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LaCroix Davis LLC

Vinyl Composite Tile Investigation

450 N Street, Sacramento, California

Report

Project No. 2372.02-572

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1. BACKGROUND

Facility historical records and more recent discussions with occupants have indicated the presence of musty odors of unknown origin on the 21st floor. From December 11, 2009 through April 1, 2010, the 21st floor was turned over to the Department of General Services (DGS) Project Team as part of the building mold remediation project. During this period, multiple measures were taken to identify and eliminate any possible sources of the odors. An extended period of time (greater than that spent on other non-odor floors) was spent in making sure the floor had been thoroughly investigated and remediated wherever warranted. In April 2010, the floor was returned to the Board of Equalization (BOE) for re-occupancy.

During the ensuing year, complaints of odors appeared to be non-existent. However, in March 2011, the DGS-BOE Project Management Team was notified by BOE Management that odors were once more reported on February 24th on the 21st floor. After a discussion between the floor occupants, Hygiene Technologies Inc. (HTI) and LaCroix Davis LLC (LCD), it was revealed that the floor occupants had begun experiencing the musty odors only a short time after re-occupying the floor in April 2010.

On March 4, 2011, Liz Houser, BOE Deputy Director Administration, met with representatives from DGS, HTI, and LCD to discuss the recent odor complaints. It was in Ms. Houser's meeting that an odor investigation of the 21st floor was initiated, which eventually included investigations of the building heating, ventilation, and air conditioning (HVAC) system and floor coverings, in the form of vinyl composite tile (VCT).

This report is a summary of the VCT component of the investigation. The HVAC component will be addressed in a later summary report. The table in section 2 lists the series of events that occurred during the project team's VCT investigation. It was not until the latter part of March 2011 that the investigation team noticed a strong odor associated with the deteriorating adhesive beneath the VCT. It was this discovery that led to a detailed evaluation of the VCT in the building, starting with the 21st floor.

2. THE INVESTIGATION

The VCT investigation included activities by all of the members of the DGS BOE Remediation Project Team, including project managers, industrial hygienists, architects, and other project contractors/consultants. The following table outlines (in chronological order) the activities that occurred during the VCT investigation:

Chronology of VCT Investigation Events

Activity Date	Event Description	Present or Performed By	Conclusions/Comments
2/24/11	Odors on 21st floor initially reported to HTI	HTI	HTI records event and continues to track as part of their monitoring duties.
3/4/11	**Initiating Event:** Odor investigation meeting with Liz Houser to address new odor complaints	DGS, BOE, LCD, HTI	Floor occupants immediately began to smell odors on return to the floor.
3/19/11	21B first time VCT tiles lifted and strong odors noted.	LCD, HTI, JLS	Tested adhesive did not indicate mold growth.
3/24/11	Begin containments F21 VCT rooms starting in 21B, remove VCT and adhesive. Expands to 21D stained wall materials and delamination of VCT strong odor, then on to 21E.	LCD, HTI, JLS	First time strong odors attributed to VCT and adhesive.
3/25/11	F21 Inspection of carpet tile and concrete by quadrant begins.	LCD, HTI, JLS	Not all carpet tiles that were inspected were stained.
3/28/11	F21 Sample taken on joint compound beneath carpet tile under NE water fountain indicates visible mold growth (VMG). Testing of water fountains also includes hard ceiling.	LCD, HTI, JLS	DGS authorizes testing of all hallways and elevator lobbies in F21 with carpet tile,
4/1/11	Begin inspection in F21 core halls and elevator lobby – carpet/concrete - observe three conditions: 1) stains on level compound, 2) splotchy patches on adhesive and 3) stains in concrete cracks	LCD, HTI, JLS	Based on the finding of fungal growth beneath the carpet at one of the locations in the hallway, HTI made a recommendation to DGS for the inspection of the remaining hallway and elevator lobby carpet (concern was for any additional fungal growth).
4/4/11	F21 begin core hall carpet and adhesive removal + all rooms with VCT	LCD, HTI, JLS	VMG on the leveling compound and cracks
4/7/11	F21 begin removal of all core areas (rooms and halls) adhesive (carpet and VCT) to test concrete	LCD, HTI, JLS	
4/11/11	Construction Services & Investigations, Inc. (CSI) preps for concrete testing F21 (limited carpet tiles removed for access).	CSI LCD, HTI, JLS	pH and moisture testing: RH was normal (<75%); all pH was elevated between 10 -14
4/26/11	CSI Concrete Slab Testing Report	CSI	CES report released indicating high variation in pH
5/2/11	CE Schmidt (CES) Draft Technical Memorandum - Results of the May 2, Surface Flux Chamber Testing and Ambient Air Testing at the DGS Building Located in Sacramento, California (included pH testing)	CES	CES determines that floor tile adhesive is one of the sources of odor.

