FLUKE®

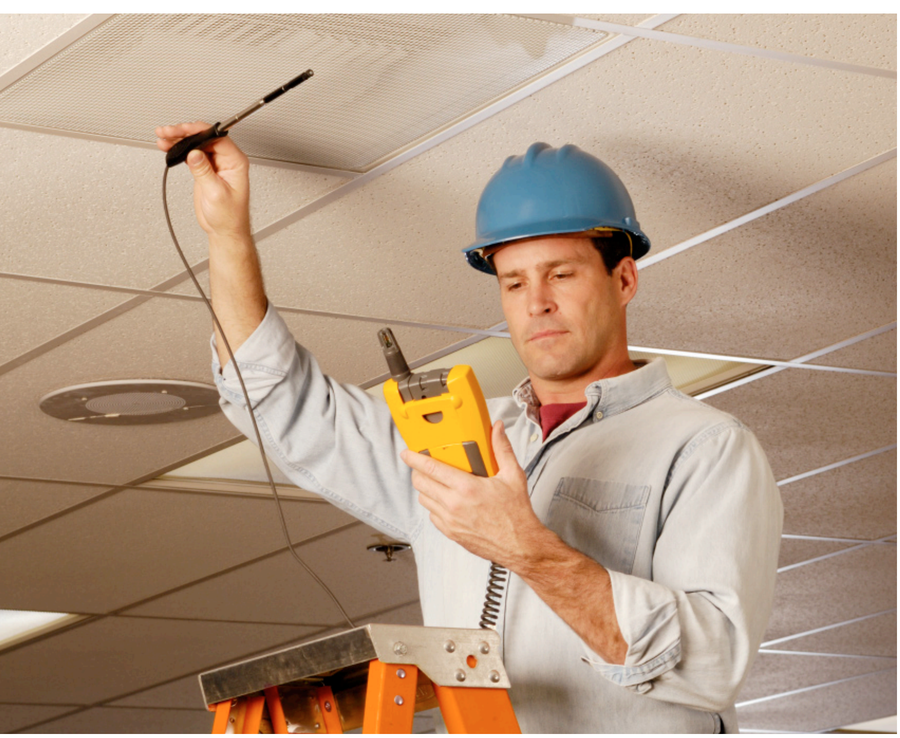
Fluke 975 Air Meter: Environmental carbon dioxide analysis

Application Note

Carbon dioxide (CO_2) is a naturally occurring, colorless, odorless, non-combustible gas that is ever present in the atmosphere, usually ranging in concentrations from 300-600 ppm (parts per million).

In nature, CO_2 is used in plants for photosynthesis (CO_2 in, O_2 out), released through the respiration of aerobic organisms (O_2 in, CO_2 out), released by decaying life forms and outgassing volcanoes, and is a product of the complete oxidation (combustion) of carbon based compounds. CO_2 is also commercially produced and has many commercial and industrial uses from beverage carbonation to "dry ice" to fire extinguishers. How, then, is CO_2 a significant factor in environmental Indoor air quality?

Processes that produce CO_2 in a typical occupied space include human and animal respiration, decaying plant and animal life, such as garbage in a kitchen, and combustion processes of fossil fuel burning equipment. Most fossil fuel burning equipment, such as furnaces, boilers, water heaters and fireplaces, has provisions to vent the combustion products directly to the outdoors—but venting systems can become inhibited or even fail. Stoves, ovens and space heaters may not utilize a vent system, relying instead on exhaust hoods, building ventilation, or in the case of many residential applications, natural ventilation through stack effect and structural leakage.



Measuring air flow at a supply register.

CO_2 standards

ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality addresses minimum requirements for ventilation and indoor air quality for typical indoor breathing spaces that will be acceptable to occupants. The requirements are "intended to minimize the potential for adverse health effects." The standard is applicable to indoor occupied spaces except when other usages or standards require greater amounts of ventilation. Generally speaking, ventilation rates are selected for contaminant and odor control based on the maximum expected occupant density and activity level.

- When these ventilation rates are maintained, CO_2 levels created by human respiration should always be at acceptable, healthy levels.
- When the occupied space is at maximum expected occupancy with the recommended ventilation rate, CO_2 levels will generally be, depending on space usage, about 350-1,000 ppm above outside air CO_2 levels.

