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Evaluation Program

Evaluation of Indoor Dampness, Mold, and Ventilation at a College

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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 USC 669a(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].

Availability of Report

Copies of this report have been sent to the employer, employees, and union at the facility. The state and local health departments and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

Recommended Citation

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Introduction

Request

In June 2022, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation request from union representatives and confidential employees regarding concerns about indoor dampness, mold, and ventilation system maintenance in multiple buildings located on a college campus.

Workplace

The college campus included 14 buildings located on approximately 100 acres. Buildings were used as residence halls, dining rooms, lecture halls, laboratories, study rooms, auditoriums, student and recreational services, library, museum, guest housing, and facilities/maintenance. The college had approximately 420 employees, and approximately 1,100 students lived and learned on the campus. Employee concerns about indoor dampness and mold had especially been noted after a new campus-wide water chiller system was completed in 2018. Multiple employees reported a wide range of health concerns, many with work-related patterns that involved multiple body systems and were severe enough to necessitate approved or requested full-time virtual work.

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

Our Approach

We visited the college on two occasions to learn more about the concerns related to indoor dampness, potential exposure to mold, and ventilation system operations and maintenance. Before our visits, we reviewed documents provided to NIOSH, including indoor air sampling reports, campus building floor plans, ventilation maps and drawings, and employee reports of indoor environmental quality and health concerns.

During the first visit on August 9–11, 2022, we

- Held an opening meeting with employee representatives, union representatives, and management.
- Toured nine buildings and talked with employees, union representatives, and management.
- Assessed the interior and exterior of buildings for indications of water damage or mold growth.
- Observed building ventilation systems.
- Learned about the campus-wide water chiller system.
- Held a closing meeting with employee representatives, union representatives, and management.

After the first visit, we

- Requested follow-up documents, including additional mechanical ventilation systems drawings. Management promptly provided the additional documents.
- Provided an interim report on September 27, 2022 with recommendations for improving indoor environmental quality.
- We provided a second interim report on January 4, 2023 that summarized reports of air sampling for mold in various campus buildings during 2011–2022.

During the second visit March 7–9, 2023, we

- Held an opening meeting with employee representatives, union representatives, and management.
- Conducted ventilation assessments of four buildings.
- Learned from facilities management about their methods for responding to occupant health and safety concerns.
- Held a closing meeting with employee representatives, union representatives, and management.

After the second visit, we

- Reviewed field notes, mechanical drawings, and ventilation assessment information.

During our visits, facilities management and union representatives were helpful in facilitating access to various areas across campus. They showed us examples of moisture issues and ongoing remediation efforts throughout different buildings and discussed with us current efforts to address mold and moisture concerns comprehensively across the entire campus.

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

Our Key Findings

Persistent high indoor humidity and concerns for proper ventilation system operation

- Building evaluation reports covering years 2011 through 2022 documented high indoor humidity in multiple campus buildings.
- Throughout campus buildings, we observed areas with high indoor humidity levels; indoor air above the dew point; and condensation leaking from ventilation system supply vents, duct work, and chilled water piping.
- High indoor humidity levels were observed which can contribute to the growth and spread of mold and other moisture-related issues.
- Condensation leakage from ventilation systems was observed, highlighting the need for maintenance and repair to prevent further moisture-related problems.

Lack of vapor barriers in crawl spaces

- The observed crawl spaces had dirt floors and no vapor barriers installed.
- The absence of vapor barriers in the crawl spaces can promote indoor moisture issues and potential humidity concerns.

Campus-wide mold and moisture concerns

- Building evaluation reports covering years 2011 through 2022 documented water staining or damage, musty odors, visible mold, and higher than expected levels of mold in indoor air across multiple campus buildings.
- Widespread mold and moisture damage was observed throughout various areas of the campus, indicating underlying moisture problems that require immediate attention.
- Mold and moisture damage throughout campus was most often observed in areas with leaking ventilation condensation, high humidity levels, or areas without a crawl space vapor barrier.

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
↑ Easier employee recruiting and retention
↑ Enhanced image and reputation
↑ Superior products, processes, and services
↑ May 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 practical, 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: Reduce moisture and humidity in basements and crawl spaces

Why? Uncontrolled moisture in basements and crawl spaces can compromise a building's structural integrity. Excessive moisture and increased humidity create an ideal environment for mold and mildew growth in basements and crawl spaces. Dampness and mold in basements and crawl spaces can contribute to poor indoor environmental quality and high humidity levels throughout building interiors. Controlling moisture and humidity in basements and crawl spaces helps prevent mold growth which is known to cause adverse health outcomes.

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

Control moisture and humidity in basements and crawl spaces.

- When implementing crawl space recommendations reference relevant standards and guidelines such as, ASHRAE Standard 90.1, International Building Code Section 1203.3.1, and ASTM E779-10and ASTM E1827-96 (2022) .
- Consider actions to keep ground water out of basements and crawl spaces:
    - Regrading areas where the ground slopes towards the building to prevent water pooling around building exteriors.
    - Regularly clean gutters and inspect downspouts to prevent water overflow near building foundations.
    - Inspect whether downspouts drain water too close to building foundations. If needed, install downspout extension to redirect water away from building foundations.
    - Before installing a vapor barrier, inspect buildings during or after heavy rains to ensure any existing rainwater or groundwater drainage issues have been remediated.
- To ensure effective crawl space moisture control, the following actions are recommended for vented and non-vented crawl spaces:
    - Vented crawl spaces:
        - Specify one or more layers of insulation in the floor system to meet the insulation levels required by ASHRAE Standard 90.1.

        - Provide air-sealing details to create a continuous air barrier between the above-grade wall and the crawl space floor.
        - Where concrete slab does not exist, consider installing a plastic or elastomeric membrane to form a vapor barrier to prevent moisture from traveling into the crawl spaces and potentially moving into the building interiors.
        - Install screened vents that comply with International Building Code requirements for ventilated crawl spaces (Section 1203.3.1).
    - Non-vented crawl spaces:
        - Consider using a plastic or elastomeric membrane as an alternative to a concrete slab to create a vapor barrier to prevent moisture from traveling into the crawl spaces and potentially moving into the building interiors.

Recommendation 2: Maintain ventilation systems for optimal indoor air quality

Why? Poor ventilation in buildings is a common problem and frequently due to lack of proper attention to the building's heating, ventilation, and air conditioning (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:

Ensure ventilation systems meet ANSI/ASHRAE Standard 62.1-2022, *Ventilation for Acceptable Indoor Air Quality* for applicable areas across campus.

- Follow the manufacturer's recommended maintenance schedules for the ventilation 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. In addition, make sure water does not pool near fresh air intakes.
- Follow the manufacturers' recommended maintenance schedules for the in-wall air conditioner units, including care of the filters, checking drip pans, evaporator coils, and condenser coils.
- Identify any potential sources of condensation on duct work or supply vents through visual inspection and apply methods to prevent condensation. Properly insulating ductwork and piping or controlling indoor humidity levels can help to minimize

condensation. Minimizing condensation from ventilation equipment will help reduce moisture damage to building materials and limit opportunities for indoor mold growth.

- Maintain indoor temperature and relative humidity according to ASHRAE/ANSI Standard 62.1-2022 and U.S. Environmental Protection Agency (EPA) guidelines and reduce chance of microbial growth.
    - In buildings that are mechanically cooled, during occupied and unoccupied periods, maintain the indoor-air dew-point temperature at 60°F or lower at all times to limit condensation and adsorption of water on surfaces that promotes indoor microbial growth.
    - For all buildings, maintain indoor relative humidity between 30% and 50% to reduce mold growth.
    - During unoccupied hours, if not already done, operate the HVAC system on a reduced setting instead of turning the system off.

Ensure proper use of dehumidifiers and portable air cleaners.

- Ensure that dehumidifiers are cleaned and maintained according to the manufacturer's recommendations.
- Be aware that some portable air cleaners produce ozone which can cause adverse respiratory health effects and should be avoided. Information about ozone generators sold as air cleaners can be found on the EPA website.

Recommendation 3: Correct sources of dampness and remediate moisture- and mold-damaged materials

Why? Moisture and mold damage were observed during our walkthrough and visual assessments. 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 a wide range of health effects affecting multiple body systems, including respiratory, digestive, neurological, and endocrine problems, that improved when away from campus buildings.

