HealthHazard Evaluation Program

Evaluation of respiratory and other health concerns at a law enforcement office building with indoor environmental quality issues

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Disclaimer

The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 (29 U.S.C. § 669(a)(6)). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CFR Part 85).

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Introduction

Request

In July 2018, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation request from management, union representatives, and confidential employees to investigate skin, eye, respiratory, and other health concerns at a law enforcement office building.

Workplace

The law enforcement building had general office spaces, evidence rooms, an armory, and a mechanical room. In 2013, the building was purchased to become a new law enforcement office building. The building was originally a hospital and had been vacant for approximately 10 years prior to being purchased. In 2015, building renovations were completed, and employees were moved into the building. Employees reported experiencing skin, eye, respiratory, and other symptoms including headaches, fatigue, and difficulty concentrating soon after moving into the building. At least 40 employees submitted workers' compensation documents. In June 2018, employees were evacuated from the building and relocated to other available office spaces. At this time, employees remain evacuated from the building, and there are no plans to return to the building

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

To learn more about the indoor environmental quality and health concerns, we visited the law enforcement office building on September 6, 2018. Before our visit, we reviewed documents provided to NIOSH, including reports of environmental evaluations by consultants, workers' compensation claims, and an employee roster.

On our visit, we

- Held a brief opening meeting with employee representatives and management.
- Toured the building and talked with employees, union representatives, and management.
- Conducted private, voluntary interviews in-person and by telephone with employees.
- Requested additional documents, including building floor plans, architectural drawings, and ventilation testing and balancing reports.

After our visit, we

- Provided photos to the county engineer of some of the building conditions identified during the NIOSH site visit.
- Provided additional information to the law enforcement agency on remediating mold-contaminated books and papers.

- Requested follow-up environmental consultation reports.
- Provided an interim report on October 2, 2018 with the following recommendations:
    - Have a contractor with expertise in building science (preferably one not previously associated with this building) evaluate the building for water intrusion through the building envelope and conduct an inspection for hidden mold (which might include cutting inspection openings in the interior dry-wall). Particular attention should be placed on the east side of the building from which the health complaints came.
    - Ensure all downspouts located around the exterior of the building have extenders long enough to direct water runoff away from the building. Ensure grading of ground around the building also directs water away from the building.
    - Ensure dehumidifiers used to dry the evidence are cleaned and maintained regularly according to the manufacturer's recommendations.
    - Continue to work towards eliminating any condensation issues related to the walk-in refrigerator and freezer in the evidence room.
    - Clean documents from the building with a vacuum equipped with a high-efficiency particulate air (HEPA) filter, make copies, or create electronic versions of documents when occupants report health symptoms associated with handling the documents.
    - Have a qualified ventilation contractor (preferably one not previously associated with this building) evaluate the positions and control sequence for the outdoor and return air dampers in each air-handling unit. Ensure the minimum required outdoor air is supplied to all occupied areas of the building under all operating conditions.

Our Key Findings

A consultant hired by the county to evaluate the law enforcement building before the NIOSH Health Hazard Evaluation reported indoor environmental quality issues

- Relative humidity in the building was around 60% with higher measurements in some areas. This indicated the heating, ventilation, and air-conditioning (HVAC) system was not removing enough humidity from the air in the building.
- Water vapor in the building ranged from 15 mg per liter air (mg/L) to 100 mg/L air. The highest measurements were in areas of the building where evidence was stored.
- Dampness and visible mold were observed on the wall behind and between the evidence refrigerator and freezer in Room 138.
- Dust buildup was noted on some desks, shelves, and a sprinkler pipe in the building.

We observed signs of building dampness

- We observed rust on the metal roof in the evidence room and room 129 (Figures 1 and 2).

Figure 1. Rust on ceiling in the evidence room. Photo by NIOSH.

Figure 2. Rust on metal roof above the ceiling tiles in room 129. Photo by NIOSH.

- We observed visible water damage/stains in front of the refrigerator and between the walk-in freezer and refrigerator in the evidence area (Figures 3 and 4).

Figure 3. Visible water damage/stains in front of the walk-in refrigerator in evidence area. Photo by NIOSH.

Figure 4. Visible water damage/stains between the walk-in freezer and refrigerator in the evidence area. Photo by NIOSH.

- We observed visible stains and a mold odor under a plastic mat on concrete floor (Figure 5).

Figure 5. Visible stains and mold odor under plastic mat on concrete floor in the evidence room. Photo by NIOSH.

- We observed water pooling under the fresh air intake near the emergency generator (Figure 6).

Figure 6. Water pooling under fresh air intake near the emergency generator. Photos by NIOSH.

- We observed runoff from the roof accumulating at the foundation of the building allowing for potential water infiltration into the building. Water was pooling in mulch and against the building from some down spouts (Figures 7 and 8).

Figure 7. Water pooling in mulch and against building from downspout at front of building. Photo by NIOSH.

Figure 8. Water pooling in mulch and against building near outdoor patio space. Photo by NIOSH.

- We observed patches on the roof, indicating a possible mechanism for past water intrusion (Figure 9).

Figure 9. Patching on roof. Photo by NIOSH.

- We observed areas of exposed cement block at the base of the exterior wall, allowing for potential water infiltration into the building. (Figure 10).

Figure 10. Exposed cement block near the base of exterior wall. Photo by NIOSH.

We observed that existing ventilation systems were functional and well-maintained

- We observed the four main air-handling units providing ventilation to the building.
- We observed the four main air-handling units were providing fresh, outdoor air to occupied spaces, but not as initially planned during building renovation.
- We observed one REME HALO® In-duct Air Purifier was installed inside the supply duct of each air-handling unit.
- We observed two 60-ton chillers providing chilled water to the air-handling units, two ductless split systems providing additional cooling to the mechanical room and information technology/electrical room, and 11 exhaust fans in the facility.

During interviews with NIOSH, employees reported indoor environmental quality issues and building-related symptoms

- Employees reported stagnant or stuffy air; others reported humid, muggy, clammy, damp, or sticky air.
- Employees reported musty, mildew, or stale odors; others described a cardboard or dead odor.
- Employees reported temperature control issues; the building was either too cold or too hot.
- Employees reported skin, eye, respiratory, and other symptoms such as headaches, fatigue, difficulty concentrating, or memory issues that improved away from the building; most health complaints were from employees working in the east side of the building.
- Employees reported eye, skin, or respiratory symptoms when handling paper documents retrieved from the building.
- Employees expressed concerns for potential exposure to asbestos during renovation activities in the training building located on the property.

- The symptoms employees reported during the NIOSH interviews were similar to symptoms reported on workers' compensation documents that NIOSH reviewed.

Following the NIOSH site visit, environmental consultants were hired by the county, and they found evidence of moisture, mold, and bat droppings in the building

January 2019

- Hidden moisture, mold, and bat droppings were found in wall cavities.
    - Mold was observed on the backside of drywall in a wall between the evidence refrigerator and freezer. Tape lift samples confirmed mold. Condensation on the coolant piping was causing mold growth on the drywall.
    - Elevated moisture was identified at the base of the perimeter concrete block wall in the Main Evidence Storage Room.
    - Older appearing wood was observed within an upper wall cavity in the southwest corner of the Main Evidence Room and in a wall cavity on the south side of the Narcotics Evidence Storage Room. A tape lift sample taken from the wood in the main evidence room showed high mold spore counts.
    - Bat droppings were observed in the upper wall cavity in the southeast corner of the Training Room. A swab sample of droppings identified a fungus called *Histoplasma capsulatum*.
- Hidden moisture or mold were found under flooring and a plastic floor mat on concrete and behind a vinyl wall base.
    - Moisture was observed by the northeast exit door in the Investigations Room and behind vinyl wall base, which is a wall trim used at the base of the wall where the wall meets the floor.
    - Moisture and wet adhesive were observed on the slab when some carpet tiles were removed. Musty or visible mold was noted on the backside of the carpet tiles and underlying concrete. Tape lift samples identified mold and hyphal fragments. Hyphal fragments are an indication of mold growth.
    - Visible mold was observed below a vinyl floor tile in the southeast common hallway.
    - A musty odor and visible mold were observed below a plastic floor mat on concrete in the Evidence Reception Room 134.
    - The consultants noted that carpet tiles and adhesive created a vapor barrier at the top of the slab resulting in condensation and mold growth on the backside of the carpet tiles. They noted a similar issue was occurring on the backside of the vinyl flooring in the corridor and under plastic mats on concrete in the Evidence Reception Room.
- Mold was identified in the HVAC system.
    - Tape lift samples from the coils of air-handler unit (AHU) 1 and AHU 4 identified mold.
    - A tape lift sample from the metal housing by the blower wheel of AHU 4 identified mold and hyphal fragments. Hyphal fragments are an indication of mold growth.

- Potential areas for water infiltration into building were identified.
    - The exterior insulated finish system (EIFS) cladding was in good shape, but the consultants noted potential for water infiltration at some of the mechanical and electrical penetrations through the wall.
    - Paving by the front (north) and rear (south) walls was flush with the floor level inside the building with poor drainage away from the building. This allowed water to accumulate along the base of the walls and potentially infiltrate into the building.
    - A swale, which is a low-lying depression, at the base of the east wall in the northeast quadrant sloped towards the building instead of away. Based on the consultant's observations, the county performed grading, repaving, and swale installation in April 2019 to better direct water-runoff and reduce moisture intrusion below the walls.

