USDA

United States
Department of
Agriculture

Forest Service

Technology &
Development
Program

7300–Facilities
August 2008
0873–2841–MTDC

Is My Building Sick?

A Manager's Guide to Identifying and Solving Indoor Air Quality Problems

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6E62F37 Air Quality Evaluation Guide for Managers

August 2008

Cover photo—A view of the reception desk in the interpretive and reception area that was added in 2004 to the 1950s-vintage McKenzie River Ranger Station, Willamette National Forest, Pacific Northwest Region. Both new and old buildings can experience poor indoor air quality.

Table of Contents

Acknowledgments

The authors would like to thank Art Johnston, Mark McDonough, and Beverly Young for reviewing this report and providing helpful suggestions. Thanks also to Tom Cassell, Kate Endersbe, Mike Godfrey, Steve Oravetz, and Thad Schroeder for providing photos.

Introduction

Indoor air quality has become a concern in the workplace because poor air quality can harm the health, comfort, well-being, and productivity of building occupants.

While most buildings don't have severe indoor air quality issues, even well-run buildings sometimes experience episodes of poor air quality. The Occupational Safety and Health Administration estimates that as many as a third of American employees work in a building that has indoor air quality issues.

Poor indoor air quality is usually not as easy to identify or correct as a wobbly desk or a leaky faucet. Indoor air quality is influenced by many factors inside and outside a building that may change over time. Sometimes employees think other factors that affect their health or comfort are indoor air quality problems.

Although it may seem counterintuitive, the first step to solving indoor air quality problems is not an air quality test. This report will help building managers understand the actions they can take to identify and correct the most common sources of indoor air quality issues. Funds can be used to fix problems rather than pay for expensive tests. This report also explains when to get assistance from a specialist, such as a facilities engineer or industrial hygienist.

Highlights...

- Even well-run buildings can sometimes have poor indoor air quality.
- Poor indoor air quality can harm the health, comfort, well-being, and productivity of a building's occupants.
- This report helps building managers locate and correct common sources of indoor air quality problems.

Responsibilities

All employees have a responsibility to inform their supervisor of any personal, physical, or mental condition that could compromise the safety or health of themselves or coworkers (Health and Safety Code Handbook, FSH 6709-11, section 04.4). Employees need to let their supervisor know if they experience symptoms as a result of indoor air quality issues. Issues can't be addressed if they are not identified.

First-line supervisors are responsible for identifying job-related hazards and eliminating potential causes of accidents and injuries to the best of their ability. Most supervisors can best protect their employees by reporting air quality problems that don't have obvious and immediate solutions to their line officer rather than trying to solve the problem. Line officers are responsible for the health, safety, and training of employees. Line officers usually direct the facilities manager to investigate and solve indoor air quality problems.

Be sure to let all of the building's occupants know when an indoor air quality issue or complaint is being investigated. When you locate the source of a problem, let occupants know what was found, and how and when it will be fixed. Occupants who are well informed are more likely to cooperate with an investigation and participate in a solution, and they are less likely to file a grievance or complain to a regulatory agency about the problem.

Symptoms

Often the first signs of an air quality problem are employee complaints of symptoms such as:

- Eye, nose, and throat irritation
- Coughing and sneezing
- Headaches
- Fatigue
- Irritability
- Allergies and sinus congestion
- Dizziness
- Difficulty concentrating
- Shortness of breath
- Skin irritation
- Nausea

Figure 1—One of these Forest Service employees could experience symptoms related to poor indoor air quality while the other could be unaffected. Natural sensitivities and stress can make people more likely to experience symptoms related to poor indoor air quality.

Of course, these symptoms are not always caused by air quality problems; they can have other causes, including minor illnesses such as the common cold, lack of sleep, smoking, medications, or serious illnesses. Still, if building occupants report these symptoms—especially if the symptoms occur mainly when employees are in the building or when several individuals are affected—their concerns must be taken seriously.

