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ASSESSMENT OF INDOOR AIR QUALITY AND ASHRAE STANDARD 62

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ABSTRACT

Today, laws and regulations play a major role in just about everything we do. The declining quality of the air in our buildings is causing movement towards regulations relating to how buildings should be designed and operated. It is important that designers and operators are aware of all current design and operating standards. ASHRAE Standard 62, "Ventilation for Acceptable Indoor Air Quality" developed in 1989 and now under revision, has created new challenges for designers and engineers. This paper proposes a three-step approach to the determination and assessment of indoor air quality problems. Starting with a series of observations and inspections to be made during a building walk-through, progressing to simple measurements and finally taking necessary corrective action. In addition, the proposed changes to the ASHRAE Standard 62 in relation to Indoor Air Quality (IAQ) have been reviewed, as these updated standards will influence the way buildings-new facilities, those undergoing renovation and existing facilities will be constructed and maintained in the years ahead.

KEYWORDS

Air quality, Office buildings, Sick building syndrome

INTRODUCTION

Indoor Air Quality (IAQ) is an emerging issue of concern to building managers, operators, designers and occupants. Increasing publicity and the resulting public awareness has lead the building community to become sensitized to IAQ problems and issues. Buildings are characterized as 'sick' when their occupants complain of acute symptoms such as headache; eye, nose and throat irritation; dizziness; nausea; sensitivity to odors; and/or difficulty in concentrating (See Table 1).

As public awareness of IAQ issues continues to grow, pressure is building up to provide safe indoor environments for occupants. Currently there are no regulated standards for indoor air quality, but certain guidelines for pollutant exposures and ventilation rates have been issued by several government and professional organizations.

Causes of Indoor Air Quality Problems

Air pollutants and ventilation both play a part in determining indoor air quality. The pollutants come from a variety of sources as indicated in Table 2, and emission from these sources may be weak or strong. The situation can be regarded as a contest between the pollutants and the ventilation system. If a source is weak and the ventilation system is performing as designed, air quality will be good; however, if a strong source is present, then the ventilation system may be overwhelmed and air quality will be bad. Other factors are temperature, humidity and microbiological contamination.

PRELIMINARY ASSESSMENT

Background Assessment

The intent of the background assessment shall be to obtain as much

historical information as practical on the building itself (like when it was constructed, its fabric type, ventilation system, previous problems and previous investigations into air quality, recent renovations, etc.). The "**initial site visit**" shall be conducted in three separate steps: a walk through evaluation, personal interviews, and environmental monitoring. The "**walk-through evaluation**" is needed to obtain any additional background information not obtained during the background assessment (architectural plans, engineering reports, or previous environmental assessments, etc.) and to gain, first-hand, a visual appreciation for the building's design and floor plan. A critical inspection of the ventilation system is also important in order to thoroughly characterize the building with respect to potential sources of chemical and microbiological contaminants. The "**personal interviews**" are needed to better characterize the building population

Table 1: Health Effects - Sick Building Syndrome

Symptom	Possible Contaminants	Primary Sources	Environmental Condition
Headache, Fatigue, Poor Concentration, Dizziness, Tiredness	Bioaerosols VOCs	Ventilation systems, humidifiers, drip pans, cooling coils in AHVs, plants, outside air	Ergonomic conditions, noise and vibration
Headache with nausea, ringing in ears, pounding heart	CO and Formaldehyde	Incomplete combustion (vehicle exhaust, stoves, fireplaces), building products, furnishings	Ergonomic conditions, noise and vibration
Dry Throat, shortness of breath or bronchial asthma and irritation and infection of respiratory tract	NO_2, Formaldehyde, VOCs, and particulates	Incomplete combustion, building products, furnishings, smoking	Relative humidity
Nasal Problems -Stuffiness -Irritation	NO_2, Formaldehyde, Bioaerosals	Incomplete combustion, building products, furnishings, ventilation systems, humidifiers, drip pans, cooling coils in AHVs, outside air	Relative humidity and high temperatures
Skin Problems -Dryness -Irritation -Rashes	Formaldehyde	Ventilation systems, humidifiers, outside air	warm air, low relative humidity, and excessive air movement
Eye Problems -Burning -Dry gritty eye -Watery eyes	NO_2, Formaldehyde, VOCs, Bioaerosols, particulates	Incomplete combustion, building products, furnishings, ventilation systems, humidifiers, cooling coils in AHVs, outside air, product deterioration	Artificial light

