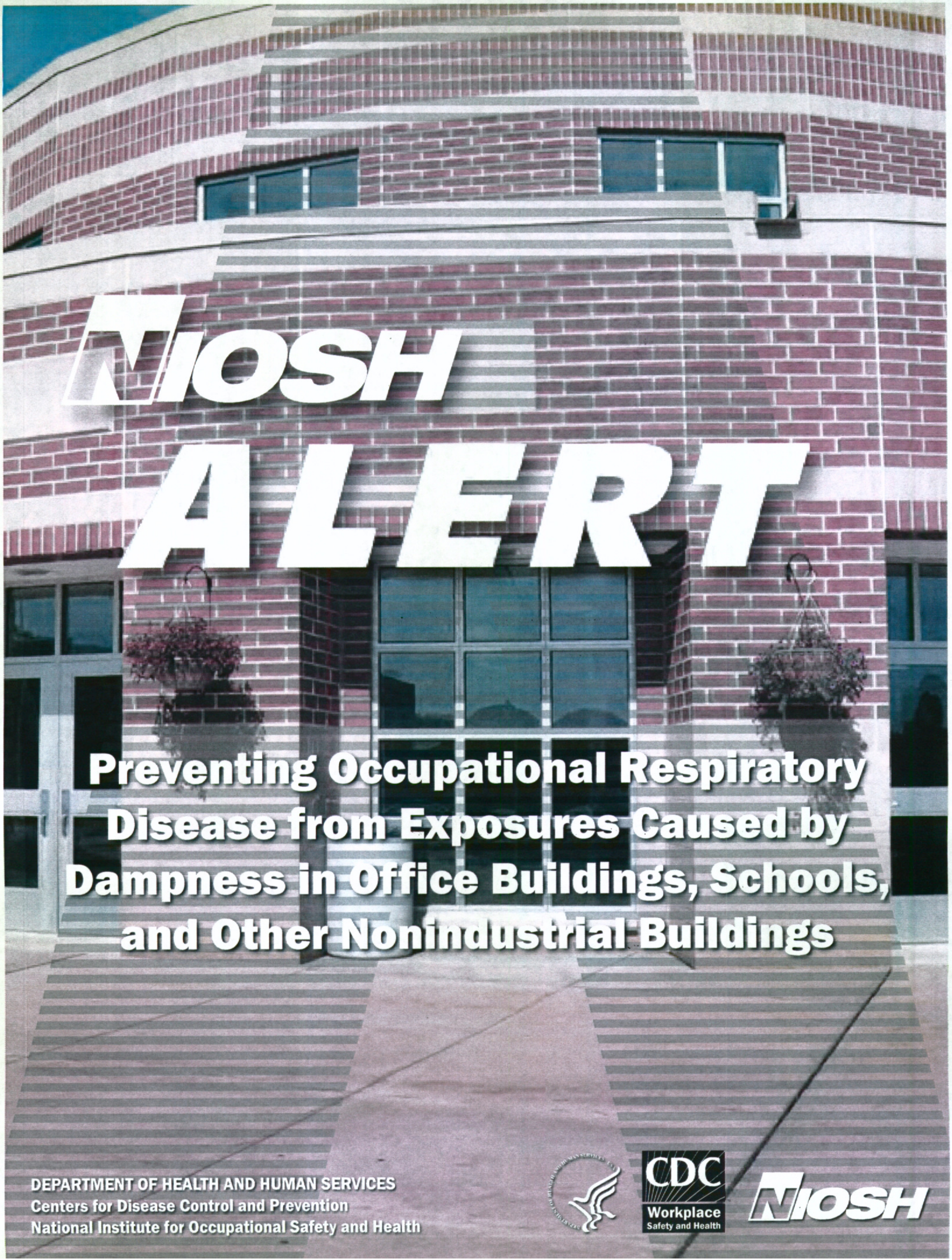


NIOSH ALERT

Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

CDC Workplace Safety and Health

NIOSH

Ordering Information

To receive documents or other information about occupational safety and health topics, contact NIOSH:

Telephone: **1–800–CDC–INFO** (1–800–232–4636)
TTY: 1–888–232–6348
E-mail: cdcinfo@cdc.gov

or visit the NIOSH website at **www.cdc.gov/niosh**.

For a monthly update on news at NIOSH, subscribe to *NIOSH eNews* by visiting **www.cdc.gov/niosh/eNews**.

DHHS (NIOSH) Publication No. 2013–102

November 2012

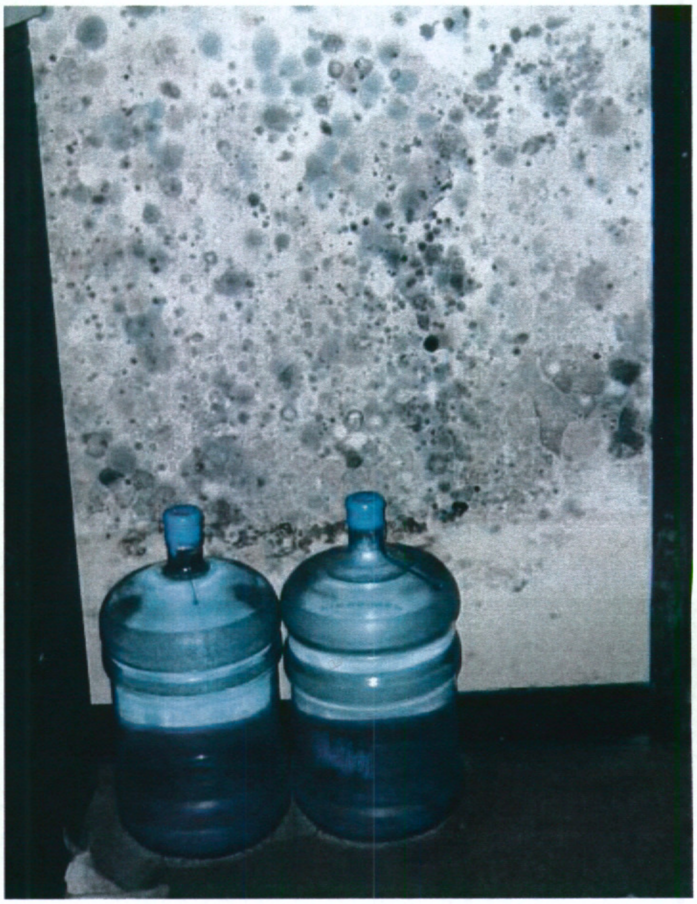
SAFER • HEALTHIER • PEOPLE™

Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings

WARNING!

Occupants within damp office buildings, schools, and other nonindustrial buildings may develop respiratory symptoms and disease.

Office buildings, schools, and other nonindustrial buildings may develop moisture and dampness problems from roof and window leaks, high indoor humidity, and flooding events, among other things. For this Alert, we define "dampness" as the presence of unwanted and excessive moisture in buildings [AIHA 2008]. This can lead to the growth of mold, fungi, and bacteria; the release of volatile organic compounds; and the breakdown of building materials. We use the term "mold" for a group of fungi that are common on wet materials. Outdoors, molds live in the soil, on plants, and on dead or decaying matter. There are thousands of species of molds and they can be any color. Different mold species can adapt to different moisture conditions. Research studies have shown that dampness-related exposures from building dampness and mold have been associated with respiratory symptoms, asthma, hypersensitivity pneumonitis, rhinosinusitis, bronchitis, and respiratory infections in research studies. Individuals with asthma or hypersensitivity pneumonitis may be at risk for progression to more severe disease if the relationship between illness and exposure to the damp building is not recognized and exposures continue.



Mold growth on wall board.

Building dampness and subsequent respiratory illness in some building occupants (including children) occur in part from a lack of knowledge and understanding of the nature and severity of these problems among designers, builders, building owners, employers, and building occupants. Building dampness problems frequently occur because of suboptimal design, construction, and commissioning (assessing the building's construction and operation prior to occupancy) of new buildings. These problems and associated health effects can be prevented by making dampness prevention a goal during the design, construction, and commissioning phases. Once built, buildings may also develop dampness problems from improper or insufficient maintenance or operation and weather events. The best current evidence suggests observations of dampness, water damage, mold, or mold odors are the best indicators of dampness-related health hazards, rather than microbiologic measurements. Owners, employers, or occupants should use the following approaches to minimize the likelihood of persistent building dampness and subsequent respiratory problems in exposed occupants.