Some individuals are more sensitive to air contaminants than others. Sometimes only one or a few individuals in a building suffer from symptoms, while other employees don't even notice a problem (figure 1). That doesn't mean that problems experienced by a few employees are "all in their head" and can be ignored. A sensitive individual can be the "canary in the coal mine," exhibiting symptoms of a problem that may subtly affect the productivity of most of the workforce. On the other hand, sometimes nobody other than the sensitive individuals will ever be affected. In either case, it's in everybody's best interest to make sure indoor air quality problems don't harm employees.

You will often hear the terms "sick building syndrome" and "building-related illness" when poor indoor air quality is discussed. If 20 percent of the building's regular inhabitants experience related symptoms for more than 2 weeks, the problem is classified as sick building syndrome. If the symptoms of the employees are long lasting and can be clinically diagnosed, it is a building-related illness. If you want to know more about sick building syndrome or building-related illness, see the "More Information About Indoor Air Quality" section at the end of this report.

Sometimes working conditions can cause symptoms that employees blame on poor indoor air quality. Noise, too little light, glare, too much or too little heat or humidity, vibration, overcrowding, poor ergonomics, and job-related psychosocial issues can produce symptoms similar to those associated with poor indoor air quality. Those conditions can add stress that may make people more likely to be affected by indoor air quality issues. Problems related to working conditions should be corrected, but are not addressed in this report.

Asbestos and radon are sometimes considered indoor air quality issues. However, symptoms from asbestos and radon usually don't appear for many years after exposure, so these contaminants usually will not produce symptoms that lead to employee complaints about poor air quality. For more information about asbestos in Forest Service buildings, see the "Asbestos" section of the Facilities Toolbox (*http://www.fs.fed.us/eng/toolbox/haz/haz02.htm*). For more information about radon in Forest Service buildings, see the "Radon" section of the Facilities Toolbox (*http://www.fs.fed.us/eng/toolbox/haz/haz05.htm*).

Identifying the Causes

To cure indoor air quality problems, you need to know what's causing them. The causes of most air quality problems can be identified by interviewing employees and conducting a thorough inspection of the building.

Occupants' symptoms can help you focus the search for the cause of indoor air quality problems. For example, if employees are complaining about a solvent smell, throat and eye irritation, and headaches, you are probably looking for a chemical being used nearby, a solvent spill, or something that is offgassing chemicals (figure 2). Knowing where and when the symptoms are experienced can provide clues to the source of the problem. For example, the chemical use, spill, or offgassing is probably occurring near the area where employees experience the symptoms or somewhere connected by air distribution. Inspecting those areas will probably reveal the cause of the problem.

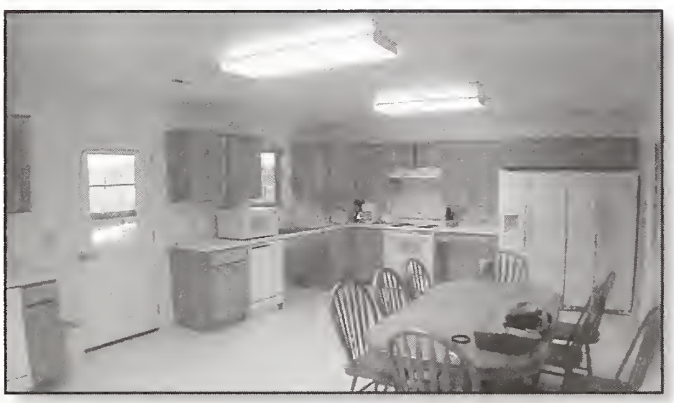

Figure 2—New cabinets, such as those in this bunkhouse, are sometimes the source of chemicals that offgas, contributing to poor indoor air quality and possibly causing headaches or throat and eye irritation.

