Demand Controlled Ventilation

Based on

Monitoring of

Carbon Dioxide (CO2)

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CONTENTS

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A. FAQ

1. What is Carbon Dioxide (CO_2)?

Carbon Dioxide or CO_2 is one of the more frequent found gases on the Earth. It is a by-product of combustion processes and the natural metabolism of living organisms.

We inhale oxygen and exhale CO_2. The CO_2 level in exhaled air is rather constant, about 3.8% (or 38,000 ppm). When CO_2 is exhaled it will quickly be mixed with the surrounding air. If the ventilation is good, the concentration will be reduced to harmless levels.

2. What are the outdoor and indoor CO_2 levels?

Indoor CO_2 level usually varies between 400 and 2000 ppm (parts per million). Outdoor CO_2 level is usually 400 – 450 ppm. However, heavily industrialized or contaminated areas may periodically have CO_2 concentration of up to 600 ppm. The levels of outdoor CO_2 are higher in areas where traffic is very heavy.

3. Why monitor CO_2 and control system?

Either too little or too much fresh air in a building can be a problem. Over-ventilation results in higher energy usage and costs than are necessary with appropriate ventilation. While potentially increasing IAQ problems in warm, humid climates, inadequate ventilation leads to poor air quality that can cause occupant discomfort and health problems.

The solution of the problem is Demand-controlled ventilation (DCV) using CO_2 as a tracer gas. The heating, ventilation and air-conditioning (HVAC) system can use DCV to tailor the amount of ventilation air to the occupancy level.

DCV using CO_2 is a combination of 2 technologies; CO_2 sensors that monitor CO_2 levels in the air inside a building, and air-handling systems that uses data from the sensors to regulate ventilation. CO_2 sensors continually monitor the air in a conditioned space. Since people exhale CO_2, the difference between the indoor CO_2 concentration and the level outside the building indicates the occupancy and/or activity level in a space and

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thus its ventilation requirements. The sensors send CO_2 readings to the ventilation controls, which automatically increase ventilation when CO_2 concentrations in a zone rise above a specific level.

4. What are the advantages of CO_2 based DCV?

1. **Improved IAQ**
   By increasing the supply of fresh air to the building, if CO_2 levels rise to an unacceptable level, the technology could prevent under-ventilation that results in poor air quality and stuffy rooms.

2. **Improved humidity control**
   In humid climates, DCV can prevent unnecessary influxes of humid outdoor air that causes occupants to be uncomfortable and encourages the growth of mold and mildew.

3. **Records of air quality data**
   Sensor readings can be logged to provide a reliable record of proper ventilation in a building. Such records can be useful in protecting building owners against ventilation-related illness.

4. **Estimated savings**
   The potential of CO_2-based DCV for operational energy savings has been estimated at $0.05 to more than $1 per square foot annually. The highest payback can be expected in high-density spaces in which occupancy is variable and unpredictable (eg auditoriums, some school buildings, meeting areas and retail establishments), in locations with high heating and/or cooling demand and in areas with high utility rates.

   Improving the ability to condition the building could delay start-times of the HVAC equipment during morning pre-conditioning periods by as much as several hours on a Monday morning in humid climates, resulting in incremental energy and cost savings.