<u>July 2019</u>

- Hidden moisture or mold were found under flooring.
    - Moisture, musty odors, or suspect visible mold growth were observed under 18 of 21 floor-level carpet or tile locations evaluated, including newer carpeting.
- The building concrete slab had elevated moisture levels, which resulted in moisture and mold under flooring.
    - Of 35 moisture vapor emission rate measurements:
        - Fourteen indicated moisture emission rates exceeded generally accepted maximum values for floor covering installation.
        - Eight indicated moisture emission rates with the potential to exceed generally accepted maximum values for floor covering installation.
        - Thirteen had moisture emission rates below generally accepted maximum values for floor covering installation.
    - Of the 35 tested locations, 29 of the relative humidity measurements indicated elevated slab moisture levels.
- Mold spores were identified on old wood in wall cavities in the southeast corner of the Main Evidence Storage Room, Narcotics Storage Room, and Training Room 129.
    - Four tape lift samples contained non-viable mold spores from different molds including *Cladosporium* and *Penicillium/Aspergillus*.
    - Viable fungi were identified on swab samples from the old wood in the Narcotics Storage Room (*Aspergillus*, *Cladosporium*, *Penicillium*, and *Paecilomyces*) and the southeast Training Room 129 (*Paecilomyces*) near the bat droppings.
- Reportedly, a water leak developed at some point after the 2015 renovation and the leak was repaired; the location of the water leak was not known at the time of the evaluation. Also, at some point after 2015, some carpet tiles were replaced reportedly due to aesthetic reasons.

Following the NIOSH site visit, HVAC consultants hired by the county found the HVAC system was not operating properly

- None of the AHUs had outdoor airflow monitoring stations installed, even though installation was planned during the renovation.
- The amount of outdoor air each AHU provided to the occupied spaces was not set properly.
- The building was receiving appropriate amounts of outdoor air after balance and adjustments were performed by the HVAC contractor in February 2019.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Benefits of Improving Workplace Health and Safety:

- Improved worker health and well-being
- Better workplace morale
- Better employee recruiting and retention
- Improved image and reputation
- Better products, processes, and services
- Could increase overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/topics/hierarchy/.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in "Recommended Practices for Safety and Health Programs" at https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Take corrective action to end source of dampness or other identified issues. Ensure proper containment methods are used to prevent worker exposures and contamination of unaffected sections of the building during remediation.

Why? Moisture, musty odors, and visible mold growth were observed in wall cavities, under carpet and vinyl flooring, and under a plastic floor mat. Damp building conditions promote the growth of mold, bacteria, and other microbial agents. Moisture can also attract cockroaches, rodents, and dust mites. Dampness can contribute to the breakdown of building materials and furniture, which can result in adverse health effects. Employees reported skin, eye, respiratory, and other symptoms including headaches, fatigue, difficulty concentrating, and memory issues that improved when away from the building.

How? At your workplace, we recommend these specific actions:

Ensure water is directed away from the exterior building.

- Downspouts around the exterior of the building may require extenders long enough to direct water runoff away from the building.
- Grading of ground surrounding the building should direct water away from the building.

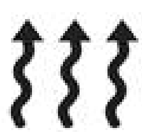
Routinely inspect the building for water intrusion and damage and take corrective action upon discovery. During and after heavy rains, walk through the building and check for water incursion.

- Identify any potential sources of dampness or mold through visual inspection and make proper repairs to prevent further problems from occurring.
- If dampness or mold is not identified during visual inspections but suspected because of musty odors or continued health complaints of building occupants, continue to look for hidden problems such as under flooring or in wall cavities. Also, thermal imaging after heavy rains can be used inside and outside buildings to look for leaks.
- Monitor repaired areas to ensure repairs and remedial actions are effective.
- Keep a record of when and where mold or water-damaged materials are discovered and what has been done to promptly fix the underlying problem leading to the water damage.

Any mold and moisture-damaged materials should be removed or cleaned with appropriate containment to minimize exposure for remediation workers, building occupants, and unaffected sections of

the building. Inappropriate remediation can cause further problems with building degradation and symptoms in occupants.

- Remove mold and moisture-damaged flooring and any other damaged materials such as plastic floor mats and vinyl wall base.
- Remediate the mold on the concrete slab and old wood framing in the wall cavities according to the guidance below.
- If health symptoms are associated with handling paper documents from the law enforcement building, clean them with a vacuum equipped with a HEPA filter, make copies of the paper documents, or create electronic versions of documents.
- Information about remediating mold-damaged building materials can be found in the following documents:
    - New York City Department of Health and Mental Hygiene document, *Guidelines on Assessment and Remediation of Fungi in Indoor Environments* (https://www1.nyc.gov/assets/doh/downloads/pdf/epi/epi-mold-guidelines.pdf)
    - U.S. Environmental Protection Agency (EPA) document, *Mold Remediation in Schools and Commercial Buildings* (http://www.epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide)



Allow the concrete slab to dry and test the concrete slab for moisture before installing new flooring.

- Ensure the replacement flooring product is compatible with the slab moisture levels.
- Locate and review records from partial carpet tile replacement and water leak repair work reported to the environmental consultant in July 2019 to determine if these events are related to the floor moisture issue.
- If concrete slab moisture cannot be controlled, consider using breathable floor coatings or installing a moisture vapor suppression system.

Recommendation 2: Remove bat droppings from wall cavity in the southeast corner of the Training Room.

Why? Animals or animal products such as dander, hair, fur, saliva, and body wastes contain allergens that can cause respiratory and skin disorders. The protein in urine from rats, for example, is a potent allergen. When it dries, it can become airborne. Infectious diseases can also result from exposure to rodent feces and urine. In January 2019, a consultant for the law enforcement agency collected a swab sample from the bat droppings found in the upper wall cavity in the southeast corner of the Training Room and identified a fungus called *Histoplasma capsulatum*. *Histoplasma capsulatum* often lives in environments that contains large amounts of bird or bat droppings. Histoplasmosis is caused by inhaling spores of *Histoplasma capsulatum*. Histoplasmosis is not contagious, and it cannot be transmitted from an infected person or animal to someone else. Most people with infections caused by *Histoplasma capsulatum* do not have any symptoms. If symptoms do occur, they usually start 3 to 17 days (on average 10 days) after exposure. Symptomatic persons generally have disease ranging from a self-limited influenza-like illness (e.g., general ill feeling, fever, chest pain, dry or nonproductive cough, headache, loss of appetite, shortness of breath, joint and muscle pains, chills, or hoarseness) to pneumonia. Immunocompromised individuals are at risk for disseminated disease (spreading of the fungus to other organs outside the lungs) and reactivation of inactive (latent) histoplasmosis years after infection.

Information on removing bat droppings and protecting workers from histoplasmosis such as by controlling aerosolized dust and using appropriate personal protective equipment can be found in the following NIOSH document: *Histoplasmosis: Protecting Workers at Risk*, https://www.cdc.gov/niosh/docs/2005-109/pdfs/2005-109.pdf?id=10.26616/NIOSHPUB2005109.

Recommendation 3: Maintain the ventilation system according to ASHRAE standards and manufacturer's recommended maintenance so it operates properly and provides acceptable indoor air quality.

Why? Poor ventilation in buildings is a common problem and frequently due to lack of proper attention to the building's HVAC system. HVAC systems include all the equipment used to ventilate, heat, and cool the building; to move the air around the building (ductwork); and to filter and clean the air. These systems require maintenance and care to operate properly and provide acceptable indoor air quality. When neglected, HVAC systems can have a significant impact on how pollutants are distributed in and removed from spaces.

How? At your workplace, we recommend these specific actions:

Introduce the required amounts of fresh, outdoor air to all occupied spaces of the building throughout the full operational range of the variable air volume air-handling units.

- The amount of fresh air delivered to occupied spaces was appropriately adjusted by Holistic Test and Balance, Inc. during their ventilation test and balance assessment on February 4, 2019.
- If building spaces are renovated or repurposed for different uses in the future, new testing and balancing of the impacted ventilation systems should be performed to ensure appropriate outdoor airflow to those occupied areas.

Maintain indoor temperature and humidity levels according to ASHRAE Standards.

- Indoor temperatures should range from 68.5°F to 75°F in the winter, and from 75°F to 80.5°F in the summer.
- Indoor humidity should be maintained to provide a maximum indoor-air dew-point temperature of 60°F during occupied and unoccupied periods.

Develop a comprehensive, written HVAC operation and maintenance plan for the facility. The operation and maintenance plan should include:

- Preventive maintenance schedules and all regularly scheduled maintenance tasks (filter changes, fan belt inspections, etc.) and who is responsible for conducting each task.
- Written procedures for each maintenance task to ensure the work is done properly each time, regardless of who performs the work.
- Training requirements for maintenance staff.
- A method for logging maintenance activities for each AHU.
- A method for updating or revising the written plan as procedures or systems change.
- Follow the manufacturer's recommended maintenance schedules for the HVAC system, including replacing air filters, checking drip pans, ensuring thermostats are in working order, and checking and cleaning ventilation system dampers to ensure proper functioning.

Recommendation 4: Develop a communication system and a health and safety committee.

Why? Indoor environmental quality exposures and outcomes are reported frequently in buildings. NIOSH has found that indoor environmental quality problems can generally be corrected using remediation practices that are fairly standardized if conditions are not neglected. It is important that clear procedures for recording and responding to indoor environmental quality complaints be established to ensure adequate and timely response and to prevent small complaints from becoming major health or comfort problems. Communicating with building employees and involving them in the process of addressing indoor environmental quality problems is essential. Health and safety committees incorporating employee input can be helpful dealing with indoor environmental issues.

How? At your workplace, we recommend these specific actions:

Maintain a communication system with employees about building-related issues.

