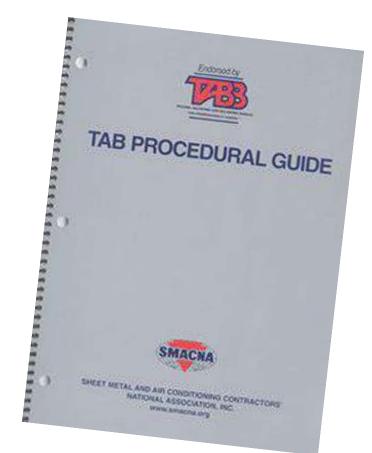
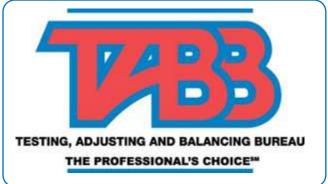




#### What is TAB? What is TABB?

- TAB (<u>Test</u>, <u>Adjust</u>, and <u>Balance</u>) is the process of measuring, proportioning, and setting HVAC system components to meet design requirements.
- TABB (<u>Testing</u>, <u>Adjusting</u>, and <u>Balancing</u>
   <u>Bureau</u>) is a TAB certifying organization.
- TABB certified professionals follow SMACNA TAB Procedures.
- TABB is the only ANSI Accredited ISO/IEC 17024 TAB Certification Program





# **COVID-19 Building Readiness**



Ventilation, Airflow, and Pressurization

**Filtration** 

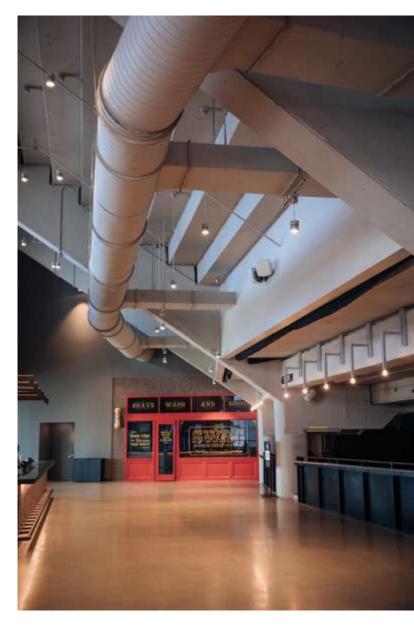
Temperature and Humidity

Germicidal Irradiation (UVGI)

**Acceptance Testing** 

CO2 Monitoring







# Industry Expert Recommendations



# **Centers for Disease Control and Prevention**

Interim Guidance for
Schools, Businesses and
Employers to Plan and
Respond to Coronavirus
Disease 2019



American Institute of Architects

Re-occupancy Assessment
Tool V2.0



• Hierarchy of Controls

#### **ASHRAE**

- Epidemic Task Force
- <u>Position Document on</u>
   Infectious Aerosols
- Building Readiness
- Reopening Schools



American Society for Healthcare Engineering

Recovery Guidance and Checklists



### Comprehensive Approach

- IAQ and disease transmission control requires a comprehensive approach that involves many strategies and trades.
  - Infectious doses vary widely among different pathogens.
- Majority of large droplets land on surfaces within 3-7ft.
- Microbiologist now understand that droplets containing pathogens, previously thought to be spread by contact, can shrink by evaporation and become aerosols (droplet nuclei) which spread transmission through airflow patterns.

