WAUNAKEE COMMUNITY SCHOOL DISTRICT
BOARD OF EDUCATION FACILITY COMMITTEE
Monday, May 3, 2021
6:30 PM

Waunakee Community School District
905 Bethel Circle
Waunakee, WI 53597

Members of the public may attend Board of Education meetings in-person, subject to space limitations, as well as guidelines and orders that are in place for indoor gatherings.

Public comments will be limited to 3 minutes. The Board will allow 1 hour for public comments.

Public comments may be sent to Rebecca McDonough at district_administrator@waunakee.k12.wi.us up to one hour before the start of the Board meeting. All comments will be reviewed by the Board members. Emailed comments will be reviewed by the board but not read out loud. Comments must include the commentator's name, address, and must identify their connection to the District (if any) and any group they are representing in order to be considered by the Board.

If you would like to address the Board in-person during the public comments section of the meeting, you will be greeted outside the buildings and brought into the meeting individually to present; if you are attending the Board meeting in person, you will be asked to check in with District personnel when you arrive so that you can be recognized and address the Board when your name is called.

You will be required to abide by guidelines and/or orders required for indoor public locations in Dane County and Wisconsin.

A recording of the meeting will be posted on the District webpage within 24 hours of the meeting time.

AGENDA

I. **CALL TO ORDER**
II. **ROLL CALL**
III. **APPROVE AGENDA**
IV. **PUBLIC COMMENTS**
V. **REVIEW 2021-22 FUND 41 CAPITAL PROJECT LIST** 3
Attached please find an updated 2021-22 Fund 41 Capital Projects list. This list has been revised since the last meeting. Please look for any changes highlighted in yellow.
VI. **REVIEW 2021-22 ENERGY CONSERVATION PROJECTS** 4
Attached please find the 2021-22 Energy Conservation Project proposal. Administration is recommending approval of this project. This project is a continuation of the work at the High School that was started during the 2020-21 school year.
VII. **CLEANING COST ANALYSIS PROGRAM** 9

Attached please find a Cleaning Cost Analysis Program as prepared by Hillyard. Staff from Hillyard will be present at the meeting to review this document. This agenda item is connected to both the Kleenmark Supplemental Staffing Agreement and the equipment expenditures under the Operational Referendum funds.

VIII. **KLEENMARK SUPPLEMENTAL STAFFING AGREEMENT** **10**

Attached please find the Kleenmark Supplemental Staffing Agreement. The intent behind this agreement is to temporarily hire custodial staff to clean our buildings while we continue to attempt to hire custodial staff as well. At this time we have 7.5 positions currently unfilled in the District. Administration is requesting 10.5 positions through the Kleenmark Supplemental Staffing Agreement.

IX. **OPERATIONAL REFERENDUM FUNDS** **12**

Attached please find a list of requested purchases from the Operational Referendum Funds. These requested purchases are related to COVID expenditures and efficiencies with equipment that were identified through the Cleaning Cost Analysis Program. The Operational Referendum provides $2.1million in funding to the District for each of the next four years. Administration is recommending approval of the purchases on this list.

X. **HUMIDIFICATION OF SCHOOL BUILDINGS** **13**

XI. **FUTURE MEETINGS**

XII. **ADJOURN**

"Any person who has a qualifying disability as defined by the Americans with Disabilities Act who requires assistance with access or materials should contact the Waunakee Community School District Office at 849-2000, 905 Bethel Circle Drive Waunakee, WI 53597, at least twenty-four hours prior to the commencement of the meeting so that necessary arrangements can be made to accommodate the request."

2021/2022 Capital Projects

Item No.	Location	Description	Original Funds Requested	Funds Adjustments	Revised Funds Requested	Projected Final Costs	Net Difference	Change from Approved 21-22 Capital Projects
1	AES	Water Heater	$15,000	$12,000	$27,000	$27,000	**$0**	Changed scope of project to spec 2 smaller sized water heaters to prevent building from being without hot water
2	AES	Music Room Carpeting	$7,000		$7,000	$7,000	**$0**	
3	AES	Exterior doors on storage closet	$7,000		$7,000	$7,000	**$0**	
4	AES	Snow tractor	$15,000	$11,200	$26,200	$26,200	**$0**	Replacement-Upgraded equipment and added accessories
5	AES or PES	Radon Mitigation	$25,000	-$25,000	$0	$0	**$0**	Received final report, mitigation not required at 2 schools tested (AES & PES)
6	football stadium	Press Box Carpet	$5,000	-$825	$4,175	$4,175	**$0**	Project proposal accepted
7	Bethel	HVAC engineer/reconfigure/replace	$30,000		$30,000	$30,000	**$0**	FOE rebates Possible office addition will impact HVAC evaluation and redesign
8	Bethel	Generator	$50,000	$25,000	$75,000	$75,000	**$0**	4.22.21 Waiting on formal quotes from Cummins & Westphal - better estimate $75,000
9	Bethel	repair parking lot	$32,000	-$32,000	$0	$0	**$0**	Repair estimate is $30,000-$50,000. Full Replacement $130,000-$160,000 - Moving to 22-23 Capital Projects
10	District	Playground maintenance & upkeep	$25,000		$25,000	$25,000	**$0**	
11	District	Truck Mounted Leaf Vac	$5,000		$5,000	$5,000	**$0**	New Grounds Equipment
12	District	HVAC Repairs	$30,000		$30,000	$30,000	**$0**	
13	District	Roof Repairs	$25,000		$25,000	$25,000	**$0**	
14	District	Re-key exterior doors	$7,000		$7,000	$7,000	**$0**	
15	District	Door and Building Repairs	$20,000		$20,000	$20,000	**$0**	
16	District	Playground Crack Fill	$30,000	-$10,000	$20,000	$20,000	**$0**	AES,PES, WIS, WMS & HES = $19,050. HES estimate is $3250
17	District	Kitchen Equipment replacement	$31,000	-$9,000	$22,000	$22,000	**$0**	Griddle replacement WHS $6000 , PM program $10,000, & reach-in coolers $3000 ea (2)
18	District	Plumbing Repairs	$22,000		$22,000	$22,000	**$0**	
19	WMS	Snow tractor	$35,000	$7,000	$42,000	$42,000	**$0**	New tractor. Added accessories
20	PES	Playground Drainage	$16,000		$16,000	$16,000	**$0**	
21	PES	Classroom Carpet	$33,000	-$12,000	$21,000	$21,000	**$0**	
22	Pool	Replace Men's lockers	$20,000		$20,000	$20,000	**$0**	
23	WHS	Old Gym BB Safety straps/motors	$15,000		$15,000	$15,000	**$0**	
24	WHS	Classroom carpet replacement	$3,000	-$1,500	$1,500	$1,500	**$0**	
25	District	~~6 walk behind snow blowers~~			$0	$0	**$0**	
26	WMS	upstairs hallway carpet	$0	$22,000	$22,000	$22,000	**$0**	
27	WMS	Remodel classroom 223 for science	$22,000	$3,125	$25,125	$25,125	**$0**	adding cabinets, finish work
28	Pool	Repairs	$0	$10,000	$10,000	$10,000	**$0**	Add line item for unplanned equipment failure/replacement
			$525,000	**$0**	**$525,000**	**$525,000**	**$0**	