Carbon Monoxide/Combustion Byproducts

-Does the building contain an enclosed parking garage?

-Does the building contain an internal loading dock?

-Does the building contain a kitchen with gas/electric stoves?

-Does the building contain a gas-fired heating system?

-Does the building contain any small freestanding gas heaters?

Table 2 - Causes of Air Quality Complaints

Other Causes	Frequency of Occurrence	Most Common Indoor Sources
Inadequate Ventilation	Frequently	Causes include: Overzealous energy savings, poor designs or maintenance, occupant intervention
Temperature and Humidity Extremes	Occasionally	Causes include: Faults in placing or operation of thermostats (temperature), inability of system to compensate for climate extremes and leaky buildings (humidity)
Other Physical Stressors	Occasionally	Symptoms induced by acoustic or visual stress can be the same as those of the "sick building syndrome"
Asbestos	Rarely	Insulation or fire retardant lining a ventilation duct
Carbon Dioxide	Frequently	People
Carbon Monoxide	Occasionally	Auto exhaust : Parking garages, Loading docks
Formaldehyde	Occasionally	Unsealed plywood or particle board, adhesive, carpets, glues, furnishings, etc.
Nitrogen Dioxide	Rarely	Diesel exhaust, combustion of natural gas or kerosene used for heating or cooling
Ozone	Rarely	Photocopiers, electronic air cleaners/filters
Radon	Rarely	Soil, Groundwater
Volatile Organic Compounds	Occasionally	Copying and printing machines, tobacco smoke, cleaning materials, carpets, furnishings, glues, etc.
Biological Material	Occasionally	Stagnant water associated with HVAC system, plants, water-damaged furnishings
Particulate	Occasionally	Contaminated air intakes, tobacco smoke, hard water residue, insulation lining a duct or plenum

Radon

-Are there basement or sub-basement areas or crawl spaces with dirt floors?

-Are there rooms with sizable holes in the walls or floors, such as sump pits or gas and water entrances, in which there is exposed soil?

-Are there cracks in the walls of the basement that could allow soil gases to seep into the building (for example, get dissolved in ground water that leaks in)?

Other Pollutant Sources

-Are there showers in the building?

-Does the building contain wet-process photocopiers?

-Does the building contain a print shop?

and to determine the nature of the symptoms and complaints being reported. The personal interviews are also critical in determining the magnitude of the problem, specifically, if the problem is widespread throughout the building or among a certain group of employees. On-site **"environmental monitoring"** is needed to confirm or to rule out a number of problem source possibilities identified from the background assessment, the walk-through evaluation, and the personal interview portions of the initial site assessment. The most common instruments that can be used are; detector tubes for carbon dioxide, psychrometers for measuring temperature and humidity, and smoke tubes for determining air movement.

SELF-EVALUATION OF INDOOR AIR QUALITY PROBLEMS

The information in this section will provide guidelines on how to proceed in order to evaluate your specific question of indoor air quality. The questions are straightforward - most requiring a simple 'YES' or 'NO' answer. The six parts of the assessment survey deal with the following problems:

HVAC Systems and Operation

-Is the amount of fresh air used by the ventilation system the same all year round?
-Does the HVAC system use an economic cycle?
-Is air supplied to the floors by constant volume/variable air volume (VAV) boxes/heat pumps/other or unknown?
-At what temperature is the tank supplying hot water to the building maintained?
-Are there distinct fresh air intakes for the building's HVAC system?
-Are there any pollution sources near any of the intakes?
-Does the building has a particulate (Dust) filter system installed in the fresh air intake?
-Is the ventilation system in the work areas decreased or shut off overnight or on weekends?
-Are spray/steam humidifiers used in the building?
-Does this building has an air-chilling system?
-Are the ventilation ducts or plenums insulated?