Chronology of VCT Investigation Events (cont.)

Activity Date	Objective	Present or Performed By	Conclusions/Comments
5/6/11	CES releases odor panel results	CES	CES identifies list of chemicals that may be the source of odor on the floors.
5/16/11	CES Technical Memorandum #1 released.	CES	
5/20/11	Gordon Bizieff reviews F21, 22, 23 re: decks and concrete VCT adhesive issues	LCD	Forensic Architect evaluated VCT replacement options.
6/2/11-6/5/11	CaCl moisture testing room 21B following JLS bead blasting	LCD	Bead blasting had no apparent effects on moisture content of concrete floor
6/17/11	Begin VCT visual inspection all floors and areas with committee (complete Floors 24 to 17)	LCD, DGS, HTI, BPM, BOE	Survey to determine extent of VCT odor and deterioration throughout building
Need date	Remove VCT and adhesive in rooms 22B and 2222; on F21 trim base of GB walls to accommodate application of thin set on concrete.	LCD, DGS, HTI,	Evaluating VCT replacement methodology
6/21/11	VCT inspection Floors 16 to 6 pH Testing by LCD	LCD, DGS, HTI, BPM, BOE	Survey to determine extent of VCT odor and deterioration throughout building
6/22/11	VCT inspection Floors 5 to 1	LCD, DGS, HTI, BPM	Survey to determine extent of VCT odor and deterioration throughout building
6/23/11	VCT inspection of miscellaneous rooms that were inaccessible during initial surveys	LCD, HTI	Survey to determine extent of VCT odor and deterioration throughout building
7/13/11	CES returns to collect additional air samples.	CES, LCD	Additional samples collected to strengthen data set used to make decisions regarding VCT replacement
8/12/11	pH Testing by LCD	LCD	To determine extent of high pH conditions beneath VCT in building
8/20/11	Avomeen Analytical Services (AAS) collects VCT field samples	AAS, LCD, JLS	To identify the chemical processes that may be responsible for the breakdown of the VCT adhesive
9/3/11	pH Testing by LCD	LCD, JLS	To determine extent of high pH conditions beneath VCT in building
9/4/11	pH Testing by LCD	LCD, JLS	To determine extent of high pH conditions beneath VCT in building
9/22/11	pH Testing by LCD	LCD, JLS	To determine extent of high pH conditions beneath VCT in building

Chronology of VCT Investigation Events (cont.)

Activity Date	Objective	Present or Performed By	Conclusions/Comments
9/22/11	Avomeen (AAS) completes analytical report.	AAS	
10/2/11	pH Testing by LCD	LCD, JLS	To determine extent of high pH conditions beneath VCT in building
10/19/11-10/26/11	VCT Survey	LCD, DGS	To determine potential hazard of delaminating VCT (does not include perimeter tiles) See Table 3. Original and Amended VCT Survey Results

3. Subject Matter Experts

3.1. Construction Services and Investigations, Inc.

Construction Services and Investigations, Inc. (CSI) were utilized to assist in characterizing the moisture content and pH in the concrete decks of the building. CSI used a variety of ASTM methods to determine moisture content and pH in relation to floor coverings and their installation. CSI's test report is included in Appendix B.

3.2. Charles E. Schmidt, Ph.D. Environmental Consultant (CES)

Dr. Charles E. Schmidt (CES) is an expert in vapor intrusion. His services were engaged to assist in identifying the chemical identity of odors emanating from the VCT and various other surfaces of the building. Testing was conducted by CES in May and July 2011 to assess air emissions of odor and odor-related compounds from floor surfaces identified as a potential odor source during the CSI testing.

The CES May 2011 investigation included surface flux measurements and ambient air testing on Floors 19, 21, and 22. Three surface conditions were tested: 1) undisturbed VCT, 2) decomposing adhesive under VCT, and 3) floor slab where VCT and adhesive were removed as part of remodeling activities.

