

The logo for the ASHRAE Learning Institute is a hexagonal shape with a textured, grey, stone-like background. Inside the hexagon is a white outline of a hexagon. The word "ASHRAE" is written in white, bold, sans-serif capital letters across the middle of the white hexagon. Below it, the words "Learning Institute" are written in a smaller, white, sans-serif font.

V in HVAC – What, Why, Where, How, and How Much

Hoy Bohanon, P.E., Member ASHRAE

Copyright

- Copyright © 2019, 2020 and 2021 by ASHRAE. All rights reserved. No part of this presentation may be reproduced without written permission from ASHRAE, nor may any part of this presentation be reproduced, stored in a retrieval system, or transmitted in any form or by any means (electronic, photocopying, recording, or other) without written permission from ASHRAE.
- ASHRAE has compiled this presentation with care, but ASHRAE has not investigated and ASHRAE expressly disclaims any duty to investigate any product, service, process, procedure, design or the like, that may be described herein. The appearance of any technical data or editorial material in this presentation does not constitute endorsement, warranty or guaranty by ASHRAE of any product, service, process, procedure, design, or the like. ASHRAE does not warrant that the information in this publication is free of errors. The user assumes the entire risk of the use of the use of any information in this presentation.

AIA/CES Registered Provider

- ASHRAE is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Attendance for non-AIA members are available on request.
- This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



EDUCATION PARTNER

V in HVAC – What, Why, Where, How and How Much

By ASHRAE

GBCI cannot guarantee that course sessions will be delivered to you as submitted to GBCI. However, any course found to be in violation of the standards of the program, or otherwise contrary to the mission of GBCI, shall be removed. Your course evaluations will help us uphold these standards.

Course ID: 920020737

Approved for:

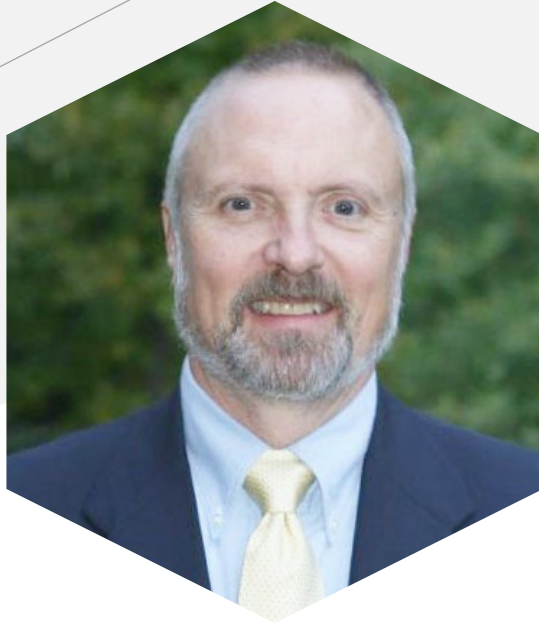
3

General CE hours

0

LEED-specific hours

☐☐☐☐☐☐



Hoy Bohanon, PE

ASHRAE Life Member

President of Hoy Bohanon Engineering a firm that works closely with clients to promote healthy, sustainable environments and improve energy efficiency with a focus on existing mission-critical buildings.

He is past chair of SSPC 62.1 *Ventilation for Acceptable Indoor Air Quality*, past member of ASHRAE's Environmental Health Committee, member of ASHRAE 62.2 *Ventilation and Acceptable Indoor Air Quality in Residential Buildings* and an ASHRAE Distinguished Lecturer.



Marwa Zataari, PhD ASHRAE Member

Dr. Marwa Zaatari is a partner in D-Zine Partners, a nationwide boutique design firm dedicated to delivering performance-based solutions to achieve IAQ and energy efficiency goals. She serves on multiple ASHRAE committees and their Epidemic Task Force. She is a member of the USGBC Board. Dr. Zaatari is an expert in building energy and environmental management, HVAC ventilation, filtration and air cleaning.

LEARNING OBJECTIVES

At the end of this course the attendee should be able to:

1. Explain the three major types of contaminants in the air and give an example of a source for each.
2. List the five major requirement sections of ASHRAE Standard 62.1-2019
3. Understand that different approaches to HVAC design using the Ventilation Rate Procedure result in different quantities of outside air at the outside air intake
4. Contrast the Ventilation Rate Procedure, the Indoor Air Quality Procedure, and the Natural Ventilation Procedure

COURSE OUTLINE

1. Why do we ventilate and where did the numbers come from?
2. Fundamental IAQ principles
 - ***acceptable indoor air quality***: air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction
 - Indoor air quality has two components – Health and Perception
 - What's in the Air?
 - What are the sources of the things in the air?
 - How do people respond to the indoor environment?
3. ASHRAE 62.1-2019
 - Section 4 outdoor environment design requirements
 - Section 5 systems and equipment design requirements
 - Section 6 procedures for calculating ventilation
 - Sections 7 & 8 Commissioning, and O&M requirements
4. Wrap-up and descriptions of more advanced courses.

1. Why Do We Ventilate and from Where Did the Numbers Come?

ASHVE

- Established _____

ASHVE

- Established 1894

Why?

- Sign of the times
- Heating systems
- Ventilation systems





Compulsory School

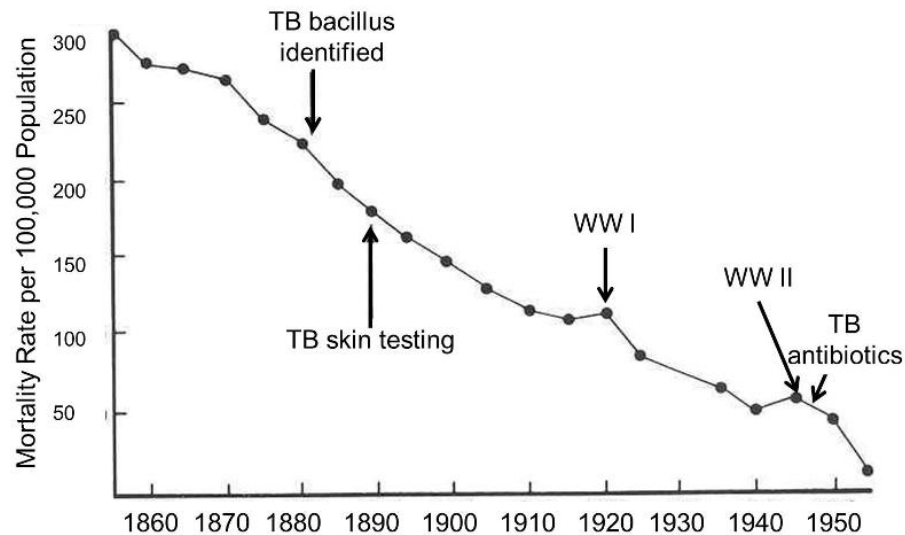
- By 1900, __ states had compulsory schooling laws;

Compulsory School

- By 1900, 34 states had compulsory schooling laws;

