4		---	---	+++	
1 v 5		---	---	+++	
1 v 6		---	---	+++	
2 v 3				+++	
2 v 4		0.025	0.024	+++	
2 v 5		0.014	0.013	+++	
2 v 6				+++	
3 v 4		---	---	+++	
3 v 5		---	---	+++	
3 v 6		---	---	+++	
4 v 5		---	---	+++	
4 v 6		---	---	+++	
5 v 6		---	---	+++	

Table 46. Task 1 Office Buildings Lighting by Zone: Building 005

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	+++	3.850; 0.026	n.s.	+++	n.s.
1 v 2	+++			+++	
1 v 3	+++			+++	
1 v 4	+++			+++	
1 v 5	+++	0.040		+++	
1 v 6	+++			+++	
2 v 3	+++			+++	
2 v 4	+++			+++	
2 v 5	+++			+++	
2 v 6	+++			+++	
3 v 4	+++			+++	
3 v 5	+++			+++	
3 v 6	+++			+++	
4 v 5	+++	0.035		+++	
4 v 6	+++			+++	
5 v 6	+++			+++	
Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	17.000; 0.004	17.000; 0.004	n.s.	n.s.	n.s.
1 v 2	+++	+++			
1 v 3	+++	+++			
1 v 4	+++	+++			
1 v 5	+++	+++			
1 v 6	+++	+++			
2 v 3	+++	+++			
2 v 4	+++	+++			
2 v 5	+++	+++			
2 v 6	+++	+++			
3 v 4	+++	+++			
3 v 5	+++	+++			
3 v 6	+++	+++			
4 v 5	+++	+++			
4 v 6	+++	+++			
5 v 6	+++	+++			

Table 47. Task 1 Office Building Lighting by Zone: Building 007

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	n.s.	n.s.	n.s.	+++	n.s.
1 v 2				+++	
1 v 3				+++	
1 v 4				+++	
1 v 5				+++	
1 v 6				+++	
2 v 3				+++	
2 v 4				+++	
2 v 5				+++	
2 v 6				+++	
3 v 4				+++	
3 v 5				+++	
3 v 6				+++	
4 v 5				+++	
4 v 6				+++	
5 v 6				+++	
Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	n.s.	17.000; 0.004	n.s.	n.s.	11.152; 0.048
1 v 2		+++			
1 v 3		+++			
1 v 4		+++			
1 v 5		+++			
1 v 6		+++			
2 v 3		+++			
2 v 4		+++			0.043
2 v 5		+++			
2 v 6		+++			
3 v 4		+++			0.033
3 v 5		+++			
3 v 6		+++			
4 v 5		+++			
4 v 6		+++			
5 v 6		+++			

Table 48. Task 1 Office Buildings Lighting by Zone: Building 008

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	3.941; 0.024	19.402; 0.000	8.846; 0.001	+++	n.s.
1 v 2				+++	
1 v 3				+++	
1 v 4		0.000		+++	
1 v 5		0.003		+++	
1 v 6				+++	
2 v 3				+++	
2 v 4		0.001		+++	
2 v 5				+++	
2 v 6			0.042	+++	
3 v 4	0.041	0.000		+++	
3 v 5		0.049		+++	
3 v 6			0.042	+++	
4 v 5		0.048		+++	
4 v 6	0.023	0.000		+++	
5 v 6		0.014		+++	
Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	n.s.	n.s.	n.s.	n.s.	13.757; 0.017
1 v 2					
1 v 3					
1 v 4					0.009
1 v 5					0.046
1 v 6					0.001
2 v 3					
2 v 4					0.016
2 v 5					
2 v 6					0.002
3 v 4					0.010
3 v 5					0.050
3 v 6					0.001
4 v 5					
4 v 6					
5 v 6					

