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CONDUCTING AN INDOOR AIR QUALITY INVESTIGATION USING PHASE ASSESSMENT

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ABSTRACT

Conducting an Indoor Air Quality (IAQ) investigation using phase assessment provides the most practical and cost effective method for evaluating illnesses caused by Sick Building Syndrome (SBS) and Building Related Illness (BRI). Phase assessment begins with a general investigation and proceeds to the most specific. Phases I and II involve obtaining baseline information through a general walk-through inspection and occupant questionnaires. Phase III involves basic parameter sampling; temperature, relative humidity, carbon dioxide and carbon monoxide. Phase IV involves specific parameter sampling such as Volatile Organic Compounds (VOC), mold spores and particulate matter. Phase V involves proactive monitoring and recurrence prevention. Efficiency and cost effectiveness results from the option to combine phases or eliminate phases such as Phase IV which involves possible extraneous laboratory testing and more expensive testing equipment and complicated data analysis. For example, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) established solid Phase III parameters, whereas mold sampling and analysis in Phase IV requires data analysis interpretation thus reducing the efficiency and cost effectiveness due to more expensive sampling, lab testing and data analysis.

BACKGROUND

On February 26, 2007, an Indoor Air Quality (IAQ) investigation was conducted at the Logan County Electric Cooperative office building, 1587 County Road 32 North, Bellefontaine, Ohio. The complaint was in response to general indoor air quality health complaints such as: sore throat, red/itchy eyes and inflamed mucous membranes. Consistent with IAQ guidelines, the inspection was conducted in phases from general to more specific: visual inspection, questionnaires, moisture sampling, and basic IAQ parameter sampling. Based on a completed questionnaire(s), the described symptoms of the office occupants were consistent with Sick Building Syndrome (SBS). Four basic parameters are used to assess existing Indoor Air Quality (IAQ): ambient room temperature, carbon dioxide, carbon monoxide and relative humidity. These parameters were measured as part of an IAQ investigation to determine potential causes of SBS. A TSI IAQ-CALC Model 8762 was placed in the occupied office area with the four parameters being continually logged from approximately 7:30 am to 5:30 pm. Pre-occupation and post-occupation parameters were measured to determine specific patterns, if any. A Delmhorst BD-2100 Moisture Meter was used to obtain moisture readings. In addition, a general visible inspection was conducted. The office building has partitioned work stations with several private offices with doors. A separate garage and service area is also part of the larger total office area. The garage/service area and the main office area are each served by a separate HVAC system. The IAQ assessment was limited to the office area as this is where the complaints originated.

Building Related Illness (BRI) is an illness with a specific etiological cause that exists in a building and has been diagnosed by a physician. Such illnesses include Pontiac Fever and Legionnaires Disease where the typical reservoirs are drip pans and air-conditioner/condensation units. In contrast, Sick-Building Syndrome (SBS) is a term used to denote a series of adverse health effects which have no distinct cause. These adverse health effects are exacerbated when an individual is exposed to a particular indoor environment and tend to subside upon leaving the particular indoor environment. The adverse health effects cause inflammation of the upper respiratory tract with symptoms such as: red and itching eyes, sore throat, stuffy and runny nose, coughing, etc. Sources of irritants may be biological (mold, bacteria, etc.), physical (particulate matter), chemical (VOC's, formaldehyde, ozone, etc.), or any combination of these.

INVESTIGATION

An IAQ investigation is best done in phases to maximize efficiency and be the most cost effective. In general, Phases I to II involve baseline information by means of questionnaires and a qualitative walk-through inspection. Phases III to IV involve quantitative sampling beginning with the two basic parameters; temperature and humidity. In this investigation Phases III to IV were partially overlapped with carbon monoxide and carbon dioxide data being obtained along with temperature and humidity. Phase IV also involves more specific physical, chemical and biological sampling for particulate matter, VOC's and mold, respectively. The purpose of a phase-based investigation is to begin general and work toward specific indicators cumulatively, with the investigation ending at Phase V where proactive monitoring and recurrence prevention is conducted.

A Delmhorst BD-2100 moisture meter was used to obtain baseline moisture measurements. Two office areas were checked where existing mold was observed and remediated prior to the investigation. The substrate was drywall with wallpaper. The measurements were consistently 0.2% (See TABLE 1) indicating that the substrate was sufficiently dry and was properly remediated.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 55 recommends ambient room temperatures to be 68-74 degrees Fahrenheit in the winter and 73-79 degrees Fahrenheit. in the summer. The reason that the indoor temperature range is lower in the winter and higher in the summer is to account for occupants wearing heavier clothing or lighter clothing, respectively. The measured temperature range was 66.3-72.9 degrees Fahrenheit with an average of 72 degrees Fahrenheit (See FIGURE 1 OF 4) which falls within the ASHRAE standard. No recommendations were noted with regard to ambient air temperature.