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

Routinely inspect buildings 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 is suspected because of musty odors or continued health complaints, consider other methods to look for hidden problems such as under flooring or in wall cavities. Also, thermal imaging, with an infrared camera, after heavy rains can be used inside and outside buildings to look for leaks. NIOSH does not typically recommend air sampling for mold with building air quality evaluations.
- 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.
- As a resource for monitoring dampness in buildings, the NIOSH Dampness Mold and Assessment Tool can be an inexpensive mechanism to track, record, and compare building conditions over time.
    - The assessment form and associated instructions can be downloaded from the NIOSH website.
    - Detailed instructions on using the tool and an example Excel file for data entry is available in the below publication and supplementary materials.

        Park J-H and Cox-Ganser JM [2022]. NIOSH dampness and mold assessment tool (DMAT): Documentation and data analysis of dampness and mold-related damage in buildings and its application. Buildings *12*(8):1075, https://doi.org/10.3390/buildings12081075 .

All mold-damaged materials should be removed and cleaned with appropriate containment to minimize exposure for remediation workers, building occupants, and unaffected sections of the buildings.

- Inappropriate remediation can cause further problems with building degradation and symptoms in occupants.
- Guidelines for remediating mold-damaged building materials and maintaining acceptable indoor environmental quality during construction and renovation can be found in the following documents:
    - New York City Department of Health and Mental Hygiene
      Guidelines on Assessment and Remediation of Fungi in Indoor Environments
    - EPA
      Mold Remediation in Schools and Commercial Buildings
      Moisture Control Guidance for Building Design, Construction and Maintenance
    - NOISH
      Maintaining Acceptable Indoor Environmental Quality (IEQ) During Construction and Renovation Projects

Recommendation 4: Continue communication, reporting, and information dissemination for building-related issues

Why? 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. OSHA also has helpful guidance on recommended practices for safety and health programs.

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

Continue to establish a communication system with employees for use when building-related issues arise. If not already available, consider implementing anonymous reporting in this system, as many employers find this more effective. Continue to provide information on response actions to all employees, including posting exposure and environmental assessment reports.

- Continue to identify methods for the health and safety committee (consisting of employees, union representatives, management, and building maintenance) to increase communication between employees, union representatives, and management and help alleviate concerns. Take measures to document the activities of this committee and share them with employees, such as the current practices of sharing meeting minutes and updates of open or closed work orders.
- Encourage employees to report new, persistent, or worsening symptoms, particularly those with a work-related pattern, to their personal healthcare providers and, as instructed by their employer, to a designated individual in their workplace.

Recommendation 5: Consider implementing institutional and organizational changes that support long-term remediation efforts.

Why? While short-term solutions such as replacing ceiling tiles and spot-cleaning items affected by mold growth are necessary to remediate these issues as they occur, successful remediation of the underlying causes of the widespread and severe indoor dampness, mold, and ventilation issues will require investment in long-term solutions.

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

Designate a senior individual to oversee the implementation of current and future long-term repair and remediation efforts.

- This designated individual should have a thorough understanding of the historical indoor dampness, mold, and ventilation challenges.
- To preserve long-term continuity, appoint a designated individual with a focus on long tenure to oversee the implementation of current and future long-term repair and remediation efforts.
- Promote regular communication among this designated individual, building managers, and facilities engineering personnel.

Supporting Technical Information

Evaluation of Indoor Dampness, Mold, and Ventilation at a College

HHE Report No. 2022-0077-3422

June 2025

Section A: Workplace Information

Employee Information

Number of employees at time of evaluation: The college had approximately 420 employees.

Union: Employees were represented by two unions: a non-faculty union and a faculty union. Other employees were not part of either union.

Buildings

The public college campus included 14 buildings located on approximately 100 acres. Buildings on the college campus were originally constructed at various times, the oldest in the 1930s, and were used as residence halls, dining rooms, lecture halls, laboratories, study rooms, auditoriums, student and recreational services, library, museum, guest housing, and facilities/maintenance.

History of Issue at Workplace

Request basis: Campus buildings had a history of water intrusion, high humidity, and mold growth. Employee concerns about water intrusion, humidity, and mold had been reported since the 1980s and were noted especially after the campus-wide water chiller system was completed in 2018. Employee and union concerns were summarized into six main themes, and management confirmed these issues were ongoing at the time the health hazard evaluation was requested:

1. Cold, humid air blowing from supply vents and high indoor temperature and humidity when the ventilation systems were set to operate in cooling mode.
2. Condensation on supply air vents and ductwork.
3. Water intrusion from roof leaks, crawl space moisture, and building structural issues.
4. Water-damaged building materials not removed during repairs, renovations, or remediations.
5. Visible mold on flat surfaces, ceiling tiles, and carpets; these items were sometimes cleaned, repaired, or replaced, but the mold returned after wiping flat surfaces, painting, or replacing ceiling tiles/carpet.
6. Ventilation maintenance issues.

Health concerns: Reported health issues experienced by employees included systemic inflammatory response syndrome; autoimmune conditions; burning and irritation of eyes, nose, and throat; chronic rhinitis; gastrointestinal issues (nausea, vomiting, diarrhea, bloated abdomen); headaches; light sensitivity; endocrine problems; excessive sweating; short-term memory loss; and hearing issues (tinnitus, decreased hearing).

Previous issues: The Occupational Safety and Health Administration (OSHA) initiated an inspection of the workplace due to mold in October 2021. OSHA interviewed employees and managers, reviewed documents supplied by management, and conducted an on-site inspection. OSHA issued a Hazard Alert Letter to management in June 2022. The OSHA letter referenced air sampling for mold performed in September 2021 that demonstrated levels of *Aspergillus/Penicillium* mold elevated indoors relative to outdoors. The OSHA letter concluded "…a history of water intrusion and mold growth within the facilities…is apparent. It remains unclear when the water intrusion/mold growth began (possibly dating back to 2014), how widespread it was, or the extent to which remediation efforts controlled the water intrusion, mold growth, or employee concerns." The OSHA letter also stated OSHA observed "workplace conditions that may affect employee exposure to mold and result in adverse health outcomes" including lack of remediation of water-damaged building materials. OSHA recommended (1) if mold testing was indicated, perform it as part of a comprehensive plan that included assessment and correction of moisture sources and mold remediation and perform in accordance with standardized methods, (2) ensure employees experiencing symptoms or illness are removed from the area of concern and seek healthcare, (3) remediate moisture sources, water intrusion, and mold growth before employees return to the workplace, and (4) a NIOSH health hazard evaluation "to provide the employer with a more extensive assessment of any potential mold problems that need to be addressed." No OSHA citations were recommended at that time.

Section B: Methods, Results, and Discussion

On August 9–11, 2022, NIOSH visited the college in response to a union and confidential employee request for a health hazard evaluation to address health concerns regarding indoor dampness, mold, and ventilation. During this walkthrough visit, we outlined that our primary aims for the visit were to (1) visually assess the interior and exterior of buildings on the college campus for indications of water damage or mold growth; (2) visually assess the ventilation system of these buildings; and (3) assess the water chiller system. We toured nine buildings on campus. Facilities engineering, union representatives, and several faculty and facilities staff led these tours, provided access to utility rooms and crawl spaces, and answered our questions.

On March 7–9, 2023, NIOSH returned to the college to review the ventilation systems for select buildings on campus. The objectives for this visit included: (1) reviewing mechanical drawings; (2) identifying supply and return air vents throughout buildings; (3) visualizing air flow patterns using a fog generator; (4) identifying chilled or hot water supplies and reheats, where present, throughout buildings; and (5) discussing ventilation operational settings with college facilities staff. We did not measure temperature and relative humidity during this visit because the ventilation systems were in heating mode and not representative of humidity and condensation issues noted during warmer months when ventilation system were cooling. Facilities engineering provided access to all requested campus buildings and utility spaces and answered our questions.

Before, and subsequent to, our on-site visit, we received copies of reports from air sampling for mold that had been performed in various buildings on campus; some of these reports also contained results from surface sampling for mold. NIOSH reviewed these reports and provides a high-level overview here.

Methods: Review of Indoor Environmental Quality Reports

We reviewed 11 consultant reports covering years 2011 through 2022, multiple campus buildings, air sampling for mold, and surface sampling for mold (Table 1).

Table 1. Reports reviewed and the included buildings and sampling results.

