Making Air Your Ally

Frederick Dela Cruz
Trane Technologies – Sr. Solutions Advisor

Introduction

The Seminar will be hosted by Frederick Dela Cruz, CEM (Sr. Solutions Advisor, Trane West Florida). Frederick is a Chemical Engineering graduated from the University of Florida and holds certifications from the Association of Energy Engineer's Certified Energy Manager program and Trane's Controls and Energy Services Graduate Training Program. He is a founding member of the Tampa Bay Energy Efficiency Alliance (TBEEA) and has experience consulting, developing and implementing numerous conservation and construction projects throughout the Southeastern United States.

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IEQ Projects During The Pandemic

Amazon's New Safety Crisis Could Be Heat Waves

As a frying planet becomes a fact of life, air conditioning could become the next warehouse battleground.

By Whitney Kimball | 6/29/21 3:40PM | Comments (6) | Alerts

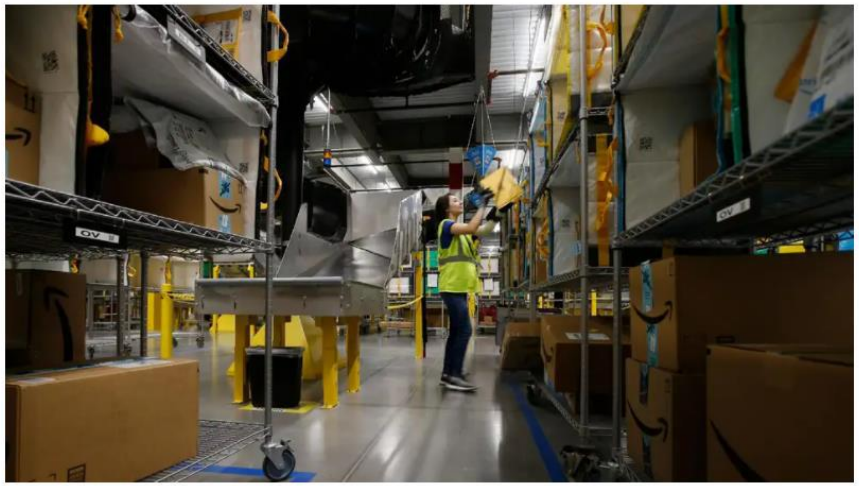

Photo: Ross D. Franklin (AP)

Amazon workers have faced no shortage of health hazards in the company's warehouses. While we've focused on injuries, inadequate restroom access, covid-19 safeguards, and psychological torment, extreme heat could become the next imminent threat in the face of climate change.

Record-breaking heat has gripped the Northwest. In a region where air conditioning isn't the norm, it's wrought havoc, including reportedly inside at least one Amazon warehouse. The Seattle Times reported that workers at the

Featured Videos

Life Found Underneath Antarctica's Ice Shelves

Hear the Table Manners of Canada Lynx in Gruesome Detail

6/02/21 12:20PM

How to Make Sure You're Streaming in 4K

5/21/21 5:45PM

G/O Media may get a commission

Amazon's Choice

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Herald-Tribune

[News] Sports Ticket Lifestyle Opinion USA TODAY Obituaries E-Edition Legals

SARASOTA

Sarasota County to start new cooling plant project on Ringling Boulevard

Timothy Fanning Sarasota Herald-Tribune

Published 12:50 p.m. ET Aug. 19, 2020 | Updated 1:46 p.m. ET Aug. 19, 2020

View Comments

Sarasota County will soon start construction of a new cooling plant at the intersection of School Avenue and Ringling Boulevard, adjacent to the Sarasota County Parking Garage. *PROVIDED BY SARASOTA COUNTY*

SARASOTA COUNTY - Sarasota County will soon start construction of a new $14.8 million cooling plant at School Avenue and Ringling Boulevard, adjacent to the Sarasota County Parking Garage.

Anticipated to be completed and operational in summer 2021, the new plant will replace the existing cooling plant, which is set to be decommissioned. The new plant will provide chilled water to the air conditioning systems that serve county campus buildings on Ringling Boulevard.

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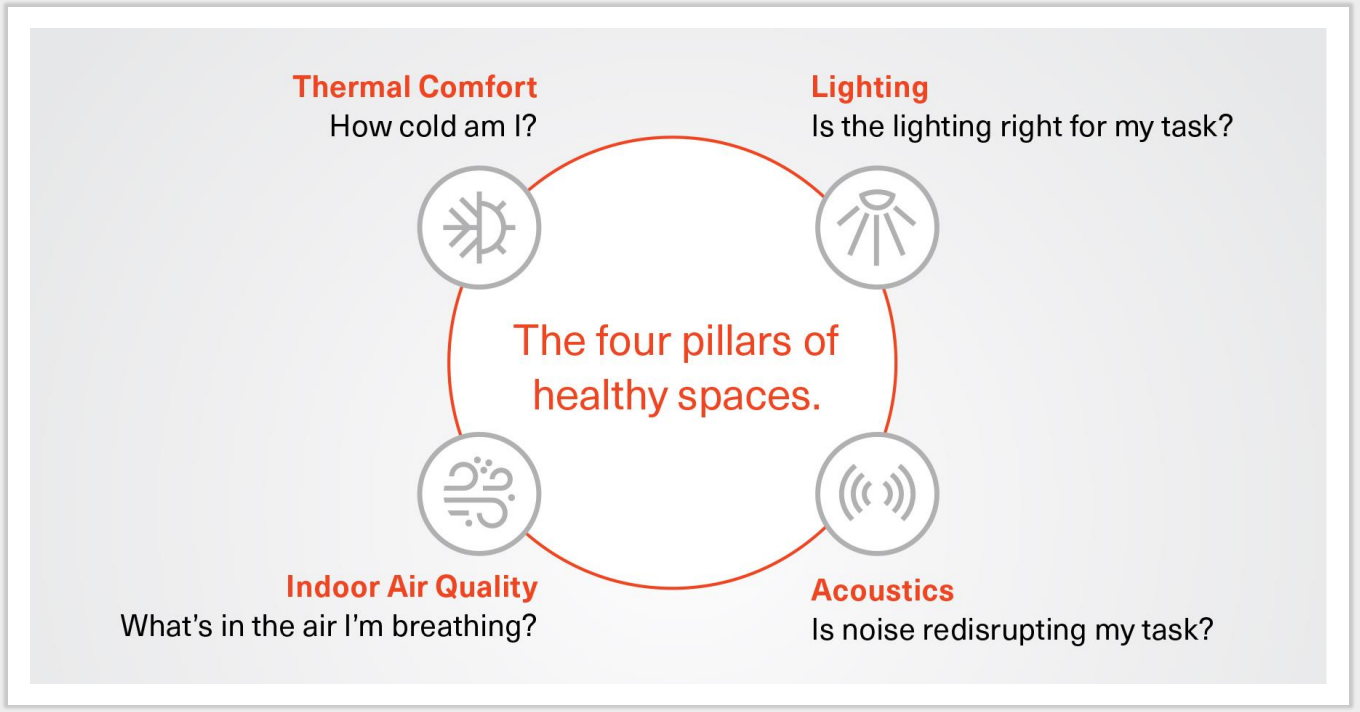
What is Indoor Environmental Quality (IEQ)?

Indoor Environmental Quality, Optimized

Addressing IEQ Holistically



Plus, balancing energy efficiency, sustainability and your business realities

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Putting Wellness First is the Future

Guiding your building to the right improvements for occupant wellness.

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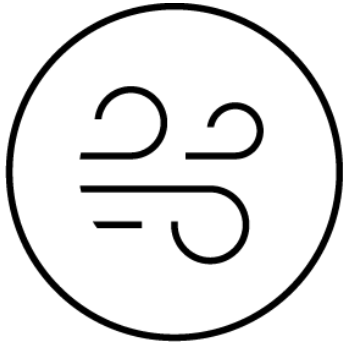
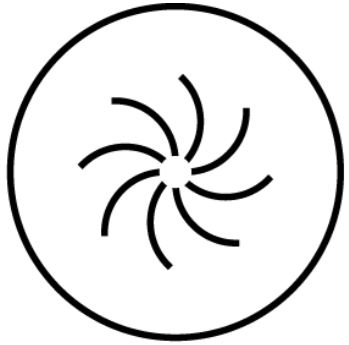
Addressing IAQ – Assess, Mitigate and Maintain

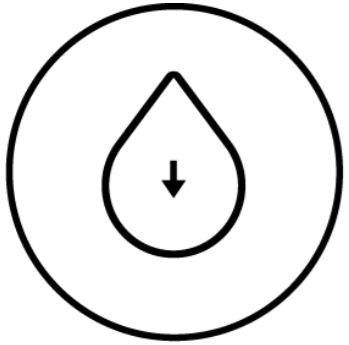
The Four Key Pillars of IAQ



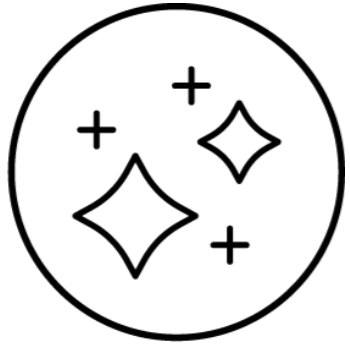
Dilute
Increase ventilation with outdoor air



Exhaust
Keep local exhausts running



Contain
Control indoor humidity



Clean
Safely use air cleaning technology as appropriate

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Air and Surface Cleaning Technology

Clean air technologies.

