INDOOR AIR QUALITY MANAGEMENT IN THE OFFICE WORKPLACE

A Project

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1. Executive Summary

Indoor air quality (IAQ) management is an emerging, interdisciplinary career that has greatly increased in importance during the last twenty years. IAQ in office buildings is gaining increased attention because millions of Americans spend two thousand hours or more per year in office buildings. Compared to houses, office buildings are often twice as crowded, have far more chemicals and materials, are much more dependent on mechanical ventilation (e.g., fewer opening windows), provide far less occupant control, and have much deeper pockets to sue.

IAQ managers need a good technical background to understand how buildings operate, good people skills to understand how people interact with buildings, and good managerial skills to help provide good IAQ as part of organizational strategy. Leadership to prevent and resolve IAQ issues should be the main responsibility of an IAQ manager, but every person can exercise some type of leadership. IAQ management is a shared responsibility among the architects and engineers who can make the biggest difference, the building managers who want IAQ to pay a return on an investment, and the occupants whose health and safety depends partly on good IAQ.

Past management practices of ignoring or managing occupant complaints from the seat of the pants is much more expensive than doing it right and is no longer an option in a competitive world where each of the parties are aware of how good IAQ can help or hinder their goal achievement. Implementing an active IAQ management plan is a very affective way to do it right. I recommend that organizations adopt a tailored version of the USEPA and NIOSH plan.

This project report evaluated how IAQ issues were managed in seven case studies. The first six illustrate how to implement the IAQ management plan presented in this project report could have been used to minimize the IAQ problems. The seventh case evaluates how a building owner, a tenant, and an IAQ consultant worked together to resolve IAQ complaints. This case seemed to have encouraged the tenant and building owner to negotiate a ten-year renewal of the lease.

Finally, this project report discussed four future changes likely to have a significant affect on office workplace IAQ. These changes support the premise that IAQ management is an emerging field that is growing faster than the ability to train qualified people to address new IAQ issues.

2. Table of Contents

3. Glossary

Acceptable Indoor Air Quality (IAQ): air without contaminants at harmful concentrations, and when 80 percent or more of occupants do not express dissatisfaction

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): an international, organization that advances the arts and sciences of heating, refrigeration, air conditioning and ventilation, the allied arts and sciences, and related human factors for the public

Building-Related Illness (BRI): similar to SBS except that health effects are clinically diagnosed and can be linked to specific pollutants or contaminants inside the building

Distributive Justice: the perceived fairness in the distribution of outcomes

Equity: the perceived fairness of the relation between what a person does and receives

Grievance: a complaint put in writing and made formal

Heating, Ventilation, and Air Conditioning (HVAC) System: a building's system that provides thermal comfort, distributes outdoor air to occupants, and removes contaminants

Multiple Chemical Sensitivity (MCS): individuals who are either physically or psychologically sensitive to a wide range of common chemicals

National Institute for Occupational Safety and Health (NIOSH): the federal agency that conducts research and makes recommendations for the prevention of work-related disease and injury

Pathway: a route between the source and the complaint location within the building

Procedural Justice: the perceived fairness of the decision-making process

Reciprocity: a feeling of obligation to give in return or "reciprocate" good treatment

Right to Privacy: freedom from unauthorized, unreasonable intrusion into personal affairs

Severance Pay: a security benefit sometimes offered to employees who lose their jobs

Sick Building Syndrome (SBS): buildings whose occupants experience acute health and comfort effects that appear to be linked to a building but not to an identifiable source

Source: contaminants present either indoors, outdoors, or within the HVAC system

United States Environmental Protection Agency (USEPA): the federal agency whose mission is to protect human health and safeguard the natural environment

Ventilation: replacing, diluting and removing contaminated air with cleaner, fresher air

Volatile Organic Compound (VOC): a large family of air contaminants that can cause poor IAQ

Whistle-blowers: individuals who report real or perceived wrongs from their employers

Workers' Compensation: benefits provided to persons injured on the job

4. Introduction

There is an increasing interest in indoor air quality (IAQ) in the office workplace that could be due to the following: increasing amount of time spent indoors; aging population; aging buildings; decreasing ventilation due to trying to save energy; increasing number of chemicals brought into the workplace; increasing reliance on mechanical ventilation with decreasing open-able windows; increasing role of energy conservation; increasing outdoor air pollution in some cases; expanding global competition; improving technology; increasing awareness of IAQ; and litigation resulting from poor IAQ getting more expensive and more common. IAQ refers to the quality of air that is circulated, conditioned, and breathed within the confines of a building. [1] IAQ is a changing interaction of complex factors that affect the types, levels, and importance of pollutants in indoor environments. These factors include pollutant sources; design, maintenance and operation of building ventilation systems; moisture and humidity; and occupant perceptions and susceptibilities. [2] The four basic, interdependent factors influencing IAQ include occupants, HVAC system, pollutant pathways, and contaminant sources. EPA and other organizations continue to learn about IAQ problems that could have been easily prevented or fixed by implementing good building management practices that do not have to significantly increase the amount of work or cost of building operation and maintenance. [3]

On a national average, people spend about 90 percent of their time indoors. This percent is higher in extremely cold, humid, or otherwise unpleasant climates. Air within homes and other buildings can be more polluted than outside air, even in the largest and most industrialized cities. USEPA studies that compare risks of environmental threats to public health consistently rank indoor air pollution (including secondhand smoke, organic compounds, and biological pollutants) among the top five risks. [3] IAQ is a major concern to building owners, building managers, and employees because it can impact health, comfort, wellbeing, and productivity of building occupants. The Clean Air Act of 1970 addresses outdoor air quality. In 1986, Congress mandated that USEPA conduct research to develop information on IAQ, which USEPA's Indoor Air Division carried out. [4] A 1989 USEPA Report to Congress concluded that improved IAQ could result in higher productivity and fewer lost workdays. USEPA estimates that poor IAQ may cost the United States tens of billions of dollars each year in lost productivity and medical care. [2] There are currently no specific federal laws to regulate office-workplace IAQ.

Indoor air levels for many pollutants can be two to five times higher and sometimes more than 100 times higher than outdoor levels, according to USEPA, which over the last 25 years has identified measurable levels of more than 107 known carcinogens in offices. [5] According to the Delaware Division of Public Health, the dirty dozen indoor air-contamination sources affecting the office workspace are: "1) inadequate maintenance of heating and cooling systems; 2) lead paint; 3) asbestos; 4) car exhaust, pollen, mold, pollution, and bird droppings from outside; 5) new carpet, paint, paneling, and furniture; 6) carbon monoxide; 7) lack of housekeeping; 8) pests such as cockroaches and mice; 9) cleaning supplies and other household chemicals; 10) pollen and plant debris; 11) tobacco smoke; and 12) excess water that allows mold and fungi to grow." [6] Pollutants can be generated by outdoor or indoor sources that can include building maintenance activities, pest control, housekeeping, renovation or remodeling, new furnishings or finishes, shipping and receiving, smoking, and other occupant activities. Many factors influence IAQ while occupants exposed to the same IAQ contaminants at similar concentrations often react differently. [7] Pollution sources can be either natural or anthropogenic.

Managing a building is a difficult and a complex job. There are many competing demands including health and safety, building maintenance, housekeeping, and communications with occupants and tenants. Building owners and managers are under pressure to contain or reduce operating costs and increase revenues, which can easily draw attention and resources away from important elements of building management such as IAQ. Good IAQ does not have to compete with other building management priorities; in fact, it can enhance some. Many aspects of good IAQ management are also common principles of good facility management. For example, the efficiencies gained by keeping the HVAC system clean and better controlled both enhance IAQ and reduce energy costs. Controlling IAQ involves integrating three main strategies. First, manage the sources of pollutants either by removing them from the building or isolating them from people through physical barriers, air pressure relationships, or by controlling the timing of their use. Second, dilute pollutants and remove them from the building through ventilation with outside air. Third, use filtration or other air-cleaning devices to clean the air of pollutants without introducing other air pollutants into the indoor air. [3] Developing and implementing an IAQ management plan can help to implement these strategies and is a good principle of human resource and public relations management as well as protection from lawsuits.

Responding effectively to IAQ problems in the workplace has a psychological as well as a technical component. There are two distinct milestones for responding to IAQ problems: when the IAQ problem is solved and when the occupants believe the problem is solved. [8] When sick-building problems occur in the workplace, the cost of rehabilitation, including repairs, expert witness testimony, and attorney fees, is directly related to the emotional response of the building occupants who are often excluded from the problem-solving process. These human factors, combined with technical, legal, economic, management, and other factors make IAQ management an emerging and interdisciplinary field. An effective IAQ manager can come from a variety of backgrounds. IAQ is a field that requires the application of many disciplines to prevent and solve problems, because no single field encompasses all the needed principles and skills. [3] It is important for the IAQ manager, like a project manager, to be goal-oriented by adopting whatever problem-solving techniques appear helpful. Compared to a functional manager, an IAQ manager should be a generalist rather than a specialist, a synthesizer rather than an analyst, and a facilitator rather than a supervisor. [9]

This project report was written for IAQ managers from an interdisciplinary management perspective. The body of this project report includes the ten sections shown in the table of contents section. I understand that five of these sections are either optional or unique to this project report. The glossary defines terms and acronyms that are useful for understanding this project report or information presented herein; terms that the reader can look up in a dictionary are not defined in this section. The IAQ background discusses five areas that could be very helpful for the reader to understand the rest of the report; the reader already familiar with these might want to read them again in the context of IAQ management in the office workplace. The IAQ management strategies section is the backbone of this project report; this section, which is independent of the rest of the report, can be used as a reference for IAQ managers. The main purpose of having the first six case studies (three groups of two each) are to show how following each of the three IAQ management strategies could have greatly decreased the cost of IAQ. The purpose of the detailed case study is to show what a typical, well-done IAQ investigation could look like. The future section discusses four trends in where IAQ management is going. I tried to include information just once in this report, as much as possible, for many topics that could fit under more than one section or subsection, to avoid unnecessary repetition and overlap.

5.1 IAQ Background – Public's Assessment of Risk Management

"Numerous opportunities were missed in the early weeks and months of the problem to effectively and inexpensively deal with the issues, but no party took leadership—there was only finger pointing and blaming." This statement reflects a growing trend in sick-building cases, in which mitigation and litigation can approach or exceed the cost of the facility. [8] By following risk-communication principles, managers can develop effective messages, maintain two-way communications and occupant trust, and defuse emotional reactions that cause many IAQ situations to escalate into public relations nightmares. Occupant trust is very difficult to regain once it is lost and emotional reactions are very difficult to calm after they are out of control.

Risk communications is based on the premise that the public assesses risk more in terms of moral/emotional issues (called "outrage" or "perceived risk") than quantitative risk (called "hazard" or "actual risk"). The perception of risk can thus be described using the following equation: Risk = Hazard + Outrage. [10] The moral-emotional issues or outrage factors can make an individual react with fear and anger, which can amplify the level of actual risk. While risk assessors typically calculate risk by multiplying the magnitude of the risk by the probability that it will occur, most of the public assigns risk according to the moral-emotional issues associated with the event. Table 1 shows relationships between occupant outrage and IAQ problems. [8]

Both management and occupants tend to react to IAQ problems in a common, recognizable pattern: Stage 1 – Denial; Stage 2 – Outrage; and Stage 3 – Acceptance. [8] Stage 1 begins when occupants view the management efforts to address complaints as less than satisfactory, conveying the message that no real problem exists or that the problem only affects overly sensitive people. During this stage, occupants try to gain more attention to their cause by hiring doctors and attorneys and talking to the media because they believe that management may be withholding information. Meanwhile, management investigates, keeps the information confidential, and says, "trust us" because they believe that threats of lawsuits are the key concern. By stage 2, both sides have developed formal positions in relation to the IAQ problem and the effort needed to resolve the conflict greatly increases and so does the cost. Emotions on both sides stabilize during stage 3 as the trust is renewed and their attorneys focus more on mediation and arbitration than on litigation, and media coverage declines. [8]

Table 1. Relationship of Occupant Outrage to IAQ Problems [8]

Outrage Factor	**Decreases Outrage**	**Increases Outrage**	**Relationship to IAQ**
Origin	Natural	Human-made	The workplace contains human-made materials separated from the natural outdoors, sometimes by sealed or inoperable windows.
Volition	Voluntary	Involuntary	Because of job security, occupants usually feel forced to return to workplaces with IAQ problems until either the problem is solved or the building is evacuated.
Familiarity	Familiar	Exotic	Illustrations should be used while scientific terms should be used sparingly when communicating with occupants.
Controllability	Controllable	Uncontrollable	Occupants usually do not feel in control over the source or the solution of IAQ problems that occur in the workplace.
Fairness	Fair	Unfair	Management may not work in the building experiencing the IAQ problem, making the situation seem unfair. Other issues include a slow response from management (real or perceived) in correcting the problem, and differences in the severity of the symptoms experienced by the occupants.

Management must first empathize with the affected occupants before it can successfully resolve the situation. Occupants often want concrete and quick answers to their questions: What have I been exposed to? What are the effects? When will you have the answers? Sharing this information early, through effective communication, is the key to avoid occupant outrage and the subsequent escalation of costs by moving quickly to stage 3. Doing so generates a sense of control, trust, and empowerment instead of feelings of fear and victimization. Anticipating the occupants' emotional responses and taking a less adversarial position can help management to develop an interactive program that includes involving occupants in the problem-solving effort. Taking the initiative sends the message that management is more concerned about employee well being than costs. These strategies minimize cost and generate good publicity. [8] Clear organizational policy regarding internal and external communications, perhaps with media training, rather than trying to muffle employee speech, can decrease perceived risk.

5.2 IAQ Background – Standards, Regulations, and Court Cases

Occupational exposure standards and guidelines include OSHA's Permissible Exposure Limits (OSHA PELs); National Institute for Occupational Safety and Health's Recommended Exposure Limits (NIOSH RELs); and American Conference of Governmental Industrial Hygienists' Threshold Limit Values (ACGIH TLVs) that apply when people are at work (which could often be for forty hours per week). The USEPA National Ambient Air Quality Standards (Primary and Secondary) for outdoor air quality are much lower than the occupational exposure standards because they apply to the entire public all day, every day. The World Health Organization Air Quality Guidelines applies to IAQ, but these are not widely accepted, nor enforceable in the office workspace. Extreme caution should be used when comparing contaminant concentrations to existing occupational or public-health standards or guidelines. Occupants may experience health and comfort problems at concentrations well within these guidelines. Exceeding, or even approaching occupational standards is extremely rare, even with "sick buildings."