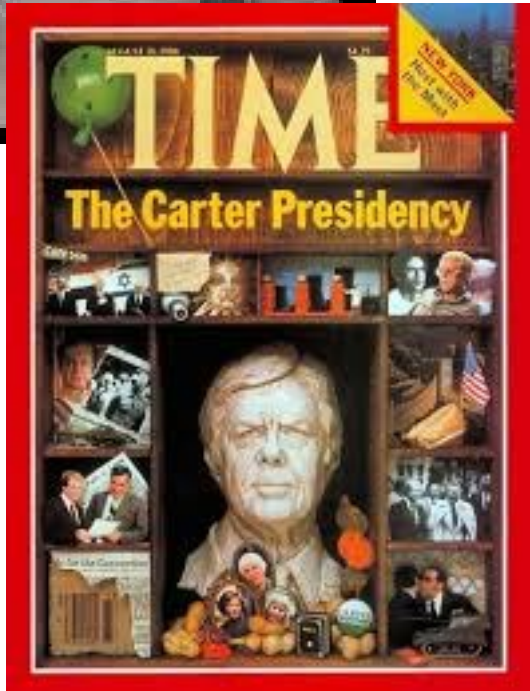


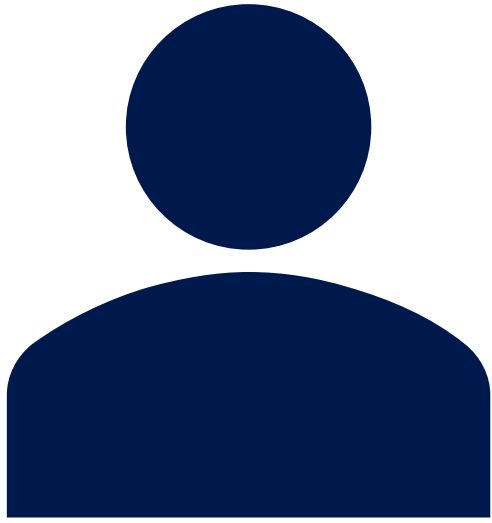




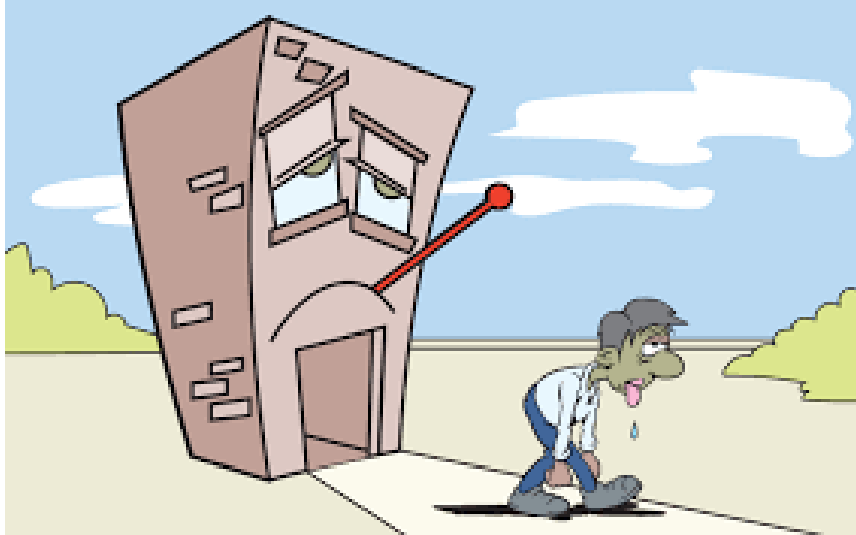
Ventilation Rates (cfm/person)

- ASHVE (1895) 30 cfm/person
- IAQ = f(T, Volume, RH) ?
- Yaglou (1936) Adults 12-20 cfm/p Children 17-25 cfm/p
- ASHRAE 62-1973 15 minimum, 20 recommended
- ASHRAE 62-1981 _____
- ASHRAE 62-1989 _____
- ASHRAE 62.1-2004 _____





5 cfm per person



1980's Research

- W. Cain, et. al (1983) and P.O. Fanger, et. al, (1983) published results of new studies that generally confirmed Yaglou's early results. Cain working at Yale University and Fanger at the Technical University of Denmark both agreed that 15 cfm (7.5 L/s) of outdoor air was needed to dilute occupant odors to a concentration acceptable to 80% (20% dissatisfied) of the "visitors" entering an occupied space. These new data did not, however confirm Yaglou's dependence on air space. Thus, Standard 62-1989 adopted 15 cfm (7.5 L/s) per occupant of outdoor air as the minimum.

62-1989

- Put it back the way it was
- 15 cfm/person for schools and other occupancies
- 20 cfm/person for offices and similar occupancies

- *“Those who cannot remember the past are condemned to repeat it.”*

George Santayana (1906)

- *"If I have seen further it is by standing on the shoulders of Giants."*

Sir Issac Newton

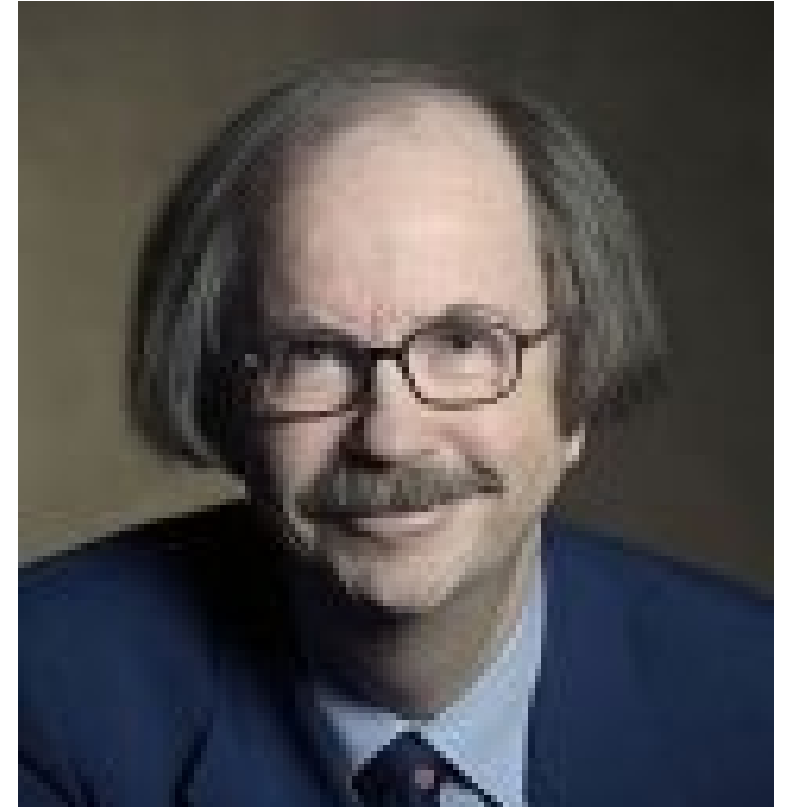
Jan Sundell

The modern scientific history started in the 1970s with a question: “did indoor air pose a threat to health as did outdoor air?” Soon it was recognized that indoor air is more important, from a health point of view, than outdoor air. Topics of concern were first radon, environmental tobacco smoke, and lung cancer, followed by volatile organic compounds, formaldehyde and sick building syndrome, house dust-mites, asthma and allergies, Legionnaires disease, and other airborne infections. Later emerged dampness/mold-associated allergies and today's concern with “modern exposures-modern diseases.” Ventilation, thermal comfort, indoor air chemistry, semi-volatile organic compounds, building simulation by computational fluid dynamics, and fine particulate matter are common topics today. From their beginning in Denmark and Sweden, then in the USA, the indoor air sciences now show increasing activity in East and Southeast Asia.



P. Ole Fanger

- **PAVEL OLE FANGER**, widely considered the world's leading expert on the effects of indoor environments on human comfort, health, and productivity, died September 18, 2006, at the age of 72, during his second visit to Syracuse University in his new role as a University Professor.
- He guided more than 100 M.S. and Ph.D. students, published 12 books or book chapters, was author or coauthor of more than 300 technical papers, and presented more than 300 invited lectures.



William S. Cain, PhD

William S. Cain, PhD, is a professor of surgery (otolaryngology) at the University of California, San Diego, where his research focuses on the human sense of smell and the irritation sense. His work has had application to indoor air quality, use of odors to warn of hazards, aging and the perception of food, and the evaluation of olfactory functioning in patients.



