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## Glossary

<b>Absorption</b>	The process by which pollutants enter the bloodstream or other body components from the site of exposure.
<b>ACGIH</b>	American Conference of Governmental Industrial Hygienists.
<b>Acute effects</b>	Those effects that occur immediately on exposure.
<b>AHERA</b>	Asbestos Hazard Emergency Response Act.
<b>AHU</b>	Air handling unit.
<b>Allergen</b>	A substance capable of causing an allergic reaction because of an individual's sensitivity to that substance.
<b>Animal dander</b>	Tiny scales of animal skin.
<b>ASHRAE</b>	American Society of Heating, Refrigeration and Air-conditioning Engineers.
<b>ASTM</b>	American Society for Testing and Materials.
<b>Bioeffluent</b>	Volatile compound given off by living organisms.
<b>Building-related illness</b>	A discrete, identifiable disease or illness that can be traced to a specific pollutant or source within a building.
<b>CFM</b>	Cubic feet per minute. Used to describe volumetric flow of a substance. The CFM attributed to a blower or fan indicates how much air it can move per minute.
<b>Chronic effects</b>	Those effects that occur after repeated long-term exposure and are seen months or years after initiation of exposure.
<b>CO</b>	Carbon monoxide. Byproduct of incomplete combustion
<b>CO<sub>2</sub></b>	Carbon dioxide. By-product of combustion and respiration.
<b>Constant volume systems</b>	HVAC systems that are designed to provide a constant airflow and vary air temperature to meet heating and cooling loads.

<b>Cyclic pattern of symptoms</b>	One or more symptoms which occur at regular interval (e.g. early morning).
<b>Diffusion</b>	Movement of molecules (gases and some liquids) from a region of higher concentration to a region of lower concentration.
<b>Dose</b>	The amount of a pollutant absorbed by the body, usually expressed as an amount per unit of body weight.
<b>EPA</b>	The federal Environmental Protection Agency.
<b>Epidemiology</b>	The study of incidence, distribution, and control of disease in a population.
<b>ETS</b>	Environmental tobacco smoke.
<b>Exposure</b>	Contact of an organism with a substance.
<b>False negative</b>	Test or investigation results that indicate a particular condition does not exist when it actually does exist.
<b>False positive</b>	Test or investigation results that incorrectly indicate the existence of a particular condition.
<b>Flow hood</b>	A device that easily measures airflow quantity, typically up to 2,500 cfm.
<b>HEPA</b>	High efficiency particulate air filters.
<b>HVAC</b>	Heating, ventilation, and air conditioning
<b>Indicator compounds</b>	Substances (such as carbon dioxide) which, when present in unusually large concentrations, indicate possible underlying causes.
<b>IPM</b>	Integrated pest management program.
<b>MMMF</b>	Man-made mineral fibers.
<b>NIOSH</b>	National Institute of Occupational Safety and Health.
<b>NIST</b>	National Institute of Standards and Technology.
<b>Off-gassing</b>	The production of gases from the chemical deterioration of a substance over time.

<b>Organic compounds</b>	Chemicals that contain carbon. Volatile organic compounds vaporize at room temperature and pressure and are found in many indoor sources, including many household products and building materials.
<b>OSHA</b>	Occupational Safety and Health Administration.
<b>Pathogens</b>	Disease-producing microorganisms or materials.
<b>pCi/L</b>	Picocuries per liter. A measurement of radioactive emissions, such as radon.
<b>ppm</b>	Parts per million.
<b>Pulmonary</b>	Relating to the lungs.
<b>Radon progeny</b>	Radon particles that can be breathed into the lung, where they continue to release radiation as they further decay. Also known as radon decay products or radon daughters.
<b>RSP</b>	Respirable suspended particulates.
<b>Sick Building Syndrome</b>	A set of symptoms that affect a number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources.
<b>Soil gases</b>	Gases that enter a building from the surrounding ground (e.g. radon, volatile organic compounds, and pesticides).
<b>Stack effect</b>	The air flow that results from warm air rising, creating a positive pressure in the higher areas of a building and a lower pressure lower areas of the building. This effect can overpower mechanical ventilation systems and disrupt ventilation and air circulation in a building.
<b>Threshold Limit Value</b>	The level of exposure to a substance (usually a chemical) that is believed to not cause adverse effects to an individual exposed during a lifetime.
<b>TSP</b>	Total suspended particulates.
<b>UFFI</b>	Urea formaldehyde foam insulation.

## Exercise 1 - Pollutant Sources and Locations

Think about your building(s), and start to make a list of any potential pollutant sources and their locations.

Sources:	Locations:



Indicate Pathways & Driving Forces  
 Identify pathways between rooms & floors  
 Indicate flow directions



Indicate IAQ Sources:  
 Equipment  
 Products  
 Activities/Processes  
 Outside sources

**EXERCISE 1: IAQ Sources, Pathways & Driving Forces**

Building: \_\_\_\_\_ Date: \_\_\_\_\_  
 Zone: \_\_\_\_\_ Initials: \_\_\_\_\_

## Exercise 2: Temperature and Humidity Exercise

1. Use the TSI Q-Trak (or similar instrument) to measure the dry bulb temperature and relative humidity in the room.

Dry bulb temperature \_\_\_\_\_

Relative humidity \_\_\_\_\_

2. Use the psychrometric chart (page C-5) to determine the dew point. (See example on next page.)

Dew point (saturation temperature) \_\_\_\_\_

3. Using the psychrometric chart, find the relative humidity assuming:

◆ Dry bulb temperature is 70°F.