Building Owners and Employers

- Always respond when occupant health concerns are reported.
- Regularly inspect building areas such as roofs, ceilings, walls, basements, crawl spaces, and slab construction for evidence of dampness; take prompt steps to identify and correct the causes of any dampness problems found.
- Conduct regularly scheduled inspections of heating, ventilating, and air-conditioning (HVAC) systems and promptly correct any problems.
- Prevent high indoor humidity through the proper design and operation of HVAC systems.
- Dry any porous building materials that have become wet from leaks or flooding within 48 hours.
- Clean and repair or replace any building materials that are moisture-damaged or show evidence of visible mold growth. Follow remediation guidelines such as those established by the following agencies:
  - Environmental Protection Agency's (EPA) *Mold Remediation in Schools and Commercial Buildings* [EPA 2008]
  - New York City Department of Health and Mental Hygiene's *New York City Guidelines on Assessment and Remediation of Fungi in Indoor Environments* [NYC DOHMH 2008]
  - American Industrial Hygiene Association's *Recognition, Evaluation, and Control of Indoor Mold* [AIHA 2008]
- Inform occupants that respiratory effects from exposure in damp buildings can occur and implement a system for response to:
  - building dampness and musty or moldy odors, leaks, and flooding incidents.
  - building-related respiratory symptoms or disease.
- Encourage occupants who have developed persistent or worsening respiratory symptoms while working in the building to see a healthcare provider; refer to local or state listings of occupational medicine physicians or the Association of Occupational and Environmental Clinics at http://www.aoec.org/directory.htm.
- Follow recommendations from a healthcare provider for relocation of occupants diagnosed with building-related respiratory disease.
- Establish an indoor environmental quality (IEQ) team to oversee implementation of an IEQ program. The IEQ team should consist of a coordinator and representatives of the building employees, employers, and building management. IEQ teams for schools may wish to include nurses, school board officials, and parents. The EPA's

Indoor Air Quality Tools for Schools (http://www.epa.gov/iaq/schools/) can be used as a model for such a program.

Occupants

- Inform your building manager/owner about signs of leaks, flooding, dampness, musty or moldy odors, and ventilation problems in the building; also, let your employer or building manager/owner know of any respiratory problems that may be building-related.
- See your healthcare provider if you have developed persistent or worsening health symptoms while working in the building:
  - Refer to local or state listings for occupational medicine physicians or the Association of Occupational and Environmental Clinics at http://www.aoec.org/directory.htm.
  - Let your employer or building manager/owner know if your healthcare provider recommends relocation to another work area to prevent exposure to mold or dampness-related contaminants that may be causing or exacerbating your symptoms in situations where dampness problems persist.
- Familiarize yourself with the IEQ program at your workplace and become an active member of the IEQ team, if needed. If there is no IEQ program at your workplace, strive for one to be established.

For additional information, see ***NIOSH Alert: Preventing Respiratory Diseases from Damp Indoor Environments*** [DHHS (NIOSH) Publication No. 2013–102]. To request single copies of the Alert, contact NIOSH:

1–800–CDC–INFO (1–800–232–4636)
TTY: 1–888–232–6348 | E-mail: cdcinfo@cdc.gov

or visit the NIOSH Web site at **www.cdc.gov/niosh**

For a monthly update on news at NIOSH, subscribe to *NIOSH eNews* by visiting www.cdc.gov/niosh/eNews

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

PAGE LEFT INTENTIONALLY BLANK

NIOSH ALERT

Preventing Occupational Respiratory Disease from Exposures Caused by Dampness in Office Buildings, Schools, and Other Nonindustrial Buildings

WARNING!

Occupants within damp office buildings, schools, and other nonindustrial buildings may develop respiratory symptoms and disease.

The National Institute for Occupational Safety and Health (NIOSH) requests assistance in preventing respiratory symptoms and disease from working in or occupying damp office buildings, schools, and other nonindustrial buildings. This Alert describes the respiratory problems that occupants may experience from exposures in damp buildings, presents summary information on outbreaks of building-related respiratory disease, and provides recommendations on how to identify, respond to, and prevent building dampness and related respiratory symptoms and disease.

BACKGROUND

In recent years, there has been much public interest in the health effects of living, attending school, or working in damp buildings. Occupants of damp office buildings, schools, and other nonindustrial buildings report a broad range of building-related symptoms and illnesses, including headache; fatigue; irritation of eyes, nose, and throat; lack of concentration; rhinitis and sinusitis (or rhinosinusitis); lower respiratory symptoms; exacerbation and onset of asthma; hypersensitivity pneumonitis; respiratory infections; bronchitis; eczema; and neurologic effects. A recent review of the occupational causes of sarcoidosis indicates that there is increasing evidence that sarcoidosis (a multiorgan granulomatous disease) has multiple causes, including exposure to mold, especially in the presence of triggers of inflammation [Newman and Newman 2012]. Not all reported types of building-related symptoms have been fully investigated. Respiratory outcomes have been the most thoroughly studied and reviewed, while the evidence is limited for the possible health effects of mycotoxins in indoor environments, including neurological outcomes [IOM 2004; WHO 2009; Mendell 2011]. This alert focuses on respiratory disease.

Research studies have shown consistent associations between the presence of dampness and mold in buildings and respiratory symptoms in building occupants. Exposures in damp buildings are complex and vary from building to building and at different locations within a building. Moisture allows increased indoor microbial growth on building materials or other surfaces. Building occupants may be exposed to structural components of microbes (e.g., spores and fungal fragments) and to specific substances the microorganisms may produce; the potential contaminants will vary depending on the species that are present and on environmental conditions. Moisture also provides a favorable environment for cockroaches, rodents, and dust mites. Exposure to chemical compounds such as volatile organic compounds released by moisture-damaged building materials may also occur. The levels at which different dampness-related exposures may pose health risks for building occupants have not been established.

Many research studies have attempted to identify the specific exposures in damp buildings that may cause health effects in occupants. Much research has focused on mold exposures, since mold growth is a common characteristic of damp buildings. Some individuals can develop diseases such as asthma and rhinosinusitis (nasal inflammation) from exposure to molds in the environment. Under certain environmental conditions, molds can produce mycotoxins that are harmful to people if inhaled or ingested. Currently, research is on-going as to whether or not inhalation exposure to mycotoxins at the levels that may occur in damp buildings poses a health risk to building occupants.

Office buildings, schools, and other nonindustrial buildings can develop persistent dampness through a variety of mechanisms. These commonly include roof and window leaks, flooding events, condensation, plumbing leaks, and high indoor humidity. A wet foundation can also cause persistent dampness. Foundations can often become wet due to water runoff from land that slopes toward the building, an inadequate gutter system that does not direct water away from the building, or a building site with a high water table. Problems with dampness in buildings can begin because of inadequate design of building components and poor construction work or improper storage of materials. These and other causes can be prevented through careful attention to the design, construction, commissioning, operation, and maintenance of buildings. Prevention and control of building dampness will minimize the chance that occupants will develop respiratory symptoms and disease from exposures related to the dampness. Prevention can also help avoid potentially costly remediation of moisture damage in buildings.

RESPIRATORY SYMPTOMS AND DISEASE IN OCCUPANTS OF DAMP BUILDINGS

The Institute of Medicine (IOM) concluded that there is an association between exposure to damp indoor environments and cough, wheeze, upper respiratory tract (nasal and throat) symptoms, and exacerbation of asthma. Also, the IOM concluded that there is an association between the presence of mold and bacteria in damp indoor environments and hypersensitivity pneumonitis [IOM 2004]. A statistical analysis of well-designed, published research studies estimated percentage increases in health outcomes for subjects living in houses with dampness and mold compared to those living in houses without these conditions. The percentage increases estimated were 50% for current asthma, 33% for ever-diagnosed asthma, 30% for asthma development, 50% for cough, 44% for wheeze, and 52% for upper respiratory tract symptoms [Fisk et al. 2007].