Budget $83,894.00	**Building**	***Energy Saving Opportunities***	**Focus on Energy Rebate**	**Annual Energy Savings**	**Payback from Power Savings Years**	**Total Payback from Power & Maint (Years)**	**Projected Date**	**2021/2022 Estimate**	**Request Board Approval**	**FINAL**	**Carryover**	**ACTUAL REBATES**	
7220200024	AES	Gym (Metal halide)	$0.00	$3,904.99	4.41	2.45	Completed	$17,970.00	$19,000.00	$16,770.00		$0.00	
7220200062	WHS	Replace Drama Makeup Lights					Completed	$337.85		$337.85		$0.00	
May 2021, replacing hallway and bathroom fixtures. Starting in 1500 Hallway, oldest section of WHS	WHS	Flat panel fixtures with Occupancy sensors	$2,416.00	$2,412.18	21.26	4.56	May 2021	$68,061.00	$68,061.00	$68,061.00		$2,416.00	Will not receive until 21/22 - carried forward to 21/22 planning document
$85,630.67			$2,416.00	$6,317.17				$86,368.85	$87,061.00	$85,168.85	**$461.82**	$2,416.00	

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Budget $83,894.00	**Building**	***Energy Saving Opportunities***	**2020/2021 Carryover**	**Focus on Energy Rebate**	**Annual Energy Savings**	**Payback from Power Savings Years**	**Total Payback from Power & Maint (Years)**	**Project Date**		**Carryover, Budget plus Rebates**	**Original Funds Request BOE Approval**	**FINAL PROJECT COST**	**Net Difference**
Anticipated summer 2021 - 90 days after completion of 20/21 PHASE 1 project				$2,416.00									
Phase 2 - replacing hallway and bathroom fixtures. Oldest section of WHS	WHS	Flat panel fixtures with Occupancy sensors		$1,817.00		21.26	4.56	July 2021			$48,492.00	$0.00	
Phase 3 - WHS LMTC	WHS	LMTC		$1,500.00		15.04	3.22	July 2021			$32,240.00	$0.00	
*Small Conf Room and Restrooms -**QUOTE PENDING***	Bethel	LED flat panel with occupancy sensors						August 2021			$9,356.82	$0.00	
$83,894.00			**$461.82**	**$5,733.00**						**$90,088.82**	**$90,088.82**	**$0.00**	**$0.00**

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Catalog Number	
Notes	
Type	

Contractor Select™

CPX™

LED Panel

CPX™ from Lithonia lighting is the perfect choice for a quality LED panel at an affordable price. The smooth, even lens projects a crisp and clean aesthetic. CPX is the perfect choice for budget-conscious school, commercial office, or small retail footprint projects.

FEATURES:

- Industry standard wattages
- Long-life LEDs maintain greater than 70% of their lumen output at 50,000 hours
- 0-10V dimming driver, dims to 10%

WEIGHT:

2x2
Unit: 6.39lbs
Unit Carton: 7.72lbs
Master Carton: 30.42lbs

2x4
Unit: 11.02lbs
Unit Carton: 13.89lbs
Master Carton: 27.78lbs

Switchable Lumens

IC RATED

Catalog Number	UPC	Description	Lumens	Input Watts	CCT	CRI	Voltage	Pallet qty.
CPX 2X2 3200LM 35K M4	191848338537	2x2 LED Panel	3555	31.5	3500K	80	120-277V	40
CPX 2X2 3200LM 40K M4	191848338650	2x2 LED Panel	3659	31.5	4000K	80	120-277V	40
CPX 2X2 3200LM 50K M4	193048313642	2x2 LED Panel	3737	31.5	5000K	80	120-277V	40
CPX 2X4 4000LM 35K M2	191848338490	2x4 LED Panel	4543	38.9	3500K	80	120-277V	20
CPX 2X4 4000LM 40K M2	191848338506	2x4 LED Panel	4692	38.9	4000K	80	120-277V	20
CPX 2X4 4000LM 50K M2	193048313680	2x4 LED Panel	4766	38.9	5000K	80	120-277V	20
CPX 1X4 ALO7 SSW7 M4	194994568063	1X4 Switchable Panel	See Switchable Table	See Switchable Table	3500K/4000K/5000K	>80	120-277V	40
CPX 2X2 ALO7 SWW7 M4	193048542806	2X2 Switchable Panel	See Switchable Table	See Switchable Table	3500K/4000K/5000K	>80	120-277V	40
CPX 2X4 ALO8 SWW7 M2	193048542844	2X4 Switchable Panel	See Switchable Table	See Switchable Table	3500K/4000K/5000K	>80	120-277V	20

NOTES

1. ILBLP CP10 HE SD A remote mounted only. See ILBLP CP10 HE SD B spec sheet and ELA-PSMK-PSMKSD-PSDMT-PSRME remote mounting enclosure spec sheet here.

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LITHONIA LIGHTING®

Accessories: *Order as separate catalog number.*	
ILBLP CP10 HE SD A	IOTA 10 Watt Constant Power, High Efficiency LED Emergency Driver for CA Title 20 [1]
DGA14	Drywall grid adapter for 1X4 recessed fixture.
DGA22	Drywall grid adapter for 2x2 recessed fixture.
DGA24	Drywall grid adapter for 2x4 recessed fixture.
1X4SMKSH	Multi-Use Surface Mount Kit 1X4, Shallow Depth
2X2SMKSH	Multi-Use Surface Mount Kit 2x2, Shallow Depth
2X4SMKSH	Multi-Use Surface Mount Kit 2x4, Shallow Depth
1X4SMKSHP PAF	Multi-Use Surface Mount Kit 1X4 Post-Paint
2X2SMKSHP PAF	Multi-Use Surface Mount Kit 2X2 Post-Paint
2X4SMKSHP PAF	Multi-Use Surface Mount Kit 2X4 Post-Paint
PAC 2DNF 36	Panel Air Craft Kit, 2 cables with Y splitter, No Power Feed, 36 inches. Recommended for 1X4 or 2X2 Panel Fixtures only.
PAC 2DF 36	Panel Air Craft Kit, 2 cables with Y splitter, with Power Feed, 36 inches. Recommended for 1X4 or 2X2 Panel Fixtures only. [1]
PAC 4DNF 36	Panel Air Craft Kit, 4 cables, No Power Feed, 36 inches. Recommended for 2X4, 1X4 or 2X2 Panel Fixtures.
PAC 4DF 36	Panel Air Craft Kit, 4 cables, with Power Feed, 36 inches. Recommended for 2X4, 1X4 or 2X2 Panel Fixtures. [1]
PAC 2DNF 72	Panel Air Craft Kit, 2 cables with Y splitter, No Power Feed 72 inches. Recommended for 1X4 or 2X2 Panel Fixtures only.
PAC 2DF 72	Panel Air Craft Kit, 2 cables with Y splitter, with Power Feed, 72 inches. Recommended for 1X4 or 2X2 Panel Fixtures only. [1]
PAC 4DNF 72	Panel Air Craft Kit, 4 cables, No Power Feed, 72 inches. Recommended for 2X4, 1X4 or 2X2 Panel Fixtures.
PAC 4DF 72	Panel Air Craft Kit, 4 cables, with Power Feed, 72 inches. Recommended for 2X4, 1X4 or 2X2 Panel Fixtures. [1]

