# Ventilation and Indoor Air Quality

## ENERGY SAVING - FACT SHEET

## Introduction

In our pursuit to save energy it is also important to maintain a quality environment for the air we breath.
The quality of air in our school classrooms, corridors, offices buildings, and indoor athletic facilities is to be monitored on a regular basis to ensure the ventilation systems are working properly.

## North Carolina Schools and Offices

Some states have standards that set acceptable values for defining air quality in their schools. North Carolina refers to ASHRAE 62-2001 (or latest) as a standard that fulfils the building code requirements for indoor air quality (IAQ). This American Society of Heating, Refrigeration, and Air Conditioning Engineers Standard requires that classrooms be provided with 15 cfm/person for outside airflow to the classroom.* ASHRAE further recommends that concentrations of carbon dioxide ($CO_2$) be maintained below 1,000 ppm in classrooms and 800 ppm in offices. (ppm = parts per million, the number of molecules of carbon dioxide per million air molecules)
The fresh air we inhale will have about 350 ppm of background carbon dioxide with the life sustaining oxygen of the atmosphere. When we exhale the air it will have 35,000 ppm to 50,000 ppm of carbon dioxide and a small trace of oxygen as our lungs expel most of the air as carbon dioxide. We can measure the concentration of carbon dioxide to determine if there is proper ventilation of fresh make-up air to the room and thus meeting the 15 cfm/person prescribed by ASHRAE.

1. First measure the outside air concentration of carbon dioxide preferably close to the region where the fresh air make up is drawn into the building/ room. Record this number. Range should be between 325 ppm to 400 ppm.
2. Measure the room concentration of carbon dioxide. Should have a range of 500 ppm to 5,000 ppm, the lower the better.
3. Review the table below to estimate the amount of carbon dioxide that is being attributed to the persons being confined to the closed room space.

The carbon dioxide values in the table below are approximate, and are based upon a constant number of occupants, a constant ventilation rate, outdoor air carbon dioxide concentration of 350 ppm and good mixing of the indoor air. This seems simple enough but does require some steady conditions so that carbon dioxide concentration levels can reach equilibrium. This means that rooms that are full of occupants all day will accumulate higher carbon dioxide concentrations toward the end of the day if ventilation rates are not being maintained at standard conditions. A spot check of a room at the beginning of the day and then at the end of the day will allow some indications of concentration build-up. Another factor that obviously has an influence on the concentration rise through the day is the size of the room relative to the number of occupants. A room or occupants with a few occupants and large size or volume of air space will not come to an equilibrium carbon dioxide concentration as readily as a modular classroom with low ceiling height and small volume of air space. This is why it is important for modular classrooms to be checked on a frequent basis for proper ventilation.

What are the risks of high concentrations of carbon dioxide? ... lethargic response, sleepiness, student performance, stale or stagnant air, increasing concentrations of unhealthy airborne contaminants and the potential for infection transmission.

In the process of tracking energy gains and losses it is also very important to track the classroom, office, conference room, and work environment ventilation rates for providing a healthy environment for our students, faculty and office workers to perform at their very best.

* Note: The NC State Board of Education, Department of Public Instruction, Engineering Checklist for Public School Facilities recommends the ventilation rate should be 7.5 cfm/person but with ductwork sized for 15 cfm/person for special ventilation needs.
The website for this information is:
www.schoolclearinghouse.org/pubs/engcklst.pdf

**Ventilation Rate and Resultant $CO_2$ Concentrations****
**(At 350 ppm outdoor air concentration)**

| Indoor Carbon Dioxide ppm | Outside Air Ventilation cfm/person | $C0_2$ Differential (Inside -Outside) |
|---|---|---|
| 800 ppm suggests about | 20 cfm or less | 450 ppm |
| 1,000 suggests about | 15 cfm or less | 650 ppm |
| 1,400 suggests about | 10 cfm or less | 1,050 ppm |
| 2,400 suggests about | 5 cfm or less | 2,050 ppm |