In 2009, the World Health Organization (WHO) published *Guidelines for Indoor Air Quality, Dampness and Mold* [WHO 2009]. Based on its review of the scientific literature up to July 2007, the WHO stated that there was sufficient epidemiological evidence to conclude that occupants of damp buildings are at risk of developing upper and lower respiratory tract symptoms (including cough and wheeze), respiratory infections, asthma, and exacerbation of asthma. The WHO report further stated that limited evidence suggests an association between damp buildings and bronchitis and allergic rhinitis and that there is clinical evidence that exposure to mold and other microbial agents in damp buildings increases the risk of hypersensitivity pneumonitis, chronic rhinosinusitis, and allergic fungal sinusitis. In 2011, the WHO review was extended to include publications in the scientific literature up to November 2009. Additional evidence led to the conclusions that shortness of breath (dyspnea), bronchitis, and allergic rhinitis should be added to the list of health outcomes with sufficient evidence of an association to dampness and dampness-related agents [Mendell et al. 2011].

RHINITIS AND SINUSITIS

Rhinitis is characterized by nasal stuffiness, sneezing, and a runny or itchy nose. Occupants in damp buildings who experience these symptoms while in the building and experience improvement or disappearance of symptoms when away from the building may have rhinitis due to exposures in the building.

Sinusitis (inflammation of the paranasal sinuses) can cause symptoms similar to those of rhinitis or a cold. Sinusitis is usually caused by viruses or bacteria and less often by fungi. Inhalation of irritant substances can also be a cause.

ASTHMA

Asthma is a chronic disease of the lung airways characterized by inflammation and episodes of airway obstruction. Asthma is a fairly common disease. For adults in the United States, the occurrence of currently active asthma was approximately 7% in 2008; the adult lifetime prevalence (asthma at any point in a person's life) was approximately 13% [NCHS 2008].

Some individuals have allergic asthma, and others have non-allergic asthma. Symptoms associated with obstruction of the airways include wheeze, chest tightness, shortness of breath, and cough. The airways obstruction can be reversed with medications (e.g., inhaled bronchodilators and corticosteroids) or may resolve spontaneously with time. Lung function testing with spirometry (a test of exhaled air flow and volumes) may reveal obstruction in airflow. A methacholine challenge test for airways hyper-reactivity involves inhaling increasing concentrations of methacholine before spirometry tests to measure how sensitive the airways are. This test may be useful to establish an asthma diagnosis in individuals with symptoms who have normal spirometry.

NIOSH has estimated that 29% to 33% of new-onset adult asthma is attributable to work-related exposures and 23% of existing adult asthma is exacerbated by work [Vollmer et al. 2005; Henneberger et al. 2006; Sama et al. 2006]. If occupants develop asthma or asthma exacerbation while working in damp buildings, medical treatment may not be effective if the occupant continues to be exposed. An occupant in damp buildings with allergic asthma may experience symptoms after exposure to very low levels of a sensitizing agent that may still be present after remediation; in such cases, an occupant may require relocation to another area.

HYPERSENSITIVITY PNEUMONITIS (HP)

HP is a serious lung disease induced by an immune system response to repeatedly inhaling organic matter (material from living things, such as plants, animals, bacteria, or fungi) or other sensitizing agents. Dozens of different fungi, bacteria, animal proteins, plants, and chemicals are known causes of HP [Patel et al. 2001]. Examples of occupations in which HP is known to occur include farmers exposed to dust from moldy hay and machinists exposed to metalworking fluid mists. There also have been many reports in the scientific literature of individuals who have developed HP while working in damp office buildings and schools or living in homes with evidence of moisture damage and mold [Hoffman et al. 1993; Weltermann et al. 1998; Thorn et al. 1996; Apostolakos et al. 2001].

Two symptom patterns exist with HP. Some individuals experience episodic shortness of breath and flu-like symptoms, including cough, muscle aches, chills, fever, sweating, and fatigue (acute disease). These symptoms start within hours of exposure and last for 1 to 3 days if there is no further exposure. Other individuals develop gradual and progressive shortness of breath and cough, often accompanied by weight loss. HP can mimic a respiratory infection. The first signs that the illness is due to exposures in a building may be improvement in symptoms and medical tests during a period of time away from the building and worsening on return.

The main treatment for HP is removal from exposure to the causative agent or environment. This may be accomplished by relocation. Acute disease may resolve completely with exposure termination; corticosteroid (a type of steroid) medications may shorten disease duration. With long-term exposure, the disease may not improve or may continue to worsen and progress to permanent lung scarring even after exposure ends.

CASE REPORTS

Case 1—Development of asthma and hypersensitivity pneumonitis in a damp office building

A single-story office building had a history of recurrent wet carpets due to plumbing problems. Ceiling tiles also showed evidence of leaks. Part of the building was below ground level. A 48-year-old worker was diagnosed with asthma within 6 months of starting work in this building. Peak flow measurements revealed airflow limitation shortly after entering the building, with partial recovery on lunch breaks outside the building and full recovery on weekends. After relocation to another office building, the worker no longer had asthma symptoms, no longer needed asthma medications, and no longer had work-related airflow limitation as documented by peak flow measurements [Hoffman et al. 1993].

A 37-year-old worker in the same building developed shortness of breath on exertion, 2 years after starting work in the building. A chest x-ray showed abnormalities consistent with hypersensitivity pneumonitis. She was treated for pneumonia with two courses of antibiotics without improvement. After referral to a pulmonary physician, spirometry testing showed a restrictive pattern. Symptoms improved with treatment with prednisone tablets (corticosteroid). After discontinuation of prednisone, the worker experienced a return of symptoms and weight loss of 20 pounds. The worker's symptoms improved during a 1-month period away from work. After return to work, she experienced shortness of breath, flu-like symptoms, and fatigue; these symptoms would improve on weekends but progressively worsened over 2 weeks; lung function tests worsened. The worker was referred to an occupational medicine clinic where the worker was diagnosed with HP. Her symptoms again improved after treatment with prednisone, and she is no longer working in the building [Hoffman et al. 1993].

Case 2—Six Cases of Occupational Asthma in a Damp Hospital

Over a 2-year period, 6 of 53 workers (11%) located on the top floor of an eight-story hospital building developed asthma. The hospital had experienced multiple episodes of significant roof and window leaks during heavy rains over several years. Walls and ceilings showed mold growth. Five of the six affected workers had no previous asthma history, while one worker reported childhood asthma but had not experienced any asthma symptoms in 20 years. All six workers reported asthma symptoms that improved away from work. All six had evidence of asthma on methacholine challenge testing. Blood analyses showed that none of the workers demonstrated an allergic response to latex or common environmental allergens (e.g., house dust mites, grass, cat, dog). In four of the six affected workers, serial peak flow measurements showed a work-related symptom pattern (declines in peak flow during work days and improvement when off work); of the other two affected workers, one had a mixed pattern (drops in peak flow at work and at home) and the other showed some declines in peak flow over the work week [Cox-Ganser et al. 2009].

Case 3—Hypersensitivity Pneumonitis in a Damp School Building

A 34-year-old school teacher with no past history of respiratory problems became acutely ill with shortness of breath at the beginning of the school year in September 1988. A blood clot was suspected at the time but not found with medical tests. She improved and returned to work in the middle of October 1988. Several months later she sought additional medical evaluation for persistent shortness of breath on exertion, cough, and mild fever. Chest x-rays showed a pattern consistent with inflammation and scarring in both lungs. Spirometry showed a restrictive pattern consistent with chest x-ray findings, and a gas transfer test was low at 45% of predicted levels. Based on many other tests, she was diagnosed with atypical sarcoidosis. Over several years her shortness of breath worsened. A lung-computed tomography (CT) scan in 1994 showed severe lung scarring in a pattern called honeycombing. Her arterial blood oxygen level was low. Blood tests showed antibodies that indicated exposure to several different molds. Her diagnosis was revised to HP and she was treated with corticosteroid medications. While off work during summer vacation, her condition improved and her arterial oxygen level increased. On return to work at the end of the summer, her cough and shortness of breath worsened and her arterial oxygen level declined. She improved somewhat after medical restriction from work at the school [Thorn et al. 1996].