# Various HVAC strategies have been found to be effective at controlling transmission

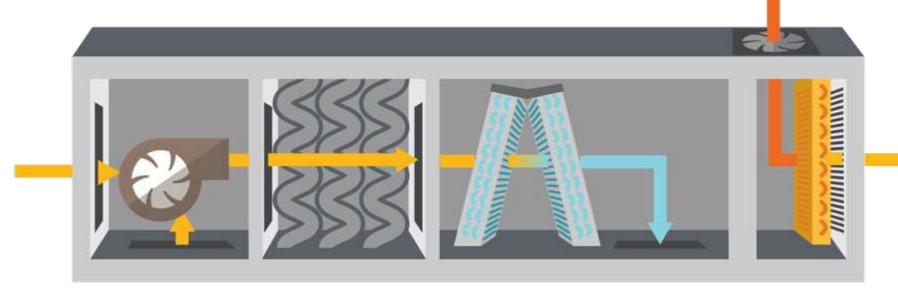


- Optimized airflow patterns
- Directional airflow
- Zone pressurization
- Dilution ventilation
- In-room air-cleaning systems
- General exhaust ventilation

- Personalized ventilation
- Local exhaust ventilation at the source
- Central system filtration
- Ultraviolet Germicidal Radiation (UVGI)
- Controlling indoor temperature and relative humidity

## Ventilation



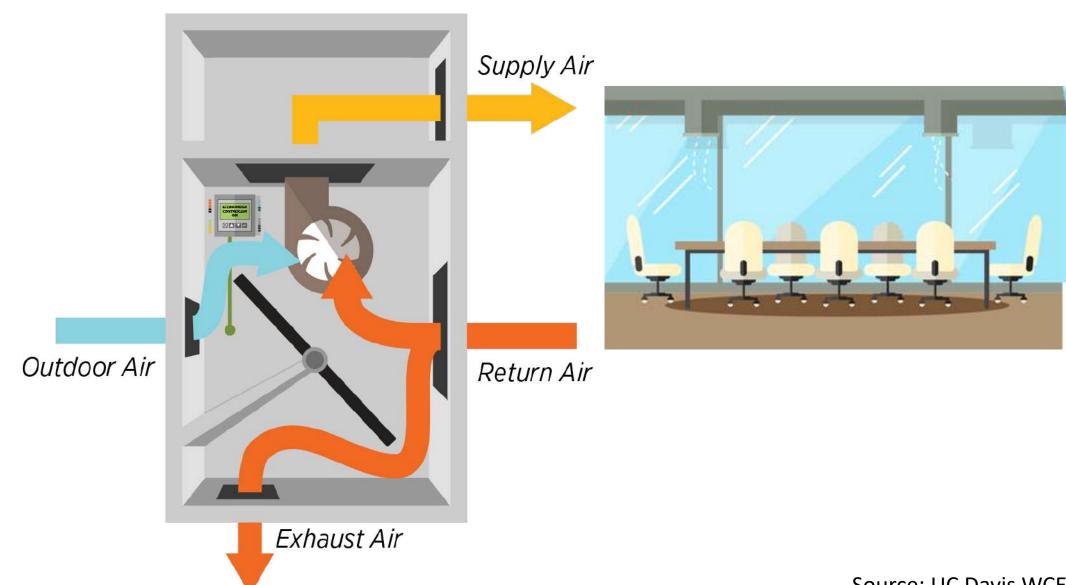




Source: UC Davis WCEC

# Ventilation



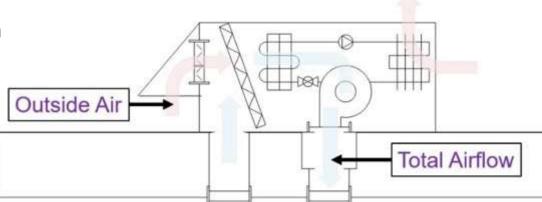


Source: UC Davis WCEC



#### Ventilation

- Measurement of Outside Air per Section B of NRCA-MCH-02-A – Outdoor Air Acceptance.
- Survey readings of inlets and outlets to verify all ventilation is reaching served zone
- Verify proper separation between outdoor air intakes and exhaust discharge outlets.
- Confirm AHU is bringing in outdoor air and removing exhaust air as intended
- Determine if additional ventilation can be provided without adversely impacting equipment performance and building Indoor Environmental Quality (IEQ).