◆ Wet bulb temperature is 60°F.

Relative humidity \_\_\_\_\_

4. Using the psychrometric chart, find the dew point temperature assuming:

◆ Dry bulb temperature is 70°F

◆ Wet bulb temperature is 60°F

Dew point temperature \_\_\_\_\_



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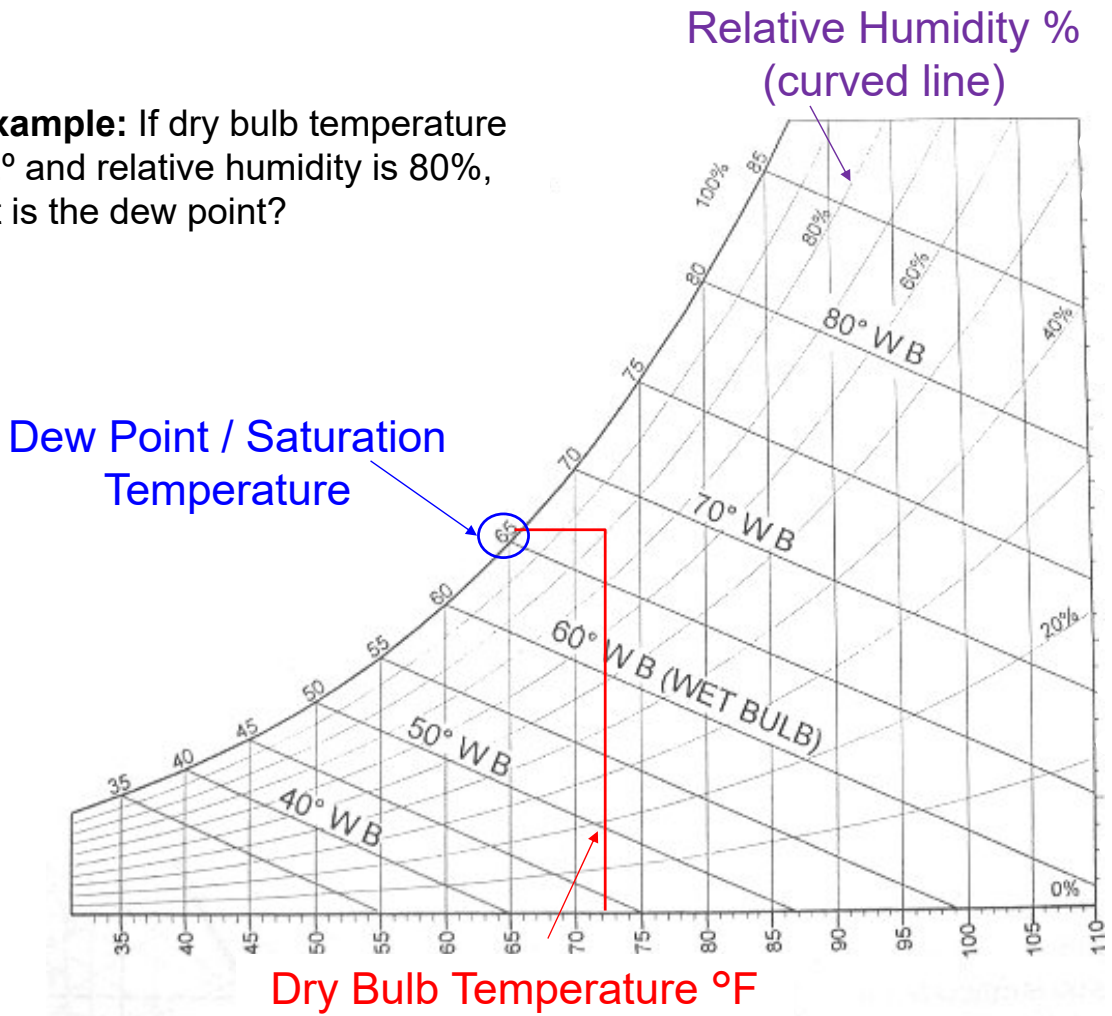
### Terminology:

**Dew Point Temperature** – the temperature at which humid air becomes saturated and the water vapor begins to condense to liquid water; also the temperature at which condensation first occurs.

