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Report for
Fungal Air Sampling

25 Sigourney Street
Hartford, CT

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Executive Summary

Air sampling was conducted at the building located at 25 Sigourney Street in Hartford, CT on November 3rd, 2000. The purpose of the sampling was to determine if areas within the building contained elevated fungal spore levels after remediation of wallboard on the 17th, 18th, and 19th floors was completed. Air sampling was performed for general indoor air quality parameters and air samples were also collected for cultureable fungal spores and total fungal spores.

The building has had a history of moisture incursion from rainwater and samples of wallboard that was repeatedly wetted identified fungal growth and amplification. Remediation specifications were developed to remove wallboard that was repeatedly exposed to rainwater and replace it with "greenboard", a substitute for wallboard that does not provide a good nutrient source for fungal growth. The contractor performing the remediation was monitored during the remediation project, which was performed when the areas were unoccupied.

There are no formal standards for cultureable fungal or total fungal spore levels. The guide generally accepted is that inside levels are lower than outside levels and the types of fungi found inside is similar to those found in outside air. Results of the cultureable and total fungal spore samples inside were at least four (4) times lower than the levels outside. We did find some fungal species inside a couple of areas that were not found in the outside air samples but the levels were very low.

The general indoor air quality parameters monitored were within acceptable levels except for relative humidity. Relative humidity levels are usually below recommended comfort levels during the winter months when cold outside air that contains little moisture is heated.

Recommendations are included in this report to communicate the results of this survey with building occupants, keep track of occupant symptoms, further improve the air quality of the building, implement a formal indoor environmental quality program, and perform follow-up evaluations if occupant symptoms continue or worsen.

Results

General Indoor Air Quality Parameters

Carbon dioxide is measured to assist in the evaluation of indoor air quality. Carbon dioxide is a natural exhalation product of human respiration and is also a component of outside air. Carbon dioxide levels in outside air will range from 300 to 400 parts per million (ppm) and when the amount of fresh air brought into a building is not adequate based upon the number of occupants present, then carbon dioxide levels inside will often reach and exceed 1,000 ppm.

On the day of the survey, the carbon dioxide level outside was 350 ppm. Carbon dioxide levels inside are primarily affected by the number of occupants in the area being monitored and the amount of fresh outside air brought into the area. The American Society of Heating, Ventilating,

and Air Conditioning Engineers (ASHRAE) recommends that indoor levels of carbon dioxide be kept below the combined total of 700 ppm plus the outdoor levels. For this building, the ASHRAE recommended maximum level would be 1,050 ppm. The carbon dioxide levels in the areas monitored ranged from 525 to 725 ppm. All areas were within the ASHRAE guidelines. Results for carbon dioxide are included in Appendix A.

The carbon monoxide levels outside are typically less than 1 ppm, and were undetected outside and inside the building on the day of the survey. Carbon monoxide results are included in Appendix A.

ASHRAE recommends that indoor temperatures range from 68.5°F to 76.0°F during the winter months. All temperatures were within the acceptable ASHRAE recommended range. The relative humidity levels in all areas monitored were below the ASHRAE recommended range of 30-60%. *It is typical for the relative humidity levels inside buildings to be below the ASHRAE recommended range in the winter months.* The temperature and relative humidity results are included in Appendix A.

Cultureable Fungal Air Samples

One location outside and eleven locations inside the building were sampled in the morning and afternoon for cultureable fungi. The results for each of the samples are included in Appendix B.

When we evaluate results of cultureable airborne fungal spores, we first look at the total number of colony forming units for each type of species and compare them with outside results. We want to see the levels lower inside than outside. In buildings with mechanical filtration systems such as 25 Sigourney Street, we would expect the airborne fungal levels indoors to be less than outside levels. *All of the inside locations were at least four times lower than the outside location.*

Next we look at the rank order of the species found inside and compare them with outside species. Cladosporium, Basidiomycetes, and Penicillium were the predominant outside fungal species. No fungal growth was present for both the morning and afternoon samples for two of the inside locations. Cladosporium was one of the predominant species for six (6) of the inside locations. Two of the inside locations had Penicillium as one of the predominant species along with a variety of other species at very low levels. One location had Rhizopus stolonifer as the predominant and only species found but the level was also very low.