Table 49. Task 1 Office Building Lighting by Zone: Building 009

ANOVA					
Zone Comparison	Variable				
	CombChromX	CombCCT	CombCRI	AmbChromY1	IllumWkSfcDrkst
Main Effect	n.s.	n.s.	n.s.	+++	n.s.
1 v 2				+++	
1 v 3				+++	
1 v 4				+++	
1 v 5				+++	
1 v 6				+++	
2 v 3				+++	
2 v 4				+++	
2 v 5				+++	
2 v 6				+++	
3 v 4				+++	
3 v 5				+++	
3 v 6				+++	
4 v 5				+++	
4 v 6				+++	
5 v 6				+++	
Nonparametric Measures					
Zone Comparison	Variable				
	CombChromY	AmbChromX1	AmbCCT1	AmbCRI1	IllumWkSfcBrtst
K-W Statistic	n.s.	17.000; 0.004	17.000; 0.004	17.000; 0.004	n.s.
1 v 2		+++	+++	+++	
1 v 3		+++	+++	+++	
1 v 4		+++	+++	+++	
1 v 5		+++	+++	+++	
1 v 6		+++	+++	+++	
2 v 3		+++	+++	+++	
2 v 4		+++	+++	+++	
2 v 5		+++	+++	+++	
2 v 6		+++	+++	+++	
3 v 4		+++	+++	+++	
3 v 5		+++	+++	+++	
3 v 6		+++	+++	+++	
4 v 5		+++	+++	+++	
4 v 6		+++	+++	+++	
5 v 6		+++	+++	+++	

Table 50. Task 13 Schools Lighting by Zone: All Buildings

χ^2 (G-value; p-value)						
School ID	Variable					
	CombCCT	CombCRI	AmbCCT1	AmbCRI1	IllumWkSfcBrtst	IllumWksfcDrkst
S01			---	---	326.029; 0.000	205.866; 0.000
S02					431.278; 0.000	780.649; 0.000
S03	50.799; 0.000		66.445; 0.000		2173.076; 0.000	1220.987; 0.000
S04					322.546; 0.000	343.920; 0.000
S05					130.780; 0.000	183.259; 0.000
S06					425.136; 0.000	342.278; 0.000
S07	28.252; 0.000				758.154; 0.000	163.395; 0.000
S08			14.999; 0.010		67.024; 0.000	174.496; 0.000
S09					741.554; 0.000	651.413; 0.000
S10					613.956; 0.000	640.367; 0.000

K-S (Z-value; p-value)				
School ID	Variable			
	CombChromX	CombChromY	AmbChromX1	AmbChromY1
S01			---	---
S02			1.476; 0.026	
S03				
S04		1.490; 0.024		
S05	1.566; 0.015			
S06				
S07				
S08				
S09				
S10				

Table 51. Task 0606 High Performance Lighting by Zone: All Buildings

χ^2 (G-value; p-value)		
HP Bldg ID	Variable	
	IllumWkSfcBrtst	IllumWksfcDrkst
HPB01	282.871; 0.000	231.365; 0.000
HPB02	87.879; 0.000	66.826; 0.000
HPB03	386.523; 0.000	114.130; 0.000
HPB04	713.999; 0.000	74.451; 0.000
HPB05	1615.865; 0.000	330.050; 0.000
HPB06	1024.243; 0.000	160.329; 0.000
HPB07	139.537; 0.000	472.492; 0.000
HPB08	478.887; 0.000	224.591; 0.000
HPB09	1756.463; 0.000	1078.375; 0.000
HPB10	177.501; 0.000	228.699; 0.000

3.5 SOUND

Sound data sets were previously not presented with the individual measurements for each day, and they were instead aggregated for each zone. This issue was remedied in this task and all tasks sound data were converted to SPSS format for statistical analysis.

Similarly to previous data sets, sound quality was analyzed to compare whether differences in samples collected were apparent both by-day and by-zone. The two variables of interest for all tasks were: cumulative probability levels for dBA at 99% (L_99_dBA) and at 95% (L_95_dBA). Univariate analysis of variance (ANOVA) was used to determine the presence or absence of a main effect among the three days for all tasks combined or the six zones for each building within the three tasks. If a main effect was observed, post-hoc analysis was performed to determine which specific days or zones differed through Tukey's Honestly Significant Difference (HSD), Bonferroni's test, or Dunnett's T3; these were for the assumption of equal variance with same sample sizes, equal variance with different sample sizes, or unequal variance, respectively.