Report Year	Report Month	Building(s)	Sampling Results Reviewed
2011	May	Hall 1	Air sampling for mold
2012	November	Hall 1	Air sampling for mold
2018	August	Hall 3 B	Air sampling for mold; surface sampling for mold
2018	October	Hall 3 B; Hall 3 C	Air sampling for mold
2018	October	Hall 5	Air sampling for mold
2018	November	Hall 5; Bookstore	Air sampling for mold
2018	December	Hall 5	Air sampling for mold
2019	March	Hall 2	Air sampling for mold
2019	July	Hall 3 C	Air sampling for mold; surface sampling for mold
2021	September	Hall 1; Hall 2	Air sampling for mold; surface sampling for mold
2022	August	Hall 6; Alumni Center	Air sampling for mold

Results: Review of Indoor Environmental Quality Reports

Air Sampling for Mold Overview

The air sampling reports that we reviewed documented indoor and outdoor air samples that were collected with Air-O-Cell® cassettes and sample volumes of 75 liters for each air sample. Some reports did not specify the sampling flow rate (liters per minute [L/min]), total sampling time, or method of sample analysis; however, these air samples are typically performed at 15 L/min for 5 minutes, for a total sample volume of 75 liters, and then analyzed microscopically. The reports indicated a limit of detection or sensitivity of 13 spores (count) per cubic meter of air (spores/m^3).

We typically expect a similar distribution of fungal types in indoor air samples as outdoor air samples. However, the air sampling results we reviewed documented fungal types in indoor air samples that were not found in outdoor air samples taken on the same day, and this finding spanned multiple buildings and years (Table C1). For example, *Stachybotrys* fungi were found in indoor air samples from Hall 3 Annex B and Hall 2 buildings in August 2018 and March 2019, respectfully. *Aspergillus/Penicillium* fungi were found in Hall 3 Annexes B and C, Hall 1, and Hall 5; *Cladosporium* fungi were found in Hall 3 Annexes B and C, Hall 1, Hall 2, and Hall 5.

Indoor air levels of fungi are usually lower than those in outdoor air samples. However, the air sampling results we reviewed also documented some fungal types that were found in both indoor and outdoor air samples taken on the same day, but the spores/m^3 were higher in indoor samples than outdoor samples. This finding spanned multiple buildings and years (Table C2).

August 2022 Report: Outdoor Air Sampling

While evaluation of potential indoor sources of mold often includes comparing indoor levels to outdoor levels, conclusions drawn from such a comparison for the August 2022 report might be misleading if both outdoor air samples are considered. The August 2022 report we reviewed included air sampling results for an Alumni Center classroom and Hall 6 Classroom 235. The fungal spore counts in the two outdoor air samples taken on August 9, 2022 (Outside #1 and Outside #2) were substantially different from each other for most of the identified molds as discussed below. Additionally, fungal spore counts in Outside #1 air sample were substantially different from their respective fungi spore counts in the other 10 reports we reviewed, for most of the identified molds.

Spore counts in this particular Outside #1 air sample were 9–4,652 times higher than the spore counts in Outside #2 air sample (for the same fungal type) (Table C3). For example, the Outside #2 air sample had 13 spores/m^3 *Pithomyces* detected, and Outside #1 air sample had 60,480 spores/m^3 *Pithomyces* detected, meaning Outside #1 had 4,652-fold higher *Pithomyces* spores/m^3 than the other outdoor air sample taken the same day.

Depending on fungal type, spore counts in Outside #1 air sample were 2–300 times higher than the spore counts among the other 10 reports reviewed (for the same fungal type) (Table C3). Only the Outside #1 spore counts for Ascospores (200 spores/m^3) and Basidiospores (1,240 spores/m^3) were within the range of previous outdoor spore counts from the other 10 reports reviewed (13–3,547 spores/m^3 for Ascospores; 13–10,173 spores/m^3 for Basidiospores). All other fungal types identified in Outside #1 air sample had spore counts that were greater than the maximum spore count for that respective fungal type among the other 10 reports reviewed. For example, Outside #1 air sample had 60,480 spores/m^3 *Pithomyces* detected, and the maximum spore count for *Pithomyces* in the outdoor air samples among the 10 other reports reviewed was 627 spores/m^3, meaning Outside #1 had 96-fold higher *Pithomyces* spores/m^3 than the outdoor air samples among all other reports reviewed.

In contrast to Outside #1 air sample, the spore counts for all identified fungal types in the August 2022 Outside #2 air sample were within their respective ranges of previous outdoor spore counts from the other 10 reports reviewed (Table C3). Therefore, Outside #2 air sample results might more closely represent the expected usual outdoor levels while Outside #1 air sample results might have artificially elevated fungi levels.

Surface Sampling for Mold

All three reports containing results for surface sampling for mold documented the presence of mold in sampled areas.

Aspergillus and/or *Penicillium* mold was documented in

- Hall 3 Annex B (August 2018),
- Hall 3 Annex C (July 2019), and
- Hall 1 (September 2021).

Cladosporium mold was documented in

- Hall 3 Annex B (August 2019) and
- Hall 3 Annex C (July 2019).

Inspector Observations

Water staining or damage were noted by inspectors in

- Hall 3 Annex B (August 2018),
- Hall 3 Annex C (October 2018 and July 2019),
- Hall 6 (August 2022).
- Hall 5 (October 2018), and
- Hall 2 (March 2019).

Musty odors were noted by inspectors in

- Hall 3 Annex B (August 2018),
- Hall 3 Annex C (October 2018 and July 2019), and
- Hall 5 (October 2018).

Visible mold was noted by inspectors in

- Hall 3 Annex B (August 2018),

- Hall 3 Annex C (October 2018 and July 2019),
- Hall 1 (September 2021), and
- Hall 5 (October 2018).

Humidity Measurements

Humidity measurements were included in eight of the 11 reports. Measured indoor humidity exceeded 50% in

- Alumni Center (August 2022),
- Hall 3 Annex B (August 2018 and October 2018),
- Hall 3 Annex C (October 2018),
- Hall 1 (September 2021), and
- Hall 5 (October 2018).

Methods: Campus Walkthrough and Dampness and Mold Visual Assessment

NIOSH conducted a walkthrough visit at the college from August 9-11, 2022, in response to concerns about indoor dampness, mold, and ventilation. The main objective of the visit was to visually assess the buildings for any signs of water damage or mold growth. NIOSH toured nine buildings on campus. We were accompanied by Facilities Engineering staff, union representatives, faculty members, and facilities staff who provided access to utility rooms and crawl spaces and answered our questions. While touring buildings, we conducted checks of indoor temperature and relative humidity.

Results: Campus Walkthrough and Dampness and Mold Visual Assessment

During our walkthrough visits, we observed areas across campus with moisture and mold damage. We observed evidence of mold growth and water staining in the vestibules of several buildings. We observed moisture from ventilation system pipes and condensation pans throughout campus contributing to moisture-stained ceiling tiles and water running onto walls and flooring. We noted potential for moisture and humidity intrusion through building crawl spaces which lacked a vapor barrier. We also observed high humidity levels indoors which contributed to condensation on flooring and increased potential for mold and moisture damage. Across campus indoor temperatures ranged from 65^{o} F to 77^{o} F, and relative humidity ranged from 55% to 75%.

During our walkthrough visits, we observed areas of Hall 4 where significant water damage had taken place due to a fire sprinkler leak. Facilities had removed occupants from this area of the building and begun remediation to remove all water damaged building materials. Additionally, we viewed an area of the clinic where a pipe leak had led to water damage and was identified through building inspection and seemed to be properly remediated.

Methods: Ventilation Assessments

During our walkthrough visits in August 2022 and March 2023, facilities provided NIOSH a tour of Hall 1, Hall 2, Hall 3, and Hall 4 on campus. The tours allowed NIOSH staff to review ventilation system operational parameters which included the following: (1) reviewing mechanical drawings; (2) identifying supply and return air vents throughout buildings; (3) visualizing air flow patterns using a fog generator; (4) identifying chilled or hot water supplies and reheats, where present, throughout buildings; and (5) discussing ventilation operational settings with college facilities staff. We focused our ventilation assessments on these four buildings on campus due to frequency of requestor concerns and occupancy in these buildings. Campus buildings primarily relied on individual heating and cooling systems, although a centralized water chiller system was implemented in 2018 to provide chilled water to select buildings in a centralized manner.

Results: Ventilation Assessments

The ventilation descriptions below represent NIOSH's interpretation and understanding of system operations at the time of our visit in March 2023.

Hall 1

Hall 1 was three stories tall with a full attic that was primarily used for teaching with classrooms, staff offices, and conference spaces. A full basement existed under one wing of the building, while an open crawlspace extended under the rest of the facility. The building received outdoor air ventilation through two large Venmar® Aston energy recovery ventilators in the attic. Outdoor air passed through the energy recovery units where it was preheated or precooled (depending on the season) with return air from the occupied spaces, before the return air was exhausted from the building. During our visits in August 2022 and March 2023, both energy recovery ventilators were out of service. This was due to a heating coil that froze during winter in 2021 and needed to be replaced. During the March 2023 visit, the college had reportedly received the coil, but installation had not occurred, yet. These had MERV 10 Glasfloss ZL filters.

