Indoor Air Quality and Gases

By Gareth Evans

Potential hazardous gases is a critical issue in the workplace. Wireless technology provides a means of monitoring and measuring toxic levels before health is at risk.

In striving for the construction of energy efficient and cost-effective buildings, the important issue of the building's indoor air quality (IAQ) is often overlooked. This can often lead to a unhealthy indoor environment and even to conditions such as sick building syndrome (SBS) or other building related Illnesses (BRI). poor IAQ is a major concern to businesses, building managers, tenants and employees because it can impact the health, comfort, well being and productivity of the building occupants. This is especially important in industries where people spend a lot of time indoors; for example, many office workers will spend their entire working day inside a building. Healthy, comfortable employees are invariably more satisfied and productive.

Thus, measurement and monitoring of hazardous gases is a critical issue in industrial and workplace safety. Conventionally, worker safety has been concerned with acute levels of airborne pollutants, and today there is also mounting concern about the effect of long-term exposure to low levels of pollutants.

The potential adverse effects from long-term exposures as well as from shorter-term higher-level exposures are specified within exposure limits. The acceptable long-term exposure range (ALTER) is that concentration range, which it is believed from existing information, that a person may be exposed over a lifetime without undue risk to health. The acceptable short-term exposure range (ASTER) is that concentration range, which it is believed from existing information, that a person may be exposed over the specified time period without undue risk to health.

Each hazardous substance will have an exposure limit; an IAQ monitor can measure and examine these substances. However, since research into the health effects of indoor air quality is at an early stage, there is a dearth of reliable information on the health effects that result from exposure to the low levels and mixtures of contaminants likely to be found.

There are many factors that can lead to an unhealthy indoor air environment including poor or inadequate ventilation, airborne and chemical pollutants, ozone emissions from printers and photocopiers, high concentrations of total volatile organic compounds (TVOCs), formaldehyde and pollution from external sources (e.g. fumes), outgassing of synthetic textiles, and even basic building materials such as drywall. (see Table 1) In the past few decades, energy conservation measures have led to airtight building construction that create problems with IAQ. Frequently the ventilation systems are set to minimize the amount of fresh air entering and circulating within the building.

Many factors can lead to an unhealthy indoor air environment

Sick building syndrome is said to occur when a substantial proportion of the occupants of a building experience symptoms associated with acute discomfort that are usually relieved upon leaving the premises. The mechanisms are still not fully understood, but poor indoor air quality is thought to contribute greatly to this problem.

Health effects from indoor air pollutants may be experienced soon after exposure. The immediate effects are usually short-term and treatable, including irritation of the eyes, skin, nose and throat, upper respiratory congestion, headaches, dizziness and fatigue. Long term exposure to low levels of pollutants could have an effect on an individual's health in future years, according to the U.S. EPA/Office of Air and Radiation, and can be severely debilitating or fatal. They can cause illnesses including some respiratory diseases, heart disease, and cancer. Exposure to high levels of some pollutants, such as carbon monoxide, can even result in immediate death.