All existing buildings were built to comply with local building and fire codes enforceable at the time of construction or remodeling. The three most important consensus standards affecting IAQ include ASHRAE 62, ASHRAE 55, and ASHRAE 52. Many building code authorities have adopted some version of ASHRAE 62 and 55. ASHRAE 52 mainly applies to the manufacturers and requires them to give certain data to IAQ managers. [11], [12], [13], and [14]

1. ASHRAE 62-1989: Ventilation for Acceptable Air Quality. Air shall be delivered to people instead of to a building; ventilation systems should prevent the growth of microorganisms; inlets and outlets shall be located to avoid contamination of intake air; where practical, exhaust systems shall remove contaminants at the source; makeup air should be provided for combustion sources or exhaust systems; relative humidities should be maintained between 30 and 60 percent; outdoor air requirements in office space should be at least 20 cubic feet per minute per occupant; and the maximum occupancy should be 7 occupants per 1000-square-feet. [12]
2. ASHRAE 55-1992: Thermal Environment Conditions for Human Occupancy. This standard attempts to predict what range of IAQ conditions will satisfy 80 – 90 percent of the occupants during summer and winter for different activity levels. Conditions include temperature, humidity, activity, clothing, air movement, and radiant heat sources. [13]

3. ASHRAE 52-1992: Methods of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter. The most critical characteristics are the filter's efficiency, airflow resistance, cost, durability, and ease of maintenance. [14]

OSHA can only regulate if they are reasonably sure that there are significant risks posed by poor IAQ that would materially impair the health and functioning of workers. [15] OSHA traditionally has focused on industrial and manufacturing buildings. OSHA has tried unsuccessfully to regulate IAQ in office buildings, too, but officials say that their efforts have been stymied because of concerns over the cost to companies. [6] In 1994, OSHA introduced a performance-based set of proposed regulations governing IAQ covering six categories: IAQ compliance program; implementing the compliance program; controlling specific contaminant sources; renovation and remodeling; employee information and training; and record keeping. OSHA received over 35,000 public comments—far more than any other single proposed regulation. [16] In 1995, OSHA tried to develop a watered-down, more qualitative version of the 1994 proposal including the following major provisions related to ventilation: keep carbon dioxide levels below 800-ppm; keep relative humidity below 60 percent; obtain and maintain records on HVAC systems; inspect, maintain, and operate the HVAC system so that it meets the criteria of the codes in force at the time the building was constructed; exhaust designated smoking areas to the outdoors and keep the area under negative pressure; locate intakes to prohibit uptake of contaminated air; and provide local exhaust of specific emitters if necessary. [11] Some states and local governments have IAQ regulations and 37 states and territories have designated staffers to handle IAQ complaints. [6] The Consumer Product Safety Commission has tried to regulate consumer products that emit the most indoor air pollutants. [17]

Most IAQ litigation cases are settled out of court. Cases that have gone to trial demonstrate that managers without reasonable, implemented IAQ management strategies are at a much higher risk for litigation, especially for jury trials. Reasonable factors that judges and juries look for include ensuring proper building ventilation, using qualified people to undertake renovations, quickly responding to IAQ complaints, warning occupants of dangerous situations, and defining IAQ responsibilities in building leases. [18] Both building owners and the employers have been sued for poor IAQ. The building owner could be more liable if there are multiple tenants.

5.3 IAQ Background – Micro and Macro-Economic Considerations

Since the occupants in office buildings are not protected by specific IAQ regulations, they may look for compensation in the form of disability claims, workers compensation, economic loss claims, and personal injury claims. In addition to the possibility of litigation and legal claims, the absence of IAQ management may lead to increased illnesses, absenteeism, decreased productivity, workers' compensation claims, and union grievances. [19] The number of IAQ cases is rising substantially, and the amount of the damages sought in some cases is increasing at an alarming rate—sometimes in the seven-figure range. The average costs per square foot per year for typical business operations (in 1995) are $0.80 to $1.50 for energy, $0.50 to $2.00 for maintenance, $4.00 to $25.00 for property value, and $200 to $400 for a middle management worker, based on 200 square feet per person (Woods, et. al. 1987). In this context, a 50 percent reduction in energy cost is counterproductive if it results in a 10 percent decrease in productivity, or a 10 percent increase in absenteeism, or if litigation occurs. [16] Studies have shown that even basic aspects, such as effective ventilation, adequate lighting and good acoustics, can increase office productivity by 6 –10 percent. [20] The economic losses associated with absenteeism and productivity can pale in comparison with the long-term impact of negative employee attitudes toward management that has not cared enough to provide healthy and safe IAQ. Some managers act and recruit on the principle that "the most critical point of customer satisfaction for the indoor worker today may in fact be the quality of their working environment." [18] Attracting, motivating, and retaining quality employees are very important for an organization's vision. [21]

Poor IAQ can mean significant economic losses to employers at a national level, also. USEPA's 1992 estimate of decreased productivity losses attributable to poor IAQ is $60 billion per year. This estimate is conservative because many workers continue to work even while experiencing symptoms that are related to poor IAQ and/or do not associate their symptoms with poor IAQ. [18] If office workers were to lose an average of 6 minutes of productive concentration per day, the impact in the United States would be about $10 billion per year according to a 1989 estimate. [18] There are also other economic reasons for effectively managing IAQ, such as the high cost of neglected maintenance. Once damage is done, attempts to identify sources of IAQ problems are often much costlier. The cost of litigation can be another big economic cost, especially if management is unable to exercise due diligence by being able to prove (more likely than not)

that all reasonable steps were taken to resolve the IAQ problem. [18] Researchers at the Lawrence Berkeley National Laboratory estimate that U.S. companies could save as much as $58 billion annually by preventing sick-building illnesses and could benefit from $200 billion in productivity increases each year. [5] Employers and employees share many of these benefits and costs, there is a lot of disagreement regarding quantifying these benefits and costs because employers pay for most of the costs while employees receive most of the benefits of good IAQ.

Having adequate IAQ in commercial buildings was once the result of construction methods that allowed for much uncontrolled ventilation through tiny cracks and holes in the building envelope. The higher cost of energy due to the oil embargo in 1973 changed the whole concept of IAQ by placing a greater emphasis on decreasing the ventilation rate and outside air. Also, the increasing use of toxic materials found in modern office equipment, cleaning agents, and synthetic building materials added more to the contaminant burden. Productivity-limiting sick building syndrome (SBS), building-related illness (BRI), and multiple chemical sensitivity (MCS) are significant economic concerns of today's building industry. [1] According to a survey by OSHA, one-third of the 70 million Americans who work indoors are quartered in buildings that are breeding grounds for an array of contaminants, from molds and bacteria to volatile organic compounds like formaldehyde. [7] OSHA estimates that the air in 30 percent of the nation's 4.4 million non-industrial buildings is unsafe. [15] OSHA estimated (in 1995) that it would cost about $1.40 per square foot (for problem buildings) to upgrade existing HVAC systems to meet the 1995 proposed standard, totaling $12 billion for the United States. Industry estimates that the total direct cost would be at least five times higher than OSHA's estimate. [11]

IAQ training investment in the organization's human capital provides good benefits but is also costly. Benefits of this training include increased production, reduction in errors and turnover, less supervision necessary, new capabilities, attitude changes, better complaint prevention, and potentially cheaper remediation costs. Costs of this training include materials, equipment, lost production, cost of facilities, transportation, and living expenses and salaries for trainers and trainees. Trying to quantify benefits and costs is often the best way to determine when IAQ training is cost-effective. Organizations are realizing that training first-line workers rather than managers often gives a higher return on the investment, especially in the short-run. [22]

5.4 IAQ Background – Human Resource Management Theories and Laws

"Human resource management is the design of formal systems in an organization to ensure the effective and efficient use of human talent to accomplish the organizational goals." [22] The employee-organizational relationship does matter and should be chosen carefully. IAQ managers who want to maximize productivity should consider reciprocity and a psychological contract—the unwritten expectations that employees and employers have about the nature of their work relationships. The performance that employers look for in individuals rests on ability, motivation, and the support received; however, motivation (the desire within a person causing that person to act) is often the missing variable. Alternate work schedules (e.g., flextime) and alternate work arrangements (e.g., telecommuting) affect IAQ by altering when employees occupy the building. Job satisfaction, organizational commitment, absenteeism, and turnover can be affected by IAQ to the extent that the employees see the IAQ as an intangible benefit or as part of a compensation package. Poor IAQ can bring these issues to the HR department's attention very quickly, which is exactly what IAQ managers should avoid. Good IAQ could possibly be used as a type of recruiting strategy, especially if the job market is tight. [22]

The Equal Employment Opportunity Commission (EEOC) has enforcement authority for charges brought under the following federal laws: Civil Rights Act of 1964, Title VII; Civil Rights Act of 1991; Equal Pay Act; Pregnancy Discrimination Act; Age Discrimination in Employment Act; Americans with Disabilities Act (ADA); and Vocational Rehabilitation Act. All of these acts have the potential to affect IAQ management, even without enforceable IAQ laws. The ADA is probably the most applicable of these laws to IAQ management and covers all employers with fifteen or more employees. [22] The U.S. Department of Justice, the U.S. Department of Health and Human Services Office for Civil Rights, and the Equal Employment Opportunity Commission have all recognized Multiple Chemical Sensitivity (MCS) as a disability. The ADA is mandated to ensure good IAQ in the affected building to create an environment for good health and equal opportunity in "academic success" for those affected by MCS. [23] The Occupational Safety and Health Act was passed "to assure so far as possible every working man or woman in the nation safe and healthy working conditions and to preserve our human resources." Major OSHA provisions for IAQ management include employees' rights to refuse unsafe work and to protect their reproductive health, the latter at the employees' discretion to

avoid conflict with the Pregnancy Discrimination Act. Employers that tolerate poor IAQ can have a dilemma of whether to let pregnant employees work with poor IAQ creating potential environmental-hazard lawsuits versus not letting the pregnant employees work with poor IAQ creating the possibility of illegal discrimination under the Pregnancy Discrimination Act. [22]

Organizations need to train managers and employees to understand IAQ by providing some basic training for the entire organization. Career development is important for all employees, but especially so for managers—including IAQ managers. Management development is a way of imparting the knowledge and judgment needed to meet the organization's strategic objectives. Training has legal implications, such as who is selected for training, the criteria used for the selection, pay differences based on training, and use of training when making promotion decisions. An increasing trend is to let employees have greater authority and responsibility for their career management, which can help avoid illegal-discrimination lawsuits. [22]

Compensation systems require balancing the interests and costs of the employer with the expectations of employees. Organizations should develop policies as general guidelines to provide for coordination, consistency, and fairness in all facets of compensating employees including wages, salaries, bonuses, medical insurance, paid time off, retirement pensions, and other factors that could affect IAQ or employees' perceptions of IAQ. IAQ is a quality of the work environment. Security benefits that affect IAQ management include workers' compensation, unemployment compensation, and severance pay. The Family and Medical Leave Act covers most employers with 50 or more employees and allows employees to take 12 weeks off for certain situations, including an illness of a family member caused by poor IAQ. [22]

Workplace litigation has reached epidemic proportions. Advocates for expanding employees' rights warn that management policies abridging free speech, privacy, or due process will lead to further national legislation. HR professionals argue that they must protect management's traditional prerogatives to lawfully hire, promote, transfer, or terminate employees as they see fit or the organization may be negatively affected. IAQ-management HR issues affecting labor relations include right to privacy, implied-contracts, employee advocacy of controversial views, whistle-blowers, employer investigations, unionism, and the grievance process. [22]

5.5 IAQ Background – Heating, Ventilation, and Air Conditioning (HVAC) Systems

Maintaining good IAQ requires attention to the building's HVAC system. About half of all IAQ episodes had their origin in the HVAC system according to NIOSH. [11] Air conditioning can imply either cooling by more accurately controlling the temperature, moisture content, cleanliness, air quality, and air circulation as required by occupants, a process, or a product in the space. [24] HVAC systems include all of the equipment used to ventilate, heat, and cool the building; to move air around the building (ductwork); and to filter and clean the air. [3] HVAC systems serve one or more of seven basic functions, either actively or passively:

1. Heating: Sensible heating is the transfer of energy to a space or to the air in a space by virtue of a difference in temperature between the source and the space or air. This process includes such forms as direct radiation and free convection to the space, direct heating of forced circulated air, or through heating of water that is circulated to the vicinity of the space and used to heat the circulated air. [24] People and the energy used in buildings can produce enough heat for a building to need cooling even in the winter.
2. Humidifying: Humidification is the transfer of water vapor to atmospheric air. The goal of this mass/latent-heat transfer process is to increase the air's water concentration. This process includes such forms as spraying fine droplets of water into the circulating air stream, boiling water, and letting wet cloth dry. [24] Occupants exhale a lot of water.
3. Cooling: Cooling is the opposite of heating and is usually done by circulating air over a surface maintained at a low temperature with water or a refrigerant as the cooling medium. [24] Water will condense out of air that is cooled below the dew-point temperature in the HVAC system or anywhere else in the building; so beware of cold spots on walls and near corners where condensation from the indoor air can occur.
4. Dehumidifying: Dehumidification is the opposite of humidifying. This process is usually done by circulating air over a surface maintained at a low enough temperature to cause the water vapor in the air to condense out. Spraying cold water into the air stream is another method that is sometimes used. [24] Removed water needs to be discarded.
5. Cleaning: Screens filter relatively big particles while fine filters, electrostatic precipitators, water sprays, cyclones, and baghouses usually filter the relatively small particles. Absorption, physical adsorption, and ionization usually remove gaseous air pollutants. [24] Both indoor and outdoor air might need cleaning to varying degrees.

6. Air Motion: The motion of air in the occupant's vicinity should be strong to accomplish the above five HVAC tasks but gentle enough to be unnoticed. Supply diffusers and other devices usually accomplish this process. [24] Air motion is most easily measured using puffs of smoke from a smoke tube and observing how the puffs disperse.
7. Ventilation: Ventilation is the process of supplying outdoor air plus any treated recirculated air. [24] The ventilation capacity of an HVAC system is based on the projected number of people and amount of equipment in a building. Adequate outside air is necessary in any office environment to dilute pollutants that are released by equipment, building materials, furnishings, products, and people. Carbon dioxide concentration is a common way to measure the ventilation by observation peaks and patterns.

A combination of these processes can be passive or active, and either manual or automated. Some HVAC systems were designed (or modified) for cost and energy savings more than for IAQ considerations, especially if they were built in the 1970s. From an IAQ manager's perspective, it can be helpful to learn about the type of building's HVAC system (e.g., constant air-volume or variable air-volume). HVAC systems should work as designed if they are well designed, maintained, and operated. However, even good HVAC systems eventually wear out or may require modification to accommodate changes when building use changes or when the number of occupants increases. The IAQ manager should pay more careful attention to more complicated HVAC systems because they have more parts that can break.

An important HVAC principle from an IAQ perspective is "zones"—i.e., the areas within the building that share the same HVAC needs and whose control devices use the same sensors. Air in a single zone has small air-property variations (e.g. temperature and humidity), especially if there are point sources (e.g., a heater or humidifier) in the zone. Small pressure differences and diffusion cause air mixing between zones (and within the same zone) and can vary a lot depending on weather and building use leading to seasonal or other predictable fluctuations. Neighboring zones are not totally isolated, even if walls separate them. Pathways connecting zones include hallways, plenums, elevator shafts, return air vents, utility conduits, chimneys, and tiny pores in the building structure. Zones can be affected by pressure imbalances in far-away zones due to unexpected events such as combustion-appliance or exhaust-vent back drafting.