Switchable Table

Size(ft)	Nomenclature	Lumen Package	CCT	Lumen	Wattage	Efficacy
1x4	CPX 1x4 AL07 SWW7 M4	Low Lumen	3500K	2430	19.7	123.4
			4000K	2594	19.7	131.7
			5000K	2483	19.5	127.3
		Med Lumen	3500K	3289	28.4	115.8
			4000K	3583	27.2	131.7
			5000K	3369	28.2	119.5
		High Lumen	3500K	3914	35.7	109.6
			4000K	4280	33.7	127
			5000K	4009	35.5	112.9
2x2	CPX 2X2 AL07 SWW7 M4	Low Lumen	3500K	2399	19.1	125.6
			4000K	2570	18.5	138.9
			5000K	2456	19.1	128.6
		Med Lumen	3500K	3356	28.7	116.9
			4000K	3649	27.5	132.7
			5000K	3427	28.5	120.2
		High Lumen	3500K	4131	37.5	110.2
			4000K	4564	35.8	127.5
			5000K	4212	37.3	112.9
2x4	CPX 2X4 AL08 SWW7 M2	Low Lumen	3500K	3813	28.94	131.8
			4000K	4033	28.1	143.5
			5000K	3938	28.86	136.5
		Med Lumen	3500K	4677	36.8	127.1
			4000K	5009	35.55	140.9
			5000K	4834	36.65	131.9
		High Lumen	3500K	6048	50.56	119.6
			4000K	6563	48.53	135.2
			5000K	6241	50.24	124.2

NOTES

1. For MVOLT only, not available with 347V.

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LITHONIA LIGHTING®

Specifications

INTENDED USE:
CPX is a low-glare panel featuring an external driver. This cost-effective, reliable panel is visually comfortable and can be recessed mounted. Suitable for many applications such as schools, offices, retail, convenience stores and other commercial spaces. **Certain airborne contaminants can diminish integrity of acrylic. Click here for Acrylic Environmental Compatibility table for suitable uses.** Adjustable Lumen (ALO7, ALO8) and Switchable White (SWW7) configurations available. **U.S. Patent No. 10,681,784.**

CONSTRUCTION:
The extruded aluminum frame with satin white lens provides excellent shielding and uniform luminance. The low-profile design of CPX provides increased installation flexibility especially in restricted plenum spaces. The backplate includes integral T-bar clips for installation into T-grid ceilings.

ELECTRICAL:
Long-life LEDs, coupled with a high-efficiency driver, provide superior illumination for extended service life. Greater than 70% LED lumen maintenance at 50,000 hours (L70>50,000). 0-10V dimming driver, dims to 10% and contains non-isolated dimming leads.

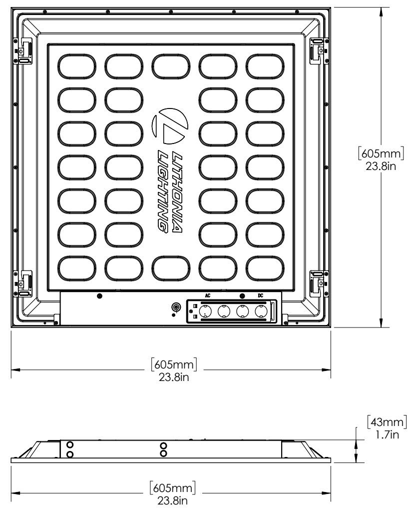
LISTINGS:
CSA certified to meet US and Canadian standards. Damp location listed. IC rated. IP5X Rated. DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org/QPL to confirm which versions are qualified. Product is rated and certified to meet NSF Splash Zone 2. NOM Certified.

WARRANTY:
5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/support/warranty/terms-and-conditions

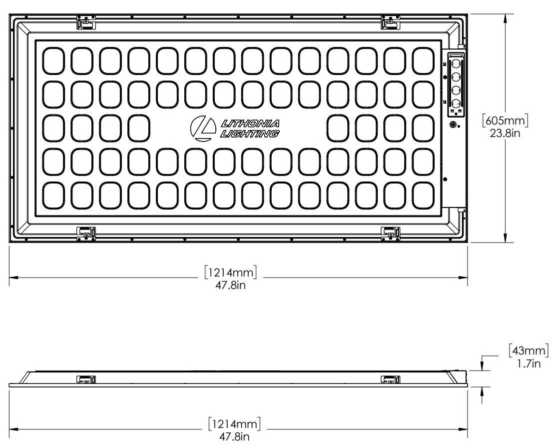
Note: Actual performance may differ as a result of end-user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C. Specifications subject to change without notice.

Dimensions

2'x2'



2'x4'



All dimensions are inches (millimeters) unless otherwise indicated.

							SAVINGS					
Building	**Cleanable Square Feet**	**Current Daily FTE (includes Head Custodian)**	**Current Sq Ft Per FTE**	**Recommended Sq Ft Per FTE**		**Daily Recommended FTE** (Head Custodian is included, assigned zero cleaning)	**FTE Switch to Battery Backpack** (10 of xx ordered)	**FTE - Add Restroom/locker room Cleaning Equipment**	**Total Adjusted Daily Recommended FTE after equipment purchases**	**Additional FTE needed by building**	**Current open positions (HR)**	**Requesting to HIRE**
Arboretum	79,951	3.50	22843	18212		4.39	0.82	0.31	3.26	-0.24	0.00	
Heritage	124,764	5.00	24953	18538		6.73	1.32	0.41	5	0.00	0.00	
Prairie	106,652	4.00	26663	19427		5.49	0.76	0.33	4.4	0.40	0.00	0.40
Intermediate	141,053	5.50	25646	19783		7.13	1.12	0.47	5.54	0.04	2.00	2.04
Middle School	101,839	4.50	22631	18652		5.46	0.64	0.13	4.69	0.19	0.50	0.69
High School	334,754	9.20	33375	24833		13.48	1.04	0.79	11.65	2.45	4.60	7.05
TLC	5,612	0.30	5612	5612		0.32	0.06	0	0.26	-0.04	0.00	
Bethel	12,601	0.38	12601	12601		0.71	0.18	0.08	0.45	0.07	0.40	0.47
		32.38				43.71	5.94	2.52	35.25	**2.87**	**7.50**	**10.65**

Does not account for any athletic function setups/teardowns

short 4.5 FTE. Need to hire 8 FTE for HS.

Does not account for athletic events.

April 13th 2021

John Cramer
Waunakee Community School District

Dear John,

This letter serves as an agreement between KleenMark Services Corp and Waunakee Community School District.

KleenMark will provide the following services to Waunakee School District in accordance with the following terms and conditions.

Project Work Listed: Full Time Janitorial Services
Service Frequency: Monday – Friday starting 3:30PM – 12:00AM, excluding holidays.

KleenMark's service fee will be $22.50/Hour. KleenMark will issue an invoice to Waunakee Community School District by the 1st working day of the following month for the previous months labor provided multiplied by the hourly service fee of $22.50/Hour.

Solicitation: During the course of this agreement and for a period of one (1) year after its termination, Waunakee Community School District shall not solicit any employee or subcontractor of KleenMark to perform services substantially similar to those provided by KleenMark under this agreement. Should Waunakee Community School District be interested in hiring a KleenMark employee or subcontractor this may be arranged for a buy-out payment not to exceed three (3) months of the employee's subcontractor's current pay.