The CES July 2011 investigation included eight rooms selected for flux chamber and ambient air testing based on the LCD comprehensive building VCT survey. In each room, two locations were selected for flux chamber testing on VCT that showed signs of tile adhesive decomposition. In addition, an ambient air sample set was collected in each test room. The test rooms were selected based on the odor ranking in the room (high odor, moderate odor, low odor) and the condition of the VCT. Weight was also given to the location of rooms between floors so as to obtain spatial representativeness. Four rooms were selected that had high odors, and four rooms were selected that had moderate to low odors based on survey information. All eight rooms were tied into the building ventilation system.

In addition to the odors, CES also evaluated the presence of microbial volatile organic compounds (MVOC). CES reports are included in Appendices C and D.

3.3. Gordon M. Bizieff, LCD Director of Architectural Services

LCD forensic architect Gordon M. Bizieff was retained to assist with the research, analysis and preparation of recommendations to address the issues of de-bonding and odors associated with the 21st floor vinyl flooring. As part of his research, Mr. Bizieff reviewed the technical report generated by CSI and the first technical memorandum generated by CES. Mr. Bizieff is a Registered Architect in California. Mr. Bizieff's report is included in Appendix A.

3.4. Avomeen Analytical Services (AAS)

Avomeen Analytical Services is a full-service chemical testing laboratory specializing in deformulation, pharmaceutical testing, investigative analysis, product development, and chemical litigation support services. Avomeen's services were engaged to assist in identifying the chemical processes that may be responsible for the breakdown of the VCT adhesive and their potential effect on the removal and replacement with new VCT. Avomeen's analytical report is included in Appendix E.

4. Findings

4.1. CSI Test Results

The CSI testing report dated 4/26/2011 presents the results of the concrete slab testing. Calcium chloride testing of the concrete slab revealed moisture vapor emitting from the slab at the rate of 3.6 pounds per 1000 square feet over 24 hours, which is within the vinyl flooring manufacturer's recommendations and would not be deleterious to vinyl flooring performance. The relative humidity (RH) at the time of testing was documented to be below 75%. The documented RH readings are acceptable levels according to published vinyl flooring manufacturer's recommendations for flooring installation. However, the pH testing performed by CSI following ASTM F710 requirements documented pH levels in excess of 9.0 for ten out of the twelve locations tested.

4.2. CES Test Results

Two field testing events were conducted in order to assess air emissions of odor and odor-related compounds from various test surfaces in the DGS building, and indoor air quality associated with potential sources of odor and odor-related compounds. These testing efforts were considered to be a 'detailed screening effort' since only a limited data set was collected for the purposes of engineering and potential exposure evaluation.

4.2.1. MAY 2011 AIR SAMPLING EVENT

Field and laboratory quality control data indicate acceptable data quality for the methods used. System blank levels were acceptable and precision between replicate field samples were all within quality control limits.

The results of the ambient air testing in the rooms where flux chamber testing took place showed a total of three compounds detected above reporting limits for the TO-15 volatile organic compounds (VOC) full scan analysis: acetone, 2-butanone, and benzene. Levels of benzene and 2-butanone were elevated in the rooms with exposed adhesive as compared to the scraped floor or the testing with the VCT undisturbed. The highest levels of these compounds observed were: acetone at 29 $\mu g/m^3$ (Room 22B, exposed adhesive), 2-butanone at 2.2 $\mu g/m^3$ (Room 19B, exposed adhesive), and benzene at 5.7 $\mu g/m^3$ (Room 22B, exposed adhesive).

Dilution-to-threshold techniques dilute an odor sample with odorless air at a number of levels and the dilution series is presented in ascending order of odor concentration. From one level to the next, the dilution decreases and the amount of odorous air increases. The first few levels include the sample diluted with a large amount of odorless air so evaluation can begin below the threshold of detection. Preferably, multiple presentations (two odorless air samples and the diluted odor sample) are made at each level of dilution.

Odor levels were about the same in all test cases with odor ranging from 11 dilution/threshold (D/T) to 16 D/T (method blank level at 10 D/T). The highest odor (16 D/T) was observed in Room 22B prior to the VCT removal. Note that this room was only infrequently used and the door was kept closed. Also note that although the odor bag sample was not highest in this room post VCT removal, field personnel noted higher odor in Room 19 after the tile removal as compared to Room 22B. This might be related to the ventilation or traffic in and out of the room and/or when in the tile removal process the odor sample was taken as compared to the odor flux, which was highest in Room 19B.