This is well below the OSHA workplace threshold of 5,000 ppm CO_2. NIOSH and ACGIH further stipulate a maximum exposure rate of 30,000 ppm CO_2 for 15 minutes. **CO_2 is an asphyxiant, and at 50,000 ppm CO_2 is considered to be an immediate threat to life.**

Proper ventilation must be maintained in occupied spaces, but ventilation is not free. HVAC equipment must be sized, not only for the building load, but the ventilation load as well. Outside air used for ventilation must be heated, humidified and cleaned in the winter, and cooled, dehumidified and cleaned in the summer. A building may not have maximum occupancy in all spaces at all times. Since ventilation rates are based on maximum occupancy, over-ventilation will occur when spaces are not at maximum occupancy. When ventilation is more than required, energy is wasted.

CO_2 monitoring and demand controlled ventilation

CO_2 can be used as a gauge for determining the effective ventilation rate of occupied spaces and as a warning signal for some processes that may have gone wrong. It's a predictable indicator of occupancy. When CO_2 monitoring is used to control building ventilation rate, it's called demand controlled ventilation (DCV).

The primary purpose of DCV is to avoid over-ventilation and thereby reduce energy costs when spaces are not at full occupancy. One or more CO_2 sensors are used to control the position of the ventilation air dampers based on the CO_2 level within the occupied space.

The maximum open position of the outdoor air dampers is based on the ventilation rate, as though DCV were not being used. The minimum open position during the occupied period is normally set at 20 % of the maximum rate regardless of the CO_2 content of the occupied space, however, depending on the age and usage of the building, this base ventilation rate could be anywhere from 15 to 50 %. This minimum position is required for basic building function ventilation, such as materials off-gassing.

To qualify for DCV, a time lag requirement must be met. To meet it, proper CO_2 levels must be achieved within a time period, and that time period depends on the total cfm/person ventilation rate and the volume of the space to be ventilated. The data logging function of the Fluke 975 AirMeter™ test tool can be used to ensure the time lag conditions are being met.

The three most common DCV control schemes are proportional control, PI or PID control, or setpoint control. With proportional control, the ventilation rate is directly proportional to the rising and falling indoor CO_2 level. PI or PID (Proportional+Integral+Derivative) control compensates or compensates and anticipates for rising and falling CO_2 levels by accelerating the ventilation rate according to the indoor CO_2 rate of change.

For spaces that are typically either empty or fill rapidly, like a classroom, setpoint control goes to maximum ventilation as soon as an increase in CO_2 is sensed. Since CO_2 can vary widely depending on environment (300-600 ppm), DCV target ventilation rates are based on the differential between outdoors and indoors. The outdoor air damper "start open" setpoint should be set at the minimum outdoor CO_2 level unless CO_2 differential is used. CO_2 differential uses an outdoor CO2 sensor to compare actual outdoor verses indoor CO2 levels for more accurate control.

Mysterious CO_2

Fossil fuel burning appliances such as stoves, ovens, furnaces, boilers and water heaters produce high concentrations of CO_2 during complete combustion and are not always directly coupled to a vent system. While a properly ventilated occupied space may have CO_2 levels of 1,500 ppm, the combustion products of a fossil fuel burning appliance has CO_2 levels ranging from 70,000-120,000 ppm, with 30-70 ppm CO as well if the appliance is clean and properly set up.

Stoves and ovens may be unvented in residential applications, or rely on exhaust hoods in commercial applications to vent the combustion products to the outdoors. Improperly applied kitchen exhaust systems can ventilate the kitchen, but not the appliance. This can be checked by monitoring CO_2 levels in the kitchen and adjoining spaces.

Until recent years, gas furnaces, boilers and water heaters were decoupled from the vent system (chimney) by a draft hood. Vents that produced excessive draft would ventilate the equipment room, but not necessarily the gas appliance because of the "cold curtain" that was created at the draft hood. The result of this was flue products spilling into the equipment room.

DCV differential target levels are based on the ventilation cfm requirement per person. Combined with those figures, the 975 AirMeter™ can be used to determine whether the space is properly ventilated, over-ventilated, or under-ventilated. And with that kind of information, technicians can ventilate the space at the lowest possible heating and cooling cost.