#### Ventilation – Minimum Ventilation

Sample requirement for a 900 square foot meeting room or assembly area

Standard	Method	15 People	25 People	35 People
ASHRAE 62.1 2019	$10  CFM/person + 0.12  CFM/ft^2$	258 CFM	358 CFM	458 CFM
California T24 (2019)	15 CFM/person Use	225 CFM	375 CFM	525 CFM
California Title 24 (2019)	$0.38  CFM/ft^2$ Larger	342 CFM	342 CFM	342 CFM

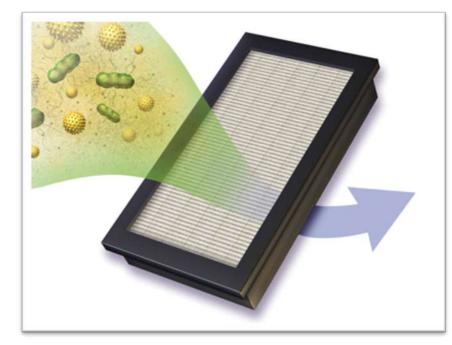
CFM = Cubic Feet per Minute



#### **Filtration**

- Filtration will not eliminate all risk transmission of airborne particles.
- Verify filters are installed correctly and replace if needed. Workers should wear proper PPE and follow appropriate containment procedures for filter disposal.
  - A properly-fitted respirator (N95 or higher), eye protection, and disposable gloves
- Determine if additional filtration can be provided without adversely impacting equipment.
- Apply the highest Minimum Efficiency Reporting Value (MERV) applicable for the HVAC units considering airflow and conditioning capabilities. MERV 13 or better is recommended.
  - MERV 13 and higher are most efficient at capturing airborne viruses







#### Airflow

- Room pressure differentials and directional airflow help control airflow between zones.
- Ensure airflow patterns are adjusted to minimize occupant exposure to particles
- Verify coil velocities and coil and unit discharge air temperatures required to maintain desired indoor conditions and to avoid moisture carry over from cooling coils.
- Perform an initial air flush of all spaces for 1 week prior to the resumption of operations, verify a daily flush is scheduled 2 4 hours prior to occupancy.





#### Pressurization

- Verify building pressure relative to the outdoors. Adjust building air flows to prevent negative pressure differential.
- Airborne Infection Isolation Rooms (AIIRs)
- Design and build inherent capabilities to respond to emerging threats.



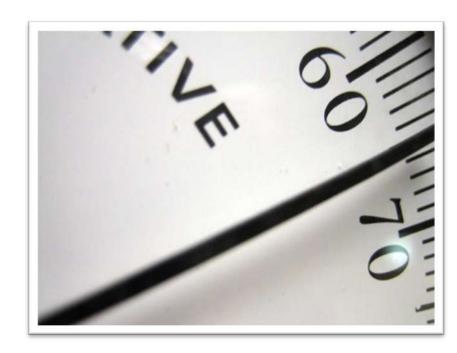




# Temperature and Humidity

- System maintains design temperature and humidity.
- Unfavorable survival for microorganisms when Relative Humidity (RH) is between 40% and 60%
- Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and airconditioning systems is not a recommended measure to reduce the transmission of the virus. ASHRAE Statement







#### General Maintenance

Systems only function as designed if installed, adjusted, and maintained by a **Skilled Trained and Certified Workforce**.

- Verify coil condition, condensate drainage, refrigerant charge, heat exchanger operation, and drive assembly.
  - See ASHRAE Guidelines on Maintenance Checks
  - ASHRAE 180
- Operation and Scheduling
- Controls Commissioning
- Repairs and Upgrades if unable to achieve minimum safety requirements.









- Ultraviolet light inactivates viral, bacterial, and fungal organisms
- UV-C (wavelengths od 200-280 nm) is the most effective
  - 265 nm is optimal
  - Shorter Wavelength (185 nanometers) UVGI creates ozone (O3).
- The ability to deactivate cells depends on the intensity of the UV light, the duration of irradiation, humidity, the target organism, and other factors.