Times Change: Where would you want to be in February 2020?



Coronavirus (COVID-19) Response Resources from ASHRAE and Others

ASHRAE has developed proactive guidance to help address coronavirus disease 2019 (COVID-19) concerns with respect to the operation and maintenance of heating, ventilating and air-conditioning systems.

To learn more visit:

<https://www.ashrae.org/covid19>

2. *Ventilation, Filtration, Air Cleaning*

- 2.1 Provide and maintain at least required minimum outdoor airflow rates for ventilation as specified by applicable codes and standards.
- 2.2 Use combinations of filters and air cleaners that achieve MERV 13 or better levels of performance for air recirculated by HVAC systems.
- 2.3 Only use air cleaners for which evidence of effectiveness and safety is clear.
- 2.4 Select control options, including standalone filters and air cleaners, that provide desired exposure reduction while minimizing associated energy penalties.

4. *HVAC System Operation*

- 4.1 Maintain temperature and humidity design set points.
- 4.2 Maintain equivalent clean air supply required for design occupancy whenever anyone is present in the space served by a system.
- 4.3 When necessary to flush spaces between occupied periods, operate systems for a time required to achieve three air changes of equivalent clean air supply.
- 4.4 Limit re-entry of contaminated air that may re-enter the building from energy recovery devices, outdoor air, and other sources to acceptable levels.

Where did the ventilation numbers come from in Standard 62?

- 62-2004
- With input from Cain, Fanger, Sundell, and many others in the 1990's, ASHRAE SSPC 62 established that there were two main sources of pollutants and that they should be added together
- People – based on requirements for adapted occupants
- Building – based on low-emitting European Buildings

Requirements – Ventilation Rate

- **6.2.1.1 Breathing Zone Outdoor Airflow.** The design outdoor airflow required in the *breathing zone* of the occupiable space or spaces in a zone, i.e., the *breathing zone outdoor airflow* (V_{bz}), shall be determined in accordance with Equation 6-1.

- $$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \quad (6-1)$$

where:

- A_z = *zone floor area*: the net occupiable floor area of the zone (ft^2).
- P_z = *zone population*: the largest number of people expected to occupy the zone during use.
- R_p = outdoor airflow rate required per person as determined from Table 6-1.
- R_a = outdoor airflow rate required per unit area as determined from Table 6-1.

WORKSPACES

Research: Stale Office Air Is Making You Less Productive

by Joseph G. Allen

MARCH 21, 2017



How often do you consider the air quality in your office and how it affects employees and their productivity? Chances are it's not often.

2. Fundamental IAQ Principles

Definitions

- ***Acceptable indoor air quality:*** air in which there are no known **contaminants** at harmful **concentrations** as determined by **cognizant authorities** and with which a substantial majority (80% or more) of the people exposed **do not express dissatisfaction**.

Definitions

- ***Contaminant:*** an unwanted airborne constituent that may reduce acceptability of the air.
- ***Concentration:*** the quantity of one constituent dispersed in a defined amount of another.

Definitions

- ***Cognizant authority:*** an agency or organization that has the expertise and jurisdiction to establish and regulate concentration limits for airborne contaminants or an agency or organization that is recognized as authoritative and has the scope and expertise to establish guidelines, limit values, or concentration levels for airborne contaminants.

Indoor Air Quality has Two Components: Health and Perception

- Health effects can be acute or chronic
- Perception is influenced by environment and culture

What's in the Air?

- Gases
- Particles
- Organisms

Composition of Air

N_2

O_2

Ar

H_2O

CO_2

Ne

He

CH_4

Kr

H_2

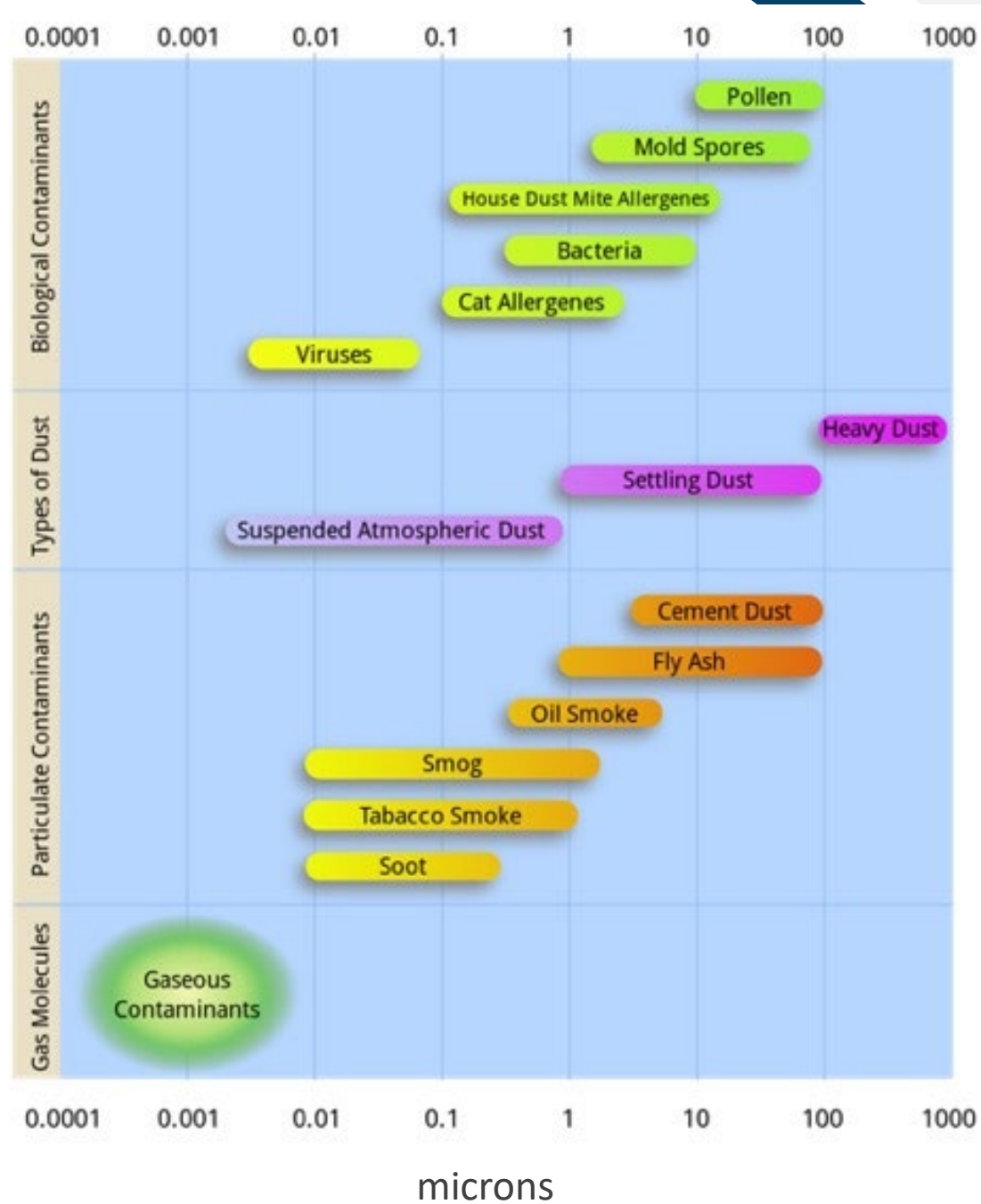
And many
others

Gases

- What is an organic compound?
- VOC
- SVOC
- Aldehydes
- Sulfur compounds
- Other
- Health Effects

Particles

- PM
- PM₁₀
- PM_{2.5}
- PM₁ ultrafine
- Condensable particulate
- Particles with gas molecules attached
- Health Effects



Organisms

- Bioaerosols
- Viable
- Nonviable
- Bacteria
- Fungi
- Virus

What are the sources of the things in the air?

