Session #5:

UV-C Technology

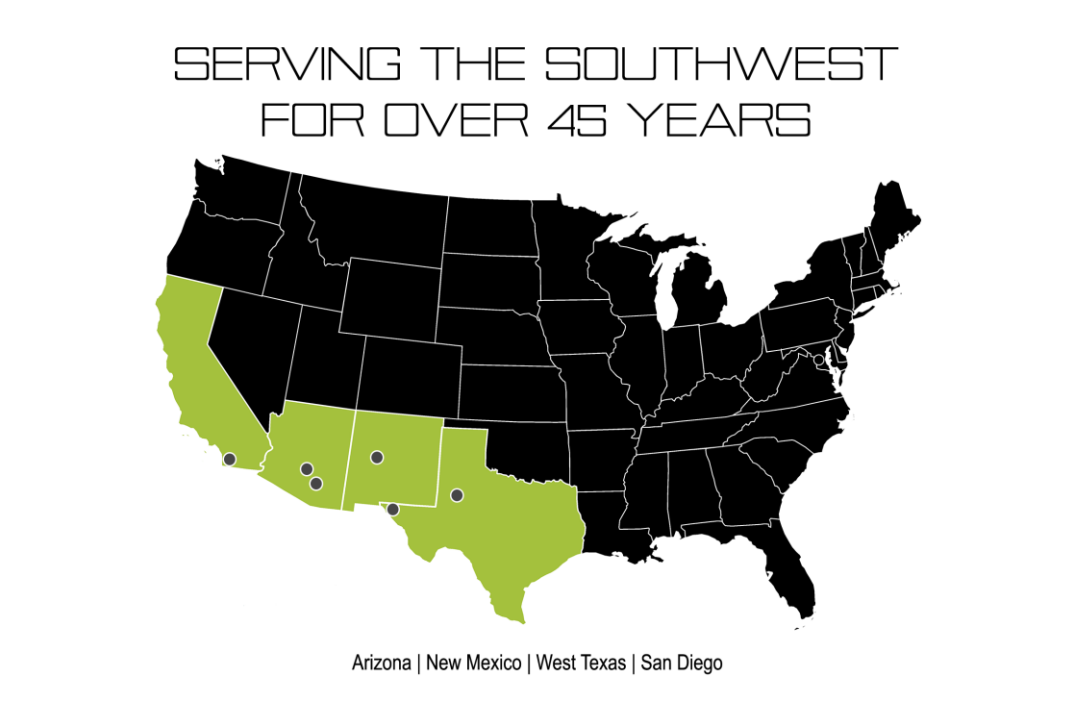
Introduction

- **Education:**
  - University of Arizona – Chemical Engineering
    - 1974 thru 1976
  - University College London – BFA Degree (Sculpture)
    - 1978 thru 1983
  - Boston University – MFA Degree (Sculpture)
    - 1983 thru 1985

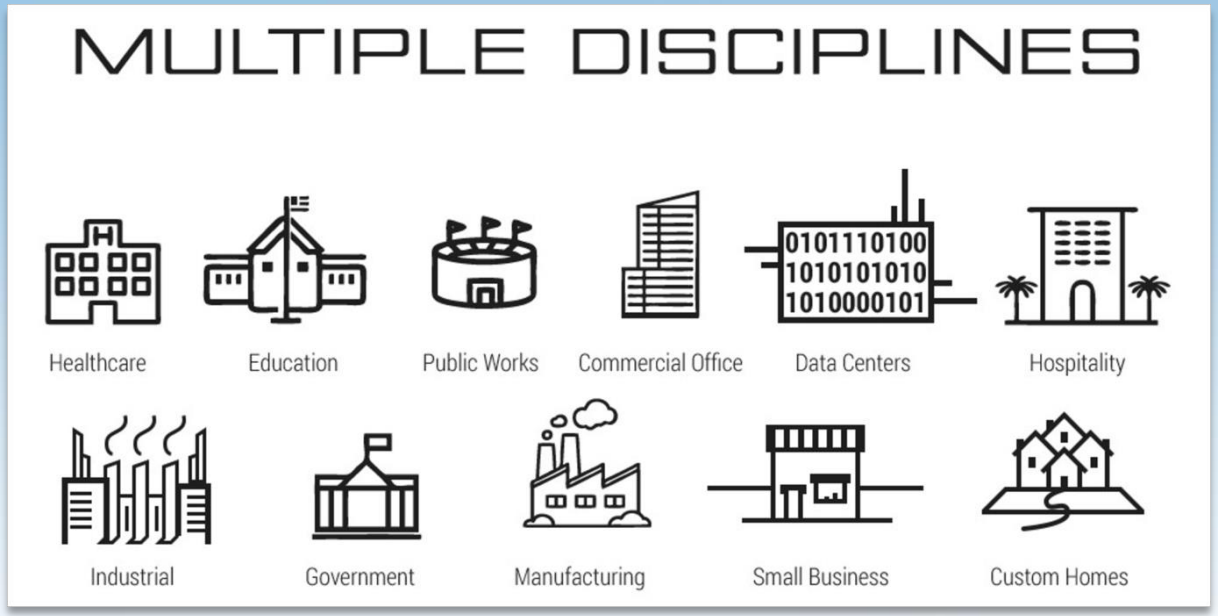
- **Industry:**
  - Norman S. Wright SW: Estimator/Sales
    - 1985 thru 1999
  - Air Specialty Products/ThermAir Systems – Outside/Engineering Sales
    - 2000 thru 2008
  - **Varitec Solutions:**
    - Senior Sales Engineer/Educator (High Performance HVAC)
    - 2016 thru present

Varitec: The HVAC System Solution

Varitec: The HVAC System Solution



Varitec: The HVAC System Solution



Varitec: The HVAC System Solution

System Solutions:

- Variable Refrigerant Systems
- Mixed Air VAV Systems
- Package Central Plants for Air & Water Cooled Designs
- Cloud Based Controls
- Humidity Control
- Underfloor Air Systems
- 100% OSA Systems
  - DOAS Technology
  - Active Chilled Beams
  - Passive Hydronic Cooling & Heating Systems

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VARITEC™ TECHNICAL INSTITUTE

Varitec: The HVAC System Solution

Shaping
The Future
Of HVAC

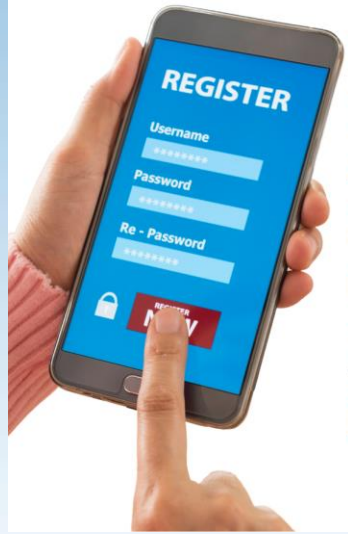
Varitec Technical Institute

Mission:

To provide an educational platform for continued learning in the HVAC industry with a focus on high performance buildings and innovative technologies for a better built environment.

Varitec Technical Institute

2021 Educational Webinar Schedule



▶ Wedensday, February 10 at 11:00 am PST
ASHRAE Epidemic Task Force – Review and Navigating

▶ Wedensday, February 24 at 11:00 am PST
Physics of Pathogen Migration

▶ Wedensday, March 17 at 11:00 am PST
ASHRAE 62.1 2019

▶ Wedensday, April 14 at 11:00 am PST
Humidification - Technology and Application

▶ Wedensday, May 12 at 11:00 am PST
UV Lights - Technology and Application

▶ Wedensday, June 9 at 11:00 am PST
Needlepoint Bipolar Ionization - Technology and Application

▶ Wedensday, July 14 at 11:00 am PST
Dilution and Thermal Stratification - Displacement Ventilation

▶ Wednesday, August 11 at 11:00 am PST
Pathogen Mitigation: HVAC System Design Concepts

▶ Wednesday, September 8 at 11:00 am PST
ASHRAE 90.1 2019 and 189 2019

▶ Wednesday, October 13 at 11:00 am PST
Low-Pressure VAV Systems

▶ Wednesday, November 3 at 11:00 am PST
100% OSA Systems Part 1

▶ Wednesday, December 8 at 11:00 am PST
100% OSA Systems Part 2

▶ Wednesday, January 12, 2022 at 11 am PST
ASHRAE 170 2017

PDH CREDITS AVAILABLE

NSWC NORMAN S. WRIGHT CLIMATEC MECHANICAL EQUIPMENT

VARITEC™ TECHNICAL INSTITUTE

Physics of Pathogen Transmission

Presentation Resources:

