A RATIONAL PROCEDURE FOR INVESTIGATING INDOOR AIR QUALITY PROBLEMS

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ABSTRACT

There is an increasing amount of litigation occurring regarding indoor air pollution in non-industrial buildings such as residences and office buildings. In the course of personal injury suits related to indoor air quality we can expect to see a significant amount of liability associated with the sick building investigators who conduct the inspection of the building and measurements of the air contaminants which the plaintiffs and defendants are relying upon in pursuit of their respective cases. In the absence of a standard building investigation protocol, the protocol used should be formulated for the specific building(s) to be studied (i.e. building use, potential indoor sources, type of ventilation system), performed, and presented in a scientific rational manner. Additionally, the protocol should be rigorous and comprehensive enough to withstand anticipated cross-examination. A rigorous rational and comprehensive indoor air quality investigation should contain each of the following six elements: Symptom Description, Potential Source Inspection, Ventilation System Inspection, Contaminant Measurements, Data Interpretation, Mitigation Recommendations. This paper describes the details of each of these six elements and in particular discusses the difficulty of determining if the factors one finds are causally related to the occupant reported symptoms. In addition there is a discussion of failures in some indoor air quality inspections that can result in professional malpractice for the sick building investigator.

INTRODUCTION

There is an increasing amount of litigation occurring regarding indoor air pollution in non-industrial buildings such as residences, office buildings, schools and hospitals. In the course of personal injury suits related to indoor air quality we can expect to see a significant amount of liability associated with the sick building investigators who conduct the inspection of the building and measurements of the air contaminants which the plaintiffs and defendants are relying upon in pursuit of their respective cases. Professional malpractice amongst sick building investigators can result from a number of causes of action ranging from professional negligence, to gross negligence, to reckless or willful disregard, to intentional infliction of injury, to deliberate misrepresentation relied upon to the detriment of the other party (i.e. fraud). The last three causes of action can result in substantial punitive damages.

Professional negligence results from work that is performed below the "standard of care" for the profession. The standard of care is usually defined by experts brought in by both the plaintiffs and defendants as well as any applicable standards or guidelines. Errors may be acts of omission, as in the reporting a low concentration when a higher concentration really existed (i.e. a false negative), or errors of commission, as in reporting a high concentration when a lower one really existed (i.e. a false positive). In the former example, personal injury may occur or worsen as a result from continued exposure, and in the latter example may lead to costly unneeded mitigation. While there is no standard sick building investigation protocol there are standards and guidelines for the minimum amounts of ventilation air and for the maximum concentration of some contaminants. Professional negligence by sick building investigators may arise from failures in all areas of provided professional service including the investigation of the building, the interpretation of the data, and the recommendations for mitigation.

In the absence of a standard building investigation protocol, the protocol used should be formulated for the specific building(s) to be studied (i.e. building use, potential indoor sources, type of ventilation system), performed, and presented in a scientific rational manner. Additionally the protocol should be rigorous and comprehensive enough to withstand anticipated cross-examination. The Indoor Air Division of EPA and the National Institute of Occupational Health published a 1991 document "Building Air Quality: A Guide for Building Owners and Managers" which in Chapter 6, Diagnosing IAQ Problems, describes an indoor air quality investigation as a cycle of information-gathering, hypothesis formation, and hypothesis testing. There is also an EPA publication package “Tools for Schools Action Kit”, which contains recommendations for solving indoor air quality problems in schools. Although this paper is primarily written with a focus on large office buildings, the basic principles apply to other non-industrial spaces such residences, schools, hospitals etc.

These indoor air quality diagnostic protocols all utilize approaches which rationally produce hypotheses from analyses based upon the fundamental principle of mass balance. This principle maintains that mass can neither be created nor destroyed. Contaminants emitted into a building are either removed from the building or remain in the building increasing the concentration of the building. Inherent in such an approach is the recognition of the many factors which determine indoor concentrations of pollutants. In order for an indoor air quality investigation to have diagnostic value one must account for all significant contaminant source and removal mechanisms.

IAQ DIAGNOSTIC PROTOCOL

A rigorous rational and comprehensive indoor air quality diagnostic should contain each of the following six elements:

- Problem Description
- Potential Source Inspection
- Ventilation System Inspection
- Contaminant Measurements
- Data Interpretation
- Mitigation

A flow chart depicting each of these elements is presented in Figure 1.