Supply vents 9-inch by 9-inch (6-inch round duct) in the ceilings of occupied spaces provided the basement areas of the building with some outside air from the attic units. Heating and cooling in the basement were provided by 2-pipe, wall-mounted fan-coil units. During heating season, the fan-coil units were fed hot water through a hot water converter loop heated with steam from the central boiler plant. During cooling, they were fed chilled water from the central chiller plant. Condensate during cooling season was pumped up and out of the fan coil units with non-submersible condensate pumps, through the exterior wall of the building, and dripped onto the ground above grade.

The first and second floors of the building were heated and cooled with ceiling-mounted fan-coil units in the occupied spaces and wall-mounted fan coil units in hallways. The 2-pipe, ceiling-mounted units received 20% of their supply air from the energy recovery ventilator units in the attic. The remaining 80% of air was recirculated from the ceiling plenum by the units. The 2-pipe, wall-mounted fan coil units did not receive outdoor air and only recirculated and tempered air from the space.

Hall 2

Hall 2 was primarily a teaching building with classroom, staff offices, and conference spaces. The building consisted of three floors with a partial basement. The ventilation layout was similar to Hall 1. There were two small heating, ventilation, and air conditioning units in the attic which brought in outdoor air. Neither of the units had a dual temperature coil so the outdoor air brought in was untreated. The outdoor air did mix with some recirculation air for some tempering. The first, second, and third floors each had two air handling units (AHUs) mounted in the ceiling above the hallways on each floor, one at each end. The two ceiling-mounted units on each floor were fed with approximately 20% outdoor air from the attic units. The remaining ~80% air through the units was recirculated air from the ceiling plenum space. The two ceiling-mounted units then fed variable-air-volume (VAV) boxes that served the occupied spaces. The hallways had an extensive series of radiators under the windows and some wall-mounted fan coil units. The basement had one AHU in a mechanical room that fed the VAV boxes in the occupied spaces of that floor. The basement also housed a simulation laboratory which had its own 36-ton HVAC system to handle the cooling load requirements.

During cooling season, the AHU units mounted on the floors (excluding the attic) and the wall-mounted fan coil units provided cooling with chilled water from the central chiller plant. The water valves serving the VAV boxes and radiators were closed so that chilled water was not provided to that equipment. During heating season, the AHUs on each floor (excluding the attic) and the wall-mounted fan coil units, VAV boxes, and radiators were all provided hot water through a hot water converter loop heated with steam from the central boiler plant.

Hall 3

Hall 3 was the primary residential building for students at the college. The building was constructed in five major sections (called Annexes) beginning in the early-1930s to the mid-2000s. All students, regardless of class, lived in Hall 3 while on campus. The annexes were four stories tall (except for a portion of Annex D which was 3 stories) on a full basement.

Annex A

Annex A had a distinct U shape with the open end pointing toward the northeast. It was the oldest portion of Hall 3 constructed in 1931 (with a minor addition in 1942). The basement housed a few office spaces, a barber shop, post office, laundry facility, and numerous storage areas and mechanical spaces. However, most of the basement consisted of an abandoned shooting range or only partially excavated areas. The main section of the first-floor housed staff offices, while the two first-floor wings consisted of primarily living spaces with associated bathroom facilities and mechanical spaces. The second, third, and fourth floors were all living spaces, with bathroom facilities, mechanical spaces, and some common areas.

At the time of the NIOSH visits, the main section of Annex A did not have cooling, though there were plans to add cooling systems to that portion of Annex A in the intermediate future. The main portion did have hot water heat through a series of hot water radiators. The radiators got their hot water through a hot water converter loop heated with steam from the central boiler plant. The wings of Annex A had both heating and cooling. Each room was equipped with at least one, 2-pipe vertical fan coil unit (typical of many hotel rooms) on an interior wall (closest to the hallway). The fan coil units received hot water during heating season (through the hot water converter loop) or chilled water during cooling season (from the central chiller plant). The fan coil units only recirculated air within each room and helped maintain temperature control. Each room also received a small amount of tempered 100% outdoor air provided through an HVAC system and associated supply ductwork from nearby mechanical rooms. The hallways were also supplied with 100% tempered outdoor air through ceiling diffusers. There was no return air back to the HVAC systems. Exhaust air from the spaces was through the hallways and out through the large bathroom exhaust systems centrally located on each floor. This ventilation scenario resulted in each room being under strong positive pressure relative to the corridor. There had been some reports of mold/moisture problems in the wings of Annex A.

Annex B

Annex B was added to the Hall 3 in 1960. It connected to Annex A at the end of both wings. The basement housed various mechanical and electrical spaces, along with storage for the large dining room. The dining room, where students ate meals, was located on the first floor. The dining room was connected to a large one-story building that housed a large kitchen and a dining room that provided meals to faculty, staff, and guests. The second, third and fourth floors consisted of living spaces with associated bathroom facilities and mechanical spaces.

Annex B had both heating and cooling. Each room was equipped with at least one, 2-pipe vertical fan coil unit (typical of many hotel rooms) on an exterior wall. The fan coil units received hot water during heating season (through the hot water converter loop) or chilled water during cooling season (from the central chiller plant). The fan coil units did have small outside air dampers that opened when the fans were powered on. Most of these dampers had been disconnected intentionally. Thus, the fan coil units only recirculated air within each room and helped maintain temperature control. There were mechanical rooms at the end of the long hallways of dorm rooms that included 100% outdoor air HVAC units. These units pulled outdoor air inside and then tempered the air with either hot water or steam (depending on the side of the building) during heating season. During cooling season, the systems used chilled water from the central chiller plant and electric reheat. The HVAC systems then dumped the tempered outdoor air into the hallways through large diffusers at each end. The hallways served as ductwork for the outside air as it traveled from each end toward the center, aided by the bathroom exhaust systems near the center of the hallways. The outdoor air was supposed to enter each of the dorm rooms through open doors (or under the doors when the doors were closed). There was no return air back to the HVAC systems. Exhaust air from the spaces was through the hallways and out through the large bathroom exhaust systems centrally located on each floor. This ventilation scenario resulted in each room being under strong negative pressure relative to the corridors, especially when the fan coil units were powered off. The pressure differential was somewhat impacted by the speed of the fan in the individual fan coil units. The position of the doors (open or closed) between Annex B and the adjacent Annexes A or C also had an impact on overall pressure differentials between the hallways and dorm rooms. It appeared that keeping all doors into adjacent Annexes closed provided the most outdoor air flow into dorm rooms in Annex B. There had been time periods over the last few years with significant reports of mold/moisture problems in Annex B.

Annex C

Annex C was added to Hall 3 in 1966. It connected to Annex B on the northwest end (and also to Annex D and Annex E described below). The basement housed various mechanical and electrical spaces, along with a clothing locker and tailor shop. The remaining four floors of Annex C were living areas with associated bathroom facilities, electrical closets, and mechanical spaces.

The ventilation systems in Annex C were upgraded as part of major Annex C renovations, in two phases. The areas renovated during the first phase had been occupied by students since the start of the 2022–2023 academic year. The areas renovated as part of phase two were getting furniture installed during our visit in March 2023. The new ventilation scheme, regardless of the renovation phase, was the same in all of Annex C. Mechanical rooms along each corridor included new 4-pipe AHUs that mix outdoor air with return air and heat (hot water) or cool (chilled water from the central chiller plant) the air as necessary. The supply air from these AHUs went to new VAV boxes with hot water reheat (for use during cooling season to help remove excess moisture). Each VAV box then provided supply air to multiple dorm rooms, corridors, and/or bathrooms. The temperature was controlled by a thermostat in one of the rooms. Some air from the area was exhausted directly outdoors through the bathroom exhaust systems and small exhausts in janitor closets. The rest of the return air traveled back to the AHUs where it was mixed with outdoor air. There had not been reports of mold/moisture problems in Annex C since the ventilation upgrades.

Annex D

Annex D was constructed in 1970 and was attached to the western end of Annex C. It connected to the main area of Annex A by a bridge on the second floor. The northern end of Annex D also connected to Annex E (described below). The basement of Annex D consisted of some storage areas, but a large portion was unexcavated. The first floor of Annex D had classrooms. The first floor of the three-story section was primarily offices for staff. The remaining area on the first floor was dorm rooms for students and associated bathroom facilities. The second, third, and fourth (where it existed) floors were living areas for students.