Upper-Air Disinfection requires air mixing and low UV-reflectivity of walls..

Figure 2. Distribution of UV radiation from a typical wall-mounted UVGI fixture

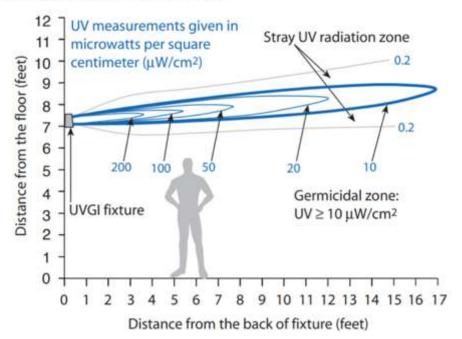


Image source: <a href="https://ultraviolet.com/wp-content/uploads/downloads/2015/12/980904.pdf">https://ultraviolet.com/wp-content/uploads/downloads/2015/12/980904.pdf</a>





In-Duct Air Disinfection:
Effectiveness of UVGI is
dependent on exposure time.
Typically 500 FPM, 2 feet of
irradiance, exposure time of 0.25
seconds

Portable Room Decontamination.

Positioning of unit for full exposure along with routine use increases effectiveness.

Image source: <a href="https://www.americanultraviolet.com/germicidal-healthcare-solutions/documents/AUV-Mobile-UVC-brochure.pdf">https://www.americanultraviolet.com/germicidal-healthcare-solutions/documents/AUV-Mobile-UVC-brochure.pdf</a>







#### **Dynamic Assessment**

- Static Determination Versus Dynamic Assessment
- Periodic Acceptance Testing
  - Generic Acceptance Forms