<u>Problem Description</u>. This important first step is often overlooked by investigators who are more anxious to use their instrumentation to measure contaminants in the building air. In order to diagnose a problem one must <u>first</u> define the problem. This step involves interviewing the building occupants and carefully documenting descriptions of the complaints including physical symptoms and perceptions (i.e. odors, thermal comfort). Often important information regarding the problem is developed which assist in the formulation of the test protocol. This information may be collected by either informal oral interviews or by written questionnaires. Oral interviews are often preferred because they are more personal and allow for collection of more detailed information than would be possible with a written questionnaire. However, a written questionnaire administered to the entire building may be useful in discovering additional "silent" dissatisfied occupants which may be indicative of additional problem areas.

Potential Source Inspection. This important second step is also often overlooked by investigators more intent upon measuring contaminants than conducting a comprehensive diagnostic investigation. In order to diagnose a problem and prescribe mitigation one must have an idea of the different sources of contaminants in the building. This step involves a walk through of the building, the building ventilation system, and adjacent outdoor locations, during which one collects a detailed inventory of potential sources of contaminants. Sources of contaminants may arise from indoor sources such as off gassing of new materials installed during a building renovation, outdoor sources such as motor vehicle exhaust from parking garages and loading docks, and from underground sources such as gasoline from contaminated underground soil and water. A contaminant source inspection of the building ventilation system should include a description of any sources of contaminants which may be entrained into the outside air inlet (e.g. sewer vents or fume hood exhausts) and any standing water or visible microbiological contaminants (e.g. slime or mold) in the cooling coil condensate drip pan or inside the duct work downstream of the cooling coils. Also the cooling coil drain should be checked to see if it is properly trapped. In addition the prior use of the building should be investigated to determine if there is any potential of exposure to contaminants associated with the previous use (e.g. lead dust in a firing range being renovated to office space).

Ventilation System Inspection. The operation of the building ventilation system is an important variable determining the concentrations of all indoor air contaminants. Thus it is important that the operation of the building ventilation system be thoroughly understood. Air contaminant measurements made in a building without consideration for the amount of outside air being delivered into the building during the time of the contaminant measurements are prone to false negatives and preclude a diagnosis of the cause of elevated concentrations and development of an effective mitigation plan. The indoor concentration of contaminants with indoor sources is inversely proportional to the outside air exchange rate. For example, since the outside air exchange rate in buildings with economizer controls may vary from as little as 5% during hot or cold weather to 100% during mild weather conditions, the indoor concentration contaminants may be expected to vary by as much as a factor of twenty. Additionally, buildings experiencing indoor air quality problems are often put into a 100% outside air mode as an immediate mitigation method prior to any contaminant measurements. Thus it is important that the investigation measure both the percentage of outside air in the building ventilation system which is occurring during the investigation and the minimum amount of outside air percentage so that the indoor concentrations may be projected for worst case minimum percent outside air conditions. A successful understanding of the building ventilation system controls is greatly facilitated by communication with the building engineer.

Contaminant Measurements. While not a recommended first step, it is often desirable to collect contaminant measurements as part of an indoor air quality investigation especially those cases headed for litigation. The sick building investigator needs to consider what, how, when, where, and when to measure before beginning measurements. As sick building investigations have very real cost limitations it is important that the resources dedicated to measurements be optimized to provide a sound case without excess expense.

It is also important to note that sick building inspectors must beware of being contracted to performing very limited scopes of work which are likely to prevent discovering the real cause of the problems in the building. Thus, the inspector with such scope of work constraints is not really a sick building inspector, rather they are just data collectors. It is not infrequent that sick building investigators are asked to investigate a sick building by just measuring the concentration of carbon dioxide in the space. Such requests should be declined. If a sick building investigator is asked to perform a limited scope of work, their contract and subsequent report should clearly state that the work is being done at the request of the building owner / property manager and is not a comprehensive indoor air quality inspection but rather is just a report of the requested data. No conclusions regarding the acceptability of the air quality in the building could be made outside of these measurements

What to Measure. The contaminants to measure should be selected only after a careful consideration of the physical symptoms being reported by the occupants and only after a careful review of the potential indoor sources which may be contributing to the occurrence of the reported occupant complaints. A few examples are: volatile organic compounds in new or newly renovated buildings, formaldehyde in buildings with substantial amounts of pressed wood products, carbon monoxide and nitrogen dioxide in buildings with suspected entrainment of motor vehicle exhaust, and airborne fungi in buildings with chronic water damage. In addition to airborne contaminant measurements, consideration should be given to collecting surface measurements to, for instance, assess fiberglass contamination following a building renovation.