- Outdoors
- Buildings
- People
- Equipment

Outdoor Sources

- Anthropogenic
 - Transportation
 - Industry
 - Fires (cooking/heating)
 - Waste disposal
- Biogenic
 - Farms
 - Plants
 - Animals

Building Sources

- Building materials
- Furnishings
- Cleaning
- Occupant activity
 - Cooking
 - Devices that add substances to the air
 - Operating equipment (everything from copiers to ice resurfacing machines)

People Sources

- Particles
- VOCs
- Other Gases
- Bacteria
- Fungi

HVAC Equipment Sources

- Mold
- Legionella
- Particles

How to people respond to the indoor environment?

- People respond to IEQ (indoor environmental quality)
 - Sight,
 - sound,
 - thermal sensations,
 - odors
- Often the interactions between the senses affect reporting of perception when people are asked about the quality of the air

3. ASHRAE 62.1-2019

ASHRAE Standard 62.1-2019

- Ventilation for Acceptable Indoor Air Quality
- Code-Intended Standard
- Minimum Requirements in Mandatory Language
- Contains some informative text
- Corresponding User's Manual for application explanation and examples

2. SCOPE

- **2.1** This standard applies to spaces intended for human occupancy within buildings except those within dwelling units in residential occupancies in which occupants are nontransient.
- **2.2** This standard defines requirements for ventilation and air-cleaning-system design, installation, commissioning, and operation and maintenance.
- **2.3** In addition to ventilation, this standard contains requirements related to certain contaminants and contaminant sources, including outdoor air, construction processes, moisture, and biological growth.
- **2.4** This standard does not prescribe specific ventilation rate requirements for:
 - Spaces that contain smoking or that do not meet the requirements in the standard for separation from spaces that contain smoking
 - Patient care areas not listed in this standard
 - Laboratories with hazardous materials

ASHRAE 62.1-2019

- Section 4 outdoor environment design requirements
- Section 5 systems and equipment design requirements
- Section 6
 - Ventilation Rate Procedure
 - Single Zone
 - 100% Outdoor Air
 - Multiple Zone Recirculating
 - Natural Ventilation Procedure
 - IAQ Procedure
 - Exhaust
- Sections 7 & 8 Commissioning, and O&M requirements

Section 4. Outdoor Air Quality

- Regional air quality
- Local air quality
- Documentation





Regional Air Quality

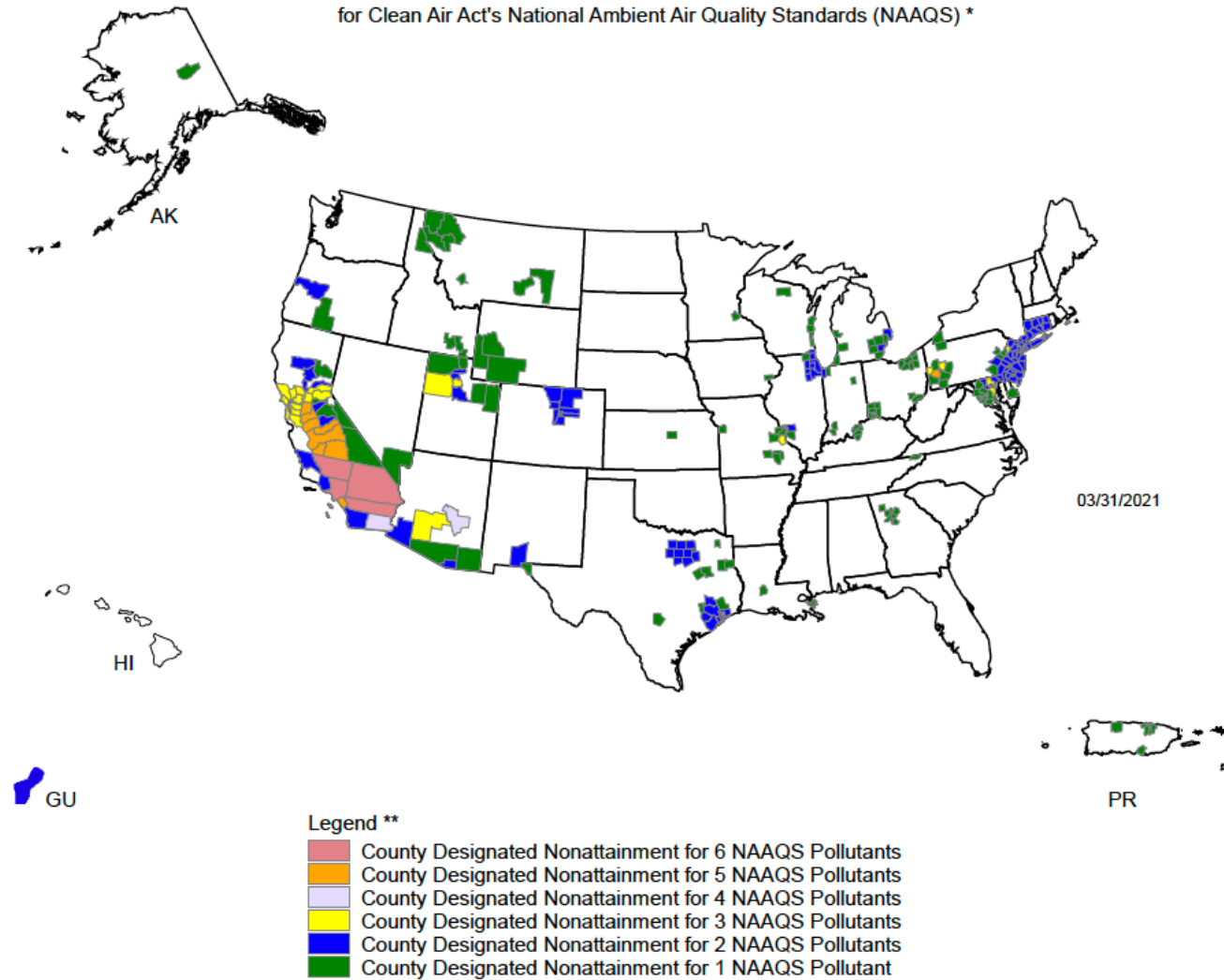
- Attainment status is determined by EPA
- The status changes at least annually
- The following maps are from the EPA website: <https://www.epa.gov/outdoor-air-quality-data>
- For exact boundaries, consult EPA website and/or Federal Register
- Boundaries are usually, but not always, designated by county