There was no cooling provided in Annex D, except for some window air conditioning units on the first-floor offices for staff. Heating in Annex D was provided through hot water radiators throughout the occupied spaces. There had not been reports of mold/moisture problems in Annex D.

Annex E

Annex E was built in 2007, and all the HVAC systems were included as part of the original construction. It comprised the northernmost piece of Hall 3 and connected by a walkway to the northern end of Annex D and to the northern end of Annex C. The basement in Annex E included some mechanical, electrical, and storage spaces, but much of it was unexcavated space that served only as a piping chase. The first through fourth floors consisted of living spaces with associated bathroom facilities and mechanical spaces.

Annex E had both heating and cooling. Each room was equipped with at least one, 2-pipe vertical fan coil unit (typical of many hotel rooms) on an interior wall (closest to the hallway). The fan coil units received hot water during heating season (through the hot water converter loop) or chilled water during cooling season (from a chiller in the basement of the annex). The fan coil units only recirculated air within each room and helped maintain temperature control. Each room also received a small amount (estimated 30 cubic feet per minute [CFM]) of tempered 100% outdoor air from a single, large 4-pipe (with steam preheat) AHU (AHU-1) in a basement mechanical room (same mechanical space as the chiller). The hallways were also supplied with 100% tempered outdoor air (2,000 CFM per floor) through large diffusers in the walls from a vertical duct directly above AHU-1. There was no return air back to the HVAC systems. Exhaust air from the spaces was through the hallways and out by the large bathroom exhaust systems located on each floor. This ventilation scenario resulted in each room being under positive pressure relative to the corridor. There had not been reports of mold or moisture problems in Annex E.

Hall 4

Hall 4 was predominantly used for transient housing for guests at the college. It was four stories tall. The first three floors each had around 24 housing rooms, each with their own bathroom. The fourth floor was similar, except that a large eating and socialization room replaced the six housing rooms on the northern end of the building. There were also various storage areas, television and reading rooms, and laundry facilities on each floor. The first floor had a large attached mechanical space that housed equipment serving the building. The third and fourth floors had additions extending from near the center of the building. The third-floor space housed a security office, ID office, transient student housing office, various staff offices, and bathroom facilities. The fourth-floor housed staff offices and a large conference room.

Hall 4 had both heating and cooling. Each housing room was equipped with a 2-pipe vertical fan coil unit (typical of many hotel rooms) on an interior wall. The fan coil units received hot water during heating season (from hot water converters served by steam from the central boiler plant) or chilled water during cooling season (from a chiller in the first-floor mechanical space). The fan coil units recirculated and tempered air within each room. The building received outdoor air ventilation through a large energy recovery unit in the penthouse of the building. Outdoor air passed through the energy recovery units where it was preheated or precooled (depending on the season) with exhaust air from bathroom exhaust from the housing rooms. The outside air was provided to each housing room and the hallways of the main portion of the building.

The third and fourth-floor additions each had their own 2-pipe AHU that brought in 25% outdoor air that mixed with 75% recirculated air. The AHUs were on variable speed drives, and they fed a series of 2-pipe VAV boxes that controlled the flow of air and space temperature based on thermostat setpoints. The eating and socialization room had its own 2-pipe, constant-volume AHU that tempered 25% outdoor air mixed with 75% recirculated air from the space.

Methods: Reporting and Responding to Indoor Environmental Quality Concerns

During our walkthroughs, NIOSH discussed with facilities how individuals on campus might report indoor environmental quality concerns or receive updates related to indoor environmental quality concerns or remediation activities. Management provided a high-level overview of opportunities to review updates related to indoor environmental quality across campus or submit requests for concerns.

Results: Reporting and Responding to Indoor Environmental Quality Concerns

During our visit, facilities management shared methods for responding to occupant health and safety concerns and herein we summarize our understanding of available response methods at the time of our visit. Facilities management noted building occupants could report health and safety concerns or needed facilities work orders through an online submission tool. Submissions were triaged and routed to the appropriate point of contact for remediation. When a request was submitted, an email notified the requestor that the request had been received. Employees could also report health and safety concerns or needed facilities work orders through (1) building managers, (2) administration officials, or (3) Office of Inclusion and Diversity. Additionally, monthly emails were sent to building managers on open work orders to provide routine updates on which work order requests were open or had been completed. Management also reported Safety Committee meetings were conducted quarterly. Meetings included facilities management and union representation and included a presentation brief on current and ongoing topics. Meeting minutes were distributed following the meeting. We also discussed documents and procedures used by the college to help address indoor environmental quality concerns such as occupant interviews, Occupant Environmental Responsibility document, FAQs and Safe Work Practices for Mold and Moisture Issues, and the College Mold Response Guide.

Discussion

Multiple buildings we evaluated have a history of indoor dampness and visible mold, as evidenced by our review of indoor environmental quality reports spanning 11 years and our walkthrough observations and visual assessments. As with most building materials that incur water or mold damage, if not properly repaired, these areas become problematic and can cause health effects. Below we discuss potential health effects from exposure to indoor dampness and mold, air sampling for mold, routine building evaluation and mold remediation, and building ventilation considerations.

Health Effects from Exposure to Indoor Dampness and Mold

Research has found that damp building conditions can lead to respiratory illnesses in occupants [Mendell et al. 2011; Park and Cox-Ganser 2011; WHO 2009]. We observed multiple conditions contributing to indoor dampness in campus buildings, and occupants of damp buildings can be exposed to pollutants in the air from biological contaminants and the breakdown of building materials. Damp building conditions promote the growth of mold, bacteria, other microbial agents, dust mites, and cockroaches. Dampness can also contribute to the breakdown of building materials and furniture. Musty odors, as were noted by multiple inspectors, are a sign of microbial contamination.

Health concerns regarding mold involves multiple fungal components, including fungal allergens, mycotoxins, microbial volatile organic compounds, fungal cell wall components such as (1→3)-β-D-glucan, and spores [EPA 2025a; Dylag et al. 2022; Park and Cox-Ganser 2011; Rudert and Portnoy 2017]. Fungal allergens can cause adverse health effects through complex immune-mediated mechanisms; however, only a few fungal allergens, such as those of *Alternaria*, *Aspergillus*, *Cladosporium*, and *Penicillium*, have been extensively studied. Mycotoxins are substances produced by fungi that could have a toxic or harmful effect on microorganisms. *Stachybotrys* mold sometimes found on damp indoor building materials, can produce mycotoxins under certain circumstances, and one mycotoxin produced by *Stachybotrys chartarum* has been suggested to be associated with a wide range of respiratory, gastrointestinal, and neurologic symptoms [Dyląg et al. 2022]. Although a definitive link between *Stachybotrys chartarum* mycotoxin and these adverse health effects has not been established, presence of this mold inside buildings indicates damp indoor conditions conducive to mold and bacteria growth. Microbial volatile organic compounds are produced by molds and released into the air. Although these compounds are non-allergenic, they can have an irritant effect and cause adverse health effects such as headache, nasal irritation, dizziness, fatigue, and nausea [EPA 2025a]. The fungal cell wall component

(1→3)-β-D-glucan is thought to cause adverse health effects by increasing susceptibility to respiratory infections by changing the body's immune response or by causing inflammation. Finally, spores are molds' reproductive strategy and are found in indoor and outdoor air. Spores may be easily disturbed and float through the air or they may be sticky and cling to various surfaces; regardless, spores may remain allergenic for years even if they are no longer viable to grow into mold [EPA 2025a; Park and Cox-Ganser 2011; Rudert and Portnoy 2017].

Immune and inflammatory responses to these various fungal components can lead to respiratory diseases such as rhinitis, asthma, and hypersensitivity pneumonitis and symptoms associated with these diseases. Few fungal components have specific, validated, and standardized tests for use in clinically diagnosing fungal allergy. Given the complex and individual nature of immune responses to fungi, the wide immunologic cross-reactivity among different fungal allergens, and the unknown required exposure duration for health effects to occur, a direct cause and effect relationship between a certain fungi and an individual's health effects may be difficult to demonstrate [Rudert and Portnoy 2017]. However, 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 sufficient epidemiological evidence of associations with upper and lower respiratory symptoms, asthma development and exacerbation, respiratory infections, allergic rhinitis, bronchitis, and eczema as well as clinical evidence of association with hypersensitivity pneumonitis [Mendell et al. 2011; WHO 2009]. There was limited or suggestive evidence of association with allergy/atopy [Mendell et al. 2011].