Building Usage, Maintenance & Design

-What year was the building constructed?
-Can the windows in the work areas be opened?
-Have there been any changes in the floor layout since the building was opened?
-Is the occupant density higher than originally planned anywhere in the building?
-Have any work areas been re-carpeted recently?
-Have any work areas been painted recently?
-Is there foam insulation in the walls of the building?

Occupant Complaints & Complaint Area Survey

-Describe the usual temperature at your location?
-How would you usually describe the air here?
-Are you bothered by any type of odor at your location?
-Do you have a history of allergies? Describe your symptoms.
-What times of day are your complaints worst?
-Do the symptoms coincide with or follow cleaning or maintenance activities in your area?
-Describe the general condition of the "complaint area".
-Is this an enclosed/open office area?
-Describe the conditions of air supply diffusers.
-Are there any air exhaust louvers?
-Are there any pollutant sources within 30 feet of this work area?

provided at the rate of 15 cubic feet per minute (CFM) per occupant. ASHRAE Standard 62-1989 guidelines recommend for a wide variety of commercial, institutional and industrial facilities, including office buildings.

Table 3: Sampling Test Locations/Time for Measuring Pollutants

Pollutant	Test Location	Time to Measure
Carbon Dioxide	Air intakes, Outdoors, Street level or roof, Indoors, Unoccupied area	Late morning, late afternoon when fresh air rate low
Carbon Monoxide	Air intakes, outdoors, roof or upper floor, indoors, above second floor	Early morning, late afternoon when fresh air rate low
Formaldehyde	Air Intakes, Outdoors, roof or upper floor on the building side of the particulate filters	Early morning when fresh air rate low
Particulates	Air intakes, Outdoors, roof or upper floor on the building side of particulate filters, indoors, unoccupied area	Afternoon
Radon	Outdoors, sheltered area, indoors, away from identified pollutant sources	When fresh air rate low
VOC	Air intakes, outdoors, street level or roof, indoors, away from identified pollutant sources	early morning. Monday or late afternoon when fresh air rate low
Biological Contamination	Air intakes, outdoors, roof, indoors, areas with no mold, no water, no plants	Early morning, , when fresh air rate low, summer

INTERPRETATION & RECOMMENDATIONS

Three factors must be assessed before deciding whether an air quality problem warrants further investigation with sophisticated instruments or not. One can remember them as PIP - People, Inadequate Ventilation and Pollutants. The following represent some of the possible general trends and recommendations to pursue that have been identified through CO_2 monitoring.

(i) Initial CO_2 readings inside the building are close to outside readings (250-300 ppm). This suggests that fresh air intake is sufficient. Perhaps, the first approach to improving the livability will be to look at temperature and humidity, and check for imbalances in the ventilating system.

(ii) Initial CO_2 readings inside the building are appreciably higher than outside readings. This may simply be due to the shutdown of the ventilating system when the building is unoccupied, or it may be due to under-ventilation, which will require provision of significant amount of fresh air. In this case it will be necessary to arrange to have the system left on for several hours after the occupants leave.

(iii) Temperature, humidity and airflow readings compare unfavorably with specified guidelines. Steps should be taken to adjust systems to comply with the guidelines.

PROPOSED ASHRAE 62 STANDARD

While the current ASHRAE 62 standard is primarily a design standard, the forthcoming standard will likely emphasize both design and building operation, and maintenance procedures. The proposed standard will also be written in code language to simplify its adoption by governing agencies into law. But, even if the standard does not rise to the level of law and remains voluntary, it will still have a regulatory effect. Because the standard

-Does the building contain a laboratory that uses chemicals (for processing, cleaning)?
-Does the building contain stored chemicals (pesticides, waste solvents, etc.)?
-Does the building contain a store room or storage area with shelves made of fairly new plywood or particleboard?
-Are large amounts of paper stored or handled in this building?
-Are large amounts of textiles stored in this building?

