



Application Note A41: Demand Control Ventilation Carbon Dioxide (CO₂) measurement & control in office and living spaces

This describes how to apply **VALTRONICS** CO₂ monitors for use in office and living spaces (Refer to **ASHRAE STANDARD 62-1989R¹**). Higher CO₂ levels (above 0.2% or 2000 ppm) apply to industrial spaces (see **Application Note A11**) like food storage, wineries, breweries, areas with CO₂ blasters, chemical processing, etc. Our Model **6289D** Direct CO₂ DUCT-STAT™, our Model **6289W** CO₂ WALL-STAT™ and our Model **2166** 0.2% CO₂ outside air monitor apply here.

The **ASHRAE STANDARD** recommends keeping the CO₂ 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 CO₂ 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 CO₂ will be forced into the space. Since people breath out about 30,000 ppm of CO₂ (depends upon their metabolic rate and activity level) at the end of their breath, the average CO₂ level in an enclosed space relates to the occupancy level and the amount of fresh air introduced. This assumes no other sources of CO₂ like combustion, fermentation, or tanks of CO₂ are present in that space. See page 2: diagram of a simple HVAC system.

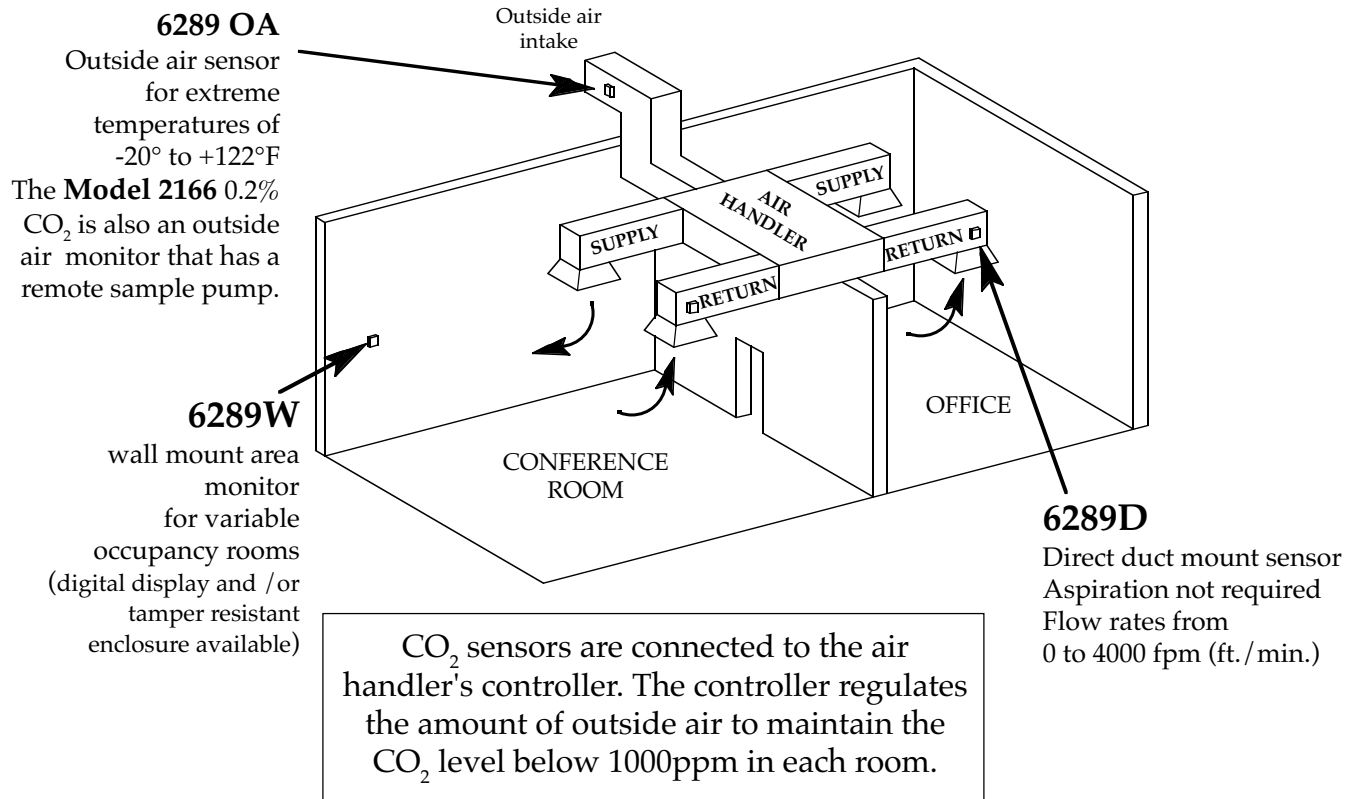
CO₂ as a surrogate air quality measurement: Ideal indoor air would contain only fresh outside air. The reality is that it is contaminated by the CO₂ people breath out and by other chemical compounds that are out gassed from people and the materials in the building like volatile organic compounds² (**VOCs** 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 CO₂ was chosen by **ASHRAE** as a cost effective method for measuring indoor air quality; "Since CO₂ 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 CO₂ 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

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 CO₂ and other more toxic gases. See **App. Note A9 Carbon dioxide (CO₂) monitoring in parking garages or near loading docks.**

See **VALTRONICS** Model 2166 0.2% (2000 ppm) CO₂ monitor for remote sample draw monitoring.



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, CO₂ 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.

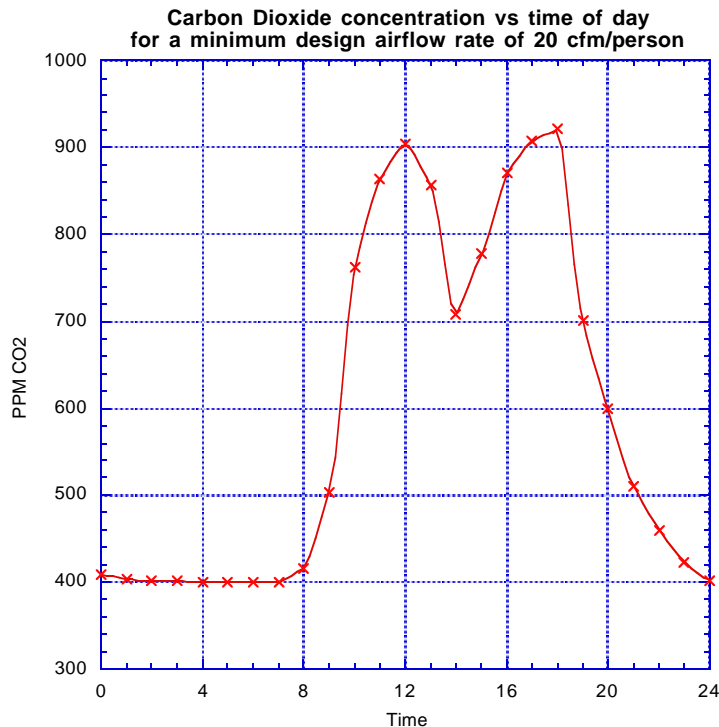
CO₂ sensors that monitor outside air (**Model 2166** 0.2% CO₂), supply air and return air ducts (**Model 6289D**), give the air handler / controller's computer the data it needs to calculate the optimum fresh air / recirculated air ratio. Area CO₂ sensors like our **Model 6289W** may be necessary in some rooms where large numbers of people gather like conference rooms. This would give the controller earlier warning that CO₂ is building up in that room.



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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*.