6.1.1 IAQ Management Strategies – An Ounce of Prevention – Architects and Engineers

The creation of a healthy and comfortable indoor environment starts with the conscious decision to both build an environment that contributes the fewest contaminants possible. Proper material and product selection and concerned building, architecture, and engineering firms can all contribute to a healthy building as described in seven stages. [25]

Design Stage: Air quality concerns and the goals to be achieved in the subsequent stages should be specified early. The expected occupants and the activities to be carried out in the building will determine the degree of air quality required. Areas within a proposed building will have varying air quality requirements and others will act as a source of contaminants. Consideration of these contaminant sources should be reflected in the building layout and mechanical systems. Cleaner areas should be grouped together and pressurized, with buffer areas (e.g., corridors) next to the areas of poor air quality. Limiting the variety of materials and products used in the structure may reduce the contaminants and make future IAQ problems easier to evaluate.

Site Planning: This is an important step in preventing air quality problems from arising. The site itself and the surrounding area may be a source of contaminants and will have an impact on the building's air quality. Outside noteworthy conditions to look for include the following:

- Local Geography and Geology – bodies of water, soil/subsurface conditions, ambient air quality, and local vegetation (e.g., sources of natural allergens)
- Urban Sources – industrial sites and adjacent buildings and their functions
- Rural Sources – sanitary landfills, agricultural process, and local industries
- Transportation Corridors – exhaust and noise from trains, planes, and cars

Mechanical System Design: Many air quality problems can be avoided with a properly designed mechanical system. The architect or engineering firm that designs the HVAC system should be well versed in air quality concerns. The following points should be considered:

- Use heat recovery ventilators (air-to-air heat exchanger) to increase fresh air while decreasing energy costs, especially in very cold or very hot climates
- Locate supply and return air registers to afford the best circulation possible and eliminate dead areas of air (i.e., no circulation) and back drafting

- The fresh air intake vents and the exhaust vents should be located to prevent cross contamination and intake from loading docks and parking lots
- The building layout should ensure that the maintenance staff has convenient access to the building's mechanical systems to help them do their jobs
- The ventilation system should provide positive air pressure at interior areas open to the outside where potential sources of contaminants may be found

Material Selection: The awareness and selection of building materials, furnishings, and finishes with respect to their offgassing characteristics will help mitigate air quality problems before they happen. Select target products that may be large emitters of volatile organic compounds (VOC) by considering the quantity and building distribution and the chemical stability and toxicity. The building specifications should require supplier material information. Common building materials can be evaluated whether the material is a good, fair, or poor choice for IAQ.

Construction: This stage may introduce considerable amounts of contaminants into the building at a time when the ventilation system may not be in operation. Suggestions during this stage include letting products air out, install a temporary ventilation system until the permanent one is in place, do as much dirty work as possible outside the building, install materials that could act as VOC sinks last, and clean up during construction using non-toxic cleaners and processes.

Commissioning: The commissioning stage allows the building manager and operators the opportunity to familiarize themselves with the building's design, operation, and maintenance documentation. HVAC systems are checked to ensure that the operational performance meets the design specifications. If possible, the air in the building should be flushed out (with lots of extra ventilation) and/or baked out (by increasing the indoor temperature to speed up offgassing).

Renovations: This stage can introduce considerable amounts of contaminants into the building environment when the workforce is present. Renovation activities should be well contained to prevent contamination. Maximum outside ventilation should be used to dilute and remove the VOC offgassing from new furnishings and finishes. Renovations should account for designed ventilation pattern and changes to room purposes should be reflected in ventilation changes.

6.1.2 IAQ Management Strategies – An Ounce of Prevention – Building Management

Effective communication through the following objectives can encourage occupants to improve their work environment through positive contributions. First, provide accurate information through a health and safety committee about the factors that affect IAQ to help occupants understand how their activities affect IAQ. This committee will be most successful if it represents the diverse interests in the building, including the building owner, building manager, facility personnel, health and safety officials, tenants and/or other occupants who are not facility staff, and union (or other worker) representatives. Second, clarify the responsibilities of each the parties in relation to IAQ. Categories of responsibilities to communicate to the occupants can include use of space, occupancy rate, modifications, and notification of planned activities. These responsibilities can be incorporated into documents such as lease agreements and employee manuals. Third, establish an effective system for logging and responding to complaints should they occur. Occupants need to know how to express their complaints, how to locate responsible staff, and where to obtain complaint forms. Complaints should be handled promptly and given serious attention. A record-keeping system is recommended to track IAQ complaints. [3]

The IAQ manager should develop an IAQ profile of the building—i.e., a description of the features of the building structure, function, and occupancy that impact air quality. This should provide an understanding of the current status of the IAQ and baseline information on the factors that could cause IAQ problems in the future. This will help management fix potential problem areas and to prioritize budgets for maintenance and future operations. The process of gathering information for the IAQ profile includes three major stages: collect and review existing records; conduct a building walkthrough inspection; and collect detailed information on the HVAC system, pollutant pathways, pollutant sources, and building occupancy. The key questions are:

1. How was this building originally intended to function (HVAC and non-HVAC)?
2. Is the building functioning as designed when it was or should have been commissioned?
3. What changes in building layout and use have occurred since construction?
4. Is there a need for additional ventilation due to increased occupants or activities?
5. What changes may be needed to prevent IAQ problems from developing?
6. Do staff members understand how the HVAC system should operate?
7. Has there been a pattern of complaints or other signs of potential IAQ problems? [3]

In order for any HVAC system to operate properly and consistently over its life span, commissioning, testing/trouble-shooting, and maintenance are required. Commissioning is a process in which a new HVAC system's performance is identified, verified, and documented to ensure proper operation and compliance with codes, standards, and design intentions. Commissioning often requires tests and demonstrations to verify that the system operates properly. Testing and balancing is periodically required for all systems. This involves the testing and adjusting of system components to ensure adequate air distribution to the occupied spaces. Specialized knowledge of testing and balancing is required on the complex HVAC systems of today. Simple tasks that building managers should do include becoming familiar with the HVAC systems characteristics; learning the intended or desired operating parameters; and performing ventilation checks with smoke tubes, velometers, and pressure-measuring equipment. One approach that managers can take to become familiar with an HVAC system is to follow the system from start to finish—i.e. a building walkthrough. Go first to the air intakes and follow the air as it flows through the dampers, filters, fans, coils, ductwork, terminal boxes, and supply registers. Then identify return grills and follow the air back to the air handler. The following should be noted: air intake/exhaust, supply/return register, and thermostat locations; damper settings; supply air quality; movement of air; and potential contaminant sources. [11]

Correct operating procedures and maintenance of the HVAC system will ensure its continued and consistent effectiveness. Maintenance is time-consuming and expensive but has proven to be cost-effective. Labor-intensive maintenance requires trained workers, good materials, and good management. The "if it isn't broken, don't fix it" management philosophy represents a false economy. Preventative maintenance programs usually prevent problems before they arise; checklists can be helpful in establishing a good preventative-maintenance management program. Duct cleaning itself can cause IAQ complaints for a short time afterward, but it can be warranted in some cases as preventative maintenance. Ducts can become both the source and the pathway to spread air contaminants throughout the building. ASHRAE 62-1989 and other standards suggest that efforts be made to keep dirt, moisture, and high humidity from ductwork. Filters must be kept in good working order to keep contaminants from collecting in the HVAC system. The mere presence of contaminants in ducts has no effect on the occupants if the contaminants do not leave the ducts and the ducts do not generate odors or other contaminants. [11]

6.1.3 IAQ Management Strategies – An Ounce of Prevention – Building Occupants

Most IAQ problems can be prevented or corrected easily and inexpensively through the application of common sense and vigilance on the part of everyone in the building. Success depends on cooperative actions taken by building management and occupants to improve and maintain good IAQ. Tenants and occupants who are knowledgeable about IAQ can better help building managers maintain a comfortable and healthy building. Occupants should remember that any building might experience periods of bad IAQ. Some factors might be out of everyone's control while many of factors are controlled by both the occupants and building management. Good IAQ is a shared responsibility through good leadership. [2] Leadership is "influencing the activities of others toward goal accomplishment." Any employee, regardless of position in the organization, can provide leadership at the individual, program, or organizational level. [21]

These are some things that almost all occupants can do to improve IAQ: [2]

1. Do not alter or imbalance the HVAC system by blocking air vents or grilles, adjusting the settings on HVAC controls, or disabling HVAC equipment.
2. Comply with the smoking policy and smoke only in designated areas.
3. Water and maintain office plants properly.
4. Clean up all water spills promptly and report water leaks right away. Water creates a hospitable environment for the growth of microorganisms.
5. Dispose of garbage promptly and properly in appropriate containers that are emptied daily to prevent odors and biological contamination.
6. Store food properly. Food attracts pests. Perishable food products should not be stored in the workspace, refrigerators should be cleaned on a regular basis, and kitchen and dining areas should be kept clean and sanitized.
7. Avoid bringing products into the building that could cause odors or contaminants.

These are some things that supervisors and labor unions can do to improve IAQ: [2]

1. Help building management to develop a good IAQ management program. Occupants can provide lots of valuable information because they work in the building.
2. Maintain a good working relationship with building management. Cooperative efforts are the best way to prevent and to quickly solve many IAQ problems.

3. Place office furniture and equipment with air circulation, temperature control, and pollutant removal functions of the HVAC system in mind. Place computers and other heat-producing equipment away from HVAC sensors.
4. Establish a smoking policy that protects nonsmokers from involuntary exposure to secondhand smoke. Design properly ventilated smoking rooms that do not allow smoke to circulate through the ventilation system or to adjoining workspaces.
5. Avoid and provide extra ventilation for procedures and products that can cause IAQ problems. Solvents, adhesives, cleaners, and pesticides as well as copiers, printers, and fax machines can give off pollutants and odors.
6. Encourage building management to ensure safe uses of pest control and non-chemical methods. If a chemical pesticide is selected, it should be used in strict accordance with label directions and baits should be used instead of spraying.
7. Work with building management regarding every aspect of remodeling. Isolating the area to be remodeled from other spaces and the HVAC equipment and working around the occupants' schedules can help to minimize IAQ problems.

Some IAQ problems are often comfort problems and many symptoms, such as headaches, can have causes that are not related to building factors. Occupants might have some control over some factors that affect IAQ or the perceptions of IAQ: odors; heat and glare from sunlight, ceiling lights, or computer screens; furniture crowding; stress in the workplace or home; feelings about physical aspects of the workplace; work space ergonomics; and selection, location, and use of office equipment. Occupants should communicate with building management any time any of the following occur: an IAQ problem is suspected or identified; cleaning or maintenance service is needed; new office equipment will be installed; renovations or remodeling are planned; or when leaks, spills, or accidents are observed. Occupants who are experiencing health or comfort problems that they suspect may be caused by poor IAQ can do the following: inform the building management through the usual and proper channels; talk with their doctor or other health care provider, report the problems to the company physician, nurse, or health and safety officer; and cooperate with management during an IAQ investigation and remedial activities. Finally, occupants should be part of the IAQ solution—rather than part of the problem—by exercising some constraint before talking to government officials, lawyers, or the media.

6.2.1 IAQ Management Strategies – A Pound of Remediation – General Guidelines

Those who can demonstrate their ongoing efforts to provide a safe indoor environment are in a strong legal and ethical position if and when IAQ problems arise. Due to the fear of lawsuits, building managers may understandably be reluctant to share test results or consultants' reports with their tenants or employees, but secrecy in such matters can backfire. It is in the building manager's best interest to respond to all complaints about the indoor environment promptly and seriously and to establish credibility through open communication. Listening and responding to occupants is critical to achieving successful resolution of IAQ complaints, whether the complaints are the result of poor IAQ or other issues such as job stresses. The biggest mistake that building managers can make in the face of an IAQ complaint is to underestimate the problems that can result if the occupants believe that no action is being taken or that important information is being withheld. Without open communication, an IAQ problem can become complicated by anxiety, frustration, and distrust. Management should attempt to be factual and to the point and not give incorrect representations of risk—either worst or best case. [3]

Building managers are often alerted to potential IAQ problems by complaints from occupants. The complaints can be vague, to the effect that people feels "sick" or "uncomfortable" or that someone has noticed an unusual odor. The complaints may be specific, e.g., blaming a particular material as the cause of discomfort or health problems. Occupants are usually reacting to a real problem, so their complaints should be taken seriously and their theories about the problem should be heard respectfully but weighed cautiously. Paying attention to communication, as well as problem solving, helps to ensure the support and cooperation of building occupants as the complaint is investigated and resolved. The messages to convey are that management believes it is important to provide a safe and healthy building, that good IAQ is an essential component of a healthful indoor environment, and that complaints about IAQ are taken seriously. Productive relations will be enhanced if occupants are given basic information during the investigation and remediation, while potential critics can become allies if they are invited to be a part of the problem-solving process and become better educated about IAQ and building operations. Discussion with occupants may reveal patterns that relate the timing of complaints to the cycles of equipment operation or to other events in the building such as painting, installation of new carpeting, or pest control. This can be very helpful for finding intermittent complaints. [3]

An IAQ investigation begins with one or more reasons for concern or an occupant complaint. This process successfully ends when the concern is resolved or the complaints are reduced or eliminated. The goal is to identify and solve the concern or complaints so that it does not recur and does not create other problems. The use of in-house personnel builds skills that could be helpful in minimizing and resolving future IAQ problems and is usually a great place to begin an IAQ investigation. Professional help might be necessary or desirable in the following situations: mistakes or delays could have serious consequences; specialized knowledge, experience, equipment, or skills are useful; an independent investigation is important; or in-house staff have not been able to resolve the problem. As with any hiring process, better knowing one's own needs makes it easier to select a firm or individual. [3] If the problem seems widespread or potentially serious, then it might be advisable to contact the local or state health department.

An IAQ investigation is a cycle of information gathering, hypothesis formation, and hypothesis testing. The easily available information about the history of the building and of the complaints should be gathered first. Next, the known HVAC zones, complaint areas, and key individuals needed for access and information should be identified, followed by notifying the occupants of the upcoming investigation. The initial walkthrough of the problem area should then be conducted; this provides information about all four of the basic factors influencing IAQ and should direct further investigation if it does not provide enough information to resolve the problem. Hypotheses development—potential explanations of the IAQ complaint—is a process of narrowing down possibilities by comparing them with one's own observations. The investigators may think of and pause to consider many hypotheses as they develop an understanding of how the building functions, where pollutant sources are located, and how pollutants move within the building. Modifying the HVAC system or attempting to control the potential source or pollutant pathway to see whether the symptoms can be relieved can test hypotheses. When it is difficult or impossible to manipulate the factors that could be causing the IAQ problem, the hypothesis may be tested by trying to predict how building conditions will change over time (e.g., in response to extreme outdoor temperatures). Spatial, timing, and symptom patterns can provide important clues to help develop hypotheses. The information gathered should be logged and recorded using published forms. Small copies of basic floor plans, such as fire evacuation plans, are convenient for noting locations. [3]

NIOSH, in studies of over 1,300 IAQ episodes since the late 1970s, categorized major causes or sources of IAQ problems (rounded to the nearest ten percent). The results showed that thirty percent related to some indoor air contaminant, such as formaldehyde, solvent vapors, dusts, or microbiological agents. Ten percent could be attributed to an outdoor source, such as motor vehicle exhaust, pollen, fungi, smoke, or construction dusts. Ten percent had no observable cause. Fifty percent related to deficiencies in the HVAC system of the building such as lack or poor distribution of outside air and contaminants in the system. Simple troubleshooting of the HVAC system—the biggest single cause—involves talking to those who are complaining to characterize the problem, gathering background data, and trying to establish causes or sources of the problem. According to NIOSH, common patterns emerge from HVAC-origin IAQ problems, which include: forced ventilation is common; buildings are energy efficient; people perceive that they have little control over their environment (e.g., there is no thermostat in the room); and there are more complaints when population densities are higher. [11] Table 2 lists typical causes.