Gas	Sources	Health effects	Standards and Guidelines
Carbon Monoxide	Common sources of carbon monoxide include that from improperly vented furnaces, malfunctioning gas ranges. Vehicle exhaust from nearby roads is also a common source.	Symptoms include fatigue, headache, dizziness, nausea and vomiting, cognitive impairment, and tachycardia. At high concentrations CO exposure can be fatal.	The OSHA standard for workers is 50 ppm for 1-hour. NIOSH recommends no more than 35 ppm for 1-hour.
Volatile Organic Compounds (VOCs)	Household products including: paints, paint strippers, and other solvents; wood preservatives; aerosol sprays; cleansers and disinfectants; air fresheners; stored fuels and automotive products	Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans.	Standards applicable to individual VOCs are based on significant levels found in industrial or manufacturing situations. The high demand for documenting trace indoor VOC levels, especially when dealing with complaint or health situations, stems from an occupant relations and/or a litigious due-diligence need —not to mention the desire to insure a healthy working environment.
Formaldehyde	Pressed wood products (hardwood plywood wall panelling, particleboard, fiberboard) and furniture made with these pressed wood products. Urea-formaldehyde foam insulation (UFFI). Combustion sources and environmental tobacco smoke. Durable press drapes, other textiles, and glues.	Watery eyes, burning sensations in the eyes and throat, nausea, and difficulty in breathing in some humans exposed at elevated levels (above 0.1 parts per million). High concentrations may trigger attacks in people with asthma.	TWA: airborne concentration of formaldehyde which exceeds 0.75 parts formaldehyde per million parts of air (0.75 ppm) as an 8-hour TWA. Short Term Exposure Limit (STEL): airborne concentration of formaldehyde which exceeds two parts formaldehyde per million parts of air (2 ppm) as a 15-minute STEL.
Nitrogen Dioxide	Kerosene heaters, un-vented gas stoves and heaters. Environmental tobacco smoke.	NO_2 acts mainly as an irritant affecting the eyes, nose, throat, and respiratory tract. Continued exposure to high NO_2 levels can contribute to the development of acute or chronic bronchitis. Low-level NO_2 exposure may cause increased bronchial reactivity in some asthmatics, decreased lung function in patients with chronic obstructive pulmonary disease and increased risk of respiratory infections, especially in young children.	No standards have been agreed upon for nitrogen oxides in indoor air. ASHRAE and the US EPA National Ambient Air Quality Standards list 0.053 ppm as the average 24-hour limit for NO2 in outdoor air.
Ammonia	Ammonia is used in refrigeration, it is also used in the manufacture of fertilizers, nitric acid, explosives, plastics, fuel cells, rocket fuel, synthetic fibers, dyes, and is present is some detergents and cleaning products.	Low-level exposure can cause health effects such as irritation of the eyes, nose and throat. In addition, chronic exposure to ammonia may irritate the lungs resulting in bronchitis (inflammation of the airways) with cough, phlegm, and/or shortness of breath.	The Occupational Safety and Health Administration has set a short-term (15min) exposure limit of 35ppm for ammonia. The National Institute for Occupational Safety and Health recommends that the level in workroom air be limited to 50ppm for 5 minutes of exposure.
Carbon Dioxide	Humans are the main indoor source of carbon dioxide.	Carbon dioxide at levels that are unusually high indoors may cause occupants to grow drowsy, get headaches, or function at lower activity levels.	ASHRAE standard indicates that carbon dioxide levels less than 800 ppm will indicate that sufficient ventilation is being supplied to the building for the populations.
Ozone	Ozone is emitted from many sources, all commonly found in a workplace environment such as printers, photocopiers etc.	Symptoms include shortness of breath, chest pain when inhaling deeply, wheezing and coughing.	The EPA's ozone standards specify 0.075ppm over a 8 hour period.and 0.12ppm over a 1 hour period.
Sulphur Dioxide	From outdoor air pollution sources entering into the indoor environment.	Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO2.	EPA set the one-hour SO_2 health standard at 75 parts per billion (ppb), a level intended to protect against short-term exposures ranging from five minutes to 24 hours.

