VALTRONICS

# Application Note A41: Demand Control Ventilation

## Carbon Dioxide ($CO_2$) measurement & control in office and living spaces

This describes how to apply ***VALTRONICS*** $CO_2$ monitors for use in office and living spaces (Refer to **ASHRAE STANDARD 62-1989R**[1]). Higher $CO_2$ levels (above 0.2% or 2000 ppm) apply to industrial spaces (see **Application Note A11**) like food storage, wineries, breweries, areas with $CO_2$ blasters, chemical processing, etc. Our Model **6289D** Direct $CO_2$ DUCT-STAT™ , our Model **6289W** $CO_2$ WALL-STAT™ and our Model **2166** 0.2% $CO_2$ outside air monitor apply here.

The **ASHRAE STANDARD** recommends keeping the $CO_2$ level below **1000 ppm** in office and living spaces for **comfort** and as a surrogate measurement for general air quality. This gives added margin to the higher levels allowed for purely **safety** reasons. Although the **TLV** (threshold limit value) and **TWA** (8 hour time weighted average) for $CO_2$ is 5000 ppm (0.5% by volume), keeping the level below 1000 ppm will help assure that a minimum of **15 CFM** per person occupancy of **fresh air** containing about **400 ppm** of $CO_2$ will be forced into the space. Since people breath out about 30,000 ppm of $CO_2$ (depends upon their metabolic rate and activity level) at the end of their breath, the average $CO_2$ level in an enclosed space relates to the occupancy level and the amount of fresh air introduced. This assumes no other sources of $CO_2$ like combustion, fermentation, or tanks of $CO_2$ are present in that space. See page 2: diagram of a simple HVAC system.

$CO_2$ as a **surrogate air quality measurement**: Ideal indoor air would contain only fresh outside air. The reality is that it is contaminated by the $CO_2$ people breath out and by other chemical compounds that are out gassed from people and the materials in the building like volatile organic compounds[2] (**VOC**s like solvents, paints, cleaning compounds, refrigerants, aerosol propellants, pesticides, glues, cosmetics, disinfectants, plastics, paper, particle boards, etc.). Examples of these VOC type compounds are propane, butane, benzene, toluene, xylenes, ethanol, methanol, acetone, formaldehyde, and many others. Some of these compounds are very toxic but typically occur at very low ppm levels. They are difficult and expensive to measure accurately at the low ppm or ppb (parts per billion) levels. This is why $CO_2$ was chosen by **ASHRAE** as a cost effective method for measuring indoor air quality; "Since $CO_2$ is now widely recognized as both a surrogate for odor and an indirect measure of the adequacy of mixing outdoor and recirculated space air and the ability to deliver supply air into the occupied breathing zone, one may use $CO_2$ as a sensing control strategy capable of maintaining ventilation rates at currently recommended levels pursuant to **ASHRAE Standard 62-1989** under all foreseeable operating conditions"[3]. The tables below and on page 3 show data taken from a Los Angeles high-rise office building. This came from an **ASHRAE Journal article** titled ***Evaluating IAQ Compliance in Buildings Utilizing Carbon Dioxide Level Monitoring*** by **Milton Meckler,** P.E., Fellow ASHRAE in 1993. See Application Note A27, Building Commissioning Process & the H.V.A.C. System.

Calculated hourly carbon dioxide concentrations for an outside air design rate of **15 cfm**/person

| Time of day | people % | min outside air CFM | # people per hour | outside air per person CFM | air exchange rate ($H^{-1}$) | **Initial $CO_2$ PPM** | **Final $CO_2$ PPM** |
|---|---|---|---|---|---|---|---|
| 7:00 | 5% | 2700 | 9 | 300 | 0.70 | **400** | **418** |
| 8:00 | 30% | 2700 | 54 | 50 | 0.70 | **418** | **516** |
| 9:00 | 100% | 2700 | 180 | 15 | 0.70 | **516** | **813** |
| 10:00 | 100% | 2700 | 180 | 15 | 0.70 | **813** | **961** |
| 11:00 | 100% | 2700 | 180 | 15 | 0.70 | **961** | **1034** |
| 12:00 | 80% | 2700 | 144 | 19 | 0.70 | **1034** | **1000** |
| 13:00 | 40% | 2700 | 72 | 38 | 0.70 | **1000** | **840** |
| 14:00 | 80% | 2700 | 144 | 19 | 0.70 | **840** | **903** |
| 15:00 | 100% | 2700 | 180 | 15 | 0.70 | **903** | **1006** |
| 16:00 | 100% | 2700 | 180 | 15 | 0.70 | **1006** | **1057** |
| 17:00 | 100% | 2700 | 180 | 15 | 0.70 | **1057** | **1082** |
| 18:00 | 30% | 2700 | 54 | 50 | 0.70 | **1082** | **845** |
| 19:00 | 25% | 2700 | 45 | 60 | 0.70 | **845** | **710** |
| 20:00 | 10% | 2700 | 18 | 150 | 0.70 | **710** | **590** |
| 21:00 | 5% | 2700 | 9 | 300 | 0.70 | **590** | **512** |
| 22:00 | 0% | 2700 | 0 | 0 | 0.70 | **512** | **456** |
| 23:00 | 0% | 2700 | 0 | 0 | 0.70 | **456** | **428** |
| 0:00 | 0% | 2700 | 0 | 0 | 0.70 | **428** | **414** |
| 1:00 | 0% | 2700 | 0 | 0 | 0.70 | **414** | **407** |
| 2:00 | 0% | 2700 | 0 | 0 | 0.70 | **407** | **403** |
| 3:00 | 0% | 2700 | 0 | 0 | 0.70 | **403** | **402** |
| 4:00 | 0% | 2700 | 0 | 0 | 0.70 | **402** | **401** |
| 5:00 | 0% | 2700 | 0 | 0 | 0.70 | **401** | **400** |
| 6:00 | 0% | 2700 | 0 | 0 | 0.70 | **400** | **400** |