Table 2. Deficiencies in HVAC Systems and Their Causes [11]

Deficiency	**Potential Causes or Problems**	**Potential Corrections**
Insufficient total air delivery to occupied space	Inadequate fan capacity	Increase fan speed
	Worn fan blades	Replace/repair wheel
	Faulty fan components	Provide maintenance
	Imbalanced air-supply system	Balance air-distribution system
	Increased number of occupants	Increase air; redistribute occupants
Insufficient outdoor air delivered to occupied space	OA dampers set too low	Increase OA; provide fixed minimum OA delivery
	Imbalanced supply/return systems	Balance systems
	OA damper controls broken	Inspect, calibrate, reset controls
	Low heating/cooling capacity	Increase system capacity
Air distribution within space not adequate; improper; insufficient	Improper supply system balancing	Rebalance
	Poorly operating dampers, boxes	Repair, maintain, inspect boxes and control equipment
	Thermostat/controls maladjusted	Calibrate thermostats
	Improper supply-diffuser location	Relocate diffusers or occupants
	Diffusers blocked	Remove obstructions
	Office partitions resting on floor	Raise or remove partitions
	Diffusers/supply-ducts unattached	Inspect, reattach connecting ducts
HVAC components not operating properly	System starts up too late or shuts down too soon for the occupants	Reformat controls
	Filters inadequate	Install and change filters per manufacturers' instructions
	Controls inoperative	Monitor or calibrate; maintain

6.2.2 IAQ Management Strategies – A Pound of Remediation – Fifteen IAQ Problems

The following was taken from Section 7 of U.S. EPA's Building Air Quality A Guide for Building Owners and Facility Managers to illustrate common building IAQ problems. [4]

Problem #1 Outdoor Air Ventilation Rate is Too Low

Examples: Routine odors from occupants and normal office activities result in problems
Peak carbon dioxide (CO2) concentrations above 1000-ppm indicates poor ventilation

Solutions: Open, adjust, repair, or replace HVAC system to ensure proper ventilation
Increase outdoor or reduce the pollutant and/or thermal load on the HVAC system

Problem #2 Ventilation Rate Good, But Poorly Distributed and/or Not Sufficient in Some Areas

Examples: Measured outdoor air meets guidelines at building air inlet, but there are zones where heat, routine odors from occupants, and normal office activities result in complaints

Solutions: Open, adjust, repair, or replace HVAC system to ensure proper air distribution
Seal leaky ductwork, fix return air plenum, and control pressure relationships
Limit activities or equipment use that produce heat, odors, or contaminants

Problem #3 Contaminant Entering Building From Outdoors

Examples: Soil gases such as radon, gasoline from tanks, and methane from landfills
Contaminants from nearby activities or the outdoor air intake is near a source

Solutions: Remove or reduce the source or relocate elements of the ventilation system
Change air pressure relationships to close or control pollutant pathways
Add special equipment to HVAC system such as filters or scrubbers

Problem #4 Occupant Activities Contribute to Air Contaminants or to Comfort Problems

Examples: Smoking and special activities such as print shops, laboratories, and kitchens
Interference with HVAC system operation in response to unresolved problems

Solutions: Communicate through policy setting and educational outreach to eliminate an activity
Install new local exhaust or adjust HVAC system to accommodate the activity

Problem #5 HVAC System is a Source of Biological Contaminants

Example: Surface contamination by molds or bacteria on drain pans, ductwork, or filters

Solutions: Remove source by improving operating and maintenance procedures
Inspect, clean, and replace equipment while using biocides with extreme caution
Provide access to items that must be cleaned, drained, or replaced periodically

Problem #6 HVAC System Distributes Contaminants

Examples: Unfiltered air bypasses loose, poorly maintained, or incorrectly sized filters
Recirculation draws dirty air from soil gases or from high or special-use areas

Solutions: Modify air distribution system to minimize recirculation of contaminants
Minimize air contaminants through improved housekeeping and pest control
Install improved filtration equipment that is properly sized and maintained

Problem #7 Non-HVAC Equipment is a Contaminant Source or Distribution Mechanism

Examples: Non-HVAC equipment such as photocopiers can produce contaminants
Elevators, acting as pistons, can distribute contaminants between floors

Solutions: Install local exhaust near machines and provide adequate makeup air
Separate the machines from the people by space, barriers, or schedules
Change air pressure relationships to keep contaminants out of elevator shafts

Problem #8 Surface Contamination Due to Poor Sanitation or Accidents

Examples: Fungal, viral, bacterial (organisms or spores) in crawlspace or building shell
Bird, insect, rodent parts or droppings, hair, or dander near outdoor air intakes
Spills of water, beverages, cleansers, or specialized products or fire damage

Solutions: Remove sources of microbiological contamination by cleaning and discarding
Modify environment to prevent recurrence of microbiological growth
Provide access to all items and space that require periodic maintenance

Problem #9 Mold and Mildew Growth Due to Moisture from Condensation

Examples: Wall near thermal bridge—e.g., an uninsulated spot around structural member
Carpeting on cold floors and locations where humidity promotes condensation

Solutions: Clean and disinfect to remove mold and mildew—cautiously using chemicals
Increase surface temperatures at locations that are subject to condensation
Reduce moisture levels in locations that are subject to condensation

Problem #10 Building Materials and Furnishings Produce Contaminants

Examples: Odors from newly installed carpets, furniture, and wall coverings and plants
Newly dry cleaned drapes or other textiles and accumulated dust in an office

Solutions: Remove source with appropriate cleaning methods or encapsulate the source
Store new furnishings in a clean, dry, well-ventilated area until VOCs offgass
Replace materials that are producing the emissions with cleaner alternatives

Problem #11 Housekeeping or Maintenance Activities Contribute to Problems

Examples: Cleaning products, painting, caulking, and lubricating emit chemical odors

Cleaning—which may be infrequent—causes particulates to become airborne

Solutions: Remove source by modifying standard procedures or maintenance frequency

Use HEPA (high efficiency particle arrestance) vacuums with local exhaust

Problem #12 Specialized Use Areas as Sources of Contaminants

Examples: Food preparation, art or print rooms, laboratories, and chemical storage rooms

Solutions: Change pollutant pathway relationships keeping the pollutants downstream

Remove source by ceasing, relocating, or rescheduling incompatible activities

Select materials to minimize contaminants while maintaining safety and efficacy

Reduce source by using proper sealing and storage for contaminant-emitting materials

Problem #13 Remodeling or Repair Activities Produce Problems

Examples: Temporary activities and demolition produce odors and contaminants

Adequate ventilation not provided for new occupancy or arrangement of space

Solutions: Modify ventilation to prevent recirculation by sealing off returns in work area

Schedule work for unoccupied periods and keep ventilation system operating

Carefully select and install the materials and request installation procedures

Modify HVAC or wall partition layout if necessary to serve new occupancy

Problem #14 Combustion Gasses

Examples: Vehicle exhaust when near a parking garage, loading dock, or service garage

Combustion gasses from appliances, local chimneys, or mechanical rooms

Solutions: Seal to remove pollutant pathway between the source and occupied space

Repair appliances, prevent back drafting, and relocate or turn off parked cars

Install local exhausts around parking garages and pressurize nearby spaces

Problem #15 Serious Building-Related Illness

Examples: Legionnaire's disease and hypersensitivity pneumonitis

Solutions: Some building-related illnesses can be life-threatening and even a single confirmed diagnosis should provoke an immediate and vigorous response

Work with public health authorities and evacuate if recommended or required

Drain, clean, and decontaminate water sources using protective equipment

Discontinue processes that deposit moisture in the air distribution system

6.3.1 IAQ Management Strategies – A Ton of Litigation – USEPA/NIOSH Plan Summary

Disclaimer: This plan is based upon scientific and technical understanding of the issues presented. Following the advice given will not necessarily provide complete protection in all situations or against all health hazards that may be caused by indoor air pollution. [3]

Step 1: Designate an IAQ Manager

The first step to good IAQ management is to assign the job of IAQ manager whose job is to coordinate all IAQ activities in the building. Having overall responsibility makes it easier to manage the building's IAQ and keep occupants informed and involved. The IAQ manager could be the facility manager, the building operating engineer, the health and safety director, or the employee-relations manager and may be responsible for more than one building. Whatever the job title, the IAQ manager should be given sufficient authority to make decisions and implement improvements. The IAQ manager can come from a variety of backgrounds—no single field encompasses all of the needed principles and skills—but must be familiar with the building's structure and function and sufficiently conversant with IAQ issues to communicate effectively with occupants, facility personnel, and the building owner(s). The IAQ manager may choose to seek assistance from outside contractors or consultants, but should retain primary responsibility.

Step 2: Develop an IAQ Profile of Your Building

The next step in the plan is to document the current IAQ situation and existing operation and maintenance practices in the building. The IAQ Profile describes the features of the building's structure, function, and occupancy that impact IAQ which provides an understanding of the current status of the IAQ and factors that may cause future problems. The two parts include:

1) Identify and Review Existing Records – The records include control system set points and ranges, building renovations, major space use changes, pressure relationships, maintenance records, and complaint logs. Old records can be a useful, but these should be updated or created as needed so that information will be complete and reliable.
2) Conduct a Walkthrough to Assess Current IAQ Situation – This team activity helps to get a good overview of occupant activities and building functions that may impact IAQ. This walkthrough with IAQ in mind is important even for IAQ managers intimately familiar with the building. Seemingly inconsequential items could indicate IAQ problems.

Step 3: Address Existing and Potential IAQ Problems

The purpose of this step is to fix or mitigate all existing or potential IAQ complaints in order to protect the health, comfort, and productivity of a building's occupants. The IAQ Manager does this by identifying current practices or conditions that could, or already do, adversely affect IAQ. The goal of this IAQ investigation is to identify and solve the IAQ complaint in a way that prevents it from recurring and that does not create other problems. It is impossible to prescribe one specific blueprint, but the following general strategies might be helpful:

1) Identify, remove, reduce, seal, or cover sources and/or modify the environment.
2) Improve ventilation to provide fresh air to occupants, and dilute or exhaust pollutants.
3) Improve air filtration to clean air from outside and inside the building.
4) Control occupant exposure to pollutants through administrative approaches.

Some complaints can be resolved very simply while others could require detailed testing by an experienced IAQ professional. Many IAQ problems have more than one cause and may require several corrective actions. In some cases, resolving an IAQ problem may require working with others outside the building. Complicated IAQ investigations are often a repetitive cycle of information gathering, hypothesis formation, and hypothesis testing. The information gathered should be about building occupants, the HVAC system, pollutant pathways, and pollutant sources (sampled if needed). Standard forms are available from USEPA, NIOSH, and HVAC or industrial hygienist textbooks and should be used to document the IAQ investigation. A follow-up validation confirming that the IAQ problem has been solved should be the final step.

Step 4: Educate Building Personnel About IAQ

Educating employees about IAQ issues will help employees, who are often not trained to think about IAQ issues or to recognize potential IAQ problems. For example, staff may observe, but fail to recognize the importance of, unsanitary conditions, blocked vents, evidence of leaks in tenant spaces, or other indicators of potential IAQ problems. Effective education can include structured training courses and materials, distribution of IAQ information and fact sheets, self-training materials, seminars, or informal discussions. In some cases, education can be critical to comply with a law or as a defense in a court case. OSHA requires that employees, who handle hazardous chemicals, be informed and trained about how to read, understand and follow label instructions and Material Safety Data Sheets. These chemicals can be a source of poor IAQ.

Step 5: Develop and Implement a Plan for Facility Operations and Maintenance

Operations and maintenance should be planned considering IAQ because IAQ is affected by the quality of maintenance and by the materials and procedures used. Consider the following:

1) HVAC Operations – This daily/weekly/monthly schedule needs to reflect the actual use of the building, ensuring that the HVAC system is providing ventilation during and before all periods of significant occupancy. This schedule should be a one-stop reference that is complete, easily updated, and accessible to all who need it.
2) Housekeeping – Housekeeping procedures that detail the proper use, storage, and purchase of cleaning materials should be prepared and followed. Be aware of the housekeeping products and equipment used in the building. Purchase the safest available housekeeping products that meet the cleaning needs.
3) Preventative Maintenance – This should include monitoring, inspecting, and cleaning HVAC components such as outside air intakes, outside air dampers, air filters, drain pans, heating and cooling coils, the interior of air handling units, fan motors and belts, air humidification, controls, and cooling towers.
4) Unscheduled Maintenance – The IAQ Manager should be immediately notified when these events require prolonged deactivation or modification of building HVAC equipment. The IAQ Manager should recommend how to proceed without compromising the building's IAQ and should notify the occupants.

Step 6: Manage Processes with Potentially Significant Pollutant Sources

Indoor contaminants can be drawn in from outside or can originate within a building if the contaminant sources are not controlled, even if the HVAC system is ok. Consider:

1) Remodeling and Renovation – These work areas should be isolated to protect occupied spaces from dust, odors, microorganisms and their spores, and VOCs.
2) Painting – Painting can also produce irritating or harmful vapors. Low VOC-emitting paint, which is now commercially available, reduces this threat.
3) Pesticides – Chemical pesticides must be stored, applied, and handled carefully. Integrated Pest Management emphasizes using non-chemical pest management.
4) Shipping and Receiving – Ensure that materials are handled safely and that vehicle exhaust does not enter the building. Vestibules or air locks can be helpful.

Step 7: Communicate with Occupants About Their Role in Maintaining Good IAQ

Early and frequent communication with occupants is important both to prevent IAQ problems from occurring and to secure their cooperation when solving existing problems. It is important for building occupants to understand that their activities can create indoor air quality problems and that their cooperation is critical for maintaining good IAQ in their building. The IAQ Manager should inform tenants, and where applicable building occupants, about building conditions, policies, or activities such as unscheduled maintenance events that may have a significant adverse IAQ impact. The IAQ Manager should also notify occupants when major renovation, remodeling, maintenance, or pest control activities are planned. Tenants and building occupants should notify the IAQ manager when activities are planned that could affect the building's IAQ and should promptly bring unusual conditions to the attention of the IAQ Manager. An example of this communication comes when tenants are planning construction, remodeling or renovation activities; the IAQ Manager should be made aware of these plans in order to review them with the whole building's IAQ in mind. Both parties should use chemicals and materials in accordance with their label instructions and Material Safety Data Sheets.