A few data points were not collected for a particular zone in the following buildings: in Task 1, Tuesday for Zone 2 in building O04 and Wednesday for Zone 2 of building O10; in Task 13, all Tuesdays for zones 1-6 in building S06; and in Task 0606, all Thursdays for zones 1-6 in building HPB02. Additionally in Task 0606, no data were collected from zones 1, 2, 5, & 6 of building HPB01. In an effort to retain homogeneity of samples, buildings O04, O10, S06, HPB01, and HPB02 were excluded from comparisons by-day, whereas zone analyses for HPB01 were not conducted. Although no differences were found by-day for either L_99_dBA [$F(2, 477) = .08$; $p = 0.92$] or L_95_dBA [$F(2, 477) = 0.25$; $p = 0.78$], significant differences were found among zones for all tasks as shown in the tables (Table 52 - .

Table 52. Main Effects of Sound Variables for by Building

Task 1				
Bldg ID	L_99_dBA		L_95_dBA	
	F-value	P-value	F-value	P-value
001	12.017	<0.001	36.989	<0.001
002	81.686	<0.001	42.987	<0.001
003	1.589	0.236	4.612	0.014
004	5.129	0.011	4.798	0.014
005	3.113	0.050	8.480	0.001
006	4.702	0.013	14.195	<0.001
007	11.396	<0.001	23.483	<0.001
008	9.504	0.001	47.483	<0.001
009	6.290	0.004	5.986	0.005
010	9.619	0.001	8.445	0.002
Task 13				
Bldg	L_99_dBA		L_95_dBA	
	F-value	P-value	F-value	P-value
S01	2.640	0.078	1.875	0.173
S02	7.863	0.002	6.164	0.005
S03	7.253	0.002	7.834	0.002
S04	4.976	0.011	5.477	0.007
S05	0.636	0.677	0.312	0.897
S06	12.890	0.004	29.758	<0.001
S07	17.263	<0.001	19.600	<0.001
S08	0.866	0.531	0.592	0.707
S09	9.566	0.001	14.721	<0.001
S10	9.324	0.001	7.724	0.002
Task 0606				
Bldg ID	L_99_dBA		L_95_dBA	
	F-value	P-value	F-value	P-value
HPB01	Excluded			
HPB02	9.370	0.008	9.703	0.008
HPB03	46.353	<0.001	50.595	<0.001
HPB04	28.004	<0.001	31.030	<0.001
HPB05	1.669	0.216	1.853	0.177
HPB06	14.348	<0.001	14.390	<0.001
HPB07	3.167	0.047	3.055	0.052
HPB08	22.890	<0.001	24.930	<0.001
HPB09	8.233	0.001	9.398	0.001
HPB10	68.208	<0.001	57.686	<0.001

Table 53. L_99_dBA for Task 1 by Zone

Zone Comparison	Building ID									
	001	002	003	004	005	006	007	008	009	010
Main Effect	<0.001	<0.001	0.236	0.011	0.050	0.013		0.001	0.004	0.001
1v2		<0.001	not per-formed							0.007
1v3		<0.001								
1v4		<0.001								
1v5		<0.001								0.011
1v6		0.008						0.020		0.001
2v3		0.040		0.033				0.003		
2v4		0.004								
2v5		<0.001								
2v6	0.002	0.015					0.002		0.027	
3v4								0.012		
3v5		0.001						0.014		
3v6		<0.001					0.037	0.001		
4v5		0.010								
4v6	0.002	<0.001			0.034		0.002			
5v6	0.017	<0.001					0.009			

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

= Equal variances, but unequal samples among zones; post-hoc via Bonferroni's test

003 Post-hoc tests not performed due to non-significant main effect

Table 54. . L_95_dBA for Task 1 by Zone

Zone Comparison	Building ID									
	001	002	003	004	005	006	007	008	009	010
Main Effect	<0.001	<0.001	0.014	0.014		<0.001	<0.001	<0.001	0.005	0.002
1v2		<0.001				0.005				0.010
1v3		0.001								
1v4		<0.001				0.006		0.039		
1v5		<0.001						0.039		
1v6								0.017		0.005
2v3						0.049				
2v4						0.001				0.048
2v5		0.018								
2v6	0.001	<0.001			0.021		0.014		0.036	
3v4			0.008					0.003		
3v5		0.001	0.040					0.042		
3v6	0.010	0.001			0.027		0.033	0.001	0.031	
4v5		0.009					0.041			
4v6	<0.001	<0.001					0.004	0.001		0.026
5v6	0.022	<0.001					0.001			

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

= Equal variances, but unequal samples among zones; post-hoc via Bonferroni's test