References:

- Daniel Jones, President UV Resources
- Bob Kline P.E. (Acutherm)
- ASHRAE Handbook 2019
- ASHRAE Epidemic Task Force
- Center for Disease Control

UV-C Technology

Agenda:

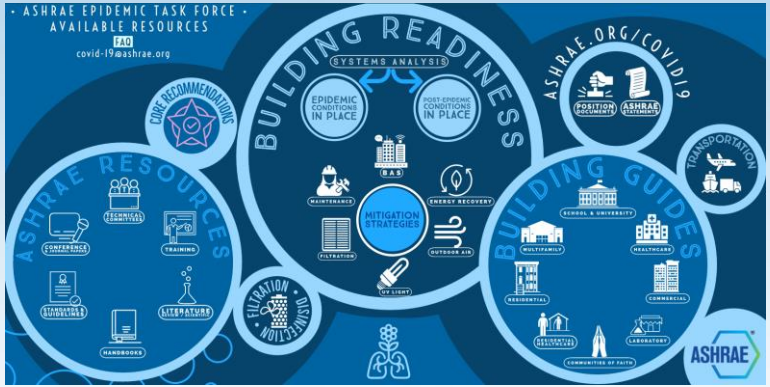
- **Webinar Series Review**
- **CDC & ASHRAE: COVID-19 Transmission Update**
- **ASHRAE Epidemic Task Force**
  - Position Document on Infectious Aerosols: Filtration & Disinfection

Webinar Series Review

VTI: Webinar Series Review

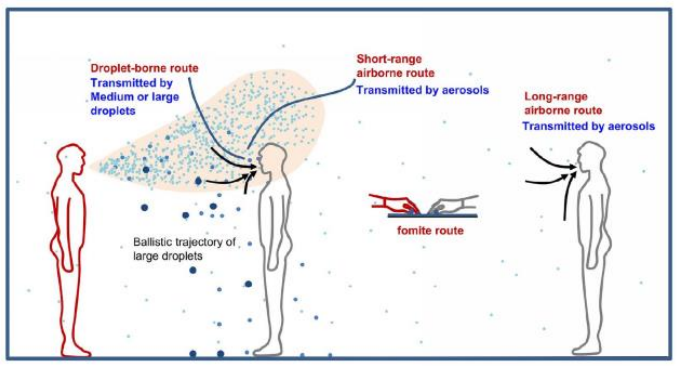
Session #1:

ASHRAE Epidemic Task Force: Review & Navigating



- Position Document on Infectious Aerosols
- Guide to COVID-19 Pages
- Core Recommendations for Reducing Airborne Infectious Aerosol Exposures
- Building Readiness

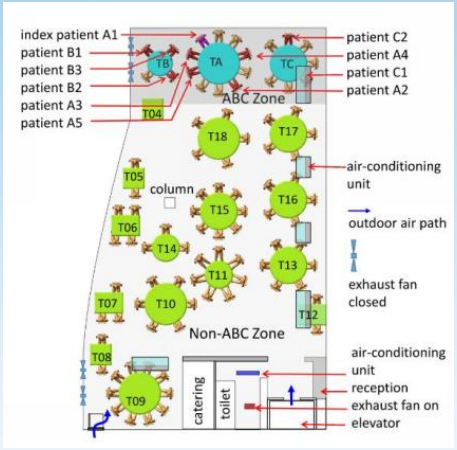
VTI: Webinar Series Review



Session #2:

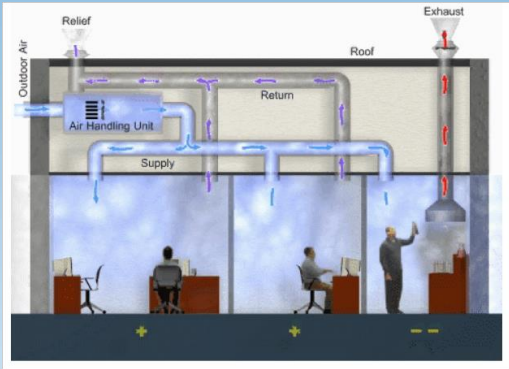
The Physics of Pathogen Migration

- The Physics of Falling Objects
- The Expiratory Event: Discharge of Pathogen
- Environmental Impacts on Pathogen Travel
- Airflow and Ventilation
- Displacement Ventilation
- Prescriptive Measures & The Future



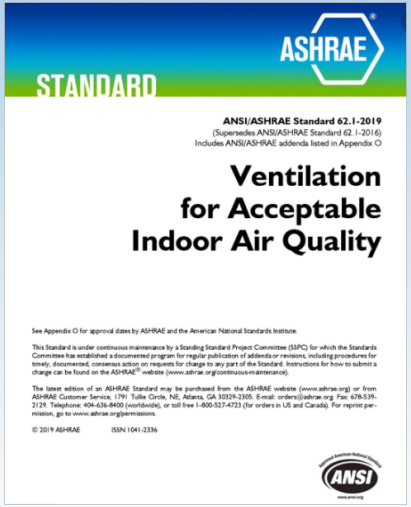
(Guangzhou Restaurant Table Layout)

VTI: Webinar Series Review



Session #:3

ASHRAE Standard 62.1-2019



- The Purpose of Standard 62.1
- 2019 Updates to the Standard
- The Importance of Outdoor Air
- Ventilation rates per Standard 62.1: Minimum for COVID-19 mitigation

VTI: Webinar Series Review

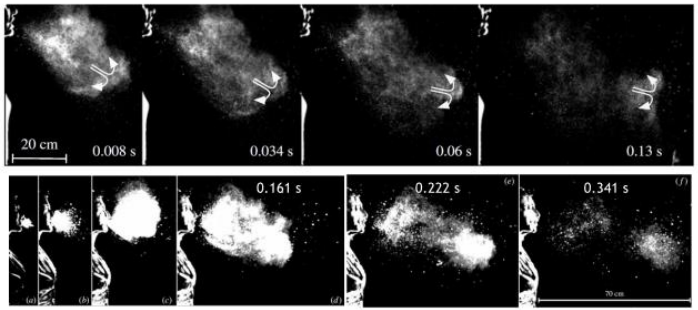


Figure 7. High-speed camera images of a sneeze illustrating salient processes of counter-rotating flow at the leading edge and bifurcation of the droplet plume (Bourouiba et al. [6]).

Session #:4

Humidification

- The Nature of Water
- The Physics of Water Vapor
- Expiratory Events, Evaporation & Aerosolization
- The Risk of Infection
- Humidity an the Immune System

CDC & ASHRAE:
COVID-19 Transmission Update

CDC & ASHRAE: COVID-19 Transmission Update

The New York Times

The Coronavirus Outbreak › | LIVE Latest Updates | Maps and Cases | Vaccine Rollout | Second Dose | Outdoor Mask Guidance

The virus is an airborne threat, the C.D.C. acknowledges.

People crowded together at a bar in El Paso, Tex., in March. The coronavirus spreads through airborne transmission, particularly indoors, the C.D.C. emphasized on Friday. Justin Hamel for The New York Times

By Roni Caryn Rabin and Emily Anthes

May 7, 2021

Federal health officials on Friday updated public guidance about how the coronavirus spreads, emphasizing that transmission occurs by inhaling very fine respiratory droplets and aerosolized particles, as well as through contact with sprayed droplets or touching contaminated hands to one's mouth, nose or eyes.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

SARS-CoV-2 is transmitted by exposure to infectious respiratory fluids

The principal mode by which people are infected with SARS-CoV-2 (the virus that causes COVID-19) is through exposure to respiratory fluids carrying infectious virus. Exposure occurs in three principal ways: (1) inhalation of very fine respiratory droplets and aerosol particles, (2) deposition of respiratory droplets and particles on exposed mucous membranes in the mouth, nose, or eye by direct splashes and sprays, and (3) touching mucous membranes with hands that have been soiled either directly by virus-containing respiratory fluids or indirectly by touching surfaces with virus on them.

People release respiratory fluids during exhalation (e.g., quiet breathing, speaking, singing, exercise, coughing, sneezing) in the form of droplets across a spectrum of sizes.[1-9] These droplets carry virus and transmit infection.