How to Measure. Sampling and analytical protocols should be selected to provide the necessary analytical sensitivity. Many sick building investigators which are matriculating from the industrial hygiene community with industrial experience into non-industrial investigations have instruments incapable of measuring concentrations associated with irritation (e.g. usually at concentrations < 1% of occupational OSHA PEL's or ACGIH TLV's). The EPA published in 1990 a "Compendium of Methods for the Determination of Air Pollutants in Indoor Air" which describes methods for measuring nine different classes of pollutants at concentrations commonly encountered in indoor air. ASTM Committee D-22 on Sampling and Analysis of Atmospheres has also published a number of recommended sampling and analytical methods specifically for indoor air.

Where to Measure. Indoor air quality diagnostic investigations should always be conducted simultaneously at indoor locations in the occupied zone and at an outdoor location near the outside air inlet of the ventilation system. Measurements may also be collected in complaint and non-complaint areas. For general building assessments a minimum of one sample location per ventilation system zone along with a subset of sample duplicates and sample field blanks. Again, because of cost limitations, a thorough understanding of the mixing of air in buildings is necessary to prepare an optimal sampling matrix.

When to Measure. While time averaged 8-hour samples provide a good measure of the average concentration they provide no information regarding peak indoor concentrations. Building related contaminants normally will peak in the morning (if the HVAC system is shut down at night) and occupant related contaminants will normally peak in the afternoon. Negative test results from contaminant measurements made during projected peak concentration periods are stronger negatives than if measured at other times.

Data Interpretation**.** This step is where all of the collected data regarding problem description, potential source inspection, ventilation system inspection, and contaminant measurements are pulled together and the sick building investigator prepares a hypothesis for the cause of the problem. During this step the sick building investigator considers results of the investigation in context with applicable ventilation and contaminant standards. The ventilation standard in the United States which defines the minimum standard of care is ASHRAE Standard 62-1989 "Ventilation for Acceptable Indoor Air Quality". This standard prescribes minimum supply rates of outside air on a cubic feet per minute (cfm) basis per occupant or square foot of building space depending upon the type of space. The standard currently recommends a minimum of 20 cfm/occupant for office spaces. ASHRAE 62-1989 also contains a number of tables summarizing United States, Canadian, European and Japanese standards for indoor air contaminants in residences, offices and other non-industrial environments. There is also a European document, "Ventilation Requirements in Buildings" which contains a number of contaminant exposure guidelines.

With respect to the use of recognized occupational health guidelines/standards (e.g. OSHA PEL's) for interpreting contaminant exposures non-industrial sick building investigations, it must be emphasized that these exposure guidelines are not appropriate. The occupational health guidelines are selected for purposes of protecting health and minimizing irritation. For health, the acceptable level of occupational lifetime risk of premature death is typically on the order of one in one thousand. For irritation, the acceptable incidence of discomfort (e.g. headache etc.) can be as high as 50% for a population of healthy workers.

Non-industrial guidelines/standards, such as the EPA NAAQS, have been developed for much lower levels of health risk and irritant incidence. For health the acceptable level of lifetime risk of premature death is typically selected to be one in one hundred thousand, or one percent of the industrial occupational health guidelines. For irritation the acceptable level of discomfort (e.g. headache etc.) is typically less than 20% for sensitive people, including children, elderly, and individuals with allergies (e.g. up to 30% of the general adult population have allergies).

Thus, non-industrial guidelines, which are considerably lower than the industrial occupational health guidelines (i.e. OSHA), are the appropriate guidelines to use in diagnosing indoor air quality problems in non-industrial environments which have sensitive occupants. In addition the concentrations associated with these guidelines are readily achievable in non-industrial buildings with adequate outside air ventilation and no unusual sources of air contaminant.

Utilizing the information collected in the occupant interviews, the potential source investigation, and the contaminant measurements the investigator is now prepared to postulate a hypothesis as to the cause of the complaints. This hypothesis then forms the basis for the mitigation plan. A hypothesis sometimes put forth by sick building investigators is that everything is OK and the occupant complaints are psychosomatic.