Table 55. L_99_dBA for Task 13 by Zone

Zone Comparison	Building ID									
	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Main Effect	0.078	0.002	0.002	0.011	0.677	0.004	<0.001	0.531	0.001	0.001
1v2	not performed	0.013			not performed		0.009	not performed		
1v3										
1v4			0.003							
1v5			0.041	0.041			<0.001			
1v6						0.028	0.014			
2v3										
2v4						0.025	0.02			
2v5		0.003					0.046			
2v6						0.006				
3v4						0.024				
3v5		0.027		0.023			0.001			0.014
3v6						0.006				0.006
4v5		0.015					<0.001			
4v6							0.032			
5v6		0.029				0.024	0.029			

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

S01, S05, & S08 Post-hoc tests not performed due to non-significant main effect

Table 56. L_95_dBA for Task 13 by Zone

Zone Comparison	Building ID									
	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Main Effect	0.173	0.005	0.002	0.007	0.897	<0.001	<0.001	0.707	<0.001	0.002
1v2	not performed	0.025			not performed		0.003	not performed		
1v3										
1v4			0.007			0.018				
1v5			0.039	0.023			<0.001			
1v6			0.027			0.003	0.008			
2v3										
2v4			0.007			0.002	0.008			
2v5		0.005	0.039	0.033						
2v6			0.027			0.001				
3v4						0.005				
3v5		0.050		0.018			<0.001			0.009
3v6						0.001			0.037	0.004
4v5		0.043				0.013	<0.001			
4v6							0.019			
5v6						0.002	0.027			

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

S01, S05, & S08 Post-hoc tests not performed due to non-significant main effect

Table 57. L_99_dBA for Task 0606 by Zone

Zone Comparison	Building ID									
	HPB01	HPB02	HPB03	HPB04	HPB05	HPB06	HPB07	HPB08	HPB09	HPB10
Main Effect	Excluded	0.008	<0.001	<0.001	0.216	<0.001	0.047	<0.001	0.001	<0.001
1v2			0.017	0.008	not performed	0.035				<0.001
1v3			0.003	0.019			0.010	0.005		<0.001
1v4			0.012			0.015		<0.001		
1v5				0.001			0.013	<0.001		
1v6			<0.001					0.002		
2v3			<0.001	<0.001			0.020			<0.001
2v4			0.001	<0.001		<0.001		0.004		<0.001
2v5				<0.001			0.026	<0.001		<0.001
2v6		0.047	0.001	0.046		0.005			0.011	0.001
3v4						0.008				<0.001
3v5							0.045	0.005		<0.001
3v6		0.026		0.004					0.011	<0.001
4v5						<0.001				
4v6		0.010		0.024					0.009	
5v6		0.007		<0.001		0.041		0.012	0.001	0.027

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

HPB05 Post-hoc tests not performed due to non-significant main effect

HPB01 Excluded due to several zones not measured

Table 58. L_95_dBA for Task 0606 by Zone

Zone Comparison	Building ID									
	HPB01	HPB02	HPB03	HPB04	HPB05	HPB06	HPB07	HPB08	HPB09	HPB10
Main Effect	Excluded	0.008	<0.001	<0.001	0.177	<0.001	0.052	<0.001	0.001	<0.001
1v2			0.004	0.004	not performed	0.039	not performed			<0.001
1v3			<0.001	0.016				0.002		<0.001
1v4			0.009			0.016		<0.001		
1v5				0.001				<0.001		
1v6			0.003					0.003		
2v3			<0.001	<0.001						<0.001
2v4			0.002	<0.001		<0.001		0.004		<0.001
2v5				<0.001				<0.001		<0.001
2v6		0.044	0.001	0.019		0.008			0.007	<0.001
3v4						0.003				<0.001
3v5								0.004	0.012	<0.001
3v6		0.021	0.038	0.004						<0.001
4v5						<0.001				
4v6		0.008		0.021					0.006	
5v6		0.007		<0.001		0.041		0.004	0.001	

Notes: Post-hoc tests not highlighted are performed via Dunnett's T3 (unequal variances as confirmed by Levene's Test)

= Equal variances as confirmed by Levene's test; post-hoc via Tukey's HSD

HPB05 & HPB07 Post-hoc tests not performed due to non-significant main effect

HPB01 Excluded due to several zones not measured

4. INTERPRETATION OF THE DATA

This task was focused on interpretation of the statistical analysis to provide conclusions as to the robustness of the monitoring package in providing reliable building measurement data with a finite number of monitoring stations and a limited time frame for monitoring. It is expected that this interpretation will increase the utility of the data and provide previously available information.