- The largest droplets settle out of the air rapidly, within seconds to minutes.
- The smallest very fine droplets, and aerosol particles formed when these fine droplets rapidly dry, are small enough that they can remain suspended in the air for minutes to hours.

(Date: May 7, 2021)

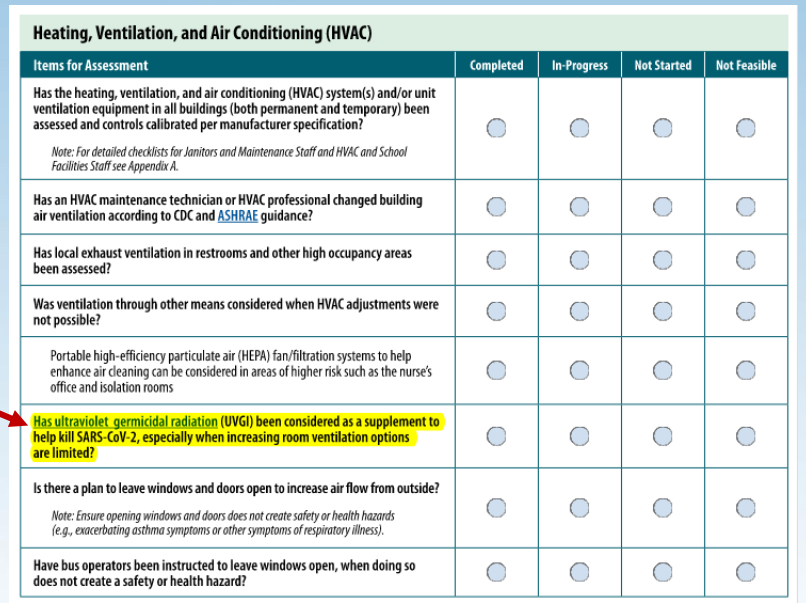
CDC & ASHRAE: COVID-19 Transmission Update

CDC & ASHRAE: COVID-19 Transmission Update

CDC: K-12 Schools COVID-19 Mitigation Toolkit

- **Checklist #4: Heating, Ventilation, and Air Conditionsin (HVAC)**

Has **Ultraviolet germicidal radiation (UVGI)** been considered as a supplement to help kill SARS-CoV-2, **especially when increasing room ventilation options are limited?**



Heating, Ventilation, and Air Conditioning (HVAC)

Items for Assessment	Completed	In-Progress	Not Started	Not Feasible
Has the heating, ventilation, and air conditioning (HVAC) system(s) and/or unit ventilation equipment in all buildings (both permanent and temporary) been assessed and controls calibrated per manufacturer specification? *Note: For detailed checklists for Janitors and Maintenance Staff and HVAC and School Facilities Staff see Appendix A.*	○	○	○	○
Has an HVAC maintenance technician or HVAC professional changed building air ventilation according to CDC and ASHRAE guidance?	○	○	○	○
Has local exhaust ventilation in restrooms and other high occupancy areas been assessed?	○	○	○	○
Was ventilation through other means considered when HVAC adjustments were not possible?	○	○	○	○
Portable high-efficiency particulate air (HEPA) fan/filtration systems to help enhance air cleaning can be considered in areas of higher risk such as the nurse's office and isolation rooms	○	○	○	○
Has ultraviolet germicidal radiation (UVGI) been considered as a supplement to help kill SARS-CoV-2, especially when increasing room ventilation options are limited?	○	○	○	○
Is there a plan to leave windows and doors open to increase air flow from outside? *Note: Ensure opening windows and doors does not create safety or health hazards (e.g., exacerbating asthma symptoms or other symptoms of respiratory illness).*	○	○	○	○
Have bus operators been instructed to leave windows open, when doing so does not create a safety or health hazard?	○	○	○	○

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

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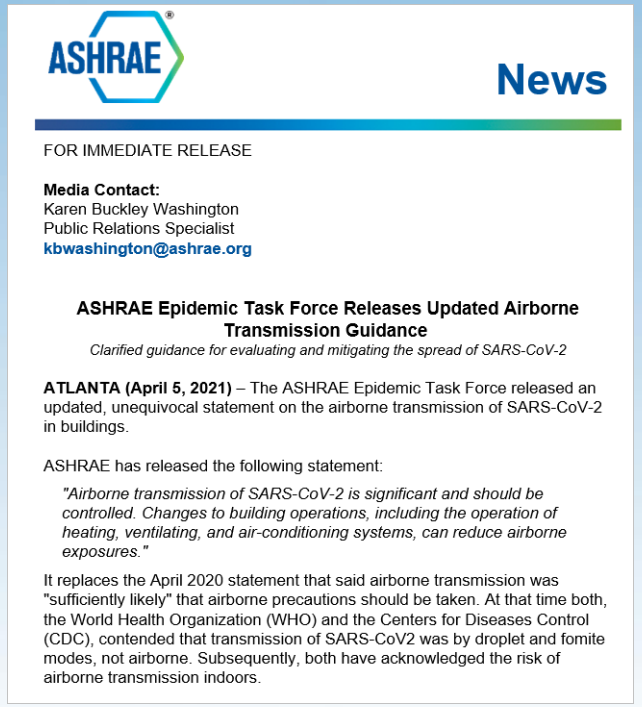
CDC & ASHRAE: COVID-19 Transmission Update



ASHRAE

News

FOR IMMEDIATE RELEASE

Media Contact:
Karen Buckley Washington
Public Relations Specialist
kbwashington@ashrae.org

ASHRAE Epidemic Task Force Releases Updated Airborne Transmission Guidance

Clarified guidance for evaluating and mitigating the spread of SARS-CoV-2

ATLANTA (April 5, 2021) – The ASHRAE Epidemic Task Force released an updated, unequivocal statement on the airborne transmission of SARS-CoV-2 in buildings.

ASHRAE has released the following statement:

> *"Airborne transmission of SARS-CoV-2 is significant and should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures."*

It replaces the April 2020 statement that said airborne transmission was "sufficiently likely" that airborne precautions should be taken. At that time both, the World Health Organization (WHO) and the Centers for Diseases Control (CDC), contended that transmission of SARS-CoV2 was by droplet and fomite modes, not airborne. Subsequently, both have acknowledged the risk of airborne transmission indoors.

ASHRAE: Epidemic Task Force Review

ASHRAE NEWS: (April 5, 2021)

Updated Airborne Transmission Guidance

"Airborne transmission of SARS-CoV-2 is significant and should be controlled.

Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.

It replaces the April 2020 statement…"

CDC & ASHRAE: COVID-19 Transmission Update

MOST RECENT NEWS

May 12, 2021: ASHRAE Announcement

ASHRAE News

FOR IMMEDIATE RELEASE

Media Contact:
Karen Buckley Washington
Public Relations Specialist
kbwashington@ashrae.org

ASHRAE and IUVA Sign Memorandum of Understanding
Collaboration on ultraviolet technology and indoor environmental quality source publications

ATLANTA (May 12, 2021) – ASHRAE and the International Ultraviolet Association (IUVA) have signed a new Memorandum of Understanding (MOU) formalizing the organizations' relationship.

ASHRAE and IUVA Sign Memorandum of Understanding

(*Collaboration on ultraviolet technology and indoor environmental quality source publications*)

- "ASHRAE and the International Ultraviolet Association (IUVA) have signed a new **Memorandum of Understanding (MOU)** formalizing the organization's relationship"
- "Establishing and maintaining improved indoor environmental quality is **the bedrock of ASHRAE's sustainability mission** and **the use of ultraviolet technology is a critical component** towards addressing the challenges of minimizing the spread of infectious diseases,…"

CDC & ASHRAE: COVID-19 Transmission Update

MOST RECENT NEWS

May 12, 2021: ASHRAE Announcement

ASHRAE News

FOR IMMEDIATE RELEASE

Media Contact:
Karen Buckley Washington
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ASHRAE and IUVA Sign Memorandum of Understanding
Collaboration on ultraviolet technology and indoor environmental quality source publications

ATLANTA (May 12, 2021) – ASHRAE and the International Ultraviolet Association (IUVA) have signed a new Memorandum of Understanding (MOU) formalizing the organizations' relationship.