- Make sure to provide information on response actions to all employees, including posting environmental assessment reports and updates on remediation activities.
- Inform employees of any asbestos-containing materials in the buildings on the property and what precautions are in place to prevent asbestos exposures.
- If not already done so, start a health and safety committee that consists of employees, management, and maintenance. This can help increase communication between employees and management, and help alleviate concerns.

Encourage employees to report new, persistent, or worsening symptoms, particularly those with a work-related pattern, to their healthcare providers and, as instructed by their employer, to a designated individual at their workplace.

- In the future, employee health questionnaires may be helpful to collect information on building-related symptoms, particularly among persons new to the building after remediation. Even if most employees experience improvement in their symptoms, and new employees remain free of building-related symptoms, some employees with allergic conditions may not notice improvement because their immune systems may continue to react to very small amounts of allergens. An individualized management plan (such as assigning an affected employee to a different work location, perhaps at home or a remote site) is sometimes required, depending upon medical findings and recommendations of the individual's healthcare provider.

- The occurrence of new or ongoing symptoms in the workforce should prompt consideration of work-related health conditions and re-evaluation of the law enforcement building for potential exposures.

Supporting Technical Information

Evaluation of respiratory and other health concerns at a law enforcement office building with indoor environmental quality issues

HHE Report No. 2018-0157-3369

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Section A: Workplace Information

The law enforcement building had general office spaces, evidence rooms, an armory, and a mechanical room. At the time of our survey, there were no employees working in the building. Approximately 70 employees had been relocated to an alternative worksite. The building was one-story on concrete slab and approximately 46,000 square feet. The building was originally a hospital built in 1979. In 1987, an underground 6,000-gallon diesel tank was removed. In 1999, another underground 6,000-gallon diesel tank was removed. Diesel released during the 1989 tank removal resulted in soil and ground water testing and subsequent soil removal and ground water remediation. Twenty-three monitoring and recovery wells were installed. In 2004, the state department of environmental protection determined further testing was no longer required and issued a site rehabilitation completion order.

The building had been vacant for approximately 10 years prior to being purchased by the county in 2013 to become a new law enforcement office building. The building was gutted including drywall and plumbing. The exterior walls consisted of an exterior insulated finish system (EIFS) cladding over original concrete masonry unit walls. In 2015, the building renovations were completed including the installation of the heating, air-conditioning, and ventilation (HVAC) system, and employees moved into the building. Employees began experiencing skin, eye, respiratory, and other symptoms including headaches, fatigue, and difficulty concentrating, soon after moving into the building. From 2015 to 2018, at least 40 workers' compensation claims were filed. In June 2018, employees were relocated to other available office spaces. At this time, employees remain evacuated from the building, and there are no plans to return to the building

Section B: Methods, Results, and Discussion

On September 6, 2018, we held a brief opening meeting at the law enforcement agency with employee representatives and management to discuss this health hazard evaluation request and to describe the objectives and activities for our walkthrough visit. We outlined our primary aims for the visit, including (1) visually assessing the interior and exterior of the law enforcement building for indications of water damage or mold growth; (2) visually assessing the roof and ventilation system of the law enforcement building; and (3) informally speaking with employees about their work and any work-related health concerns.

Methods: Facility Walkthrough and HVAC System Visual Inspection

After the opening meeting, we toured the law enforcement building starting with general office areas followed by the mechanical room and secure areas, and then the roof and building exterior. Employee representatives and the building's energy manager led the tour and answered our questions.

Results: Facility Walkthrough and HVAC System Visual Inspection

During our walkthrough visit, we observed water runoff from the roof accumulating at the foundation of the building. We noted areas of the roof that had been patched, indicating possible past water intrusions. We observed some areas near the base of the exterior walls with exposed cement block. We noted there might be the potential for water intrusion through the building envelope, and thus a potential for hidden mold growth. We noted this potential for hidden mold was consistent with employee reports of musty odors, especially after rains, and health symptoms. We observed evidence of water stains from condensation around the walk-in refrigerator and freezer in the evidence room.

All HVAC equipment was installed during building renovations in 2015, and all equipment appeared well-maintained during the NIOSH visit. The HVAC system in the building consisted of four main air-handling units (AHUs) that supplied air to variable-air-volume (VAV) boxes through lined sheet metal ductwork. After the VAV boxes, the supply air traveled through fiberglass flexible ductwork to supply vents in the occupied spaces. One REME HALO® In-duct Air Purifier (RGF Environmental Group, Inc., Riviera Bach, FL) was installed in the main supply duct (after the supply fan) in each of the four main AHUs.

Return air traveled back to the AHUs through unlined sheet metal ductwork where it mixed with some fresh, outdoor air and was recirculated through the AHUs. While the units were providing fresh, outdoor air to the occupied spaces, the amount of outdoor airflow was not being controlled as initially planned during system design and installation. Air conditioning was facilitated by chilled water coils inside the AHUs that were fed by two 60-ton (nominal) chillers installed just outside the mechanical room. When necessary, heat was provided to the air by electric heaters inside each VAV box.

In addition to the four main AHUs, two ductless split systems provided conditioned air to the mechanical room (Room 145) and the information technology/electrical room (room 153). A series of 11 roof-mounted exhaust fans provided exhaust from specific areas of the building, including all bathrooms.

Methods: Voluntary Employee Interviews with NIOSH

After the walkthrough of the building, NIOSH staff members conducted voluntary employee interviews at the county courthouse. All employees were invited to participate. Employees were informed that the interviews were voluntary and confidential. Employees were offered copies of an informational handout describing the NIOSH site visit and booklets about the NIOSH Health Hazard Evaluation Program.

Results: Voluntary Employee Interviews with NIOSH

We interviewed 26 of approximately 70 available employees. Most health complaints came from occupants located on the east side of the building. Many employees reported systemic, neurologic, or skin symptoms including exhaustion, tiredness, or fatigue; headaches, not thinking clearly, difficulty concentration, or memory issues; itchy skin, rashes, bumps, sores, or hives. Locations of skin symptoms included the scalp, face, neck, chest, back, arms, legs, or other areas. Some employees reported eye, upper respiratory, or lower respiratory symptoms including dry, scratchy, grainy, irritated, or burning eyes; stuffy nose, scratchy throat, sneezing, postnasal drip, or sinus issues; cough, breathing problems/difficulties, shortness of breath, or wheezing. A few employees reported stress, anxiety, irritability, loss of interest in hobbies, or depression due to their building-related symptoms. Some employees reported their symptoms improved on weekends, vacations, patrol, training away from the building, or when relocated to the old jail administration building or courthouse. Some employees reported eye, skin, or respiratory symptoms when handling paper documents or files retrieved from the law enforcement building.

Many employees reported musty, mildew, or stale odors in the building. Others described a cardboard or dead odor. Some employees reported the building odor was worse in the morning or after rains. Some employees reported smelling marijuana in the building when it was brought into the evidence area for drying; dehumidifiers in the drying room were reportedly often full. The building air was described as stuffy, stagnant, humid, muggy, clammy, damp, or sticky. Employees reported temperature control issues; the building was either too cold or too hot. There was a concern about potential exposure to asbestos during renovation activities in the training building adjacent to the law enforcement building.

Methods: Review of workers' compensation claims related to the law enforcement building

On August 3, 2018, prior to NIOSH's visit to the law enforcement building, NIOSH requested copies of the workers' compensation claims pertinent to respiratory or skin issues. General Counsel for the law enforcement agency provided copies of Petitions for Workers' Compensation Benefits or First Report of Injury or Illness forms for 40 individuals who reported symptoms related to working in the law enforcement building.

Results: Review of workers' compensation claims related to the law enforcement building

Many employees reported systemic, neurologic, or skin symptoms including fatigue, exhaustion, or tiredness; headaches, cognitive impairment, difficulty concentration, dizziness, or memory issues; itchy skin, rashes, bumps, sores, or hives. Locations of skin issues included the scalp, face, neck, shoulders, chest, back, arms, legs, or other areas. Employees also reported eye, upper respiratory, or lower respiratory symptoms including blurry, itchy, or irritated eyes; throat irritation, congestion, postnasal drip, or sinus issues; coughing, breathing problems/difficulties, shortness of breath, or chest tightness. A few employees reported concerns about possible asbestos exposure while gutting the training building next to the law enforcement building.

Methods: Review of environmental consultant report completed prior to the NIOSH site visit

In May 2018, the county engineer contacted ESi, an environmental consulting firm, to evaluate the air quality concerns at the law enforcement building. Employees had expressed concerns about various symptoms including headaches, itchy skin, rashes, and watery eyes. ESi conducted their initial walk-through of the building on June 4, 2018 and followed by sampling collection and testing on June 14 and June 15, 2019. We reviewed the ESi Indoor Air Quality Investigative Report dated July 12, 2018.

Results: Review of environmental consultant report completed prior to the NIOSH site visit

June 2018

At the time of ESi's evaluation at the law enforcement building, the majority of employees had relocated to another building. ESi noted the law enforcement building appeared to be clammy and had a light odor of volatile organic compounds (VOCs) in some areas of the building. ESi noted the relative humidity in portions of the building was around 60% with higher measurements in some areas of the building, which they noted was an indication the HVAC system in the building was not removing sufficient humidity from air inside the building. ESi suggested a mechanical engineer review the design and operation of the system.

In Room 138, ESi noted water on the floor from an apparent leak or condensation issues. The wall behind and between the walk-in refrigerator and freezer was damp and had some visible mold. ESi recommended repair of the leak and replacement of damaged drywall. ESi observed significant dust accumulation in the following areas: 1) on a water sprinkler pipe above the files shelves in Room 138 2) in Room 137 on top of the sprinkler pipe, 3) on a desk in room 129, 4) on two desks in Room 111, 5) on a desk in the Room 126, and 6) on a desk in Room 157.

