Safety Guideline for Indoor Airborne Transmission of COVID-19

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History: 6-4-2020 (v1), 7-1-2020 (v2), 8-16-2020 (v3) posted on medRxiv 9-1-20, 9-16-2020 (v4),
This version: 11-1-2020 (v5)

For instructions, references and updates, please visit http://www.mit.edu/~bazant/COVID-19

Reference: Martin Z. Bazant and John W. M. Bush, medRxiv preprint (2020)
"Beyond Six Feet: A Guideline to Limit Indoor Airborne Transmission of COVID-19"
https://www.medrxiv.org/content/10.1101/2020.08.26.20182824v1

Green Room

(4 Fans operating at 1000 ACFM)

Input values in the pink cells.

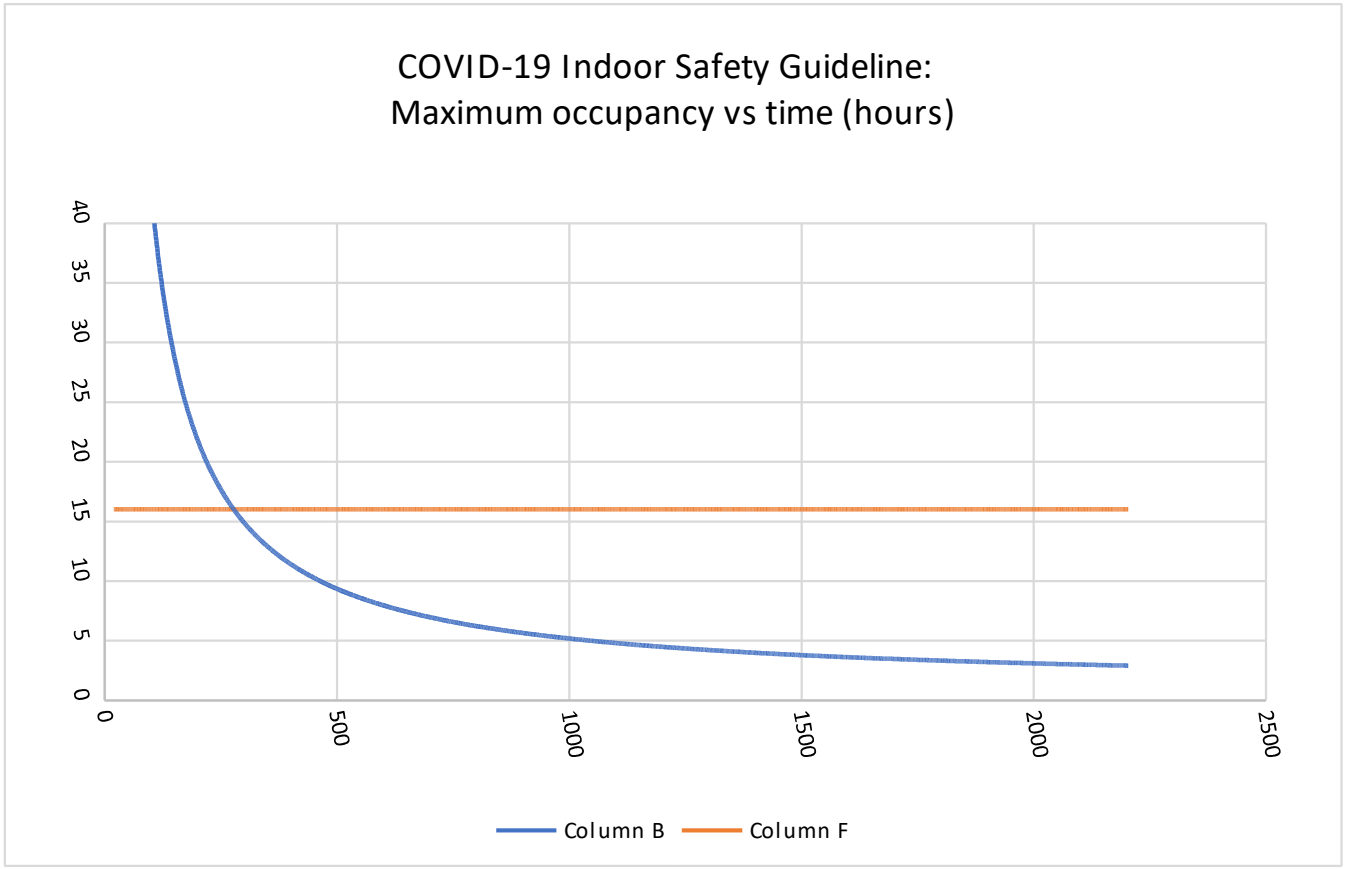
12/02/20

Physical Parameters			
Floor area, *A*	576 ft^2	53.5122 m^2	Customer Spaces
Mean ceiling height, *H*	8 ft	2.4384 m	Average
Room volume, *V*	4608 ft^3	130.484 m^3	Customer Spaces
Outdoor air exchange rate, λ_a	0.2 /hr (ACH)		
Ventilation (outdoor air) flow rate, *Q*	15.36 ft^3/min	26.0968 m^3/hr	
Recirculation air exchange rate, λ_r	52.1 /hr (ACH)	(includes HVAC & air filtration units)	Fans @ 1000 ACFM
Recirculation (return) flow rate, Q_r	4001.3 ft^3/min	6798.22 m^3/hr	
Primary (total) air flow rate, $Q+Q_r$	4016.6 ft^3/min	6824.31 m^3/hr	
Primary outdoor air fraction, Z_p	0.0038	(=1.0 natural ventilation, or no recirculation)	
Aerosol filtration efficiency, p_f	0.9	(>0.9997 HEPA, =0.2-0.9 MERVs, =0 no filter)	MERV 6 + MERV 13
Air filtration rate, λ_f	46.89 /hr		Effective Rate
Relative humidity, *RH*	45 %		

Physiological Parameters

Mean breathing flow rate, Q_b	0.2943 ft^3/min	0.5 m^3/hr (=0.5 rest, =1-3 active)	Loud Speaking
Respiratory aerosol radius, r	2 μm	(depends weakly on activity, disease)	Conservative Est.