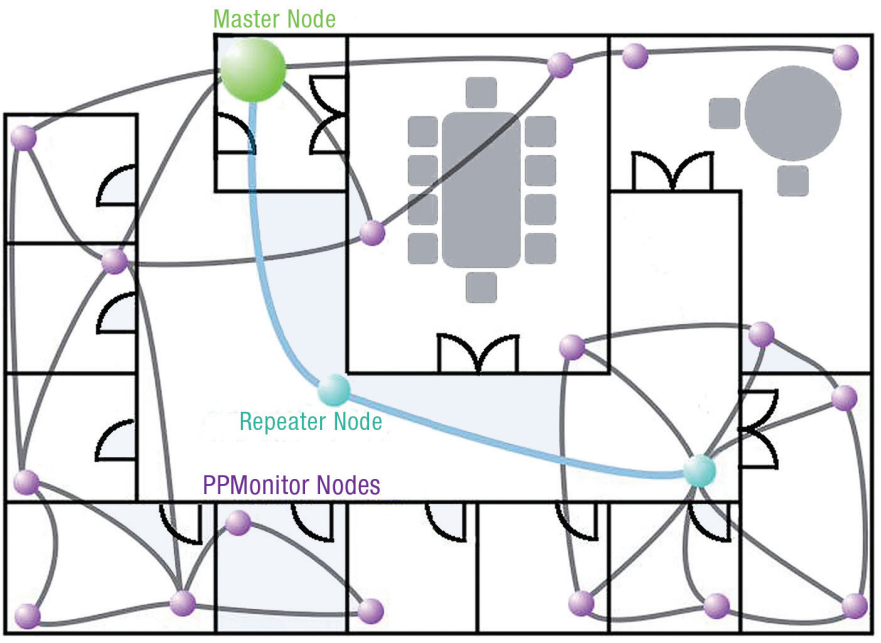

Figure 1. How Wireless units can be placed in any location to enable a building-wide analysis of IAQ.

Typical indoor air quality investigation and examination consists of taking single point measurements of pollutant levels. This monitoring method is unreliable, as the pollutant level is subject to hourly, daily and indeed seasonal fluctuations (see Figure 1). Building service professionals and designers alike have regarded such IAQ examination methods as being inadequate bearing in mind today's plethora of potential contaminants.

Continuous Monitoring vs. Single Point Measurements

Continuous monitoring means the problems associated with single-point measurements are eliminated. The advances in technology have made it possible for a wireless system to control and monitor IAQ parameters continuously in real-time. State-of-the art gas sensors, automatic sampling, data logging, digital technology and IT, have made it possible for IAQ profiling to be accurate, efficient and therefore cost effective system.

PPM Technology have utilized this continuous monitoring technology in developing the Wireless IAQ Profile PPMonitor; it enables an effective and flexible management of IAQ; it is able to collect a complete and accurate record of IAQ; presenting facility managers and health and safety officers with the data they need for the effective management of air quality within the building.

A wireless system enables simple continuous detection and measurement of many of the factors that contribute to a building's indoor air environment; such as temperature, humidity and a number of toxic gases and compounds including carbon dioxide, carbon monoxide, nitrogen dioxide, sulphur dioxide, ozone, ammonia, formaldehyde and total volatile organic compound's (TVOCs). Controlling these IAQ parameters would improve the comfort and work efficiency of the occupants as well as their immediate and long-term health. These substances are amongst the hundreds under the regulation of Occupational Exposure Limits (OEL). These are limits to control exposure to dangerous substances in the workplace; this is achieved by setting the maximum amount of (air) concentration of a specific substance.

Occupational Exposure Limits in the United States vary from state to state. The major providers of OELs in the USA are the American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Health and Safety Administration (OSHA), and the National Institute for Occupational Safety and Health (NIOSH).

The ACGIH publishes the Threshold Limit Values (TLVs), defined as an exposure limit "to which it is believed nearly all workers can be exposed day after day for a working lifetime

Figure 2. The PPMonitor software shows results collected in real-time, the graphical display means trends and patterns can be identified easily.