ESi tested for VOCs under the concrete slab in two locations. ESi drilled into the slab in two locations, and the air from under the slab was collected into sampling canisters for approximately 7.5 hours. ESi also collected air samples using the canisters in five location in the building. ESi indicated the VOCs in the building were within currently accepted guidelines. The ESi report stated the concrete slab was an "effective barrier from VOCs migrating through the slab and significantly affecting the air quality on the inside of the building." The ESi report also stated the results for VOCs in the law enforcement building "compared with criteria for residential and office environment fall into an ideal category for off gassing and are below the criteria for individual compounds proposed by ASHRAE and LEEDS." ESi also measured carbon monoxide, oxygen, water vapor, and carbon dioxide in the seven air samples (two below the slab and five above the slab in the building). Carbon monoxide was below the limit of detection in the seven air samples. Water vapor ranged from 15 mg per liter air (mg/L) to 100 mg/L air above the slab. The evidence portion of the building had the highest water vapor measurements. Below the slab water vapor was 29 mg/L air and 40 mg/L air. In the seven air samples, carbon dioxide ranged from 600 ppm to 660 ppm; however, the building had only a few occupants at the time of the carbon dioxide levels were measured. Carbon dioxide is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual occupant density at the time it is measured.

Methods: Review of Building Visual Assessment and Destructive Sampling Conducted after NIOSH site visit

On January 3 and 4, 2019, Terracon Consultants, Inc. performed a visual assessment and limited destructive testing on the building envelop and assemblies, a visual assessment of the building exterior, and collected surface and air fungal spore samples for laboratory analysis. We reviewed the Terracon report dated February 28, 2019.

On July 25, 26, 29, and 30, 2019, Terracon Consultants, Inc. performed follow-up visual assessment of the building envelop and assemblies, collected surface and air fungal spore samples for laboratory analysis, and assessed the building's concrete slab moisture levels. We reviewed the Terracon report dated October 28, 2019.

Results: Review of Building Visual Assessment and Destructive Sampling Conducted after NIOSH site visit

January 2019

Terracon Consultants conducted destructive test cuts at 36 locations in the drywall either at the base or top of the exterior walls. Mold was observed on the backside of drywall in the wall between the evidence cooler and freezer; tape lift samples confirmed mold (*Cladosporium*, *Stachybotrys/Memnoniella*). Water in the air was condensing on the cooling pipe causing damp conditions that supported mold growth on the drywall. Elevated moisture was identified at the base of the perimeter concrete block wall in the Main Evidence Storage Room. Some surface rust was observed in the sill track in the wall cavities in the Sheriff's Office, Chief Deputy's Office, Records Room, and Files Room; however, no moisture was encountered. The consultant report indicated the rust could have resulted from standing water during construction. Older appearing wood was observed within an upper wall cavity in the southwest corner of the main evidence room and in a wall cavity on the south side of the Narcotics Evidence Storage Room. A tape lift sample taken from the wood in the Main Evidence Room showed high mold counts of *Aspergillus/Penicillium* and *Cladosporium*. In the upper wall cavity in the southeast corner of the Training Toom, bat droppings were observed on top of the concrete masonry unit. A swab sample of the droppings identified a fungus called *Histoplasma capsulatum*.

Terracon Consultants observed moisture, musty odors, or visible mold growth in 11 floor-level destructive testing locations below carpet and tile flooring. Terracon Consultants report noted moisture was observed behind vinyl wall base by the northeast exit door in the Investigations room. Moisture was also observed on the slab with wet adhesive when some carpet tiles were removed. Musty or visible mold was noted on the backside of the carpet tiles and underlying concrete including in the Investigations Room and Muster/Assembly Room. Tape lift samples identified mold (e.g., *Cladosporium*, *Aspergillus/Penicillium*, *Scopulariopsis/Microascus*) and hyphal fragments. Hyphal fragments are an indication of mold growth. Visible mold was observed below a vinyl floor tile in the southeast common hallway. A musty order and visible mold were observed below a plastic floor mat in the Evidence Reception Room 134. The consultants noted that carpet tiles and adhesive created a vapor barrier at the top of the slab resulting in condensation and mold growth on the backside of the carpet tiles. They noted a similar issue was occurring at the backside of the vinyl flooring in the corridor and plastic mats on concrete in the evidence reception room.

The consultant report indicated potential areas for water infiltration into building. The EIFS cladding was in good condition, but the consultants noted potential for water infiltration at some of the mechanical and electrical penetrations through the wall. Paving by the front (north) and rear (south) walls was flush with the floor level inside the building with poor drainage away from the building, allowing water to accumulate along the base of the walls and potentially infiltrate into the building. A swale at the base of the east wall in the northeast quadrant sloped towards the building instead of away. Following the observations in January 2019, the county performed grading, repaving, and swale installation on April 4 and 10, 2019 to better direct water-runoff and reduce moisture intrusion below the walls.

Overall, the HVAC equipment was in good condition. The consultant report indicated the county energy management coordinator stated the actuators in the AHUs had been programmed to close the make-up air dampers when the building's emergency generator was undergoing testing because of past diesel odor complaints. According to the consultant report, he also reported that approximately 16 VAV boxes in Zones 1 and 2 along the north and east side of the building were not communicating with the programmed system and were scheduled for repair in January 2019. Tape lift samples identified mold on the coils from AHU 1 (*Cladosporium*) and AHU 4 (*Ascospores*, *Basidiospores*, *Ganoderma*). A tape lift sample from the metal housing by the blower wheel of AHU 4 identified mold (*Ascospores*, *Cladosporium*, *Epicoccum*) and hyphal fragments. The interior temperatures ranged from 70.9°F to 77.2°F. The interior relative humidity levels ranged from 45.6% to 55.5%.

Terracon Consultants collected total non-viable fungal spore trap samples using Air-O-Cell® sampling cassettes and a Zefon Bio-Pump® at a flow rate of 15 liters per minute for 10 minutes. The total airborne mold spore concentration from 16 indoor air samples ranged from 40 counts per cubic meter (counts/m^3) to 420 counts/m^3. The total outdoor mold spore concentration from three outdoor air samples ranged from 1,730 counts/m^3 and 8,544/m^3. The Terracon Consultants report noted the fungal genera identified from the indoor air samples were qualitatively consistent with the fungal genera identified in outdoor samples. Indoor *Aspergillus/Penicillium* fungal counts collected in the Evidence Freezer Room (210 counts/m^3) and northeast Investigations Room (250 counts/m^3) were higher compared to only one of the outdoor air samples (40 counts/m^3). However, indoor *Aspergillus/Penicillium* fungal counts were not elevated when compared to the average of the three outdoor air samples (287 counts/m^3).

Terracon Consultants recommended the following:

Exterior of building
1. Seal penetrations through the EIFS cladding at the rear and west sides of the building.
2. Seal tops and sides of electrical boxes to prevent water intrusion.
3. Regrade the east side to provide a grade level slightly below floor level and positively sloped into the swale. Dig the swale deeper as needed. The consultant report noted the county was performing this work under a separate contract.
4. Cut in and install trench drains at the front and rear paving adjacent to the building to eliminate standing water against the building. The consultant report noted the county was performing this work under a separate contract.
5. Evaluate base of the concrete wall on the south side of the Main Evidence Storage Room and seal as necessary.
6. Evaluate gutter drainage away from the building and repair as necessary.

Interior of the building
1. Conduct VOC air sampling in the building to evaluate for the presence of elevated VOCs which may be related to moisture below floor finishes.
2. Evaluate the concrete floor slab to measure the moisture level and vapor emission rate.
3. Conduct upper wall cuts in the vicinity of old wood in the upper wall cavity along the south and southeast side of the building to further evaluate old wood.
4. Evaluate the extent of apparent bat droppings in the southeast upper wall cavity by performing wall cuts and surface investigation with ultraviolet light.
5. Further evaluate the extent of mold or moisture under flooring. Contract with a state licensed mold remediation firm to remove, clean, and sanitize identified areas of moisture, impacted floor finishes, at the base of walls by the northeast exit in the Investigations Room 111, and between the Evidence walk-

in refrigerator and freezer. Removal activities should be in accordance with the U.S. Environmental Protection Agency's *Mold Remediation in Schools and Commercial Buildings*.
6. Seal concrete floor where elevated floor moisture was identified with product designed to reduce moisture emissions. Conduct moisture testing on the sealed concrete slab prior to reinstallation of new floor finishes to evaluate replacement options.
7. Conduct HVAC repairs to the VAV boxes, test and balance the systems, and clean the AHU interiors, including coils. The consultant report noted the county was performing this work under a separate contract.
8. Conduct an indoor air quality follow-up evaluation to include air sampling at the conclusion of interior demolition work.

July 2019
Terracon Consultants observed varying degrees of moisture, musty odors, or suspect visible mold growth at 18 of 21 floor-level carpet or tile locations evaluated, including newer carpeting in Room 150 and Room 178. Terracon Consultants report indicated no odors were present prior to removal of the floor coverings.

Terracon Consultants conducted 35 measurements of the concrete slab for moisture vapor emission rate (MVER) (using ASTM Test Method F1869-16a) and relative humidity (using ASTM Standard F2170). Fourteen of the 35 measurements indicated moisture emission rates exceeding generally accepted maximum values for floor covering installation (greater than 5.0 MVER); eight of the 35 measurements indicated moisture emission rates with the potential to exceed generally accepted maximum values for floor covering installation (between 3.0 and 5.0 MVER); and 13 of the 35 measurement results had moisture emission rates below generally accepted maximum values for floor covering installation (less than 3.0 MVER). At 29 of the 35 tested locations, relative humidity measurements indicated elevated slab moisture levels. According to the consultants, the elevated relative humidity measured in the 29 locations generally indicated a saturated slab at depth.

