

# Indoor Air Quality Services

Due to the increase in regulatory attention and public awareness, indoor air quality has become a major issue with building occupants, businesses and institutions. Although the long term health affects of poor environmental conditions are currently under study, both OSHA and the EPA have prioritized this issue as the number one health concern for occupancy in buildings.

## What is an IAQ Problem?

It is a condition that occurs in buildings when the concentrations of pollutants in the indoor air (particles, chemicals or bioaerosols) increase to the point where they can cause physical discomfort, allergic reactions or illness to the occupants.

Symptoms commonly attributed to IAQ problems include:

- Headache, fatigue and shortness of breath
- Sinus congestion, coughing and sneezing
- Eye, nose, throat and skin irritation
- Dizziness and nausea

Complainants often report that their symptoms subside soon after leaving the building.

## How Do IAQ Problems Arise?

IAQ problems arise by three conditions occurring in a building at the same time:

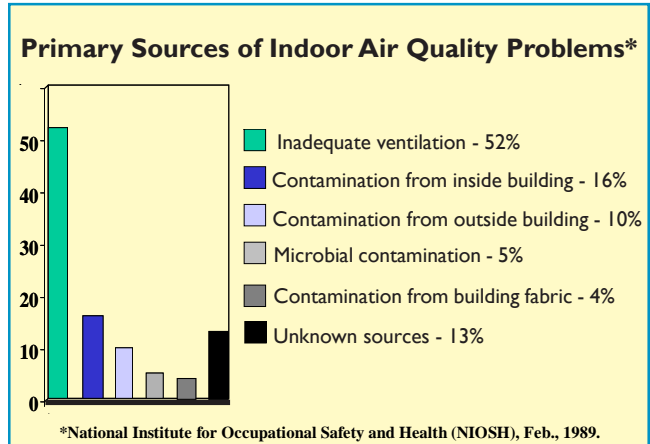
- A new or increasing pollutant source
- Inadequate ventilation
- Susceptible (sensitive) building occupants

IAQ problems in buildings result from a combination of three fundamental causes:

- Building design errors or omissions
- Construction or equipment defects
- Operations and maintenance issues

Unfortunately many IAQ consultants do not have the technical expertise or training necessary to diagnose all three causes of the problem.

At **Halliwell Engineering Associates (HEA)**, we have combined the expertise of our mechanical engineering group and our industrial hygiene services to become a national leader in IAQ diagnostics and management.



## HEA's Indoor Air Quality Services include:

### Emergency Complaint Response

- Emergency Response Service
- Crisis Control and Stabilization
- On-site Investigations and Recommendations
- Follow-up Evaluation and Remediation

### Building Investigation

- Pollutant Source Inventory
- Ventilation System Evaluations
- HVAC Systems Analysis
- Tracer Gas Studies
- Building Envelope Evaluations
- Air Sampling and Analysis
- Infectious Disease Containment (Hospitals)

### Remediation Programs

- HVAC Remediation Design and Management
- Ventilation System Cleaning, Supervision and Inspection
- Microbial Decontamination

### Building Air Quality Management Services

- IAQ Management Plans
- Pollutant Source Control
- IAQ Engineering Controls for Construction Activities
- Due Diligence HVAC Design Reviews
- HVAC System Commissioning
- Operator Training
- IAQ Maintenance Programs for HVAC Systems

### IAQ Litigation Support

- Documentation of Problems, Causes, Resolutions, Costs
- Attorney, Client Conferences
- Case Development and Project Reports
- Depositions and Expert Testimony

# Indoor Air Quality Services -continued-

*The World Health Organization estimates that approximately 30 percent of all buildings have an IAQ problem. In the past, the importance of IAQ was generally overshadowed by concerns with the outdoor environment. Today our focus is shifting to the indoor environment, where we spend upwards of 90 percent of our time. The quality of our indoor air is now a major health and legal issue for building owners, managers and tenants.*

## Some Examples of Potential Indoor Air Contaminants

- Tobacco smoke
- VOCs from new carpets
- VOCs from photocopying machines
- Cleaning products
- Insect control pesticides
- Dusts from insulation materials
- Formaldehyde off-gassing from wood paneling
- Mold growth in HVAC systems

Even the act of breathing contaminates the air with carbon dioxide. However, simply increasing the ventilation in a building will not solve every IAQ problem. Many IAQ complaints are resolved more cost effectively by identifying and removing the source of pollution or contamination into the building's air stream.

Some facilities can be modified to make more efficient use of the ventilation they already have, while other IAQ problems can be solved by improving the HVAC system's maintenance procedures.