In addition to fungi, indoor dampness is also associated with other allergenic organisms such as dust mites and bacteria, and these may also contribute to adverse health effects. What building occupants react to is largely unknown. It can 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. Regardless of the specific causative agent – whether a microbial agent, breakdown of building materials, or other factor associated in indoor dampness – some employees with allergic conditions may continue to have immunologic reactions to very small amounts of allergens, even after an otherwise successful remediation. Such individuals may have to avoid the building(s), and 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.

NIOSH's published Alert, Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings, further describes respiratory disease related to indoor dampness and general recommendations for preventing and remediating damp buildings [NIOSH 2012].

Air Sampling

NIOSH does not typically recommend air sampling for mold with building air quality evaluations. Musty/moldy odors, visible mold growth, or water intrusion/damage, all of which were documented within the air sampling reports we reviewed or were directly observed during the NIOSH site visit, are the best indicators of contamination. In these situations, air sampling is not necessary to document a public health problem from dampness. There are no U.S. health-based exposure limits for biological contamination set by OSHA or recommended by NIOSH. Additionally, there is no scientific basis for the use of air sampling to demonstrate a room or building is "safe" for occupants.

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, short-term sampling for mold spores is conducted; however, the results might not be representative of actual exposures. Repeated air sampling for fungi often results in highly variable levels over the same day or at different locations in the same room. Because of this variation, taking a couple air samples in one or two locations within a room at one point in time may not accurately depict the degree of contamination and exposure. 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. This variability and the resulting limitations of air sampling for mold were highlighted in the August 2022 report, where the spores/m^3 counts of many fungi in Outside #1 sample were substantially greater than both Outside #2 and their respective fungi spores/m^3 counts from the other 10 reports we reviewed. Strong outdoor fungi source(s) near the Outside #1 sampling location at the time of sampling could have resulted in the higher concentrations of fungi in Outside #1 air sample. Comparing the indoor air samples to only Outside #2 fungi spores/m^3 counts, which were all within their respective ranges of previous outdoor spore counts from the other 10 reports from years 2011–2021, revealed *Alternaria*, *Aspergillus/Penicillium*, *Curvularia*, *Epicoccum*, and *Pithomyces* fungi were found at higher levels in the Alumni Center classroom, and *Aspergillus/Penicillium*, *Epicoccum*, and *Pithomyces* fungi were found at higher levels in the Hall 6 Classroom 235.

Although counts of fungi in the air, whether spores or colony forming units, are difficult to interpret, sometimes sampling is helpful. If the air sampling data finds that the distribution of fungal types indoor differs from outdoors, an indoor source of fungal growth may exist. In the reports we reviewed, some fungal types were higher in indoor samples than outdoor samples or did not occur in outdoor samples. This finding suggests there were indoor sources of mold growth, as was evident visually by inspection and by smelling musty odors. However, there is always the risk of false negative samples when dampness does exist. Additionally, no difference in concentration by fungal type at the genus level between indoors and outdoors could be a false negative if there is substantial difference at the species level. Although there is no species identification in the reports reviewed, some fungal species among the genera identified, such as *Stachybotrys chartarum*, *Penicillium digitatum*, and *Botrytis cinerea*, require high level of moisture for growth and are often associated with indoor dampness [Northolt et al. 1995]. Therefore, concluding no difference in concentration by fungal type between indoors and outdoors, based on only genus-level identification, should be interpreted with caution. NIOSH has not found air sampling helpful when there are reservoirs of hidden mold within walls or under carpets.

Although very high concentrations of fungi may be a sign of dampness, a scientific criterion which indicates a health concern versus no health concern does not exist. However, as we discuss above, indoor dampness has been shown repeatedly to be associated with increases in respiratory symptoms and diseases. After repairs and remediation of water- and mold-damaged building materials 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.

Routine Building Evaluation and Mold Remediation

NIOSH has found that thorough visual inspections or detection of problem areas by musty odors are reliable methods of identifying indoor dampness concerns. These methods have been used in past NIOSH research and have shown a correlation with health risks in buildings that have indoor environmental complaints [Cox-Ganser et al. 2009; Park et al. 2004].

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. As a resource for monitoring dampness in buildings, NIOSH has developed dampness and mold assessment tool. The tool provides an inexpensive mechanism to track, record, and compare conditions over time [Park and Cox-Ganser 2022]. The assessment form and associated instructions for general buildings and schools can also be downloaded from the NIOSH website [NIOSH 2018a,b]. Using moisture meters and infrared cameras can also sometimes identify sources of dampness.

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 with proper containment are recommended to minimize exposure to building occupants. Inappropriate remediation (e.g., painting over water-damaged materials or moldy surfaces) can cause further problems with building degradation and symptoms in occupants.

The New York City Department of Health and Mental Hygiene has guidelines on assessment and remediation of fungi in indoor environments that provides guidance for cleaning mold-damaged materials [NYCDH&MH 2008]. The U.S. Environmental Protection Agency (EPA) publication, Mold Remediation in Schools and Commercial Buildings, provides specific guidelines on remediation activities (e.g., wet vacuum, damp wipe, high-efficiency particulate air [HEPA] vacuum, discard) and personal protective equipment (e.g., respiratory protection, gloves, eye protection) based on the material type and amount of surface area affected by mold [EPA 2025a]. The EPA also has guidance on moisture control for building design, construction and maintenance [EPA 2013]. NIOSH has a Workplace Solutions document on maintaining acceptable indoor environmental quality during construction and renovation projects [NIOSH 2020].

Once repairs and remediation of water- and mold-damaged building materials are 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 after remediation, some employees may continue to experience building-related health symptoms, as discussed above, and require work accommodations based on their healthcare provider’s findings.

Ventilation

Poor ventilation in buildings is a common problem and is frequently caused by improper inspection and maintenance 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 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 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.

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. We checked temperature and relative humidity during our August visit when building systems were in heating mode which is when concerns for high humidity were reported. We did not measure temperature and relative humidity during our March visit because the ventilation systems were in heating mode and not representative of humidity and condensation issues noted during warmer months when ventilation system were cooling. 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 55-2023: 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 2023]. Assuming slow air movement (around 20 feet per minute) and 50% indoor relative humidity, the operative temperatures recommended by ASHRAE are around 64.5°F to 74°F in the winter, and from 69.5°F to 77°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 2022]. Using indoor-air dew-point temperature to limit humidity limits 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 below 60%, ideally between 30% and 50%, to reduce mold growth [EPA 2025a,b].

Outdoor Air Supply

Adequate supply of outdoor air, typically delivered through the HVAC system, is necessary in any indoor environment to dilute pollutants that are released by equipment, building materials, furnishings, products, and people. ANSI/ASHRAE Standard 62.1-2022: *Ventilation for Acceptable Indoor Air Quality* guidelines provide specific details on ventilation for acceptable indoor environmental quality. ANSI/ASHRAE 62.1-2022 recommends outdoor air supply rates that consider people-related sources as well as building-related sources. For example, ANSI/ASHRAE 62.1-2022 recommends 5 cubic feet per minute of outdoor air per person (cfm/person) for people-related sources in barrack-style sleeping areas and an additional 0.06 cfm for every square foot (cfm/ft^2) of occupied space to account for building-related sources. Information for other relevant spaces is provided in Table C4 below. To find rates for other indoor spaces, refer to Table 6-1 in ANSI/ASHRAE 62.1-2022 [ANSI/ASHRAE 2022]. A qualified ventilation system expert can help meet ASHRAE ventilation guidelines in the building.

Carbon dioxide (CO_2) is a normal constituent of exhaled breath; thus, levels of CO_2 will also increase as building occupancy increases. Carbon dioxide levels are routinely collected in air quality studies because they can provide a rough indicator for whether enough outdoor air is being introduced to an occupied space for acceptable odor and contaminant control. However, care needs to be taken when interpreting indoor CO_2 measurements. Carbon dioxide concentration 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. Similarly, open doors and windows that are not usually open will have an impact on measured CO_2 levels. There are also complexities that arise when multiple spaces are served by the same recirculating HVAC system, as the CO_2 concentration in one space might be impacted by what is happening in the other spaces. Elevated CO_2 concentrations suggest that concentrations of other indoor contaminants may also be increased. Understanding those caveats, if CO_2 concentrations are elevated above a predetermined level or when CO_2 levels increase substantially during the workday the amount of outdoor air introduced into the ventilated space may need to be increased.