During the evaluation, it was shared that there had been a water leak at some point after 2015 when the building was occupied. It was not clear of the exact location of the water leak; however, the water leak was reportedly repaired. Also, apparently portions of the flooring carpet tile from the original renovation were removed or replaced for aesthetic reasons.

Terracon Consultants collected two total non-viable fungal spore trap samples using Air-O-Cell® sampling cassettes and a Zefon Bio-Pump® at a flow rate of 15 liters per minute for 10 minutes. One air sample was collected outside, and the other air sample was collected in the Evidence Freezer Room (Room 139). The total airborne mold spore concentration from the indoor air samples was 310 counts/m^3. The total outdoor mold spore concentration from the outdoor air samples was 27,000 counts/m^3. In general, the fungal genera identified from the indoor air sample were qualitatively consistent with the fungal genera identified in the outdoor sample including *Aspergillus/Penicillium* (which was slightly elevated in the January 2019 indoor air sampling compared to the outdoor air sampling).

Terracon Consultants performed cut tests in old wood in the upper wall cavities in the southeast corner of the main evidence storage room (four cut tests), south side of the narcotics storage room (one cut test), in the south wall in the training room 129 (four cut tests). Additionally, they did a cut test (two cuts combined into one) in the lower wall cavity in the southeast corner of the training room below the location of location where bat droppings had been observed in the upper wall cavity behind the wall finishes. The consultants observed old yellow insulation in the Narcotics Evidence Storage Room cut test and in the three upper enclosed wall cavities in Training Room 129.

The consultants observed old wood within the upper wall cut in the Main Evidence Room and an upper wall cut in the Narcotics Evidence Storage Rooms, which adjoined the main Evidence Storage Room to the west. Some staining was observed on the old wood (blocking between the top of the concrete perimeter wall and roof deck), but the wood was solid and dry with no visible mold or musty odors. The consultants took tape lift samples from the old appearing wood in the Main Evidence Room, Narcotics Storage Room, and southeast corner of Training Room 129. The tape lift samples contained non-viable spores from different molds including *Cladosporium* and *Penicillium/Aspergillus*.

The consultants also took swab samples to look for mold on the old wood framing in the upper enclosed wall cavity behind the wall finishes along the south wall in the Main Evidence Room, Narcotics Storage Room, and southeast Training Room 129. Viable fungi were identified on swab samples from the old wood in the Narcotics Storage Room (*Aspergillus*, *Cladosporium*, *Penicillium*, and *Paecilomyces*) and the southeast Training Room 129 (*Paecilomyces*) near the bat droppings.

Bat droppings in Training Room 129 identified during the earlier evaluation in January 2019 appeared to be localized to the top corner of the southeast concrete wall. Visual assessment using an ultraviolet light showed no visible evidence of bat urine or guano on the ceiling, wall, or floor in the south area of Training Room 129.

Terracon Consultants recommended the following:
1. Properly clean and sanitize the old wood framing using a state licensed mold abatement firm; also remove the bat droppings in the southeast corner of the Training Room 129 and clean the area.
2. Remove rubber-backed carpet tiles with MVER above 5 to allow the slab to dry out. Also appropriately remediate mold on the concrete slab.
3. Have a qualified leak detection firm evaluate the slab conditions in the buildings' restrooms and in concrete test locations 11 (corridor between male restroom 159 and corridor 160), 22, and 24 (in the Muster/Training Room) to evaluate for possible sources of elevated slab moisture measurements.
4. Locate and review records from the previous partial floor replacement efforts and water leak repair work to determine if it has any bearing on the floor moisture issue.

Methods: Review of Ventilation and Balance Report Conducted after NIOSH Site Visit

A building ventilation test and balance assessment was performed on February 4, 2019. Holistic Test and Balance, Inc. evaluated building pressure at all doors, AHUs, and damper set points. We reviewed the Holistic Test and Balance report dated February 14, 2019.

Results: Review of Ventilation and Balance Report Conducted after NIOSH Site Visit

The office building was under slightly positive pressure. None of the AHUs had outdoor airflow monitoring stations installed, even though installation was planned during renovation of the building. It was also noted the amount of outdoor air each unit provided to the occupied spaces was not set properly. Holistic Test and Balance, Inc. reported no diversity in the AHU systems and the VAV sensors should be at the maximum or minimum level when calibrating the ventilation system. After the ventilation test and balance and adjustments performed by Holistic Test and Balance, Inc., the office building was receiving appropriate amounts of outdoor air throughout the full range of VAV system operation.

Discussion

The law enforcement office building has a history of dampness and mold. Moisture damage, musty orders, and visible mold growth were observed throughout interior areas of the building, within the building envelope, on building assemblies, and under carpet and tile flooring.

Dampness in Buildings

Research has found that damp building conditions can lead to respiratory illnesses in occupants. Dampness in buildings can occur for a variety of reasons such as high indoor humidity, condensation, and exterior water intrusion like through the concrete slab or exterior walls. Damp building conditions promote the growth of mold, bacteria, and other microbial agents, as well as dust mites and cockroaches. Dampness can also contribute to the breakdown of building materials and furniture. Musty odors are a sign of microbial contamination. Building occupants in damp buildings can be exposed to pollutants in the air from biological contaminants and the breakdown of building materials.

Building-Related Symptoms

Comprehensive reviews have been conducted of previous scientific studies evaluating the development of health effects associated with exposures from damp indoor conditions. The findings include associations with upper and lower respiratory symptoms, asthma development and exacerbation, hypersensitivity pneumonitis, respiratory infections, allergic rhinitis, bronchitis, and eczema [Mendell et al. 2011; WHO 2009]. NIOSH has published an Alert, *Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings*, that may be helpful to you. The Alert provides information on respiratory diseases related to indoor dampness and recommendations for preventing and remediating damp buildings [NIOSH 2012].

Air Sampling

Air sampling was performed as part of the environmental consultant reports reviewed by NIOSH. We do not typically recommend air sampling for mold with building air quality evaluations. There are no U.S. health-based exposure limits for biological contamination set by the Occupational Safety and Health Administration (OSHA) or recommended by NIOSH. Measurements of mold in air are highly variable and dependent on the mold species' lifecycle stages (e.g., spore formation) [NIOSH 2012]. In many cases, very short-term sampling for mold spores is conducted; however, the results may not be representative of actual exposures. Furthermore, spore counts and culture results, which tend to be what are included in indoor air quality reports, do not capture the full range of exposures. What building occupants react to is largely unknown. It may be mold, a compound produced by mold, something related to bacteria, or compounds that are released into the air when wet building materials break down.

We have found that thorough visual inspections or detection of problem areas by musty odors are more reliable. These methods have been used in past NIOSH research and have shown a correlation with health risks in buildings that have indoor environmental complaints.

Routine Visual Inspections

Implementing periodic room inspections for dampness can help to identify trouble areas before they become major problems. For example, conducting observational inspections in buildings quarterly or two times per year (spring and fall) provides documentation of dry versus damp areas and helps to prioritize maintenance and repair. The NIOSH Dampness and Mold Assessment Tool provides an inexpensive mechanism to track, record, and compare conditions over time. The assessment form and associated instructions can be downloaded from the NIOSH website (https://www.cdc.gov/niosh/docs/2019-115/) [NIOSH 2018].

If dampness or mold is not identified during visual inspections but suspected because of musty odors or continued health complaints, other methods, such as looking in wall cavities and under flooring, should be used to look for hidden problems. Using moisture meters and infrared cameras can also sometimes identify sources of dampness. In the law enforcement office building, moisture and mold were identified in wall cavities, under flooring, and behind a vinyl wall base molding.

Remediation

Wetted materials need to be dried within 48 hours of getting wet to prevent mold growth, and necessary repairs need to be made to prevent further water entry into the building. If mold is identified on materials, appropriate remediation guidelines with proper containment are recommended to minimize exposure to building occupants. The document, *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, developed by the New York City Department of Health and Mental Hygiene (NYCDH&MH), provides guidance for cleaning mold-damaged materials [NYCDH&MH 2008]. Inappropriate remediation (e.g., painting over water-damaged materials or moldy surfaces) can cause further problems with building degradation and symptoms in occupants.

After Remediation

After repairs and remediation are completed, employees and management often wish to know if the building is "safe." Building consultants often recommend and perform "clearance" air sampling after remediation work has been completed in an attempt to demonstrate that the building is safe for occupants. However, there is no scientific basis for the use of air sampling for this purpose. Once remediation is completed (moldy and damaged materials removed; musty odors no longer evident), the best evidence that the building is safe may be that employees no longer experience building-related symptoms. In large populations of workers, using employee health questionnaires may be helpful to collect information on building-related symptoms, particularly among persons new to the building after remediation (i.e., those without "sensitizing" historical exposures during a period of water damage). Unfortunately, even if most employees experience improvement in their symptoms, and new employees remain free of building-related symptoms, some employees with allergic conditions may not notice an improvement because their immune systems may continue to react to very small amounts of allergens. Such individuals may have to avoid the building even after an otherwise successful remediation. An individualized management plan (such as assigning an affected employee to a different work location, perhaps at home or a remote site) is sometimes required, depending upon medical findings and recommendations of the individual's physician.