# MCH-02-A Outdoor Air Acceptance

Overfloor Air Acceptance    Compliance Repurbs:   Does NOT Comply   Sentemental Agency use initial Date	Outdo	oor A	TE OF ACCEPTANCE			CALIFORNIA ENERGY COMMISSION NRCA MICH
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Ambithod of derivering conside air to the heating or cooling unit select one of the followings: 28.7.5.5.1.1 (et. Mc.7.5.1.1.10):     Reset Network Ductor Confern that control air is ducted to whith 5-art 5.5.1.5. (et. Mc.7.5.1.1.10): Selection and extensive air superification and extensive requirements of heating or cooling unit as specified by NRCC-660x-5. Section M. (6.10.5.6.15.5.1): But destine Ductors are approximately as the selection of direction of the conference of the unit, or economism?     Pre-occupancy Purge     Verify that the pre-occupancy purge has been programmed for the 1-hour period immediately before the building is norm.     consider to provide verification as indicated on MCC-560x-6. (2.M.2. Ma.7.5.1.3.1.10), (6.WM.5.5.3.1.10, 16.9.1.30.1002).	-					
Return Plenum Ductied. Confirm that outside air is deuted to within 5 or 15 h. beith decision and electify requirement) of heating or cooling unit as openfied by NBC 4604-5, Section H. (\$125.0616.82)      B. Deet 1881 Ducties. Return air plenum in NDT used to distribute outside air is the heating or cooling unit. (i.e. outside air is ducted directly to the unit, outside air is provided independent of the unit, or economizer).  4. Pre-occupancy Purge  A. Pre-occupancy Purge  A. exception in the pre-occupancy purge has been programmed for the 1-hour period immediately before the building is norm, excepted to provide vereliation as independent of the 1-hour period immediately before the building is norm.	_					
hearing or cooling unit as specified by <u>MECS-MONE_Section 18_1920_10101.8.27</u> B. Direct thint Ducted. Return a plannum is NOT used to distribute outside air to the hearing or cooling unit, (i.e. outside air is ducted directly to the unit, outside air a provided independent of the unit, or economizer).  A Pre-occupantly Purge  Wriffy that the pre-occupancy purge has been programmed for the 1-hour period immediately before the building is norm: a consider to provide verifiation as indicated on MECS-MCV-E_EAX_NA_2_5_1_1_1_0, (6V-NA_2_5_1_2_10_5_120_1002).	2	Methy				
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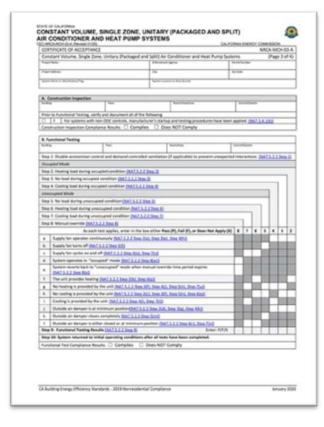
Outdoor	Air Acceptance					(Page 2 of 3)
Proper forte		Ethyration spin	-		7	- Number
Project Address		06			80	riter .
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B. Funct	ional Testing		No.	andre.	Carrent	unam
Steps:	-				CAV	VAV
1	Disable demand control vertilation of applic	ublied (wide	- 10	Check F NA	0	()
	Verify unit is not in economizer mode during					
2	(economicer disabled)	11770	- 1	Check FNA	0	0
)	(VAV - NA 7.5.1.1.2 Step 1, CAV - NA 7.5.1.2 CAV and VAV testing at full supply sinflow	2 5840 11		-		
	Adjust supply air to achieve design airflow or	r maximum aid	Sone at full proofs	ne.		-
4.	(NA 7.5.1.1.2 Step 2)			-		.0
b.	Measured outdoor airflow reading (cfm)	NAME OF TAXABLE PARTY.			cin	de
	(VAV - NA 7.5.1.1.2 Step 2a, CAV - NA 7.5.1.) Required outdoor sinflow (dire)	LLYesle			ctm	- Ox
€.	(refer to NRCC-MOn-E, Section (I)				clin	dr
d.	Time for outside air damper to stabilize after	Tull supply and	flow is achieved	(minytes):		- 2
4	VXX Testing at reduced supply airflow					Più
-	Adjust supply airflow to either the sum of the	e minimum pon	te pirflows, full I	heating, or		
	30% of the total design airflow: (NA 7.5.1.1.)	2.5tep.31				0
b.	Measured outdoor airflow reading (cfm), (NA	A7.51.1.2 Step	3a[			di
	Required outdoor sirflow (d/m) (refer to NRCC-MOH-E, Section II)					efe
	Time for outside air damper to stabilize after	reduced supply	ly airfore is achi	ieved		
6.	(minutes):					100
5	(NA 7 S. 1.1.2 Step 3h) Return to initial conditions (NA 7.5.1.1.2 Step	e-(1)		_	0	0.00
6	Calculations					
	re Percent Outside Air at full supply airflow (NO	OA) for Step 3	(\$130.100)			
	NGA <sub>cs</sub> - Measured outdoor airflow reading.					,
	100 x (Step.Nt/Step.Nc)			_		
b	NOA., is within 10% of design Dutside Air. I				7/1	P/1
_				THE RESERVE OF THE PARTY OF THE		P/1
WAY STIN						
	100 x (Step4b/Step4c)	Luednista ongo	nour airmout read			,
b.	NOAm is within 10% of design Outside Air. (5	90% 5 %DA <sub>108</sub> 5 1	110%2			775
	Outside sir damper position stabilizes within	5 minutes. (See	eg-4d < 5 minut	re)		P/1
Function	nal Testing Compliance Results: [] Compl	iles 🗆 Doe	s NOT Comply			
b.	NiOA <sub>ss</sub> is within 10% of design Outside Air. (f Outside sir damper position stabilizes within	ggly airflow (No /Required outs) 90% 5 %OA <sub>to</sub> 5 5 minutes. (See	CA <sub>10</sub> ) for Step 4 toor airflow read 330N2 ag 4d 4 5 minut	(8.120.1873) Sing.		P