Step 8: Establish Procedures for Responding to IAQ Complaints

Occupant complaints about IAQ may be vague or specific, but they should always be taken seriously and investigated fully. In many cases, occupants may first alert the IAQ Manager to potential IAQ problems. Establishing procedures for responding to and resolving complaints will ensure that all complaints are handled in a consistent and fair manner. If building occupants know that they will get a response, then they will be more likely to provide prompt, helpful input about building conditions. Clear procedures for recording and responding to IAQ complaints will help ensure that all complaints are handled in a consistent and fair manner and should include the following: logging entries into the existing work-order system; collecting information from the complainant; ensuring the confidentially of information and records obtained from complainants; determining the response capability of in-house staff; identifying appropriate outside sources of assistance; applying remedial action; providing feedback to the complainant; and following up to ensure that remedial action has been effective. The building occupants and tenants should be informed of these procedures and periodically reminded how to locate responsible staff and where to obtain complaint forms.

6.3.2 IAQ Management Strategies – A Ton of Litigation – USEPA/NIOSH Plan Evaluation

Christopher A. Daly [18] compared eight IAQ management plans in the United States and Canada. Daly wrote that USEPA and NIOSH's plan was designed to help building managers and owners prevent IAQ problems and promptly resolve them if they do arise and recommends practical actions that can be carried out by facility staff and/or outside contractors. The USEPA and NIOSH plan is also designed to help building managers and owners integrate IAQ-related activities into an existing organization. The USEPA and NIOSH plan is a long and detailed document, and along with one other IAQ plan, represents the most complete of the IAQ management plans reviewed. Daly believes that the USEPA and NIOSH plan is however, less comprehensive in incorporating non-IAQ environmental factors and people-related factors into its management strategy, although it does contain a section on communications. The USEPA and NIOSH plan does not include diagnostic procedures as part of the plan, but rather as separate procedures. Daly noted that methods of communication to prevent and resolve IAQ problems and the development of an IAQ profile were included in the same document as the management plan. Regarding non-IAQ factors, Daly wrote that the USEPA and NIOSH's plan elaborated in relatively good detail on how factors other than IAQ are important to the indoor environment. These management plans, however, like the others, viewed non-IAQ factors as confounding factors of IAQ, rather than problems in themselves. This is not surprising, since the reviewed IAQ management plans focused on indoor air quality. It is suggested, however, that viewing non-IAQ factors as externalities to the real problem of IAQ represents a fundamental barrier to the management of indoor environments. Regarding communication procedures, Daly wrote that the USEPA and NIOSH plan, along with two other IAQ plans, were the most complete, in terms of communication procedures. These management plans, overall, emphasize the importance of communication procedures, but it is clear that not one of these plans by itself provides sufficient guidance in terms of internal and external communication procedures. Daly suggested that, "extensive media coverage has contributed to the phenomena SBS/MCS has become today. In some cases, building managers have 'allowed the press to diagnose a problem and prescribe a solution even before anyone could be certain a real problem existed' (Hansen 1991). Situations like this result in part from the building managers' inability to communicate effectively with internal and external interests. The keys to successful communications are: openness, candor and adherence to the foremost rule of press relations: *never speculate* (Hansen 1991)." [18]

While Daly seems to believe that the main weaknesses of EPA and NIOSH's IAQ management plan is the lack of focus on non-IAQ factors and external communication, I believe that the main weakness of this plan is that it does not include enough detail about the IAQ manager. Another key weakness of the EPA and NIOSH plan is that it does not adequately address non-technical issues such as human resource management, risk management, and litigation management. Like Daly, I would like to point out the lack of diagnostic procedures, but I think that this was appropriate for IAQ managers because detailed IAQ investigations should be conducted by outside experts. Diagnostic procedures are beyond the scope of a simple IAQ management plan.

I believe that implementing any IAQ management plan could be done using a project management approach until the plan gets phased into the organization's normal, ongoing operations. The USEPA and NIOSH plan did not discuss how the plan could be implemented. This paragraph introduces key aspects of projects and project managers to suggest how the USEPA and NIOSH's plan could be efficiently implemented in most organizations. The Project Management Institute has defined a project as a temporary endeavor undertaken to create a unique product or service. The ability to meet performance, time, and cost goals is rarely known with certainty at the project start. A project should be created when an organization's functional departments cannot achieve the desired outcomes alone. A project focuses the responsibility and authority for the attainment of specific goals by a project manager and project team (e.g., an IAQ manager and IAQ committee) whose major responsibilities include dealing with the uncertainty. The project manager often lacks the authority that is consistent with the assigned level of responsibility and therefore must depend on the goodwill of functional managers for some of the necessary resources. Three major questions face the project manager. What must be done, when must it be done, and how to acquire resources to complete the project? The project manager is expected to integrate all aspects of the project, ensure that the proper knowledge and resources are available when and where needed, and above all, ensure that the expected results are produced in a timely, cost-effective manner. Valuable project-manager leadership skills are technical and administrative credibility, political sensitivity, and an ability to get others to commit to the project. Project management tools—including work breakdown structure, linear responsibility charts, network techniques (PERT and CPM), Gantt Charts, computerized project management information systems, project audits, and final project reports. [9]

7.1 Case Study #1: Odors, Dust, and Missing Old Office Play IAQ Roles

This IAQ case study is about an expensive, new building with IAQ complaints from a lot of people that appear could be caused by mainly by technical and non-technical factors rather than by poor IAQ. The following is taken from an article in the Los Angeles Times. [26]

Soon after the new 10-story Los Angeles Airport Courthouse opened—finishing four years behind schedule and nearly $40 million over budget—about 60 employees in a staff of about 200 people reported IAQ-related health problems. County officials, worried about the $107-million building, hired a team of environmental consultants to conduct a series of exhaustive chemical tests and confidential interviews with employees. The $30,000 study concluded that the reported health problems were real and stemmed in part from leftover construction dust and the lingering smells of new paint, carpeting, and furnishings. But compounding all that, the report concludes, was the psychological trauma that some staffers felt in reluctantly leaving their old offices. The old building was at a decades-old, breezy beachside courthouse with a very pleasant view. The new building is in an industrial district less than a mile from an airport runway. One occupant said that he loved that building, even though it's funky, rickety, and broken down because at least he could open the windows and get fresh air. Other discomfort complaints included a lack of privacy in the open floor plans, increased noise, and sun glare on computer screens. One supervisor said it is outrageous that every conversation can be heard down the hall.

Employees on the first two floors, however, said that they knew nothing about the environmental study and had experienced no health problems since moving in and one of them suggested that the complaints boiled down to resistance to change. The architect said that the design reflects the recommendations of county courthouse staff for an open and user-friendly building. Officials insist that they are taking the complaints seriously and have carefully avoided saying the causes are completely psychological. Officials noted that the complaints have been decreasing and have credited the decrease to the recent completion of the building's cafeteria and register-recorder's office on the lower floors. Building maintenance workers increased the fresh-air circulation to get rid of odors from construction materials and new office furnishings even though the ventilation was fine before, but the complaints continued. A consultant tested for hundreds of pollutants, but the results showed that there was nothing abnormal or dangerous.

Evaluation of Case Study #1

Enough employees are affected to classify this a sick building. This technical/non-technical problem could probably have been prevented by the architect, the building managers, and by the occupants; these are all tied together. The technical components appear to include a new building not designed for good IAQ, whose construction was poorly planned or managed, and which was not properly commissioned. The architect seems to pass the blame by implying that the occupants did not know what they wanted—which was probably true. The parties should have communicated better during the design process and should have tried to realistically predict consequences of design decisions. The building managers and planners should have reconsidered spending a lot of money to construct a new building at a new site without enthusiasm from the majority of the occupants. The budget and schedule overruns probably encouraged the project manager to cut corners to minimize damage, but which created other problems. Occupants should not have moved into the building until after construction was either complete or isolated, and preferably after the building was commissioned. The non-technical components are also very important in this case and should be have been incorporated into an IAQ action plan much sooner. Effective communication, developing an IAQ profile, and educating the parties about their IAQ roles are prevention steps in an IAQ action plan.

I have seven opinions regarding this case. First, problem prevention is a very important part of IAQ management that starts before the building is ever constructed. Second, managing IAQ management is an art as well as a science, and a social science as well as a natural science. Third, people can be hesitant to change, especially when forced to because we can become very attached to our space. Forth, stressed occupants are probably more sensitive to poor IAQ, perhaps due in part to weakened immune systems. Fifth, the nose can sometimes measure and quantify bad odors better than monitoring devices, and can be irritated by short-term odors that might go undetected by long-term tests. Sixth, another big psychological component seems to be an us-versus-them culture of this organization. The people inside the building seem separate from the managers who seem to work elsewhere while the occupants on the lower two floors seem separate from the occupants on the upper floors. Seventh, effective communication and some action (physical or administrative) can help to show some good will and eliminate some of the us-versus-them mentality and should make solving the technical problems a lot easier.

7.2 Case Study #2: Workers Say Diesel Smell Endangering Their Health

This IAQ case study is about a courthouse built on a diesel-fuel contaminated site by the former landowner that intermittently creates obvious IAQ problems for a county that claims that it has little money and no liability. The following is taken from an article in the Bismark Tribune. [27]

An on-again, off-again smell of diesel fuel in a law enforcement center in North Dakota is more than a nuisance to many of the employees. In 1998, three of the employees became so sick that they had to quit working there at their doctor's insistence. Eighteen others have also filed complaints about the problem and have joined the lawsuit. Their doctors and their lawyer—noting many similarities in symptoms—said that there is no doubt that their health problems are from diesel fumes permeating the law enforcement center for several years, especially during times of a high water table. The sick employees said that they were spurned for months as "all in her head," a "personality problem," or because they were "uniquely sensitive." The lawyer said that his clients were all previously healthy people who for a long time did not want to admit that they were getting sick. The lawyer's experts said that they could smell the diesel fumes from outside and asked how people could keep working there. Their lawyer noted a memo from the police chief telling the employees not to talk to the news media about IAQ and a memo from the local health inspector saying that long-term exposure to diesel fumes is not dangerous.

The police chief and the emergency management director said that they've done everything they can to find out why their employees are sick, that there's no proof diesel has anything to do with it, and that they would like to have answers, too. They hired their own experts who concluded that there is no harmful diesel fumes in the building who said that just because there's a noticeable odor doesn't mean there's a measurable concentration and that the odor does not necessarily correlate to hazardous levels. They said that employees should not be blaming the county even if diesel was the problem because the county did not put the diesel in the ground and that they have to balance helping employees with fiscal responsibility to the taxpayers. They later had some of the employees relocated while the building owner paid for extensive renovations. The police chief thinks the appearance of an obvious diesel problem ignited people's concerns after nine years of silence. The fumes resulted from of a big diesel spill that was discovered, and ignored, in 1984 when the county constructed the building.

Evaluation of Case Study #2

It is good IAQ management to keep air intakes away from diesel exhaust and from fuel tanks as much as possible. The fact that the complaints about the diesel smell occur during high water tables seems to show a clear pattern that diesel fuel is very likely the source of the complaints although there may also be other sources. This problem could probably have been prevented by the architect, the building managers, and by the occupants either together or separate. Many of the steps that could have been taken for prevention can be taken from remediation, but at a much higher cost. County officials might have been foolish and/or ignorant to construct a building on a site that they knew was contaminated with diesel fuel. The county should have researched the history of the property and/or had the property tested for likely contaminants so that they did not purchase the property to begin with. If the county already owned the property, then they could have either avoided building on it or at least installed depressurization and ventilation under the foundation before construction to decrease the amount of fumes that could get into the building. Ground-water monitoring wells near the foundation would have also been helpful to establish an image of the spill before making building decisions. After becoming aware of the diesel contamination, the county should have tried to remove the source by making sure that diesel cannot easily get into the building, provided more ventilation, and/or cleaned the indoor air.

I have five opinions regarding this case. First, the occupants certainly have a valid reason to complain about diesel fumes. Building managers are also correct that small, local governments usually do not have very much money. Voters/tax-payers might blame poor management if emergency funds are requested. Second, trying to save face by covering up foolish decisions and fear of having to clean up a contaminated site might partly explain why this problem has been ignored for so long. Poor managing of private or public resources is a lot more expensive in the long run for a lot of reasons—i.e. these county managers are not saving the taxpayers money. Third, the managers should provide flexibility by allowing them to work in safer places until these strategies prove to fix the IAQ problem and should consider allowing sensitive employees to transfer to other agencies or retire early. Forth, the managers should work more in the building and communicate better with their employees. This could provide some very practical IAQ education. Fifth, the managers have already spent too much time and money studying the IAQ complaints. Leaders seldom have overabundant information before making decisions.

7.3 Case Study #3: Claims Have OSHA Checking Lockheed

This IAQ case study is about a serious list of IAQ and environmental complaints at Lockheed in Georgia that OSHA and union leaders believe is open and forthcoming about information but slow to take action. The following is taken from an article in the Marietta Daily Journal. [28]

The following is a list of complaints on Lockheed Martin Aeronautical Systems Company that was submitted to the Occupational Safety and Health Administration: two employees have contracted Legionnaires' disease; the rare vacuuming just stirs dust and debris in the air; asbestos is present in almost all of the building structure; dust and residue from outlet vents are visible on furniture, papers, and floor; respiratory illnesses seem to be unusually prevalent at all times of the year; cockroaches are numerous in the rest rooms and hallways; pooled water on the floors and counter tops is also prevalent; trucks and automobiles send exhaust into the stairwells and office areas; and noxious fumes from paint chambers make the air unfit to breathe. An allegation of unsafe conditions is all that's required for a non-formal complaint letter to be sent to OSHA. OSHA often steps in when employees fear their company's assurances about a safe workplace are unfounded. However, the non-complaint letter gives companies a chance to tell their side of the story before OSHA takes action. If the company shows that these allegations have no merit, then OSHA would close the case. This is a method to address the complaints without putting a company into jeopardy of penalties, until the evidence is in that we need to do this. OSHA said that they would investigate the complaints and would go in if the complaints were founded. OSHA follows up about 500 of IAQ complaints per year.

A Lockheed official said that the charges in the OSHA letter are inaccurate, but said that the company will nonetheless respond. A Lockheed spokesman said that they are going to look into the allegations and that the safety environmental unit at the plant is very proactive and is always out there testing. Both machinist's union leaders and OSHA officials have praised Lockheed management for being open with information. OSHA also believes that Lockheed has been actively involved and has been forthcoming with information since the first day we believe they became aware of the situation. Lockheed quickly responded to the first complaint by testing the water in the plant. One of the complaints of Legionnaires' disease was unfounded and Lockheed does not believe that the other employee contracted the disease at the plant.

Evaluation of Case Study #3

The complaints in this case seem to clearly match many of the fifteen problems discussed in this report. [4] Contaminants could be entering from outdoors by car exhaust and paint chambers (problem #3). The HVAC system could be a source of biological contaminants, whereas dust and residue from the air outlets could confirm that the ducts are dirty (problem #5). The HVAC system could be distributing contaminants if the building's air intakes are near outdoor sources or near puddles of water (problem #6). The plumbing fixtures that have yellow water that smells bad could be a contaminant source or distribution mechanism (problem #7). Surface contamination from cockroaches (e.g., their wastes or insect parts) and the pooled water from the leaking plumbing fixtures could be causing surface contamination (problem #8). The puddles of water from the leaking plumbing fixtures or possible condensate from the air conditioner that some of the occupants said are not maintained properly could be causing mold and mildew growth (problem #9). The building materials and furnishings are probably not offgassing if they are old, but they (e.g., the carpets, walls, and furniture) could act as pollution sinks from the past that could linger even after the source is removed (problem #10). The rare vacuuming that just stirs up dust is a sign of poor housekeeping (problem #11). The noxious fumes from the paint chambers that are vented outside but could be drawn back into the building are an example of specialized use areas as a source of contaminants (problem #12). Any future remodeling or repair that stirs up the asbestos in the building structure could be disastrous (problem #13). The combustion gases from automobiles could a source of IAQ complaints (problem #14). The two complaints of Legionnaire's disease are a serious building-related illness (problem #15).