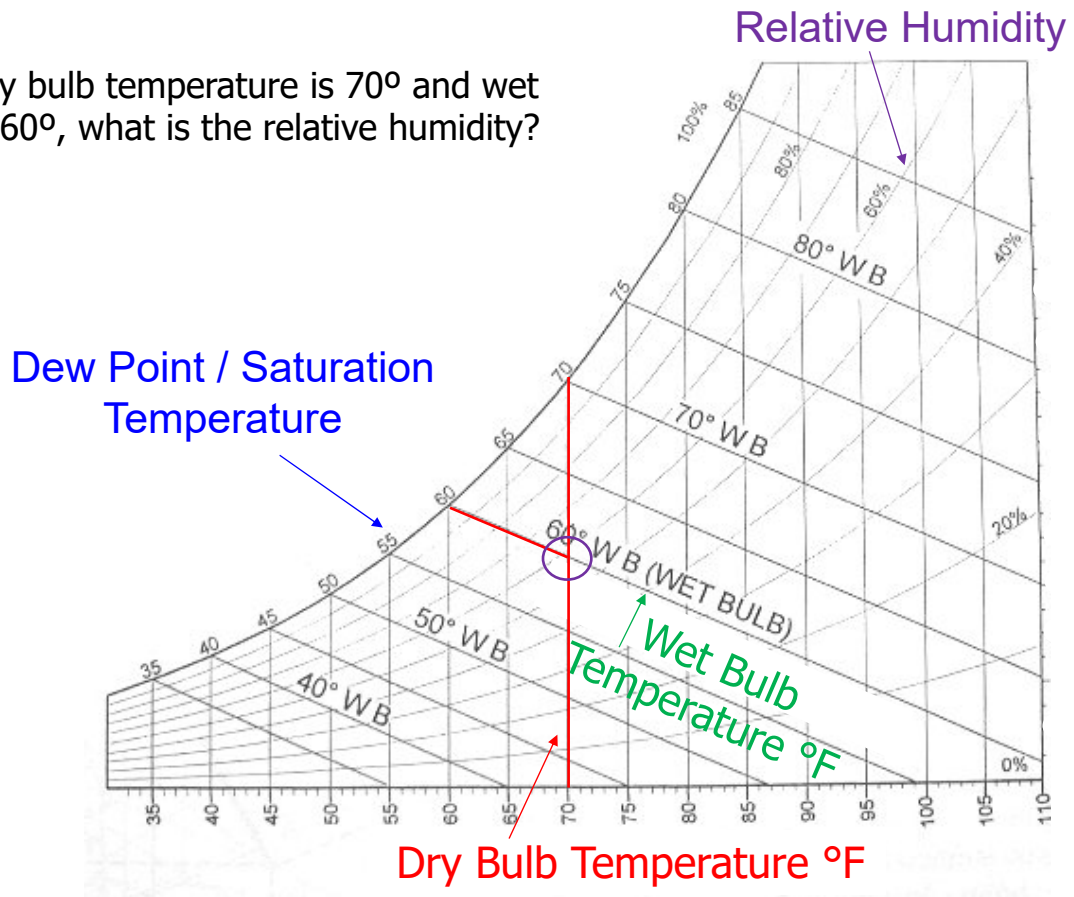
**Water Vapor Pressure** – the pressure of water vapor at a given temperature; also the component of air pressure contributed by the presence of water vapor.

**Relative Humidity** – amount of moisture contained in a volume of air, relative to the maximum amount of moisture the air can hold at that same temperature; also, the ratio of the water vapor pressure to the maximum possible water vapor pressure at that same temperature.

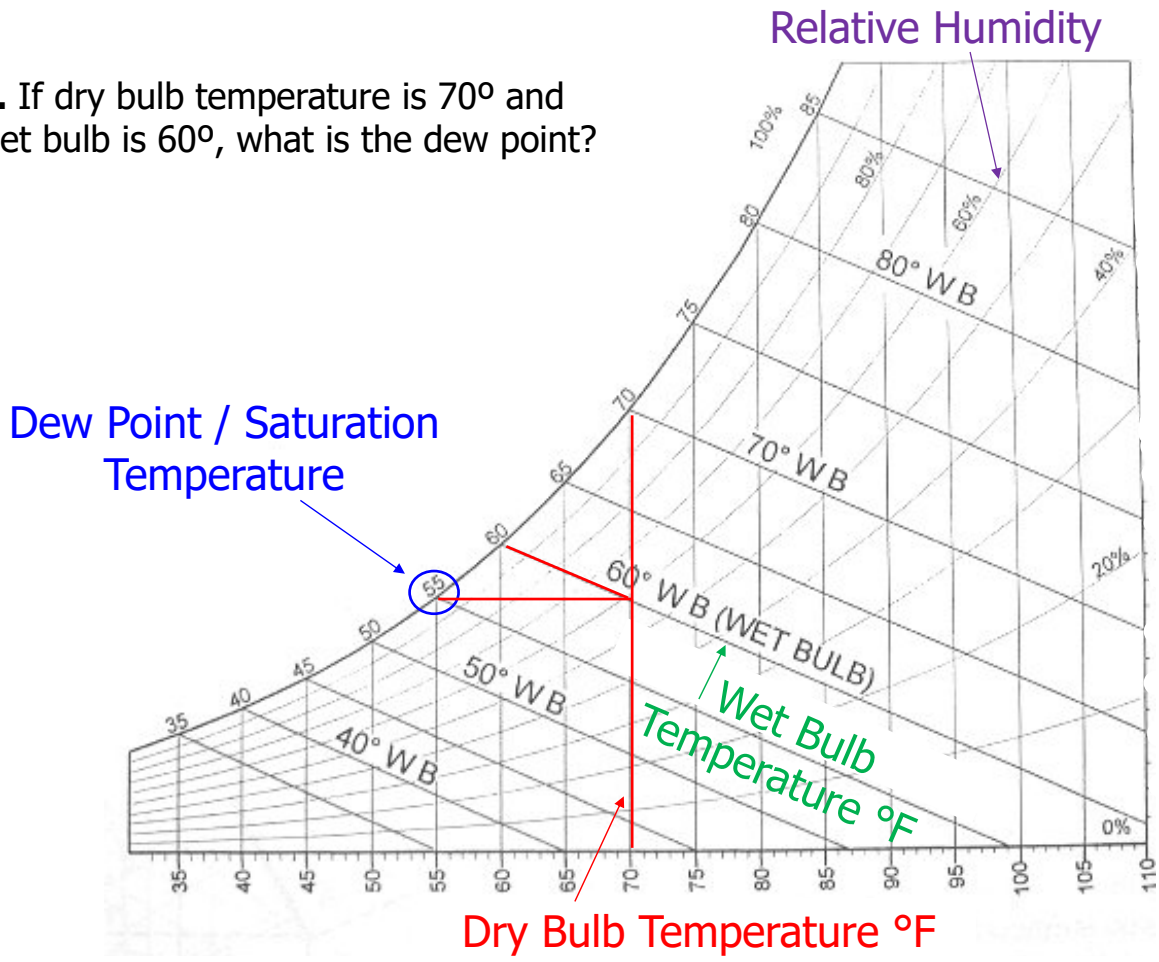
**2. Example:** If dry bulb temperature is 72° and relative humidity is 80%, what is the dew point?