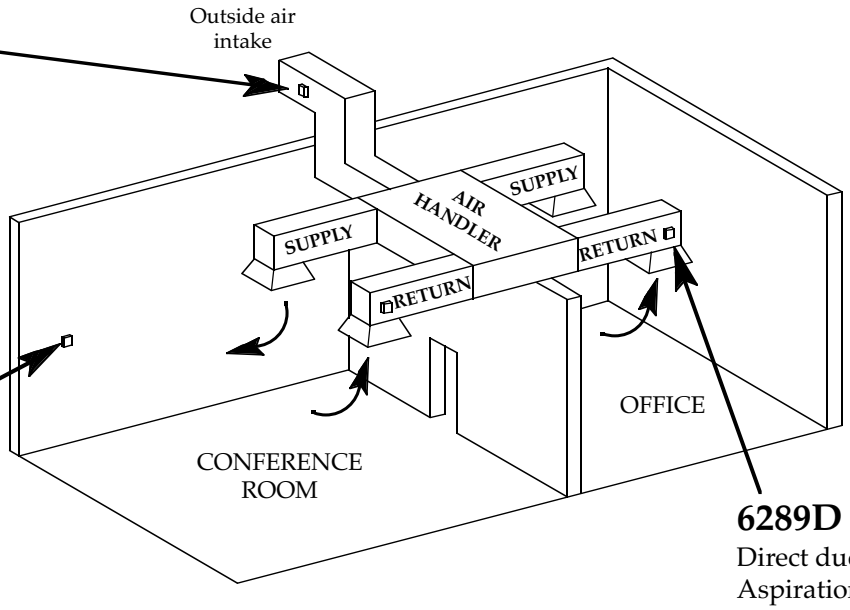
e-mail: bpynenbb@goldrush.com • 3463 Double Springs Road • Valley Springs, CA 95252 • (209) 754-0707 • FAX (209) 754-0104

**Outside air is not always fresh.** If the **OUTSIDE AIR** intake is near a highway, parking lot, or smoke stack the air may have elevated levels of $CO_2$ and other more toxic gases**.** See **App. Note A9 Carbon dioxide ($CO_2$) monitoring in parking garages or near loading docks**.

See ***VALTRONICS*** Model 2166 0.2% (2000 ppm) $CO_2$ monitor for remote sample draw monitoring.

**6289 OA**
Outside air sensor for extreme temperatures of -20° to +122°F
The **Model 2166** 0.2% $CO_2$ is also an outside air monitor that has a remote sample pump.




**6289W**
wall mount area monitor for variable occupancy rooms (digital display and /or tamper resistant enclosure available)

**6289D**
Direct duct mount sensor
Aspiration not required
Flow rates from 0 to 4000 fpm (ft./min.)

$CO_2$ sensors are connected to the air handler's controller. The controller regulates the amount of outside air to maintain the $CO_2$ level below 1000ppm in each room.

