

This article was published in ASHRAE Journal, September 2022. Copyright 2022 ASHRAE. Posted at www.ashrae.org. This article may not be copied and/or distributed electronically or in paper form without permission of ASHRAE. For more information about ASHRAE Journal, visit www.ashrae.org.

Revisiting the 1,000 ppm CO₂ Limit

What author Robert E. Stumm P.E., writes in “Revisiting the 1,000 ppm CO₂ Limit” in the June 2022 *ASHRAE Journal*, is both interesting and stimulating.

It takes me back to the seven years I spent with John Janssen, Chair, Dave Grimsrud, Vice-Chair and the other 62.1981R members writing Standard 62-1989. Back then outdoor CO₂ ppm levels were in the low 300s, whereas today they exceed 400. At the time, the maximum 1,000 ppm CO₂ level guide set in the 62-1989 standard was based on an outdoor level of just over 300 ppm and an outdoor air ventilation rate of 15 cfm/person. The need for 15 cfm/person minimum outdoor air supply arose from the committee members’ experience. It is also my experience since then.

Recall that the 1978 worldwide energy embargo crisis led to building ventilation systems’ intake air quantities being reduced to as little as 5 cfm/person to save heating and cooling energy. Some buildings even boarded up their HVAC air intakes. Then came the sick building syndrome in buildings and new tighter homes with indoor air-sourced VOC and mold growth emission concentrations now several times higher.

Outdoor ventilation rates in buildings may be much higher than set in the current ASHRAE ventilation standard. For example, a 2004 survey by Persily and Gorfain found that the median outdoor air ventilation rate in a survey of 100 randomly selected office buildings was 49 L/s

per person (105 cfm per person), which is much higher than required by ASHRAE ventilation standards. This survey also measured the recirculation rate as 40% of the total air supply, or 33 L/s per person.¹

My perspective on CO₂ was, and still is, that carbon dioxide is not an indoor air contaminant of concern at levels much higher than 1,000 ppm, and a minimum of 15 cfm of outdoor air should be maintained to address indoor-generated gaseous contaminants. The air in non-nuclear submarines, for example, might contain 5,000 ppm to 7,000 ppm of CO₂.² I have been told as much as 20,000 ppm CO₂ has been measured.

Rather, for me CO₂ is an easy-to-measure tracer for a) estimating per person outdoor air ventilation rate, although one must ensure lag time to equilibrium is taken into account, and also b) as a surrogate for occupant bioeffluent concentration, where human bioeffluent comprises not only many gases besides carbon dioxide.

In the case of a person ill with a respiratory infection, it also includes infectious aerosols from their normally exhaled breath, and these aerosols can float in the air for hours and some of them can be inhaled by others. Think COVID-19, the flu, the common cold, measles, chicken pox and tuberculosis.

So, we need our ventilation systems not only to dilute contaminant gases but also infectious aerosols. That need not be only with outdoor air or HEPA filters in the recirculation air system.³ MERV 13 filters, commonly used in buildings, will remove 50% of infectious aerosols of all sizes, while 1 in. pleated MERV 12

electrostatic filters available for residences will remove 20%.^{4,5}

So, yes, ventilation with at least 15 cfm/person of outdoor air even at higher levels of CO₂ should continue. However, if the higher levels of outdoor CO₂ are accompanied by higher levels of SVOCs such as combustion particulate aerosols, they should be filtered out first.

References

1. Persily, A., J. Gorfain. 2008. “Analysis of Ventilation Data from the U.S. Environmental Protection Agency Building Assessment Survey and Evaluation (BASE) Study.” National Institute of Standards and Technology.
2. Perrson, O., L. Wadso. “Indoor air quality in submarines.” *Indoor Air 2002 Proceedings* 806–811.
3. Walkinshaw, D. 2020. “COVID-19 and beyond: a brief introduction to passenger aircraft cabin air quality.” *ASHRAE Journal* (10) <https://tinyurl.com/6an9xasw>
4. Owen, K., G. Kerr. 2020. “What you can and can’t do with ASHRAE Standard 52.2.” *ASHRAE Journal* (12).
5. Diez Maroto, M. 2011. “Filtration Efficiency of Intermediate Ventilation Air filters on Ultrafine and Submicron Particles.” Master’s Thesis. Department of Energy and Environment, Division of Building Services Engineering, Chalmers University of Technology.

Douglas S. Walkinshaw, Ph.D., P.Eng.,
Fellow/Life Member ASHRAE, Ottawa, ON, Canada

The Author Responds

It is documented that submarine crews on long deployments experience hypercapnia. Upon returning to shore, the hypercapnia abates. What will happen when people will have to contend with elevated atmospheric CO₂ levels life-long? It is a major paradigm shift to think the outdoor air we use to cleanse our indoor air may one day become unhealthy worldwide.

Robert Stumm

The Perfect Economizer

I want to congratulate David Sellers, P.E., Member ASHRAE, on an excellent column, “The Perfect Economizer,” in the April 2022 *ASHRAE Journal* on airside economizers and the identification of system malfunctions that can lead to energy waste rather than recovery during winter variable air volume (VAV) supply fan operation.

You are quite correct in identifying accurate mixed air temperature measurement as a leading contributor to lost energy savings in economizer systems, especially mixed air wet bulb (WB) and dew point (DP) temperatures.

The ASHRAE Epidemic Task Force has published a list of best practices that HVAC designers may follow to mitigate the risk of spread of airborne pathogens in infectious aerosols indoors such as COVID-19. Indoor relative humidity (RH) should be maintained between 40% to 60% to reduce the spread of

airborne pathogens indoors, within the human breathing zone, during cold and dry ambient conditions.