The school, a one-story, flat-roofed, mechanically ventilated building, was built in 1980. It had a long history of roof and plumbing leaks. Many employees had complained of symptoms (especially fatigue) and smells due to poor air quality. Building investigations had identified high water content in walls and floors. The flat roof was replaced with an inclined roof in 1992; severe water damage occurred during the construction period. Water-damaged materials (e.g., wall boards) were replaced by 1995 [Thorn et al. 1996].

For information on IEQ-related evaluations, go to the NIOSH Workplace Health Hazard Evaluation Web link at http://www.cdc.gov/niosh/hhe/.

FAILURE TO PREVENT BUILDING DAMPNESS CAN BE EXPENSIVE

Preventing dampness in buildings and rapidly correcting dampness problems when they occur are important considerations, not only for protecting the health of occupants, but for minimizing costs associated with repair or replacement of moisture-damaged building materials. Extensive remediation costs can amount to millions of dollars. In addition, there may be costs from relocation of employees, sick leave, workers' compensation, decreased productivity, consultant evaluations, and litigation.

A costly example is a county courthouse and attached office building built in southern Florida from 1986 through 1989. Within weeks of moving into the building, workers reported a variety of symptoms, including eye and throat irritation, fatigue, and headaches. They also reported visible mold growth under the wall paper on the perimeter walls of the building [NIOSH 1996].

The exterior walls of each building consisted of a brick veneer on the first floor and a stucco veneer on the upper floors. In 1988, the exterior walls developed cracks that allowed rainwater to enter the exterior wall cavities over the next several years. Weep holes, which allow rainwater in wall cavities to drain to the outside, were missing or plugged with mortar at the base of the brick veneer. Vinyl wall paper trapped moisture within these walls. By 1992, approximately 100 square meters of wall board (mostly along the perimeter walls) appeared to have mold growth. Carpet along the perimeter of each floor was chronically wet from rainwater intrusion. The ventilation systems could not properly dehumidify outdoor air brought into the buildings. From 1988 to 1992, the relative humidity in both buildings often exceeded 70% and sometimes exceeded 80%. Water leaked onto ceiling tiles from ventilation units located above the suspended ceiling on each floor and from condensation on cold water pipes that were insufficiently insulated. By 1992, almost all ceiling tiles in both buildings were sagging or warped due to high indoor relative humidity. More than 100 ceiling tiles were water stained and visually moldy. The air in both buildings smelled musty [Hodgson et al. 1998].

Among the approximately 200 employees working in the buildings, at least 14 submitted workers' compensation claims for building-related illness. The employees were relocated for 2 years during remediation work. The cost of the remediation and restoration exceeded $24 million, more than twice the $11 million original cost to build the buildings. In a jury trial, Martin County, Florida, the owner of the buildings, was awarded $13.7 million in damages from a construction company and three insurance companies. Martin County also settled related law suits against other parties for close to $3 million [LBNL 1998].

CURRENT STANDARDS AND RECOMMENDATIONS

There are no Federal Occupational Safety and Health Administration (OSHA) regulations or NIOSH recommended exposure limits pertaining to moisture in indoor environments or the associated microbial colonization. Nonetheless, public health agencies recommend that indoor dampness be remediated because it creates conditions conducive to microbial growth, potentially resulting in health risks.

Several states have regulations on workplace exposures to indoor dampness. Be sure to check with your state for updates and additions to these regulations or new regulations that have been adopted.

The California Labor Code 142.3 requires the correction of water entry, leakage from interior water sources, or other uncontrolled accumulation of water in workplaces. As a condition of receiving state school facility funds, the California Education Code §17070.75,17002(d)(1) requires school districts to establish an inspection system for facilities that ensures school buildings are maintained in good repair. "Good repair" is defined to include interior surfaces free from water damage and showing no evidence of mold or mildew and to include functional and unobstructed HVAC systems.

The Maryland Education Code §5-301 requires that Board of Public Works for the state adopt regulations to establish standards to enhance indoor air quality in relocatable (portable) school classrooms, including specifications for preventing mold and water damage, limiting infiltration of pollutants, providing continuous ventilation, and using low-emitting building materials.

The Massachusetts State Sanitary Code, Chapter II, establishes Minimum Standards of Fitness for Human Habitation and applies to all dwelling units, including leased units. The code includes provisions addressing underlying causes of mold and moisture problems (Code of Massachusetts Regulations (CMR) 410.000 et. seq.). In the Massachusetts General Laws, ch. 70B, §3, regulations governing state-funded projects (963 Code Mass. Regs. 2.04) require that the Massachusetts School Building Authority and school building grant program make all reasonable efforts to insure suitable indoor air quality and to establish specific requirements for ventilation and thermal comfort, containment procedures for pollutants created during renovation, filtration, walk-off mats, gas-fired equipment, siting of outside air intakes, and prevention of mold and water damage in building materials.

Montana's Code § 70-16-703 requires sellers, landlords, or their agents to inform buyers and renters of the presence of mold in a building and to provide results of any mold tests that have been conducted.

The New Jersey Statutes §§ 34:6A-1, et seq., New Jersey Public Employees Occupational Safety and Health Indoor Air Quality Standard (N.J.A.C 12:100-13.4), require control of microbial contamination when found during regular or emergency maintenance activities or during visual inspection. Controls involve the prompt repair of water intrusion that can promote growth of biologic agents; remediation of damp or wet materials by drying, replacing, removing, or cleaning within 48 hours of discovery; continued remediation until water intrusion is eliminated; and removal of visible microbial contamination of areas such as ductwork, humidifiers, dehumidifiers, condensate drip pans, heat exchange components, other HVAC and building system components, or on building surfaces such as carpeting and ceiling tiles. Rules adopted under the law (N.J. Admin. Code 12:100-13.1 et seq.) require employers to establish and implement a preventative HVAC maintenance plan that includes a number of specified practices, undertakes prevention and clean-up practices for microbial contamination, protects indoor air quality during renovation, responds to indoor air quality complaints, and maintains and makes available records of maintenance activities.

North Carolina General Statutes §115C-521.1 requires public school classrooms used as licensed child care facilities for preschool students to have floors, walls, and ceilings that are free from mold, mildew, and lead hazards. North Carolina General Statutes § 42-42 requires landlords to repair or remedy any imminently dangerous conditions on the premises, within a reasonable period of time after acquiring actual knowledge or receiving notice of the conditions. "Imminently dangerous condition" is defined to include excessive standing water, sewage, or flooding problems caused by plumbing leaks or inadequate drainage that contribute to mold.

The Virginia Code § 55-248.4—.18:2 requires landlords and tenants to maintain the premises to prevent the accumulation of moisture and mold growth. Landlords are required to promptly respond to notifications by tenants of mold or moisture accumulation. The code also provides that, where mold conditions materially affect the health and safety of a tenant, the landlord may require the tenant to temporarily vacate the premises for up to 30 days while the landlord conducts mold remediation consistent with professional standards as defined by law. Landlords are required to pay relocation costs.

Under the Revised Code of Washington §59.18.060, landlords are required to provide tenants with written or posted information approved by the Department of Health about the health hazards of indoor mold and how to control mold growth to minimize health risks.

Recommended methods for mold prevention and remediation have been published by the Centers for Disease Control and Prevention, OSHA, the EPA, the American Industrial Hygiene Association, and the New York City Department of Health and Mental Hygiene. Guidelines on indoor air quality for large buildings are provided by the EPA-supported American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) publication, *Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning* [ASHRAE 2009b]. Also, the Sheet Metal and Air-Conditioning Contractors' National Association provides guidance in IAQ Guidelines for Occupied Buildings Under Construction, 2nd ed. ASHRAE's recently approved *Position Document Limiting Indoor Mold and Dampness in Buildings* [ASHRAE 2012] underlines the Society's stance on the importance of limiting indoor mold and dampness in buildings. ASHRAE notes the association between building dampness and potentially adverse health outcomes. The position document describes 64 specific decisions and actions by policymakers, owners, architects, engineers, building operators, and homeowners that are known to either increase or reduce the potential for indoor dampness [ASHRAE 2012]. A systematic review of housing interventions that affect health outcomes associated with exposure to moisture, mold, and allergens is given in the publication *Housing Interventions and Control of Asthma-related Indoor Biologic Agents: A Review of the Evidence* by Krieger et al. [2010]. State and municipal building codes may provide guidance on appropriate construction methods that will prevent water entry and accumulation in buildings.