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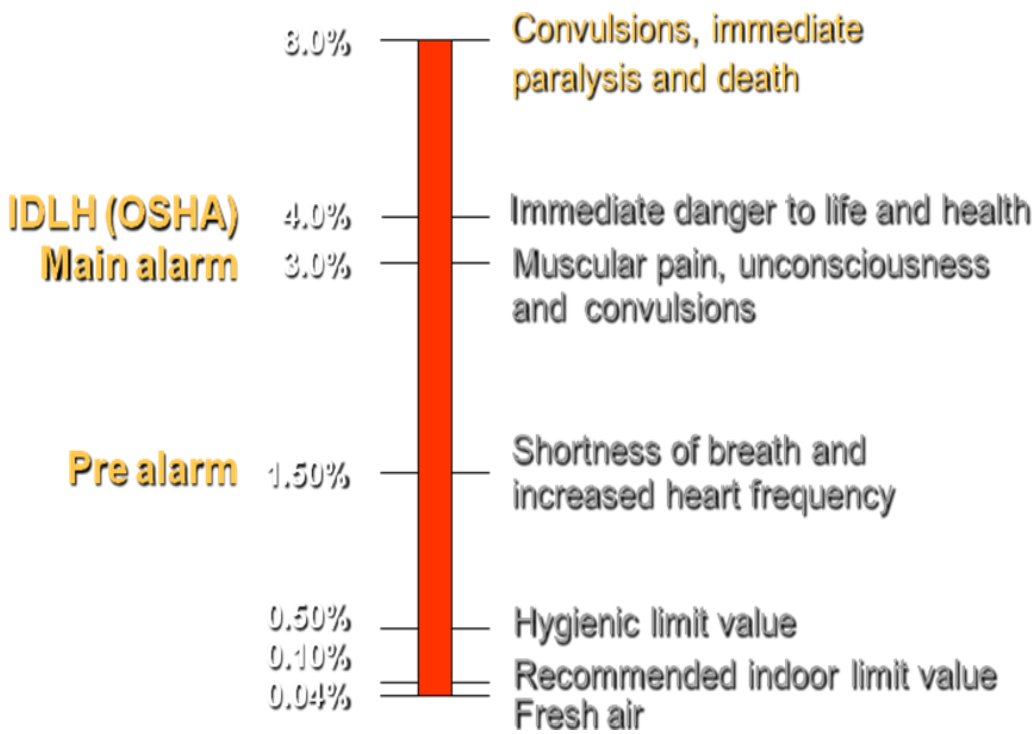
5. How does CO2 affect the human body?



6. What is the maximum permissive concentration of CO2 in occupied building?

Organizations and authorities all over the world have established recommendations for the maximum air flow in occupied buildings:

5,000 ppm	Maximum concentration during an 8-hour working-day according to the Swedish Work Environment Authority.
2,000 ppm	According to many investigations this level produces a significant increase in drowsiness, tiredness, headache and a common discomfort.
1,000 ppm	According to the American Ashrae 62-1989, this is the recommended maximum CO2 concentration in a room. It is also a recommended as the maximum comfort level in many other countries, ie Sweden and Japan. It corresponds to an airflow (a need of fresh air) of approximately 7 litres/second and person.
800 ppm	The company, Ericsson, suggests this value as a maximum CO2 level. It is also a maximum permitted concentration for offices in California. It corresponds to an flow of about 10 litres/second and person.

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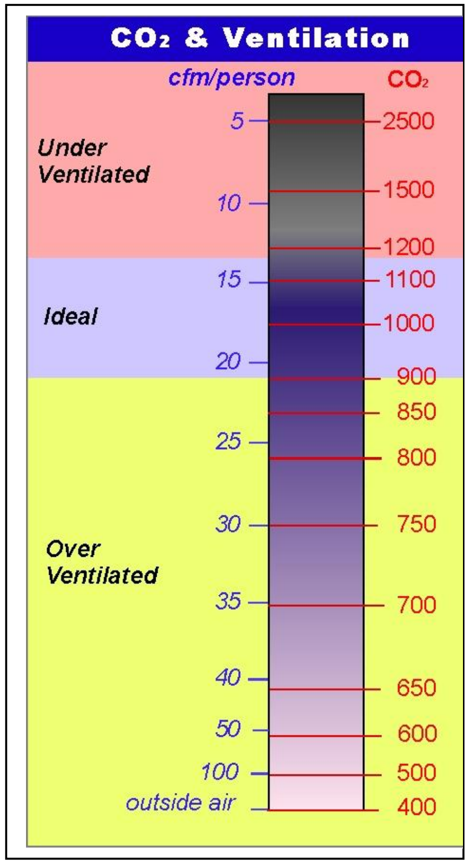
400 – 600 ppm	Risk for over-ventilation.
380 – 450 ppm	A common outdoor concentration.