Carbon monoxide is a severe health hazard caused by incomplete combustion of fossil fuels in space heaters, wood stoves, etc. Idling vehicles in the vicinity of air intakes can also be an indirect source of carbon monoxide. Carbon monoxide has a much greater binding affinity for red blood cells than oxygen. Treatment usually involves the use of a hyperbaric chamber to force oxygen into the body to displace the carbon monoxide. Common symptoms of carbon monoxide poisoning are: lethargy, confusion and flushing of the skin. The Occupational Health and Safety Administration (OSHA), the National Institute of Occupational Health and Safety (NIOSH) and ASHRAE all have standards. OSHA set a legal Permissible Exposure Limit (PEL) at 55 ppm as an 8-hour time-weighted average (TWA) [29 CFR Table Z-1]. NIOSH established a Recommended Exposure Level (REL) of 35 ppm as a TWA and a ceiling limit of 200 ppm. ASHRAE 62-1989 set an 8-hour recommended exposure limit at 9 ppm; however, readings above 5 ppm indicate the presence of a combustion source which requires adequate venting. Ideally carbon monoxide should be zero ppm, but consistent and practical readings are usually 2-4 ppm. The measured range during this assessment was 1.4 - 3.9 ppm with an average of ~2.7 (See FIGURE 2 OF 4). No recommendations are noted with regard to carbon monoxide.

Relative humidity is perhaps the most sensitive IAQ parameter because a narrow range must be obtained. Relative humidity is the amount of moisture in the air in proportion to the saturation point (100%) at that specific temperature. Humidity in excess of 100% will therefore cause condensation. If the humidity is too high moisture can accumulate and condensation can occur. If the humidity is too low and as a result there is low moisture in the air then mucous membranes become dry and common upper respiratory tract symptoms exist: red and itchy eyes, sore throat, coughing, sneezing. Low humidity problems are most common in the winter when the outside air is dry and enters the building when the doors are opened and closed. USEPA recommends maintaining humidity between 30 and 50% and ASHRAE recommends below 60%. Humidity below 30% can cause drying of the mucous membranes and thus lead to upper respiratory tract symptoms which can increase the risk of infection. Humidity above 60% will increase moisture in the air and lead to condensation and an increased risk of mold growth. The measured range during this assessment was 23.4% to 29.8% with an average of 27% (SEE FIGURE 3 OF 4). Increasing the existing humidity to at least 40%, but no more than 60%, should alleviate upper respiratory tract symptoms by providing moisture in the air and preventing drying of the mucous membranes which will aid the bodies' natural defense mechanisms; however, humidity greater than 60% will provide enough moisture to allow mold growth on cellulose materials such as drywall and insulation. Sealing all air leaks will prevent dry outside air from entering the building and lowering the humidity and continuously running a humidifier will increase moisture in the air to relieve upper respiratory tract symptoms. Adequately cleaning and draining the humidifier will prevent the accumulation of stagnant water which may act as a microbial reservoir.

Carbon dioxide is exhaled as part of the respiratory process and can be an indicator of the efficiency of an HVAC system. High relative carbon dioxide readings can indicate inadequate intake air flow rates. ASHRAE Standard 62-1989 sets carbon dioxide levels at 1000 ppm which can lead to the misunderstanding that 1000 ppm or greater can create a health hazard. The revised ASHRAE Standard 62-2001 set the new level at no more than 700 ppm in addition to the outside control measurement. Standard 62.1-2004 mentions no numerical standard. Because outside ambient temperatures were below freezing (which can lead to inaccurate measurements) the 1000 ppm standard was used during this investigation.

462-666 ppm was the measured carbon dioxide range with an average of 564 (See FIGURE 4 OF 4). This was a very favorable reading with regard to HVAC intake and distribution. No recommendations are noted with regard to carbon dioxide.

CONCLUSIONS

Phases of an IAQ investigation may be combined or revised as needed, but should always proceed from general to specific. In this particular investigation the last phase was basic IAQ sampling: humidity, temperature, carbon monoxide and carbon dioxide because it was determined that the humidity levels were below 30% which causes drying of the mucous membranes of the upper respiratory tract (sinuses and throat) as well as drying of the eyes. Mucous membranes act as natural defense mechanisms for all types of airborne biological, chemical and physical matter and when these membranes are dry they are not as efficient at trapping airborne matter. If basic IAQ sampling had not revealed specific patterns then the next phase of investigation would require more specific IAQ sampling such as VOC's and mold/fungal swabs or spore sampling; however, during this investigation phase sampling is the most cost effective and practical way of conducting an investigation. The following summary recommendations represent Phase IV in which proactive monitoring and recurrence prevention is conducted:

SUMMARY RECOMMENDATIONS
1) Raise humidity to 40-60% to prevent upper respiratory tract symptoms;
2) To raise humidity, seal all openings to prevent dry outside air from entering the building;
3) To raise humidity, continuously run a humidifier until humidity equals 40-60%
4) Clean and drain the humidifier regularly to prevent a microbial reservoir;
5) Monitor the relative humidity with a hygrometer;

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FIGURE 1 OF 4: TEMPERATURE VERSUS TIME