The main point to remember is that IAQ complaints are on the rise. As concerned and prudent owners and building managers, preemptive steps must be taken to prevent these problems from occurring in the first place.

HEA's goal is to help our clients avoid IAQ problems from occurring by educating them on the benefits of an IAQ proactive management and monitoring program. This ongoing program identifies conditions *before* they become a problem.

## Resolving a Current IAQ Problem

HEA's approach focuses on capitalizing and utilizing all of the research that has been performed to date. Our engineers use the following protocol to resolve IAQ problems efficiently and effectively:

- Investigate and evaluate the building and the IAQ performance of the HVAC system
- Investigate and evaluate the sources of any contamination from inside or outside the building
- Recommend and implement engineering changes to the HVAC system and operational changes, as needed, to remediate the IAQ problems in the building.

## Experience You Can Rely On

HEA has developed and implemented corporate IAQ programs, policies and procedures for clients who prefer a pro-active approach to IAQ. In addition to these programs, HEA has developed and presented IAQ management training programs for building managers and their engineers which have been presented throughout the country to commercial real estate managers.

In 1998 our Principal, Jack Halliwell was appointed to the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Committee (SSPC 62), charged with writing indoor environmental standards that will be offered into law via the National Building Codes.

Subsequently he was appointed and served as Chairman of the ASHRAE subcommittee charged with developing standards for maintaining acceptable indoor air quality through building operations and maintenance practices; and was also appointed Chairman of the subcommittee charged with writing standards to maintain acceptable indoor air quality during and immediately following building renovations.

In addition, HEA has provided technical support to the EPA and OSHA on the development of indoor environmental programs and engineering standards.

At **Halliwell Engineering Associates**, our goal is to provide superior environmental consulting and engineering services to our clients. Please contact our offices for further information on IAQ problems, remediation, or prevention, as well as information on the full range of services that we offer.

# Indoor Air Quality

## ... Managing Mold

*In the past, relative humidity (RH) was the primary indicator of mold and mildew growth in buildings. However in recent years, experience and research indicates that RH in an occupied space is not always an accurate indicator of the moisture content throughout the building, and is not a reliable mechanism for controlling fungal growth. A change in focus to the routes of moisture entry into a building is a better predictor for finding these problems and providing strategies for their solutions.*

### Mold is the Problem; Moisture is the Cause:

When mold and mildew growth occurs in a building, there are actually two problems that must be solved:

- 1) **Remediate the mold/mildew growth itself.**
- 2) **Eliminate the moisture source causing the growth.**

Remediation of the mold/mildew growth means removal of the fungi and the surface materials upon which the fungi is growing. Textured materials such as fiberglass-lined ductwork, ceiling tiles, wall board and carpet cannot be effectively cleaned if mold growth on the surface material itself has occurred.

Further, if the mold/mildew and the surface materials are removed, but the moisture source is not eliminated, the problem will return in a short amount of time. Moisture is the cause of the problem; fungal growth is the result.

### Eliminating the Moisture Problem:

#### The Relationship between RH and ERH

The relationship between RH in a space, and the Equivalent Relative Humidity (ERH) on surface materials is key to understanding and preventing fungal growth in buildings. Fungal growth does not occur in the air, it takes place on the building's surface materials. Therefore, the moisture content of the surface material becomes most important in controlling the problem.

The measurement of moisture in building materials is best presented as water activity, defined as the ratio of water vapor pressure at the surface of the moist material to that of a pure liquid surface at the same temperature and pressure. This is referred to as the ERH.

### Understanding Relative Humidity Control

<b>Absolute Humidity</b>	=	$\frac{\text{The mass of water vapor in a sample of air}}{\text{The volume of that sample}}$
	=	$\frac{\text{Grains of water}}{\text{pound of dry air}}$
<b>Relative Humidity</b>	=	$\frac{\text{Actual vapor pressure in the air}}{\text{Vapor pressure at saturation}}$
	=	Percent RH (dimensionless)

**As temperature increases, RH decreases**  
**As temperature decreases, RH increases**

ERH is equal to RH at the surface of the material only when the vapor pressure at the surface is equal to the vapor pressure above the surface. However, this rarely occurs since there is usually some gradient of vapor pressure from the surface into the air above, due to air movement. In summary, the RH of the air has an *indirect* influence on the surface materials' ERH, through the moistening and drying of the materials it contacts.