For smaller buildings, you often can pinpoint affected areas and identify symptoms simply by walking through the building and talking to occupants. In larger buildings, relevant information can be difficult to collect and track. A feedback form completed by building occupants can help an investigator obtain information. The "Indoor Air Quality Problem Fact Sheet" at the end of this report or another form can be used to gather information. Feedback forms should be completed by all building occupants, not just those who have complained of air quality problems, to obtain a complete picture of the problem.

Once you have learned the locations that appear to be affected and have an idea of the occupants' symptoms, you need to investigate the affected area. A small-scale drawing of the building's floor plan, such as a building evacuation map, can be used to record your findings. The table of "Common Symptoms, Causes, and Solutions to Indoor Air Quality Problems" at the end of this report contains information that can help you find the source of indoor air quality problems. More comprehensive information and tables are available in the "Diagnosing and Solving Problems" section of the U.S. Environmental Protection Agency's "Indoor Air Quality Building Education and Assessment Model (I-BEAM)" Web site at *http://www.epa.gov/iaq/largebldgs/i-beam/text/diagnosing.html.*

Use common sense and investigate thoroughly. For example, if occupants complain of a musty smell or have symptoms consistent with mold, look for places where mold might be growing. If the basement floor is wet and mold has begun to grow on the floor joists (figure 3), look for plumbing leaks. If you don't find plumbing leaks, look for ways that water could have entered the crawl space from outside the building, such as improperly adjusted irrigation sprinklers, slopes that funnel runoff to window wells, downspout discharges against a foundation wall, blocked foundation drains, and so forth.

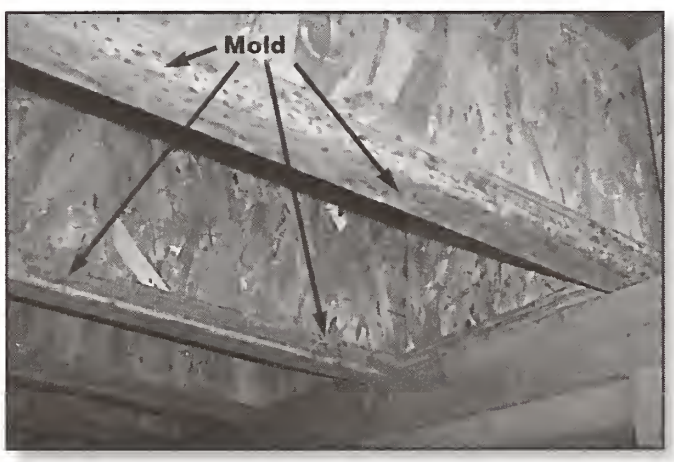

Figure 3—The light and dark gray spots on these floor joists are mold that could cause wheezing, skin rashes, eye irritation, or other symptoms.

Over half of all indoor air quality problems are due to inadequate ventilation. When buildings are properly ventilated, contaminants are less likely to become concentrated enough to affect people's well-being. "Dilution is the solution to pollution" is an old saying with a lot of truth to it.

If the source of an indoor air quality problem is not evident, check the heating, ventilation, and air conditioning (HVAC) system for any of the following problems:

- Air intakes are blocked.
  - » Air return grills are covered inside the building.
  - » Air intake vents outside the building are covered or misadjusted.
  - » Automatic dampers for air intake vents are not functioning properly.
- The ventilation rate is inadequate for the number of people in the space.
  - » Appropriate ventilation rates are explained in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards 62.1 and 62.2.
  - » The recommended ventilation rate is 20 cubic feet per minute per person in most office areas.
  - » You can learn more about ventilation standards from the "More Information About Indoor Air Quality" section at the end of this report.
  - » Your facilities engineer can help you determine whether the ventilation rate is adequate.
- Air filters have not been changed or cleaned recently or are not the correct type.
- Air handlers and ducts are not clean.
- Fumes such as those from shop work, office equipment, restrooms, or janitor's supply rooms are being pulled into the HVAC system through return air ducts rather than being exhausted directly outdoors.
- Pollutants or irritants such as vehicle exhaust, pollen, mold, or welding fumes are being sucked into the building through the outside air intake or return air grills for the HVAC system.
- Air pressure differences cause exhaust air or flue gasses to be drawn back into the building.
- Slime or mold is growing inside a cooling tower, drip pan trays, or ductwork.
- Accumulated deposits in boiler tubes, furnace flues, or piping prevent the efficient flow of combustion air, exhaust, or fuel.