3. If dry bulb temperature is 70° and wet bulb is 60°, what is the relative humidity?



4. If dry bulb temperature is 70° and wet bulb is 60°, what is the dew point?



# Psychrometric Chart Sample

Testo Inc.  
 35 Ironia Rd.  
 Flanders, NJ 07836  
 Tel: 800-227-0729  
 Fax: 973-252-1729  
 email: [info@testo.com](mailto:info@testo.com)  
 web: [www.testo.com](http://www.testo.com)



## PSYCHROMETRIC CHART

Normal Temperature  
 I-P Units

### SEA LEVEL

BAROMETRIC PRESSURE: 29.921 in. HG

### Heat Gain/Loss Equations

- $Q_s = 1.1 \times \text{CFM} \times \Delta T$
- $Q_l = 0.68 \times \text{CFM} \times \Delta \text{grains}$
- $Q_t = 4.5 \times \text{CFM} \times \Delta h$
- $\text{CFM} = \text{btuh output} / (1.085 \times \Delta T)$
- Air Velocity (FPM) =  $4005 \times \sqrt{V_p}$

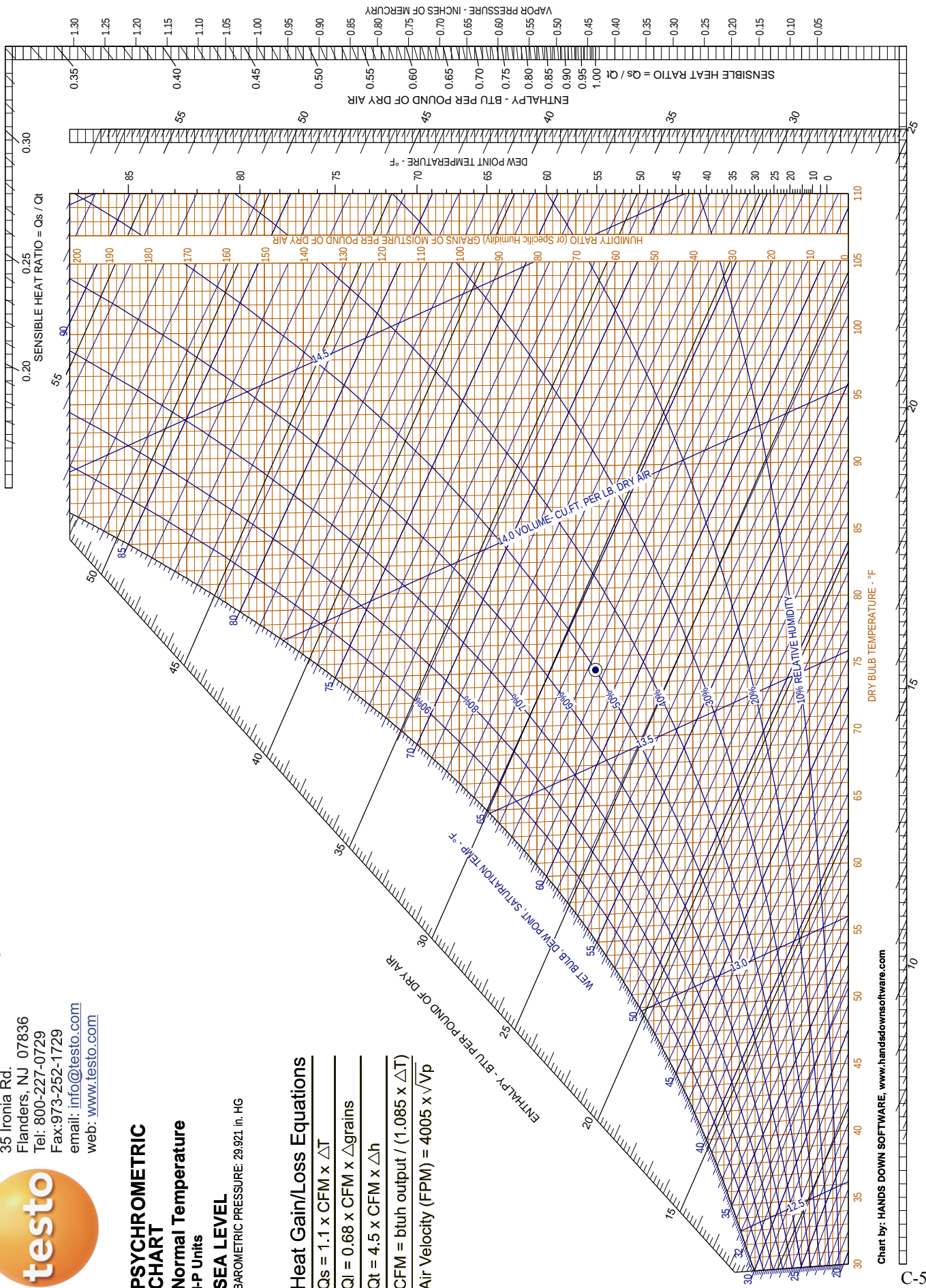


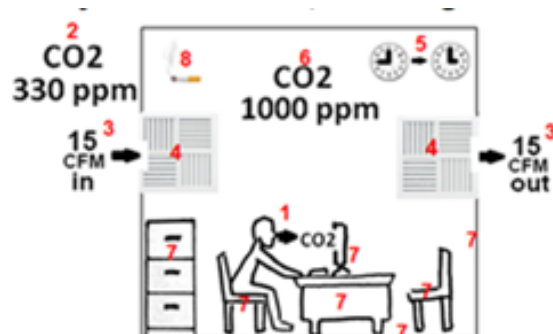
Chart by: HANDS DOWN SOFTWARE, [www.handsdownsoftware.com](http://www.handsdownsoftware.com)



Class Room Number	Room Carbon Dioxide Measurements (ppm)		
	8:30 AM	10:00 AM	11:30 AM
1	725	950	970
2	650	850	825
3	950	1400	900
4	875	1300	850
5	575	975	900
6	900	1050	1225
7	650	950	1175
8	575	725	1880
9	650	1310	1975

Based on this new information, which classrooms, if any, need more outdoor ventilation air? **List:**

- Which rooms, if any, appear to have reached *steady state* based on these CO<sub>2</sub> measurements? **List:**
- Are the carbon dioxide levels in any of the rooms dangerously high? (That is, should you advise the administration to evacuate any of these rooms?) If so, **list** the rooms:
- After obtaining her BOC Certificate, a building engineer working in a high school receives an air quality complaint from one of the teachers. The teacher purchased a personal CO<sub>2</sub> monitor meter for \$99 off the internet. She has taken some readings and found they are much higher in her “team” class, with readings leveling off in the afternoon at almost 1500. She is very upset because the meter is coded Green < 800ppm, Yellow 800-1400ppm, Red > 1400ppm, with green=good, yellow=caution, and red=audible alarm; and the alarm went off. She points out that 1500 is almost twice 800! The building engineer checks everything out to see if it agrees with what she learned in her 1005 BOC course. What should she check? Hint: at least 8 or more things.