While this is a possibility it is most likely beyond the expertise of the investigators to conclude this unless they have professional psychologists involved and difficult to prove without extensive testing. One must keep in mind that there are a number of other factors besides air contaminants which may produce the physical symptoms being experienced by the occupants including exposure to surface contaminants (e.g. fiberglass), lighting flicker and glare, low frequency noise, thermal stress, and organizational dysfunction.

Mitigation. In this step the sick building investigator must formulate a mitigation plan to fix the hypothesized problem. Once the mitigation is completed the building should be re-tested and the occupants re interviewed to measure the effectiveness of the mitigation. If problems still persist the hypothesis is disproved and further analysis must be performed to determine the cause. Of course if the mitigation is successful it does not necessarily prove the hypothesis true, a task which may require additional testing and analysis. Actually it is not ever possible to absolutely prove a hypothesis true, it is only possible to prove it false. Thus, a hypothesis is usually held to be true as long as it can withstand challenges.

DISCUSSION

A sick building investigator may find him or her self in professional malpractice suit resulting from negligence if their performance falls below the professional standard of care in any of the aforementioned elements of a sick building investigation.

There are many industry groups getting involved in providing professional indoor air quality advice including environmental consulting firms, ventilation system contractors, and duct cleaning contractors. New comers to the rapidly increasing field will be especially prone to professional malpractice suits. Also there can often be a significant gap between what is usually determined in a court to be the professional standard of care and the average standard of care associated with the practitioners. Since the indoor air quality field is rapidly evolving this gap can be expected to grow, thus exposing increasing numbers of practitioners offering indoor air quality investigation services to professional malpractice suits.

One example of an industry group with a significant amount of liability are duct cleaning contractors who use a small number of often inappropriately collected contaminant samples, such as gravitational settling dishes or surface wipes for microbiological contaminants, to write a report to a building owner recommending costly mitigation to clean the ventilation system ducts. The collection of mold spores with settling dishes is specifically never recommended for study of indoor bioaerosols and has been described by some as an inexpensive promotional scare tactic designed to intimidate building owners into cleaning ducts. As one duct cleaning contractor responded regarding the appropriateness of doing such contaminant sampling, "we just do it to get our foot in the door". In this situation there is obviously a clear conflict of interest and in the absence of any legislation the doctrine of "caveat emptor" or buyer beware should be kept well in mind.

Another example of a group with a significant amount of liability are environmental firms with experience and tools for assessing industrial environments but little experience in conducting indoor air quality investigations. When these firms are contacted by the building owner/manager for the purpose of diagnosing an indoor air quality problem they are often asked to simply “test the air and let us know what is there”. Since many of these firms proceed with the testing of the air without consideration of the occupant complaints, potential sources, or operation of the ventilation system, it is more likely than not that the wrong contaminants will be measured with the wrong instrumentation and under the wrong ventilation system operating conditions, giving rise to the strong possibility of getting a “below detection limit” result. While this may be what the building owner/manager wants (e.g. a clean bill of health), this data cannot serve as a diagnosis. Those environmental firms that are drawn into this type of situation have a significant exposure to professional negligence law suits by the building occupants, who may suffer from the continued contaminant exposure following their “clean bill of health” report. The building owner/manager who hired them or the insurance company covering the claims may also seek to cover losses resulting with a professional malpractice suit against the environmental firm.

CONCLUSIONS

Sick building investigators need to take care in preparing a rational indoor air quality investigation. A rigorous rational and comprehensive indoor air quality investigation should contain each of the following six elements: Symptom Description, Potential Source Inspection, Ventilation System Inspection, Contaminant Measurements, Data Interpretation, Mitigation Recommendations. Conducting a sick building investigation without consideration of each of these elements exposes the investigator to possible professional malpractice law suits Building owners, tenants, attorneys, and insurance companies should look for the following when hiring a competent sick building investigator: credentials, experience, and client references. A strong investigating team should include industrial hygienists certified by the American Board of Industrial Hygienists, licensed professional mechanical engineers, and certified laboratory analysts and microbiologists. The sick building investigator should also be able to demonstrate relevant experience in solving sick building problems which can be substantiated with client references.

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