CDC and ASHRAE Recommendations

CDC – HVAC Related Recommendations

DILUTE

- **Make sure your ventilation systems are serviced and meeting code requirements** (defined by ASHRAE Standard 62.1)
- **Disable demand-controlled ventilation** (DCV)
- *Consider* increasing outdoor airflow, if possible, when outdoor conditions allow
- *Consider* implementing pre- and post-occupancy purge sequences to flush building with outdoor air

CONTAIN

- *Consider* installing humidity sensors, update control sequences, and possibly adding equipment to maintain indoor humidity in the desired range

EXHAUST

- **Ensure restroom exhaust is operating whenever building is occupied, and during pre- and post-occupancy purge**
- **Inspect exhaust systems and minimize re-entry of contaminated exhaust air**

CLEAN

- **Upgrade filters to MERV-13** (or higher, if possible) **and ensure effective air seals**
- If not possible to upgrade HVAC filters, *consider* portable room air cleaners, particularly in higher-risk areas
- *Consider* retrofitting air-handling equipment (or occupied space) with a suitable air cleaning device (e.g., UVGI, ionization, dry hydrogen peroxide)
- *When possible*, increase total airflow supplied to space so recirculated air passes through the filter or air cleaner more frequently (for simple thermostats, switch fan control from “AUTO” to “ON” to enable continuous airflow)

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Ventilation in Buildings, CDC, updated 23 March 2021
Ventilation in School and Childcare Programs, CDC, updated 26 February 2021

IAQ-Related Recommendations (Version 2.0) - CDC

DILUTE

1. **Make sure your ventilation systems are serviced and meeting code requirements** (defined by ASHRAE Standard 62.1)
2. **Disable demand-controlled ventilation** (DCV)
3. *Consider* increasing outdoor airflow, if possible, when outdoor conditions allow
4. *Consider* implementing pre- and post-occupancy purge sequences to flush building with outdoor air

CONTAIN

- *Consider* installing humidity sensors, update control sequences, and possibly adding equipment to maintain indoor humidity in the desired range

https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html

Ensure Heating, Ventilation, and Air Conditioning (HVAC) settings are maximizing ventilation.

children separated by 6 feet as much as possible. Help children 2 years and older wear masks whenever possible. Children under age 2 should not wear masks.

1. **Make sure your ventilation systems are serviced and meeting code requirements.** They should provide acceptable indoor air quality, as defined by ASHRAE Standard 62.1 , for the current occupancy level for each space.* Home-based childcare programs should meet requirements established by their state and local regulatory authorities.
3. **Set HVAC systems to bring in as much outdoor air as your system will safely allow.** Reduce or eliminate HVAC air recirculation, when practical and with expert HVAC consultation.*
   - **Increase the HVAC system's total airflow supply to occupied spaces** when you can. More air flow encourages air mixing and ensures any recirculated air passes through the filter more frequently.
2. **Disable demand-controlled ventilation (DCV) controls** that reduce air supply based on occupancy or temperature. This way the air supply will remain constant throughout the day.
   - **For simple HVAC systems controlled by a thermostat,** setting the fan control switch from "Auto" to "On" will ensure the HVAC system provides continuous air filtration and distribution.
4. **Consider running the HVAC system at maximum outside airflow for 2 hours before and after the building is occupied** to refresh air before arrival and remove remaining particles at the end of the day.

Filter and/or [illegible] childcare program

- *When possible*, increase total airflow supplied to space so recirculated air passes through the filter or air cleaner more frequently (for simple thermostats, switch fan control from "AUTO" to "ON" to enable continuous airflow)

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IAQ-Related Recommendations (Version 2.0) - CDC

EXHAUST

5. **Ensure restroom exhaust is operating whenever building is occupied, and during pre- and post-occupancy purge**
6. **Inspect exhaust systems and minimize re-entry of contaminated exhaust air**

https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html

Use exhaust fans in restrooms and kitchens.

6. **Inspect and maintain exhaust ventilation systems** in restrooms and kitchens.
5. **Ensure restroom and kitchen exhaust fans** are on and operating at full capacity while the school or childcare program is occupied and for 2 hours afterward.

Ventilation in Buildings, CDC, updated 23 March 2021

Ventilation in School and Childcare Programs, CDC, updated 26 February 2021

IAQ-Related Recommendations (Version 2.0) - CDC

DILUTE

- **Make sure your ventilation systems are serviced and meeting code requirements** (defined by ASHRAE Standard 62.1)
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CONTAIN

7 • *Consider* installing humidity sensors, update control sequences, and possibly adding equipment to maintain indoor humidity in the desired range

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

7 Should indoor temperature and humidity be used to help reduce the risk of COVID-19 transmission?

For COVID-19, the first steps in reducing the indoor concentrations of the virus are wearing face masks, physical distancing, and reducing occupancy levels. Improved ventilation is an additional prevention strategy. For ventilation systems, increasing outdoor air above the code minimum requirements, increasing total ventilation, and increasing filtration efficiencies are more effective at controlling infectious disease transmission than controlling indoor temperature and humidity. However, the use of temperature and/or humidity to reduce the risk of disease transmission should be considered on a case-by-case basis, taking into account the building enclosure, heating, ventilation, and air-conditioning (HVAC) system capabilities, level of control and/or building automation, local COVID-19 transmission rates, any unique clinical features of the occupants, and local climate.

Both temperature and humidity can influence the transmission of infectious diseases, including COVID-19, but that influence has practical limitations. Research on the impact of temperature has shown that SARS-CoV-2, the virus that causes COVID-19, is sensitive to elevated temperatures, with over 99.99% inactivation in only a few minutes at 70°C (158°F). However, this temperature is far outside the limits of human comfort and could damage some building materials. While temperatures lower than 70°C (158°F) are also effective, the required exposure time for inactivation increases as the temperature decreases. So, elevated temperatures offer the potential for decontamination of SARS-CoV-2 virus in the air or on surfaces, but the use of increased temperature solely for decontamination is not generally recommended and is not realistic for occupied spaces. Another important consideration is that when the temperature in a space is elevated, the corresponding relative humidity level decreases.

Current evidence is not persuasive that humidity significantly reduces transmission of SARS-CoV-2 beyond the level resulting from good ventilation and filtration. Some research studies have shown that the survival of viruses, including human coronaviruses, may be reduced when the relative humidity is in the 40–60% range. However, the reductions are modest and there are outliers to these findings. Consequently, neither ASHRAE nor CDC recommends introducing humidification for the sole purpose of limiting transmission of COVID-19. While not affecting transmission, there are peer-reviewed studies that suggest preventing excessive dryness in the air could help maintain the effectiveness of the human body's immune system.

Some HVAC systems can actively control both temperature and humidity. However, the majority of HVAC systems do not have dedicated humidification capabilities. Some dehumidification happens during warmer months as a byproduct of cooling humid warm air below its dew point and causing water to condense out of the air. Less common is the ability to limit low humidity by introducing water vapor into the dry supply air.

Most existing residential and commercial buildings located in cold climates are not constructed to resist the corrosion and excessive moisture accumulation that can result from long-term, whole-building humidification. If additional winter humidification is used to maintain comfort and prevent excessive dryness of nasal and ocular membranes, first analyze the building enclosure to verify that condensation and moisture accumulation will not become a problem. ASHRAE Standard 160 (Criteria for Moisture-Control Design Analysis in Buildings) provides guidance for hygrothermal analysis of building enclosures. For commercial buildings that are properly constructed to allow for long-term humidification, and which have humidification capabilities already installed, there is no reason not to humidify the air to comfortable levels during the winter months.

In residential settings, portable in-room humidifiers may be used for sensory comfort and to reduce excessively low relative humidity levels. In these instances, use a humidifier with a built-in humidistat and control the relative humidity level near 40%. Higher humidity levels are not necessarily better and may lead to localized mold growth, mildew, and other long-lasting indoor air quality issues. Maintenance and cleaning of portable humidification systems is very important. Change the water in the humidifier daily and maintain and clean the humidifier in

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Ventilation in School and Childcare Programs, CDC, updated 26 February 2021

IAQ-Related Recommendations (Version 2.0) - CDC

https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html

Filter and/or clean the air in your school or childcare program.

- 8 • **Improve the level of air filtration as much as possible** without significantly reducing airflow.
- 8 • **Make sure the filters are sized, installed, and replaced according to manufacturer's instructions.**
- 9 • **Consider portable air cleaners that use high-efficiency particulate air (HEPA) filters** to enhance air cleaning wherever possible, especially in higher-risk areas such as a nurse's office or sick/isolation room.
- 10 • **Consider using ultraviolet germicidal irradiation (UVGI)** in schools and non-home-based childcare programs as a supplemental treatment to inactivate the virus that causes COVID-19, especially if options for increasing ventilation and filtration are limited. Consult a qualified professional to help design and install any UVGI system.

Ensure Heating, Ventilation, and Air Conditioning (HVAC) settings are maximizing ventilation.

children separated by 6 feet as much as possible. Help children 2 years and older wear masks whenever possible. Children under age

- 11 • **Increase the HVAC system's total airflow supply to occupied spaces** when you can. More air flow encourages air mixing and ensures any recirculated air passes through the filter more frequently.
- 11 • **For simple HVAC systems controlled by a thermostat,** setting the fan control switch from "Auto" to "On" will ensure the HVAC system provides continuous air filtration and distribution.

Filter and/or clean the air in your school or childcare program

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

10 Many new air disinfection devices are marketed for their ability to inactivate SARS-CoV-2. How can I tell if they work as advertised?

CDC does not provide recommendations for, or against, any manufacturer or product. There are numerous technologies being heavily marketed to provide air cleaning during the ongoing COVID-19 pandemic. Common among these are ionization, dry hydrogen peroxide, and chemical fogging disinfection. Some products on the market include combinations of these technologies. These products generate ions, reactive oxidative species (ROS, which are marketed using many names), or chemicals into the air as part of the air cleaning process. People in spaces treated by these products are also exposed to these ions, ROS, or chemicals.

While variations of these technologies have been around for decades, relative to other air cleaning or disinfection

CLEAN

- 8 • **Upgrade filters to MERV-13** (or higher, if possible) **and ensure effective air seals**
- 9 • If not possible to upgrade HVAC filters, *consider* portable room air cleaners, particularly in higher-risk areas
- 10 • *Consider* retrofitting air-handling equipment (or occupied space) with a suitable air cleaning device (e.g., UVGI, ionization, dry hydrogen peroxide)
- 11 • *When possible*, increase total airflow supplied to space so recirculated air passes through the filter or air cleaner more frequently (for simple thermostats, switch fan control from "AUTO" to "ON" to enable continuous airflow)

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IAQ Science & Solutions

Assess. Mitigate. Manage.