CONCLUSIONS

Office and school buildings may develop persistent excessive moisture due to roof and window leaks, high indoor humidity, and flooding events, among other contributors. Occupants (including children) may be exposed to microbial products and emissions from breakdown of water-damaged building materials. Some exposed occupants may develop respiratory symptoms and diseases, such as asthma and HP.

Many building dampness problems occur because of suboptimal design, construction, and/or commissioning in new or existing buildings. These problems and associated health effects can be prevented by making dampness prevention a goal in the early development phases. Continued prevention requires on-going attention to building maintenance and operation. This includes regular monitoring and maintenance of HVAC systems and other building components that are subject to moisture problems and prompt identification and correction of causes. Moisture-damaged or moldy building materials should be remediated (cleaned and repaired or replaced), with precautions taken to prevent remediation workers and building occupants from being exposed to mold or dust during the remediation. Prevention and control of building dampness will minimize the chance that occupants will develop respiratory symptoms and disease from exposures related to the dampness.

RECOMMENDATIONS

Preventive Building Design, Construction, Renovation and Commissioning

Many causes of persistent building dampness can be prevented through careful attention to details in the design, construction, and commissioning phases. Owners and developers should be aware of the importance of preventing building dampness and the reasons why buildings can become persistently damp. Contracts should provide specific details on the design and choice of building materials and when and how they are to be assembled and installed. Contracts should also specify which individuals (e.g., general contractor, construction manager) are responsible for ensuring that correct construction techniques are used and that, once installed, the different building systems function as designed to prevent building dampness. Building mechanical systems, which are critical to indoor environmental quality, should be reviewed by the maintenance personnel who will be responsible for maintaining the equipment. Provided below are examples of important building dampness prevention issues that should be considered by owners, architects, engineers, contractors, and others involved in the construction of new buildings.

Keep the foundation dry

A foundation that is frequently affected by flooding or is chronically damp can lead to moisture damage of building materials and microbial growth. A damp foundation can occur due to a high water table or poorly managed rainwater drainage [AIHA 2008]. For this reason, careful selection and preparation of the building site are extremely important issues for prevention of building dampness problems. The foundation should have an adequate drainage system and the adjacent land should slope downward and away from the building.

Keep moisture-sensitive building materials dry during the construction process

Porous building materials, which can support microbial growth, should be protected from getting wet during construction. Stored wall board that has become wet should be dried out quickly or not used; gypsum board that has become fully saturated as a result of wicking through the exposed edge typically will not dry without becoming damaged and/or moldy [AIHA 2008]. Wall board and flooring materials should not be installed over masonry block or a cement slab, respectively, that is not sufficiently dry. If active drying of a building is necessary during construction to allow installation of interior finish materials, a professional drying service should be used rather than using the HVAC system; starting the HVAC system early before it is fully commissioned, tested, and balanced can damage the equipment, and construction dust can clog cooling coils and reduce their useful life and cooling capacity. ASHRAE recommends that HVAC system components and duct work be kept clean and dry prior to installation, as insulation lining that becomes wet and dirty will support mold growth [ASHRAE 2009a]. Interior insulated duct lining should be avoided, especially downstream of coils.

Minimize the amount of rainwater that penetrates the building envelope

Leaks through the building envelope can begin during construction due to inadequate design and/or installation of building components. Thirty-five percent of new buildings show evidence of leaks through or around windows as a result of improper installation [ASHRAE 2009a]. Entry of rainwater into exterior building walls at openings for windows, doors, and balconies is typically prevented through the installation of flashing. Proper installation of flashing at the corners of these openings is a complicated process and involves many different construction workers installing various building materials. Problems often arise when workers do not have the necessary information and instructions to perform the installation. Architects or contactors can prevent this problem by providing (1) detailed 3-D drawings that clearly show all the layers and the installation sequence for all flashing details at all corners in addition to all straight joints in the exterior wall and (2) mockup wall sections that show these details for construction workers to refer to on the jobsite. Correct installation of flashing material is also important for other openings in the building envelope (e.g., openings for ducts, pipes, and wires).

Exterior walls should be designed so any rain water that penetrates openings in the exterior cladding (e.g., brick veneer) can dry and/or drain out of the wall. A common way to accomplish this is by maintaining an air space between the cladding and the next wall layer (the sheathing) and covering the sheathing with a continuous and completely sealed water barrier. Drain holes and flashing are provided at the bottom of the space and air vents at the top. This design is sometimes referred to as a "rain-screen wall" [ASHRAE 2009a].

Ensure dehumidification of indoor air through proper design, installation, and operation of building HVAC systems

High indoor humidity can lead to increased moisture content of building materials or to condensation on cold surfaces (which can then wet nearby moisture-sensitive materials such as wallboard). This can cause deterioration of building materials and microbial growth. Therefore, air should be dehumidified as needed to prevent high indoor humidity. An HVAC system that dehumidifies solely through the operation of air-conditioning cooling coils may not be able to lower indoor humidity sufficiently without making the occupied space overly cool. This is a common problem with over-sized HVAC systems where short cycles achieve cooling but are insufficient for adequate dehumidification. Even properly sized systems may be unable to control humidity in some cases. For instance, on days where the outdoor air is at the design temperature but overly humid, the low demand on HVAC systems prevents adequate dehumidification.

An additional dedicated unit to dehumidify outdoor ventilation air may be necessary for times when the cooling demand is low (e.g., when the building is unoccupied) but humidity is still high. The EPA recommends maintaining indoor relative humidity below 60% and ideally in a range from 30% to 50% to prevent mold growth, and ASHRAE recommends that relative humidity be maintained at or below 65%. For hot and humid climates, ASHRAE recommends that HVAC units monitor and control the air dew point rather than the relative humidity of the air, as the latter provides no information on the relative humidity on cool surfaces (where increased moisture content or condensation may occur). The dew point is a better indicator of this potential problem; ASHRAE recommends maintaining the indoor air dew point below 55°F [ASHRAE 2009a]. ASHRAE also recommends making sure that connections in ventilation return air ducts and in exhaust ducts are tightly sealed to prevent negative air pressure in building cavities (i.e., inside walls and above the ceiling); negative air pressure in building cavities can cause humid outdoor air to be drawn into the building through cracks in the building envelope, which in turn can lead to increased moisture content in, or condensation on, building materials in building cavities (e.g., increased moisture content on the back of gypsum board and condensation on pipes).

Other issues

- Vinyl wall coverings should not be used on the indoor surface of exterior walls in air-conditioned buildings in hot and humid climates, because they greatly reduce permeability of the wall assembly. Instead, these walls should be painted or covered with highly permeable wall coverings attached with adhesives that pass water vapor freely [ASHRAE 2009a].
- The risk of mold growth on paper-faced gypsum board can be minimized by specifying that it be installed with a gap (¼ inch is the minimum) between the finished floor and the bottom of the wall. The gap acts as a capillary break so that water on the floor or behind the wall cannot wick up into the wall during mopping, carpet cleaning, or a minor flooding event (i.e., the water would have to be at least ¼-inch deep before it could reach the wall) [ASHRAE 2009a].
- Cold-water pipes and chilled-water lines should be adequately insulated to prevent condensation.
- Water supply lines should be located in an area of the building where freezing temperatures are unlikely to occur. Freezing water pipes could result in flooding.

Greater detail on the issues discussed above and on other considerations for building dampness prevention through proper building design and construction can be found in journal articles and books specifically dedicated to this subject. One source for such information is the Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning, published by ASHRAE [2009b]. IAQ Design Tools for Schools, published by the EPA [2008], gives detailed guidance on school design and construction, the general principles of which can be applied to most buildings. Indoor Air Quality Solutions for Stationary Engineers, published by the American Technical Publishers [IUOE 2009], features an overview of indoor air quality and HVAC systems for institutional and commercial facilities.

Building Maintenance and Operation

Proper operation and maintenance of the HVAC system and prompt identification and elimination of sources of excess building moisture are important for prevention of damage to building materials and microbial growth. Building management and maintenance staff should implement protocols that indicate specific maintenance tasks that will be performed on a regular basis; they should also implement mechanisms that allow early identification of moisture problems and have written policies that outline the steps that will be taken for prompt correction of any problems identified. Building maintenance and repairs should never be neglected.