7. What is the relationship between ventilation rate and CO2 concentration?

To ensure adequate air quality in buildings, the Ashrae recommended a ventilation rate of 15-20cfm per person in Ashrae Standard 62-1999. To meet the standard, many ventilation systems are designed to admit air at the maximum level whenever a building is occupied, as if every area were always at full occupancy. The result, in many cases, has been buildings that are highly over-ventilated.



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8. **What is the coverage of the CO_2 sensor?**

Some manufacturers indicates 4,000 to 6,000 square feet (or 400 to 600 square meters) of coverage for each of their sensor. This is based on the assumption that the room is quite open; that is without blockage or dead corners.

9. **How to determine number of sensing points required?**

This incidentally is very similar to the approximation or estimation of CO sensors in car park (AS1668.2 – 1991). The sensor quantity guideline is given by:

N = A/1000 x SQRT (L/W) x [SF]

Where :
N is the number of sensors required to cover the room or space
A is the area of the room in square meters
L is the length of the room
W is the width of the room
SQRT is the square root function
SF is a safety factor and it is optional. This is used when one would like to be conservative in his design. It can range from 5% to 20% depending on room conditions

10. **Where to place the sensor?**

Some simple guidelines:

1. Choose location that is representative of area to be controlled
2. Avoid location with bad air mixing or air drafts
3. Avoid location near door, window opening and/or fresh-air intakes
4. Place the sensor near to the returned air as oppose to location nearer to fresh air inlet
5. Installation height is recommended to be 1.5m to 2m above slab level.

11. **How to carry out testing and commissioning?**

We calibrate and check all our sensors before sending them to customers. Customers can request for calibration certificate of the sensors (batch Calibration) which is free of charge (chargeable for individual calibration certificates). All sensors come with Automatic Background Correction (ABC) function, thus they are calibration free. However, we recommend a re-calibration or verifications every 1 to 2 years so as to ascertain the function of the sensors.

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Sensors can be sent to our office for re-calibration at a nominal cost.

If required, field testing and commissioning can be done.

12. **Product country of origin?**

    CO_2 sensors – Sweden
    CO_2 sensor/controller – Singapore

13. How many models of CO2 sensor does Telasia Symtonic have?

Models made in Sweden: tSense, eSense, aSense
Models made in Singapore : VC2008T, VC2008F, VS08, VS18 & VC2007

14. What are the minimum requirements of a typical CO2 sensor?

Sensor shall have:

1. Operating principle : Non-dispersive Infra Red (NDIR)
2. Standard range : 0 ~ 2000ppm
3. Accuracy : better than +/- 70ppm +/-3% of reading

15. What are the different types of control strategy?

1. ON/OFF control and/or modulating, by VSD or modulating damper
2. Modulating : VSD or Modulating Damper

16. What is the warranty period?

One year limited warranty against faulty parts and manufacturing defects.

17. What type of connection cable is suitable?

For analog signal, use a shielded twisted pair control cable.
For voltage free relay contact , use 1mm wire

18. What is the power consumption?

Less than 2 watts., 24V AC or DC.

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B. Testing & Commissioning Procedures for Carbon Dioxide (CO_2)

The testing of CO2 sensor should be separated into 2 parts.

1. Sensor Verification

a. Method 1 : Data tracking

If Building Measurement System, BMS, is available, the sensor reading can be tracked over a week. From the data trend, identify the daily low reading of the sensor. In Singapore, the typical low point readings will be around 400 to 450ppm.

b. Method 2 : Compare with reference CO2 meter

Sensor reading can be verified by comparing with a reference CO2 meter.

c. Method 3 : Using reference gases

Inject the known CO2 gases into the sensor (observing the manufacturer's recommendation). Check if the sensor reading is within specification.

Special notes:

- Check sensor operating requirement before verification process. Some sensors require continuous operation for 3 weeks before any accuracy checks. Others may require calibration after installation.
- CO2 products from SenseAir and Telasia Symtonic require 3 weeks continuous operation to ensure the Automatic Background Calibration (ABC) kick in

2. System Verification

This involves injecting more CO2 into the sensor and verify how the system responses. This can be done by simply blowing into the vents of the sensor. (Note : human breathing contains ~ 38,000ppm (varies with activity level).)