Next we look for any unusual species found in inside samples that are not in the outside samples. Five of the inside sample locations had species that were not found outside. This is only significant if the same species was found in many locations and not outside or if the total number was significantly high. Only one (16th Floor, Zone 7) of the five sample locations would be considered unusual because three of the four species found in this location were not found outside. The levels for each of these species, however, were very low.

Total Fungal Spore Counts

Four total fungal spore samples were taken inside the building and one sample was taken outside for comparison purposes. The results are included in Appendix C. The results of the spore counts indicate that low levels of fungi spores were present for the inside locations sampled.

We also look at the total fungal spore counts in the same manner as the cultureable airborne fungal spore levels. The total number of fungal spores was very low for all of the inside locations. The only significant finding was that the Aspergillus/Penicillium spores were present in two of the inside samples and not in the outside sample. However, the levels of Aspergillus/Penicillium spores for the two inside locations were very low and are not unusual for inside office building with no moisture problems.

Discussion

Moisture Incursion

Rainwater incursion has occurred primarily near the balconies on the 17th and 19th floors of the 20 story building. The 19th floor has balconies at the corner office areas and the 17th floor has balconies between the corner office areas. Water incursion for the 18th floor occurred primarily around the windows but also below the corner offices in some areas.

Microbial growth and amplification usually results whenever soft building materials such as wallboard are allowed to remain wet for more than 48 hours or are repeatedly wetted. The thin paper on both sides of wallboard provides a good nutrient source for fungal growth that has been repeatedly wetted.

Bulk samples were collected of the wallboard in areas with visible moisture exposure indicated potential fungal growth and amplification occurred. Results indicated that the wallboard in areas repeatedly wetted needed to be removed. Remediation specifications were developed to address removal of wallboard that was repeatedly wetted. Remediation was only performed during non-occupancy periods and protective measures were required to limit dispersion and protect remediation personnel.

The remediation specifications divided areas to be remediated into four (4) categories based upon the amount of wallboard that needed to be removed. Level 1 was assigned to areas that were less than 10 square feet, Level 2 was for areas greater than 10 but less than 30 square feet, Level 3 was between 30 and 100 square feet and Level 4 was anything greater than 100 square feet. The majority of areas identified for remediation were Level 1 and 2 and none of the areas were Level 4.

Remediation of the wallboard began on September 11th and was completed in early November of 2000. Most of the Level 2 and 3 remediation areas were completed during September. The remediation contractor employees performing the remediation were required to have special training. Either someone from Occupational Risk Control Services, Inc., or Tunxis Property

Management oversaw the remediation work to ensure the contractor followed the remediation specifications.

Carbon Dioxide, Carbon Monoxide, Temperature, And Relative Humidity

The temperature, carbon dioxide, and carbon monoxide levels were within the ASHRAE recommendations for all areas monitored. We recommend that temperatures be kept at the lower end of the ASHRAE range because it is easier for occupants to add clothing and air quality is often perceived as being better when the air is cooler. Carbon monoxide is usually present where combustion is occurring and we would not expect to find carbon monoxide inside unless it was brought in from the outside.

The occupant density was low for most of the areas monitored and the Heating, Ventilating, and Air Conditioning (HVAC) system is providing adequate quantities of fresh outside air for the number of occupants present on the day of the survey. We would not expect elevated carbon dioxide levels as long as the occupant density did not increase significantly and the HVAC system continues to bring in adequate quantities of fresh outside air.

The relative humidity levels within the areas monitored were below the ASHRAE recommended range of 30-60%. During the winter months in northern climates, it is common to find lower indoor relative humidity levels, especially when cold outside air is brought in and heated. Low relative humidity can cause eye and upper respiratory irritation and may also be responsible for dry skin. We do not recommend the use of humidifiers since they can create microbial growth problems. We suggest persons affected by the low relative humidities to drink plenty of fluids and use moisture creams.

Cultureable Airborne Fungal Spore Sample Results

A comparison of the outside samples to the inside samples indicated that low levels of cultureable fungal spores were present in the areas monitored during the survey. Ten of the twenty two samples did not contain any microbial growth. This indicates that adequate quantities of fresh outside air were being brought in and filtered at the main air handling units and the variable air volume (VAV) units.