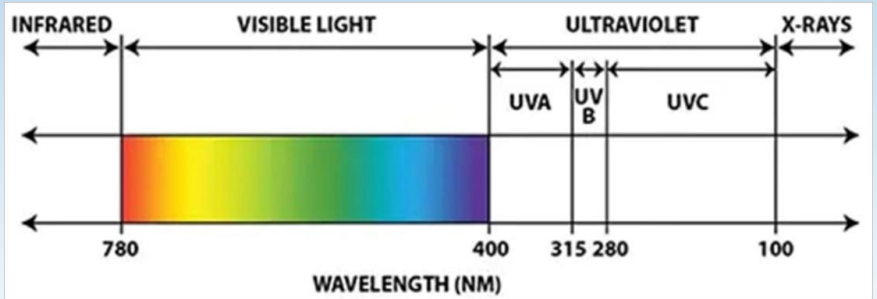
"**The MOU includes**,…, the following initiatives…

- **Test and measurements** on specific pathogens **across a specified light spectrum** (e.g. antimicrobial UV-C: 200-280nm) and in specific mediums (e.g. **aerosols**, large droplets, surface-dry & wet, **…**
- **Test and measurements** on efficacy outcomes **for antimicrobial UV-C devices and systems** in well **defined testing environments** (e.g. simulated hospital rooms…
- **Test and measurements** on efficacy outcomes **for antimicrobial UV-C devices** and systems installed **in 'upper room' HVAC applications**

ASHRAE Epidemic Task Force

Position Document on Infectious Aerosols

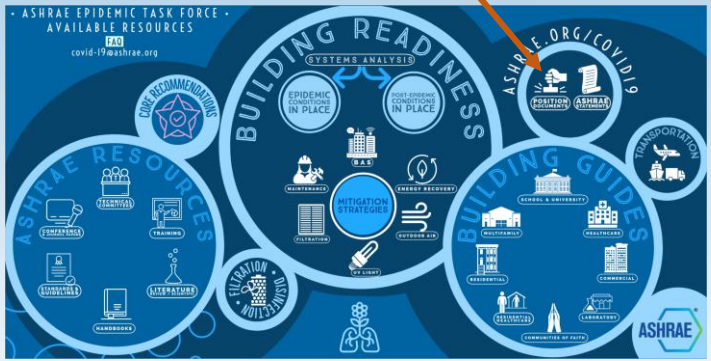
Ultraviolet Germicidal Irradiation: (UVGI)

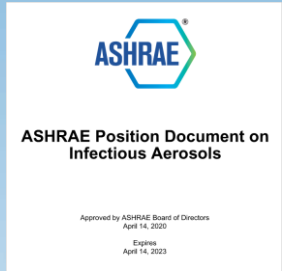


Ultraviolet Germicidal Irradiation: (UVGI)

Guide to the COVID-19 Pages

COVID-19: Position Documents





Ventilation and Air-Cleaning Strategy

- The entire ultraviolet UV spectrum can kill or inactivate microorganisms
- Ultraviolet Germicidal Radiation (UVGI) inactivates microorganisms by damaging the structure of nucleic acids and proteins…
- …the **effectiveness dependent upon the UV dose and the susceptibility of the microorganism**.

Ultraviolet Germicidal Irradiation: (UVGI)

Guide to the COVID-19 Pages

www.ashrae.org/technical-resources/resources

Filtration / Disinfection

Ultraviolet Energy (UV-C)

- Ultraviolet energy inactivates viral, bacterial, and fungal organisms so they are unable to replicate and potentially cause disease.
- The entire UV spectrum is capable of inactivating microorganisms, but UV-C energy (wavelengths of 100-280 microns provides the most germicidal effect…
- Roughly 95% of the energy produced by these lamps is radiated at a near-optimal wavelength of 253.7 microns

Ultraviolet Germicidal Irradiation: (UVGI)

Modes of Transmission | Airborne Transmission | Transmission through Air in Toilet Rooms | Facilities/Maintenance – PPE Basics | HVAC System Maintenance and Filter Replacement | Mechanical Air Filters | Minimum Efficiency Reporting Value (MERV) | ASHRAE MERV vs. ISO 16890 Ratings | High-Efficiency Particulate Air (HEPA) Filters | Electronic Air Filters | Gas-Phase Air Cleaners | Ultraviolet Energy (UV-C) | UV-C LEDs | UV-C In-Duct Air Disinfection | UV-C Upper-Air Disinfection | UV-C In-Duct Surface Disinfection | UV-C Portable Room Decontamination | Photocatalytic Oxidation (PCO) | Bipolar Ionization/Corona Discharge / Needlepoint Ionization and Other Ion or Reactive Oxygen Air Cleaners | CDC Position on Bipolar Ionization | Ozone | In-Room or Portable Air Cleaners | Chemical Disinfectants | Vaporized Hydrogen Peroxide (VHP) | Pulsed Xenon (Pulsed UV) | 405 nm Visible Light | Far Ultraviolet | Special Precautions | Summary

UV-C In-Duct Air Disinfection

UV-C Upper-Air Disinfection

UV-C In-Duct Surface Disinfection

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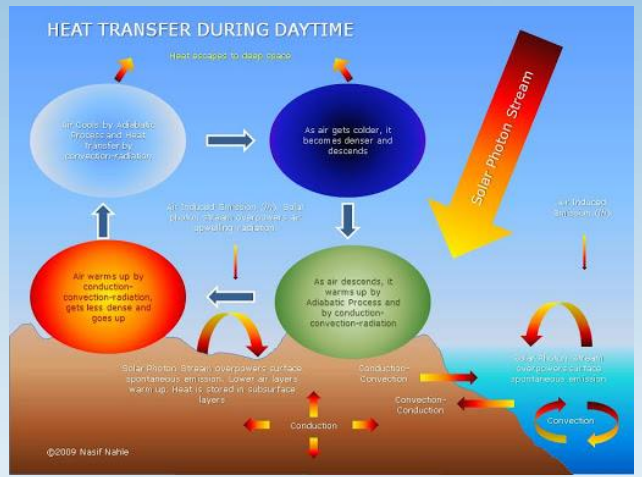
The Nature of Light

The Nature of Light

What is Light?: Electromagnetic Radiation



Session #3:

- **Definition: Energy -** "Energy, in physics, the capacity for doing work. (Britannica)"

Four Methods of Energy (Heat) Transfer:

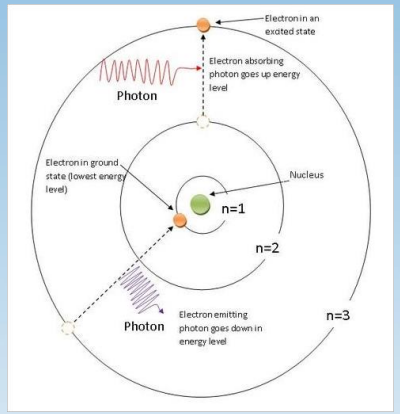
- **Conduction:**
  - Energy transfer through a continuous body
- **Convection:**
  - Warm fluids rise, cold fluids fall
- **Evaporation:**
  - Energy transferred for a fluid phase change from liquid to vapor
- **Electromagnetic Radiation (EMR):**
  - Discrete energy "quantum" (photons) that move in the form of waves

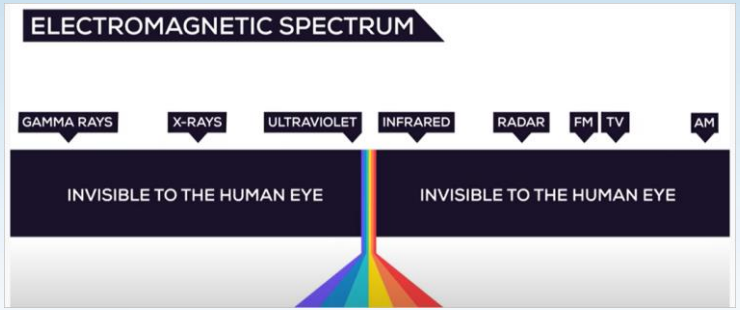
The Nature of Light

What is Light?: Electromagnetic Radiation

Photon Emission = Radiation

- **Photons:** when an atom's electron falls from unstable higher to more stable lower energy orbitals a photon is emitted





Light Facts:

- **Photons:** The smallest quantity of energy that can be transported
- Photons behave like a wave-particle duality when transported

The Nature of Light

Electromagnetic Radiation: Intensity

The Nature of Electromagnetic Waves:

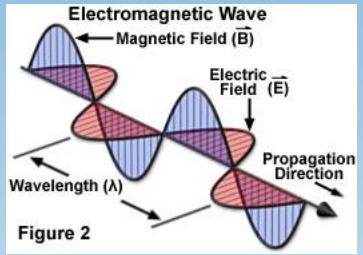
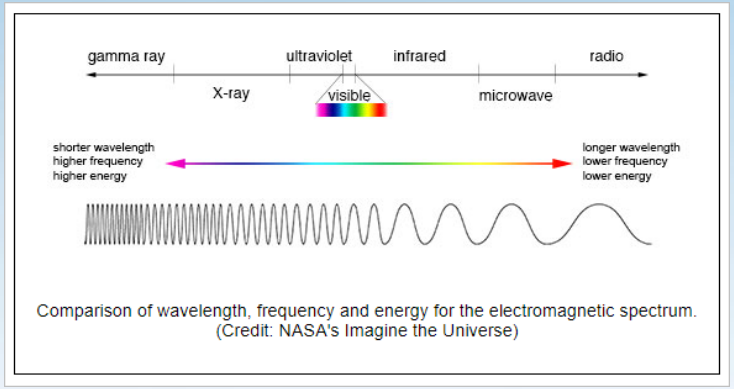


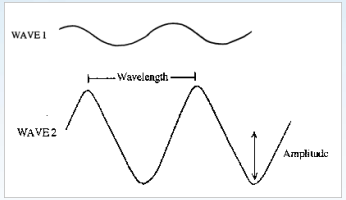
Figure 2

- **High Energy Levels:**
  - Shorter the **wavelength (Nanometers)**
  - Higher the **frequency (Hertz)**

- **Low Energy Levels:**
  - Longer the wavelength
  - Lower the frequency



Comparison of wavelength, frequency and energy for the electromagnetic spectrum. (Credit: NASA's Imagine the Universe)



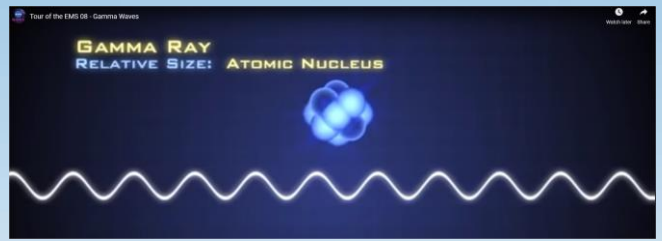
- **Amplitude:** ½ the height of a wave from its peak to its trough defining intensity or brightness

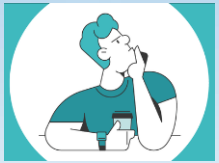
The Nature of Light

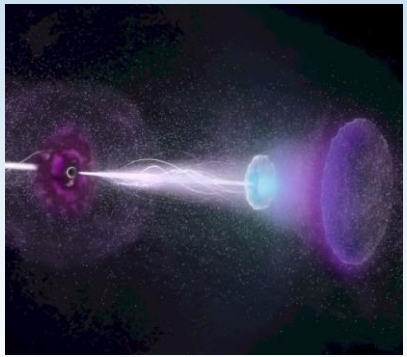
Electromagnetic Radiation: Gamma Rays

High Intensity Electromagnetic waves:

- **Gamma Rays**
  - Radiation of the greatest intensity are.
  - Wavelengths are the **size of an atom's nucleus**







Gamma Wave Facts:

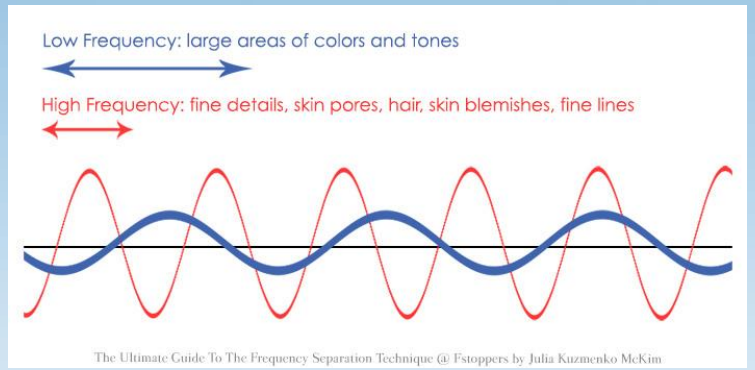
- Wavelengths at ~10 picometers (PM = 10^-12 meters)
- A supernova gamma ray burst can release more energy in 10 seconds than our sun throughout its life
- **Lethal to living cells**

ASHRAE Epidemic Task Force

Electromagnetic Radiation: Radio Waves

Low Frequency Radio Waves:

Extremely Low Frequency Radio Waves:



Radio Wave Facts:

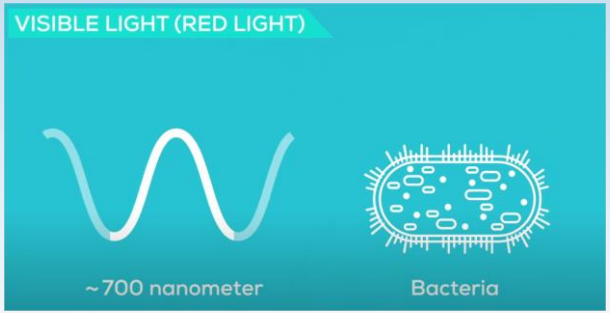
- Low energy wavelengths = ~ **62.14 miles**
- Extremely Low Frequency wavelengths = ~ **62,137 miles**
- **2.5 times greater than the size of Earth**

The Nature of Light

Electromagnetic Radiation:

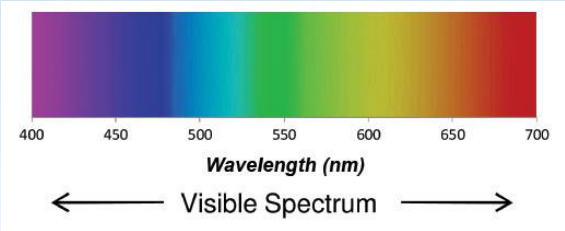
Visible Light

- Radiation perceivable by the human eye (**visible light spectrum**)
- Wavelengths: 400 (nm) violet to 700 (nm) red
- Wavelengths = **Size of bacteria**



High Energy Visible Light:
- **400 nm (violet)**

Low Energy Visible Light:
- **700 nm (Red)**

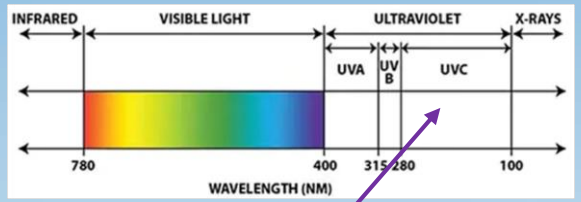


The Nature of Light

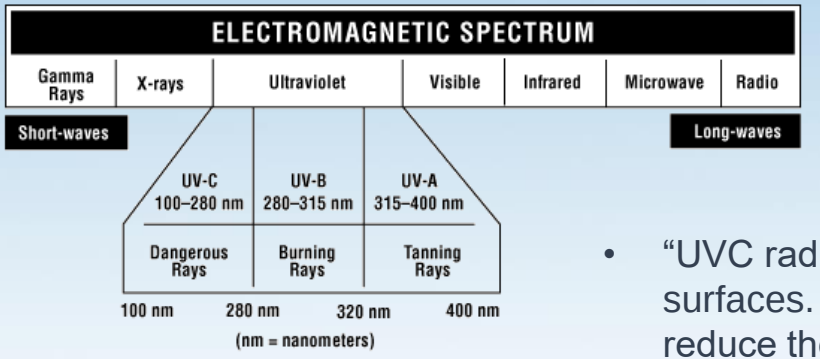
Electromagnetic Radiation:

Ultraviolet Light:

- UV light is not perceivable by the human eye
- Wavelength Range: 100 to 400 (nm)



UV-C Range: 100 – 280 microns



The Food and Drug Administration

- "UVC radiation is a known disinfectant for air, water, and nonporous surfaces. UVC radiation has effectively been used for decades to reduce the spread of bacteria, such as tuberculosis."
- UVC radiation **MAY** also be effective in inactivating the SARS-CoV-2 virus…"

Ultraviolet Germicidal Irradiation (UVGI)

Electromagnetic Radiation:
Ultraviolet Light: Levels of Intensity

UV-A long-wave

Responsible for skin tanning & wrinkles

400-315 nm

UV-B medium-wave;

Primarily responsible for skin reddening and skin cancer

315- 280 nm

uv-c

UV-C short-wave;

Most effective Germicidal control

280-200 nm

Vacuum UV

Can produce ozone (O3) in air

100 - 200 nm

- UV-C wavelength has more electron volt energy
- Well absorbed by all organic substances
- **More energy = more destructiveness**

UV Light Generators

UV Light Generators

UV-C Lamp Technology:

Low Pressure Mercury Lamps

- Similar to fluorescent tubes: electric discharge through argon gas striking mercury vapor
- Unlike fluorescent tubes, **no internal phosphor coat**
- Tube glass: engineered **fused quartz or vycor 7913**
- **UV-C light at 253.7 nm emitted**
- 90% of energy converted to UV-C, 4% given up as heat

- Low- and high-pressure mercury lamps exhibit negative resistance and may require a ballast
- **Lamp life:** approximately 9000 hours or **one year**

A modern American ballast for powering a variety of American T8 office lamps.