CERTIFICATE OF ACCEPTANCE			NRCA MCH-02-
Outdoor Air Acceptance			(Page 3 of 1
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Proper letters	06		As law
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NOCUMENTATION AUTHOR'S DECLARATIO	N STATEMENT		
1. I certify that this Certificate of Accepts	ner documentation is as	curate and complete.	
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FIELD TECHNICIAN'S DECLARATION STATES I certify the following under penalty of peo-			
<ol> <li>I am the person who performed the ac</li> <li>The construction or installation identified indicated in the plane and specification requirements and procedures specified.</li> <li>I have confirmed that the Certificate(), has been completed and signed by the permitt() issued for the lociting.</li> </ol>	led on this Certificate of to approved by the enfor if in Reference Nonnesids Lof Installation for the or	Acceptance complies with the ap- convent agency, and conforms to critial Appendix NA7, ancitraction or installation identifie	plicable acceptance requirements the applicable acceptance ed on this Certificate of Acceptance
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# MCH-03-A CONSTANT VOLUME, SINGLE ZONE, UNITARY (PACKAGED AND SPLIT) AIR CONDITIONER AND HEAT PUMP SYSTEM

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_	200	men linera na combinanta	PROC BO	a appropriate to				(conomiser off when )
	Devi	си Туре	Clim	sete Zone	Equation			Description
			0	1, 3, 5, 11-16	T <sub>50.</sub> > 75'9	- 1	Outdoor air tempe	erature exceeds 75°F.
9	0	Fixed Dry Bulb	0	2, 4, 10	T <sub>OA</sub> > 73'9'	- 1	Dutdoor air tampe	mature exceeds 73°F.
4	·~.	FORCE CAS BEING	(2)	6,8,9	Tox > 71%		Outdoor air tempe	erature exceeds 71°F.
3			0	7	T <sub>(in.</sub> > 69°F		Outdoor sir temperature exceeds 69°F.  Outdoor sir temperature exceeds return sir temperature.	
Capital 140			D	1, 3, 5, 11-16	$T_{\rm OA} > T_{\rm NA}$			
Limit	0	Differential Dry Bulb	0	2, 4, 10	$T_{(m)} \succ T_{(m)} \cdot 2^{n} F$		temperature minu	
9112	-	Chilesensia ory acco		6.8,9	$T_{(0)} > T_{(0)} \cdot A^* V$		temperature minu	
Ampaired			0	7	Tox > Tox - 6'F		Outdoor air temperature exceeds return air temperature minus 6°F.	
ž	0	Fixed Enthalpy and Fixed Dry-bulb	All		N <sub>CH</sub> > 28 60s/6 T <sub>CH</sub> > 25°F	bor	Dutidoor air entha	s 677. Up exceeds 28 Bhy/fb of dry air trature exceeds 7577.
£		Others such as Dew Point	Found to	sthelpy.				California unless approval for u
Compliance P		Electronic Enthalpy, and C Controls	Merect	al Enthalpy	is provided by APPROVAL NO	the Ene (57 00 /	rigy Commission E ATTACHED:	secutive Director.
F	0	NOTE: Devices with select						2 Bru/St of the setpoint listed.
Š	D	NOTE for Fixed Enthalpy and Fixed Dry-builb device	enth		and 50% relative	e humid	ity. As an example	alpy limit value must be set to to t, at approximately 6,000 foot
3.	too	nomizer reliability features a	re prese	nt as specified in	the Energy Code:	(check a	of the following	OSA 7.5-4.10%, \$140,466200
	А.	5-year manufacturer wa	rtantly of	economizer asse	while (\$140.40x)2	01		
0	b.	The economiser assemb have been tested and ar	ly (include e able to	ling but not limite agen and close a	d to outdoor air i	damper,		r, drive linkage, and actuator) e system for 60,000 damper
0	ı		en air da	impers have a ma		une of 10	Octim/of at 250 Pac	cals (1.0 inch of water) when
_	-	tested in compliance will if the high-limit control is				se bedle i	then it must have	an adjustable selected
	4.	DVA2.5.4.101.5140.404		1		a const.	CHICAGO CONTRACTOR	and the second