Two of the cultureable airborne fungal samples had *Stachybotrys chartarum.* This is unusual to find this fungus using the sampling protocol we followed. It is significant in that we found this fungus on two samples, however the levels were extremely low. We did not find *Stachybotrys chartarum* spores on the Total Fungal Spore sample (Sample A-1) taken in one of the same areas that identified *Stachybotrys chartarum* in the cultureable airborne fungal sample. The Total Fungal Spore samples are more likely to identify fungal growth and amplification because the samples are taken over longer periods of time and a larger air volume is collected.

It is possible that the spores originated when the remediation was performed and either remained suspended in the air or had settled and was disturbed and re-suspended prior to sampling. It is also possible that not all of the wallboard with fungal growth and amplification was removed. *Stachybotrys chartarum* requires a cellulose rich nutrient media such as the paper on wallboard

and very moist conditions for growth and amplification to occur. Keeping wallboard from getting wet would reduce the chance for further growth and amplification. The 16th floor, Zone 7 area should be evaluated for wallboard that may have been repeatedly wetted but not remediated.

Total Fungal Spore Air Sample Results

Four inside samples and one outside total fungal spore sample were taken on the day of the survey. These levels also indicated that low levels of airborne fungal spores are present inside for the locations monitored when compared to the outside sample.

We take total fungal spore air samples in conjunction with cultureable airborne fungal samples because not all fungal species are able to survive the cultureable airborne fungal sampling protocol. The total fungal spore air sampling methodology is also not used by itself because it has several limitations. One limitation is that fungal spores can only be identified and grouped by genus and not by species.

Occupant Symptoms

Four employees were interviewed during the survey. Employees reported symptoms that they believed were caused by the air quality in the building. Symptoms included difficulty breathing, coughing, skin itchiness, rashes, skin swelling, dizziness, headaches, burning nostrils, and dry mouth.

Conclusion

Results from the cultureable airborne fungal spore and total fungal spore samples were very low. These results are only representative of a short time period but are similar to counts of fungal spores that we typically find in areas with few indoor air quality symptoms. The only area that had what we would consider unusual results was the 16th floor, zone 7. This area should be evaluated for possible moisture incursion sources.

It is very important that water incursion into the building be eliminated. The wallboard that was remediated and replaced with "greenboard" should not support fungal growth and amplification even if it gets wet. Wallboard that was not remediated and is exposed to moisture incursion can allow for microbial growth and amplification to occur.

Occupants continuing to experience symptoms believed to be related to the building air quality should all be referred to an occupational health physician. A more detailed evaluation including a review of the air handling system may be needed if occupants continue to experience symptoms and the occupational health physician believes they are related to air quality of the building.

Recommendations

1. **Provide the results of this report to facility occupants.**

   It is important that all persons working in the offices that were monitored be informed of the results of this survey. Information should include results of monitoring, remediation efforts, and follow-up procedures. Informational meetings should be held with room occupants and feedback should be encouraged.

2. **Building occupants that experience symptoms they believe are related to the building should use a symptom log.**

   Building occupants experiencing symptoms should keep track of them using a log. A copy of a log was previously faxed so occupants can keep track of their symptoms. This log should help to identify any patterns and help develop hypotheses of possible causes. The logs, once completed, should be submitted to Human Resources.

   An Occupational Health Physician should then be involved in reviewing occupant symptoms and addressing any further symptoms that may arise. Persons experiencing dermatitis are seeing different physicians, which makes it difficult to determine if they are all experiencing the same exposure.

3. **Eliminate the possible air pathways between wall cavities and occupied areas.**

   There is a space between the greenboard and the windows in several areas that were remediated. This space allows air exchange between the occupied area and the space inside of the walls where fungal growth was identified. These areas should be resealed to ensure that air within the walls does not enter occupied areas.

   Also seal any areas above the ceiling tiles where air from the exterior wall cavities can migrate to the VAV boxes. During the wallboard remediation where ceiling tiles were lifted, several areas had a gap where air from the wall cavities could migrate into the return air plenum above the ceiling tiles. Caulk or seal the space between the wallboard and the building concrete or brick columns so that air inside the wall cavities does not enter the ceiling plenum.