UV Light Generators

UV-C Lamp Technology:

Variety of Types:

- **Single ended:**
  - Inserted through a plenum or duct into airstream
  - **Ease of changing out the bulb**
- **Double ended:**
  - Pins at both ends installed into specific length fixtures usually containing a ballast like a fluorescent light
    - **Standard Output:**
    - **High Output:** (Recommended)
    - **Fluorinated Ethylene Propylene (FEP):** Encapsulation for glass containment

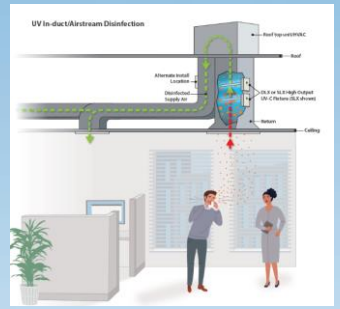
FIGURE 3: Lamp installed through a plenum

UV Light Generators

UV-C Lamp Technology:

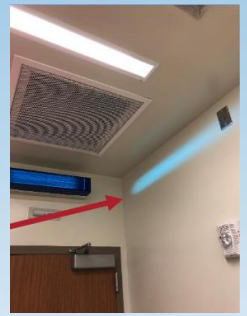
Applications:

- **In-Duct Air Disinfection**
- **Upper- Air Disinfection**
- **In-Duct Surface Disinfection**



Return Air Duct Installation

Upper Room Installation



Coil Surface Cleaning

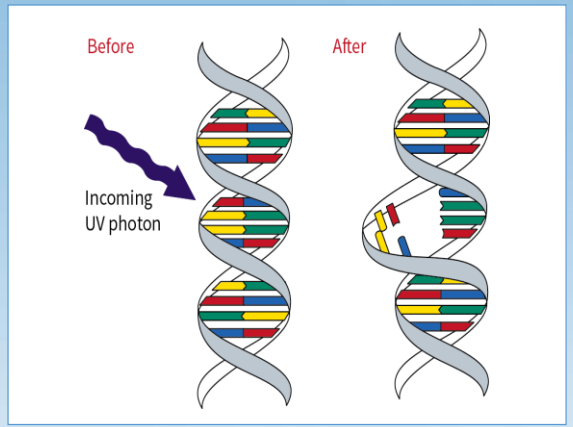
Discharge of Supply Coil

Ultraviolet Germicidal Irradiation (UVGI)

The Nature of Light

Pathogenic Mitigation:
UV-C: 253.7 NM Wavelength

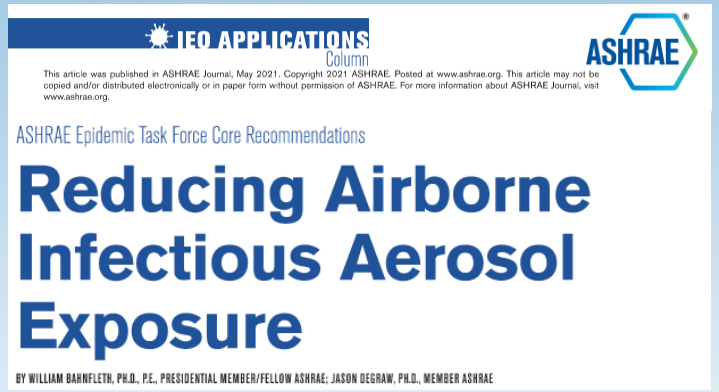
- Inactivates virtually all microbes
  - Breaks molecular bonds of nucleic acids (RNA & DNA) and proteins
  - Deactivates reproduction of pathogen
- Pathogens absorb UV-C at different rates (called rate constant “K”)



Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:
ASHRAE Journal: May 2021

- "Only use air cleaners for which evidence of effectiveness and safety is clear."
- **Germicidal ultraviolet light is one technology for which there is strong documentation of effectiveness and safety."**



IEQ APPLICATIONS Column

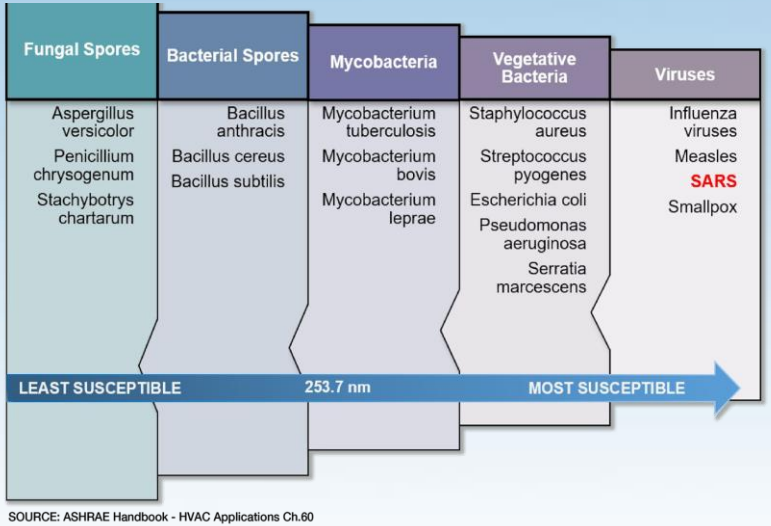
ASHRAE

ASHRAE Epidemic Task Force Core Recommendations

Reducing Airborne Infectious Aerosol Exposure

BY WILLIAM BAHNFLETH, PH.D., P.E., PRESIDENTIAL MEMBER/FELLOW ASHRAE; JASON DEGRAW, PH.D., MEMBER ASHRAE

- **Viruses like influenza, measles, SARS**, coronavirus and smallpox tend to be more susceptible to UV-C inactivation in an airstream.



SOURCE: ASHRAE Handbook - HVAC Applications Ch.60

Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:

UV-C PATHOGEN SUSCEPTIBILITY

* Microwatts per seconds per cm²

PATHOGEN	90%	99.9%
MOLD		
• Aspergillus Niger	132,000*	333,000*
BACTERIA		
• Bacillus Subtilis	5,800	11,000
• Mycobacterium Tuberculosis	6,200	10,000
• Staphylococcus Aureus	2,600	6,600
VIRUS		
• Influenza	3,400	6,600
• Coronavirus (Walker 2007)	700	2,000

Test Dosage:

- **At 2,000 *m*W/cm^2 99.9% of coronavirus will be deactivated.**
  (Source: ASHRAE Handbook – HVAC Applications)

Upper-Air Disinfection:

- Goal: 30-50 *m*W/cm^2 99.9%
- 99.9% deactivation aerosolized pathogens on a first-pass basis have been modeled
- Concentrations further reduced with each subsequent pass
  (HPAC Engineering: June 2020 – Limit the Spread of Contagious Diseases and Bacteria with Germicidal UV)

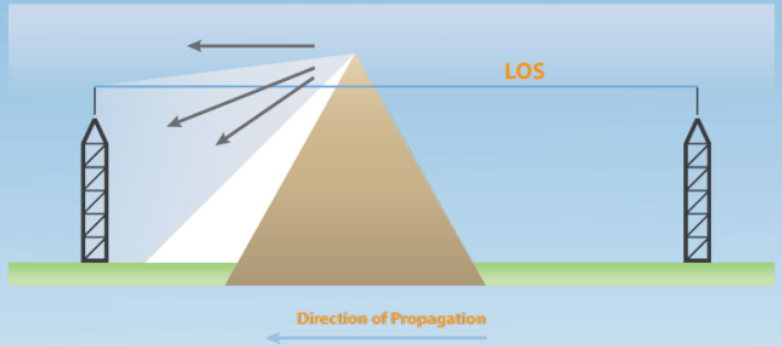
Ultraviolet Germicidal Irradiation (UVGI)