Walk-Through Survey

A walk-through survey of the building is essential to ensure that information collected through interview and/or questionnaire is accurate. A walk-through survey of the building is also helpful in assessing the overall condition of the building and to determine the systems are functioning properly.

At this stage of the evaluation, it is quite possible that specific problems such as non-functioning ventilation equipment, poor temperature control, etc. will become evident as a major factor contributing the problem. If this is the case, the problem or problems should be corrected before the evaluation continues. Correction of problems may or may not require assistance from outside contractor.

In other instances, the cause or causes of an indoor air quality problem may not be so easily determined. In such instances, a simple approach to evaluate the effectiveness of the ventilation system, may include temperature and humidity factors.

Sampling Techniques

CO_2 concentrations can easily be determined by using direct reading detector tubes that indicate concentration as a function of length of color change on a sampling tube. Start sampling first thing in the morning and also try to get samples during and at the end of the workday. Record all CO_2 measurements in ppm, by specific location and time of day. (See Table 3)

To round up the monitoring, temperature and humidity should be checked at various times and places throughout the day, and if necessary, air flows at vents and return air grills should be evaluated as well. Although wet bulb, dry bulb thermometers can be used, but that degree of accuracy is unnecessary. A desk thermometer and relative humidity meter should be adequate. Air movement from vents can be easily checked by using smoke tubes. Exact measurements are less important at this stage of the evaluation.

ASSESSMENT SUMMARY

Carbon Dioxide Levels

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area or not. The outdoor, ambient concentration of CO_2 is usually 250-350 ppm. If CO_2 concentrations are maintained below 600 ppm, with comfortable temperatures and humidity levels, complaints about air quality should be minimal. If CO_2 levels are greater than 1000 ppm, widespread complaints may occur and thus 1000 ppm should be used as upper limit guidelines.

Temperature and Humidity

The 'comfort' chart by ASHRAE presents a comfort zone considered to be both comfortable and healthy. This zone lies between 73° and 77° F (23° and 25° C) with 20 to 60 percent relative humidity. Relative humidity levels below 20% are associated with increased discomfort and drying of the mucous membranes. These guidelines are intended to achieve thermal conditions in a given environment, that at least 80% of the persons who occupy that environment will find acceptable 'comfort'.

Provision of Adequate Amounts of Outside Air

For general office where smoking is not permitted, indoor air quality is considered adequate if outside air is

will have been adopted by a professional organization, it is possible litigators will be able to prove negligence if a facility manager/building owner doesn't reasonably adhere to the IAQ recommendations of ASHRAE 62.

Ambient Air Quality

The new standard will continue to assume that outdoor air meets federal ambient-air standards but, unfortunately, there is no equivalent of a weather bureau to tell you exactly how good or bad the air surrounding a facility will be at a given time. The quality of outdoor air being brought into a building is affected by proximity of louvers to sources of contamination, including engine exhaust from heavily traveled roads and truck-loading docks, effluents from boiler flues, and the like.

Variations in the quality of ambient air can have significant practical results. For one thing, it means that even a perfectly designed and ideally maintained HVAC system may not offer adequate air quality protection. It also means that, in some cases where elevated VOC levels are detected indoors, searching for the culprit inside the facility may amount to a waste of time.

Indoor Sources of Contamination

The second troublesome assumption of the present Ventilation Rate Procedure that indoor environment contains no "unusual" sources of contamination is likely to be modified by the new standard, which will take into account not only the number of occupants of an indoor environment to determine the appropriate ventilation rate but also the volume of the space to be ventilated. By considering volume, the standard will in effect acknowledge that building materials, furnishings and equipment are important factors contributing to IAQ. For facility managers/building owners, this entails paying greater attention to preventing indoor contamination through careful screening of building materials, furniture, and finishes as well as through prohibition of certain kinds of polluting equipment or through exerting localized control over that equipment, which can even include the HVAC system itself.