NIOSH has evaluated numerous buildings and found that, if building dampness is not neglected, these problems can generally be corrected using remediation practices (with appropriate containment to minimize exposure of building occupants) that are fairly standardized. The NIOSH publication, *Maintaining Acceptable Indoor Environmental Quality (IEQ) during Construction and Renovation Projects* [NIOSH 2020], and U.S. Environmental Protection Agency (EPA) publications, *Mold Remediation in Schools and Commercial Buildings* [EPA 2008] and *Moisture Control Guidance for Building Design, Construction and Maintenance* [EPA 2013], have useful information that might be helpful. For additional information, you may wish to visit the NIOSH IEQ website (http://www.cdc.gov/niosh/topics/indoorenv/), EPA website (http://www.epa.gov/iaq/), or OSHA website (http://www.osha.gov/SLTC/indoorairquality/).

Building Ventilation and Indoor Environmental Quality

Poor ventilation in buildings is a common problem and is frequently due to lack of proper attention to the building's HVAC system. HVAC systems include all of the equipment used to ventilate, heat, and cool the building; to move the air around the building (ductwork); and to filter and clean the air. These systems can have a significant impact on how pollutants are distributed in and removed from spaces. They can even act as sources of pollutants in some cases, such as when ventilation air filters become contaminated with dirt or moisture, when microbial growth results from stagnant water in drain pans, or from uncontrolled moisture inside of air ducts.

Ventilation System Design

The air delivery capacity requirements of an HVAC system are based in part on the projected number of people and the area of the occupied space. Proper distribution of ventilation air throughout all occupied spaces is essential. When areas in a building are used differently than their original purpose, the HVAC system may require modification to accommodate these changes. For example, if a storage area is converted into space occupied by people, the HVAC system may require alteration to deliver enough conditioned air to the space.

Outdoor Air Supply

Adequate supply of outdoor air, typically delivered through the HVAC system, is necessary in any office environment to dilute pollutants that are released by equipment, building materials, furnishings, products, and people. Carbon dioxide (CO_2) is a normal constituent of exhaled breath; thus, CO_2 will also increase during building occupancy. CO_2 levels are routinely collected in air quality studies because they can indicate whether a sufficient quantity of outdoor air is being introduced to an occupied space for acceptable odor control. A rule of thumb is that indoor CO_2 concentrations no greater than 700 parts per million (ppm) above outdoor CO_2 concentrations will satisfy a substantial majority of building occupants. This would typically correspond to indoor concentrations below 1200 ppm because outdoor CO_2 concentrations usually range from 375 ppm to 500 ppm. However, CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual occupant density at the time the CO_2 is measured. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. If CO_2 concentrations are elevated, the amount of outdoor air introduced into the ventilated space may need to be increased.

A common complaint from occupants of the law enforcement office building was stale air, which they often attributed to a lack of fresh outdoor air. The four main AHUs that ventilated the occupied spaces in the building were providing some fresh, outdoor air to those spaces. However, the HVAC control system was modulating the outdoor airflow differently than the original design intent. The units were originally designed to supply at least the minimum amount of fresh, outdoor air required by mechanical codes to the occupied areas of the building. A series of emails between various mechanical and control systems contractors, dated September 24, 2015 through October 8, 2015, indicated that each AHU was supposed to include outdoor airflow monitoring stations to continually measure the amount of outdoor air delivered by each unit. These flow monitoring stations would help ensure the minimum required outdoor airflow was delivered as the variable frequency drive (VFD) controlled the supply fan speed for each unit over the entire range of supply flow rates. However, the emails stated the airflow monitoring stations were not included during final installation of the AHUs. No reason for the lack of airflow monitoring stations was given, but without the airflow monitoring stations, adjustments had to be made to the control sequences for each unit to regulate the outdoor airflow. The decision was ultimately made, on October 8, 2015, to control the amount of outdoor air delivered by adjusting the outdoor air damper and return air damper according to the VFD speed for each AHU. For instance, data from the daily inspection log from June 19, 2017 show AHU-1 running with the VFD at 51% speed, the outdoor air damper was 58% open and the return air damper was 58% closed. When more total supply air was required on July 10, 2017, the VFD was at 79% and the outdoor air damper was only 39% open while the return air damper was 39% closed. Similarly, on February 2, 2018, the VFD was down at 44% and the outdoor air damper was 64% open and the return air damper was 64% closed. Similar trends hold for the other three AHUs.

Using proportional control for the outdoor air damper position relative to supply fan speed is typical in smaller VFD systems. However, further incorporating the return air damper position into the control strategy, as was the case with the law enforcement office building AHUs, could lead to potential issues with control. For the new control strategy to work properly, the outdoor air damper and the return air damper within each AHU needed to be carefully selected so they would properly matched. Damper matching would not be as critical if outdoor airflow monitoring stations were used. Given that flow monitoring stations were expected but not actually used in the end, it was possible the existing dampers in each AHU are not well-matched. Without careful matching of the two dampers, the mixing ratio between outdoor and return air would not be controlled in a linear way (as the proportional control method used would indicate), even in constant-volume systems. The variable air volume systems in the law enforcement office building could complicate the issue further.

Additionally, at the time of our visit, there were no available documents indicating the control strategy currently being used was tested to assure proper flows of outdoor air. The Testing, Adjusting, and Balancing (TAB) Report issued by Bay To Bay Balancing (Lutz, FL), after the AHUs were installed in the law enforcement office building, was dated September 28, 2015. Thus, it appears the final testing and balancing of the systems occurred prior to the modification of the control sequences. The TAB report did indicate that proper outdoor airflow rates were achieved at maximum supply flow. However, the email thread mentioned above indicates that to achieve this, the linkage was removed from the return air damper, and it was in a single, fixed position during the testing. It was not modulating as it has been since the change to the controls sequence. After our visit, Holistic Test and Balance, Inc. (Jacksonville, FL) was contracted to redo testing and balancing of the HVAC systems in the law enforcement office building. They arrived onsite on February 4, 2019 and issued their report dated February 14, 2019. They also found the AHUs did not have outdoor airflow stations installed, and the amount of outdoor air provided by each AHU did not appear to be set properly. As part of their work, they set the outdoor air damper position through a controlled damper setpoint in the controls system, which better controlled outdoor air delivery to all the occupied spaces in the building.

In some cases, building owners/managers or occupants will open doors or windows to increase the amount of outdoor air coming into their building. However, relying on open doors may cause problems. For example, the air coming into the building through the doors may not reach all the office areas in the building. The incoming air is unfiltered and might contain outdoor air pollutants such as pollen and dust. Additionally, open doors might affect the ability of the HVAC system to adequately control temperatures and humidity. The American National Standards Institute (ANSI) and ASHRAE have developed consensus standards and guidelines for HVAC systems. ASHRAE guidelines provide specific details on ventilation for acceptable indoor environmental quality. A ventilation system expert can help meet ASHRAE ventilation guidelines in the building. ANSI/ASHRAE Standard 62.1-2019, *Ventilation for Acceptable Indoor Air Quality*, recommends outdoor air supply rates that take into account people-related sources as well as building-related sources. For office spaces, conference rooms, and reception areas, five cubic feet per minute of outdoor air per person (5 cfm/person) is recommended for people-related sources, and an additional 0.06 cfm for every square foot (cfm/ft^2) of occupied space is recommended to account for building-related sources. To find rates for other indoor spaces, refer to

Table 6-1, which is found in ANSI/ASHRAE 62.1-2019 [ANSI/ASHRAE 2019]. ASHRAE standards are generally incorporated into legally-enforceable building codes, including the International Mechanical Code, which is adopted by many states, cities, and municipalities as part of their building codes. Care should be taken to meet the ventilation requirements most appropriate for the locality and building type.

Exhaust Rates

For spaces where airborne contaminants and odors are prevalent, ANSI/ASHRAE 62.1-2019 offers minimum exhaust rates from the space. For copy and printing rooms, the standard recommends an exhaust rate of at least 0.5 cfm/ft^2, while janitor closets and rooms for trash storage or recycling should exhaust 1.0 cfm/ft^2. Storage rooms containing chemicals should exhaust 1.5 cfm/ft^2. The air should be exhausted directly outdoors, away from outdoor air intakes, operable windows and doors, or outdoor gathering spaces. The makeup air for this exhaust air can consist of any combination of outdoor air, recirculated air, or air transferred from adjacent spaces. When normal dilution ventilation does not reduce occupant exposures to emissions from office equipment to acceptable levels, some form of local exhaust ventilation must be considered to remove the contaminant from the source before it can be spread throughout the occupied space. However, little scientific research has been done to develop or test the performance of local exhaust systems for typical office equipment.

To control humidity and odors, restrooms should exhaust more air than the AHU is supplying. This will maintain these areas under negative pressure. Separate exhaust fans should be used to exhaust air directly outdoors at least 25 feet from any air intakes. For high occupancy public bathrooms, the ANSI/ASHRAE Standard 62.1-2019 recommendation is based on expected usage, and it states that 70 cfm per water closet should be exhausted when periods of heavy use are expected to occur. If periods of heavy use are not anticipated, then exhausting 50 cfm per water closet is sufficient. For private toilets in bathrooms intended to be occupied by only one person at a time, it specifies the exhaust ventilation should be 50 cfm if the exhaust fan only operates during periods of occupancy (e.g., exhaust fan controlled by a wall switch). When the exhaust fan is designed to operate continuously, 25 cfm of exhaust air is adequate. In general, there should be no recycling or re-entrainment of return/exhaust air from the bathrooms.

Outdoor Air Quality

When present, outdoor air pollutants such as carbon monoxide, pollen, and dust may affect indoor conditions when outdoor air is taken into the building's ventilation system. Properly installed and maintained filters can trap many of the particles in outdoor supply air. Controlling gaseous or chemical pollutants might require more specialized filtration equipment and sometimes relocation of the outdoor air intakes. Section 4 of ANSI/ASHRAE Standard 62.1 specifies that any outdoor air brought into occupied spaces must be in compliance with the EPA’s National Ambient Air Quality Standards (NAAQS). The standard further stipulates that a local outdoor air quality assessment should be conducted at a building and the immediate surroundings during periods the building is expected to be occupied to identify and locate contaminants of concern. If any outdoor contaminants exceed the

NAAQS limits, the outdoor air must be appropriately treated prior to introduction of that air to occupied spaces.