4.1 IEQ

Table 1 demonstrated that Thursday measures were significantly different from Tuesday, and most Wednesday measures for all variables of Tasks 1 & 13. Data for all three days appeared to vary for Operative Temperature, whereas only Tuesday and Thursday differed for Draft Rate 1m. Although no Draft Rate measures within Task 0606 were found to significantly differ by-day, Temperature measurements for Tuesday and Thursday showed variation. Moreover, Wednesday measurements of Relative Humidity within Task 0606 varied significantly from either Tuesday or Thursday.

As shown in Tables 2-31, the majority of differences by-zone were highly significant ($p<0.001$), with the exception of Relative Humidity in some buildings. Although all zone comparisons are listed in the tables, several zones were excluded due to lack of collection of measurements for one of the zones. For example, if no data were acquired for Zone 3 of a particular building, then all post-hoc analyses against Zone 3 were excluded. Additionally, Bldg 02 zone 1 of Task 0606 only contained two points of data, and thus was excluded from all variable comparisons.

4.2 Airborne and Surface-associated Mold

When all task data were combined (30 buildings) neither the airborne culturable fungi nor the airborne non-culturable spore data differed in the concentrations found at any indoor location in terms of day of collection. However, the concentrations of surface-associated fungi varied among the day of collection. Specifically, there was a lower concentration of mold on Tuesday than on Wednesday, for all tasks combined.

As expected, variation was found in the concentrations of both airborne culturable fungi and airborne non-culturable fungal spores between indoor zones (1-6) and the outdoor zone (zone 0). No variation was found among the indoor zones of office buildings for Task 1 in the concentrations of airborne culturable fungi. However, airborne non-culturable spores did vary among zones in one building in Task 1 and variation was noted between zones in surface-associated fungi.

4.3 Lighting

Due to the lack of multiple measurements for Tasks 13 and 0606, by-day comparisons were only performed for Task 1. No statistical differences were observed with respect to the day of collection. There was a wide range of variability by-zone among seven of the office buildings. Although few differences were found for IllumWkSfcBrtst and IllumWkSfcDrkst in Task 1, there was a great amount of variation for these variables in Tasks 13 and 0606 ($p < 0.001$). Other variables that differed by-zone in Task 13 include CombCCT and AmbCCT1 for S03, S07, and S08. Additionally, AmbChromX1, CombChromY, and CombChromX varied by-zone for school buildings S02, S04, and S05, respectively.

4.4 SOUND

Tables 52a-52c provide an overview of the variability among each building within each task. Although all tasks demonstrated significant differences by-zone, some of the buildings within each task did not appear to differ in sound quality. Hence, post-hoc tests were not appropriate and individual zones were not compared for these buildings. As shown in Tables 55 and 56, buildings S01, S05, and S08 do not provide further information beyond the p-value of the main effect.

It is interesting to note that some buildings were widely varied with most zone comparisons and other buildings varied between only a few zones. For instance, Table 53 shows that the difference between zones for O02 were highly significant except in the comparison of zones 3 and 4. Whereas, for O04, only zones 2 and 3 differed from each other. Another pattern observed was a major difference of a single zone as compared to all other zones. As can be seen in Table 58, of the zones in HPB02, only zone 6 appeared to differ from the other zones with the exception of zone 1.

5. JOURNAL ARTICLE

This task was focused on the submission of an article to a peer reviewed journal describing the results of the statistical analysis and interpretation, and recommendations for a reliable monitoring strategy for assessing indoor environmental quality in the built environment. This journal article will provide dissemination of previously unavailable information on energy usage, building characteristics and indoor environmental quality measurement data in buildings across the United States.

A journal article detailing the results of the mold data is in the final stages before submission to a peer-reviewed journal focusing on indoor air quality and monitoring issues.

6. REFERENCES

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NATIONAL CENTER FOR ENERGY MANAGEMENT AND BUILDING TECHNOLOGIES

601 NORTH FAIRFAX STREET, SUITE 250

ALEXANDRIA, VA 22314

WWW.NCEMBT.ORG