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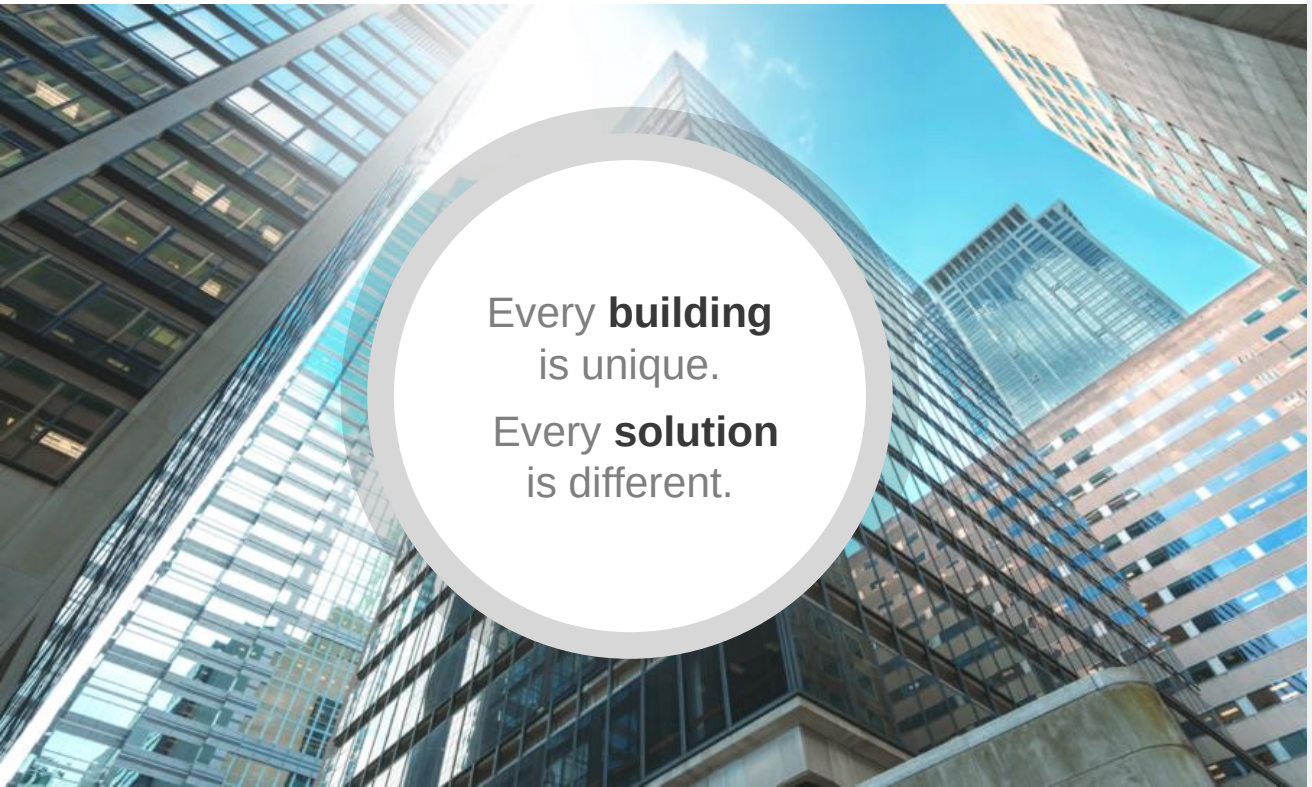
How to Make Air Your Ally

Taking a holistic view

A facilities interconnected systems and the interactions between those systems result in an occupant experience that is influenced by IEQ.



ASSESS

- Analyzing current state/determining needs
- Projecting the future of the space

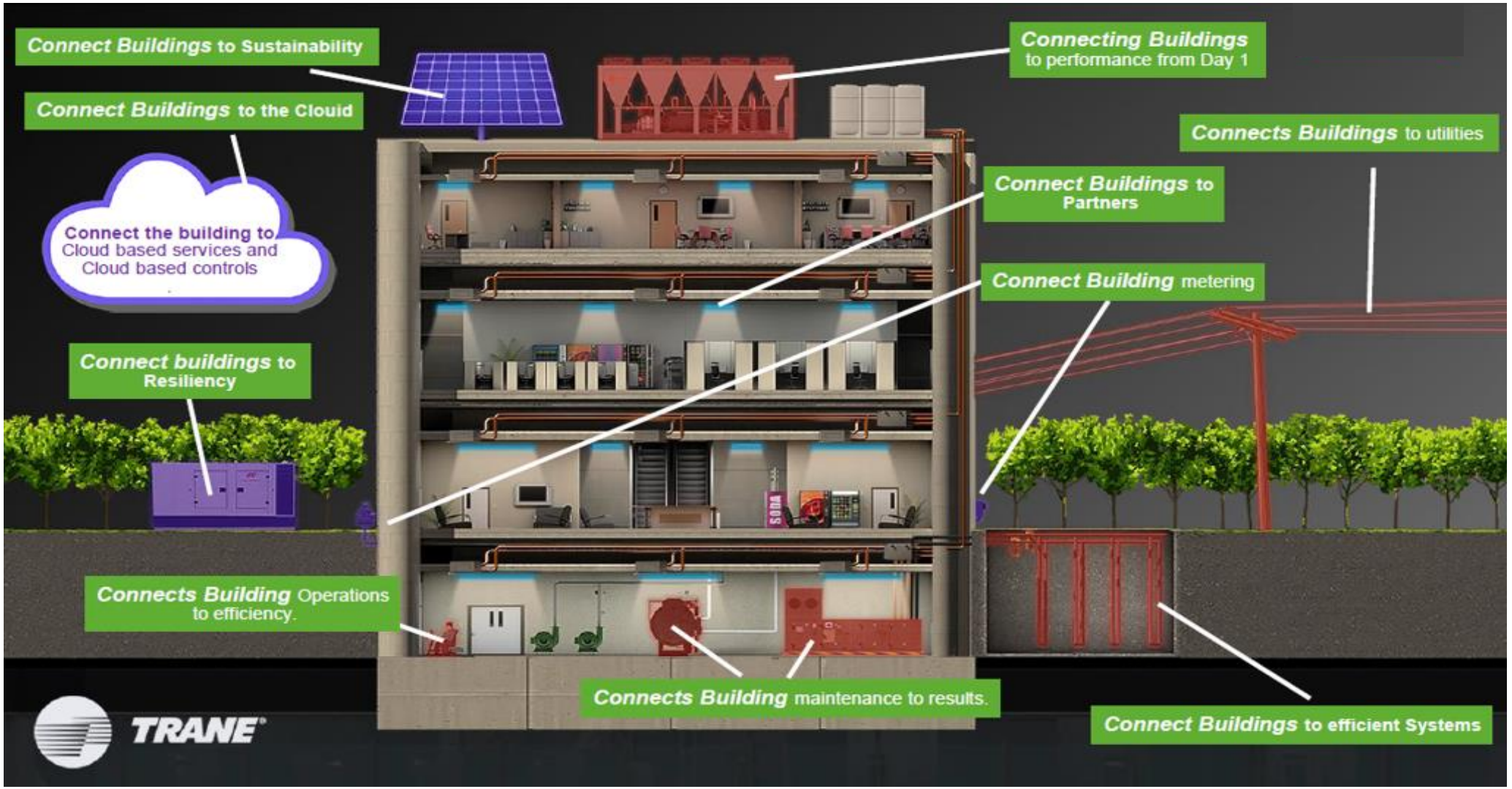
MITIGATE

- Developing occupant-centric strategies
- Implementing the solutions
- Improving energy efficiency and sustainability

MANAGE

- Ongoing optimization
- Continuous managing and monitoring

Holistic Approach to Understanding Your Environment



Assess Pillar

Maintaining Trust In Your Facility Begins Here
IAQ Assessment: Establish a Baseline. Make a Plan.

Indoor Air Quality Assessment

- Fact based, data-driven analysis of your building's indoor air quality
- Aligned to latest industry guidelines for operating HVAC systems
- Recommend ways to improve IAQ today
- Highlight opportunities for future upgrades

Why an IAQ Assessment?

Confidence
Staff and patients want to know that their concerns are being addressed

Resilience
Today it's a global pandemic; what's next? IAQ will be an ongoing focus for hospitals

Sustainability
Ensure clean indoor air efforts are in tune with community values

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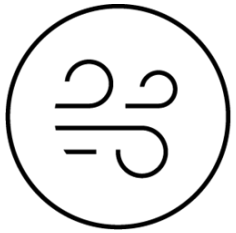
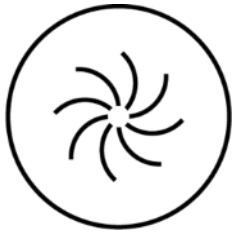
Mitigate Pillar

The Four Key Pillars of IAQ



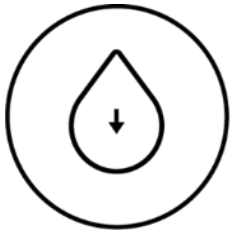
Dilute

Making sure plenty of fresh outdoor air dilutes the buildup of indoor contaminants through proper ventilation



Exhaust

Getting exhaust air out is equally important, especially air from kitchens, restrooms, and combustion systems



Contain

Keeping indoor humidity levels within the ASHRAE®-recommended range maximizes occupant comfort and reduces the risk of microbial growth

Clean

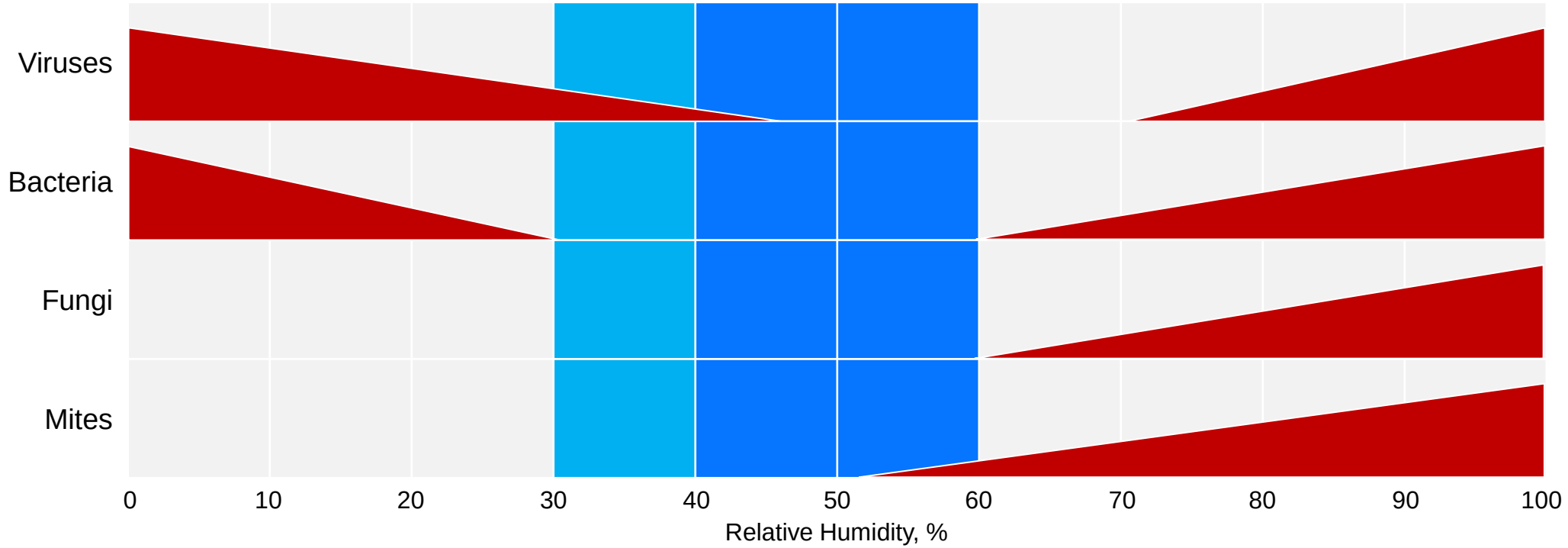
Reducing particles, odors, or micro-organisms (such as mold, bacteria, and certain viruses)