In-Duct Ultraviolet Germicidal Irradiation (UVGI) Systems

Typical in-duct UVGI systems use ultraviolet (UV) energy to inactivate viral, bacterial, and fungal organisms on surfaces so they are unable to replicate and potentially cause disease. In-duct UVGI systems are mounted inside AHUs or ventilation ductwork. When selected to produce appropriate irradiance levels, in-duct systems are effective for AHU surface disinfection. The goal of surface disinfection is to reduce or eliminate microbial growth on internal surfaces of HVAC systems, typically cooling coils and drain pans. This is generally easy to achieve because the surfaces are not moving and are continuously irradiated with UV energy. The entire spectrum of UV wavelengths is capable of inactivating microorganisms, but UV-C energy (100-280 nanometers) provides the most germicidal effect, with 265 nm being the optimum wavelength. Since solar UV-C energy is unavailable on the surface of the earth, UV-C radiation must be produced by artificial sources. A variety of available lamps produce some energy in the ultraviolet spectrum, but the majority of modern UVGI lamps create UV-C energy with an electrical discharge through a low-pressure gas (including mercury vapor) enclosed in a quartz tube. Roughly 95% of the energy produced by these lamps is radiated at a near-optimal wavelength of 253.7 nm. Although UV-C is invisible to the human eye, small amounts of energy released at visible wavelengths produce the blue glow commonly associated with UVGI lamps.

UVGI inactivates microorganisms by damaging the structure of nucleic acids and proteins at the molecular level. The most important of these is deoxyribonucleic acid (DNA) that is responsible for cell replication. Absorbed UV photons can damage DNA in a variety of ways, but the most significant damage event is the creation of pyrimidine dimers, where two adjacent thymine or cytosine bases bond with each other instead of across the double helix as usual. In general, the DNA molecule including pyrimidine dimers is unable to function properly, resulting in either an inability of the organism to replicate or death. An organism that cannot reproduce is no longer capable of causing disease.

While the REME-HALO® units do include a UV lamp, the device uses a significantly different principle to disinfect air. According to the RFG Environmental website for the REME-HALO (https://www.rgf.com/products/air/reme-halo/):

> *The REME HALO® in-duct air purifier utilizes RGF's patent-pending Reflective Electro Magnetic Energy technology. Installed into the supply plenum of your existing air conditioning or heating system air ducts, the REME HALO® in-duct air purifier produces Hydro-Peroxide plasma that is distributed through the air handler, through the duct system and into the conditioned living space. Unlike passive air technologies, which need pollutants to pass through the unit for purification or filtration, the REME HALO® in-duct air purifier sweeps through your home actively purifying pollutants at the source. In addition, the charged plasma induces particles to coagulate or stick together making them bigger and easier for your filter to catch. Hydro-Peroxide occur naturally in the earth's atmosphere and are part of nature's process of cleaning the air.*

The redesigned and improved REME HALO® HVAC unit features higher Ionized Hydro-Peroxide output, which gives faster kill rates for microbial contaminants in the air as well as on surfaces. This higher output also drops more particulates from the air bringing relief to those who suffer from allergies and other respiratory issues. Now with quick release features for the cell and housing for faster cell replacement and an adjustable shroud for customization of the advanced oxidation plasma output.

The REME-HALO® units are reportedly acceptable AHUs with sizes between 2.5 tons–16.25 tons (cooling) and 1,000 cubic feet per minute–6,500 cubic feet per minute. Thus, according to the manufacturer, they are appropriate for AHU-2, AHU-3, and AHU-4 in the law enforcement office building. The design flowrate for AHU-1 is above the upper limit for the REME-HALO, so it may not perform as well in that unit. It is not clear what impact, if any, the REME-HALO devices have on air quality in the law enforcement building.

Maintenance of HVAC Equipment

Diligent maintenance of HVAC equipment is essential for the adequate delivery and quality of building air. All well-run buildings have preventive maintenance programs that help ensure the proper functioning of HVAC systems.

HVAC Duct Cleaning

We do not recommend duct cleaning unless it is found to be contaminated with mold or other irritant particles affecting the employees' health. Improper duct cleaning can release large amounts of dust and other contaminants into the work area. Fiberglass ductwork that has mold growth must be replaced; it cannot be cleaned. If metal duct cleaning is deemed necessary, it should only be performed by contractors who are members in good standing of the National Air Duct Cleaners Association. The National Institutes of Health (NIH) has a fact sheet on HVAC duct cleaning [NIH 2015]; it can be found online at https://www.ors.od.nih.gov/sr/dohs/Documents/HVACDuctCleaning.pdf.

Temperature and Relative Humidity

Temperature and relative humidity measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The ANSI/ASHRAE Standard 55-2017, *Thermal Environmental Conditions for Human Occupancy*, specifies the combinations of indoor environmental and personal factors that produce acceptable thermal conditions to a majority of occupants within a space [ANSI/ASHRAE 2017]. Assuming slow air movement (less than 40 feet per minute) and 50% indoor relative humidity, the operative temperatures recommended by ASHRAE range from 68.5°F to 75°F in the winter, and from 75°F to 80.5°F in the summer. The difference in temperature ranges between the seasons is largely due to clothing selection. ASHRAE Standard 62.1 also recommends that indoor humidity be maintained to provide a maximum indoor-air dew-point temperature of 60°F in buildings that are mechanically cooled, during occupied and unoccupied periods [ANSI/ASHRAE 2019]. Using indoor-air dew-point temperature to limit humidity regulates the total mass of water vapor available for condensation and adsorption on surfaces indoors. Condensation and adsorption of water on surfaces is largely responsible for indoor microbial growth. For other mechanical system types or where spaces are not served by mechanical systems, Standard 62.1 has no humidity limitations. The EPA recommends maintaining indoor relative humidity between 30% and 50% to reduce mold growth [EPA 2019].

Occupied and Non-occupied Settings

Buildings with simple HVAC systems often operate the ventilation system during occupied hours and then turn them off completely at night or other periods when the building is unoccupied. While turning the system off may save energy, operating a building with mechanical cooling in this fashion should be avoided. It can create significant issues with condensation and adsorption of water vapor on indoor surfaces when humid outdoor air infiltrates into buildings during the "off" periods. More sophisticated HVAC systems with programmable thermostats or building automation systems allow for the ventilation equipment to be "set back" during unoccupied periods. This method still allows the indoor temperature and humidity to drift further from the occupied set-points, but eventually the HVAC system will come on to prevent fluctuations as extreme as they might otherwise be with the equipment powered off. This "set back" method still provides significant energy savings, but if the indoor-air dew-point temperature is always maintained at 60°F or lower, microbial growth is not expected to occur. Whether the system runs continuously or is "set back" when spaces are unoccupied, the required fresh, outdoor airflow and the indoor temperature and humidity conditions should always meet recommendations found in ANSI/ASHRAE 62.1-2019 and ANSI/ASHRAE 55-2017 any time the building is occupied [ANSI/ASHRAE 2017, 2019].

Dusty Environments

A large amount of settled dust in occupied spaces is an indicator of potential indoor environmental quality problems. ESi observed heavy dust accumulation in some areas of the building. Dusty environments can be problematic especially when the dust is stirred-up and suspended into the air allowing dust particles to be inhaled. This can subsequently cause a reaction in some people, particularly those who suffer from dust allergies. In contaminated buildings, dust may contain mold and bacteria due to dampness. Carpeted areas, upholstery, and areas with fleecy materials such as partitions or desk chairs may serve as reservoirs for accumulated dusts and are frequently associated with increased building-related symptoms. We recommend attention to work area cleanliness by establishing a routine cleaning schedule. The floors and surface areas should be clutter free to allow for easier cleaning. Vacuums should be equipped with high-efficiency particulate air (HEPA) filters in order to not re-suspend the dust. If cleaning products are used when cleaning work areas, they should be used according to the manufacturer's directions.

Construction and renovation projects can create the release of airborne dusts, microbiological contaminants, gasses, and odors. Careful planning is essential to prevent exposures to building occupants. To protect employees from contaminants being released during construction/renovation, areas should be isolated using proper containment barriers. Additionally, construction areas should be negatively pressurized from occupied areas to prevent migration of contaminated air into employee workspaces. As discussed earlier, the NIOSH document, *Maintaining Acceptable Indoor Environmental Quality (IEQ) during Construction and Renovation Projects* [NIOSH 2020], has information that might be helpful.

Volatile Organic Compounds

The ESi consultants noted the law enforcement building had a light odor of volatile organic compounds (VOCs) in some areas of the building. The wet adhesive (and mold) under the flooring that Terracon Consultants, Inc. identified might have been contributing to the VOC odor. VOCs are common in indoor environments as they are widely used in household and consumer products, furnishings and building materials, office equipment, cleaning products, air fresheners, and paints [Ayoko 2004]. In addition to those generated indoors, VOCs from outdoor sources such as vehicle traffic and industrial emissions contribute to the indoor loading. VOCs include a variety of different chemicals, some of which may have short- and long-term adverse health effects. Many VOCs have well-established exposure guidelines for workers in industrial settings; however, in an indoor setting such as an office, the link between health effects and indoor VOC levels is still largely unknown. For more information on VOC sources, health effects and steps to reduce exposure, visit EPA's *Indoor Air Quality (IAQ): Volatile Organic Compounds' Impact on Indoor Air Quality* website [EPA 2017] at http://www2.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality#intro.