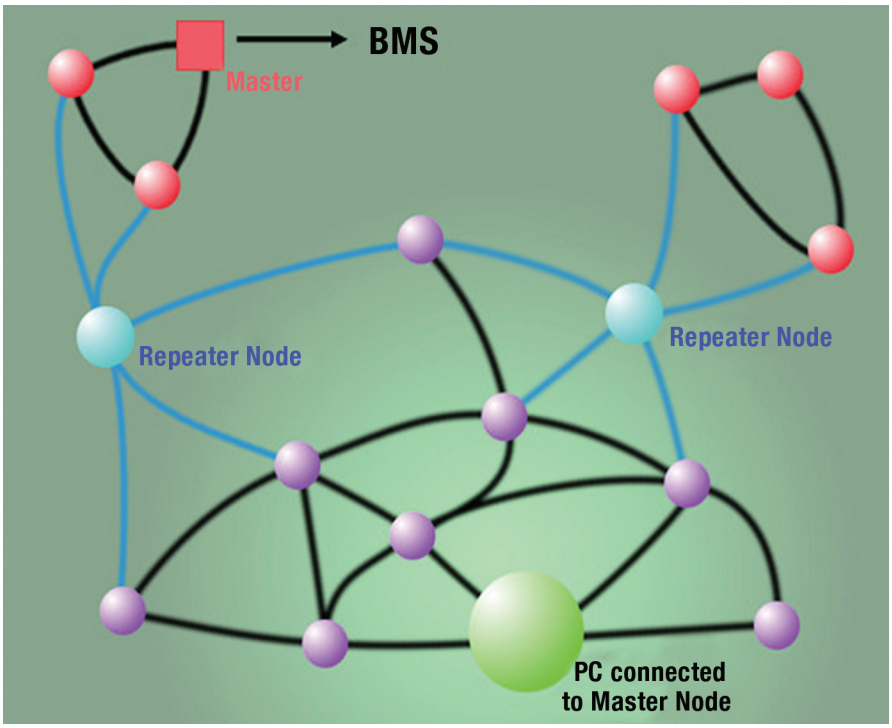

Figure 3. Diagram of a typical wireless system design

without ill effect". The list of TLVs includes more than 700 chemical substances and physical agents, as well as dozens of Biological Exposure Indices for selected chemicals. Substances are nominated by the TLV Committee based on new occupational exposure data or requests of governmental organizations, workers, industry etc.

The limits are meant to protect workers from excessive exposure to toxic substances. They are averaged over a specified period of time referred to as a time-weighted average (TWA). Two time periods are used—long term (eight hours) and short term (15 minutes). Short-term exposure limits (STELs) are set to help prevent effects such as eye, nose, and throat irritations, headaches, dizziness, and fatigue. These symptoms can occur following exposure of a few minutes.

The ACGIH's Threshold Limit Values do not have legal force in the USA, they are only recommendations. It is the Occupational Safety and Health Administration (OSHA) who define the regulatory limits. They publish the Permissible Exposure Limits (PEL). PELs are regulatory limits on the amount or concentration of a substance in the air, and they are enforceable.

NIOSH has the statutory responsibility for recommending exposure levels that are protective of workers. NIOSH has identified recommended exposure levels (RELs) for around 700 hazardous substances. These limits have no legal force. NIOSH recommends their limits in criteria documents issued to OSHA and other OEL setting institutions.

Should the level of a specific toxic substance exceed the TWA and STEL limits for the parameter, the monitoring system software will give an immediate warning. The system can also initiate immediate audible and/or visible warning of the presence of harmful gases in the air thus protecting employees and the public. Buildings can be immediately evacuated minimizing exposure to the building occupants.

An alarm can be used to give a warning that gas concentration levels have reached a non-critical but elevated level. It can then trigger the air conditioning system to respond before the gas concentration reaches a critical level. A further alarm can give a more severe warning when the gas concentration reaches a critical level.

A wireless gas detection system has many advantages over conventional detection techniques. First of all there is reduced installation costs, a wireless system means there is no need for expensive cables and underground cable conduits. The entire system can be configured and operational in less than a day.

A wireless IAQ sensor network also has the ability to monitor in inaccessible locations where a wired infrastructure is not viable or possible. A building-wide network of monitoring units can be achieved; this means a more detailed representation of indoor air quality in general. A network can be extended simply by adding dedicated repeater nodes or additional wireless units; each unit can be tailored to unique sensor specifications if necessary.

It is also possible to integrate the monitoring system with the building automation system; dedicated software allows an entire wireless system to be managed and controlled from a single PC, and the software can set parameters for temperature, humidity and concentrations of hazardous gases, which can then activate and control the air conditioning and ventilation systems. It can also turn on or off heating and trigger building alarms.

The collected data is presented on the controller PC in real-time. A graphical display enables the user to identify trends and patterns in the sampling; simple user interfaces enable ease of use and operation of the software. The user can monitor and control each individual unit and sensor using the software. Limits can be set on each parameter, which when exceeded will set off an on-screen alarm. Relays can also be installed which can give visual and/or audible warnings if the limit is exceeded. The user can create monitoring schedules using the software if monitoring only needs to take place for a set period of time, for example during work hours only.

Continuous monitoring of IAQ enables a profile of the indoor air environment to be created, and analysis of the recorded data through dedicated software allows for more efficient management of resources and energy. If the building service engineer has the correct data relating to the day-to-day operation of the air conditioning system, improvements to the design and management of the ventilation system can be made. A more effective air-conditioning or ventilating system also has a positive impact on the environment. It would also ensure optimum human comfort, energy conservation, cost effectiveness and health and well-being of those inside the building.

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