This agreemenent shall be effective beginning (TBD) and shall remain in effect until terminated by either party with a 30-day written notice

KleenMark Services Corp	**Client**
Signature: ______________________	Signature: ______________________________
Print Name: ____Michael Staver____	Print Name: ___________________________
Title: __________Vice President___	Title: __________________________________
Date Signed:____________________	Date Signed: ___________________________

Building	**Description**	**Quote No.**	**2021/2022**	**Notes**
District	PPE - masks, gloves, etc.		$15,000.00	
District	Hand Sanitizer		$10,000.00	
District	Dinsfecting Wipes		$8,000.00	
District	RRCleaning with vac (6 machines)	100672341	$16,721.94	Machines disinfect restrooms and reduce man-hours during summer cleaning/preps cartpets for cleaning
District	RRCleaning with shelf (10 machines)	100672342	$20,275.70	Same as above
District	Cleaning Chemicals - Sanitizer for lunchrooms, etc	100672343	$20,000.00	
District	Cleaning Chemicals -Disinfecting Chemicals		$20,000.00	
District	Remaining Bottle FIllers		$55,000.00	Removed from original proposals to meet expediture cap required by BOE
District	Touchless faucets - restrooms		***$200,000.00***	Need to begin a count at each building. Only a beginning estimate.
AES	HIL56086 Trident Extractor EX 12	100673661	$3,678.57	
AES	HIL56019 Floor Mach ORB Trident FMD20	100673661	$2,010.67	
HES	HIL56019 Floor Mach ORB Trident FMD20	100673665	$2,010.67	
HES	HIL56005 Scrub WB Disc Trident T20SC Pro 20in	100673665	$6,638.43	
HES	Hoover Backpack Battery vacuum ($810.06 each - need 5)	100670337	$4,050.30	
PES	HIL56019 Floor Mach ORB Trident FMD20	100673663	$2,010.67	
PES	Hoover Backpack Battery vacuum ($810.06 each - need 2)	100670337	$1,620.12	
WMS	HIL56087 Trident Extractor ex 20 Gallon	100673667	$7,375.57	
WMS	Hoover Backpack Battery vacuum ($810.06 each - need 3)	100670337	$2,430.18	
WHS	HIL56009 Scrub Ride Disc Trident R30SC 30 in Btty	100681633	$12,726.89	
WHS	HIL56019 Floor Mach ORB Trident FMD20	100673663	$2,010.67	
WHS	HIL56005 Scrub WB Disc Trident T20SC Pro 20in	100681621	$6,638.43	
HES/PES	Replacement Washing Machine (qty 2)		$2,000.00	
WHS	Replacement Heavy Duty washing machine with Commercial Grade		$2,000.00	
			$418,198.81	

Indoor Air Quality

Ensuring Your Building's Health and Safety

A Systematic Approach to IAQ

Unique Challenges for Building Owners and Managers

While your building's indoor air quality (IAQ) has always been important, the Coronavirus pandemic has dramatically redefined it. Regardless of your building's size, type or location, how you address its health and safety is now crucial for each employee, customer or visitor to your facility.

In many cases, buildings have been unoccupied for a significant period of time since the start of the pandemic. This, in itself, can wreak havoc with critical operating systems such as HVAC components and controls.

Forward-thinking building owners and managers confidently turn to Comfort Systems USA North American Mechanical, Inc. (NAMI) for implementing the correct tactics for reducing the potential spread of the virus while improving IAQ.

Our Approach to Successful, Sustainable IAQ and Building Safety

We know that your response to ensuring the highest degree of IAQ and safety will require informed and strategic planning, decision-making, and implementation.

Comfort Systems USA NAMI utilizes a three-tiered approach to address all of your building's IAQ issues:

Evaluate → Plan → Implement

First, we establish a baseline by executing an *evaluation* of your building's current conditions. Once completed, a comprehensive *plan* is developed from the data obtained. Here, building issues are organized and prioritized, resources and costs estimated, and execution timelines identified. Lastly, we deploy our team of industry professionals to *implement* your proactive, defined plan.

Indoor Air Quality Confidence

We couple our extensive knowledge in all building types with the latest IAQ strategies so that every employee, customer or visitor to your facilities feels safe and secure.

Here's a sampling of recommendations designed to help mitigate COVID-19 and improve IAQ:

- Increase Ventilation Rates
- Improve Air Filtration
- Evaluate Airflow Patterns and Velocities
- Control Indoor Humidity Levels
- Extend HVAC System Runtimes
- Consider Ultraviolet-C (UV-C) Lamp Systems
- Consider Needlepoint Bi-Polar Ionization (NPBI)
- Consider Air Scrubbers or Air Purifiers

From Shutdown to Reopening

The pandemic has reinforced our obligation to support building owners and managers in ensuring the health and safety within their commercial buildings.

We can help in the transition process of reopening by improving your overall IAQ by not only minimizing viral risks, but also reducing negative impacts of particulate, odors, microbials and volatile organic compounds (VOCs).

![NAMI Comfort Systems USA]

Protecting Your Occupants and Investment

All Building Types.

All HVAC Systems.

All Controls Systems.

All Locations.

All the Time.

A Proactive Plan, Informed Decisions and Effective IAQ Strategies

Providing the highest degree of safety and confidence to *all* occupants of your building is paramount... it's your responsibility. At the same time, protecting all your building's assets and infrastructure in a financially responsible manner is also very real.

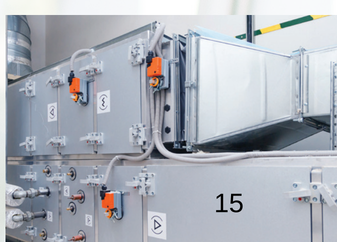
Comfort Systems USA NAMI's trained personnel can help you plot an effective course to mitigate the impact of COVID-19, while also addressing your longer-term solutions for potential IAQ challenges.

Any recommendation we make to you will be based on our extensive industry knowledge of HVAC and control systems. In addition, we follow the guidance as provided by national health and industry organizations such as the Centers for Disease Control (CDC) and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

It's important to remember that while COVID-19 may be driving the urgency for you to act today, many of the actions *taken* today will provide long-term IAQ benefits for a healthier and profitable building.

Relative Complexity and Costs to Implement Select IAQ Strategies in an Existing Building

1. Maintenance
2. Increase Ventilation Rates
3. Filter Efficiency (MERV 13)
4. Humidity Control
5. Control Strategies
6. Ultraviolet-C (UV-C)
7. Needlepoint Bi-Polar Ionization (NPBI)
8. Air Purifier / Air Scrubber
9. Dedicated Outdoor Air System (DOAS)
10. Redesign HVAC System



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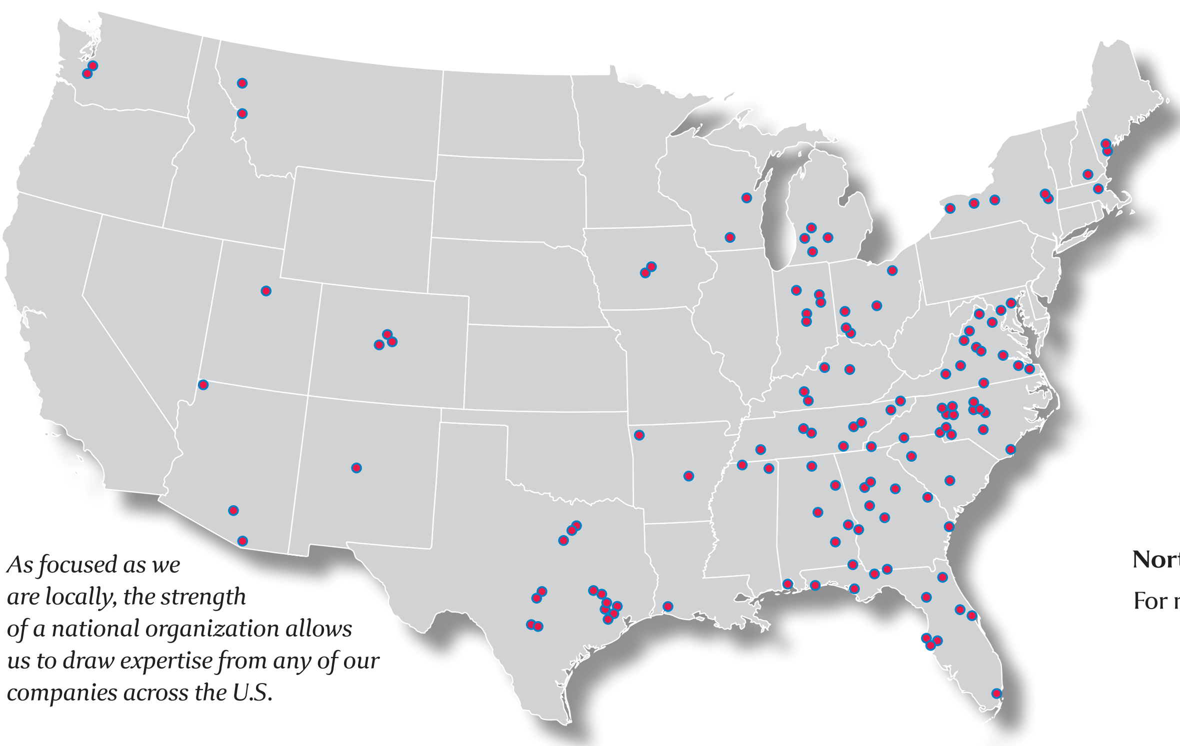