Humidity-adjusted radius	1.7986 μm		
Disease Parameters			
Infectiousness of exhaled air, C_q	30 infection quanta/m^3	(depends on activity, Fig. 2)	
Viral deactivation rate, λ_v @ 50% RH	0.3 /hr	3.33333 hour deactivation time	
Humidity-adjusted deactivation rate	0.27 /hr	(assume linear in RH)	
		(can increase with UV and chemical disinfectants)	
Infectious Aerosol Properties			
Effective settling speed, $v_s(r)$	0.3882 mm/sec	1.39747 m/hr.	
Concentration relaxation rate, λ_c	47.933 /hr	0.02086 hour relaxation time	
Dilution factor, f_d	8E-005 infectiousness of ambient air / exhaled breath		
Infectiousness of room air, $f_d C_q$	0.0024 infection quanta/m^3 in steady state		
Precautionary Parameters			
Mask aerosol passage probability, p_m	0.1	(=1 no masks, 0.05-0.5 fabric, <0.05 surgical mask)	Medical Masks
Airborne transmission rate, β_a	1E-005 /hr	(per pair of persons in steady state)	
Risk tolerance, ε	0.05	(bound on R_{in}, expected transmissions per infector)	Conservative
Safe Room Occupancy			
Exposure time, τ	0.5 hours	(net before testing/removal/recovery)	Max Estimated
Maximum safe occupancy, N_{max}	**8688 persons**	(with transient aerosol buildup)	
	8340 persons	(steady state aerosol concentration)	
6 FOOT RULE (CDC)	16 persons		
1 METER RULE (WHO)	53 persons		
Maximum occupancy for outdoor air	1.28 persons		
Minimum outdoor airflow / person	12 ft3/min	5.66337 L/s	Estimated Act OA
Safe Exposure Time			

Room occupancy, *N*	8 persons			Max Estimated
Maximum exposure time, τ_{max}	**595.69 hours**	35741 minutes	(transient)	
	595.67 hours	35740 minutes	(steady state)	



https://www.usatoday.com/story/news/factcheck/2020/06/11/fact-check-n-95-filters-not-too-large-stop-covid-19-particles/5343537002/