The results of the flux chamber sampling showed a total of four compounds detected above reporting limits for the TO-15 VOC full scan analysis: acetone, carbon disulfide, 2-butanone, and benzene. The VOCs found above reporting limits in the ambient air samples strongly correlated to these data. Flux on freshly exposed adhesive surfaces was higher than on the scraped surface and the undisturbed VCT surface. The highest levels of these compounds in the flux samples were: acetone at 0.82 $\mu g/m^2$, min-1 (Room 22B, adhesive), carbon disulfide at 0.072 $\mu g/m^2$, min-1 (Room 22 B, adhesive), 2-butanone at 0.41 $\mu g/m^2$, min-1 (Room 19B, adhesive), and benzene at 2.1 $\mu g/m^2$, min-1 (Room 22B, adhesive). Odor flux ranged from an average of 0.44 $(D/T)/m^2$, min-1 on the undisturbed VCT and 0.64 $(D/T)/m^2$, min-1 on the scraped slab surface to 3.7 $(D/T)/m^2$, min-1 on the adhesive surface (Room 19B, adhesive).

Tentatively identified compound (TIC) analysis (TO-15 full scan analysis) showed a total of 14 TICs in the ambient air sample data set with acetonitrile the highest detected compound at 40 ppbv (estimated concentration), and 19 TICs in the surface flux sample data set with the highest detected compound at 57 ppbv (estimated concentration).

USEPA Method TO-11 was used to assess aldehyde compounds from two flux chamber tests conducted in Room 22B on freshly exposed adhesive. Three compounds were detected at moderately low levels: acetone, butyraldehyde, and valeraldehyde.

A 'finger print' type TO-15 analysis by selective ion-mode (SIM) was performed in an attempt to identify a pattern of VOCs associated with microbial respiration. No such pattern was observed, with the exception of occasional and low level furans and methyl furans as a class of organic compounds identified in some of the ambient air samples at low levels, and low level furans and methyl furans as well as hexanones detected in some of the surface flux samples.

These data can be used to assist in identifying odor sources in the DGS building and quantifying emissions potential from undisturbed, deteriorating VCT (Room 22B), scraped floor (Room 21B), and freshly exposed adhesive immediately after VCT removal (Rooms 19B and 22B).

4.2.2. AUGUST 2011 AIR SAMPLING EVENT

Field and laboratory quality control data indicate acceptable data quality for the methods used. System blank levels were acceptable and precision between replicate field samples were all within quality control limits.

The results of the ambient air testing in the rooms where flux chamber testing was performed showed a total of 12 VOCs and odor detected above reporting limits in one or more rooms for the TO-15 VOC full scan analysis. This list of compound is similar to the data collected during the first testing event.

The results of the ambient air testing in the rooms where flux chamber testing was performed showed a total of three of the four compounds investigated by TO-15 SIM detected above reporting limits in one or more rooms. These data provide information regarding selected compounds of interest found in the study areas.

The results of the flux chamber sampling showed a total of three VOCs and odor detected above reporting limits for the TO-15 VOC full scan analysis: acetone, dichloromethane, and 2-butanone as shown below. The VOCs found above reporting limits in the ambient air samples strongly correlated to these data. These data on undisturbed VCT show fewer compounds and lower flux rates as compared to other test data where VCT was removed, are similar to undisturbed flux data, and correlate well with ambient data, although other compounds are found in ambient air that are not similar to the flux data on undisturbed VCT and are thus related to outdoor air (building ventilation) and other indoor air sources.

The results of the flux chamber testing in the rooms showed a total of two of the four compounds investigated by TO-15 (SIM detected above reporting limits in one or more rooms. These data are useful for understanding the type and level of compounds emitted from deteriorating adhesive under undisturbed VCT.

The indoor air quality data collected during the follow-up testing event can be used to evaluate exposure by comparing these data to health-based criteria. Note that this data set is limited by the number of samples taken (one sample per room) and the frequency of testing (one event), and is not equivalent to a detailed and robust air monitoring program.

4.3. VCT ADHESIVE AND pH ASSESSMENT RESULTS

4.3.1. CST TECHNICAL REPORT REVIEW

The pH testing performed by CSI following ASTM F710 requirements documented pH levels in excess of 9.0 for ten out of the twelve locations tested. Multiple commercial flooring manufacturers, including Armstrong and Congoleum, have published maximum pH levels of 9.0 for their products and recommend testing concrete for pH levels prior to installation of vinyl floor coverings.