8. After reviewing her 1005 handbook again, the building engineer gets the building drawings to examine the original design. It was designed to ASHRAE 2004 with addendum 62n. She also sees that the team class is a large class because it is team taught by three teachers in a college lecture style. It is in a large classroom that has density equal to a lecture room of 62n. She also finds that the outdoor CO2 level at the High School is higher than 330, it is 430. And she checks the internet to find that the \$99 meter has a reading accuracy of only 7%. Does the 1500 reading meet ASHRAE 62 2004 with addendum 62n?

**Design O.A. Ventilation Rates set from per Person  
PLUS per Space Area SF (sample)**

Space	62n People	62n Space	Default	62n set from	62, 2001
	O.A. Rate	O.A. Rate	# P	People + Space	Set from
	cfm/p	cfm/SF	/1000 SF	@default occupancy	People only
Offices	5	0.06	5	17	20
<b>Classroom:</b>					
Ages 5-8	10	0.12	25	14.8	15
Ages 9+	10	0.12	35	13.4	15
Lecture	7.5	0.06	65	8.4	15
Conference	5	0.06	50	6.2	20
Auditorium	5	0.06	150	5.4	15

9. After showing the teacher the slides in her BOC 1005 Handbook and having lunch together, the teacher says she still thinks the ventilation should be increased, because what prompted her to buy the meter was a chemical smell that comes and goes. She also says that Green buildings can have 30% more outside air, and that would fix the problem. What should the building engineer do? Would increasing the outside air by 30% significantly reduce the smell?

<b>Starting at</b>		<b>Starting at 62n</b>	
<b>Low O.A.</b>	Units of	Percent	<b>'Office' O.A.</b>
cfm/p	Pollution	Reduction	cfm/p
3	100	base	17
6	50	-50%	34 *see notes
12	25	-75%	68 *only on
24	12.5	-87.5%	economizer, see notes

Doubling ventilation is effective if initial O.A. is low.  
Problematic if initial O.A. is at ASHRAE 62n levels,  
except for 'economizer free-cooling' in mild weather.



## **Exercise 4, Part-2: Characterizing IAQ Complaints Case Study**

Because of your outstanding reputation as a facility manager, you have been asked by the mayor to facilitate an IAQ investigation of complaints in the city hall building.