Water is a common cause of air quality problems because mold will grow anywhere there is moisture and food (dead organic material such as fabric, dirt, particleboard, or lumber). If there has been recent flooding (especially in crawl spaces or other hidden areas), a leaky roof, or any other accumulation of moisture inside the building for a week or more, mold could be growing.

Objects inside your building could be offgassing chemicals. Formaldehyde and other gasses are often given off by new building materials, especially paint, glue, carpeting, and furnishings. Areas where solvents, glues, chemicals, or other hazardous materials are stored or used may not be properly vented. A can of solvent or other volatile material may have spilled.

If you can't find the source of the problem, contact your facilities engineer for assistance. Be sure to tell the facilities engineer what you've already done and the possibilities you have investigated. Your facilities engineer can conduct a more thorough investigation of the building's systems or conduct simple air tests. Chemical smoke tests can detect air movement that might indicate entry points of pollutants. Carbon dioxide and relative humidity test results can indicate potential problems. Your facilities engineer can also help you find a good industrial hygienist, if you need one.

An industrial hygienist can test the air in your building for hazardous substances. An experienced industrial hygienist also should be able to offer suggestions about where the pollutants may be originating and how they may be getting to the affected areas. An industrial hygienist's services are expensive, so hire one only when the hygienist's expertise is likely to help solve your problem.

No affordable test can analyze all the substances in the air. Even tests for individual substances or classes of substances can be expensive. One national forest spent $25,000 trying to determine the cause of symptoms affecting two employees. The tests provided no insights into the problem.

That's why it's important to do an investigation first—you need to have a reasonably good idea of what you're looking for before spending money on testing. Also, since most problems can be identified during an investigation, air tests are usually unnecessary. If you do a thorough investigation, you can usually spend your money solving problems rather than testing air.

It doesn't help just to know which pollutants are in the air. Even knowing the concentrations of pollutants may not help. Tests that can help solve problems include those that:

- Compare concentrations of pollutants in different parts of the building and possibly the outdoors to help pinpoint sources of pollutants.
- Check emissions from a particular piece of equipment to determine whether the equipment is the source of the problem.
- Determine the concentration of compounds or conditions that identify a particular type of air quality problem.
  - Carbon dioxide concentrations higher than 1,000 parts per million indicate inadequate ventilation of occupied areas.
  - Carbon monoxide averages higher than 9 parts per million for 8 hours, or a 1-hour average higher than 35 parts per million indicate the presence of combustion gasses.
  - Relative humidity higher than 50 percent may indicate inadequate ventilation, depending on outdoor conditions and whether the building has an air conditioning or dehumidification system. Mold is more active when humidity and temperatures are high.

Testing also can compare measured concentrations to exposure standards or public health guidelines for some specific pollutants. When deciding whether tests and comparisons will help you solve an indoor air quality problem, keep in mind that it is rare for these standards and guidelines to be exceeded in a Forest Service building. The exposure limits are established to avoid acute medical problems in industrial settings. Much lower exposure levels and milder symptoms are typical in office buildings with poor indoor air quality. You can learn more about pollutant guidelines and standards in the "More Information About Indoor Air Quality" section at the end of this report.