### Building Surfaces, RH and Microbial Growth

Although RH is not always an accurate indicator of moisture content in a building, research does indicate that maintaining an acceptable RH level (consistently held below 60 percent) serves as an effective inhibitor of microbial growth. In buildings where the RH is not kept below 70%, microbials can grow on building materials depending upon:

- The amount of time that the RH is elevated
- The temperature in the space
- The fungal spores that are present
- The building surface materials present

### Basic Routes of Moisture Entry into a Building

There are basically three ways that moisture gets into buildings:

- Bulk water intrusion through the building envelope (i.e. roof, exterior walls, foundation slab and walls)
- Moisture vapor diffusion through the exterior walls (i.e. misplaced, missing or discontinuous vapor barriers, and building depressurization)
- Moisture created as a result of the air-conditioning process itself (i.e. condensation; equilibrium relative humidity)

# Indoor Air Quality

## ... Managing Mold -continued-

### Mold/Mildew Remediation:

Removal of fungal growth in an occupied building is a delicate undertaking. Most fungal spores are designed in nature to be easily disbursed through the air. They are highly prone to becoming airborne with the slightest physical movement or adjacent air currents.

Fungal spores can cause allergic reactions in humans, and the enzymes that some species produce (mycotoxins), can elicit toxic reactions. As a result, the removal of mold and mildew from contaminated building surfaces must be performed within a negative-pressurized containment, with trained personnel utilizing hepa-filtered respirators, tyvec suites, gloves and boots.

Close monitoring of the containment effort is crucial to control the escape of airborne fungal contaminants, since removal activities will generate high concentrations of bioaerosols within the containment area.

### Prevention of Fungal Growth:

If you want to prevent fungal growth in buildings, you need to control moisture.

As identified on page one, there are a number of ways moisture can enter a building:

- Leaks in the roofing, walls, foundation
- Vapor diffusion through exterior walls
- As a direct or indirect result of the air-conditioning process

Remember that air-conditioning will elevate the RH within the HVAC system, and also can elevate or reduce the RH within the building.

When fungal growth has already occurred, understand that to solve the problem completely you will need to:

- Remove the mold from the reservoir surfaces
- Decontaminate the affected areas
- Eliminate the moisture source(s)

<b>The Team Approach to Managing Mold</b>			
	<b>Industrial Hygiene</b>	<b>Laboratory</b>	<b>Mechanical Engineer</b>
<b>INVESTIGATION</b>	<ul style="list-style-type: none"> <li>• Site Investigation</li> <li>• Health complaints (questionnaire, and interviews)</li> <li>• Extent of microbial growth</li> <li>• Sampling strategy (coordinated with laboratory)</li> </ul>	<ul style="list-style-type: none"> <li>• Sampling methodology</li> <li>• Sampling strategy</li> </ul>	<ul style="list-style-type: none"> <li>• Moisture sources: where it is coming from; where it goes</li> </ul>
<b>EVALUATION</b>	<ul style="list-style-type: none"> <li>• Evaluation of the microbial problem</li> <li>• Health effects associated with microbials identified</li> </ul>	<ul style="list-style-type: none"> <li>• Sample analysis</li> <li>• Analytical report and interpretation</li> <li>• Health affects associated with microbials identified</li> </ul>	<ul style="list-style-type: none"> <li>• Evaluation of the moisture and/or high humidity problems</li> </ul>
<b>REMEDIATION</b>	<ul style="list-style-type: none"> <li>• Design remediation of the microbial problem</li> <li>• Sampling strategy during remediation</li> </ul>	<ul style="list-style-type: none"> <li>• Sampling methodology and strategy for remediation and clearance</li> <li>• Sample analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Design remediation of the moisture/ water problem</li> </ul>

### Team Approach to Solving Microbial Growth Problems in Buildings:

Prevention and remediation of microbial growth in buildings means that we are actually dealing with two problems at once (i.e. the microbial growth/contamination problem and the excessive moisture problem).

We can solve both problems effectively and completely if we take a team approach, including the combined expertise of a microbiologist/laboratory; an industrial hygienist, and a mechanical engineer. Each member of the team plays an integral role in solving the problems of microbial growth in buildings.

For more detailed information on mold remediation, or the other services that Halliwell Engineering Associates offers, please contact our office listed below.

## Indoor Air Quality Experience

*Halliwell Engineering Associates (HEA) has had extensive experience in IAQ investigations and the remediation of mold/mildew growth, as well as failed building and mechanical systems. In addition, we have developed management plans and IAQ maintenance programs to help our clients pro-actively manage IAQ in their buildings. Listed are sample projects to highlight this experience.*



### **Investigation/Cost Recovery Litigation**

#### **High Rise Condominium San Francisco, California**

HEA was part of an investigation team for a condominium association claim against the developer, for water intrusion damage and microbial growth. The claim was settled for twelve million dollars.