I have two opinions regarding this case. First, I understand that this employer provides high-paying jobs to the employees, a good tax base for the community, and an important product for the nation creating a big hesitation by employees, community leaders, and politicians to make this employer unhappy. This must be difficult issue for labor unions, which want both high-paying jobs and good working conditions. Second, steady pressure by OSHA can do a lot to help Lockheed to improve IAQ, even without specific or strict IAQ regulations because these complaints seem easy to document and appear serious enough for OSHA's limited resources. The human-resource department should be the first to hear the IAQ complaints while the media should be the last option because the media can hinder party communication and shatter trust.

7.4 Case Study #4: Sick-building Syndrome at Southwest Airlines

This IAQ case study is about black mold that is 200 times above OSHA limits at an office building that has aspirin routinely available with some workers that have alleged cover-up and deception regarding the mold. The following is taken from an article in Time magazine. [7]

Interviews with 14 current and past employees of Southwest Airlines, as well as building-inspection reports, suggested that this workplace is a "sick building" whose closed-circulation air supply has been contaminated by toxin-producing molds and bacteria. Headaches became so common that many aspirin-popping employees began routinely getting aspirin at the office. Ambulances often arrived to treat people for breathing problems, fainting, seizures, and even strokes. By the time the first clean-up attempt was made in 1994, workers say that fungi were literally dropping out of the ceiling vents into their coffee. All of the renovations, including removal and replacement of mold-infested carpeting, ceiling tiles and wallboards, and chemical scouring of the HVAC system, were done while employees were working. Southwest Airlines terminated Bernice Polansky for failing to return to work after her medical leave was all used up. Ms. Polansky and the other half a dozen employees who have spoken out about their health problems are consumed by mounting medical and legal bills. This appears to have created a widespread reluctance among employees to speak openly about the problem, especially if they could feel stranded without a job. A few employees told reporters of documented problems and cover-ups. The Air Transport Union believes that their hands are tied because no one is filing formal complaints, but there are rumors that the union has unofficially discouraged them from speaking out, noting that $20-per-hour jobs with profit sharing are hard to find in San Antonio.

Southwest Airlines undergoes annual cleanings and monthly inspections and says that they are "known as a company that cares for its people." Inspection reports from 1995 and 1996 noted active molds and bacterial levels 200 times higher than OSHA's suggested contamination threshold. The 1996 IAQ report prepared for Southwest Airlines' insurance company, rated airborne spore-counts as "normal" compared with those outside. Despite these expert reviews, Southwest Airlines maintains that the company is the victim of a litigious campaign by a biased observer known for diagnosing sick-building syndrome. Southwest Airlines' countercharge that Ms. Polansky is an opportunist whose medical problems are unrelated to the building.

Evaluation of Case Study #4

The complaints in this case seem to match some of the fifteen problems discussed in this report. [4] Some occupants think that the outdoor air ventilation rate is too low (problem #1). If Southwest Airlines monitoring indicates that there is enough circulation with enough outdoor air, then it could be that the air is poorly distributed or is not sufficient in some areas (problem #2). This mold problem seems too big to be caused only by the HVAC system, but this could be part of the problem (problems #5 and #6). Mold and mildew growth due is definitely a big part of the problem, and these need moisture to grow, and the moisture could be coming from condensation (problem #9). The building materials and furnishings seem to producing contaminants, but seem to be more of a symptom rather than the problem (problem #10). The remodeling and repair work that was done while employees were in the building could be a big part of the problem (problem #13). The most applicable remediation guideline in this case could be to hire an outside expert to solve the cause of the mold problem and then to treat the symptom.

I have three opinions regarding this case. First, I believe that the cause of this problem is probably vapor barriers installed improperly and/or there is too much uncontrolled airflow through the building envelope. Climates with the highest potential for moisture problems from condensation are cold, dry climates and hot, humid climates because of the huge differences in relative humidity between the outdoor and indoor air when the outdoor air is heated or cooled to room temperature. Moisture problems can also cause structural damage to buildings, which occurred in this case. Replacing the water-damaged materials will not solve the moisture problem without proper vapor barriers and uncontrolled ventilation because moisture within walls and ceiling can reaccumulate within weeks or months, depending on the weather. If the architect or contractor who designed or constructed this building were from a region that is not hot and humid, then I would be even more suspicious. Second, I understand that educating the employees before the problem is resolved could make this IAQ problem worse by adding to the perceived risk. Educating the employees before fixing the problem is most helpful when the employees can best implement a solution or are contributing to poor IAQ (problem #4). Third, the higher wages seem to be “golden handcuffs” for employees who are tempted to turn a blind eye to poor working conditions. It appears that these shortsighted employees became addicted to higher wages and the shortsighted managers became addicted to sloppy management.

7.5 Case Study #5: Mold to Blame for Work Illness

This IAQ case study is about lots of mold complaints that occurred after flooding. The building owner agrees that mold is probably causing an IAQ problem, but believes that the occupants' responses are exaggerated. The following is taken from an article in the Sacramento Bee. [29]

Employees returned to work at the office at California Job Journal after Thanksgiving weekend 1999 to find a burst bathroom pipe and hundreds of square feet of carpet submerged under water and the whole office stinking like a truckload of unrefrigerated meat. Next, the office workers started having allergy attacks following more severe health problems with no explanation and a mounting number of employee absences shortly after the flooding event. The employer did not quickly respond to the chronic nosebleeds, migraines, ear infections, and respiratory trouble. One of the occupants noted that she first encountered mold spores at work shortly after heavy January rains caused water to seep into the building. Within a week, this tenant's face broke out in hives so severe that at times her eyes swelled shut, and her staff began experiencing many of the same symptoms. The hives subsided since she moved but her business never recovered. An environmentally sound move in severe cases can be costly and time consuming, partly because spores can remain in paper, upholstery, and even phones and fax machines long after the move.

The landlord eventually sent a crew to dry out the building. The editor of California Job Journal hired an industrial hygienist to test the air after it became clear that there was a pattern of illnesses with no explanation. The culprit appeared to be mold, which is common when there is excess moisture in poorly ventilated buildings. The chief of occupational medicine at Kaiser Permanente in Sacramento said unlike most potential mold cases, this case appears to be conclusive. Armed with this assessment, the editor asked her landlord to relocate her business. They complied, but the new site was also mold-infested as noted by other tenants. The building owner said that he believes that the allegations are grossly exaggerated and that it is their policy to refrain from providing specific responses to the media for disputable allegations. He hired a company to spray fungicide at a mold growth inside a damp wall cavity about a week before the hives outbreak. Specific provisions were not negotiated in the lease to address mold or indoor air quality, which could have been the tenant's best protection. OSHA could not help because there are no medical tests that can positively link specific health symptoms to a mold outbreak.

Evaluation of Case Study #5

EPA and NIOSH's IAQ Action Plan [3] could have been very helpful to minimize the damage in this case. I believe that the steps that could have been the most helpful were steps 1, 3, 5, and 8.

Step 1: designate an IAQ manager. The tenant was too sick to effectively manage this case. There should have been a leader to serve as a single point of contact. The tenant could have hired a person to perform this duty as a secondary role if none of here staff were qualified.

Step 3: address existing and potential IAQ problems. Every water-damaged material should have been quickly identified and discarded. The ventilation rate should have increased until the building dried. The building owner could have considered administrative approaches.

Step 5: develop and implement a plan for facility operations and maintenance. This should be done more carefully and vigorously after IAQ complaints are founded. These procedures can not only help dry and clean, but they can help to identify specific solutions or problems.

Step 8: establish procedures for responding to IAQ complaints. It seems there was poor communication between the occupants and the building owner so that both of these parties could probably have benefited from this step after an IAQ manager was designated.

I have three opinions regarding this case. First, I wonder if some of the occupants could have been sensitized to mold when it was not quickly cleaned up. According to Dr. Claudia Miller of the University of Texas Health Science Center at San Antonio, repeated exposure to mold and bacteria toxins may hypersensitize people to the point that they react to even low levels of these toxins. It may also weaken their tolerance to everyday chemicals in car exhaust, perfumes, cleaning agents, and some foods and drugs. [7] Second, the building owner appeared to greatly underestimate the amount of damage that water can cause. It is important to control moisture and relative humidity in occupied spaces because the presence of moisture and dirt can cause molds and other biological contaminants to thrive. This includes moisture from water-damaged materials that are not dried promptly (usually within 24 hours). [3] Third, I believe that all three parties could have done a lot more to minimize this IAQ problem. The building owner should have tried a lot harder, a lot sooner to repair the water damage. The building managers should have assisted with drying up the water-damaged building and considered trying to partially recover the costs later from the building owner. The occupants should have requested alternate work arrangements, helped more with the cleanup, or quit sooner to protect their health.

7.6 Case Study #6: State Employees Blame Building for Health Woes

This IAQ case study is about a State building in Anchorage, Alaska where about 40 out of 200 occupants complained about the IAQ shortly after moving in a building that the other tenants think has good IAQ. The following is taken from an article in the Anchorage Daily News. [30]

For years, many of the 200 office workers at the Alaska Division of Energy at the building have complained regarding symptoms that they believe were caused by bad IAQ. The building's heating and cooling system broke, exposing workers to alternating blazing hot and frigid cold temperatures, adding to the problem. One worker jumped right back out of a coworker's office when his eyes began tearing and burning and he said that he was "kind of like the parakeet" referring to the canaries that coal miners sent into tunnels to check for the presence of poisonous gases. The point person on building problems for these workers has a stack of complaints an inch thick, including a 1992 letter from a union shop steward threatening a walkout because of cold offices. She received about 40 complaints filling more than 20 pages when she asked workers to submit their concerns via email. The Alaska Division of General Services Director said that the situation had become potentially volatile since the state moved into the building in 1990. The director, who oversees about 380 state leases throughout Alaska, said that this building ranks as the most problematic in terms of state workers unhappy with their workspace. The director's staff wrote a sternly worded letter to the building's manager stating that the indoor air quality in the building did not comply with the lease. The State of Alaska leases more than half of the 88,000-square-foot, 27-year old building that was originally built as a small mall.

Not everyone who works in this building thinks something is wrong, however. The owner of a private business in the building who has been in the building since the mid-1970's said that they have not experience any problems, smelled any bad odors, nor felt any discomfort. The owner of another business said that they have not experienced any problems and that the state workers are "blowing it out of proportion." The building owners said that they are doing everything that they can, noting that they have looked into every complaint seriously even though they have not found any bad odors. A spokesman added that they are very motivated to correct the problem adding that that they want to keep their tenants. Plans are in place to spend about $120,000 to fix and replace the building's air exchange units and clean the ventilation system.

Evaluation of Case Study #6

EPA and NIOSH's IAQ Action Plan [3] could have been very helpful to minimize the damage in this case. I believe that the steps that could have been the most helpful were steps 2, 4, 6, and 7.

Step 2: develop an IAQ profile of the building. The owner should develop this profile for the entire building, not just the State's portion. This step is important when a building is used differently or remodeled and is an important first step for investigating IAQ complaints.

Step 4: educate building personnel about IAQ. This step is important because the cause of the IAQ complaints is not clearly known and the occupants could be very helpful at finding the cause. Also, these occupants might have less fear and distrust if they are part of the plan.

Step 6: manage processes with potentially significant pollutant sources. This step can be done by process of elimination, starting with the most likely sources. This step can start with the building owner, but should be delegated to an IAQ expert if likely sources are not found.

Step 7: communicate with tenants and occupants about their role in maintaining good IAQ. The occupants could be contributing to or causing a potentially significant pollutant source. This step can be a great follow up to step 4 and can be an efficient way to collect IAQ data.

I have four opinions regarding this case. First, this case seems to show that this case is typical compared to the rules of thumb in the economics background section of this report. For example, the occupational density in this case is based on approximately 200 occupants per 44,000 square-feet. This is less than 5 occupants per 1000-square-feet, which is less than the 7 occupants per 1000-square-feet recommended by ASHRAE 62-1989. Second, the State director could have used his leverage to threaten to cancel the lease and/or not to renew their lease and then carried out this threat if the building owners were unresponsive. The building owners should have done this early on by taking a lot more visible action to show that they care about the IAQ. The building owners probably measured response times on very different scale than the occupants and might not have been keenly aware of the lease conditions. Third, I think it is possible that compared to the retail workers in the rest of the building that did not complain about IAQ, professional government employees could be more sensitive to and less fearful of complaining about IAQ. If this is true, then the building owner might have won the competitive building-lease bid by not including IAQ into the total cost. Fourth, the broken HVAC system that was not quickly fixed could have provided some tangible reasons to justify IAQ complaints.

7.7.1 Case Study #7: ADEC's Fairbanks Office – Synopsis

The Alaska Department of Environmental Conservation's Fairbanks office moved into its current, $23,000 per month leased building in 1993 with a five-year lease with up to five one-year renewals allowed in the lease contract with Bill Beistline's rental company. [31] ADEC is currently on the final year of the one-year extensions and is negotiating with the building owner about renewing the lease for another ten years. The main part of the building, which existed since before ADEC moved into it, consists of a main floor, a top floor, and a daylight basement each with equal floor space and the floors built directly on top of each other. An elevator was installed the building in 1993 prior to ADEC moving into the building to comply with the ADA requirement to make the building handicap accessible. At ADEC's request, a 1,700 square-foot garage was added onto the building in 1996, and an equal area of office space was added above the garage's tarred roof in 1997. [31] The space above the garage provides one small conference room plus workspace for about 10 employees and connects to the main building by a hallway; the garage has only outside entrances and is not connected to the building by a hallway. The building is heated by a forced-air, constant-air volume, quadruple-zone system—one zone for each of the three floors in the main part of the building and one zone in the office space above the garage (the garage is unconnected to these zones). The half of the parking lot closest to the building was paved in summer 2001. These are the only renovations since 1993. This 15,600 square-foot building provides workspace for about 70 employees. [31]

The first IAQ complaints at this building came in 1999 from some employees in the office space above the garage. [32] ADEC notified the building owner, Bill Beistline who hired John Hargesheimer's company—Nortech Environmental & Engineering Consultants—to investigate the complaints and make recommendations to eliminate the most likely potential causes. All of these recommendations were implemented and there were no further complaints until spring 2001. [31] Nortech did a more thorough investigation in 2001 and made several recommendations to try to eliminate every potential source; all of these recommendations were implemented. There have not been any complaints since 2001, but ADEC does not yet considered this investigation closed. [32] Following this synopsis, this case lists a chronological summary, summarizes the technical aspects of Nortech's 2001 inspection report, reports the interview results of the three main parties, and concludes with an evaluation of this case.