Fixing the Problems

Once you know what's causing an indoor air quality problem, you can fix it. Most fixes are pretty obvious—clean, repair, unblock, replace, switch to a different product, and so forth. If you're not sure what to do, check the table of "Common Symptoms, Causes, and Solutions to Indoor Air Quality Problems" at the end of this report. The cure may be one or several of the suggested solutions. More comprehensive information and tables are available in the "Diagnosing and Solving Problems" section of the U.S. Environmental Protection Agency's "Indoor Air Quality Building Education and Assessment Model (I-BEAM)" Web site at *http://www.epa.gov/iaq/largebldgs/i-beam/text/diagnosing.html*.

Your facilities engineer can help you identify an effective solution if one isn't obvious. The facilities engineer will probably begin by comparing the design or original performance characteristics of the building and its components to the current design and performance characteristics.

Often, something has changed since the building was constructed and building systems must be modified to accommodate the change. For instance, a new carport may have been constructed near the outside air supply for an office's HVAC system (figure 4). Fumes from vehicles warming up under the carport canopy on frigid mornings could be drawn into the building's air distribution system. The solution, which would depend on many variables, could be as expensive as relocating the air intake or carport, or as inexpensive (but inconvenient) as instituting a policy that vehicles must be moved away from the carport while idling.

One of the most common changes that can cause poor indoor air quality is the addition of partitions, such as walls or cubicles within a building. Added partitions often hinder air circulation because they divide the space into small areas that don't have HVAC supply or return grills. The result can be areas or rooms with stagnant air where pollutants can concentrate. Occupants also may notice inadequate heating or cooling. Correcting these problems may require elevating cubicle dividers above the floor, cutting holes in doors or walls to install louvered vents, adjusting ductwork, adding fans or exhaust vents, or even replacing the whole HVAC system.

Figure 4—Vehicle exhaust could be drawn into a building's HVAC system if a carport is near the air intake. The air intake for this building is on the roof to prevent vehicle exhaust from being drawn into the Nogales Ranger Station of the Coronado National Forest in the Southwestern Region.

In some situations, the most effective solution may be to relocate affected individuals. For instance, if one or a few people are affected adversely by a material that is needed to protect other employees or to accomplish essential work, and no acceptable substitute material is available, it may be better to relocate persons who are being affected rather than to eliminate use of the material.

Final Thoughts

The best way to cure indoor air problems is to prevent them. It's not possible to prevent all indoor air quality problems. However, assuring that each building's HVAC system is working properly and that employees follow proper procedures when working with hazardous substances can go a long way toward minimizing indoor air quality problems.

Indoor Air Quality Problem Fact Sheet

To help identify and solve an indoor air quality problem, we need information from all building occupants. Please complete this fact sheet—it will help us improve your work environment.

Your name: _____ Date: _____

Your work location: _____ Phone: _____

If you have recently experienced symptoms or discomfort related to the quality of the air in this building, please describe them in this space:

Where are you when you experience the symptoms or discomfort? _____

Where do you spend most of your time in the building? _____

When did these symptoms or discomfort start? _____

When are they generally worst? _____

Do they go away? If so, when? _____

Who else has these symptoms? _____

What events (weather, activities inside or outside the building, etc.) or conditions (temperature, humidity, drafts, stagnant air, odors, etc.) tend to occur at about the same time as your symptoms? Please describe in this space:

Is there anything else we should know about this problem? Please describe in this space:

Thanks for your help!