The results of the CSI testing on the 21st floor eliminate current high moisture as a potential cause and establish high pH as a possible source of the vinyl flooring conditions. The high pH levels are likely due to previous high moisture from inadequately cured concrete that was trapped by the installation of the vinyl flooring.

4.3.2. CES TECHNICAL MEMORANDUM #1 REVIEW

Flux chamber testing was conducted on the 21st floor in the mail center room 21B at two locations on bare slab after VCT were removed and adhesive was scraped off. One ambient air sample was collected from the room center and analyzed for the presence of VOC and MVOC. The purpose of the testing was to assess the off-gassing of odors and odor related compounds from the slab after VCT and adhesive removal, demonstrating the effectiveness of the tile remedial activity.

4.4 AAS VCT CHEMICAL IDENTIFICATION AND ANALYSIS RESULTS

For the purposes of their laboratory testing, Avomeen selected five sets of samples, based on the quality of the samples collected and to represent a wide range of room conditions, including samples with the highest odor and delamination and control samples exhibiting little to no failure.

The pH values for the five samples of concrete tested found variations in concrete pH levels from 10.1-11.2. These pH values seemed to correlate with level of odor and delamination at the original sample locations.

Fourier-Transform Infrared Spectroscopy (FT-IR) analysis found some variation between the peak heights of 'suspect' and 'control' samples. For the adhesive samples, higher IR spectral peak values correlated with greater stickiness and odor.

For the concrete samples, we found low correlation between the peak heights of various samples and the characteristics of these samples.

Gas chromatography-mass spectrometry (GC/MS) analysis could not conclusively determine the chemical composition of the odor since sufficient odorous compounds could not be collected from the samples. Some of the chemical components that were detected and identified (e.g., halogenated compounds) displayed characteristic GC profiles associated with a specific compound.

Energy-dispersive X-ray analysis (EDXA) analysis found that the three major ingredients in the concrete samples were calcium, silicon, and oxygen. The ratio of calcium vs. silicon and oxygen in these samples was higher in the odor samples vs. the non-odor samples. This increased level of calcium in samples could be the cause of higher pH values in the concrete.

Based on the data from the samples tested, we believe that the composition of the concrete is most likely leading to the failure of the adhesive, which then causes a source of odor. Concrete composition and pH values should be monitored during the installation process of any future tiling projects. Concrete with high pH levels could be treated or coated to prevent future degradation of the tile adhesive.

5. Conclusions

5.1. CSI Concrete Slab Testing

The relative humidity (RH) at the time of testing was documented to be below 75%. These readings are at acceptable levels according to published vinyl flooring manufacturer's recommendations for flooring installation. However, the pH testing performed by CSI following ASTM F710 requirements documented pH levels in excess of 9.0 for ten out of the twelve locations tested. Multiple commercial flooring manufacturers, including Armstrong and Congoleum, have published maximum pH levels of 9.0 for their products and recommend testing concrete for pH levels prior to installation of vinyl floor coverings.

5.2. Surface Vapor Intrusion Testing

The CES chemical analyses of the flux chamber and ambient air samples did not identify any hazardous chemicals in concentrations that would pose a health or safety risk to building occupants.

5.2.1 May 2011 Field Event

Odor levels were about the same in all test cases with odor ranging from 11 D/T to 16 D/T (method blank level at 10 D/T). The highest odor (16 D/T) was observed in Room 22B prior to the VCT removal. The odor flux was highest in Room 19B.
The VOCs (benzene and 2-butanone) found above reporting limits in the ambient air samples strongly correlated to the flux data. Flux on freshly exposed adhesive surfaces was higher than on the scraped surface and the undisturbed VCT surface.

USEPA Method TO-11 was used to assess aldehyde compounds. Three compounds were detected at moderately low levels: acetone (pungent or fruity odor), butyraldehyde (pungent odor), and valeraldehyde (woody, vanilla, fruity, nutty odor).

A 'finger print' type TO-15 analysis by SIM was performed in an attempt to identify a pattern of VOCs associated with microbial respiration. No such pattern was observed; these data were inconclusive for microbial respiration. A microbial source for odor and odorous compounds was not identified by the MVOC data.