Measurements of CO_2 can be made using a calibrated, continuous fixed monitor or spot checks can be taken using a calibrated portable meter. Traditionally, fixed CO_2 monitoring systems are expensive, require extensive knowledge to accurately install and set up, and require sophisticated control programs to effectively interact with the building HVAC systems in real time. They were not designed to ensure effective ventilation to building occupants but were instead designed with the primary intent of maximizing energy efficiency through reductions in outdoor air delivery, when possible. Fixed-position CO_2 monitors measure CO_2 concentration as an indicator of the number of people in the space. As the CO_2 concentration increases, the HVAC system increases the amount of outdoor air ventilation in the space to dilute CO_2 (and vice versa). This is known as demand-controlled ventilation (DCV). The number of CO_2 sensors, the placement of those sensors, and their calibration and maintenance are collectively a large and complex issue that must not be overlooked. For example, the CO_2 concentration measured by a fixed, wall-mounted monitor may not always represent the actual concentrations in the occupied space. If air currents from the room, HVAC, or even make-up air from windows flows directly over this monitor location, the corresponding concentration measurements will be artificially low. If the room has good air mixing, the measured concentration should approximate the true concentration, but rooms are rarely well mixed, particularly in older buildings with aging ventilation systems (or none at all). Also, depending on HVAC system design, if an elevated CO_2 concentration results in an air flow increase to one room, that air may be “stolen” from other rooms on the same HVAC system. This may result in elevated CO_2 concentrations in those other spaces which the HVAC system is unable to control.

A more modest, cost-efficient, and accurate use of CO_2 monitoring is the use of portable instruments combined with HVAC systems that do not have modulating setpoints based on CO_2 concentrations. The CO_2 meter can be purchased for under $300, and its measurements can be collected/logged near the breathing zones of occupied areas of each room. It is critical to select calibrated CO_2 meters whose sensors are reliable and accurate to draw meaningful inferences from measured indoor CO_2 concentrations. Under this approach, validate that the HVAC system is operating appropriately and is meeting or exceeding code-minimum outdoor air requirements based on current use and occupancy. Next, measure the resulting CO_2 concentrations in rooms under as-used conditions using a handheld portable CO_2 meter. These observations will be the CO_2 baseline concentrations for each room under the HVAC operating conditions and occupancy levels.

One potential target for the baseline concentrations that is used to represent good ventilation is CO_2 readings below 800 parts per million (ppm) [Seppänen et al. 1999]. CDC notes this target for use in protecting building occupants from respiratory viruses [NIOSH 2024, See FAQ #3]. For more typical building operation (not during a disease pandemic), Addendum ab to ANSI/ASHRAE Standard 62.1-2022 provides maximum allowable CO_2 concentrations that can be used as targets for some spaces (see Table C4) [ASHRAE 2023]. The values in Addendum ab are based on complex assumptions and models, and they may not be appropriate for all spaces of a particular type or all occupancies within a space type [ASHRAE 2022]. Once a target concentration is identified, compare your baseline concentrations to the target concentration. If a baseline measurement is above the target, reevaluate the context under which the measurement was obtained and if warranted, investigate the ability to increase outdoor air delivery. If unable to get below your target CO_2 value, more extensive ventilation system renovations may be necessary. Once the baseline concentrations are established, take periodic measurements in each space and compare those to the initial baselines. As long as ventilation airflow is unchanged (outdoor air or total air) and occupancy capacity is not increased, future portable CO_2 concentration measurements that exceed 110% of the baseline concentrations indicate a potential problem that should be investigated.

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 and windows may cause problems. For example, the air coming into the building through these openings may not reach all occupants in the building. The incoming air is unfiltered and may contain outdoor air pollutants such as pollen and dust. Additionally, open doors and windows may affect the ability of the HVAC system to adequately control temperatures and humidity.

Outdoor Air Quality

When present, outdoor air pollutants such as carbon monoxide, pollen, and dust may affect indoor conditions when outside 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 may 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 the occupied spaces.

Exhaust Rates

For spaces where airborne contaminants and odors are prevalent, ANSI/ASHRAE 62.1-2022 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 directly outdoors. 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 and/or test the performance of local exhaust systems for typical office equipment.

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].

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 maintained at 60°F or lower at all times, microbial growth is not expected to occur. Whether the system runs continuously or is "set back" when spaces are unoccupied, the required fresh, outdoor air flow, and the indoor temperature and humidity conditions should always meet recommendations found in ANSI/ASHRAE 62.1-2022 and ANSI/ASHRAE 55-2023 any time the building is occupied [ANSI/ASHRAE 2022, 2023].

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 other settings [EPA 2025c]. OSHA also has helpful guidance on recommended practices for safety and health programs.

Conclusions

Addressing ventilation, humidity, and indoor environmental quality concerns requires a comprehensive approach to effectively mitigate existing mold and moisture damage and prevent future issues. It is crucial to identify the sources of moisture intrusion, promptly repair them to prevent further incursion, and ensure proper remediation of mold- and moisture-damaged building materials to minimize indoor mold growth. Furthermore, implementing regular monitoring protocols is vital for detecting any reoccurring or new building-related concerns. Continuous observation and communication with building occupants about ongoing efforts are essential in maintaining optimal indoor air quality and prioritizing the well-being of all occupants.

Limitations

The observations presented herein are based on a combination of document reviews, workplace history collection, and two visits to the campus. Due to the widespread concerns and the large number of buildings on campus, our assessment was limited to visually assessing as many work areas as possible that were priority areas of concern by requestors. It is important to consider that these findings may not encompass all campus areas or reflect every potential issue present across the entire campus. Therefore, this report is a representation of the observations made during the specified timeframe. The guidance and recommendations provided in this report can be applied to the most current assessment of campus conditions.

Section C: Tables

Table C1. Fungal types found in indoor air samples that were not found in outdoor air samples taken on the same day, among the 11 reports reviewed. Values within cells indicate the year and month of the air sampling finding.

Fungal Type	Alumni Center	Hall 3 Annex B	Hall 3 Annex C	Bookstore	Hall 6	Hall 1	Hall 5	Hall 2
Alternaria		2018 (Oct)					2018 (Oct) 2018 (Dec)	
Ascospores		2018 (Oct)	2018 (Oct)	2018 (Nov)		2012 (Nov)	2018 (Nov) 2018 (Dec)	
Aspergillus / Penicillium		2018 (Oct)	2018 (Oct) 2019 (Jul)			2012 (Nov)	2018 (Nov) 2018 (Dec)	
Basidiospores							2018 (Dec)	
Bipolaris / Drechslera			2018 (Oct) 2019 (Jul)					2019 (Mar)
Botrytis		2018 (Oct)						
Cercospora			2018 (Oct)				2018 (Oct)	2021 (Sep)
Cladosporium		2018 (Oct)	2018 (Oct)			2011 (May) 2012 (Nov)	2018 (Dec)	2019 (Mar)
Curvularia		2018 (Oct)	2019 (Jul)				2018 (Dec)	2019 (Mar)
Epicoccum							2018 (Oct)	
Fusarium							2018 (Oct)	
Nigrospora	2022 (Aug)				2022 (Aug)		2018 (Oct)	
Oidium			2018 (Oct) 2019 (Jul)					
Pestalotia- / Pestalotiopsis-like		2018 (Oct)				2012 (Nov)	2018 (Dec)	
Pithomyces		2018 (Oct)	2018 (Oct)			2021 (Sep)	2018 (Nov)	2019 (Mar) 2021 (Sep)
Polythrincium			2018 (Oct)			2012 (Nov)		
Pyricularia							2018 (Oct)	
Rusts		2018 (Oct)	2018 (Oct)			2021 (Sep)	2018 (Oct)	
Smuts / Myxomycetes		2018 (Oct)	2018 (Oct)			2012 (Nov) 2021 (Sep)		2019 (Mar) 2021 (Sep)
Spegazzinia		2018 (Oct)						
Stachybotrys		2018 (Aug)						2019 (Mar)
Torula			2019 (Jul)					

Table C2. Fungal types found in indoor air samples at higher spores per cubic meter of air (spores/m^3) counts than in outdoor air samples taken on the same day, among the 11 reports reviewed. Values within cells indicate the number of times higher the indoor spores/m^3 was compared to the outdoor spores/m^3 and the year and month of the air sampling finding. Results included in the table are only those where the indoor spores/m^3 were higher than the outdoor spores/m^3 of the same fungal type. Results where the indoor spores/m^3 were lower than or equal to the outdoor spores/m^3 counts are not included.