7.7.2 Case Study #7: ADEC's Fairbanks Office – Historical Summary

The following was taken from an attachment from an ADEC letter regarding this case. [33]

1) April 15, 1999: First report of an IAQ problem in the office over the garage. Staff experienced headaches, sore throat, lethargy, and dizziness. Area was evacuated; staff worked at home or in another location in the main part of the building. Owner investigated the fresh air vents, the crawl space below the office space, and chimneys.
2) April 19, 1999: The employees returned to work area but were having the same symptoms after being in there for a while. The office manager recommended that the building owner hire an industrial hygienist to come in and monitor the air quality.
3) April 21, 1999: Owner hired Nortech Environmental & Engineering Consultants who measured carbon dioxide, temperature, relative humidity, and carbon monoxide.
4) April 23, 1999: Nortech completed a building inspection and investigated a number of sources. Nortech interviewed all of the staff members who worked in the area where the air quality problem was reported. The air handling equipment intake was modified to ensure that stack gasses were not entrained, which was confirmed by carbon monoxide monitoring. Air sampling was undertaken in both the office space and the confined (crawl space) under the floor of the office space above what had been a hot-mopped roof. Monitoring in the office space was focused on the indoor air, the carpet, and air outlets. Sampling for VOCs were all non-detect in all locations. All results for regulated compounds reported were a minimum of 3 orders of magnitude less than the most stringent criteria, of either the regulatory or recommended limits during the test. The project update indicated that certain individuals may be "hypersusceptible or otherwise unusually responsive to some industrial chemicals" even below threshold limits.
5) April 29, 1999: Lab results for VOC analysis confirmed the April 23rd findings.
6) May 10, 1999: A letter from B-Line Construction Inc General Contractors—i.e. another company owned by the building owner and Nortech's subcontractor for this project—indicated the types of remediation that were done to resolve the IAQ problem. There were four items covered during this early part of the investigation, the first before and the rest after Nortech's April 29, 1999 request. First, the air handler was checked for leaks, and although none were found, the air intake was rerouted to ensure that no chimneystack fumes were entering the building. The cost of this remediation was $2095.77, including

material and labor. Second, a continuously operating fan, between the old roof and new floor was installed that allows for a complete air change of this plenum in less than an hour and also creates a negative pressure under the floor to prevent fumes from coming from the garage or the plenum. Third, cleaning chemicals used by the custodian were considered, but quickly ruled out because few, simple cleaning chemicals were used and the spatial and time patterns were not consistent with the IAQ problems. Fourth, the capacity of the air-handling unit was measured and calculated, and it met the minimum requirements. The final recommendation was for a more comprehensive final report at the discretion and at the cost of the State of Alaska; previous costs were to the building owner. The following from this letter summarized the building owner's s perspective: "I have tried to respond quickly and responsibly to any and all complaints that I receive, and I am sensitive not to lightly dismiss matters of health and safety. However, there needs to be some level of common sense to dictate how much investigation and reports are needed, and to determine when enough has been done. I sincerely believe, from what has been learned, that there was never a level or duration of exposure to any hazardous substance, that would cause a threat to the health of the occupants of that space. Furthermore, the possible sources of the odor that have been identified, have been eliminated, and I would hope that more work or expense that cannot be justified would not be required of me. I still intend to cooperate fully with all of your requests, and address any of your concerns."

7) May 14, 1999: Nortech's further lab results for 28 VOCs indicate that the air is safe.
8) Spring 2000: No air problems noted.
9) February 28, 2001: Four office workers above the garage complained about headaches and two of these also complained about irritated eyes due to a smell. The building owner investigated the crawl-space fan, the vents, the boiler, and the filters. No problems were detected. The affected workers were relocated or they telecommuted to work.
10) March 1, 2001: Three other office workers above the garage complained of similar symptoms. A boiler service technician investigated but found no problems.
11) March 2, 2001: The more sensitive office workers above the garage notice the odors quicker than others, but eventually they all seem to get at least one symptoms.
12) March 5, 2001: The problem still persists even after the weekend.

13) March 6, 2001: The building owner and service technician continued the investigation. They did notice that sometimes the fresh air vent does not open enough.

14) March 7, 2001: A moisture problem was investigated, but the odor seemed to be coming from the hydraulics from the elevator and partly from the idling cars outside.

15) March 8, 2001: No carbon monoxide is detected. Early workers noticed that the odor seems to get bad about 8:30 a.m. when more people start coming to work.

16) March 9, 2001: The odor was noticeable even at 7:30 a.m. The elevator technician said that he thought that it also smelled like exhaust. The Alaska Department of Administration was informed of this IAQ problem.

17) March 12, 2001: The building owner noticed that the exhaust gas from cars goes into the office space above the garage and that the fresh-air vents might be slow to open during cold weather. He measured temperatures and times of day to try to find a pattern.

18) March 15, 2001: Lots of carbon monoxide monitoring done with little found.

19) March 21 – 22, 2001: More VOC testing done during warmer temperatures.

20) March 28, 2001: One office worker said that her doctor found toxins in her liver and she said, "You know I had that once before and it was two years ago when we had this air problem." She is getting numerous symptoms that she didn't have before.

21) April 3, 2001: Air-pressure theories were tested. Possible moisture problems found by water leaks, frost, and condensate. These were considered.

22) April 16, 2001: Employees noticed a propane-like odor in the afternoon when they stand up. The odor problems continue to get worse causing symptoms even after only a few minutes of exposure in the office space above the garage. Nortech stated that there were, "several air ionizers running in DEC and that affects the balance system."

23) April 23, 2001: Letter from Alaska Department of Labor to ADEC notified ADEC of the recent IAQ complaints that have continued since April 1999. The letter recommended that a competent maintenance assessment be performed on the ventilation system of the building by whoever is responsible. This letter requested further investigation and notification of the results of the investigation. This letter indicated that the affected employees have been advised that Alaska Statute AS 18.60.089 provides that "No person shall discharge or in any manner discriminate against any employee because such

employee has filed any complaint, or because of the exercise by such employee on behalf of himself or others of any right afforded by this Act."

24) April 26, 2001: The symptoms continue to get worse so that only one person can work in the office space above the garage, who is the only person with opening windows.

25) May 9, 2001: Nortech completes their IAQ investigation and submits their report to the Building owner, which is given to ADEC the next day.

26) May 14, 2001: ADEC sent a letter to the Alaska Department of Labor in response to their April 23, 2001 letter. This letter included a chronological history of the IAQ problem, indicated how ADEC and the building owner responded to the complaints, and indicated that ADEC intended to address each of Nortech's recommendations.

27) May 24, 2001: The Alaska Department of Administration sent a letter to the building owner thanking him for the extensive work that he contracted for to troubleshoot the IAQ the building's IAQ concerns. This letter indicated approval of the extensive engineering study and of the building's "deep cleaning." This letter indicated that ADEC would be requested to remove all ozone air purifiers and to repot all personal plants with safer soil. This letter requested all future complaints to be forwarded directly to their office. The letter concluded with: "I want to emphasize that the State of Alaska is grateful for the work you have done to insure that our employee work in a safe, sound and sanitary facility. We will do our best to continue to be good tenants."

28) July 3, 2001: The Alaska Department of Administration sent another letter to the building owner thanking him for meeting on June 6 during an inspection trip to the building and for the tour of the building. A letter indicated that the State of Alaska is convinced that the "sweet" odor that was present in the suites was from the overflow of the hydraulic fluid during normal maintenance of the elevator. The building owner eradicated the overflow and installed a "pit" with leeching gravel that is checked regularly by your maintenance people. Again, I want to thank you for the extensive engineering work you have completed in this lease to determine the air quality standard. Mr. Hargesheimer, PE, CIH did an outstanding job and the report is conclusive, concise and direct." Finally, this letter mostly gave the building good comments on carpet and paint, ADA compliance, comfort and lighting, maintenance and janitorial, parking, and aesthetic issues.

29) Spring 2002: No air problems noted as of the date of this project report.

7.7.3 Case Study #7: ADEC's Fairbanks Office – Interview with a Building Manager

This summary is of my interview with Bill Smyth, ADEC worksite committee coordinator. [32]

Q1: How was IAQ considered for building leasing decisions and has this changed?
A1: IAQ was not seriously considered until there was a problem and it did not need to be because the lease required the building owner to provide for good IAQ and climate controls, both which are being seriously considered regarding the decision to sign a new ten-year lease. It is a big plus that the building owner was so cooperative to fix the real or perceived IAQ problems.

Q2: What is a space committee and how does it fit into ADEC's IAQ action plan?
A2: ADEC does not have a formal action plan. A worksite space committee composed of the two staff from the division of administration and senior representative from each of the other divisions, tackle workspace problems as needed, including IAQ. This provides a local flavor.

Q3: How did human resources get involved in this case and what are the human-resource issues?
A3: HR jumped in when people got sick and got involved with relocating people within the building. HR did not get involved with the IAQ investigation; accept to make sure that there was an investigation. The labor union did not get involved and no grievances were filed.

Q4: What were your first responses when the IAQ complaints came in 1999 and 2001?
A4: Not much was done in 1999. People relied on opening windows and assumed that the problems were due to the new office space, which was constructed in the summer 1998. People were not relocated in 1999. A simple investigation was conducted in 1999 and all of the recommendations were implemented. The investigation in 2001 was a lot more thorough. One employee wrote a letter to OSHA. The affected space was evacuated and the employees were all relocated until the investigation was done and all of recommendations were implemented.

Q5: How did ADEC address internal and external communications, including the media?
A5: The administrative assistant for the Fairbanks ADEC office was the key point of contact for all communications. Memos and emails were addressed to all affected parties. Copies of all reports were put in the break rooms. Signs were posted. There was no media involvement.

Q6: How did the results and methods positively affect employee/ADEC/owner relationships?
A6: The responsiveness of the building owner set ADEC managers' and employees' minds at ease because something was quickly getting done. There have been no further complaints so far this spring about poor IAQ, but we are still waiting. If the IAQ problem does not come back this year, then there could be a good chance that ADEC will try to renew the lease.

Q7: How did ADEC ensure that the employees' rights and interests were safely protected?
A7: This was a very high priority for ADEC's managers. The employees' rights were protected. Health and safety were forced upon employees in 2001 by making everyone in the affected space above the garage to evacuate until the managers knew that it was safe. No persons filed worker's compensation claims that he was aware of.

Q8: Which tasks did ADEC delegate and which did ADEC take charge of and why?
A8: The IAQ investigation was delegated because ADEC does not have the expertise to deal with IAQ problems. ADEC also perceived that this investigation was the building owner's responsibility, not ADEC's. ADEC was the party that requested that the garage and the affected office space above the garage be constructed to meet our expanding needs. All HR issues were handled by ADEC, but the owner and the consultant were informed of every decision that was made. No parties filed complaints, claims, or lawsuits.

Q9: What was ADEC's role during the investigation? How about during mitigation?
A9: ADEC provided the consultant and the building owner information about the complaints, symptoms, and other information as requested to assist with their investigation. ADEC gave our blessing to all of the recommendations to fix the IAQ problem. ADEC wanted a third party other than ADEC or the building owner to provide more objectivity. This hopefully put minds a little more at ease and made the results appear to be more believable.

Q10: Do you have any final comments, thoughts, or lessons learned regarding this investigation?
A10: Moving into newly constructed buildings or workspace should be very carefully done. This building was not commissioned because it is just outside of the city limits and not subject to city's building codes. This building is within the less stringent Borough building codes.

7.7.4 Case Study #7: ADEC's Fairbanks Office – Interview with the Building Owner

This summary is of my interview with Bill Beistline, the ADEC's building owner. [31]

Q1: Did Pioneer Rentals build the building or buy it, and did IAQ affect this decision?
A1: Pioneer Rentals bought the building in 1993, contingent upon ADEC leasing it. Mr. Beistline also manages West Valley Plaza and College Mall. The buildings that he manages are all office or retail space. His main IAQ concern when he purchases buildings is that the HVAC system meets ventilation codes. He wants his buildings have good IAQ to attract good renters.

Q2: How was IAQ considered for building-leasing decisions and has that changed?
A2: Not really.

Q3: What type of IAQ action plan do your tenants have?
A3: Eliminate all potential sources as they occur and manage IAQ problems as they come up.

Q4: What were your first responses when the first IAQ complaints came in 1999 and in 2001?
A4: Quick on-site responses were taken.

Q5: How did you address internal and external communication, including the media?
A5: He was very glad that the media never got involved because he believes that the media can have a very negative impact on business. He wants to avoid hysteria and correct the problem. He thinks this should be the same goal for both parties. Avoid name-calling and finger pointing.

Q6: How did you take IAQ complaints seriously within budget and schedule constraints?
A6: IAQ complaints were taken very seriously to keep his big tenants happy. He did not have IAQ investigations in his budget, but he decided to fix it now and pay for it later even if there was never really a problem to fix. He thinks that the problem was mostly a sensitivity problem.

Q7: What future benefits and costs will fixing the alleged IAQ problem have on the building?
A7: Mr. Beistline is more aware of taking care of maintenance, custodial arrangements, and preventative maintenance. Some actions, like paving the parking lot, have side IAQ benefits.

Q8: Which tasks did you delegate and which did you take charge of and why?
A8: The IAQ investigation was done by Nortech and implemented by his contracting company. Nortech collected all of the IAQ data and made all of the recommendations.

Q9: What was Pioneer Rentals' role during the investigation? How about during mitigation?
A9: The outside air stinks due to cars running during temperature inversions that are worst in the spring. This odor created a sense that there was something wrong with the building. This was frustrating because there were lots of false complaints among a few valid, initial complaints from chimney fumes until the air intakes were immediately relocated although the original locations were within codes. Mr. Beistline looked at several other possibilities including elevator fluid. He mentioned plant soil as a small, possible cause of the complaints that he has no control over. He ordered special detergent from Texas to clean the building's air ducts. Eventually all likely possibilities were eliminated. He believes that some people are very sensitive and that personalities got involved as occupants stayed with their theories about what caused the complaints. HEPA vacuums are used now in the complaint area. A few spruce trees were cut down to try to reduce the pollen. Half of the parking lot was paved last summer to reduce fugitive dust and the other half is schedule to be paved this summer for a cost of about $40,000 per half paved. He requires the custodians to use greener cleaning supplies now. Most of the more sensitive people either quit or retired, but this still could be an ongoing issue. The minimum fresh air settings on the outside air-intake damper were increased just in case this was a problem, even it did not appear to be. All paint products and chemicals were removed from the garage and stored away from occupied spaces. The affected space was pressurized to help keep unconditioned air out of the affected office space. The total direct cost of the IAQ investigation (excluding paving the parking lot, which he does not consider to be a direct cost) was about $20,000. About half of this cost was for the consultant and the other half for the contractor, including labor and supplies. He did not want to provide ADEC with a reason to break the lease or to not renew it. He wanted to be responsible but did not want to chase down shadows. He thinks that these changes were good for the building and he is sure that the IAQ is clean.

Q10: Do you have any final comments, thoughts, or ideas regarding this IAQ investigation?
A10: It is hard to have air inside that is cleaner than air outside.