A questionnaire was administered to the building occupants. The results are summarized below:

- 20% of the cases were reported to physicians, half of whom suspect the building was the source of the problem but had no specific diagnosis.
- Symptoms are generally worse in the afternoon, with no other pattern in regard to timing.
- Frequency varies by individual and relief usually occurs overnight.
- More serious IAQ syndromes are not suggested.
- Zones 1 & 3 have a relatively “typical” amount of complaints about building conditions.
- Zone 2 occupants reported high rates of dissatisfaction with thermal conditions and ventilation.
- Most symptoms in Zone 2 appear to date back to the respondents’ first employment in the building.
- Zones 1 & 3 had a small number of building-related complaints (less than 10%). This percentage would be considered “typical background” for facilities in general.
- 60% of Zone 2 respondents claimed building related symptoms. This percentage is higher than “typical”.
- 55% of the respondents from Zone 2 had a symptom pattern suggesting their complaints were building related. 22% claiming to have pre-existing allergies.

1. What hypothesis (or hypotheses) could account for the reported problem?

2. What further action is needed to resolve the problem?

**INDOOR AIR QUALITY INCIDENT REPORT FORM**  
(sample)

DATE:

TO: Safety Officer

FROM:

SUBJECT: Air Quality Incident Report

This is to inform your office of another occurrence of poor air quality:

\_\_\_\_\_ This is a confirmation of our telephone conversation.

\_\_\_\_\_ We were unable to reach you by telephone.

The air quality incident occurred at approximately \_\_\_\_\_ am/pm.

At that time the air quality could be described as:

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I had the following symptoms:

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I \_\_\_ did \_\_\_ did not have to vacate the area.

If vacancy was necessary, it was for \_\_\_\_\_ minutes.

The location in the building where my symptoms started or were most severe:

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The indoor temperature was \_\_\_\_\_ (estimate).

The outdoor temperature was \_\_\_\_\_ (estimate).



# POLLUTANT & SOURCE INVENTORY

Building: \_\_\_\_\_ Date: \_\_\_\_\_  
 Investigators: \_\_\_\_\_ Time: \_\_\_\_\_

Record any indications of contamination or suspected pollutants that may require investigation or treatment. Sources of contamination may be consistent or intermittent or may be linked to single, unrepeated events. For intermittent sources, try to indicate the time of peak activity or contamination production.

## SOURCES OUTSIDE BUILDING

Source/Category	Action Required			Comments
	OK	Yes	Completed	
<b>Contaminated Outdoor Air</b>				
Pollen, dust				
Industrial contaminants				
General vehicular contaminants				
<b>Emissions from Nearby Sources</b>				
Vehicle exhaust (parking areas, loading docks, roads)				
Dumpsters				
Re-entrained exhaust				
Debris near outside air intake				
<b>Soil Gas</b>				
Radon				
Leaking underground tanks				
Sewage smells				
Pesticides				

## HUMAN ACTIVITIES

Source/Category	OK	Yes	Action Required Completed	Comments
<b>Human Activities:</b>				
Smoking				
Overcrowding (e.g. body odor)				
Cosmetics				
<b>Housekeeping Activities:</b>				
Cleaning materials				
Cleaning procedures				
Stored supplies				
Stored refuse				
<b>Maintenance Activities:</b>				
Volatile compounds (e.g. paint, caulk, adhesives)				
Biocides				
Stored supplies				
<b>Others:</b>				

## BUILDING COMPONENTS & FURNISHINGS

Source/Category	Action Required			Comments
	OK	Yes	Completed	
<b>Dust and Fibers</b>				
Dust-catching areas (e.g. shelves)				
Deteriorated furnishings				
<b>Unsanitary Conditions/Water Damage</b>				
Microbial growth on or in soiled or water-damaged furnishings				
<b>Chemicals Released from Building Components or Furnishings:</b>				
Volatile compounds				
Asbestos-containing material				
<b>Others:</b>				

## OTHER SOURCES

SOURCE/CATEGORY	Action Required			COMMENTS
	OK	YES	Completed	
<b>Accidental Events:</b>				
Spills (e.g. water, chemicals, beverages)				
Water leaks or flooding				
Fire damage				
<b>Special Use/Mixed Use Areas:</b>				
Smoking lounges				
Laboratories				
Print shops, art rooms				
Exercise rooms				
Beauty salons				
Food preparation areas				
<b>Redecorating/Repairing/Remodeling:</b>				
Emissions from new furnishings				
Dust, fibers from demolition				
Odors, volatile compounds				

# MAINTENANCE CALENDAR

Building: \_\_\_\_\_ Inspector: \_\_\_\_\_ Year: \_\_\_\_\_

Components	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Outdoor Air Intake												
Bird Screen												
Mixing Plenum												
Outdoor Air Quality												
Filters												
Heating Coils												
Cooling Coils												
Humidifier												
Dehumidifier												
HVAC Fans												
Air Distribution												
Terminal Boxes												
Return Plenum												
Exhaust Fans												
Cooling Tower												
Pressure Differentials												

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# Indoor Air Quality Complaint Form

This form can be filled out by the building occupant or by a member of the building staff.