4. **A formal written program should be developed to address indoor air quality issues and concerns and how they will be addressed.**

   A formal written program should be developed for indoor environmental quality issues. The log discussed in Recommendation 2 should be a part of this formal program. The formal program should include mechanisms for ensuring follow-up action is taken to address building occupant issues and concerns that may be related to the building environmental quality. A mechanism is also needed to ensure that communication between all parties involved occurs and feedback to building occupants is occurs in a timely manner.

5. **If occupant symptoms continue or worsen and recommendations have all been implemented, a more detailed evaluation may be needed.**

Remediation of the wallboard known to have been exposed to water or exhibited visible signs of water exposure should improve the building air quality. Removal of the carpets in those areas repeated exposed to rain water should also help to improve the building air quality.

Eliminating moisture incursion into the building should reduce the chance for additional microbial growth and amplification. Removing soft building materials already identified with microbial growth and amplification from the wallboard and carpeting should reduce and hopefully eliminate symptoms possibly related to exposure.

If occupant symptoms continue or worsen after completing the recommendations and moisture incursion has been eliminated, a more detailed evaluation may be needed. This may include an evaluation of the air handling systems since they were not reviewed during this survey.

Methods

The carbon dioxide, temperature, relative humidity, and carbon dioxide levels were monitored using a TSI Q-Trak Model 8551 (Serial No. 30295) monitor. The instrument measures carbon dioxide levels using non-dispersive infrared absorption (NDIR). The TSI Q-Trak detection range is from 0 to 5,000 parts of carbon dioxide per million parts of air (ppm) with a +/- 1 ppm sensitivity. Measurements were rounded up or down to the nearest 25 ppm value once the meter readings stabilized.

The monitor was calibrated prior to the survey using a calibration gas mixture. The instrument was calibrated with a gas mixture that is traceable to National Institute of Standards (NIST). The calibration procedure recommended by TSI was followed.

The cultureable fungal air sampling was conducted according to the Occupational Risk Control Services, Inc. Method No. 3. The total fungal spore sampling was conducted according to the Occupational Risk Control Services, Inc. Method No. 4. The samples were delivered overnight to an American Industrial Hygiene Association (AIHA) accredited laboratory, P&K Microbiology Services, located in Cherry Hill, NJ.

An effort was made to provide a professional evaluation of indoor air quality exposures. It must be noted there are inherent limitations to any survey project. These limitations may be due to time constraints, operational and work practice variability, and seasonal conditions. The results of this survey are representative of conditions present on the day of the survey. Conditions or operations not evaluated, or reported on, should not be assumed to be without risk.

Appendix A

Carbon Dioxide, Carbon Monoxide, Temperature, and Relative Humidity Measurements

25 Sigourney Street
Hartford, CT

November 3, 2000

LOCATION	SAMPLE TIME	CARBON DIOXIDE (ppm)	TEMP (^{0}F)	RELATIVE HUMIDITY	CARBON MONOXIDE (ppm)	OCCUPANCY	COMMENTS
19TH Floor	9:45am	725	73	28	<1	2	1 of 2 doors open:
Rm 1938	2:07pm	700	71	28	<1	2	carpeted
19th Floor	10:07am	700	72	29	<1	1	1 of 1 doors open:
Rm 1914	2:19pm	625	71	30	<1	0	carpeted
18th Floor	10:32am	600	72	28	<1	0	1 of 1 doors open:
Rm 1831	2:44pm	550	70	26	<1	0	carpeted
17th Floor	10:46am	675	74	28	<1	3	Open area
Zone 1	2:44pm	700	73	26	<1	2	
17th Floor	10:55am	625	74	26	<1	1	Open area: carpeted
Zone 6	2:51pm	625	74	24	<1	0	
17th Floor	11:05am	875	74	27	<1	3	Open area: plastic bag
Zone 3	3:00pm	700	74	25	<1	1	vent to office
17th Floor	11:22am	750	74	26	<1	2	Open area: carpeted area
Zone 3	3:10pm	700	74	25	<1	1	
14th Floor	11:34am	550	74	26	<1	1	Open area: carpeted area
Zone 7	3:23pm	575	73	23	<1	0	