Ensure proper operation and maintenance of the HVAC system

A properly operated and maintained HVAC system should provide for the thermal and ventilation needs of building occupants and should dehumidify air as needed to keep indoor humidity low. As noted above, ASHRAE recommends monitoring and keeping the indoor air dew point below 55°F. The HVAC system should be capable of sufficiently lowering indoor humidity when outdoor ventilation air is humid. This is especially important when the building is unoccupied and thermostats are reset to save energy. During unoccupied periods, closing off the outdoor ventilation air or decreasing it to a code-required minimum and dehumidifying it will minimize increased indoor humidity [ASHRAE 2009b].

It is important to minimize the amount of dust and dirt that gets into the HVAC system. This can be accomplished by using filters that are efficient at capturing fine airborne particles. Manufacturer's recommendations or the ANSI/ASHRAE Standard: 62.1-2010 *Ventilation for Acceptable Indoor Air Quality* should be consulted to determine appropriate filtration [ANSI/ASHRAE 2010]. The filters should be sized properly and should fit in the system's filter racks to prevent unfiltered air from bypassing the filters and entering the occupied space. It is also important to regularly replace air filters on a schedule recommended by the system manufacturer or HVAC consultants.

During regularly scheduled preventive maintenance checks, maintenance personnel should:

- Verify that systems are operated to meet all appropriate system settings, and seek guidance from a qualified ventilation engineer on design and sizing as needed. Information on how to determine how much outdoor air should be brought into the building is provided in the ANSI/ASHRAE Standard 62.1-2010.
- Make sure the system is still balanced and ventilating all areas of the building according to the design specifications. Using areas of the building for purposes other than the original intent may necessitate rebalancing the system.
- Regularly replace air filters on a schedule recommended by the system manufacturer or HVAC consultants.
- Check all condensate drip pans and drain lines to assure that they are draining properly, and clean the lines according to manufacturers' recommendations or in accordance with ASHRAE recommendations.
- Monitor outdoor air intakes and inlet airways for intrusion of snow and rain, dirt, and leaves.
- Ensure adequate function of damper controls; control settings should be checked to ensure that the volume of outdoor air brought in by the HVAC system is sufficient for the expected number of building occupants.
- Monitor for wet or moldy conditions in air ducts and make necessary changes to correct the problem. If ducts are lined with a fibrous material and wet or moldy conditions are found, the liner should be removed and replaced with non-fibrous, hard-surfaced materials.

Other components of the HVAC system should be evaluated as recommended by the system manufacturer or HVAC consultant, and any identified problems should be corrected. Management should ensure that building occupants know to report any ventilation problems or concerns (e.g., temperature, smells) to maintenance personnel and not to obstruct supply or return air ducts.

Ultraviolet germicidal irradiation (UVGI) devices installed inside HVAC equipment are being used to prevent microbial growth and maintain coil cleanliness. Little scientific research on in-duct UVGI devices for these applications has been conducted [Levitin et al. 2001]. Most UVGI research focuses on upper-air UVGI systems typically used in health care settings to prevent airborne disease transmission, and not on in-duct devices for indoor office environments or schools [NIOSH 2009]. Scientific evidence linking in-duct UVGI systems to improved indoor air quality or reductions in occupant symptoms is lacking [Menzies et al. 2003]. Similarly, research studies have not yet established clear economic benefits associated with in-duct UVGI systems over traditional coil cleaning and HVAC maintenance practices [Bahnfleth et al. 2009, Lee et al. 2009].

While further research needs to be conducted, facility managers and building maintenance staff should be aware of such systems and the safety precautions necessary when working with any UVGI devices. ASHRAE [2011, 2012] provides additional information on UVGI installation in HVAC systems and associated safety practices.

Remove settled dust

A large amount of settled dust in the occupied spaces is an indicator of potential IEQ problems. In contaminated buildings, dusts may contain mold and bacteria due to dampness. Be sure to remove settled dust, including dust present on above-floor surfaces, by using a high-efficiency particulate air (HEPA) vacuum in order not to re-suspend the dust.

Promptly identify and correct sources of excess building moisture

Most buildings will periodically experience events that occur from outside or inside the building that will contribute to excess moisture or water damage (e.g., improper drainage around building foundations, roof leaks, window leaks, and condensation and leaks from pipes). Building materials such as wall board and carpets that become wet during leaks or floods will eventually deteriorate and can allow bacteria and mold to grow unless they dry quickly. Although some materials will require replacement due to any water or moisture damage, complete drying in less than 48 hours will prevent moisture damage and microbial growth in many wet materials [EPA 2001]. For this reason, building management should have policies in place that specify steps that will be taken to address rapid drying or replacement of building materials within 48 hours of becoming wet. Management should also identify and correct all sources of excess building moisture (e.g., roof and window leaks; inadequate drainage around the foundation), as not doing so will increase the likelihood that building occupants will develop respiratory symptoms or disease and costly repairs and remediation will be necessary in the future. Regularly scheduled inspections of the building by maintenance personnel (e.g., focusing on ceilings, dry wall and carpets adjacent to exterior walls, and basement areas) may help to identify evidence of leaks or dampness that can be addressed before extensive damage to building materials occurs (see Appendix A, Building Inspection Checklist). Management should encourage employees and/or occupants to report evidence of leaks or excessive building moisture (e.g., stained ceiling tiles; musty odors) to supervisors as soon as they become aware of the moisture

Renovation and Remediation

Renovation projects can create the release of airborne dusts, microbiological contaminants, gasses, and odors from both inside and outside of a building. Therefore, careful planning is essential to prevent exposures to building occupants. Key factors to consider include scheduling projects during times of low or non-occupancy, isolating work areas from occupied areas using temporary barriers, negative pressurization to prevent migration of air contaminants into occupied areas, and HEPA filtration. It is also important to modify HVAC operations to ensure renovation activity is isolated, to generate temporary containment barriers to separate renovation areas from occupied areas, and to increase housekeeping activities to keep construction debris and dust at a minimum. Once renovation has been completed, necessary modifications should be implemented to affected HVAC systems and other mechanical systems to ensure proper operation.

Building materials that show evidence of mold growth or moisture damage should be cleaned and repaired or replaced to minimize the risk of health effects in building occupants. Remediation activities should correct the underlying causes of the moisture problem; then clean and dry or remove and replace the damaged building materials, including cleaning of dust from indoor surfaces that may contain mold spores and other dampness-related contaminants. In addition to building materials and furnishings, it may also be necessary to clean or replace books and other paper documents that have sustained moisture damage or mold growth, especially if occupants have reported respiratory symptoms in relation to handling them. A detailed remediation plan should be developed after careful assessment and investigation of the moisture problem and affected area. It should be possible for the employer to undertake small remediation projects using in-house personnel. Larger projects may require a qualified outside contractor. Inappropriate remediation (e.g., painting over water-damaged materials, adding air-fresheners in areas to mask musty odors, and applying disinfectants or biocides to damp or moldy surfaces) can cause further problems with building degradation and symptoms in occupants. The AIHA Recognition, Evaluation, and Control of Indoor Mold [2008] contains a review of remediation guidelines that have been developed by organizations such as the New York City Department of Health, Health Canada, the EPA, the American Conference of Governmental Industrial Hygienists, the AIHA, and others; it also discusses many other important considerations for remediation work (e.g., use of biocides; management of hidden mold, and mold in the HVAC system).

Mold growth on wall board.

Precautions are necessary to prevent exposure of remediation workers and building occupants to dampness-related contaminants during remediation work. Guidance on precautions can be found in the EPA publication Mold Remediation in Schools and Commercial Buildings [2008] and the New York City Department of Health and Mental Hygiene document New York City Guidelines on Assessment and Remediation of Fungi in Indoor Environments [2008]. Even with containment, building occupants may be exposed to dampness-related contaminants during remediation work. Therefore, prior to the start of any remediation work, management should strongly consider relocating occupants who might be exposed during the remediation. This is especially true if several building occupants have developed building-related respiratory symptoms or disease that suggests high health risk from dampness-related exposures [AIHA 2008].

Is Air Sampling for Mold Necessary?