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ASHRAE Position Document on Infectious Aerosols

Approved by ASHRAE Board of Directors
April 14, 2020

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HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

The following summarizes this document's revision, reaffirmation, and withdrawal dates:

6/24/2009—BOD approves Position Document titled *Airborne Infectious Diseases*

1/25/2012—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

1/19/2014—BOD approves revised Position Document titled *Airborne Infectious Diseases*

1/31/2017—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

2/5/2020—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

4/14/2020—BOD approves revised Position Document titled *Infectious Aerosols*

Note: ASHRAE's Technology Council and the cognizant committee recommend revision, reaffirmation, or withdrawal every 30 months.

Note: ASHRAE position documents are approved by the Board of Directors and express the views of the Society on a specific issue. The purpose of these documents is to provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy. A related purpose is also to serve as an educational tool clarifying ASHRAE's position for its members and professionals, in general, advancing the arts and sciences of HVAC&R.

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ASHRAE Position Document on Infectious Aerosols

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ABSTRACT

The pathogens that cause infectious diseases are spread from a primary host to secondary hosts via several different routes. Some diseases are known to spread by infectious aerosols; for other diseases, the route of transmission is uncertain. The risk of pathogen spread, and therefore the number of people exposed, can be affected both positively and negatively by the airflow patterns in a space and by heating, ventilating, and air-conditioning (HVAC) and local exhaust ventilation (LEV) systems. ASHRAE is the global leader and foremost source of technical and educational information on the design, installation, operation, and maintenance of these systems. Although the principles discussed in this position document apply primarily to buildings, they may also be applicable to other occupancies, such as planes, trains, and automobiles.

ASHRAE will continue to support research that advances the knowledge base of indoor air-management strategies aimed to reduce occupant exposure to infectious aerosols. Chief among these ventilation-related strategies are dilution, airflow patterns, pressurization, temperature and humidity distribution and control, filtration, and other strategies such as ultraviolet germicidal irradiation (UVGI). While the exact level of ventilation effectiveness varies with local conditions and the pathogens involved, ASHRAE believes that these techniques, when properly applied, can reduce the risk of transmission of infectious diseases through aerosols.

To better specify the levels of certainty behind ASHRAE's policy positions stated herein, we have chosen to adopt the Agency for Healthcare Research and Quality (AHRQ) rubric for expressing the scientific certainty behind our recommendations (Burns et al. 2011). These levels of certainty, as adapted for this position document, are as follows:

Evidence Level	Description
A	Strongly recommend; good evidence
B	Recommend; at least fair evidence
C	No recommendation for or against; balance of benefits and harms too close to justify a recommendation
D	Recommend against; fair evidence is ineffective or the harm outweighs the benefit
E	Evidence is insufficient to recommend for or against routinely; evidence is lacking or of poor quality; benefits and harms cannot be determined

ASHRAE's position is that facilities of all types should follow, as a minimum, the latest published standards and guidelines and good engineering practice. ANSI/ASHRAE Standards 62.1 and 62.2 (ASHRAE 2019a, 2019b) include requirements for outdoor air ventilation in most residential and nonresidential spaces, and ANSI/ASHRAE/ASHE Standard 170 (ASHRAE 2017a) covers both outdoor and total air ventilation in healthcare facilities. Based on risk assessments or owner project requirements, designers of new and existing facilities could go beyond the minimum requirements of these standards, using techniques covered in various ASHRAE publications, including the ASHRAE Handbook volumes, Research Project final reports, papers and articles, and design guides, to be even better prepared to control the dissemination of infectious aerosols.

EXECUTIVE SUMMARY

With infectious diseases transmitted through aerosols, HVAC systems can have a major effect on the transmission from the primary host to secondary hosts. Decreasing exposure of secondary hosts is an important step in curtailing the spread of infectious diseases.

Designers of mechanical systems should be aware that ventilation is not capable of addressing all aspects of infection control. HVAC systems,[1] however, do impact the distribution and bio-burden of infectious aerosols. Small aerosols may persist in the breathing zone, available for inhalation directly into the upper and lower respiratory tracts or for settling onto surfaces, where they can be indirectly transmitted by resuspension or fomite[2] contact.

Infectious aerosols can pose an exposure risk, regardless of whether a disease is classically defined as an "airborne infectious disease." This position document covers strategies through which HVAC systems modulate aerosol[3] distribution and can therefore increase or decrease exposure to infectious droplets,[4] droplet nuclei,[5] surfaces, and intermediary fomites[6] in a variety of environments.

This position document provides recommendations on the following:

- The design, installation, and operation of heating, ventilating, and air-conditioning (HVAC) systems, including air-cleaning, and local exhaust ventilation (LEV) systems, to decrease the risk of infection transmission.
- Non-HVAC control strategies to decrease disease risk.
- Strategies to support facilities management for both everyday operation and emergencies.

Infectious diseases can be controlled by interrupting the transmission routes used by a pathogen. HVAC professionals play an important role in protecting building occupants by interrupting the indoor dissemination of infectious aerosols with HVAC and LEV systems.

COVID-19 Statements

Separate from the approval of this position document, ASHRAE's Executive Committee and Epidemic Task Force approved the following statements specific to the ongoing response to the COVID-19 pandemic. The two statements are appended here due to the unique relationship between the statements and the protective design strategies discussed in this position document:

Statement on airborne transmission of SARS-CoV-2: 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 heating, ventilating, and air-conditioning systems, can reduce airborne exposures.

Statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2 transmission: Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus

[1] Different HVAC systems are described in *ASHRAE Handbook—HVAC Systems and Equipment* (ASHRAE 2020).
[2] An object (such as a dish or a doorknob) that may be contaminated with infectious organisms and serve in their transmission.
[3] An aerosol is a system of liquid or solid particles uniformly distributed in a finely divided state through a gas, usually air. They are small and buoyant enough to behave much like a gas.
[4] In this document, *droplets* are understood to be large enough to fall to a surface in 3–7 ft (1–2 m) and thus not become aerosols.
[5] Droplet nuclei are formed from droplets that become less massive by evaporation and thus may become aerosols.
[6] Fomite transmission is a form of indirect contact that occurs through touching a contaminated inanimate object such as a doorknob, bed rail, television remote, or bathroom surface.