**Technical Resources and Table provided by Washington State University Energy Program
www.energy.wsu.edu/documents/building/iaq/CO2inbuildings.pdf

## Reference Conditions — Air quality

### TEMPERATURE AND HUMIDITY

The current ASHRAE recommended temperature for optimum comfort is 68 - 75 degrees Fahrenheit (°F). However, this component is very dependent on occupant sensitivity. ASHRAE also recommends that the relative humidity be maintained between 30% and 60%. Levels below 30% may lead to symptoms such as eye irritation, and drying of the mucous membranes. Levels in excess of 60% are conducive to microbial growth.

### CARBON DIOXIDE

Carbon dioxide is a product of human respiration and, in itself is not likely to pose a health hazard. The reason $CO_2$ is measured is because elevated levels of carbon dioxide may serve as an indicator of insufficient intake of fresh air into a building, or an insufficient number of air changes in the working environment. OSHA currently sets 5,000 parts per million (ppm) as their Permissible Exposure Limit (PEL) for occupational exposure to $CO_2$. The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) currently recommends that $CO_2$ levels be maintained below 1,000 ppm. $CO_2$ levels will typically increase over the course of a normal day as human exhalation buildings up. These levels usually decrease when a given area is unoccupied, such as, during lunch breaks and at the end of work or school day.

### CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that is a product of incomplete combustion of any carbon- containing fuel. It is a chemical asphyxiate that prevents oxygen from reaching the body's tissues. The Environmental Protection Agency (EPA), in the National Ambient Air Quality Standards (NAAQS), sets 9 ppm over a 24-hour time weighted average (TWA) as their standard for acceptable levels of carbon monoxide in outdoor (ambient) air. The OSHA PEL for carbon monoxide is 35 ppm over an eight (8) hour TWA, and 50 ppm over one hour. The outdoor ambient air quality level for CO is 9 ppm for 8 hours and 5 ppm for one hour.

ASHRAE has suggested these outdoors levels as targets for indoor limits in its ventilation standard (ASHRAE 62). Outdoor levels are usually between 1-10 ppm with indoor levels usually tracking outdoor levels.

## Using $CO_2$ to Calculate Percent Outside Air

Direct measurement of the amount of outside air entering a large air handling unit can be difficult and unreliable. Measuring the concentration of carbon dioxide in the outside air return air and mixed air stream is often much easier than the other methods. The values obtained are used in the following formula to determine the percentage of outside air for a particular air handling unit.

$$\text{The \% Outside Air (OSA)} = \frac{C_r - C_s}{C_r - C_o} \times 100$$

Where:

$C_o$ is the $CO_2$ (ppm) in the outside air
$C_r$ is the $CO_2$ (ppm) in the return air
$C_s$ is the $CO_2$ (ppm) in the supply or mixed air

The total supply air volume required in order to calculate the approximate cfm of outside air supplied to the building using the percentage:

Outside Air (cfm) = % Outside Air X Total Supply Air (cfm)

## Portable $CO_2$ Meters

There are several manufacturer's of instruments for detecting ppm of carbon monoxide. Most have relative humidity, temperature, carbon monoxide and carbon dioxide capability combined in a portable handheld unit capable of uploading to a computer several days of data points for seeing the effects of ventilation control or the lack thereof. A few that have these features include:

- Honeywell IAQProbe Air Quality Monitor
- Extech EA80 Indoor Air Quality Meter
- GE Telaire $Co_2$/Temperature Monitor

Most of these will have infrared sensors for determining the ppm of values shown in the previous table.

Revised by Waste Reduction Partners– 04/2010

Sponsored by the State Energy Office, N.C. Department of Administration and the U.S. Department of Energy, with State Energy Program funds, in cooperation with the **Land-of-Sky Regional Council (Waste Reduction Partners)** and the **NCDPPEA**. However, any opinion, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of either the N.C. Department of Administration or the U.S. Department of Energy.