Pests and Pest Control Programs

In January 2019, a consultant for the law enforcement agency observed bat droppings in the upper wall cavity in the southeast corning of the Training Room. Animals or animal products such as dander, hair, fur, saliva, and body wastes contain allergens that can cause respiratory and skin disorders. The protein in urine from rats and mice is a potent allergen. When it dries, it can become airborne [EPA 2018]. Many infectious diseases can also result from exposure to rodent feces and urine [CDC 2010]. An effective pest control program is the primary strategy for preventing human exposure to rodent diseases. This is achieved by cleanliness, eliminating food sources, sealing rodent entries into the work area, and trapping rodents in and around the workplace. For more information, the CDC provides guidance on preventing rodent infestation and cleaning up after rodents at http://www.cdc.gov/rodents/.

An effective pest control program is the primary strategy for preventing human exposure to pests. Current best practice is the use of an integrated pest management approach, which includes identifying the origin of the pest problem (for example, a food preparation or garbage disposal area) and eliminating the problem at the source. Cleanliness, eliminating food and water sources, and sealing gaps (e.g., around plumbing, electrical outlets, and switch plates) into the work area can help with pest control. The NIOSH document, *Reducing Pesticide Exposure at Schools*, discusses the integrated pest management program and provides an 8-step approach for schools that can be adapted for other settings [NIOSH 2007].

Any pesticides used in the workplace or public areas must be registered by the EPA for its intended use under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Pesticide application must conform to guidance from the manufacturer and the EPA. Protective equipment (skin and respiratory protection) should be worn when applying pesticides. Pesticides should not be applied in areas where human contact is likely. Even with proper use, application of pesticides may result in dissemination of these chemicals throughout the building, leading to possible occupant exposures and health effects.

If not in place, a written pest control program should be developed. If a written program already exists, the pest control procedures should be assessed to determine if updates are needed. Important components of a written pest control program include procedures, recordkeeping materials, verification procedures, and frequency. Individuals responsible for each aspect of the program should be listed. If needed, pest control experts can evaluate the plan for completeness and effectiveness.

Histoplasmosis

A swab sample from the bat droppings identified a fungus called *Histoplasma capsulatum*. *Histoplasma capsulatum* often lives in environments that contains large amounts of bird or bat droppings [CDC 2018]. Histoplasmosis is an infection caused by inhaling spores of *Histoplasma capsulatum*. Histoplasmosis is not contagious, and it cannot be transmitted from an infected person or animal to someone else. Most people with infections caused by *Histoplasma capsulatum* do not have any symptoms. If symptoms do occur, they usually start 3 to 17 days (on average 10 days) after exposure. Symptomatic persons generally have disease ranging from a self-limited influenza-like illness (e.g., general ill feeling, fever, chest pain, dry or nonproductive cough, headache, loss of appetite, shortness of breath, joint and muscle pains, chills, or hoarseness) to pneumonia. Reinfection can occur in persons who have had histoplamosis [Kauffman 2006, NIOSH 2004] although it is generally thought to be less severe than the primary infection [Wheat and Kauffman 2003, NIOSH 2004]. Immunocompromised individuals are at risk for disseminated disease (spreading of the fungus to other organs outside the lungs) and reactivation of inactive (latent) histoplasmosis years after infection [Kauffman 2006].

Histoplasma capsulatum tends to be present in geographic cluster areas. In the United States, *Histoplama capsulatum* is most common (endemic) along the Ohio and Mississippi valleys [Kauffman 2006]. However, even in regions where *Histoplasma capsulatum* is not considered highly endemic, outbreaks of histoplasmosis have resulted from work-related activities in bird roosts, which caused contaminated dust to become airborne [DiSalvo and Johnson 1979; Morse et al. 1985; NIOSH 2004]. The NIOSH document, *Histoplasmosis: Protecting Workers at Risk*, contains useful information on reducing exposures [NIOSH 2004].

Asbestos

During our site visit, employees expressed concerns for potential exposure to asbestos during renovation activities in the training building located on the property. Asbestos exposure is a well-known health hazard and can cause a great deal of concern to those who work with, or occupy buildings with, asbestos containing materials. A naturally occurring fire resistant mineral, asbestos has been used as an acoustic insulator, in thermal insulation, in fire proofing and other building materials, as well as in brake pads and industrial filters. Many products in use today contain asbestos. The EPA has information about asbestos on their website at www.epa.gov/asbestos.

Asbestos is made up of microscopic bundles of fibers that may become airborne when asbestos-containing materials are damaged or disturbed. Exposure to airborne asbestos can lead to the deposition of these durable fibers in the lung. Continued asbestos exposure can increase the amount of fibers that remain in the lung. Fibers embedded in lung tissue over time may cause serious, potentially fatal, diseases such as asbestosis (scarring of the lungs that can cause shortness of breath and cough) and lung cancer. Exposure to cigarette smoke increases the risk of developing lung cancer from asbestos exposure. Further, asbestos fibers can irritate the pleura (the membranes lining the lungs) and induce development of pleural plaques (scarring of the pleura), pleural thickening, pleural effusions (abnormal collections of fluid), or mesothelioma (a rare cancer of the pleura or of similar membranes lining the abdomen). Asbestos exposure has been linked to laryngeal cancer, retroperitoneal fibrosis (scarring around abdominal organs), and ovarian cancer [IARC 2012; Weissman et al. 2014; Wolff et al. 2015]. Although asbestos-related disease has occurred as soon as 10 years after recognized exposure, it is important to know that diseases associated with asbestos often have a long latency period. This means the development of asbestos-related diseases may take 30 or more years from the time of exposure.

Nearly everyone is exposed to asbestos at some time in their life. While there is currently no known safe level of asbestos exposure, and asbestos-related diseases have been diagnosed in individuals with only brief exposure, most individuals do not become sick from their exposure. The likelihood of eventually developing asbestos-related disease increases with increasing exposure to asbestos. Today in the United States, most occupational exposures occur during repair, renovation, removal, or maintenance of asbestos-containing building materials. Construction renovation workers, building demolition workers, and firefighters might be exposed to asbestos, as well as roofers, plumbers, plasterers, drywall installers, electricians, cable installers, floor covering installers, carpenters, insulators, maintenance workers, and auto mechanics. Occupational or environmental asbestos exposure might occur near railroads, power plants, oil refineries, and shipyards. More information about asbestos-related cancer risk can be found in a National Cancer Institute (NCI) website [NCI 2017]and in consensus reports about asbestos and cancer [IARC 2012; FIOH Health 2014].

It is important to ensure that employees are aware of the asbestos in the building and the precautions in place to prevent asbestos exposures. OSHA established regulations dealing with asbestos exposure that employers are required to follow. Information about the OSHA asbestos standards can be found on the OSHA website at https://www.osha.gov/SLTC/asbestos/standards.html. Guidance on compliance with the OSHA Hazard Communication Standard 29 CFR 1910.1200 can be found at https://www.osha.gov/dsg/hazcom/index.html.

Communication

Through health hazard evaluations, NIOSH frequently finds a breakdown in communication between management and employees regarding building-related problems. Employees sometimes fear being singled out or fear repercussion from management or from other employees when they speak up about their concerns. Management typically has more success when they develop an anonymous environmental reporting system and when they establish an indoor environmental quality team consisting of a coordinator, representatives of the building employees, employers, and building management. The EPA's Indoor Air Quality Tools for Schools Action Kit provides guidelines on how to set up such a team and how to implement a program in a school setting, which can be modified for the law enforcement office building [EPA 2009]. These guidelines can be found on EPA's website at https://www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit.

Limitations

The recommendations presented in this report are based on NIOSH performing a limited visual assessment of the building, informally speaking with approximately 37% of available employees, and reviewing medical documents as well as indoor environmental quality assessments performed by ESi and Terracon Consultants, Inc.

Conclusions

Water intrusion throughout the law enforcement building envelope resulted in hidden mold in wall cavities and under flooring. Hidden mold is consistent with employee reports of musty odors, especially after rains, and health symptoms. The county has taken action to prevent further water intrusion through the foundation, including re-grading the ground to direct water away from the exterior building. The concrete slab will need to dry out and then be tested again for moisture before installing compatible replacement flooring. If the concrete slab moisture cannot be controlled, other options need to be considered including using breathable floor coatings or installing a moisture vapor suppression system. Mold and moisture-damaged materials should be removed or cleaned with appropriate containment to minimize exposure for remediation workers, building occupants, and unaffected sections of the building. The bat droppings identified in a wall cavity also should be removed, and the area cleaned. Inappropriate remediation can cause further problems and symptoms in occupants.

The amount of fresh air delivered to occupied spaces within the building was originally incorrect, due to the elimination of planned outdoor airflow monitoring stations during HVAC system installation. However, the outdoor airflow rates were appropriately adjusted by Holistic Test and Balance, Inc. during their ventilation testing and balance assessment on February 4, 2019. If building spaces are renovated or repurposed for different uses in the future, new testing and balancing of the impacted ventilation systems should be performed to ensure appropriate outdoor airflow to those occupied areas. Temperature in occupied spaces should be maintained from 68.5°F to 75°F in the winter, and from 75°F to 80.5°F in the summer, while indoor humidity should always be maintained to provide a maximum indoor-air dew-point temperature of 60°F. Implementation of a thorough HVAC preventative maintenance program and the creation of a comprehensive, written HVAC operation and maintenance plan for the facility would further help ensure proper HVAC system operation and indoor environmental quality. Establishing a team for improved communication and reporting of environmental or health concerns can help prevent future building-related health symptoms.

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