Common Symptoms, Causes, and Solutions to Indoor Air Quality Problems

Short-Term Symptoms	Possible Causes	What To Do
Eye, nose, and throat irritation, headaches, pneumonia, fatigue, bronchitis, flu-like symptoms, dizziness, nausea, shortness of breath Impaired lung/respiratory function, lung/respiratory infections, ear infections in children	**Byproducts of combustion (such as CO, CO_2, NOx):** Unvented or poorly vented kerosene and gas heaters, gas appliances, wood- and gas-burning fireplaces and stoves, leaking chimneys and furnaces, vehicle exhaust	• Avoid use of unvented gas or kerosene space heaters. • Keep gas appliances and furnaces properly adjusted. • Install and use exhaust fans. • Change HVAC filters regularly. • Increase the supply of outside air. • Don't operate or idle vehicles near air intakes, doors, or windows. • Clean wood stoves and fireplace flues regularly; check for proper draft; assure adequate combustion air supply.
	Environmental tobacco smoke: Cigarettes, cigars, pipes	• Prohibit smoking indoors. • Offer smoking cessation classes. • Make sure that the smoking area is far away from doors, windows, or air intakes.
Eye, nose, and throat irritation, coughing, fatigue, rashes, and allergic reactions	**Formaldehyde:** Pressed wood products (hardwood, plywood, particleboard, fiberboard) used in buildings and furniture, urea-formaldehyde foam insulation, permanent press textiles, some glues, tobacco smoke, vehicle exhaust, stoves, fireplaces	• Use products with lower emission rates of formaldehyde. • Flush areas containing new materials with fresh air for 2 weeks before occupying. • Keep humidity low. • Increase ventilation. • Avoid premature aging or baking of products. • See recommendations for combustion byproducts and tobacco smoke above.
Eye, nose, and throat irritation	**Pesticides:** Garden and lawn chemicals, poisons for pest control	• Use alternate control methods when possible. • Do not store in occupied areas. • Follow manufacturer's instructions. • Increase ventilation.
Headaches, irritation in mouth, rash, excessive perspiration, kidney damage	**Heavy metals:** Paints, vehicle exhaust, tobacco smoke, soil, and dust	• Vacuum and clean surfaces regularly. • Remove deteriorated lead-based paint. • Prohibit smoking. • Eliminate entry paths for vehicle exhaust.

Short-Term Symptoms	Possible Causes	What To Do
Eye, nose, and throat irritation, headaches, loss of coordination, nausea	**Volatile organic compounds:** Paints, solvents, wood preservatives, glue, aerosol sprays, cleaners and disinfectants, moth repellants, air fresheners, hobby supplies, dry-cleaned clothes, some new furniture and carpets, large format printers, blueprint machines	• Read labels and MSDS, follow instructions and job hazard analyses. • Use in well-ventilated areas that exhaust air to the outside or use outdoors away from air intakes. • Air out drycleaned clothes for about 6 hours before bringing them into occupied areas. • Clean spills promptly. Flush the area with fresh air. • Air out new furniture, carpet, and new construction 2 weeks before occupying. • Purchase only low- or no-VOC (volatile organic compound) paints, adhesives, and building products for maintenance and repairs.
Legionnaires' disease, humidifier fever, influenza, and other airborne communicable diseases	**Bioaerosols:** Humans, pets, moist surfaces, humidifiers, ventilation systems, drip pans, cooling coils in air handling units, plants, outside air	• Remove the source. • Maintain cleanliness of HVAC and humidification equipment, including drip pans and cooling tower trays. • Use an air conditioner or dehumidifier to reduce humidity. • Change HVAC filters regularly. • Install more effective HVAC filters—check the HVAC manual.
Nasal/sinus irritation or congestion, dry hacking cough, eye irritation, wheezing, skin rashes or burning, shortness of breath, increased asthma symptoms, headaches (symptoms vary)	**Mold:** On building surfaces, inside walls, ceilings, or floors; potting soil or containers for indoor plants	• Remove the source of moisture (plumbing or structure leaks, condensation, trapped moisture). • Increase ventilation rate. • Clean impermeable surfaces. • Replace materials penetrated by mold. • Use an air conditioner or dehumidifier to reduce humidity.
Sneezing, increased asthma symptoms, nasal congestion, eye irritation	**Common allergens:** Dust, soot, pollen, etc.	• Change HVAC filters regularly. • Install more effective HVAC filters—check HVAC manual. • Keep indoor surfaces clean. • Keep windows and doors closed when allergens are present outdoors.

SOURCE: Adapted from U.S. Environmental Protection Agency and Consumer Product Safety Commission publications.