Example Buildings for Ventilation Courses

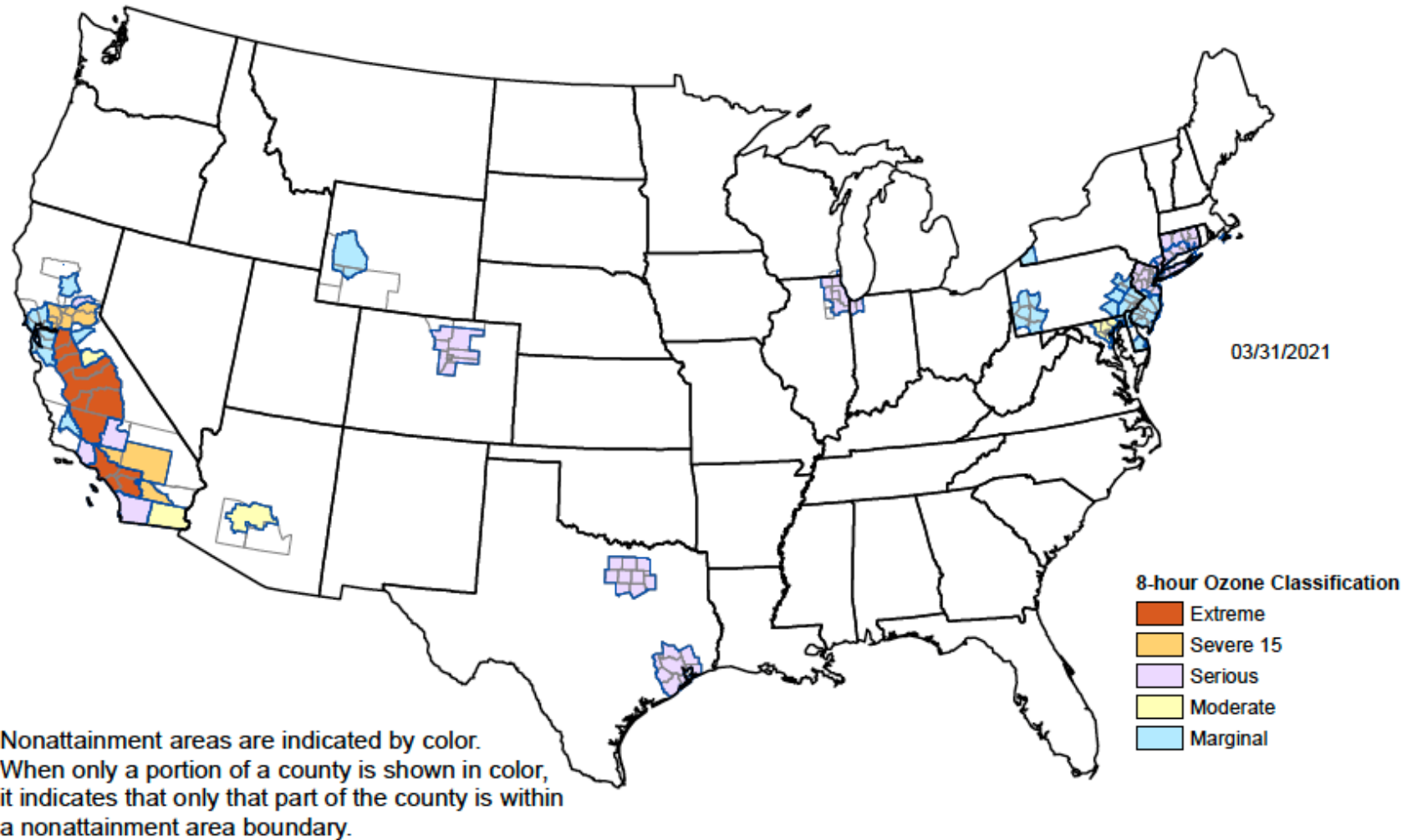
Building Types	Building Locations
Medium Office	Washington/Baltimore
Large Office	Chicago
School	Seattle
Outpatient Healthcare	Miami

Counties Designated "Nonattainment"

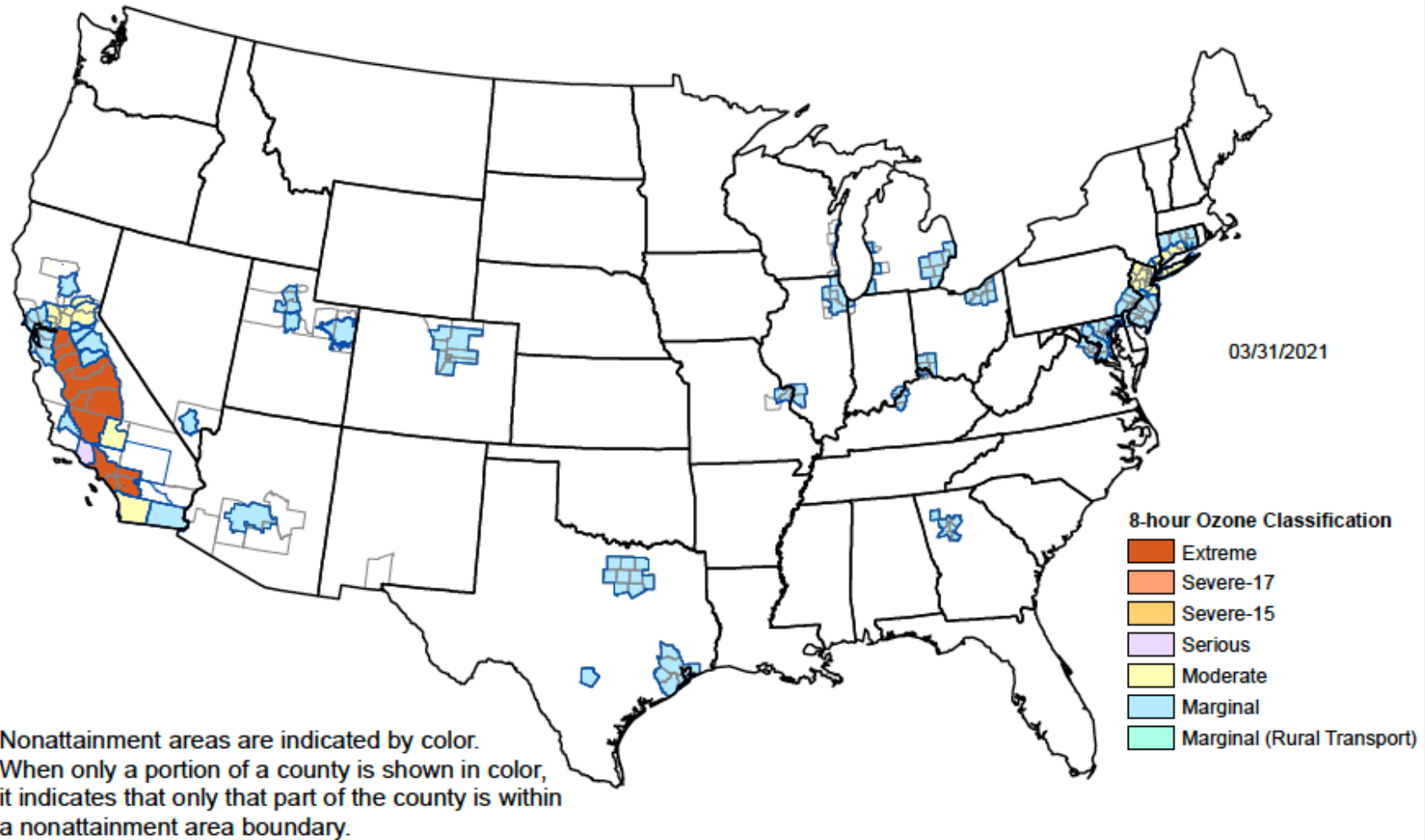
for Clean Air Act's National Ambient Air Quality Standards (NAAQS) *