- **ON/OFF fresh air control**

Check that the fresh air fan or air damper starts or opens at the required set-point, usually 1000ppm.

- **Modulating control**

Make sure the modulating damper respond with wider opening as more CO2 is introduced to the sensor.

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System Functional Test

To verify the effectiveness of the CO2 sensors, we recommend a simple functional test as stated below:

1. Blow into the top vents of the sensor
2. The reading on the display panel will increase accordingly
3. The fan will be turn 'ON' when the reading exceed the set-point, usually 1000ppm.
4. For modulating control, the modulating damper will respond with wider opening as the CO2 level increases.

C. Sensor Maintenance

1. Automatic Background Calibration (ABC)

Our CO2 sensor is incorporated with Automatic Background Calibration (ABC) function. It is a software algorithm that resides in the sensor. It keeps track of the lowest reading within the ABC period (typically seven days) and makes a self-readjustment or correction. This is done so such that the sensor's lowest value will keep track and follows fresh air concentration.

This approach has been proven and worked well in spaces that are not 24-hour occupied by people. Typically HVAC application falls under this category.

All CO2 sensors come with Automatic Background Correction (ABC) functions, as such they are calibration free when used in normal indoor air applications. However, we recommend a re-calibration or sensor verification every 1 to 2 years so as to ascertain the functionality of the sensors.

Delivery inspections and performance verification tests

Delivery inspections and performance verification tests concerning sensor reading accuracy shall not be performed directly after installation. Allow some time to pass for the sensor to acclimatize at least 24 hours. The manufacturer's recommendation is 3 weeks.

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D. Sensor Calibration

Calibration setup

The following equipment and gas mixtures are required for a full calibration of the CO2 sensor.

1. Gas bottles with single stage regulators
   a. Purified air or nitrogen gas
2. Gas flow meters (0 ~ 50cc per minute)
3. Tygon or PVC tubes for connections

The calibration setup is shown in Figure 1.0

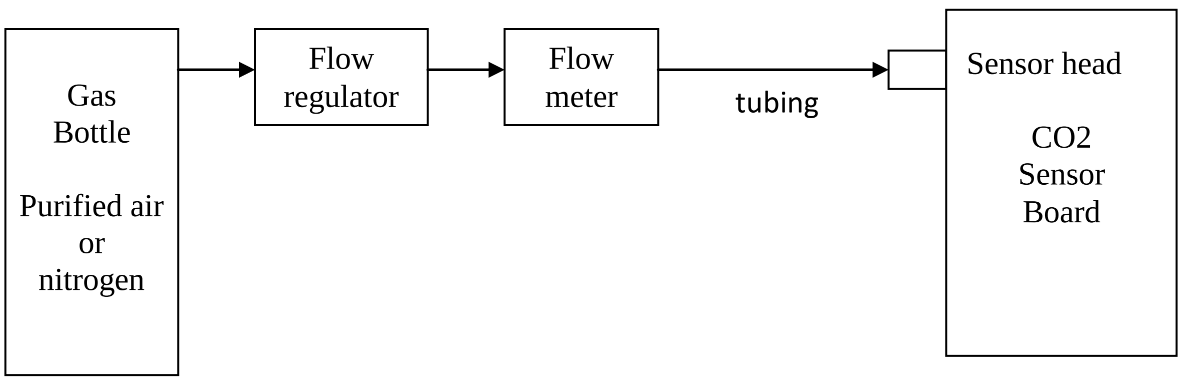

Figure 1: Calibration setup

Procedures

Zero Point calibration

1. Connect the calibration setup as shown in figure 1. Turn on the regulator of purified air/nitrogen bottle and allow purified air/nitrogen to flow into the gas inlet at a rate of 50cc/min.

Span calibration

This is not recommended by CO2 sensor manufacturers due to the difficulties in establishing stable conditions.

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