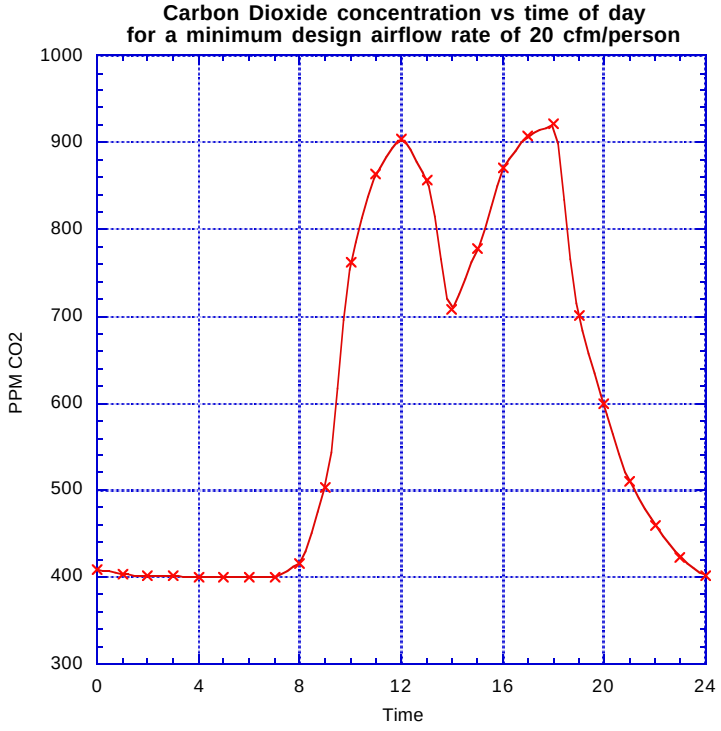
Air handler / controllers are made by companies like Siemens Building Technologies Landis Div., Invensys, Honeywell, Carrier Corporation, Johnson Controls, and YORK to mention just a few. They have sophisticated software and hardware that allows them to optimize the **balance** between **saving energy** and **indoor air quality**. They measure temperature, humidity, $CO_2$ and air flow. Automatic control of the amount of outside air to optimize the energy / air quality balance depends upon accurate and timely measurement of the above parameters.

$CO_2$ sensors that monitor outside air (**Model 2166** 0.2% $CO_2$), supply air and return air ducts (Model **6289D**), give the air handler / controller's computer the data it needs to calculate the optimum fresh air / recirculated air ratio. Area $CO_2$ sensors like our Model **6289W** may be necessary is some rooms where large numbers of people gather like conference rooms. This would give the controller earlier warning that $CO_2$ is building up in that room.

Calculated hourly carbon dioxide concentrations for an outside air design rate of **20 cfm**/person

| Time of day | people % | min outside air CFM | # people per hour | outside air per person CFM | air exchange rate ($H^{-1}$) | **Initial $CO_2$ PPM** | **Final $CO_2$ PPM** |
|---|---|---|---|---|---|---|---|
| 7:00 | 5% | 3600 | 9 | 400 | 0.93 | **400** | **416** |
| 8:00 | 30% | 3600 | 54 | 67 | 0.93 | **416** | **503** |
| 9:00 | 100% | 3600 | 180 | 20 | 0.93 | **503** | **762** |
| 10:00 | 100% | 3600 | 180 | 20 | 0.93 | **762** | **864** |
| 11:00 | 100% | 3600 | 180 | 20 | 0.93 | **864** | **904** |
| 12:00 | 80% | 3600 | 144 | 25 | 0.93 | **904** | **856** |
| 13:00 | 40% | 3600 | 72 | 50 | 0.93 | **856** | **708** |
| 14:00 | 80% | 3600 | 144 | 25 | 0.93 | **708** | **778** |
| 15:00 | 100% | 3600 | 180 | 20 | 0.93 | **778** | **870** |
| 16:00 | 100% | 3600 | 180 | 20 | 0.93 | **870** | **907** |
| 17:00 | 100% | 3600 | 180 | 20 | 0.93 | **907** | **921** |
| 18:00 | 30% | 3600 | 54 | 67 | 0.93 | **921** | **701** |
| 19:00 | 25% | 3600 | 45 | 80 | 0.93 | **701** | **599** |
| 20:00 | 10% | 3600 | 18 | 200 | 0.93 | **599** | **510** |
| 21:00 | 5% | 3600 | 9 | 400 | 0.93 | **510** | **460** |
| 22:00 | 0% | 3600 | 0 | 0 | 0.93 | **460** | **423** |
| 23:00 | 0% | 3600 | 0 | 0 | 0.93 | **423** | **409** |
| 0:00 | 0% | 3600 | 0 | 0 | 0.93 | **409** | **404** |
| 1:00 | 0% | 3600 | 0 | 0 | 0.93 | **404** | **401** |
| 2:00 | 0% | 3600 | 0 | 0 | 0.93 | **401** | **401** |
| 3:00 | 0% | 3600 | 0 | 0 | 0.93 | **401** | **400** |
| 4:00 | 0% | 3600 | 0 | 0 | 0.93 | **400** | **400** |
| 5:00 | 0% | 3600 | 0 | 0 | 0.93 | **400** | **400** |
| 6:00 | 0% | 3600 | 0 | 0 | 0.93 | **400** | **400** |




## REFERENCES

1. ASHRAE, 1989 ***ASHRAE Standard 62-1989R***, *Ventilation for acceptable indoor air quality.* Atlanta: American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc.
2. Hodgson, A.F., J.M. Daisey, and R.A. Grot. 1991. Sources and source strengths of volatile organic compounds in a new office building. *J. Air Waste Manage. Assoc.* 41(11): 1461-1468.
3. ASHRAE Journal 1993. M. Meckler, P.E. Fellow ASHRAE. *Evaluating IAQ Compliance in Buildings Utilizing Carbon Dioxide Level Monitoring*.