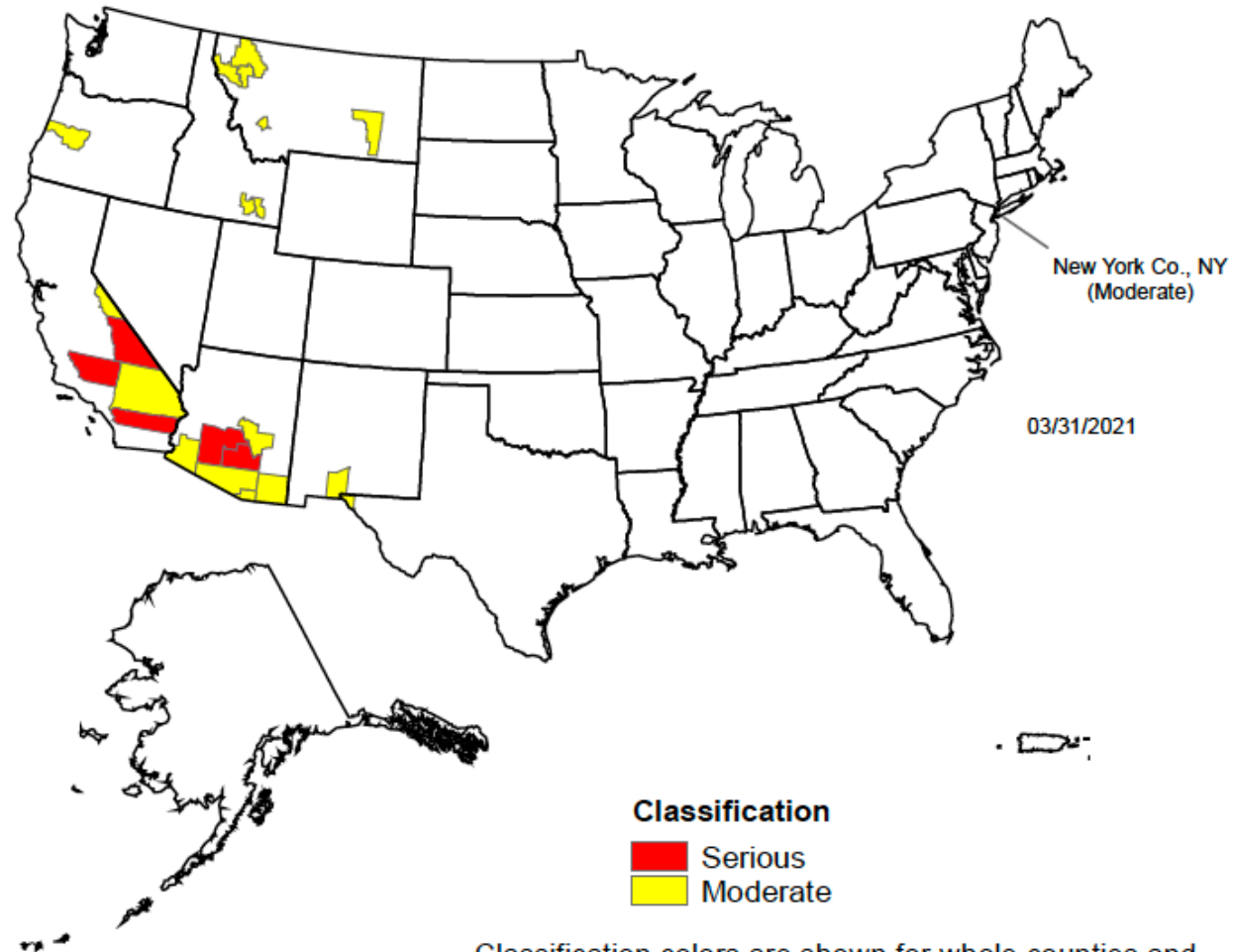
8-Hour Ozone Nonattainment Areas (2008 Standard)



8-Hour Ozone Nonattainment Areas (2015 Standard)