More Information About Indoor Air Quality

General Information

Aerias: Air Quality Sciences, Indoor Air Quality Resource Center

- "Building-related illnesses" at *http://www.aerias.org/DesktopModules/ArticleDetail.aspx?articleId=16*

U.S. Environmental Protection Agency (EPA)

- "Indoor Air Quality" Web page at *http://www.epa.gov/iaq/*
  - "Indoor Air Facts No. 4: Sick Building Syndrome" at *http://www.epa.gov/iaq/pubs/sbs.html*
- "Building Air Quality: A Guide for Building Owners and Facility Managers" at *http://www.epa.gov/iaq/largebldgs/baqtoc.html*
- "Indoor Air Quality Building Education and Assessment Model (I-BEAM)" at *http://www.epa.gov/iaq/largebldgs/i-beam/*
  - "Diagnosing and solving problems" I-BEAM text module at *http://www.epa.gov/iaq/largebldgs/i-beam/text/diagnosing.html*

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)

- "Indoor Air Quality Investigation," section III, chapter 2, in OSHA Technical Manual at *http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_2.html*

Mold

MTDC Facilities Toolbox

- "Hazardous Substances in Buildings: Mold" at *http://www.fs.fed.us/eng/toolbox/haz/haz04.htm*

New York City Department of Health and Mental Hygiene

- "Guidelines on Assessment and Remediation of Fungi in Indoor Environments" at *http://home2.nyc.gov/html/doh/html/epi/moldrpt1.shtml*

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)

- "A Brief Guide to Mold in the Workplace" at *http://www.osha.gov/dts/shib/shib101003.html*

Hazardous Materials in Buildings

MTDC Facilities Toolbox

- "Hazardous Substances in Buildings" at *http://www.fs.fed.us/eng/toolbox/haz/*

Exposure Limits

American Conference of Governmental Industrial Hygienists

- 2008 threshold limit values (TLVs) and biological exposure indices (BEIs) at *http://www.acgih.org/store/ProductDetail.cfm?id=1975*

U.S. Environmental Protection Agency (EPA)

- National ambient air quality standards at *http://www.epa.gov/air/criteria.html*

Health Canada

- Exposure guidelines for residential indoor air quality at *http://www.hc-sc.gc.ca/ewh-semt/pubs/air/exposure-exposition/index-eng.php*

National Institute for Occupational Safety and Health (NIOSH)

- "NIOSH Pocket Guide to Chemical Hazards" at *http://www.cdc.gov/niosh/npg/*

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)

- Table Z–1: Limits for Air Contaminants—1910.1000 at *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992*

World Health Organization

- Air quality guidelines: global update 2005 at *http://www.who.int/phe/health_topics/outdoorair_aqg/en/*

Ventilation Standards

American National Standards Institute (ANSI)

- Standard 62.1 "Ventilation for Acceptable Indoor Air Quality" at *http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2fASHRAE+62.1-2007*
- Standard 62.2 "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings" at *http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2fASHRAE+62.2-2007*

GPO U.S. GOVERNMENT PRINTING OFFICE: 2008—S76-262/10000

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Kristofer Kusano is a mechanical engineering student at Virginia Polytechnic Institute and State University (Virginia Tech) who worked at MTDC as a summer intern during 2007. Before working at MTDC, Kristofer worked for the Forest Service's Washington Office Engineering Staff as a student assistant.

Library Card

Snodgrass, Kathleen; Kusano, Kristofer. 2008. Is my building sick? A manager's guide to identifying and solving indoor air quality problems. Tech. Rep. 0873–2841–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 10 p.

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Keywords: facilities, heating, how to, HVAC, illnesses, industrial hygienists, inspections, molds, offgassing, offices, pollutants, productivity, safety at work, symptoms, syndromes, ventilation

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Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/eng/t-d.php

For additional information about indoor air quality, contact Kathie Snodgrass at MTDC:

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http://fsweb.mtdc.wo.fs.fed.us/search/