Fungal Type	Alumni Center	Hall 3 Annex B	Hall 3 Annex C	Hall 6	Hall 1	Hall 5	Hall 2
Alternaria	18.5–22.5* (2022, Aug) [raw[†]: 18–22]		1.5–4.0 (2019, Jul) [raw: 3–8]				2.1 (2021, Sep) [raw: 2]
Ascospores			1.2–1.4 (2019, Jul) [raw: 147–168]			4.8 (2018, Oct) [raw: 19]	5.2 (2019, Mar) [raw: 5] 11.4 (2021, Sep) [raw: 23]
Aspergillus / Penicillium	1.2–2.0* (2022, Aug) [raw: 7–12]	1.5–14.1 (2018, Aug) [raw: 12–113]		1.2–1.7* (2022, Aug) [raw: 7–10]	6.4–134.3 (2021, Sep) [raw: 13–272]		4.1 (2019, Mar) [raw: 4]
Basidiospores		29.8–484.1 (2018, Oct) [raw: 29–472]	4.1–197.0 (2018, Oct) [raw: 4–192] 1.2 (2019, Jul) [raw: 406]		1.5 (2012, Nov) [raw: 3]	1.6 (2018, Oct) [raw: 324]	2.6 (2021, Sep) [raw: 34]
Cladosporium		1.0–3.7 (2018, Aug) [raw: 4,133]	1.0–15.4 (2019, Jul) [raw: 100–1,512]			4.6 (2018, Oct) [raw: 124] 9.2–20.5 (2018, Nov) [raw: 9–20]	15.3 (2021, Sep) [raw: 31]
Curvularia	3.1* (2022, Aug) [raw: 3]						
Epicoccum	2.1–3.1* (2022, Aug) [raw: 2 –3]		2.0–169.4 (2019, Jul) [raw: 4–343]	5.2* (2022, Aug) [raw: 5]			
Fusarium			1.7–5.0 (2019, Jul) [raw: 5–14]				

Table C2 (continued). Fungal types found in indoor air samples at higher spores per cubic meter of air (spores/m^3) counts than in outdoor air samples taken on the same day, among the 11 reports reviewed. Values within cells indicate the number of times higher the indoor spores/m^3 was compared to the outdoor spores/m^3 and the year and month of the air sampling finding. Results included in the table are only those where the indoor spores/m^3 were higher than the outdoor spores/m^3 of the same fungal type. Results where the indoor spores/m^3 were lower than or equal to the outdoor spores/m^3 counts are not included.

Fungal Type	Alumni Center	Hall 3 Annex B	Hall 3 Annex C	Hall 6	Hall 1	Hall 5	Hall 2
Pithomyces	80.0–87.2* (2022, Aug) [raw: 78 –85]		3.1–57.5 (2019, Jul) [raw: 3–56]	44.1–73.8* (2022, Aug) [raw: 43–72]			
Smuts / Myxomycetes			3.1–25.6 (2019, Jul) [raw: 3–25]			1.7–2.7 (2018, Oct) [raw: 5–8] 2.1 (2018, Nov) [raw: 2] 2.1 (2018, Dec) [raw: 2]	
Zygophiala			2.1 (2019, Jul) [raw: 2]				

*When compared to Outside #2 air sample and not Outside #1 air sample (see August 2022 Report: Outdoor Air Sampling results section).

†Raw: Indicates raw count(s) of number of spores in the indoor air sample(s). Spores/m^3 equals raw count multiplied by 13 (the limit of detection or sensitivity).

Table C3. Fungal spore counts per cubic meter of air (spore counts/m^3) in Outside #1 and Outside #2 air samples from the August 2022 report, minimum and maximum spore counts/m^3 in the other 10 reports reviewed, and comparison of Outside #1 spore counts to Outside #2 and to the 10 other reports reviewed.

Fungal Type	**August 2022 Report Outside #1 (spores/m^3)**	**August 2022 Report Outside #2 (spores/m^3)**	**Outside #1 vs. Outside #2 (Fold Difference)**	**10 Other Reports Reviewed Minimum (spores/m^3)**	**10 Other Reports Reviewed Maximum (spores/m^3)**	**Outside #1 vs. 10 Other Reports Maximum (Fold Difference)**
Alternaria	293	13	23	13	40	7
Ascospores	200	320	<1	13	3,547	<1
Aspergillus / Penicillium	>160,000	80	At least 2,000	13	853	At least 188
Basidiospores	1,240	2,573	<1	13	10,173	<1
Cladosporium	>160,000	600	At least 267	13	4,013	At least 40
Curvularia	120	13	9	13	53	2
Epicoccum	160	13	12	13	27	6
Fusarium	12,000	13	923	13	40	300
Pithomyces	60,480	13	4,652	13	627	96
Rusts	1,453	—	N/A	13	13	112
Smuts / Myxomycetes	147	13	11	13	133	1

Table C4. ASHRAE/ANSI Standard 62.1-2022 Minimum Ventilation Rates in Breathing Zone for some observed applicable areas on campus. Additional areas may apply.

Occupant Category	People Outdoor Air Rate R_p cfm/person	Area Outdoor Air Rate R_a cfm/ft^2	Default Occupant Density #/1000 ft^2	Air Class	Occupied Standby (OS) Mode	CO_2 Concentration Above Ambient
Educational Facilities						
Computer lab	10	0.12	25	1		600
Corridors (age 5 plus)	—	0.12	—	1		NA
Lecture classroom	7.5	0.06	65	1	✓	1200
Lecture hall (fixed seats)	7.5	0.06	150	1	✓	1200
Libraries	5	0.12	10			600
Media center	10	0.12	25	1		600
Multiuse assembly	7.5	0.06	100	1	✓	1200
University/college laboratories	10	0.18	25	2		NA
Food and Beverage Service						
Cafeteria/fast-food dining	7.5	0.18	100	2		900
Kitchen (cooking)	7.5	0.12	20	2		NA
Restaurant dining rooms	7.5	0.18	70	2		1500
General						
Conference/meeting	5	0.06	50	1	✓	1500
Corridors	—	0.06	—	1	✓	NA
Occupiable storage rooms for liquids or gels	5	0.12	2	2		NA
Hotels, Motels, Resorts, Dormitories						
Barracks sleeping areas	5	0.06	20	1	✓	900
Bedroom/living room	5	0.06	10	1	✓	600
Laundry rooms, central	5	0.12	10	2		NA
Laundry rooms within dwelling units	5	0.12	10	1		NA
Lobbies/prefunction	7.5	0.06	30	1	✓	1500
Multipurpose assembly	5	0.06	120	1	✓	1800
Miscellaneous Spaces						
Computer (not printing)	5	0.06	4	1	✓	600
Shipping/receiving	10	0.12	2	2		700
Warehouses	10	0.06	—	2		700

Table C4 (continued). ASHRAE/ANSI Standard 62.1-2022 Minimum Ventilation Rates in Breathing Zone for some observed applicable areas on campus. Additional areas may apply.

Occupant Category	People Outdoor Air Rate R_p cfm/person	Area Outdoor Air Rate R_a cfm/ft^2	Default Occupant Density #/1000 ft^2	Air Class	Occupied Standby (OS) Mode	CO_2 Concentration Above Ambient
Office Buildings						
Breakrooms	5	0.12	50	1		1500
Main entry lobbies	5	0.06	10	1		1200
Occupiable storage rooms for dry materials	5	0.06	2	1		700
Office space	5	0.06	5	1		600
Reception areas	5	0.06	30	1		2100
Public Assembly Spaces						
Auditorium seating area	5	0.06	150	1		1800
Libraries	5	0.12	10	1		600
Lobbies	5	0.06	150	1		1800
Retail						
Barbershop	7.5	0.06	25	2		NA
Beauty and nail salons	20	0.12	25	2		NA
Coin-operated laundries	7.5	0.12	20	2		900
Sports and Entertainment						
Bowling alley (seating)	10	0.12	40	1		900
Gym, sports arena (play area)	20	0.18	7	2		900
Health club/aerobics room	20	0.06	40	2		1500
Health club/weight rooms	20	0.06	10	2		1500
Spectator areas	7.5	0.06	150	1		1500
Stages, studios	10	0.06	70	1		1500
Swimming (pool and deck)	—	0.48	—	2		NA

Note: cfm/person: cubic feet per minute of outdoor air per person in the occupied space; cfm/ft^2: cubic feet per minute of outdoor air per square foot of occupied floor space; CO_2: carbon dioxide; ppm: parts per million; N/A: CO_2 concentration is not related to occupancy level as there may be other sources generating substantial amounts of CO_2 in this space. See ANSI/ASHRAE 62.1-2022 for more detailed information.

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Promoting productive workplaces through safety and health research

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