NIOSH does not recommend routine air sampling for mold in damp building evaluations because air concentrations of molds or spores cannot be interpreted with regard to health risk and they are highly variable over time. Instead, NIOSH encourages detection by thorough visual inspections and detection via musty or moldy odors. Building consultants can sometimes identify sources of dampness with moisture meters and infrared cameras. In cases where there is no visible sign of dampness, but musty or moldy odors are still present, strategies for detection of hidden mold (e.g., the use of a boroscope) should be considered. Inspections for hidden mold are discussed further in Chapter 6 and Chapter 10 of the AIHA publication Recognition, Evaluation, and Control of Indoor Mold [AIHA 2008]. 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, NIOSH does not recommend this practice, as there is no scientific basis for the use of air sampling for this purpose. No consistent exposure-response relationships have been demonstrated for specific bioaerosol measurements that allow reassurance of building occupants that an indoor environment is safe or that a health hazard continues after remediation. Once remediation is completed (e.g., moldy and damaged materials removed, surfaces have been cleaned, and musty odors no longer evident), the best evidence that the building is safe may be that occupants no longer experience building-related symptoms. Unfortunately, even if most occupants experience improvement in their symptoms and new occupants remain free of building-related symptoms, some with allergic conditions may not notice an improvement. Such individuals may have to avoid the building even after an otherwise successful remediation because their immune systems may continue to react to very small amounts of substances.

Identification and Management of Affected Occupants

As discussed previously, some building occupants may develop respiratory symptoms and disease in response to dampness-related exposures. Individuals who develop asthma or HP may be at risk for progression to more severe disease if the relationship to building-related exposures is not recognized and they continue to be exposed. Employers and building owners should ensure that all occupants are aware of the potential for building dampness to cause respiratory problems and should provide a mechanism by which occupants can notify management of any suspected building dampness, ventilation problems, or respiratory illness concerns. Management can instruct occupants to report such issues to designated health and safety personnel who can work with maintenance staff to investigate and identify any necessary corrective measures. Occupants who have developed persistent or worsening respiratory symptoms while in the building should be instructed to see a physician for evaluation and treatment recommendations; occupants can see their own physicians or management can arrange for an evaluation by a physician.

A health and safety committee should be established and should develop a mechanism to accept reports of building-related symptoms or illness with protection of privacy. Collected information should be maintained and analyzed to assess patterns from reports of building-related health concerns, building dampness, and ventilation problems. Evaluating such information over time may help to determine the exact nature of a particular building problem that may not be readily apparent in information from individual incident reports. For example, the occurrence of several reports from areas of a building that are served by one particular HVAC unit would indicate that the unit and associated ventilation ducts should undergo a detailed inspection; the inspection may reveal that these components are a source of exposure to dampness-related or other contaminants that may be responsible for respiratory symptoms or illness.

ACKNOWLEDGMENTS

The principal contributors to this Alert were Michelle Martin, MS; Jean Cox-Ganser, Ph.D.; Kathleen Kreiss, MD; Richard Kanwal, MD; and Nancy Sahakian, MD.

Please direct comments, questions, or requests for additional information to the following:

Director
Division of Respiratory Disease Studies
National Institute for Occupational Safety and Health
1095 Willowdale Road, Suite 2900
Morgantown, WV 26505

Telephone: (304) 285–5734; or call 1–800–232–2114

We greatly appreciate your assistance in protecting the health of U.S. workers.

John Howard, M.D.
Director
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

REFERENCES

AIHA [2008]. Recognition, evaluation, and control of indoor mold. By Prezant B, Weekes DM, Miller JD, eds. Fairfax, VA: American Industrial Hygiene Association.

ANSI / ASHRAE [2010]. Ventilation for acceptable indoor air quality. Standard 62.1-2010. Washington, DC: American National Standards Institute. Atlanta, GA: American National Standards Institute American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Apostolakos MJ, Rossmoore H, Beckett WS [2001]. Hypersensitivity pneumonitis from ordinary residential exposures. Environ Health Perspect *109*:979–981.

ASHRAE [2012]. Limiting indoor mold and dampness in buildings position document. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE [2011]. Ultraviolet air and surface treatment. In: ASHRAE handbook—HVAC applications. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

ASHRAE [2009a]. The ASHRAE guide for buildings in hot and humid climates, 2nd ed. By Harriman LG, Lstiburek JW. Atlanta, GA: The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE [2009b]. Indoor air quality guide: best practices for design, construction, and commissioning. Atlanta, GA: The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Bahnfleth W, Lee L, Lau J, Freihaut J [2009]. Annual simulation of in-duct ultraviolet germicidal irradiation system performance. In: Proceedings of Building Simulation 2009. The 11th International Building Performance Simulation Association Conference and Exhibition, Glasgow, Scotland.

Cox-Ganser JM, Rao CY, Park J-H, Schumpert JC, Kreiss K [2009]. Asthma and respiratory symptoms in hospital workers related to dampness and biological contaminants. Indoor Air *19*(4):280–290.

EPA [2001]. Mold remediation in schools and commercial buildings. Washington, DC: Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Document Number EPA 402-K-01-001. http://www.epa.gov/mold/mold_remediation.html.

Fisk WJ, Lei-Gomez Q, Mendell MJ [2007]. Meta-analyses of the associations of respiratory health effects with dampness and mold in homes. Indoor Air *17*(4):284–296.

Henneberger PK, Derk SJ, Sama SR, Boylstein RJ, Hoffman CD, Preusse PA, Rosiello RA, Milton DK [2005]. The frequency of workplace exacerbation among health maintenance organization members with asthma. J Occup Environ Med *63*:551–557.

Hodgson MJ, Morey P, Leung WY, Morrow L, Miller D, Jarvis BB, Robbins H, Halsey JF, Storey E [1998]. Building-associated pulmonary disease from exposure to stachybotrys chartarum and aspergillus versicolor. J Occup Environ Med *40*:241–249.

Hoffman RE, Wood RC, Kreiss K [1993]. Building-related asthma in Denver office workers. Am J Public Health *83*:89–93.

International Union of Operating Engineers (IUOE) [2009]. Indoor air quality solutions for stationary engineers. Orland Park, IL: American Technical Publishers, Inc.

IOM [2004]. Damp indoor spaces and health. Washington, DC: National Academy of Sciences, Institute of Medicine. http://www.nap.edu/books/0309091934/html

Krieger J, Jacobs DE, Ashley PJ, Baeder A, Chew GL, Dearborn D, Hynes HP, Miller JD, Morley R, Rabito F, Zeldin DC [2010]. Housing interventions and control of asthma-related indoor biologic agents: a review of the evidence. J Public Health Man & Practice *16*:s11–s20.

LBNL [1998]. A scoping study on the costs of indoor air quality illnesses: an insurance loss reduction perspective. By: Chen A, Vine EL. Berkeley, CA: Lawrence Berkeley National Laboratory.

Lee B, Bahnfleth W, Auer K. [2009]. Life-cycle cost simulation of in-duct ultraviolet germicidal irradiation systems. In: Proceedings of Building Simulation 2009, The 11th International Building Performance Simulation Association Conference and Exhibition, Glasgow, Scotland.

Levetin E, Shaughnessy R, Rogers CA, Scheir R [2001]. Effectiveness of germicidal UV radiation for reducing fungal contamination within air-handling units. Appl Environ Microbiol 67(8): 3712–3715.

Mendell MJ, Mirer AG, Cheung K, Tong M, Douwes J [2011]. Respiratory and allergic health effects of dampness, mold and dampness-related agents: a review of the epidemiologic evidence. Environ Health Perspect *119*:748–756.

Menzies D, Popa J, Hanley JA , Rand T, Milton DK [2003]. Effect of ultraviolet germicidal lights installed in office ventilation systems on workers' health and wellbeing: double-blind multiple crossover trial. Lancet *362*:1785–1791.

NCHS [2008]. Asthma—summary health statistics for U.S. adults: National Health Interview Survey, 2008. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Health Statistics.

Newman KL, Newman LS [2012]. Occupational causes of sarcoidosis. Curr Opin Allergy Clin Immunol *12*:145–150.

NIOSH [2009]. Environmental control for tuberculosis: Basic upper-room ultraviolet germicidal irradiation guidelines for healthcare settings. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Publication No. 2009–105.