### **Investigation/Remedial Design**

#### **World Resort Hotel Orlando, Florida**

HEA was asked to investigate ground water intrusion problems in guestrooms of an 800 room resort hotel operated by a national hotel chain. Based on the findings of the inspection, HEA designed a ventilated gypsum wall board system to prevent water vapor diffusion and condensation on vinyl covered walls.

### **IAQ Study/Management Plan**

#### **National Real Estate Company Southern, Midwestern and Western States**

HEA performed a national, multi-year investigative study of IAQ in over 1,000 commercial office buildings and large retail malls throughout the United States. Based on study findings, HEA was also responsible for the implementation and management of a pro-active, on-going IAQ program.

### **Investigation/Remediation**

#### **Regional Headquarters Building Winter Park, Florida**

HEA diagnosed employee illnesses related to the buildings' systems that required over \$350,000 of remediation to prevent future microbial growth in the air-conditioning systems. Subsequent clearance testing by HEA documented a complete resolution which allowed employees to return to a healthy environment.

### **Survey/Remedial Design**

#### **State University Central, Florida**

HEA provided a survey and redesign of the return air duct system at the administrative office facility following IAQ concerns occurring in the ceiling plenums.

### **Investigation/Remediation**

#### **Community Hospital Central, Florida**

HEA investigated probable sources of Legionella bacterium in the hospital's domestic hot water and cooling tower system, after a staff member was diagnosed with Legionella. Active bacterium were discovered in the hot water system and an emergency sanitizing program was immediately developed and implemented at the facility.

### **Investigation/Cost-Recovery Litigation**

#### **High Rise Office Building San Diego, California**

A claim by a tenant attorney regarding moisture diffusion through the building envelope and subsequent microbial growth, compelled the building's attorney to hire HEA. On-site extensive investigation of the building and the subsequent report provided the background material necessary for the owner's successful defense.

### **Remediation Plan**

#### **Research Facility Durham, New Hampshire**

Design flaws were discovered in a newly constructed research facility, and HEA was called upon to develop a prioritized remediation plan to correct the original design errors which caused temperature, humidity and air pressure relationship problems.

## Indoor Air Quality Experience -continued-

*In the mid-1970s and 1980s as new building construction focused on energy efficiency, ironically the efforts to “tighten” buildings led to an increasing number of health complaints by occupants. The term “sick-building syndrome” has been used to refer to such complaints. Many reported illnesses have occurred in newly constructed or renovated buildings with inoperable windows and controlled ventilation.*

### **Investigation**

#### **High Rise Office Building Atlanta, Georgia**

HEA investigated a diagnosed case of Legionella in the building. Active bacterium was found in the cooling tower basins, and HEA assisted the treatment company in its elimination.

### **Investigation**

#### **Office Building Portland, Maine**

HEA was called upon to investigate air quality complaints in a large office building, and subsequently found design errors and potential contamination of ventilation air from cooling tower vapor fallout.

### **Investigation/Remedial Design**

#### **High School Vero Beach, Florida**

HEA provided field investigations and remedial design to correct ventilation deficiencies occurring between preconditioned outside air units and individual classroom conditioners.

### **Survey/Remediation Plan**

#### **Hospital Surgical Suite Providence, Rhode Island**

After an initial survey, HEA was asked to develop a prioritized remediation plan to correct original design errors as well as system operational and control problems which caused humidity and pressurization problems.



### **Survey/Remedial Design**

#### **Hospital Gainesville, Florida**

HEA provided an IAQ survey, engineering report and remedial design for TB isolation room ventilation as required by the U.S. Center for Disease Control. Recommendations and design included extensive modifications to the existing central air handling systems and central exhaust systems for 13 areas within the Hospital.

### **Investigation**

#### **Vocational-Technical Center Rockford, Illinois**

HEA conducted an IAQ investigation and reported findings of mold and mildew problems in an 86,000 square foot high school vocational-technical center.

### **Survey/Remediation Plan**

#### **Shopping Mall Boston, Massachusetts**

HEA was asked to perform an IAQ survey of this large facility, and issued a report on deficiencies and a detailed remediation plan.

### **Survey/Testing**

#### **Two Affiliated Hospitals Southwest, Florida**

After several hospital staff contracted multiple drug resistant tuberculosis, HEA was called upon to complete a survey and testing of isolation rooms. Poor design and inadequate commissioning was determined to be the cause of transmission of droplet nuclei to staff corridors.