Dilute – Increase Outdoor Air to Dilute Indoor Contaminants

- Disable demand-controlled ventilation (DCV)
- Raise minimum outdoor-air damper (or airflow) setpoints
- Operate mixed-air air-handling units with 100% outdoor air (no recirculation), when outdoor conditions allow
- Install additional cooling and/or heating capacity (or a Horizon® packaged dedicated outdoor air unit), if needed to enable 100% outdoor air
- Keep ventilation system operating 24/7, even if at lower airflows
- Implement a pre-occupancy purge sequence to flush the building with outdoor air
- Align with changes in ANSI/ASHRAE/ASHE Standard 170/62.1 Guidelines (Ventilation)

Contain: Humidity Control – Helps Reduce Viral Load and Lessen Impact

Viruses are typically less stable between RH of 40-60%



Information from 2016 ASHRAE® Handbook, HVAC Systems and Equipment

Air Cleaning Technologies

Best	HEPA Filters	Trane Catalytic Air Cleaning System (TCACS)	Synexis® Dry Hydrogen Peroxide (DHP)
Better	MERV 9-16 Filters	UVGI	
Good	MERV 1-8 Filters	***Technologies vary in their efficacy to reduce micro-biologicals***	

Healthcare and DHP

Mitigate

ELSEVIER

American Journal of Infection Control

journal homepage: www.ajicjournal.org

AJIC American Journal of Infection Control

Major article

Evaluation of dry hydrogen peroxide in reducing microbial bioburden in a healthcare facility

Jennifer Sanguinet DrPh, FAPIC, CIC, MBA-HCM, BSIS [a,*], Charles Edmiston PhD, FAPIC, CIC, SM (ASCP) [b]

[a] *Director of Infection Prevention and Control, Sunrise Hospital and Medical Center, Las Vegas, NV*
[b] *Emeritus Professor of Surgery, Medical College of Wisconsin, Wauwatosa, WI*

Key Words:
Environmental contamination
Dry hydrogen peroxide
Automated decontamination
Continuous microbial reduction

Background: Standard manual cleaning and disinfection practices are often inadequate. Persistent contamination in the environment poses an infection risk that may be mitigated by no-touch disinfection systems. This study evaluates the efficacy of dry hydrogen peroxide (DHP) on microbial air and surface contamination as an adjunct to routine cleaning and disinfection in a large urban hospital.
Methods: Surface samples were collected in five different hospital units, two pediatric and three adult, after manual cleaning on multiple days before and after DHP implementation. Air samples were also collected in each unit pre- and post-DHP use. Data outcomes were reported as colony forming units (CFU) with species identification.
Results: The overall mean surface microbial burden was reduced by 96.5 percent for all units post-DHP compared to baseline ($P < 0.001$), with the greatest reductions achieved on privacy curtains (99.5 %). Mean microbial air sample counts were also reduced post-DHP compared to pre-DHP.
Conclusions: This study demonstrates that DHP was effective in reducing both air and surface microbial contamination in a variety of settings within a large, tertiary care hospital.

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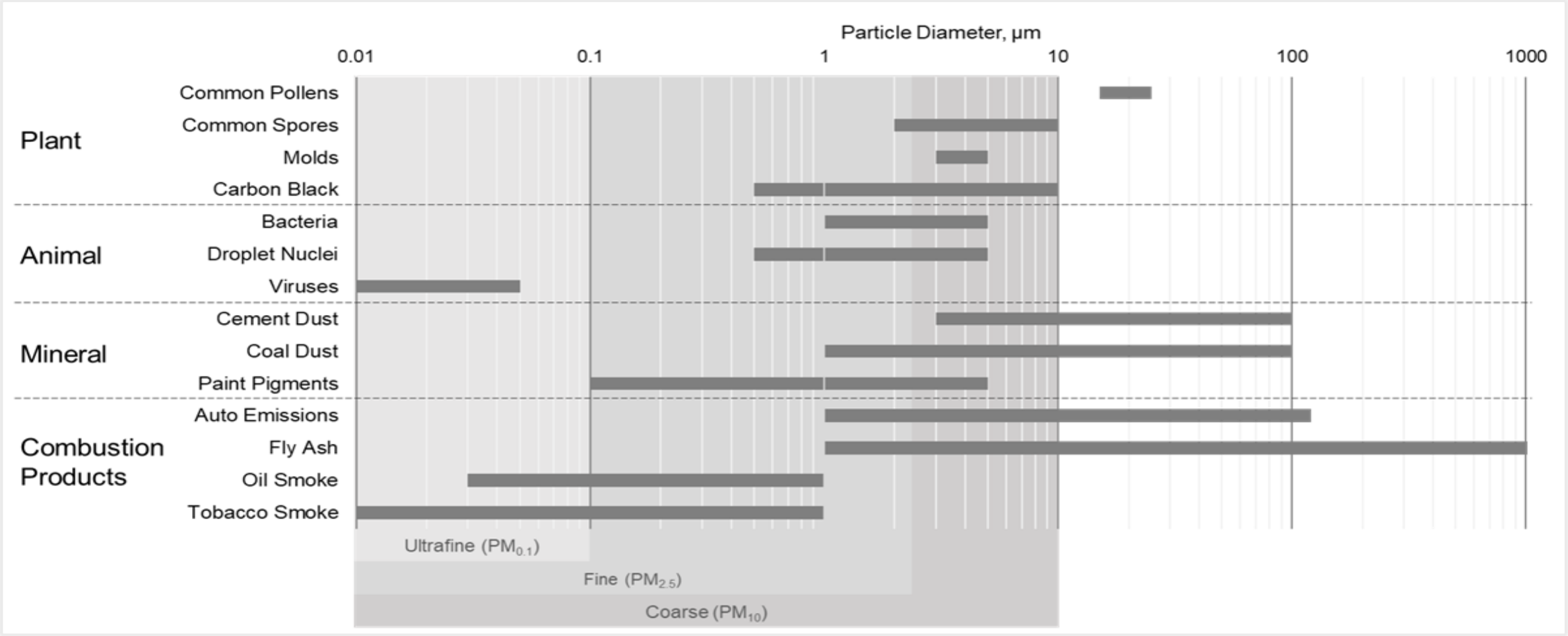
Filtration Options

How Large is the Pathogen? Typical Particle Sizes



Source: 2017 ASHRAE Handbook of Fundamentals, Chapter 11

Application Guidelines for Various Filter Types

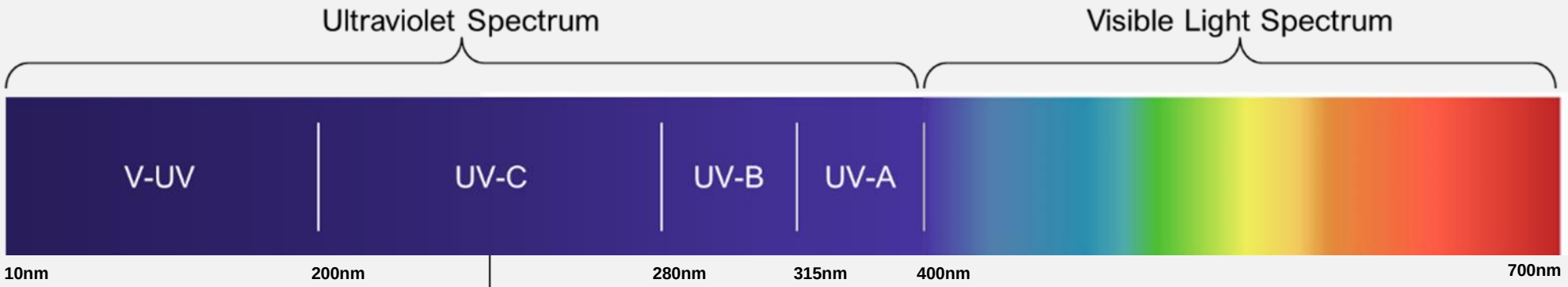
Table 3. Applications guidelines for various filter types

Collection efficiency[1]	Dust-spot efficiency	Typical controlled contaminant	Typical applications and limitations	Typical air filter/cleaner type
IEST Type F (≥ 99.999% on 0.1 to 0.2 µm particles) IEST Type D (≥ 99.999% on 0.3 µm particles) IEST Type C (≥ 99.99% on 0.3 µm particles) IEST Type A (≥ 99.97% on 0.3 µm particles)	n/a n/a n/a n/a	≤ 0.30 µm particles • Virus (unattached) • Carbon dust • Sea salt • All combustion smoke • Radon progeny	• Cleanrooms • Radioactive materials • Pharmaceutical manufacturing • Carcinogenic materials • Orthopedic surgery	**HEPA/ULPA filters**
MERV 16 MERV 15 MERV 14 MERV 13	n/a >95% 90% to 95% 80% to 90%	0.3 to 1.0 µm particles • All bacteria • Most tobacco smoke • Droplet nuclei (sneeze) • Cooking oil • Most smoke • Insecticide dust • Copier toner • Most face powder • Most paint pigments	• Hospital inpatient care • General surgery • Smoking lounges • Superior commercial buildings	**Bag filters** Nonsupported (flexible) microfine fiberglass or synthetic media, 12 to 36 in. deep, 6 to 12 pockets **Box filters** Rigid style cartridge filters, 6 to 12 in. deep, may use lofted (air-laid) or paper (wet-laid) media
MERV 12 MERV 11 MERV 10 MERV 9	70% to 75% 60% to 65% 50% to 55% 40% to 45%	1.0 to 3.0 µm particles • Legionella • Humidifier dust • Lead dust • Milled flour • Coal dust • Auto emissions • Nebulizer drops • Welding fumes	• Superior residential buildings • Better commercial buildings • Hospital laboratories	**Bag filters** Nonsupported (flexible) microfine fiberglass or synthetic media, 12 to 36 in. deep, 6 to 12 pockets **Box filters** Rigid style cartridge filters, 6 to 12 in. deep, may use lofted (air-laid) or paper (wet-laid) media
MERV 8 MERV 7 MERV 6 MERV 5	30% to 35% 25% to 30% <20% <20%	3.0 to 10.0 µm particles • Mold • Spores • Hair spray • Fabric protector • Dusting aids • Cement dust • Pudding mix • Snuff • Powdered milk	• Commercial buildings • Better residential buildings • Industrial workplaces • Paint booth inlet air	**Pleated filters** Disposable, extended surface, 1 to 5 in. thick with cotton/polyester blend media, cardboard frame **Cartridge filters** Graded-density viscous-coated cube or pocket filters, synthetic media **Throwaway** Disposable, synthetic media panel filters