NIOSH [1996]. Hazard evaluation and technical assistance report: Martin County Courthouse and Constitutional Office Building, Stuart, Florida. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HHE Report No. 93-1110-2575.

Patel AM, Ryu JH, Reed CE [2001]. Hypersensitivity pneumonitis: current concepts and future questions. J Allergy Clin Immunol *108*(5): 661–670.

Sama SR, Milton DK, Hunt PR, Houseman EA, Henneberger PK, Rosiello RA [2006].Case-by-case assessment of adult-onset asthma attributable to occupational exposures among members of a health maintenance organization. J Occup Environ Med *48*:400–407.

Thorn A, Lewne M, Belin L [1996]. Allergic alveolitis in a school environment. Scan J Work Environ Health *22*:311–314.

Vollmer WM, Heumann MA, Breen VR, Henneberger PK, O'Conner EA, Villnave JM, Frazier EA, Buist AS [2005]. Incidence of work-related asthma in members of a health maintenance organization. J Occup Environ Med *47*:1292–1297.

Weltermann BM, Hodgson M, Storey E, DeGraff AC, Bracker A, Groseclose S, Cole SR, Cartter M, Phillips D [1998]. Hypersensitivity pneumonitis: a sentinel event investigation in a wet building. Am J Ind Med *34*:499–505.

WHO [2009]. WHO guidelines for indoor air quality: dampness and mould. Copenhagen, Denmark: World Health Organization Regional Office for Europe.

GUIDANCE DOCUMENTS*

ACGIH [1999]. Bioaerosols—assessment and control. By Macher J, Ammann HA, Burge HA, Milton DK, Morey PR. Cincinnati, OH: American Conference of Governmental Industrial Hygienists. http://www.acgih.org].

AIHA [2008]. Recognition, evaluation, and control of indoor mold. By Prezant B, Weekes DM, Miller JD, eds. Fairfax, VA: American Industrial Hygiene Association.

ANSI/ASHRAE [2010]. Ventilation for acceptable indoor air quality. Standard 62.1-2010. Washington, DC: American National Standards Institute. Atlanta, GA: American National Standards Institute American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE [2009a]. The ASHRAE guide for buildings in hot and humid climates, 2nd ed. By Harriman LG, Lstiburek JW. Atlanta, GA: The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE [2009b]. Indoor air quality guide: best practices for design, construction, and commissioning. Atlanta, GA: The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Centers for Disease Control and Prevention (CDC) [2006]. Mold prevention strategies and possible health effects in the aftermath of hurricanes and major floods. MMWR Morb Mortal Wkly Rep *55* (RR08):1–27. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5508a1.htm

EPA [2008]. Mold remediation in schools and commercial buildings. Washington, DC: Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Document Number EPA 402-K-01-001. http://www.epa.gov/mold/mold_remediation.html

EPA, NIOSH [1991]. Building air quality: a guide for building owners and facility managers. Washington, DC: Environmental Protection Agency, Office of Air and Radiation, Indoor Air Division. Cincinnati, OH: U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health. http://www.epa.gov/iaq/largebldgs/baqtoc.html

International Union of Operating Engineers (IUOE) [2009]. Indoor air quality solutions for stationary engineers. Orland Park, IL: American Technical Publishers, Inc.

NJ DOH [no date]. New Jersey indoor air quality standard, NJAC *12*:100-13.4 Trenton, NJ: New Jersey Department of Health, New Jersey Department of Health and Senior Services, Public Employees Occupational Safety and Health Program. http://www.state.nj.us/health/peosh/iaq.shtml

NYC DOHMH [2008]. New York City guidelines on assessment and remediation of fungi in indoor environments. New York: New York City Department of Health and Mental Hygiene, Bureau of Environmental and Occupational Disease Epidemiology. http://www.nyc.gov/html/doh/html/epi/moldrpt1.shtml

OSHA [2006]. Preventing mold-related problems in the indoor workplace. Washington, DC: Occupational Safety and Health Administration. http://www.osha.gov/Publications/preventing_mold.pdf

SMACNA [2007]. IAQ guidelines for occupied buildings under construction. 2nd ed. Chantilly, VA: Sheet Metal and Air-Conditioning Contractors' National Association. http://www.smacna.org/pdf/06dec_smacnews(c).pdf

UCHC [2004]. Guidance for clinicians on the recognition and management of health effects related to mold exposure and moisture indoors. By Storey E, Dangman K, Schenck P, DeBernardo RL, Yang CS, Bracker A, Hodgson MJ. Farmington, CT: University of Connecticut Health Center, Division of Occupational and Environmental Medicine, Center for Indoor Environments and Health. http://oehc.uchc.edu/images/PDFs/MOLD%20GUIDE.pdf

Note: Some guidance documents and references have recommendations that differ with those provided in this NIOSH Alert.

Appendix A
Building Inspection Checklist

(Modified from U.S. Environmental Protection Agency's Indoor Air Quality Tools for Schools Action Kit)

Building Inspection Checklist	Yes	No	N/A
Ground Level			
Proper drainage is away from the building (including roof downspouts)	☐	☐	☐
Sprinklers spray away from the building and outdoor air intakes	☐	☐	☐
Walk-off mats are used at exterior entrances and are regularly cleaned	☐	☐	☐
Roof			
Roof is in good condition	☐	☐	☐
The roof is free of pooling water	☐	☐	☐
HVAC units operate properly (air flows in)	☐	☐	☐
Exhaust fans operate properly (air flows out)	☐	☐	☐
HVAC outdoor air intakes (dampers) are clear of obstruction and remain open, even at minimum setting	☐	☐	☐
Outdoor air intakes are clear of nests, droppings, or collected leaves or debris	☐	☐	☐
HVAC outdoor air intakes are free from entrainment of air from plumbing stacks and exhaust outlets	☐	☐	☐

Building Inspection Checklist (Continued)	Yes	No	N/A
All Rooms, Attic, and Plenums			
Rooms are dusted and vacuumed regularly	☐	☐	☐
Rooms, attics, or plenums are free from odors (especially moldy or musty)	☐	☐	☐
Attic, plenums; walls, ceilings, floors, air supply and return vents; and areas under plumbing are free from visible mold and mildew growth	☐	☐	☐
Attic, plenums, walls, ceilings, and floors are free from visible signs of water damage	☐	☐	☐
Inside exterior walls, windows, windowsills, and window frames are free from signs of condensation	☐	☐	☐
Cold water pipes are free from condensation	☐	☐	☐
Attic and rooms are free from evidence of plumbing leaks	☐	☐	☐
Ventilation			
Air Supply and Air Exhaust	☐	☐	☐
Air flows from supply vents	☐	☐	☐
Air supply pathway is free from obstructions	☐	☐	☐
Supply and exhaust vents are free from obstructions	☐	☐	☐
Bathrooms, restrooms, and kitchens have operating exhaust fans	☐	☐	☐
Filters	☐	☐	☐
Filters are clean	☐	☐	☐

Building Inspection Checklist (Continued)	Yes	No	N/A
Filters fit properly	☐	☐	☐
Filters are properly installed (correctly for direction of airflow)	☐	☐	☐
Filters have been changed according to the change-out schedule	☐	☐	☐
Drain Pans and Coils	☐	☐	☐
Drain pans slant toward the drain (to prevent water from accumulating)	☐	☐	☐
Drain pans are free from accumulated water and/or are not clogged	☐	☐	☐
Drain pans are clean and free of mold and mildew	☐	☐	☐
Heating and cooling coils are clean	☐	☐	☐
General	☐	☐	☐
Temperature and humidity are maintained within acceptable ranges	☐	☐	☐

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226–1998

NIOSH

Delivering on the Nation's promise:
Safety and health at work for all people
through research and prevention.

To receive NIOSH documents or more information about occupational safety and health topics, contact NIOSH:

1–800–CDC–INFO (1–800–232–4636)
TTY: 1–888–232–6348
E-mail: cdcinfo@cdc.gov

or visit the NIOSH Web site at www.cdc.gov/niosh

For a monthly update on news at NIOSH, subscribe to *NIOSH eNews* by visiting www.cdc.gov/niosh/eNews.

DHHS (NIOSH) Publication No. 2013–102

SAFER • HEALTHIER • PEOPLE™