The data indicated that a likely source of odor and odor compounds is the freshly exposed deteriorating adhesive associated with tile adhesive and high pH slab interactions.

It appears that VCT removal and floor scraping to remove visible signs of adhesive aside from a slab staining, greatly reduces odor and VOC compound emissions.

Predictions of potential impact to indoor air quality can be made using these flux data and surface area information along with ventilation data for:

- Rooms with VCT removal and floor scraping to exposed slab;
- Rooms with undisturbed VCT; and,
- Rooms with VCT removal and exposed adhesive as in a remedial activity.

Note that because very little data were collected, these data may not be representative of other portions of the building.

The limited indoor air quality data can be used to evaluate exposure by comparing these data to health-based criteria. Note that this data set is very limited and certainly not meant to take the place of data from a detailed and robust air monitoring program.

5.2.2 August 2011 Field Event Findings

The results of the ambient air testing in the rooms where flux chamber testing was performed are similar to the data collected during the May 2011 testing event.

Data on undisturbed VCT show fewer compounds and lower flux rates as compared to other test data where VCT was removed.

Other compounds were found in ambient air that are not similar to the flux data on undisturbed VCT and are thus related to outdoor air (building ventilation) and other indoor air sources.

The data can be used to assist in identifying odor sources in the DGS building and quantifying emissions potential from undisturbed VCT. They may also prove useful for planning purposes in regard to building renovation.

These data indicate that a source of odor and related odor compounds is the decomposing adhesive found in some locations.

5.3. VCT Adhesive and pH Assessment

A report published in Polymer Degradation and Stability (Vol. 93, Issue 2, 2007), "Degradation of Floor Adhesives as a Function of pH", by Anderberg and Wadso, concludes that high pH readings in the range of 11-13 can degrade vinyl flooring adhesives and create odors. This laboratory testing report, along with the CSI testing and on-site observations of conditions, points to the reaction between high pH levels in the concrete and the vinyl flooring adhesive, as the reason for the conditions occurring with the vinyl floor tile on the 21st floor.

Further research did not reveal a need or a practical method for neutralizing the high pH condition that has been documented. However, it did reveal an extensive case history developed by both manufacturers and contractors that have successfully isolated the condition to a point where it does not affect the bonding of floor products to the slab.

5.4. VCT Chemical Identification and Analysis

The AAS chemical analyses of the VCT and adhesive did not identify any hazardous chemicals in concentrations that would pose a health or safety risk to building occupants.

The pH values seemed to correlate with level of odor and delamination at the original sample locations. Odor and degree of delamination appeared to increase along with the pH level.

Fourier-Transform Infrared Spectroscopy (FT-IR) analysis found some variation between the peak heights of 'odor' and 'non-odor' samples.

- For the adhesive samples, higher peak values correlated with greater stickiness and odor.
- For the concrete samples, peak heights of various samples did not appear related to the characteristics of these samples.

The chlorinated polyethylene (CPE) identified in the FT-IR analysis is a synthetic material which is prepared from the substitution reaction of high-density polyethylene and chlorine. By changing the type of raw HDPE, degree of chlorination, it is possible to obtain the wide variety of characters from rubber like to hard plastic form. And depending on each characteristic, the chlorinated polyethylene can be used in various usages such as a modifier of PVC and ABS, elastomer and the like. As a result, the odor characteristics of this compound can vary significantly from no odor to the new car smell associated with some plasticizers.

The chemical profile of the odor could not be determined. GC/MS analysis could not conclusively determine the chemical composition of the odor since sufficient odorous compounds could not be collected from the samples.

EDXA analysis found that the three major ingredients in the concrete samples were calcium, silicon, and oxygen. The ratio of calcium vs. silicon and oxygen in these samples was higher in the odor samples vs. the non-odor samples. This increased level of calcium in samples could be the cause of higher pH values in the concrete.

Based on the data from the samples tested, Avomeen believes that the composition of the concrete is most likely leading to the failure of the adhesive, which then causes a possible odor issue.