Has your team installed and tested a WB airside economizer using a high saturation efficiency (97% to 99% RH) rigid media adiabatic evaporative cooler/humidifier (AC/H) to mix building return air with outdoor air to produce a supply air dew point that ranges between 45°F DP to 55°F DP during cold and dry ambient conditions (see my hand-drawn figure below)? The psychrometric chart shows a VAV system at 50% fan turndown with an assumed minimum 25% outdoor air to meet code ventilation requirements. The high saturation efficiency, at fan turndown to 50% flow, ensures that the delivery DB temperature off the AC/H is within a fraction of 1°F of both the WB and DP temperatures at the saturation curve. A low-cost commercial-grade DB sensor may be used with acceptable accuracy in determining the delivery DP condition of the supply air. Parasitic losses for this economizer are quite

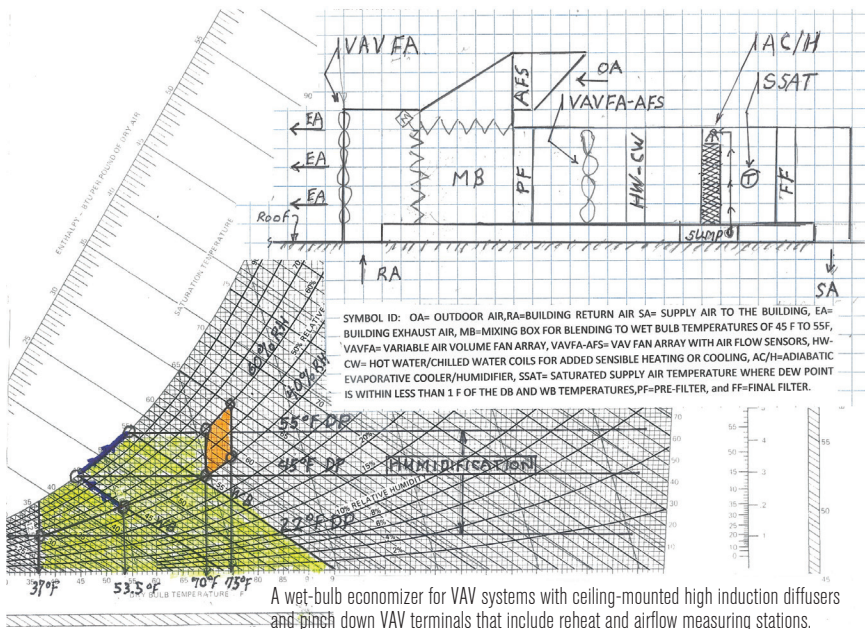
low with a static pressure loss at full flow of 0.2 in. w.g. and a water recirculation pump sized under 1.5 HP. Both the chiller and boiler are off, in the Portland Ore., climate zone for 67.4% of the annual hours of the year (yellow shaded area on the psychrometric chart), while room conditions are maintained between 40% RH and 55% RH at comfortable room air temperatures (see room target in orange shaded area). In your Portland climate, only 6% of the annual ambient conditions (below 37°F DB) would require preheating.

A 1980 Bin Weather Data reference was used to predict the Portland climate performance. Perhaps your team has more current TMY2 hour by hour ambient weather data that might more accurately reflect the effects of global warming in your area. If you do, would you be willing to share those numbers with your readers?

Mike Scofield, P.E., Fellow ASHRAE, Sebastopol, California

The Author Responds

I suspect folks with a health-care background were not surprised to see ASHRAE suggest designers consider maintaining relative humidities in the 40% to 60% range in the “ASHRAE Position Document on Infectious Aerosols” (<https://tinyurl.com/2nd3t7p5>). In that context, I suspect the system configuration you suggest may merit consideration as long as due consideration was given to the application issues the committee mentions in the *Journal's* May 2021 IEQ Applications column (“ASHRAE Epidemic Task Force Core Recommendations: Reducing Airborne Infectious Aerosol Exposure,” <https://tinyurl.com/2nd3t7p5>).



com/ASHRAEEndemicCorRec), along with the water consumed, the preheat energy required to address the humidification latent load and perhaps ultraviolet (UV) sterilization for the system.

Personally, I have not seen the specific configuration you illustrate applied in the Portland area. I did work with some 100% OA systems that used direct/indirect evaporative cooling in a Seattle project a while back.

The systems were applied to mitigate the solar load associated with a 20-story glass atrium and worked well. But there was an interesting “lesson learned.” The contrast between the environment in the rest of the facility—served by low temperature air systems—and the areas served by the evaporatively cooled systems generated a lot of occupant complaints even though the space temperatures were within a degree Fahrenheit or less of each other.

Early in my career, I saw sprayed chilled water coils in a mushroom farm and chilled water air washers in a paper products plant, both of which are similar concepts. In those cases, the system configuration was driven by process requirements rather than infection control.

A quick survey of the folks in our company reveals that we are seeing systems configured in a manner like what you suggest serving automotive paint booths, server rooms and museums. All the applications were driven by the nature of the load rather than infection control.

Your final question is a great segue into an upcoming column. In it, I will explore/contrast the various normalized data sets commonly used for energy modeling

as well as real time weather data. I have posted spreadsheets contrasting TMY2, TMY3, satellite-based TMY, and real time weather data for several sites—including Portland—on our commissioning resources website to support the column. You can find them at this link; <https://tinyurl.com/TMIAboutTMY>. Feel free to reach out to me if you have any questions, and thanks much for your comments.

David Sellers, P.E., Member ASHRAE, Portland, Ore.

Advertisement formerly in this space.