Occupant Name: \_\_\_\_\_ Date: \_\_\_\_\_

Department/Location in Building: \_\_\_\_\_ Phone: \_\_\_\_\_

Completed by: \_\_\_\_\_ Title: \_\_\_\_\_ Phone: \_\_\_\_\_

This form should be used if your complaint may be related to indoor air quality. Indoor air quality problems include concerns with temperature control, ventilation, and air pollutants. Your observations can help to resolve the problem as quickly as possible. Please use the space below to describe the nature of the complaint and any potential causes.

We may need to contact you to discuss your complaint. What is the best time to reach you? \_\_\_\_\_

So that we can respond promptly, please return this form to: \_\_\_\_\_  
IAQ Manager or Contact Person

\_\_\_\_\_  
Room, Building, Mail Code

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## OFFICE USE ONLY

File Number: \_\_\_\_\_ Received By: \_\_\_\_\_ Date Received: \_\_\_\_\_

# SCHOOL IAQ WALK-THROUGH DATA FORM

Date \_\_\_\_\_

Location \_\_\_\_\_

Investigators

Comments \_\_\_\_\_

## HVAC System: Mode of operation during Walk-Through

LOCATION ROOM #	TIME	CO <sub>2</sub>		CO		Temperature		R. H.		PEOPLE		DOORS		WINDOWS	
		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open	DP	Open	DP

**OBSERVATIONS & SOURCES:** carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities

LOCATION ROOM #	TIME	CO <sub>2</sub>		CO		Temperature		R. H.		PEOPLE		DOORS		WINDOWS	
		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open	DP	Open	DP

**OBSERVATIONS & SOURCES:** carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities

LOCATION ROOM #	TIME	CO <sub>2</sub>		CO		Temperature		R. H.		PEOPLE		DOORS		WINDOWS	
		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open	DP	Open	DP

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		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open Closed	DP WRT	Open Closed	DP WRT

**OBSERVATIONS & SOURCES:** carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities

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		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open Closed	DP WRT	Open Closed	DP WRT

**OBSERVATIONS & SOURCES:** carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities

LOCATION ROOM #	TIME	CO <sub>2</sub>		CO		Temperature		R. H.		PEOPLE		DOORS		WINDOWS	
		Room (ppm)	Supply (ppm)	Room (ppm)	Supply (ppm)	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open Closed	DP WRT	Open Closed	DP WRT

**OBSERVATIONS & SOURCES:** carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities

LOCATION		CO <sub>2</sub>		CO		Temperature		R. H.		PEOPLE		DOORS		WINDOWS	
ROOM #	TIME	Room (ppm)	Supply (ppm)	Room (ppm)	Supply Air	Room Air	Supply Air	Dry Bulb	Wet Bulb	#	Duration	Open Closed	DP WRT	Open Closed	DP WRT
<b>OBSERVATIONS &amp; SOURCES:</b> carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities															
<b>OBSERVATIONS &amp; SOURCES:</b> carpet, moisture, animals, dust, lighting, noise, materials, supplies, activities															

# IEQ Resources

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## **U.S. Environmental Protection Agency (EPA)**

IAQ Hotline: 1-800-438-4318

IAQ Hotline (in Spanish): 1-800-725-8312

IAQ Technical Hotline for Schools: 1-866-837-3721 Central Time)

“Tools for Schools” email address: tfs\_help@epa.gov

Website: epa.gov

Building Air Quality, IBEAM, Tools for Schools, and more.

<https://www.epa.gov/indoor-air-quality-iaq>

**American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)** local chapters offer resources. Visit [www.ashrae.org](http://www.ashrae.org) for local chapter contact information.

### **ASHRAE Technical Resources:**

<https://www.ashrae.org/technical-resources/resources>

## **American Lung Association of California**

**National Institute of Occupational Safety and Health (NIOSH):** Website contains table of pollutants and exposure limits.

### **Pandemic/Epidemic Related:**

ASHRAE - Practical Guidance for Epidemic Operation of ERVs

<https://www.ashrae.org/file%20library/technical%20resources/covid-19/practical-guidance-for-epidemic-operation-of-ervs.pdf>



# Airborne Infectious Particles



COVID-19 prompted new focus on airborne infectious particles and aerosols

Epidemic/pandemic events:  
Not new, not going away

HVAC strategies can help minimize risk

- Follow guidelines from ASHRAE etc.
- Stay up-to-date

Other tools: face coverings, social distancing, surface cleaning, handwashing

The COVID-19 global pandemic that severely impacted the U.S. beginning in 2020 prompted a new focus on airborne infectious particle control in buildings. It was determined that the highly infectious SARS-CoV-2 virus responsible for COVID-19 spreads easily through aerosols generated from an infected person, who may or may not be exhibiting symptoms of illness. These aerosols can be spread by coughing, sneezing, talking, or merely breathing.

The required procedures for facility operation and maintenance in general, and the HVAC system in particular, changed in response to the COVID-19 threat. The Centers for Disease Control and Prevention (CDC) as well as several organizations that have jurisdiction over the O&M of buildings including ASHRAE, OSHA and BOMA have developed various related guidelines.

These guidelines can inform strategies in the case of similar future events. Epidemic events have occurred before COVID, and will likely continue to occur. Building operators should stay informed and up-to-date on the latest guidelines from professional bodies such as ASHRAE, as recommendations may change with updated research.