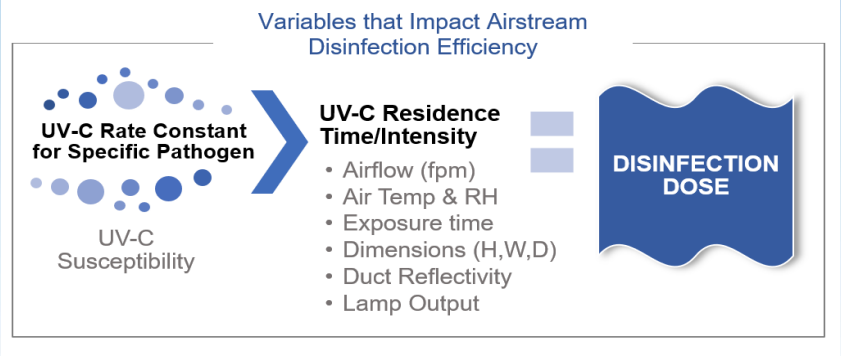
Pathogenic Mitigation:

UV-C In-Duct Air Disinfection:

Design Requirement:

- **Direct line of sight to be effective**





In-Duct Air Disinfection: "On-the-Fly"

- **Design Considerations:**
  - Duration of exposure
  - UV-C intensity; Lamp output
  - Reflection

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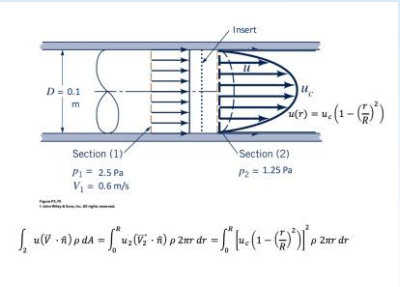
Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:

ASHRAE – Filtration & Disinfection

- **UV-C In-Duct Air Disinfection**
  - Banks of UV-Lamps installed inside AHU and HVAC or associated ductwork
  - **Requires high UV output to inactivate microorganisms “on-the-fly”**…due to limited exposure time
    - Systems designed for **500 FPM moving airstream**
    - Should always be coupled with mechanical filtration



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Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:

Air Disinfection: ASHRAE – Filtration & Disinfection

UV-C Upper-Air Disinfection:

- Wall-mounted >7ft; neutralizes airborne microbes in seconds
- Non-reflective baffles create columnated UV-C beam
- Natural air currents lift contaminated air into UV-C disinfection zone and inactivates pathogen
- Safe for occupied spaces

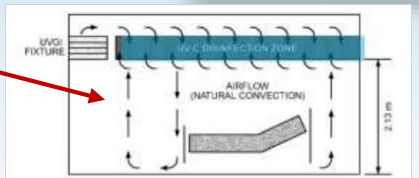


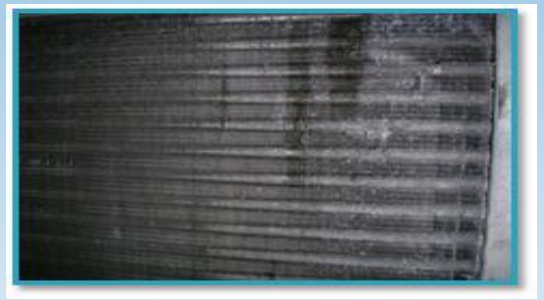
Fig. 5 Typical Elevation View of Upper-Room UV Applied in Hospital Patient Room

(ASHRAE, 2019)

Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:

UV-C: In-Duct Surface Disinfection



WEEK 1

WEEK 2

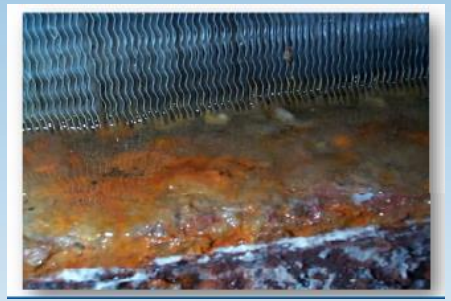
Coil Surface Cleaning:

- Restoration and preservation of heat transfer efficiency and airflow capacity (1990s)
- Reduce coil fouling and system maintenance
- Slash HVAC energy consumption by up to 25%
- Improves indoor air quality (IAQ) and reduces airborne pathogens

Ultraviolet Germicidal Irradiation (UVGI)

Pathogenic Mitigation:

UV-C: In-Duct Surface Disinfection



Bank of UV-C Lamps

ASHRAE – Filtration & Disinfection

- Banks of UV-Lamps installed inside HVAC systems, generally focused on:
  - Cooling coils
  - Drain pans
  - Other wetted surfaces

(AHU) UV irradiance can be lower than in-duct air disinfection systems due to long exposure times

- Goals are:
  - Even distribution of UV energy across the coil face
  - Generally, 12 to 36 inches from the coil face
  - Operated 24 hours a day, 7 days a week

NSWC Norman S. Wright Climatec Mechanical Equipment

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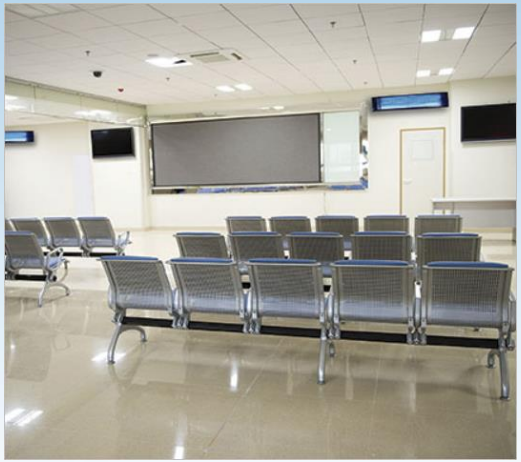
UV-C Layout:
Light Density & Design Considerations

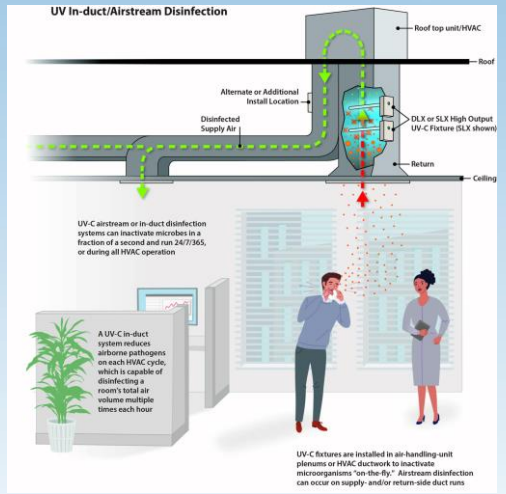


UV-C Layout: Light Density & Design Considerations

Laying Out UV-C Light Generators:

Duct-Air Disinfection:

- Disinfection of moving airstreams **“on-the-fly”.**
- UV-C dosage determined by:
  - Type of **target pathogen** germicidal energy absorbed
  - **Exposure time** of pathogen to UV-C
  - **Air Temperature:**
    - Warmer air: More effective, less UV-C output
    - Colder air: Less effective, more UV-C output
  - **Lamp Location:**
    - More effective located upstream of coil



75F air: :

- **Lamp output increased by 40%**

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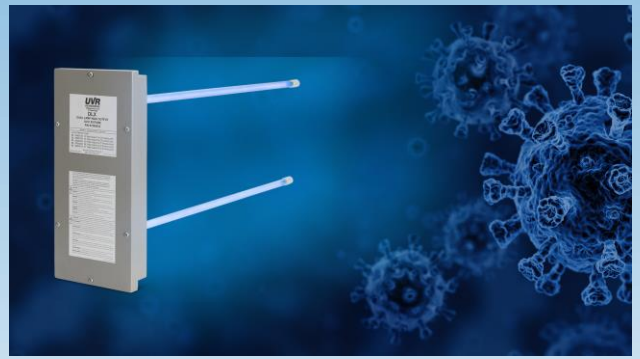
UV-C Layout: Light Density & Design Considerations

Laying Out UV-C Light Generators:

Duct-Air Disinfection:

- Consider **FEB coating** or outer sleeve to insulate lamp and increase output in colder air conditions
- **Duct reflectivity** factors:
  - UV-C energy effectiveness is multiplied as it bounces off the top, bottom, and sides of a plenum surface.