Ultraviolet Germicidal Irradiation (UVGI)

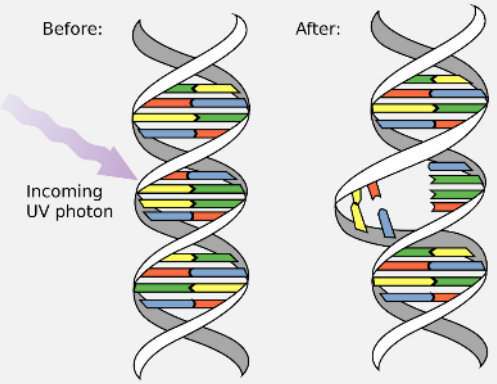
Ultraviolet Germicidal Irradiation (UVGI)

UVGI uses short wavelength ultraviolet light (UV-C) to inactivate microorganisms… destroys nucleic acids altering the structure of the RNA.



UVGI

- 254nm
- Up to 99.9% effective at inactivating microorganisms
- Known exposure risks (skin and eyes)
- Can degrade organic materials
  - *electrical insulation*
  - *elastomers and sealants*
  - *filter media*
  - *gaskets and pipe insulation*
  - *furnishings and finishes*



Source: https://commons.wikimedia.org/wiki/File:DNA_UV_mutation.svg

Ultraviolet Germicidal Irradiation (UVGI)

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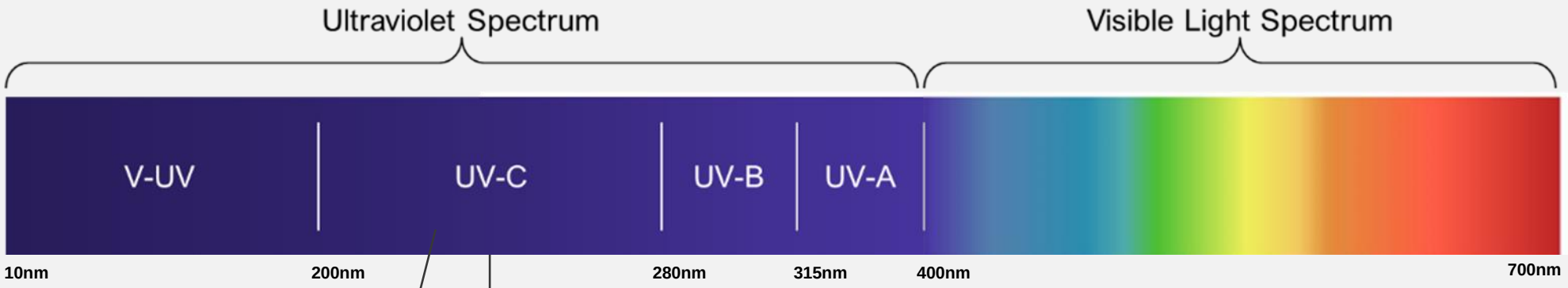

Far UV
- 222nm
- New technology
- Early tests indicate effective at inactivating microorganisms
- Unknown exposure risks

UVGI
- 254nm
- Up to99.9% effective at inactivating microorganisms
- Known exposure risks (skin and eyes)
- Can degrade organic materials
  - *electrical insulation*
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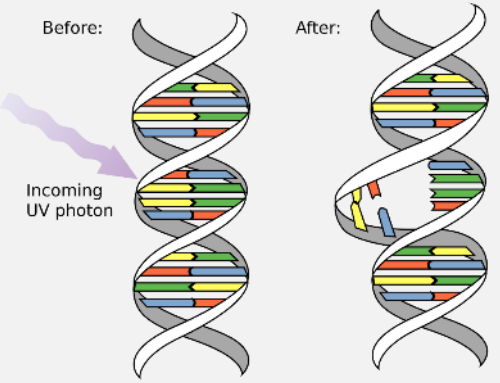
  - *gaskets and pipe insulation*
  - *furnishings and finishes*



Source: https://commons.wikimedia.org/wiki/File:DNA_UV_mutation.svg

How Does It Work?

UVGI efficacy is dependent on the UV dose… dosage required for inactivation varies by microorganism.

UV Dose = irradiance x time

Amount of light energy… irradiance decreases as you move further away from the light

Dwell time… how long the microorganism is exposed to the irradiance

Use URV ratings to determine UV intensity for pathogen kill rates

URV	Dose µJ/cm2	Influenza (virus variant)	Smalpox (virus variant)	Tuberculosis (gram-positive bacteria)
1	1	0	0	0
2	10	1	2	2
3	20	2	3	4
4	30	3	4	6
5	50	6	7	10
6	75	9	11	15
7	100	11	14	19
8	150	16	20	27
9	250	26	32	41
10	500	45	53	66
11	1,000	69	78	88
12	1,500	83	90	96
13	2,000	91	95	99
14	3,000	97	99	100
15	4,000	99	100	100
16	5,000	100	100	100
17	6,000	100	100	100
18	8,000	100	100	100
19	10,000	100	100	100
20	20,000	100	100	100

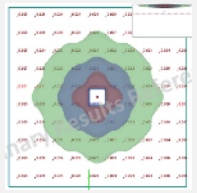
Ultraviolet Germicidal Irradiation (UVGI) Applications

In-duct surface disinfection light

In-duct air disinfection light

In-room surface disinfection light
(unoccupied space only)

Upper room disinfection light



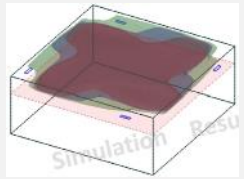


Image Source: Cooper Lighting

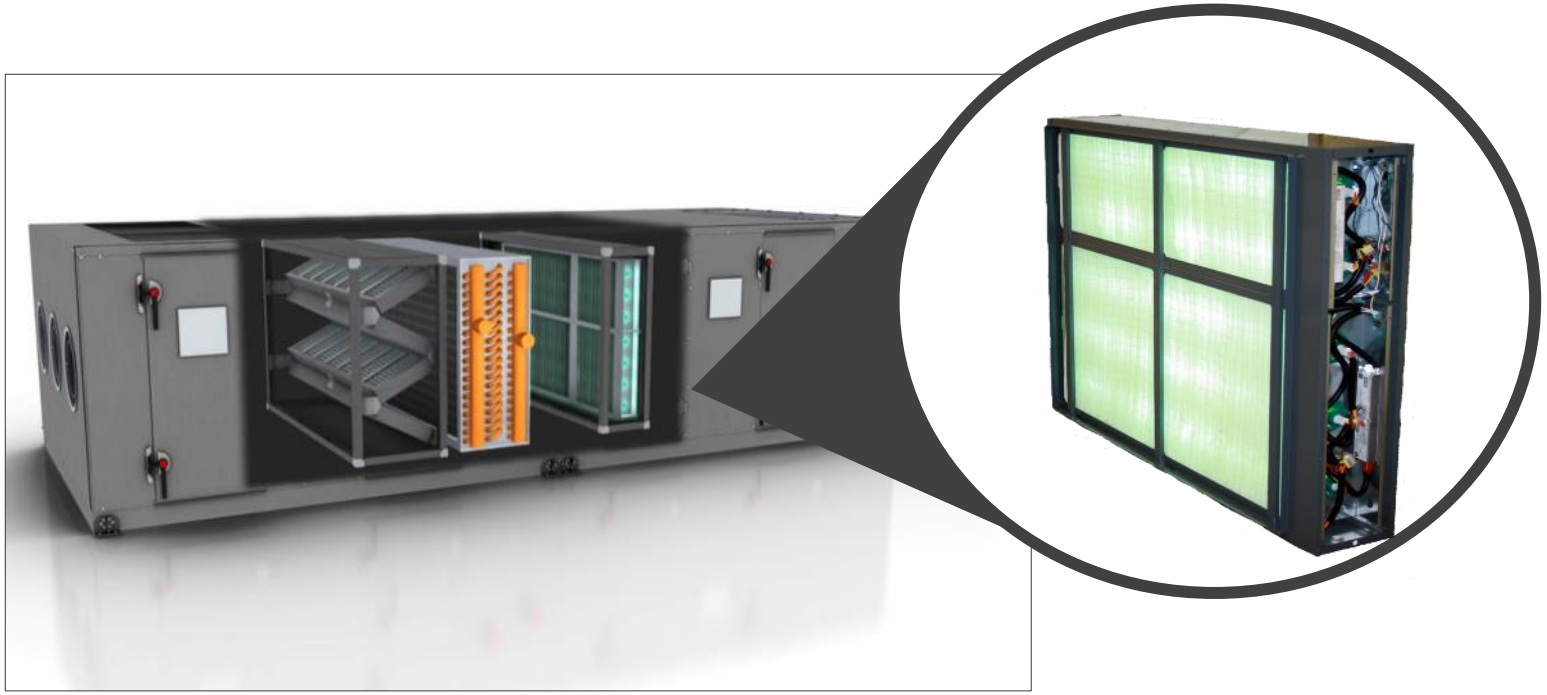
Ultraviolet Germicidal Irradiation (UVGI) Summary

- UVGI is a well-established technology with demonstrated effectiveness against many pathogens
- Recommended by ASHRAE in Re-opening Guidance dated 2-1-2021 and CDC guidelines 2-26-2021
  (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf)
  https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html
- 254 nanometer UVGI is the predominant wavelength with its high effectiveness
- UVGI can be applied to airstreams and coil surfaces in HVAC systems and to air and surfaces in spaces
- Precaution should be taken to limit human exposure and materials exposure (door switch required)

Photocatalytic Oxidation

What is TCACS?