Ventilation

For facility managers/building owners, the standard's third assumption that ventilation effectiveness approaches 100 percent means that they must work to optimize ventilation systems' efficiency by maintaining proper balancing of HVAC system, including outside-air dampers, and keeping HVAC controls in excellent condition.

ASHRAE 62-AN UPDATE

The committee revising ASHRAE's Standard 62 responding to comments from the home building industry, has recommended splitting the document into two separate standards: one for commercial and high-rise residential buildings and one for low-rise residential. In splitting Standard 62, "Ventilation for Acceptable Indoor Air Quality", the committee will follow the lead of the committee that worked on Standard 90, which regulates energy efficiency. That also comprises two standards based on the type of building. The new ventilation standards will be designated Standard 62.1 for commercial, institutional, and high-rise residential buildings, and Standard 62.2 for low-rise residential.

The biggest response to the revised standard came from the home building industry. The residential section was one of the major changes in the standard, incorporating low-rise and single-family homes for the first time. In the April 1997 meeting, committee tried to address several major issues, including some contentious ones – smoking and the question of how the standard applies to existing building without much success.

The smoking section, which details how to design ventilation for buildings where smoking will be permitted, was

originally located in an appendix. That section moved twice – once from the appendix into the main body of the standard, and then back into the appendix. The section is important because the main body of the revised standard currently applies only to buildings where smoking is not allowed, as opposed to the existing standard, 62-1989, which assumes a "moderate amount of smoking". The committee still intends to write the smoking appendix in code language so that any jurisdiction that wants to adopt the smoking provision can do so easily.

Filtering Outside Air

Another bone of contention among committee members, as well as in some comments, was whether to require cleaning the outside air in areas that don't meet National Ambient Air Quality Standards (NAAQS). The revised standard, as it went out for public review, didn't require either filtration or air cleaning for sub-standard outside air. The purists on air cleaning say that if an area has bad outside air, the standard ought to require that it be cleaned before being used as ventilation air. While many comments indicated that standard should require such cleaning and none endorsed the standard's present provision. The committee tabled the matter to allow those who want to require filtration to develop some language that others on the committee find acceptable.

What is next?

The fate of Standard 62 is not clear yet. But at any rate, it is reasonable to assume that the earliest we could see a final standard in place – at least for commercial and high-rise residential buildings – would be sometimes in October 1998.

CONCLUSION

For an IAQ program to be successful, written documentation must be maintained to ensure adherence to the program, to assist in solving IAQ problems and to defend the facility in a legal action or complaint. The program should include the following elements:

- A policy statement,
- A management plan,
- The designation of an IAQ manager,
- For this Detailed building operation and maintenance procedures,
- Complaint response mechanisms, and
- Education and training.

REFERENCES

ASHRAE Standard 62 (1989) *"Ventilation for Acceptable Indoor Air Quality"*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta.

B. A. Plog, J. Nilond, and P. J. Quinlam, (1996) *"Fundamentals of Industrial Hygiene-Chapter 21"*, National Safety Council, Itasca, Illinois.

H. Levin (1990), *"Indoor Air Quality Update"*, Vol. 3, No. 5, p. 4, Cutter Information Corp., Arlington.

M. Meckler (1990), *"The Role of Commissioning and Building Operations in Maintaining Acceptable Indoor Air Quality"*, Proceedings, 5th International Conference on IAQ, Indoor Air '90, Toronto, Canada.

Supplement to the National Building Code of Canada (1985) *"Section 3 – pp.131"*, Institute for Research in Construction, National Research Council of Canada, Ottawa.

U.S. Environment Protection Agency, (1993), *"A Guide to Indoor Air quality"*, Project Summary, EPA 402-K-93-007, Washington.