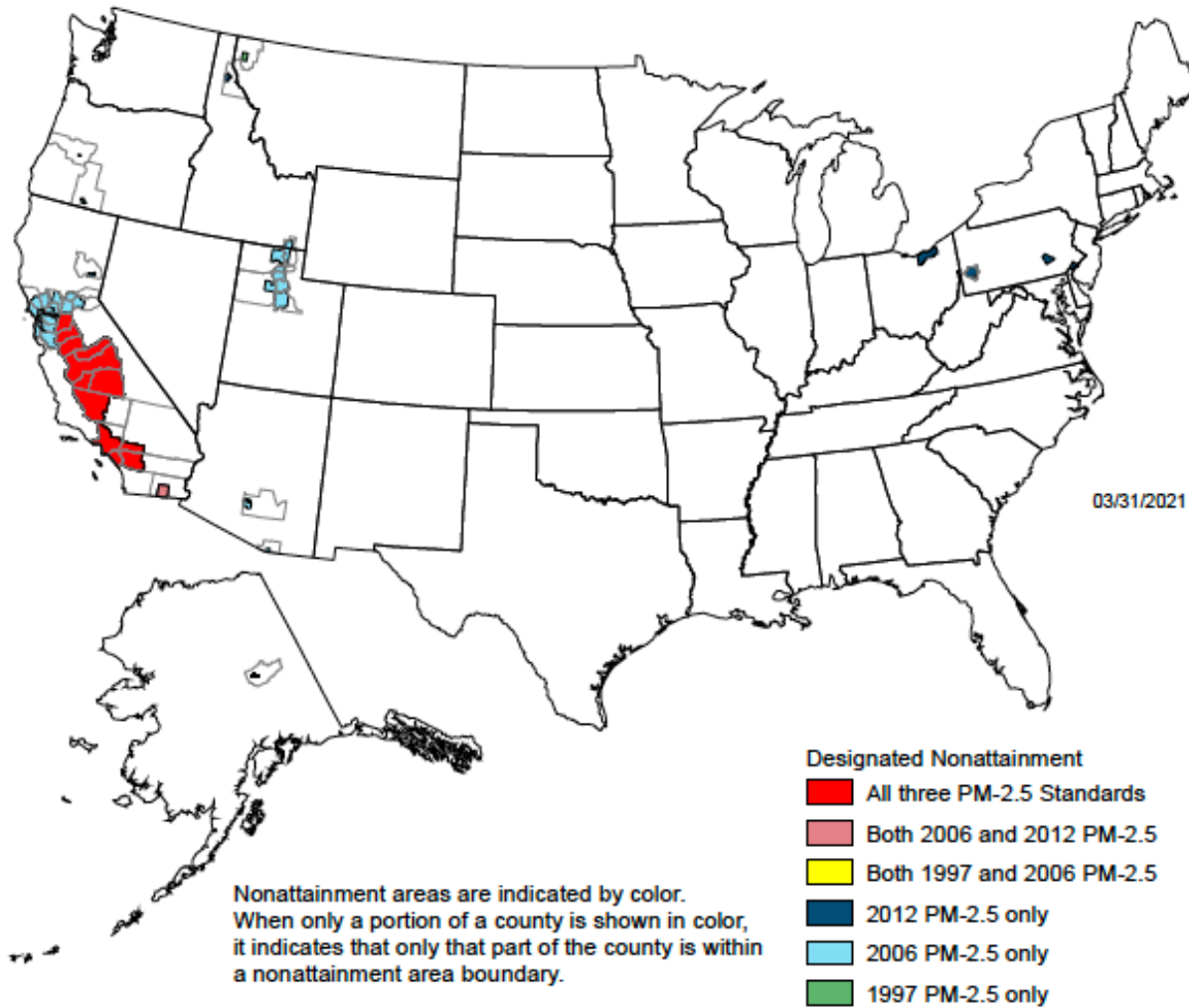


Counties Designated Nonattainment for PM-10

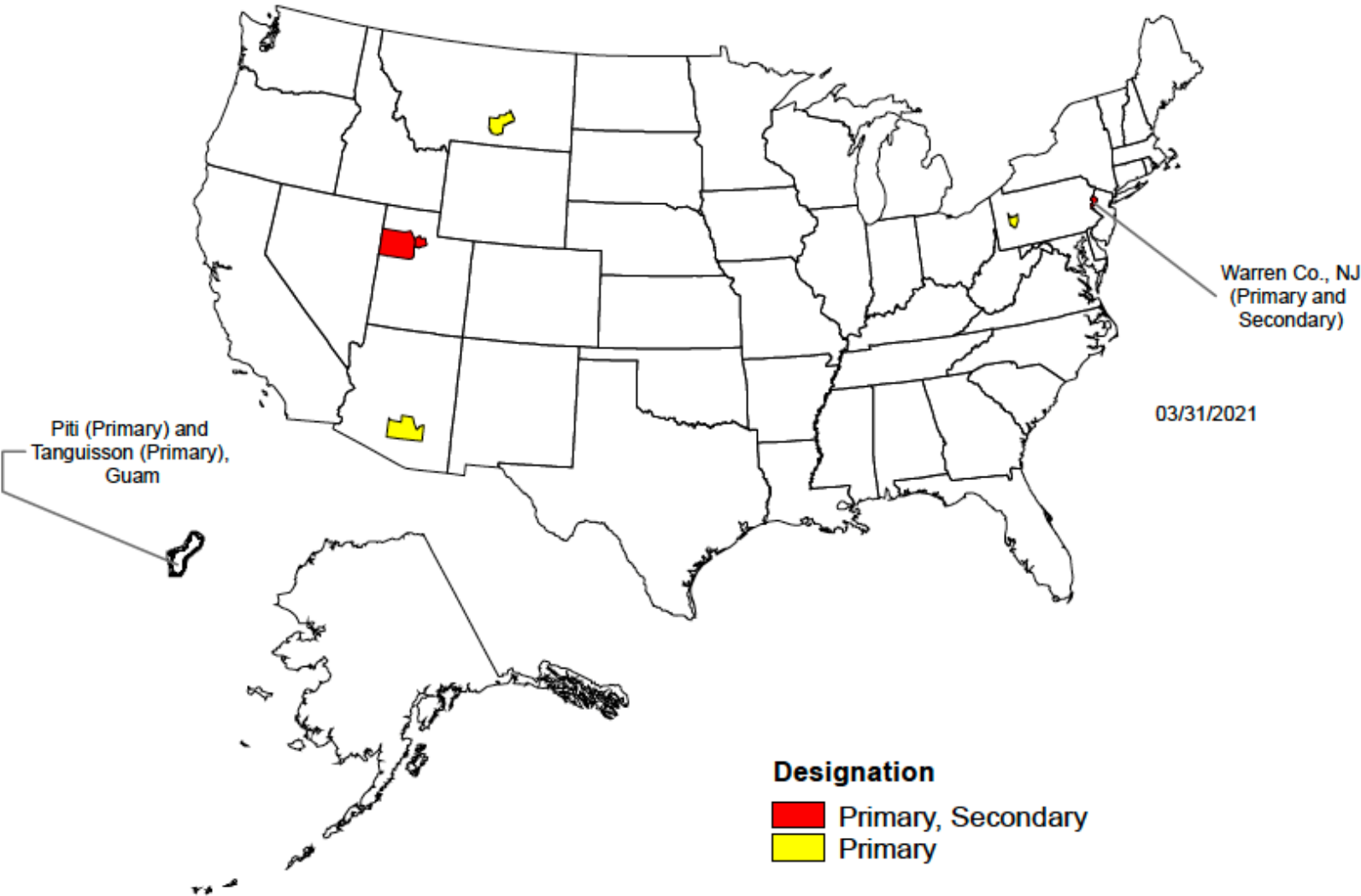


Classification colors are shown for whole counties and denote the highest area classification that the county is in

Counties Designated Nonattainment for PM-2.5 (1997, 2006, and/or 2012 Standards)



Counties Designated Nonattainment for SO2



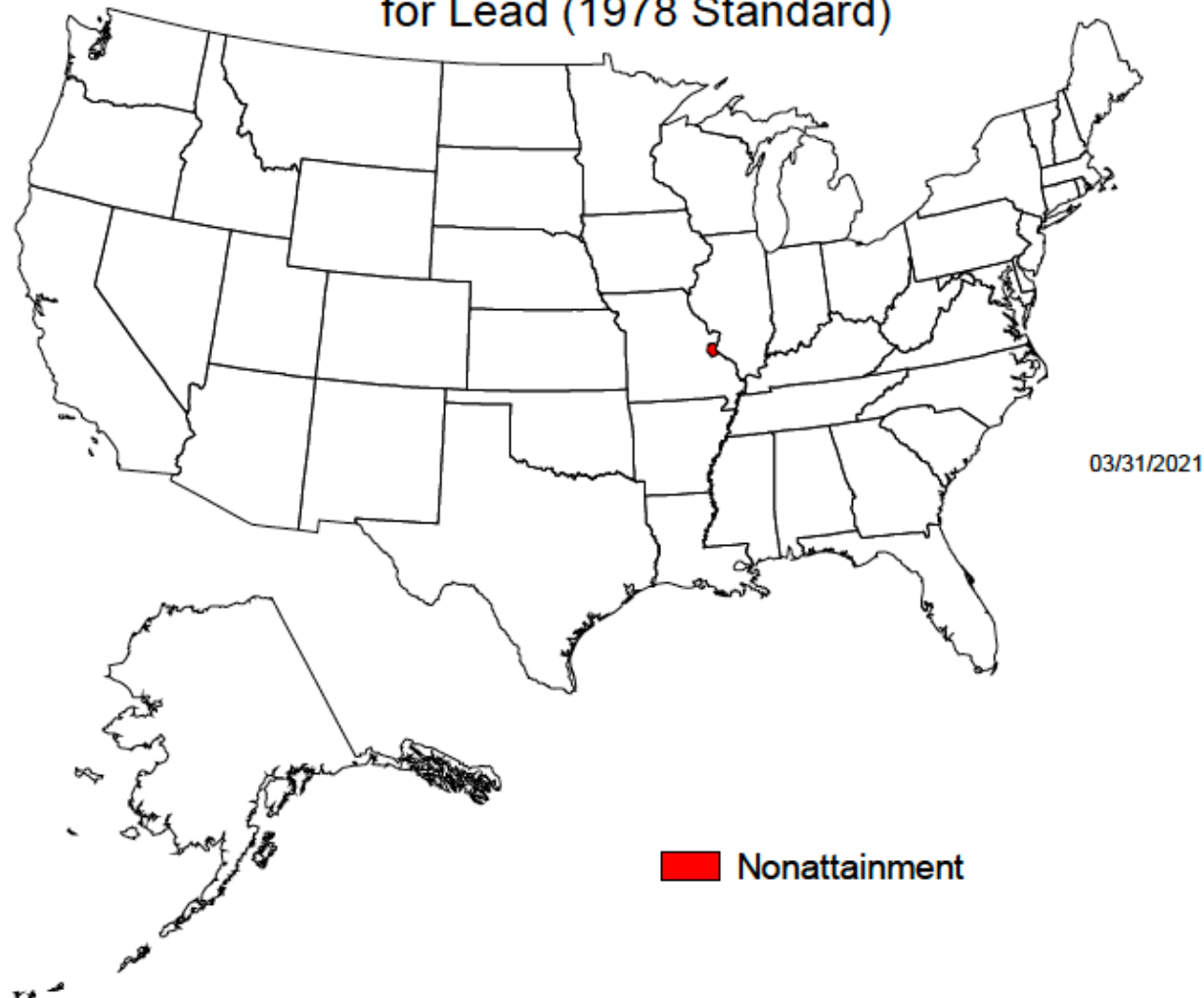
SO2 Nonattainment Areas (2010 Standard)



 SO2 Nonattainment Areas

Nonattainment areas are indicated by color.
When only a portion of a county is shown in color,
it indicates that only that part of the county is within
a nonattainment area boundary.