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 air-conditioning systems is not a recommended measure to reduce the transmission of the virus.

1. THE ISSUE

The potential for airborne dissemination of infectious pathogens is widely recognized, although there remains uncertainty about the relative importance of the various disease transmission routes, such as airborne, droplet, direct or indirect contact, and multimodal (a combination of mechanisms). Transmission of disease varies by pathogen infectivity, reservoirs, routes, and secondary host susceptibility (Roy and Milton 2004; Shaman and Kohn 2009; Li 2011). The variable most relevant for HVAC design and control is disrupting the transmission pathways of infectious aerosols.

Infection control professionals describe the chain of infection as a process in which a pathogen (a microbe that causes disease) is carried in an initial host or reservoir, gains access to a route of ongoing transmission, and with sufficient virulence finds a secondary susceptible host. Ventilation, filtration, and air distribution systems and disinfection technologies have the potential to limit airborne pathogen transmission through the air and thus break the chain of infection.

Building science professionals must recognize the importance of facility operations and ventilation systems in interrupting disease transmission. Non-HVAC measures for breaking the chain of infection, such as effective surface cleaning, contact and isolation precautions mandated by employee and student policies, and vaccination regimens, are effective strategies that are beyond the scope of this document. Dilution and extraction ventilation, pressurization, airflow distribution and optimization, mechanical filtration, ultraviolet germicidal irradiation (UVGI), and humidity control are effective strategies for reducing the risk of dissemination of infectious aerosols in buildings and transportation environments.

Although this position document is primarily applicable to viral and bacterial diseases that can use the airborne route for transmission from person to person, the principles of containment may also apply to infection from building reservoirs such as water systems with *Legionella spp.* and organic matter containing spores from mold (to the extent that the microorganisms are spread by the air). The first step in control of such diseases is to eliminate the source before it becomes airborne.

2. BACKGROUND

ASHRAE provides guidance and develop standards intended to mitigate the risk of infectious disease transmission in the built environment. Such documents provide engineering strategies for reducing the risk of disease transmission and therefore could be employed in a variety of other spaces, such as planes, trains, and automobiles.

This position document covers the dissemination of infectious aerosols and indirect transmission by resuspension but not direct-contact routes of transmission. *Direct contact* generally refers to bodily contact such as touching, kissing, sexual contact, contact with oral secretions or skin lesions and routes such as blood transfusions or intravenous injections.

2.1 Airborne Dissemination

Pathogen dissemination through the air occurs through droplets and aerosols typically generated by coughing, sneezing, shouting, breathing, toilet flushing, some medical procedures, singing, and talking (Bischoff et al. 2013; Yan et al. 2018). The majority of larger emitted droplets are drawn by gravity to land on surfaces within about 3–7 ft (1–2 m) from the source (see Figure 1). General dilution ventilation and pressure differentials do not significantly influ-

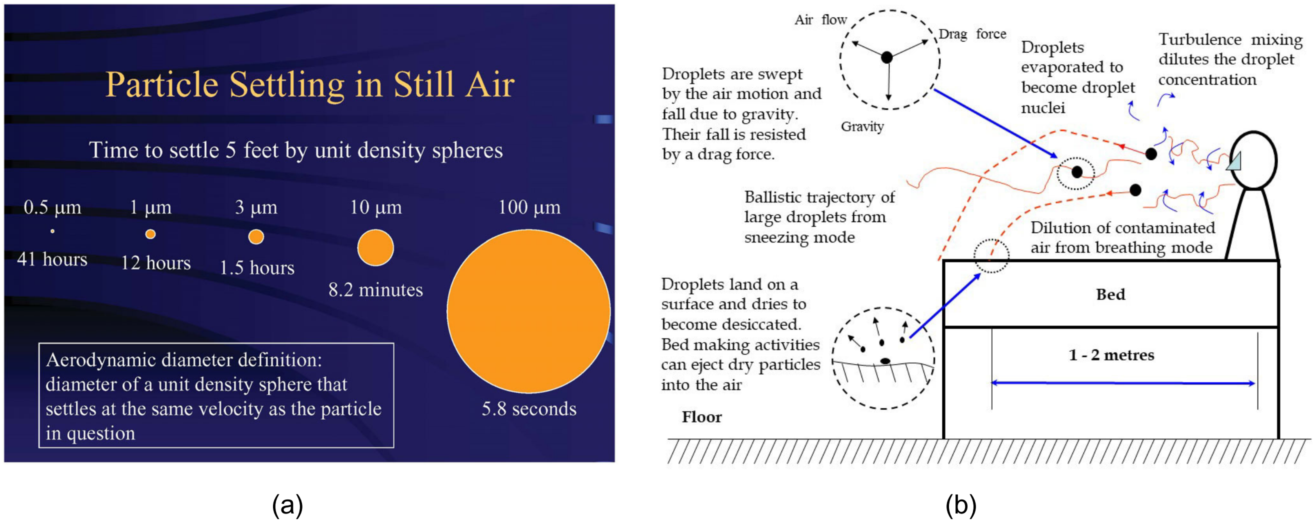

Figure 1 (a) Comparative settling times by particle diameter for particles settling in still air (Baron n.d.) and (b) theoretical aerobiology of transmission of droplets and small airborne particles produced by an infected patient with an acute infection (courtesy Yuguo Li).

ence short-range transmission. Conversely, dissemination of smaller infectious aerosols, including droplet nuclei resulting from desiccation, can be affected by airflow patterns in a space in general and airflow patterns surrounding the source in particular. Of special interest are small aerosols (<10 µm), which can stay airborne and infectious for extended periods (several minutes, hours, or days) and thus can travel longer distances and infect secondary hosts who had no contact with the primary host.

Many diseases are known to have high transmission rates via larger droplets when susceptible individuals are within close proximity, about 3–7 ft (1–2 m) (Nicas 2009; Li 2011). Depending on environmental factors, these large (100 µm diameter) droplets may shrink by evaporation before they settle, thus becoming an aerosol (approximately <10 µm). The term *droplet nuclei* has been used to describe such desiccation of droplets into aerosols (Siegel et al. 2007). While ventilation systems cannot interrupt the rapid settling of large droplets, they can influence the transmission of droplet nuclei infectious aerosols. Directional airflow can create clean-to-dirty flow patterns and move infectious aerosols to be captured or exhausted.

3. PRACTICAL IMPLICATIONS FOR BUILDING OWNERS, OPERATORS, AND ENGINEERS

Even the most robust HVAC system cannot control all airflows and completely prevent dissemination of an infectious aerosol or disease transmission by droplets or aerosols. An HVAC system's impact will depend on source location, strength of the source, distribution of the released aerosol, droplet size, air distribution, temperature, relative humidity, and filtration. Furthermore, there are multiple modes and circumstances under which disease transmission occurs. Thus, strategies for prevention and risk mitigation require collaboration among designers, owners, operators, industrial hygienists, and infection prevention specialists.

3.1 Varying Approaches for Facility Type

Healthcare facilities have criteria for ventilation design to mitigate airborne transmission of infectious diseases (ASHRAE 2013, 2017a, 2019a; FGI 2010); however, infections are also transmitted in ordinary occupancies in the community and not only in industrial or healthcare occupancies. ASHRAE provides general ventilation and air quality requirements in Standards 62.1, 62.2, and 170 (ASHRAE 2019a, 2019b, 2017a); ASHRAE does not provide specific requirements for infectious disease control in homes, schools, prisons, shelters, transportation, or other public facilities.