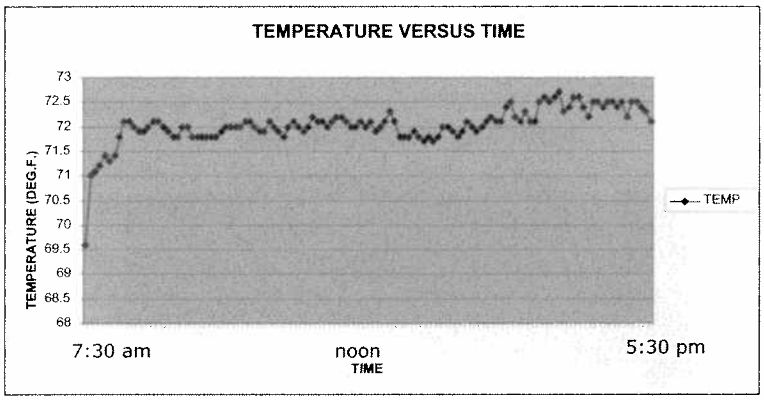

FIGURE 2 OF 4: CARBON MONOXIDE VERSUS TIME

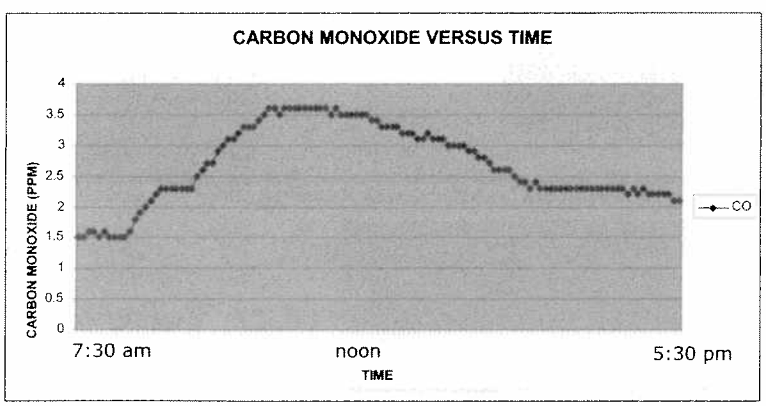

FIGURE 3 OF 4. HUMIDITY VERSUS TIME

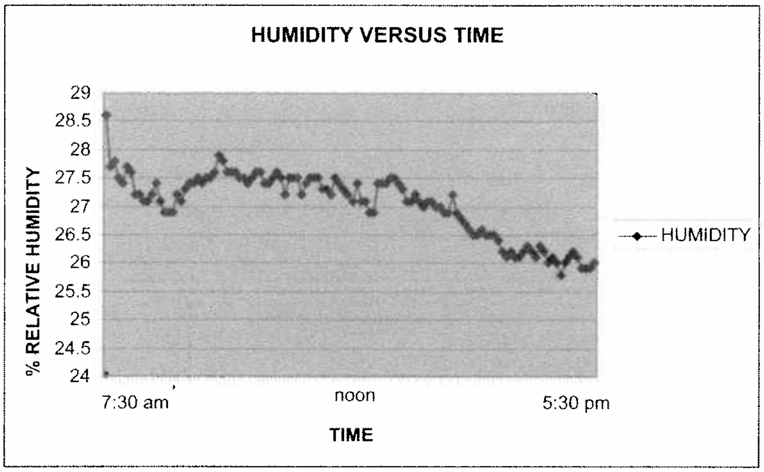

FIGURE 4 OF 4. CARBON DIOXIDE VERSUS TIME

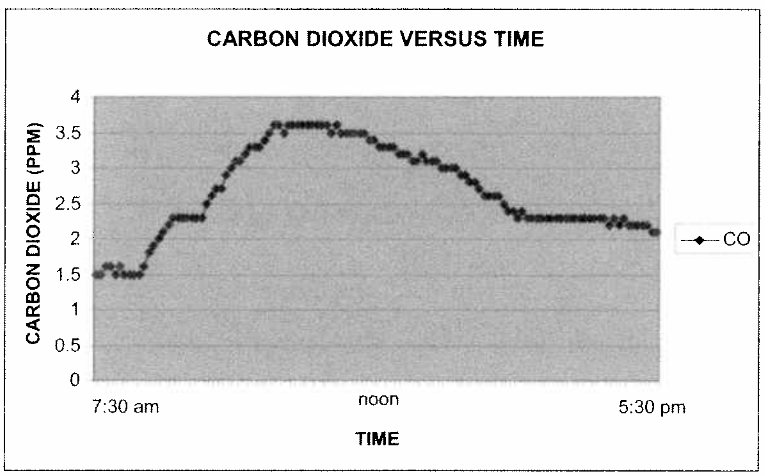

TABLE 1.

<u>DELMHORST BD-2100 MOISTURE METER SCALE</u>

GYPSUM/DRYWALL

0% - 0.5%	**sufficiently dry (0.2% measured)**
0.5% - 1%	borderline
1% +	too wet for most applications