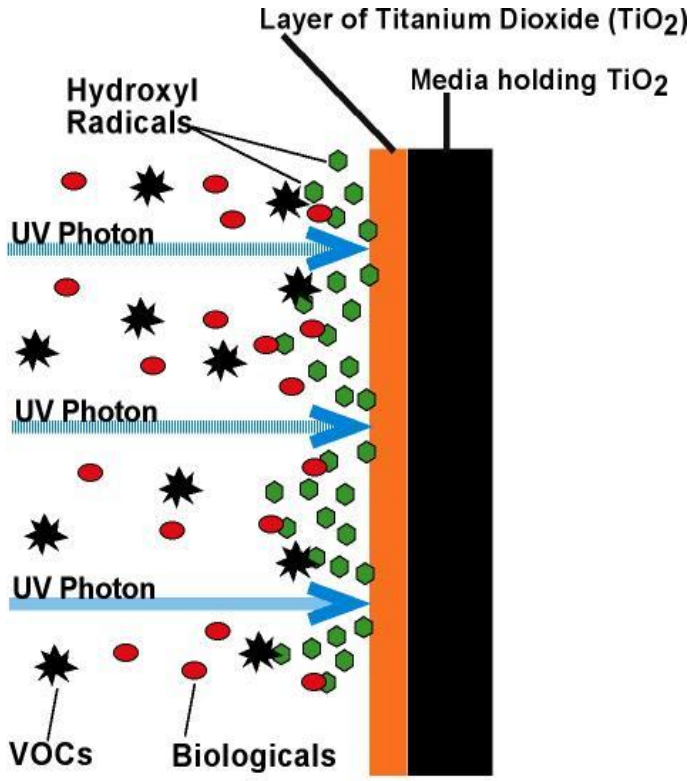
- The Trane Catalytic Air Cleaning System is an enhanced air filter containing 3 technologies: filtration, ultraviolet germicidal irradiation, and a photocatalytic oxidation (PCO) process
- TCACS can be installed in AHU, RTU, or duct mounted downstream of the coil



How Does TCACs Work?

- **UVGI:** UV radiation penetrates microorganisms and damages nucleic acids altering the structure of the RNA/DNA

- **Photocatalytic Oxidation (PCO):** UV photons react with a TiO_2 catalyst to create hydroxyl radicals (short-lived, powerful oxidizing agent)
  - UV light creates photons, a form of light energy
  - Photons are “catalyzed” by the TiO_2 forming hydroxyl radicals
  - Radicals last a fraction of a second and react with carbon-based compounds
  - Organic compounds (anything with a carbon atom) can be reduced to CO_2 and H_2O



Source: Genesis Aire

Dry Hydrogen Peroxide (DHP™)

What is DHP®?

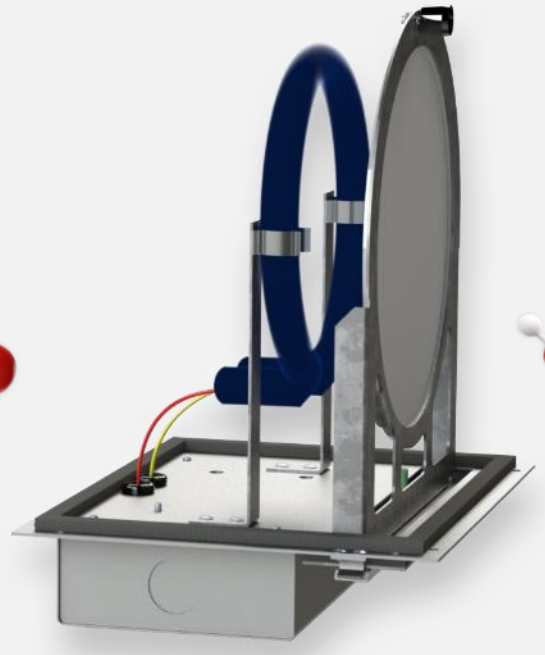
DHP is technology that creates gas phase hydrogen peroxide for use in occupied spaces. Synexis DHP is a continuous application that consistently inactivates microbes anywhere the treated air goes within a facility.

- DHP is made from the ambient humidity and oxygen already present in the space
- Visible solution in the room—helping customers gain additional confidence about improvements made in space

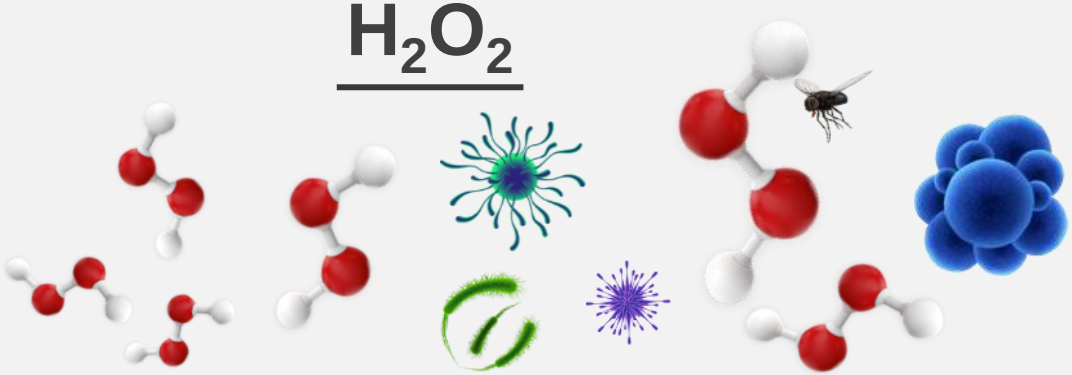
How Does Dry Hydrogen Peroxide Work?

DHP is produced at 5-25 parts per billion, which is millions of times less than vaporized hydrogen peroxide and is within acceptable safety thresholds for continuous use in occupied environments.

$H_2O + O_2$



H_2O_2

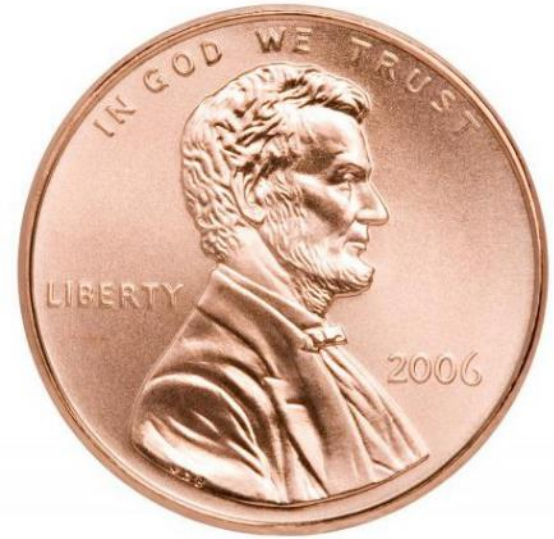


Molecules of H_2O_2		
Aqueous Vapor Droplets	**OSHA Limit TWA**	**Synexis**
150,000 – 750,000 ppb	1,000 ppb	5 – 25 ppb

Image source: Synexis

Dry Hydrogen Peroxide Efficacy

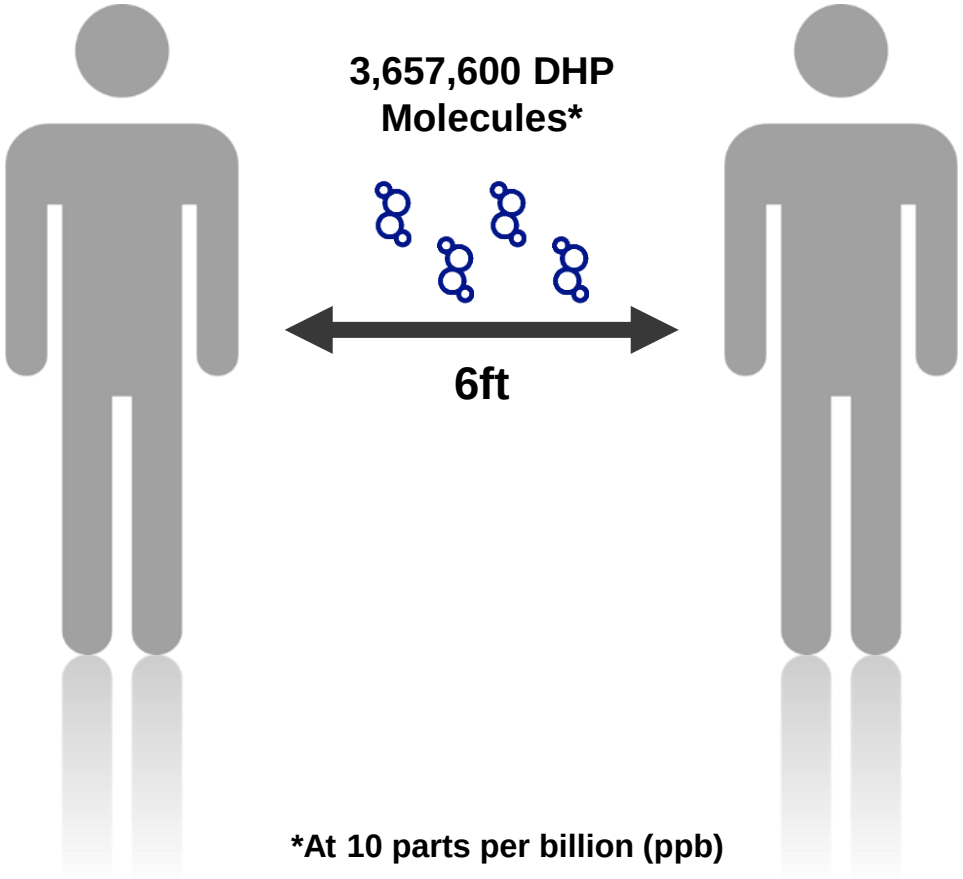
Width of a Penny



0.75 in

38,100 DHP Molecules*

Social Distancing



3,657,600 DHP Molecules*

6ft

*At 10 parts per billion (ppb)