6. REPAIR AND REPLACEMENT PROTOCOL

Based on the results of the above research, testing, discussions, and field meetings, LCD and the project team developed the following protocol to address future testing of the concrete slab and removal/replacement of the VCT:

Initial Testing of Floor – pH Testing Protocol per ASTM F710-08

1. Select area to be tested using visual indicators (e.g., delamination, staining, separation of tiles) or floor tap indicator
2. Remove the VCT from the selected floor test location
3. Remove excess adhesive and lightly sand a test area (approximately 3-inch diameter circle)
4. Apply distilled water to the area (approximately 1-inch diameter circle) at the center of the 3-inch diameter circle prepared in Step 3 above
5. Allow water to sit for at least 60 seconds
6. Perform a qualitative pH test using wide range pH paper; document result; ***or*** Perform a quantitative pH test using a calibrated digital pH meter; document results
7. One to three locations may be prepared and tested depending on the size of the room
8. When testing is completed, the test location is dried, and a new tile is installed

Determination of Tile Removal Method

When pH testing indicates a floor at <pH 10.8; the new VCT shall be re-installed using Armstrong Adhesive for High pH Applications.

When pH testing indicates a floor at a pH 10.8 or greater; the new VCT shall NOT be installed without first grinding and properly sealing the floor surface with Koester VAP I 2000®, or DGS-approved equivalent.

Define Work Area

- Identify room/area in which VCT is to be replaced.
- Depending on room/area, this step may require (with assistance from BPM) deactivation and/or isolation of various building systems (e.g., HVAC, fire alarm) in the defined work area.
- All ceiling vents/openings and other wall penetrations shall be sealed using critical barriers.

Personnel Training and Qualifications

- Only trained and qualified remediation and IH personnel shall be allowed to enter established negative-pressure containments, if visible mold growth may be present.
- Only trained and qualified personnel shall be allowed to enter established negative-pressure containments and must be accompanied by remediation personnel, if visible mold growth is present.
- All personnel involved in the physical removal or handling of VCT during the removal process shall have received benzene awareness level training.

Personal Protective Equipment (PPE)

- All remediation personnel performing VCT removal shall wear a full-face air-purifying respirator with combination volatile organic vapor/HEPA cartridges; or a half-face air-purifying respirator with combination volatile organic vapor/HEPA cartridges and tight-fitting goggles; disposable protective clothing that covers head and feet; gloves.
- Visiting personnel and consultant observers shall provide their own PPE and wear, at a minimum, a half-face air-purifying respirator with combination volatile organic vapor/HEPA cartridges; disposable protective clothing that covers head and feet; gloves.

NOTE: During the collection of clearance air samples, no respiratory protection is required; disposable protective clothing and gloves are still required.

Work Area Preparation and/or Containment

- Rooms with VCT designated for removal shall be physically isolated with critical barriers/containments with integral decon unit; and equipped with ventilation equipment to provide a minimum negative air pressure of .02 inches water gauge with exhaust directed to one of the restrooms on the floor.

- Each restroom that is selected to act as the exhaust area shall be sealed, in order to create a negative pressure condition that will draw any VCT odors out of the removal negative pressure enclosure and out the restroom exhaust system.
- The work area ventilation equipment shall be connected to the exhausted restroom by means of flexible ventilation ducting. Flexible ducting shall not be allowed to create trip hazards or other foot traffic obstacles in the hallways.

NOTE: Contractor shall determine whether the number and size of rooms to be remediated will exceed the capacity of the restroom exhaust systems.

- Once negative-pressure has been established, the room's entire cove base shall be removed and the exposed wall area behind the removed cove base visually inspected for any evidence of suspect mold growth.

Suspect Stains at Wall Bottom

Any suspect stains (i.e., physical evidence of water-related problems or suspect mold) on the gypsum board wall bottoms can be removed by simply removing a larger section of the wall bottom; the project industrial hygienist has the discretion to direct the removal of these small areas of wall without requiring a test for mold.

Suspect Stains Greater Than 100 Square Feet

Any suspect stains (i.e., physical evidence of water-related problems or suspect mold) greater than 100 square feet) on the gypsum board wall will be sampled to confirm the presence or absence of VMG; surface samples are to be collected using Bio-Tape™ or similar method(s) at the discretion of the industrial hygienist.

NOTE: All areas that are remediated or test negative for VMG shall be marked using a tinted encapsulant in order to provide future O&M personnel with an indication that the area has been properly tested or remediated.

Edge Trim Wall Bottom

The bottom ½ to 1-inch of the room's gypsum board wall (around the entire room perimeter) shall be removed using an edge trim saw. If at all possible, the edge trim shall not penetrate deeper than the first layer of gypsum board. However, if multiple layers are in contact with the floor surface, they shall also be trimmed, but shall not penetrate deeper than the wall bottom plate.