Metal	UV-C Multiplier
Stainless Steel	1.40
Galvanized Steel	1.50
Aluminum	1.75

TABLE 1: Reflectance multipliers for different surfaces.

These factors will determine appropriate lamp output to maximize pathogen deactivation for "on-the-fly" installations

UV-C Layout: Light Density & Design Considerations

Laying Out UV-C Light Generators:

Upper-Air Disinfection:

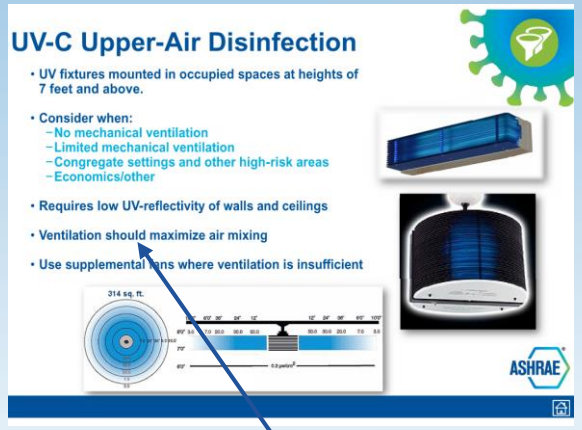
- **In-Room Applications:**
  - Immunocompromised (PE) rooms
  - Emergency Room waiting areas
  - Urgent care facilities
  - Doctor’s offices
  - Senior living centers
  - Areas that increase the potential for community spread

UV-C Layout: Light Density & Design Considerations

Air Disinfection: ASHRAE – Filtration & Disinfection

Upper Air/Room Disinfection:

- **Consider when:**
  - **Limited mechanical ventilation** or no mechanical ventilation available
  - **High occupant density** (ER waiting rooms or conference rooms) and other high-risk areas
  - **Economics** (first cost)/other factors

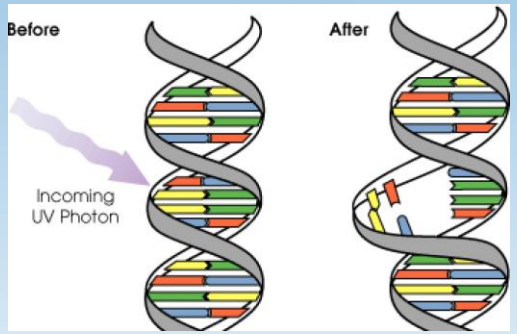


Room Air Distribution Layout

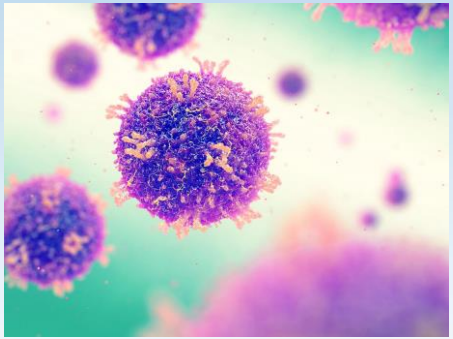
UV-C Layout: Light Density & Design Considerations

Laying Out UV-C Light Generators:

Upper-Air Disinfection:



- **Inactivates microbes: Less than a second**
  - Measles
  - Mumps
  - TB
  - Cold Viruses
  - Flu



- **Mounted 7 feet or more above finished floor**
  - Baffles to direct UV-C energy upward & outward
  - UV-C light does not enter occupied zone

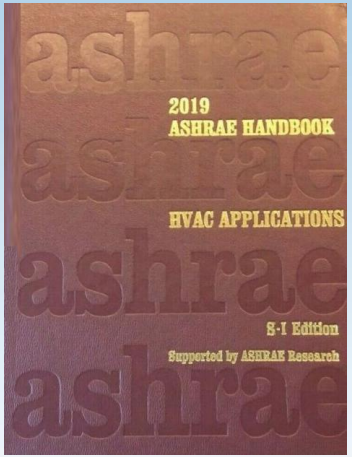
UV-C Layout: Light Density & Design Considerations

Laying Out UV-C Light Generators:

Upper-Air Disinfection:

Chapter 62.5 Section 3: UVGI Air Treatment Systems

- **Upper-Air UVC Devices**
  - Upper-Air UVC is very effective in areas with no, or minimal ventilation, 2 air changes per hour (ach), up to…levels of 6 (ach).
  - "Ventilation patterns should promote air good mixing…"
  - "…effectiveness of upper-air UVC is related to air mixing, relative humidity, and the inherent characteristics of the pathogenic organisms…" (Ka et a.. 2004; Ko et al. 2000, Rudnick 2007)
  - **"Effectiveness can improve greatly with well-mixed air"**
  - (rst et al. 2007a, 2007b; Miller et al. 2002; …)



UV-C Layout: Light Density & Design Considerations

Air Disinfection: ASHRAE – Filtration & Disinfection

Upper-Air Disinfection:

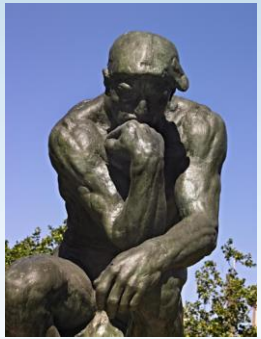
The Mixed Air System Challenge

- To minimize pathogen concentration maximum air mixing must occur for distribution and dilution of contaminant

BUT, WHAT IF?

- Rooftop package units cycle (On/Off)
- VAV boxes reduce air flow to satisfy part load conditions

- **Will contaminate concentrations vary due to reduced mixing at part load and low flow?**



UV-C Layout: Light Density & Design Considerations

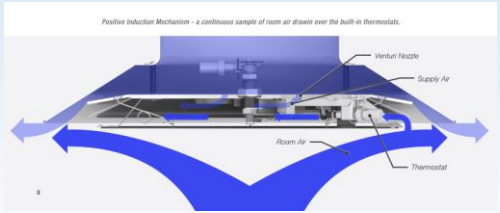
Air Disinfection: ASHRAE – Filtration & Disinfection

Upper-Air Disinfection

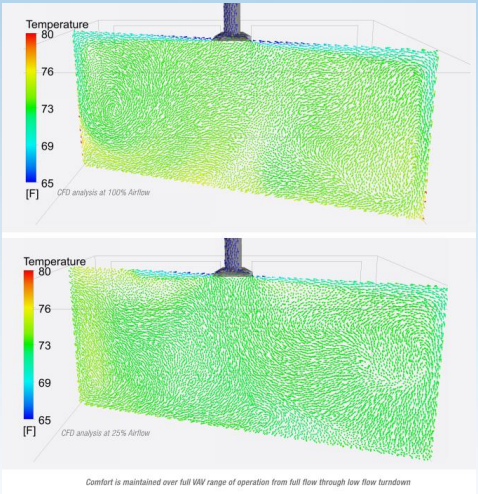
The Mixed Air System Challenge

To optimize mixing consider using low pressure VAV diffusers

- VAV diffusers maintain discharge velocity even at 25% of design flow
- Room air is continuously induced into the supply jet even at 25% of flow



(Source: Acutherm VAV Diffusers)



100% Flow

25% Flow

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Maintenance & Safety

Maintenance & Safety

UV-C Bulb Effectiveness:

- **Change bulbs annually**
  - Lamp output decreases up to 80% by 9000 hours
  - Attempting to run UV-C lamps longer than 9,000 hours will produce individual lamp outages
  - Consider using Fluorinated Ethylene Propylene (FEP coating over the glass envelop in case of breakage

Maintenance & Safety

Safety:

- **FACTILITY STAFF NEED TO BE TRAINED**
  - Wear proper eye protection when inspecting UV-C lamps
  - Ensure they are turned off during replacement and AHU service.
  - Controls: A typical control package includes a cutoff switch located just outside the plenum door.
  - Include door interlock switches that turn off the lights when an access door is opend
  - Access doors can also be equipped with UV-C blocking view ports to facilitate inspection

Conclusion

Ultraviolet Germicidal Irradiation (UVGI):

- Recommended by the Center for Disease Control (CDC)
- Endorsed by ASHRAE as a good pathogen mitigation solution
- Reasonable first cost
- Ease of operation and maintenance
- ASHRAE will expand research on UVC technology to expand its application with IUVA
- Design and support services available

Thank you.