Requiring occupants to wear a face covering for their nose and mouth has been found to be one of the biggest keys to minimizing spread of the virus, in addition to basic principles of social distancing, surface cleaning and disinfection, handwashing and other strategies. These can be paired with various HVAC strategies such as ventilation and filtration to minimize the risk, which we'll discuss in more detail.

# ASHRAE Epidemic Task Force



The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has formulated guidance to help designers retrofit and plan for the improvement of indoor air quality and to slow the transmission of viruses via the HVAC systems.

<https://www.ashrae.org/technical-resources/resources>

# ASHRAE Guidelines (Epidemic Conditions)



## Two Key HVAC Parameters:

- Ventilation with outside air to reduce concentration of harmful particles
- Reduction and filtration of recirculated air

## Important considerations:

- First step: ensure existing systems are running properly
- Consult an HVAC professional familiar with your system before making major changes

Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of HVAC systems, can reduce airborne exposures.

Ventilation and filtration provided HVAC systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air.

The ASHRAE Building Guidance clearly encourages building operators to increase their systems' outdoor air ventilation and reduce the recirculation air back to the space, and to increase the filtration efficiency of recirculated air.

**The guidance indicates that this must be done as much as the system and or space conditions will allow.**

The first step is to make sure your existing HVAC systems are running properly as designed. Certain strategies such as increased ventilation flows and filtration can put more strain on systems, which can be exacerbated by deferred maintenance or other repair issues such as:

- Operation of dampers and actuators
- Adjustment of fan belts
- Blocked, closed or disconnected air ducts and registers
- Dirty heating and cooling coils
- Obstructions of outside air intakes

Actual conditions at any specific building will vary, and the adjustments that should be made will depend on many factors such as local climate, complexity of systems involved and the use, occupancy and activities that occur in and around your building. HVAC design professionals familiar with your building's systems should be consulted before making major changes to control settings or equipment, to make sure modifications do not create additional safety issues.

# Ventilation Strategies for Airborne Disease



## Supply as much outside air as possible

- May be limited by system capacity to adequately condition more outside air
- Disable/minimize recirculation
- Disable or adjust demand-controlled ventilation (DCV).

## Flush the building: pre- and post- occupancy hours

- Flush the building for a duration sufficient to reduce concentration of airborne infectious particles by 95%.
- Typically, three air changes of outside air

When thinking about ventilation as a strategy for mitigating the spread of airborne infectious disease, the most important recommendation is to supply as much outdoor air as is reasonably possible. Close or minimize recirculation dampers manually or adjust via the building automation system (and verify). Turn demand-controlled ventilation off or set it to operate near outdoor air concentrations (typically around 400 ppm).

Flushing the building pre- and post-occupancy (including hours after janitorial staff) can help prepare the building for safer occupancy. Flush the building for a duration sufficient to reduce concentration of airborne infectious particles by 95%. For a well-mixed space, this would require three air changes of outside air (or three equivalent air changes including the effect of filtration and air cleaners).

# Filtration Strategies for Airborne Disease



## Focus on return/recirculation filters

- Upgrade to MERV-13 or HEPA
- Seal edges of filters
- No increase to filter replacement schedule
- Use PPE when changing filters

## Disinfection strategies

- Portable air cleaners - limited application in commercial buildings
- UV-C light – **safety precautions must be taken**
- Electronic (Ionizer) air cleaners

**With all air cleaners it is important to follow the application guidelines and effectiveness limitations.**

Virus-contaminated outside air is rare, and standard outdoor air filters typically provide effective fine-particle protection (as opposed to common return/recirculation air filters, which are designed primarily for dust and do not normally filter out particles with viruses effectively).

Research has shown that the particle size of the SARS-CoV-2 virus that causes the COVID-19 disease is around 0.1  $\mu\text{m}$  (micron or micrometer). However, the virus does not travel through the air by itself. Since it is human generated, the virus is trapped in respiratory droplets and droplet nuclei (dried respiratory droplets) that are around 1.0  $\mu\text{m}$  or larger. To filter out these droplet particles, upgrading return/recirculation filters to at least MERV-13 (or highest compatible with the filter rack) is recommended. HEPA-rated filters are also able to filter out these particles. Seal the edges of the filters to limit bypass.

Keep in mind that, generally, increasing filter efficiency leads to increased pressure drop which can result in reduced airflow through the HVAC system and increased fan energy.

There is no need to increase or alter the normal schedule of changing these filters. But personal protective equipment (PPE) such as gloves, goggles, and respiratory protection should always be worn by technicians when changing any filters, especially return or exhaust filters. To be safe, technicians should operate under the assumption that filters contain active microbiological material, including viruses. Turn the system off while changing the filter(s) and dispose of used filters in a sealed bag.

Air disinfection strategies such as portable air cleaners (with at least HEPA filter efficiency) have limited commercial building application, but they can be effective at removing virus particles in smaller spaces.

There is evidence that UV-C lamps (also known as germicidal lamps) may be effective at destroying some viruses in addition to other microorganisms such as bacteria, mold, fungi. But they can also be very dangerous to humans, animals, and plants, with the ability to alter DNA. More research on potential safe applications of UV-C is needed.

**Do not deploy high-dose UV in occupied spaces!**

UV may be used in contained areas maintained by trained professionals.

UV may be used in AHUs to keep coils clean. It does not effectively disinfect the air due to insufficient dwell time (air moves through the AHU too quickly).