If two or more layers of gypsum board are penetrated without encountering a bottom plate or other fire stop material, the penetration/void shall be sealed with a metal plate and fire stop material before replacing/repairing the trimmed layers of gypsum wall.

VCT Removal

Once all suspect and confirmed VMG have been properly addressed, the contractor may proceed with VCT removal. All intact VCT and debris shall be manually removed along with any adhesive. As a potential source of odor, all visible adhesive shall be removed. Do not allow any residual adhesive to remain.

- If manual removal methods are not effective in removing residual adhesive, mechanical grinding equipment may be used.
- If mechanical grinding equipment is used to remove adhesive, the adhesive free floor shall again be pH tested using the pH test methods previously described.

Air Monitoring

Whenever, an entire room/area of VCT is to be removed, a minimum of three twelve-hour Summa® Canister Air Samples shall be collected during the performance of the VCT removal work: one sample inside the room in which the VCT is being removed; one sample in the hallway outside the room where VCT is being removed (one canister sample per floor per day); and one sample shall be collected outdoors as a background sample. These samples shall be submitted to an air laboratory and analyzed by EPA Method TO-15 under standard turn-around time.

At the discretion of the industrial hygienists, random air sampling (various analytes) may be periodically performed to demonstrate the efficacy of control measures and work practices.

Areas with Visible Mold Growth

After the VCT and adhesive removal process has been completed, all work area negative pressure enclosures shall be cleared for mold, and should be dry and visually clear of contamination and debris as determined by the industrial hygienist.

- Each VCT removal area that is cleaned shall require a minimum of 12-hours of air scrubbing and be free of odors.
- Two (2) outside air samples (one outside the containment, but on the same floor; one at ground level) **prior** to collection of inside containment samples.
- The number of inside air samples shall be determined by the size of the containment and at the discretion and consensus of the project industrial hygienists; as few as one (1) and no more than five (5).

- Two (2) outside air samples **after** collection of inside samples (one outside the containment, but on the same floor; one at ground level on opposite side of the building where initial outside sample was collected).
- Criteria for successful air sample clearance:
  - Quantitative spore counts collected inside containment are less than those observed in outside samples.
  - Similar in rank order and distribution.
  - Air sample does not contain specific spores of concern that were identified during initial identification of VMG.

Housekeeping

In general, work areas should be left dry and visually clear of contamination and debris, on completion of work. Some contamination and debris may remain during intermediate stopping points in the removal and cleaning process.

VCT Replacement

Install new VCT in accordance with manufacturer's instructions.

7. Limitations and Qualifications

The assessment performed by LCD does not include or cover the following matters: Matters that are subsequently discovered that could not have been reasonably foreseen or detected, using industry standards, during the performance of the assessment. Matters that could not have been discovered by LCD because of barriers, lack of access or other matters affecting accessibility. Matters that were not disclosed to LCD prior to, during, or after the performance of the assessment. Any new deficiency that arose after the completion of the assessment by LCD.

To the extent that additional information becomes available to LCD, LCD reserves the right (without any obligation to do so) to modify its evaluation and/or this Report at any time, based upon further review and analysis of any such additional information or data.

Certain items mentioned in the Report were performed by others not involving the supervision of, or management by, LCD, but were relied upon by LCD in making its evaluation and assessment.

The assessment performed by LCD is not meant or intended to supplement, modify, or extinguish any warranty or representation made or given by third parties performing any of the recommended corrective work.

When consultation involves microbiological growth, or any assessment thereof, such microbiological growth may reoccur if the source of the growth is not remedied. All remediation of fungi in indoor environments can be inherently limited in the sense that conclusions are drawn and recommendations developed from information obtained from limited research and site evaluation. Except as may be noted in the assessment performed by LCD, subsurface areas, latent defects, or non-accessible areas and conditions were not field investigated and may differ from the conditions implied by the surface observations. Additionally, the passage of time may result in a change in the environmental characteristics at the subject property and the surrounding properties. No investigation or assessment can absolutely rule out the existence of any microbiological growth at any given site. LCD does not remediate or remedy sources of micro-biological growth.

This Report and the assessment/survey conducted by LCD is prepared, and was performed, solely for the use and benefit of the client identified at the beginning of this Report. No other party may rely on this Report for any other purpose.

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