In healthcare facilities, most infection control interventions are geared at reducing direct or indirect contact transmission of pathogens. These interventions for limiting airborne transmission (Aliabadi et al. 2011) emphasize personnel education and surveillance of behaviors such as hand hygiene and compliance with checklist protocols and have largely been restricted to a relatively small list of diseases from pathogens that spread only through the air. Now that microbiologists understand that many pathogens can travel through both contact and airborne routes, the role of indoor air management has become critical to successful prevention efforts. In view of the broader understanding of flexible pathogen transmission modes, healthcare facilities now use multiple modalities simultaneously (measures that are referred to as *infection control bundles*) (Apisarnthanarak et al. 2009, 2010a, 2010b; Cheng et al. 2010). For example, in the cases of two diseases that clearly utilize airborne transmission, tuberculosis and measles, bundling includes administrative regulations, environmental controls, and personal protective equipment protocols in healthcare settings. This more comprehensive approach is needed to control pathogens, which can use both contact and airborne transmission pathways. Similar strategies may be appropriate for non-healthcare spaces, such as public transit and airplanes, schools, shelters, and prisons, that may also be subject to close contact of occupants.

Many buildings are fully or partially naturally ventilated. They may use operable windows and rely on intentional and unintentional openings in the building envelope. These strategies create different risks and benefits. Obviously, the airflow in these buildings is variable and unpredictable, as are the resulting air distribution patterns, so the ability to actively manage risk in such buildings is much reduced. However, naturally ventilated buildings can go beyond random opening of windows and be engineered intentionally to achieve ventilation strategies and thereby reduce risk from infectious aerosols. Generally speaking, designs that achieve higher ventilation rates will reduce risk. However, such buildings will be more affected by local outdoor air quality, including the level of allergens and pollutants within the outdoor air, varying temperature and humidity conditions, and flying insects. The World Health Organization has published guidelines for naturally ventilated buildings that should be consulted in such projects (Atkinson et al. 2009).

3.2 Ventilation and Air-Cleaning Strategies

The design and operation of HVAC systems can affect infectious aerosol transport, but they are only one part of an infection control bundle. The following HVAC strategies have the potential to reduce the risks of infectious aerosol dissemination: air distribution patterns, differential room pressurization, personalized ventilation, source capture ventilation, filtration (central or local), and controlling temperature and relative humidity. While UVGI is well researched and validated, many new technologies are not (ASHRAE 2018). (Evidence Level B)

Ventilation with effective airflow patterns (Pantelic and Tham 2013) is a primary infectious disease control strategy through dilution of room air around a source and removal of infectious agents (CDC 2005). However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious doses vary widely among different pathogens) and whether these reductions warrant the associated costs (Pantelic and Tham 2011; Pantelic and Tham 2012). (Evidence Level B)

Room pressure differentials and directional airflow are important for controlling airflow between zones in a building (CDC 2005; Siegel et al. 2007) (Evidence Level B). Some designs for airborne infection isolation rooms (AIIRs) incorporate supplemental dilution or exhaust/capture ventilation (CDC 2005). Interestingly, criteria for AIIRs differ substantially between regions and countries in several ways, including air supply into anterooms, exhaust from space, and required amounts of ventilation air (Fusco et al. 2012; Subhash et al. 2013). A recent ASHRAE Research Project found convincing evidence that a properly configured and operated anteroom is an effective means to maintain pressure differentials and create containment in hospital rooms (Siegel et al. 2007; Mousavi et al. 2019). Where a significant risk of transmission of aerosols has been identified by infection control risk assessments, design of AIIRs should include anterooms. (Evidence Level A)

The use of highly efficient particle filtration in centralized HVAC systems reduces the airborne load of infectious particles (Azimi and Stephens 2013). This strategy reduces the transport of infectious agents from one area to another when these areas share the same central HVAC system through supply of recirculated air. When appropriately selected and deployed, single-space high-efficiency filtration units (either ceiling mounted or portable) can be highly effective in reducing/lowering concentrations of infectious aerosols in a single space. They also achieve directional airflow source control that provides exposure protection at the patient bedside (Miller-Leiden et al. 1996; Mead and Johnson 2004; Kujundzic et al. 2006; Mead et al. 2012; Dungi et al. 2015). Filtration will not eliminate all risk of transmission of airborne particulates because many other factors besides infectious aerosol concentration contribute to disease transmission. (Evidence Level A)

The entire ultraviolet (UV) spectrum can kill or inactivate microorganisms, but UV-C energy (in the wavelengths from 200 to 280 nm) provides the most germicidal effect, with 265 nm being the optimum wavelength. The majority of modern UVGI lamps create UV-C energy at a near-optimum 254 nm wavelength. UVGI inactivates microorganisms by damaging the structure of nucleic acids and proteins with the effectiveness dependent upon the UV dose and the susceptibility of the microorganism. The safety of UV-C is well known. It does not penetrate deeply into human tissue, but it can penetrate the very outer surfaces of the eyes and skin, with the eyes being most susceptible to damage. Therefore, shielding is needed to prevent direct exposure to the eyes. While *ASHRAE Position Document on Filtration and Air Cleaning* (2018) does not make a recommendation for or against the use of UV energy in air systems for minimizing the risks from infectious aerosols, Centers for Disease Control and Prevention (CDC) has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk and has published a guideline on its application (CDC 2005, 2009).[7] (Evidence Level A)

Personalized ventilation systems that provide local exhaust source control and/or supply 100% outdoor, highly filtered, or UV-disinfected air directly to the occupant's breathing zone (Cermak et al. 2006; Bolashikov et al., 2009; Pantelic et al. 2009, 2015; Licina et al. 2015a, 2015b) may offer protection against exposure to contaminated air. Personalized ventilation may be effective against aerosols that travel both long distances as well as short ranges (Li 2011).

[7] In addition to UVGI, optical radiation in longer wavelengths as high as 405 nm is an emerging disinfection technology that may also have useful germicidal effectiveness.

Personalized ventilation systems, when coupled with localized or personalized exhaust devices, further enhance the overall ability to mitigate exposure in breathing zones, as seen from both experimental and computational fluid dynamics (CFD) studies in healthcare settings (Yang et al. 2013, 2014, 2015a, 2015b; Bolashikov et al. 2015; Bivolarova et al. 2016). However, there are no known epidemiological studies that demonstrate a reduction in infectious disease transmission. (Evidence Level B)

Advanced techniques such as computational fluid dynamics (CFD) analysis, if performed properly with adequate expertise, can predict airflow patterns and probable flow paths of airborne contaminants in a space. Such analyses can be employed as a guiding tool during the early stages of a design cycle (Khankari 2016, 2018a, 2018b, 2018c).

3.3 Temperature and Humidity

HVAC systems are typically designed to control temperature and humidity, which can in turn influence transmissibility of infectious agents. Although HVAC systems can be designed to control relative humidity (RH), there are practical challenges and potential negative effects of maintaining certain RH set points in all climate zones. However, while the weight of evidence at this time (Derby et al. 2016), including recent evidence using metagenomic analysis (Taylor and Tasi 2018), suggests that controlling RH reduces transmission of certain airborne infectious organisms, including some strains of influenza, this position document encourages designers to give careful consideration to temperature and RH.