Appendix A

Carbon Dioxide, Carbon Monoxide, Temperature, and Relative Humidity Measurements

25 Sigourney Street
Hartford, CT

November 3, 2000

LOCATION	SAMPLE TIME	CARBON DIOXIDE (ppm)	TEMP (^{0}F)	RELATIVE HUMIDITY	CARBON MONOXIDE (ppm)	OCCUPANCY	COMMENTS
5th Floor Zone 6/7	12:02pm 3:40pm	725 700	75 72	25 26	<1 <1	0 0	Open area: in front of fax
6th Floor Zone 7	12:20pm 3:50pm	700 725	74 74	27 27	<1 <1	0 0	Open area: carpeted
16th Floor Zone 7	12:37pm 4:07pm	650 525	76 74	24 23	<1 <1	0 0	Open area
Outside 17th Floor Balcony	1:05pm 4:42pm	350 350	60 62	24 28	<1 <1	N/A	

ppm = parts per million

Appendix B

Cultureable Fungal Air Sample Results

25 Sigourney Street
Hartford, CT

November 3, 2000

Sample Number	Location	Fungal ID	Concentration (CFU/m^3)	Percentage (%)
1	Rm 1938	No Growth	<7	NA
2	Rm 1914	Rhizopus stolonifer	7 Total 7	100
3	Rm 1831	Cladosporium	7 Total 7	100
4	17th Floor Zone 1	Penicillium	7 Total 7	100
5	17th Floor Zone 6	Aureobasidium pullulans Cladosporium	7 7 Total 14	50 50
6	17th Floor Zone 3	Phoma	7 Total 7	100
7	17th Floor Zone 3	Cladosporium	7 Total 7	100
8	14th Floor Zone 7	No Growth	<7	NA
9	5th Floor Zone 6/7	Cladosporium	7 Total 7	100
10	6th Floor Zone 7	No Growth	<7 Total 7	NA
11	16th Floor Zone 7	Epicoccum nigrum Penicillium Rhodotorula glutinis Stachybotrys chartarum	7 7 7 7 Total 28	25 25 25 25
12	Outside	Alternaria alternata Basidiomycetes Cladosporium Penicillium Yeasts	7 29 79 14 7 Total 136	5 21 58 11 5
13	Rm 1938	Cladosporium	7 Total 7	100
14	Rm 1914	No Growth	<7	NA

Appendix B

Cultureable Fungal Air Sample Results

25 Sigourney Street
Hartford, CT

November 3, 2000

Sample Number	Location	Fungal ID	Concentration (CFU/m^3)	Percentage (%)
15	Rm 1831	No Growth	<7	NA
16	17th Floor Zone 1	Aspergillus versicolor Stachybotrys chartarum	7 7 Total 14	50 50
17	17th Floor Zone 6	No Growth	<7	NA
18	17th Floor Zone 3	Cladosporium	7 Total 7	100
19	17th Floor Zone 3	No Growth	<7	NA
20	14th Floor Zone 7	No Growth	<7	NA
21	5th Floor Zone 6/7	Cladosporium Yeasts	7 7 Total 14	50 50
22	6th Floor Zone 7	No Growth	<7	NA
23	16th Floor Zone 7	No Growth	<7	NA
24	Outside	Alternaria alternata Aspergillus versicolor Cladosporium Penicillium Pithomyces chartarum Rhodotorula glutinis	14 7 179 14 7 7 Total 228	6 3 78 6 3 3

ID = identification
CFU/m^3 = colony forming unit per cubic meter of air

Appendix C

Total Fungal Spore Counts

25 Sigourney Street
Hartford, CT

November 3, 2000

Sample Number	Location	Presumptive Fungal ID	Fungal Structures /m^3
A-1	16th Floor Zone 7	Asp./Pen-like Basidiospores	357 357 Total 714
A-2	17th Floor Zone 3	Basidiospores	911 Total 911
A-3	19th Floor Outside	Ascospores Basidiospores Cladosporium Rusts	340 11,550 3,737 340 Total 15,966
A-4	19th Floor Room 1937	Asp./Pen.-like Basidiospores Cladosporium	685 343 343 Total 1,371
A-5	6th Floor	Basidiospores Cladosporium	344 344 Total 389

ID = identification
m^3 = cubic meters of air