7.7.5 Case Study #7: ADEC's Fairbanks Office – Interview with the IAQ Investigator

This summary is of my interview with John Hargesheimer, PE, CIH, an IAQ investigator. [34]

Q1: What considerations do you think are helpful to prevent and minimize IAQ problems?
A1: The most important key is to have a proactive IAQ program! The exact makeup of the program will depend on the organization. A risk manager is a good person to lead this program. Listening to the occupants is very critical, too. A single person should serve as a point of contact for all IAQ complaints and for IAQ communications. An IAQ database can be a very helpful tool and should include occupant data, worker's compensation data, medical expenses, absenteeism patterns, complaints, productivity data, and basic IAQ parameters.

Q2: What actions can be taken before calling that would help you diagnose an IAQ problem?
A2: Collect data to support what could be causing an IAQ problem and analyze the data, if possible, guided by a proactive IAQ program. Awareness training for employees can be helpful if done right. The IAQ consultant is like a detective; the more data that can be provided, the better. Resolving IAQ problems is a simple matter of money; environmental dollars need cost/benefit analysis even though these can be hard to quantify. A senior manager would probably say, "no way!" if a request was made for $10,000 to fix an IAQ problem. The same manager might reconsider, however, if it was brought to their attention that this fix would save the organization $15,000. Do this cost/benefit analysis before calling the IAQ consultant.

Q3: When do you recommend building owners request outside assistance for an IAQ problem?
A3: It is time to call an IAQ consultant when internal efforts fail, when health issues are at stake, when the internal fix is very expensive, and/or when emotions run high. An IAQ consultant has the benefit of being perceived as much more objective and more appropriate credentials and experience are very helpful, too. IAQ consultants are very helpful protection from litigation.

Q4: What were your first responses when the first IAQ complaints came in 1999 and in 2001?
A4: The first responses were to conduct visual inspections and conduct preliminary interviews, followed by preliminary monitoring. Communications was very important in the beginning and throughout the investigation. The first people interviewed were those that complained.

Q5: How did Nortech address internal and external communication, including the media?
A5: Nortech identified all of the involved parties and received permission to talk to all of the parties, as they needed. Nortech kept all of the parties in the loop through email.

Q6: Did you ask the building occupants if they have any theories about the IAQ problem?
A6: Yes, this is a standard part of the interview process. The occupants' theories are taken very seriously because even if the theories are not correct, the occupants' observations are usually accurate. Some theories are based on emotions, but they are all considered.

Q7: How did you decide who to interview and when?
A7: Ideally, every occupant in the affected area should be interviewed. Questionnaires—similar to a poll—are a very good tool; they can be put on the web, are very cost affective, give good statistical samples, and can be used to decide whom to interview later. The complainers are seldom representative of the group. The clusters of data are more important than the outliers.

Q8: Which tasks did Nortech delegate and which did you take charge of and why?
A8: Nortech has delegated tasks in many different ways in different IAQ investigations, depending on the client's interests, internal skills, budget, etc. Nortech, at a minimum, assesses and analyzes the data, makes recommendations, and does quality-assurance/quality-control (QA/QC). QA/QC is critical for sensitive investigations, which IAQ complaints often are.

Q9: What was Nortech's role during the investigation? How about during mitigation?
A9: Nortech did the minimum plus IAQ monitoring and follow-up ("clearance").

Q10: Do you have any final comments, thoughts, or ideas regarding this IAQ investigation?
A10: Emotions were very high in this case, some justified and some unjustified. Trust is very important because bad emotions make even simple cases much more difficult to resolve. Building owners call much sooner due to increasing IAQ awareness. People made good efforts, but there were too many people trying to manage and make decisions. The Americans with Disabilities Act (ADA) covers IAQ. Administrative fixes to accommodate sensitive occupants—e.g., relocate or remodel their office—can be much cheaper than trying to fix an entire building.

7.7.6 Case Study #7: ADEC's Fairbanks Office – IAQ Investigation Report Summary

The following is a summary of Nortech's 2001 IAQ investigation report for this case. [35]

Nortech's IAQ investigation started with a visual inspection. Real-time, single monitoring for carbon dioxide (CO_2), carbon monoxide (CO), temperature, relative humidity, and VOCs was conducted. Bulk-sample, single monitoring for ultrafine particles and ozone was conducted. A combination of sampling techniques was conducted for microbial sampling. Specific odors, airflow characteristics, signs of water damage, humidity conditions, and general maintenance conditions were observed. The CO levels were around 0 to 1 parts per million (ppm), which was about the same as outdoor air and well below health standards, indicating that car exhaust was not getting into the building. The CO_2 levels varied between 450 and 750-ppm, which was below the recommended 800 to 1000 ppm levels, indicating that sufficient fresh air was being supplied to the office. The temperature ranged between 71 and 76 °F, averaging around 74 °F, which is within the high end of the recommended range. The relative humidity fluctuated around 11 percent, which is lower than the recommended 30 or 40 percent minimum, but is very typical in well-ventilated buildings during cold weather. VOC levels were around 40 to 210 parts per billion (ppb), which is considered within the healthy range. VOC levels in the garage were up to 4,000 ppb, which is a little elevated. Ultrafine particles were about ten times fewer in the air coming out of the supply ducts then outside indicating that the filters were removing about 90 percent of these hard-to remove small particles. Ozone levels ranged from less than 0.061 to less than 0.071-ppm, which is close to OSHA's 0.1-ppm permissible exposure limit. One species of non-lethal fungal spore was identified to be higher indoors than outdoors, but this measurement was low in the non-complaint area of the building and about ten times lower in the complaint area. One type of non-viable sample was identified to be higher indoors than outdoors, but the concentration in the complaint area was about double the outdoor concentration while the concentration in the non-complaint area was about triple the outdoor concentration. Two wall cavity samples indicated that there is no fungal growth within the exterior wall cavities of the office. Surface wipe samples identified two different mold species in the HVAC system, indicating that the air conditioning coils are a likely reservoir of mold growth. One common species of bacteria was identified in the complaint area in very low concentrations. The only space that was under negative pressure relative to the complaint area was the elevator shaft.

7.7.7 Case Study #7: ADEC's Fairbanks Office – Evaluation and Recommendations

The first item evaluated was, "How typical is this office workspace?" There are less than 5 occupants per 1000 square-feet of floor space and the cost for the leased space is about $18 per square-foot per year. The average labor cost for space in this building is about $247 per square-foot per year assuming that the average salary is $55,000 per year (e.g., employee salaries, including benefits, range from about $30,000 to $80,000 per year). These costs are all within the range of estimates provided in background of this report. [16] The cost of the entire IAQ investigation and remediation was less than the cost of one month's rent payment. [31] This 70-person office workspace could be a fairly good representative sample based on these statistics.

The second item evaluated was, "How were the key IAQ issues managed?" The IAQ complaints started soon after the office workspace was remodeled. [32] Employees had mixed feelings regarding how the IAQ affected their health. The complaints were quickly brought to the attention of the building management who quickly brought them to the attention of the building owner. [32] The building owner checked for the most obvious possible causes and fixed what he believed was the most likely culprit. [31] The building owner hired a well respected outside IAQ consultant to conduct a simple investigation after unsuccessfully trying to resolve the complaints. The IAQ consultant completed the investigation and made recommendations to the building owner, who quickly implemented all of them. [31] Complaints started after almost two years of silence. The building owner again hired the IAQ consultant to conduct another, more thorough investigation and to make recommendations to eliminate all potential culprits and/or to eliminate synergistic affects. [31] The building manager wants to wait before closing this case. [32]

The third item evaluated was, "What is the outcome of this case?" There might have been some hurt feelings by some of the people involved, but overall the relationships between the parties involved seem to be fairly good and perhaps healthier and trustier for the experience. [31] & [32] There might still be some disagreement about distributive justice, but the procedural justice seems very reasonable because of good management by all parties. [36] All parties plan to consider IAQ and remodeling in future decision-making and all parties seem eager to renew the lease (for the right price). [31] & [32] Big doctor bills, worker's compensation claims, grievances, litigation, and negative media attention were not outcomes. [31] & [32]

The fourth item evaluated was how closely this case followed the ounce-of-prevention IAQ management strategies. The original building was probably designed well considering that there were no IAQ complaints until the construction. [31] The current building owner considered IAQ by making the purchase conditional upon being able to lease the building. [31] If constructing the office space above the garage considered IAQ more carefully as suggested in the IAQ action plan, then these IAQ complaints might have been avoided or minimized. [3] The management should have requested that the building owner request outside assistance sooner. [31] & [34]

The fifth item evaluated was how closely this case followed the pound-of-remediation IAQ management strategies. The investigation seemed to go a little slow, and it probably appeared even slower when the building owner who has a stake in the matter was doing the investigating. [4] However, the investigation went pretty well after the outside consultant got involved. The occupants, the building managers, the building owner, and the consultant communicated openly and work well together to resolve the complaints. [31], [32], & [34] The biggest difficulty was probably having too many parties involved. [34] An "expert" was very helpful because this case did not fit well into the fifteen categories of potential IAQ problems. [3]

The sixth item evaluated was how closely this case followed the ton-of-litigation IAQ management strategies. None of the parties in this case had a formal IAQ management plan; their plan was to resolve IAQ complaints as they occur. [31], [32], & [34] Key components were in place, however, including: ADEC had a predetermined point of contact; the space committee was appointed; the friendly atmosphere made it easier for employees to complain without fear of retaliation and their labor union was available if needed; employees had lots of IAQ educational opportunities; there was a diligent and intelligent effort made early on to try to quickly resolve the complaints; facility operations and maintenance considered IAQ even before the complaints; and potentially significant sources of pollutant sources were managed. [31], [32], & [34]

The seventh item evaluated was what additional recommendations would I suggest. The only suggestions that I have ADEC try harder to look for administrative solutions like permanently relocating sensitive workers. ADEC could try harder to make and enforce what could be an unpopular policy of not letting cars idle near the building and not storing fuels in the garage.

8. Future of IAQ Management in the Office Workplace

This section discusses four ongoing changes that are likely to have a significant impact on office workplace IAQ. First, alternative techniques and products are being developed in an arena known as sustainable construction, or green building. Emphasizing a whole-system perspective, green building looks past the construction process and first costs, toward the life cycle of a building and the longer-term interest of the owners and occupants. Green building uses six distinct features that reduce energy consumption and pollution: resource-efficient building techniques; resource-efficient building materials; designs that utilize site-generated scrap; designs that minimize materials and waste; contracts that assure waste-minimizing job site management; and contracts that specify recyclable products. These sustainable techniques are associated with improved occupant health and productivity. A green building has six features that improve occupant conditions: operable windows and natural ventilation whenever possible; daylighting; less toxic building and cleaning materials; low out-gassing or natural paints and finishes; properly designed and maintained HVAC; and central vacuum or high quality filtration. Without diminishing the many environmental factors of green buildings, these aspects can bring green buildings into people's everyday lives by linking building interiors to human health. [37]

Second, more firms are being sued by employees who blame miscarriages or birth defects on workplace hazards. It's not just the workers who are taking action. In a growing number of cases, children are filing lawsuits against their parents' companies, claiming that exposure to occupational toxins injured them in the womb. Some courts have upheld the rights of their offspring to sue. This means that employers are worrying about how to protect themselves from plaintiffs who may not yet be conceived. Three-quarters of women of reproductive age are in the workforce and an estimated 1 million working- women in the USA may be pregnant at any one time. Mounting research shows men also are exposed to job hazards that can cause chromosomal damage and injury to the unborn. "This is a huge issue that will continue to grow in importance as more women move into jobs traditionally the domain of men," says Tim Fisher at the American Society of Safety Engineers. "It makes good business sense for employers to look at the issue. If they don't, they're risking losing employees and opening themselves up to litigation." However, protecting the unborn can be difficult because much is unknown. [38] IAQ litigation will probably continue to increase until our government decides how to regulate IAQ.

Third, workers who are scent-sensitive or allergic to the chemicals often associated with perfume are increasingly asking for a reprieve from the nasal assault. Employers in Minnesota, trying to be fair to all—and avoid lawsuits—are accommodating them. As it was with indoor smoking, Minnesota seems to be ahead of the curve when it comes to policing fragrance use at work and is considering whether to include fragrances under the Minnesota Clean Indoor Air Act. While the scent-sensitive movement has not attained the level of anti-smoking advocacy, it is growing. Attempts to protect the chemically sensitive from an overdose of perfumes are not always warmly received, and some critics raise a stink. While few, if any local companies in the Twin Cities have strict no-fragrance policies, managers say they face the issue with increasing frequency. Scent victims say that it is the chemicals in the fragrances that cause harm, not the fragrance itself. To be covered under the ADA, the scent victim must show that their sensitivity is a medically recognized condition that substantially limits a life activity. [39]

Fourth, the office workplace is now more than just a place to work; it also determines how the employees perceive their company and how productive they will be. For a large number of organizations, having an intelligent building is now part of their image-building exercise that will project them as being contemporary and smart. Knowledge workers, the backbone of most organizations now, are increasingly demanding quality workplaces and expecting a safe, secure, and comfortable environment with good IAQ. As business becomes more global and the competition for top-quality human resources increases, offices are extending their hours to provide support for multiple time zones and are providing flexibility for employees. The resulting partial occupancy creates a problem for many buildings because most HVAC and other building systems are either totally on with high-energy usage or totally off with poor IAQ. An increasingly popular choice to efficiently manage buildings with pickier occupants and more unpredictable occupant patterns is an intelligent building. According to the Intelligent Building Institute, an intelligent building provides a productive and cost-effective environment through optimization of its four basic elements—structure, systems, services, and management—and the inter-relationships between them. Intelligent buildings use the building's automation systems to reduce the energy, operations, and maintenance costs by monitoring and controlling building systems by responding to the current occupancy pattern to minimize energy and maximize operational efficiency. The payback of intelligent buildings can be three to five years. [20]

9. Conclusions

Building managers, building owners, and occupants are becoming increasingly aware of the importance of active indoor air quality management in the office workplace in the United States and in other countries and should continue to do so as more is learned about IAQ.

Indoor air quality management is an interdisciplinary career that requires an understanding of both technical and non-technical issues including: risk management; IAQ standards, regulations, and court cases; micro and macro-economic; human-resource management; heating, ventilation, and air conditioning systems; building science and design; and project management.

The three primary parties that share the responsibility for IAQ management include architects and engineers who can make the biggest difference, building managers who want IAQ to pay a return on an investment, and building occupants whose health and safety depends on good IAQ.

Quick-and-easy methods to remediate IAQ complaints and problems do not exist, but general guidelines and an awareness of typical IAQ problems can help building managers to try to resolve some. A well-respected outside IAQ "expert" should be called promptly when needed.

Successfully implementing an IAQ action plan can be very helpful for building management to avoid or win lawsuits by helping to demonstrate due diligence. The USEPA/NIOSH plan is one of the better, but not perfect, IAQ action plans and can be tailored to fit any organization.

Poor or no IAQ management can have disastrous consequences, drawing lots of media attention, on organizations and can be very expensive. Implementing good IAQ management strategies can help minimize the costs. Good examples of IAQ management are a little harder to find, but they could be right under our noses. Even well run IAQ investigations can be frustrating, but the big-picture costs should be reasonable and there can be lessons learned, too.

Future changes likely to have a significant impact on office workplace IAQ include increases in green buildings, IAQ lawsuits from unexpected plaintiffs, people seeking reprieve from nasal assault, and intelligent buildings. IAQ management will keep growing to meet these challenges.

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