10 cfm/person= 1,000 ppm CO_2 differential between indoors and outdoors

15 cfm/person= 700 ppm CO_2 differential between indoors and outdoors

20 cfm/person= 500 ppm CO_2 differential between indoors and outdoors

25 cfm/person= 420 ppm CO_2 differential between indoors and outdoors

30 cfm/person= 350 ppm CO_2 differential between indoors and outdoors

Since CO_2 is heavier than air, the CO_2 would settle at the floor where the water heater burner is typically located, depriving it of oxygen, and resulting in incomplete combustion and elevated CO. As this process continued, the concentration of CO increased creating a more dangerous situation.

Monitoring CO_2 levels in the equipment room is likely to alert occupants to potentially hazardous situations more quickly, before the process gone wrong can accelerate the production of CO. (CO_2 is heavier than air and tends to settle, CO is lighter than air and tends to rise.) Since the combustion process of fossil fuels produces 1.3 to 2 times as much water as CO_2, an unexplained increase in humidity levels, or condensation on cold surfaces, can also alert one to a venting problem.

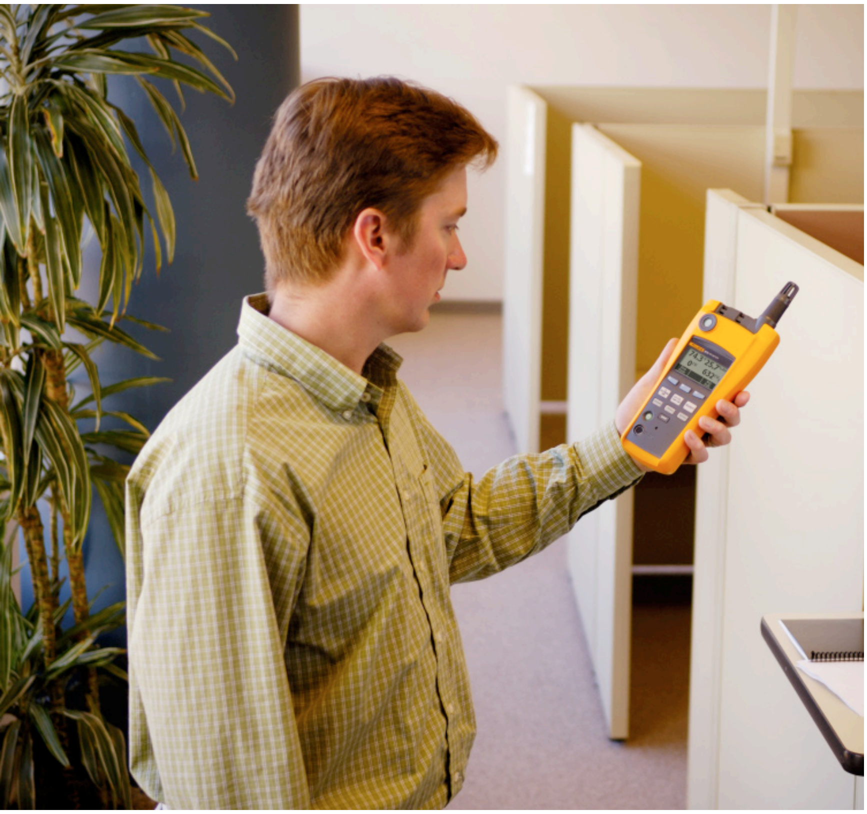
When an occupied space is adjacent to a warehouse or parking garage, simultaneous increases in both CO_2 and CO can indicate ventilation system problems. Garages and warehouses should be independently exhausted and the absolute pressure of the occupied space should be maintained above the absolute pressure of the adjoining garage or warehouse.

Conclusion

Whether one wishes to:

- spot check areas of concern
- use the MIN MAX feature on the Fluke 975 AirMeter™ to narrow in on problem sources
- use the "technical detective" data logging feature to analyze a space over an extended time period to solve elusive problems

the Fluke 975 AirMeter™ is a tool that can save time, money, and even lives.



Reading CO_2 levels in an office space.

Fluke. *Keeping your world up and running.™*

Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

Printed in U.S.A. 10/2006 2786485 A-EN-N Rev A