TRANE

Third Party Lab Data

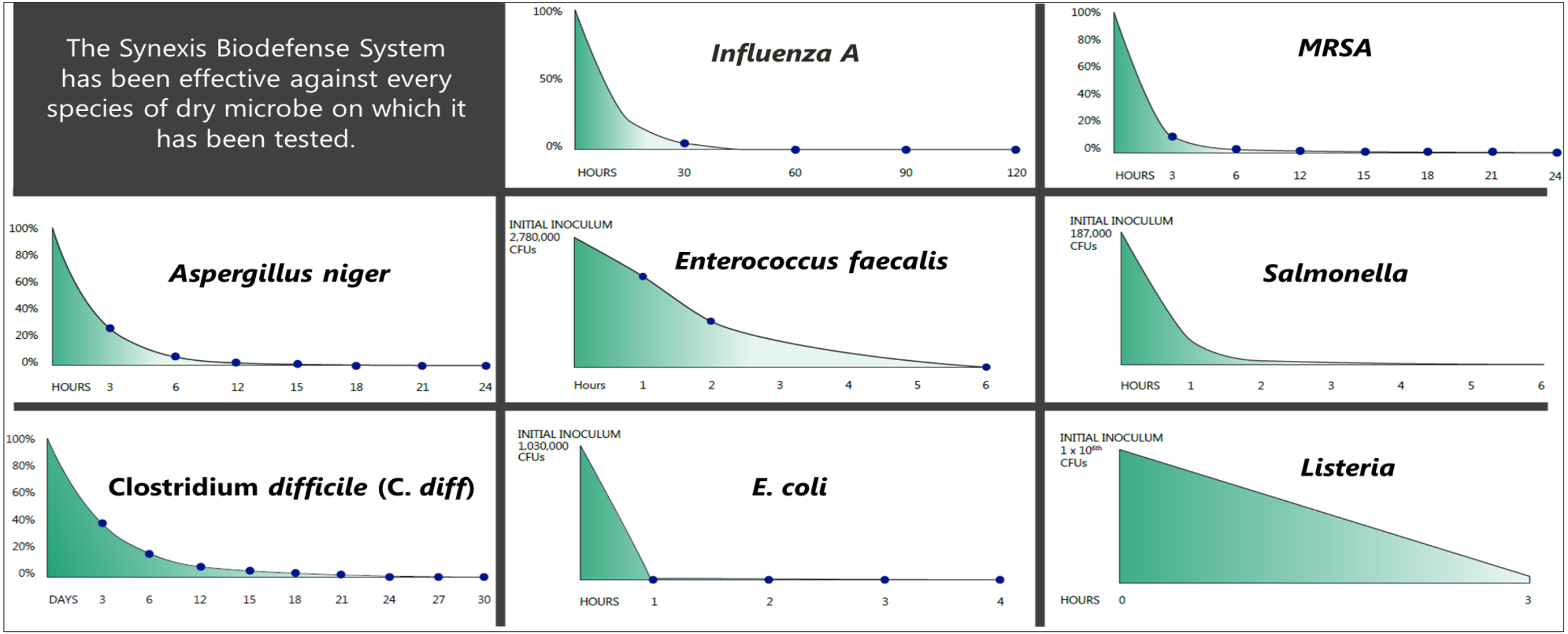


Image source: Synexis

Dry Hydrogen Peroxide Considerations

- Has been shown to effectively inactivate many viruses (including other coronaviruses) within the air stream and inside the space
- Introduces gas phase hydrogen peroxide directly to the space to provide active reaction in the zone (air does NOT need to return to air unit to be treated)
- Actively treats air, surfaces, fungi and VOCs
- Requires consultative approach when evaluating value proposition
  - Only duct mounted technology that demonstrated surface efficacy in Trane third-party testing
  - Does not require additional sections in the existing equipment
  - Low power requirements
  - Negligible air pressure drop prevents need to modify existing fans or rebalance the units
  - In-room units are “plug and play”… no system modifications/redesign

Technology Comparison

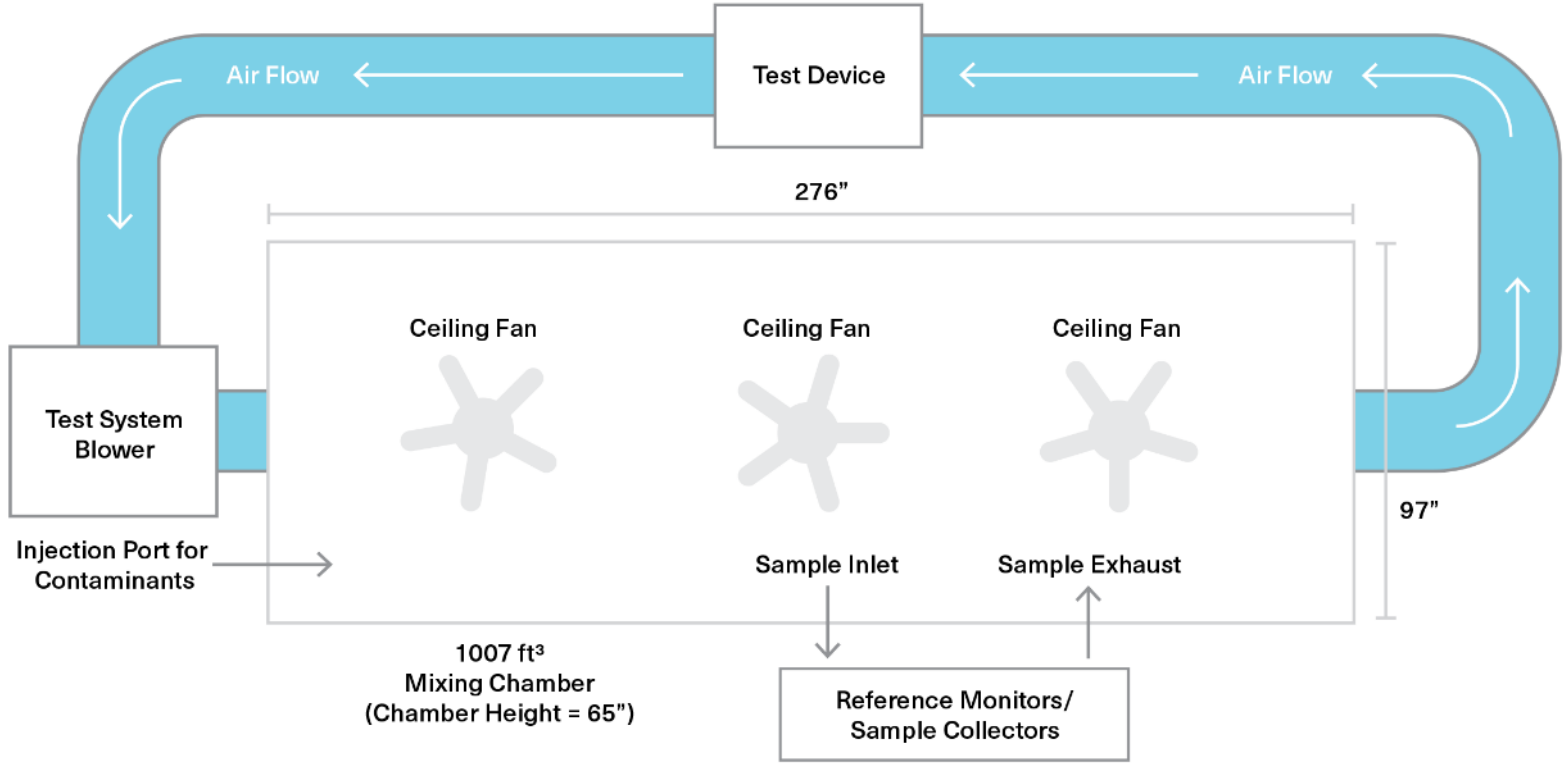
Cleaning Technology Efficacy

- In order to better understand and describe our IAQ Cleaning Technology portfolio, testing was conducted at a third-party lab to understand the efficacy of the individual technologies

- Technologies were examined for two scenarios which define potential customer scenarios
  - In-duct – In-equipment capability and/or in-duct
  - In-room – Devices located within the room – standalone

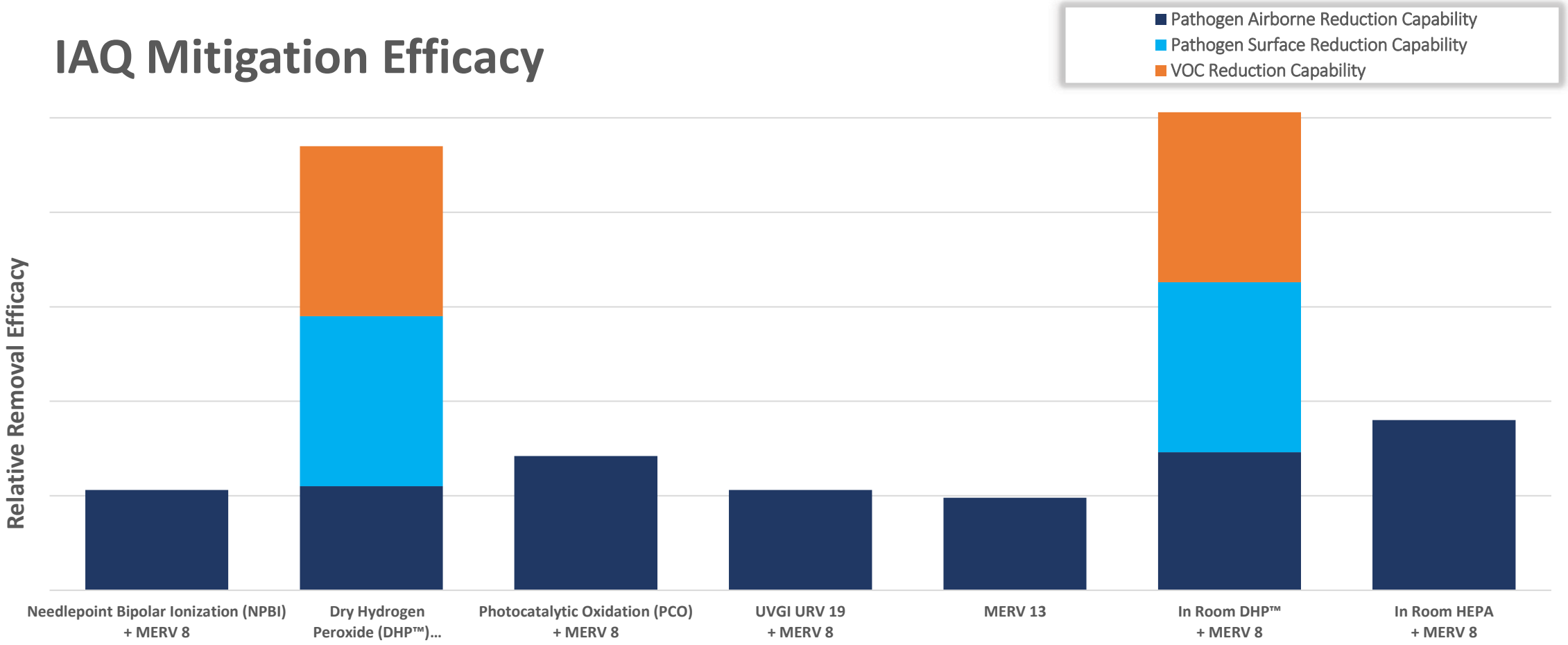
- Consistent testing methodology to compare technologies against each other and provide the first industry-wide testing of IAQ cleaning devices
  - Virus reduction capability – aerosolized and surface test with MS2 virus
  - Bacteria reduction capability – aerosolized only with Staphylococcus aureus
  - VOC reduction capability – Formaldehyde and toluene
  - Byproduct generation – ozone, ions, etc.
  - Particle reduction capability – both small (15-650 nm) and very small (< 100 nm)