In addition, immunobiologists have correlated mid-range humidity levels with improved mammalian immunity against respiratory infections (Taylor and Tasi 2018). Mousavi et al. (2019) report that the scientific literature generally reflects the most unfavorable survival for microorganisms when the RH is between 40% and 60% (Evidence Level B). Introduction of water vapor to the indoor environment to achieve the mid-range humidity levels associated with decreased infections requires proper selection, operation, and maintenance of humidification equipment. Cold winter climates require proper building insulation to prevent thermal bridges that can lead to condensation and mold growth (ASHRAE 2009). Other recent studies (Taylor and Tasi 2018) identified RH as a significant driver of patient infections. These studies showed that RH below 40% is associated with three factors that increase infections. First, as discussed previously, infectious aerosols emitted from a primary host shrink rapidly to become droplet nuclei, and these dormant yet infectious pathogens remain suspended in the air and are capable of traveling great distances. When they encounter a hydrated secondary host, they rehydrate and are able to propagate the infection. Second, many viruses and bacteria are anhydrous resistant (Goffau et al. 2009; Stone et al. 2016) and actually have increased viability in low-RH conditions. And finally, immunobiologists have now clarified the mechanisms through which ambient RH below 40% impairs mucus membrane barriers and other steps in immune system protection (Kudo et al. 2019). (Evidence Level B)

This position document does not make a definitive recommendation on indoor temperature and humidity set points for the purpose of controlling infectious aerosol transmission. Practitioners may use the information herein to make building design and operation decisions on a case-by-case basis.

3.4 Emerging Pathogens and Emergency Preparedness

Disease outbreaks (i.e., epidemics and pandemics) are increasing in frequency and reach. Pandemics of the past have had devastating effects on affected populations. Novel microorganisms that can be disseminated by infectious aerosols necessitate good design, construction, commissioning, maintenance, advanced planning, and emergency drills to facilitate fast action to mitigate exposure. In many countries, common strategies include naturally ventilated buildings and isolation. Control banding is a risk management strategy that should be considered for applying the hierarchy of controls to emerging pathogens, based on the likelihood and duration of exposure and the infectivity and virulence of the pathogen (Sietsema 2019) (Evidence Level B). Biological agents that may be used in terrorist attacks are addressed elsewhere (USDHHS 2002, 2003).

4. CONCLUSIONS AND RECOMMENDATIONS

Infectious aerosols can be disseminated through buildings by pathways that include air distribution systems and interzone airflows. Various strategies have been found to be effective at controlling transmission, including 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, UVGI, and controlling indoor temperature and relative humidity. Design engineers can make an essential contribution to reducing infectious aerosol transmission through the application of these strategies. Research on the role of airborne dissemination and resuspension from surfaces in pathogen transmission is rapidly evolving. Managing indoor air to control distribution of infectious aerosols is an effective intervention which adds another strategy to medical treatments and behavioral interventions in disease prevention.

4.1 ASHRAE's Positions

- HVAC design teams for facilities of all types should follow, as a minimum, the latest published standards and guidelines and good engineering practice. Based on risk assessments or owner project requirements, designers of new and existing facilities could go beyond the minimum requirements of these standards, using techniques covered in various ASHRAE publications, including the ASHRAE Handbook volumes, Research Project final reports, papers and articles, and design guides, to be even better prepared to control the dissemination of infectious aerosols.
- Mitigation of infectious aerosol dissemination should be a consideration in the design of all facilities, and in those identified as high-risk facilities the appropriate mitigation design should be incorporated.
- The design and construction team, including HVAC designers, should engage in an integrated design process in order to incorporate the appropriate infection control bundle in the early stages of design.
- Based on risk assessments, buildings and transportation vehicles should consider designs that promote cleaner airflow patterns for providing effective flow paths for airborne particulates to exit spaces to less clean zones and use appropriate air-cleaning systems. (Evidence Level A)
- Where a significant risk of transmission of aerosols has been identified by infection control risk assessments, design of AIIRs should include anterooms. (Evidence Level A)

- Based on risk assessments, the use of specific HVAC strategies supported by the evidence-based literature should be considered, including the following:
  - Enhanced filtration (higher minimum efficiency reporting value [MERV] filters over code minimums in occupant-dense and/or higher-risk spaces) (Evidence Level A)
  - Upper-room UVGI (with possible in-room fans) as a supplement to supply airflow (Evidence Level A)
  - Local exhaust ventilation for source control (Evidence Level A)
  - Personalized ventilation systems for certain high-risk tasks (Evidence Level B)
  - Portable, free-standing high-efficiency particulate air (HEPA) filters (Evidence Level B)
  - Temperature and humidity control (Evidence Level B)
- Healthcare buildings[8] should consider design and operation to do the following:
  - Capture expiratory aerosols with headwall exhaust, tent or snorkel with exhaust, floor-to-ceiling partitions with door supply and patient exhaust, local air HEPA-grade filtration.
  - Exhaust toilets and bed pans (a must).
  - Maintain temperature and humidity as applicable to the infectious aerosol of concern.
  - Deliver clean air to caregivers.
  - Maintain negatively pressurized intensive care units (ICUs) where infectious aerosols may be present.
  - Maintain rooms with infectious aerosol concerns at negative pressure.
  - Provide 100% exhaust of patient rooms.
  - Use UVGI.
  - Increase the outdoor air change rate (e.g., increase patient rooms from 2 to 6 ach).
  - Establish HVAC contributions to a patient room turnover plan before reoccupancy.
- Non-healthcare buildings should have a plan for an emergency response. The following modifications to building HVAC system operation should be considered:
  - Increase outdoor air ventilation (disable demand-controlled ventilation and open outdoor air dampers to 100% as indoor and outdoor conditions permit).
  - Improve central air and other HVAC filtration to MERV-13 (ASHRAE 2017b) or the highest level achievable.
  - Keep systems running longer hours (24/7 if possible).
  - Add portable room air cleaners with HEPA or high-MERV filters with due consideration to the clean air delivery rate (AHAM 2015).
  - Add duct- or air-handling-unit-mounted, upper room, and/or portable UVGI devices in connection to in-room fans in high-density spaces such as waiting rooms, prisons, and shelters.
  - Maintain temperature and humidity as applicable to the infectious aerosol of concern.
  - Bypass energy recovery ventilation systems that leak potentially contaminated exhaust air back into the outdoor air supply.
- Design and build inherent capabilities to respond to emerging threats and plan and practice for them. (Evidence Level B)

[8] It is assumed that healthcare facilities already have emergency response plans.

4.2 ASHRAE's Commitments

- Address research gaps with future research projects, including those on the following topics:
  - Investigating and developing source generation variables for use in an updated ventilation rate procedure
  - Understanding the impacts of air change rates in operating rooms on patient outcomes
  - Determining the effectiveness of location of supply, return, and exhaust registers in patient rooms
  - Conducting controlled interventional studies to quantify the relative airborne infection control performance and cost-effectiveness of specific engineering strategies, individually and in combination, in field applications of high-risk occupancies
  - Evaluating and comparing options to create surge airborne isolation space and temporary negative pressure isolation space and the impacts on overall building operation
  - Understanding the appropriate application of humidity and temperature control strategies across climate zones on infectious aerosol transmission
  - Investigating how control banding techniques can be applied to manage the risk of infectious aerosol dissemination
- Partner with infection prevention, infectious disease, and occupational health experts and building owners to evaluate emerging control strategies and provide evidence-based recommendations.
- Educate stakeholders and disseminate best practices.
- Create a database to track and share knowledge on effective, protective engineering design strategies.
- Update standards and guidelines to reflect protective evidence-based strategies.

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