	THE	ATE OF A	ACCEPTANCE				ONLEGENCY COMMITTED TO COMMITTE	A MCH 05
		omiaer Co	ontrols Azceptan	ce				(Page 2 o
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AC	and r	ution bo	pertion					
Burel			***************************************	Fee		Auto-Searchine	Service Common	
	_							
	0.		oor air, neturn air, 40450v5	mixed air, and supply a	ir sensors n	nust be calibrated as follows	(sheck all of the following)	
			Sny bulb and wet			"F over the range of 40"F to	807	
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	1.					oer instruction materials the		
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	h.					, including two-stage or elec	ctronic thermostats, that cy	Ce
_	-			esonomizers can provid		oling (NA7.5.8.193) dicated relief fans to preven	ne building mer green visiteet	ion in Eul
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# MCH-06-A DEMAND CONTROL VENTILATION SYSTEMS ACCEPTANC



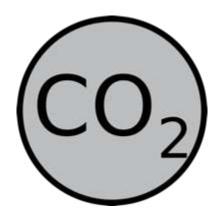
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#### CO2 - Indicator



- Proper Ventilation
- Dilution of Indoor Contaminants
  - Formaldehyde, volatile organic compounds (VOC), particles, pesticides, radon, fungi, bacteria, and nitrogen oxides
- Body Odor



#### CO2 - Indicator

- Patrons complain immediately on feeling too hot or too cold.
- Not feeling alert during an exam is attributed to the subject matter.





# CO2 – Effect on Body

- 250-350 ppm Normal Outdoor Levels
- 350-1000 ppm Typical in occupied space with proper ventilation
- 1000-2000 ppm Complaints of drowsiness and "Poor Air"
- 2000-5000 ppm Headaches, Sleepiness, "Stuffy Air", Poor Concentration,
   Loss of Attention, Increased Heart Rate, Nausea
- >5000 ppm Serious Oxygen Deprivation resulting in permanent brain damage, coma, and death.



# CO2 – Effect on Body

- 15% 33% of population show symptoms when  $CO^2$  levels are between 600 ppm and 800 ppm
- 33% 50% of population show symptoms when  $CO^2$  levels are between 800 ppm and 1000 ppm.
- 100% of population show symptoms when  $CO^2$  levels are above 1500 ppm.



# CO2 – Cognitive Performance, Productivity, and Health

- 2017 literature review summarized that 8 studies reported statistically significant improvements in some measures of student performance associated with increased ventilation rates or lower CO<sub>2</sub> concentrations, with performance increases up to 15%. Fisk 2017
- Reducing student absences caused by illness by 3.4 percent. Given attendance based funding could result in an increase \$33 million in state funding. Lawrence Berkeley National Labs/2013



## **CO2** Monitoring



Helps ensure proper ventilation is maintained throughout system operation:

- (1) Is hard-wired or plugged-in and mounted to the wall between 3 6 feet above the floor and at least 5 feet away from the door and operable windows.
- (2) Displays the  $CO_2$  readings to the teacher through a display on the device or other means such as a web-based application or cell-phone application.
- (3) Notifies the teacher through visual indicator on the monitor (e.g. indicator light) or other alert such as e-mail, text, or cell phone application, when the CO2 levels in the classroom have exceeded 1,100 ppm.
- (4) Maintains a record of previous data which includes at least the maximum CO2 concentration measured.
- (5) Has a range of 1 2000 ppm or greater;
- (6) Is certified by the manufacturer to be accurate within 75 ppm at 1,000 ppm CO2 concentration and is certified by the manufacturer to require calibration no more frequently than once every five years.





# Thank you!

Questions...

#### **Contact Information**

#### **TABB**

www.tabbcertified.org

#### **Christopher Ruch**

- <a href="mailto:cruch@nemionline.org">cruch@nemionline.org</a>
- (916)280-6281