Testing Chamber – In-Room and In-Duct



- For both In-Room and In-Duct tests a nebulizer was used to inject aerosolized MS2 virus into the room
- For In-Room testing the devices were tested with airflow and without airflow
- For In-Duct testing we conducted testing at 6 ACH and 20 ACH
- For surface pathogen inactivation testing, petri dishes were used in the room

IAQ Cleaning Technology Comparison: Airborne & Surface Pathogens, VOCs



Manage Pillar

How Do You See What You Can’t See

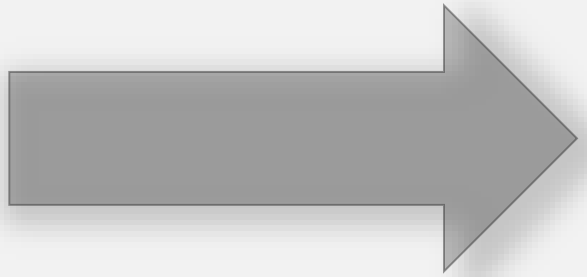
- How do you make people feel comfortable and confident in your space
- How do you know the efforts are working
- How do you share results with people

Better measure, manage and communicate indoor air quality

You Can't Manage What You Can't Measure
Using innovative solutions to meet growing consumer needs

Traditional Focus

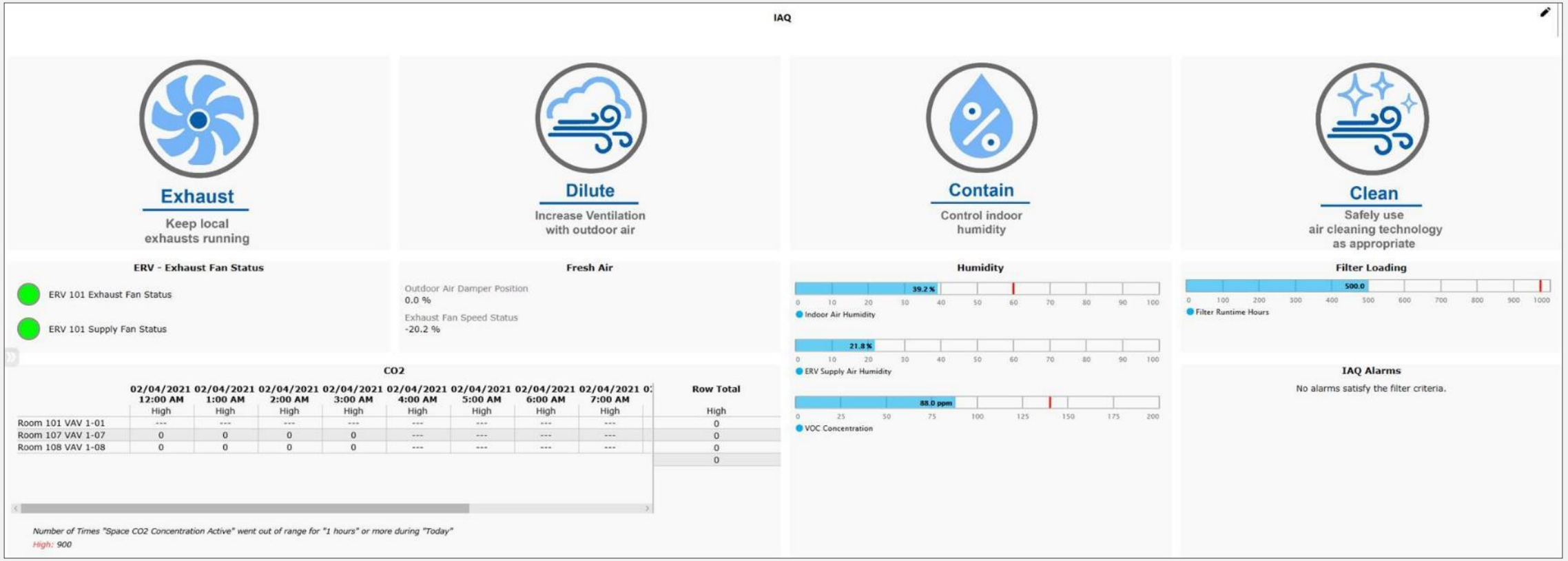
- Temperature
- Humidity
- CO_2
- Efficiency



Growing needs

- Temperature
- Humidity
- CO_2
- Efficiency
- Chemicals (VOCs)
- Fine Dust (PM2.5)
- Ambient Light (Lux)
- Ambient Noise (dBA)

Dashboards


IAQ
Exhaust
Keep local exhausts running
Dilute
Increase Ventilation with outdoor air
Contain
Control indoor humidity
Clean
Safely use air cleaning technology as appropriate
ERV - Exhaust Fan Status
ERV 101 Exhaust Fan Status
ERV 101 Supply Fan Status
Fresh Air
Outdoor Air Damper Position
0.0 %
Exhaust Fan Speed Status
-20.2 %
Humidity
39.2 %
Indoor Air Humidity
21.8 %
ERV Supply Air Humidity
88.0 ppm
VOC Concentration
Filter Loading
500.0
Filter Runtime Hours
IAQ Alarms
No alarms satisfy the filter criteria.
CO2
02/04/2021 12:00 AM
02/04/2021 1:00 AM
02/04/2021 2:00 AM
02/04/2021 3:00 AM
02/04/2021 4:00 AM
02/04/2021 5:00 AM
02/04/2021 6:00 AM
02/04/2021 7:00 AM
Row Total
Room 101 VAV 1-01
Room 107 VAV 1-07
Room 108 VAV 1-08
Number of Times "Space CO2 Concentration Active" went out of range for "1 hours" or more during "Today"
High: 900

IAQ Management: Solution Gaps

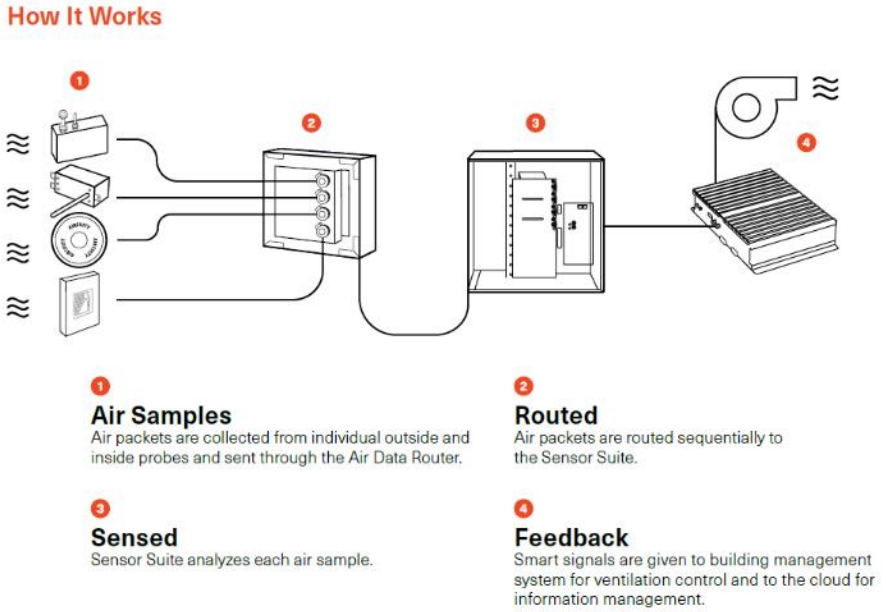
Traditional comfort space sensing technologies do not tell the whole story.

Traditional HVAC demand controlled ventilation sequences are designed to minimize ventilation (dilution) based on carbon dioxide.

We Can’t Manage What We Aren’t Measuring

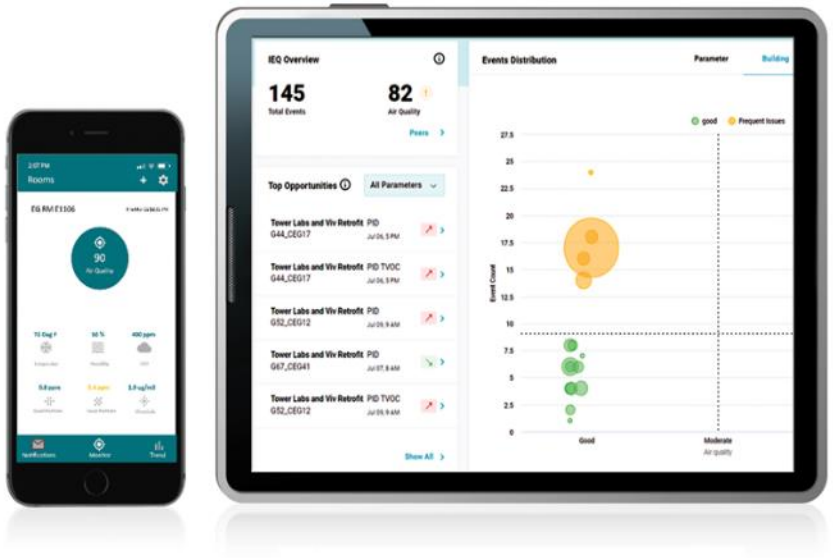
Smart Controls - IAQ

- **Accurate measurement** of science-based healthy building parameters with differential sensing architecture, industrial grade sensors and calibration program
- Demand control ventilation to **improve IAQ and optimize efficiency**
- Provide cloud-based communication of air quality



Smart Controls - IAQ Dashboards

- Gain actionable insight into IEQ events, energy savings and improvement opportunities
- Analyze entire building for IEQ requirements of your Environmental Health & Safety (EH&S) policy
- Engage stakeholders with visual demonstration of results
- Meet measuring performance requirements set by WELL, RESET or your own team



Visualize IAQ performance & energy savings
Build confidence for the people in your building

TRANE

Questions?

Thank You!

TRANE®

TRANE TECHNOLOGIES™