Counties Designated Nonattainment for Lead (1978 Standard)



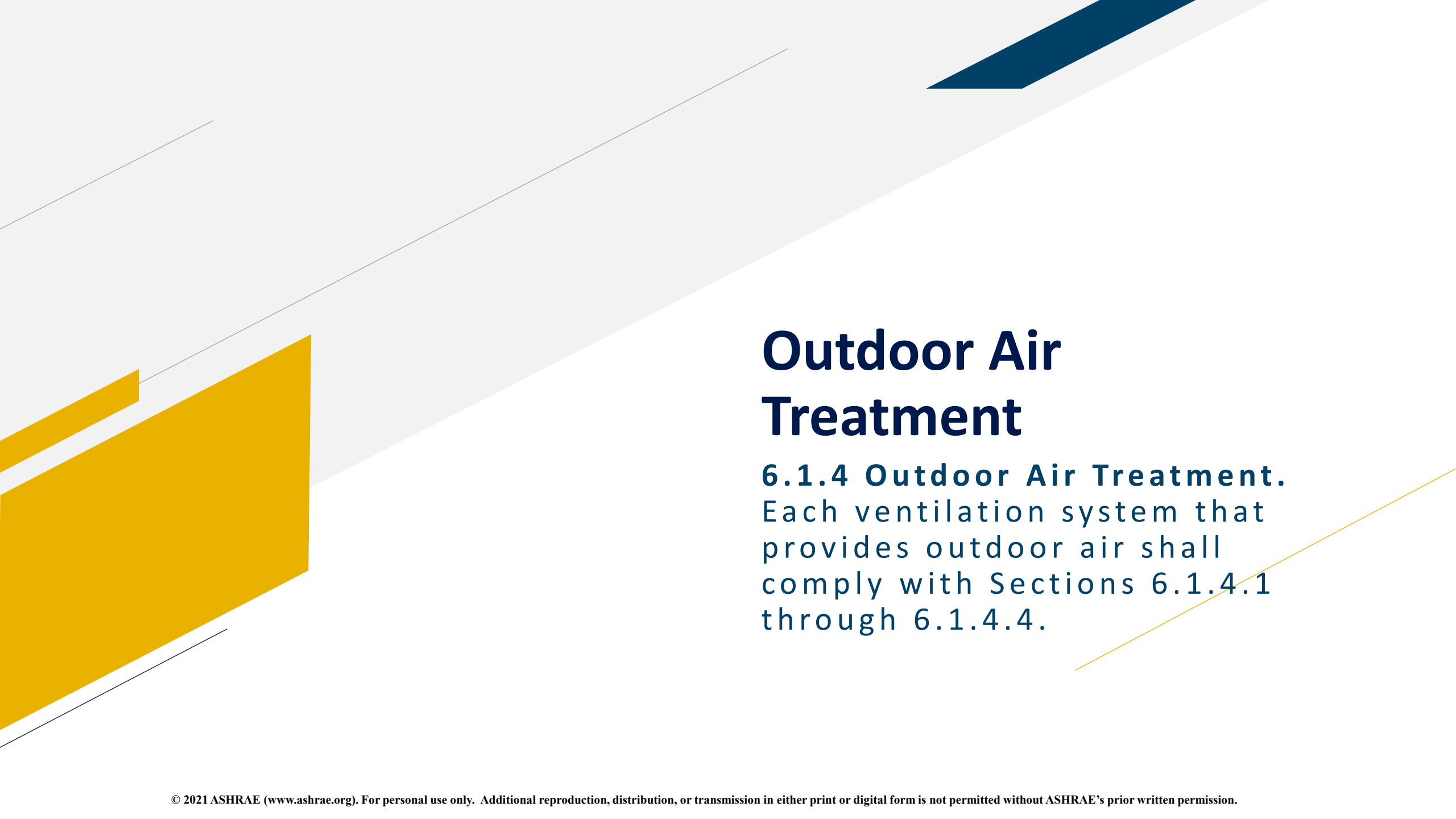
The portions of a county designated nonattainment are indicated by color on this national map. The counties with nonattainment areas are circled. The double circles indicate that there are two nonattainment areas within the same county. The State maps provide details of the smaller nonattainment areas within the county boundaries.

Carbon Monoxide (CO)

None

Nitrogen Dioxide (NO₂)

None



Outdoor Air Treatment

6.1.4 Outdoor Air Treatment.
Each ventilation system that provides outdoor air shall comply with Sections 6.1.4.1 through 6.1.4.4.

Particulate Matter PM₁₀

- **6.1.4.1 Particulate Matter Smaller than 10 Micrometers (PM10).** In buildings located in an area where the national standard or guideline for PM10 is exceeded, particle filters or air-cleaning devices shall be provided to clean the outdoor air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have either
 - a. a MERV of not less than 8 where rated in accordance with ASHRAE Standard 52.2 or
 - b. the minimum efficiency within ISO ePM10 where rated in accordance with ISO 16890

Particulate Matter PM_{2.5}

- **6.1.4.2 Particulate Matter Smaller than 2.5 Micrometers (PM_{2.5}).** In buildings located in an area where the national standard or guideline for PM_{2.5} is exceeded, particle filters or air-cleaning devices shall be provided to clean the outdoor air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have either
 - a. a MERV of not less than 11 where rated in accordance with ASHRAE Standard 52.2 or
 - b. the minimum efficiency within ISO ePM_{2.5} where rated in accordance with ISO 16890

Ozone

- **6.1.4.3 Ozone.** Air-cleaning devices for ozone shall be provided when the most recent three-year average, annual fourth-highest daily maximum 8-hour average ozone concentration exceeds 0.107 ppm (209 $\mu\text{g}/\text{m}^3$).
- Such air-cleaning devices shall have a minimum volumetric ozone removal efficiency of 40%.

Ozone Exceptions

Air cleaning for ozone is not required when:

- a) The system design outdoor air intake flow results in 1.5 ach or less.
 - b) Controls are provided that sense outdoor ozone level and reduce intake airflow to result in 1.5 air changes per hour or less while complying with the outdoor airflow requirements of Section 6.
 - c) Outdoor air is brought into the building and heated by direct-fired, makeup air units.
- **Informative Note:** In the U.S., a most recent three-year average annual fourth-highest daily maximum eight-hour average ozone concentration exceeding 0.100 ppm ($195 \mu\text{g}/\text{m}^3$) equates to a USEPA eight-hour ozone classification of “Serious” or higher (Severe 15, Severe 17, or Extreme).

Questions

- What are outdoor air filtration requirements in Example Building Medium Office located in Washington/Baltimore?

Outdoor Air Quality Information

- For information regarding outdoor air measured levels: <https://www.epa.gov/outdoor-air-quality-data>
- For information regarding air quality in Canada:
• <https://www.canada.ca/en/services/environment/weather/airquality.html>

CAAQS

CCME developed Canadian Ambient Air Quality Standards (CAAQS) for PM_{2.5}, O₃, SO₂ and NO₂. All CAAQS consist of three interrelated elements:

- an averaging time period
- a numerical value
- the statistical form of the numerical standard.



Pollutant	Averaging Time	Numerical Value			Statistical Form
		2015	2020	2025	
Fine Particulate Matter (PM _{2.5})	24-hour	28 µg/m ³	27 µg/m ³		The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
	Annual	10.0 µg/m ³	8.8 µg/m ³		The 3-year average of the annual average of all 1-hour concentrations
Ozone (O ₃)	8-hour	63 ppb	62 ppb	60 ppb	The 3-year average of the annual 4th highest of the daily maximum 8-hour average ozone concentrations
Sulphur Dioxide (SO ₂)	1-hour	-	70 ppb	65 ppb	The 3-year average of the annual 99th percentile of the SO ₂ daily maximum 1-hour average concentrations
	Annual	-	5.0 ppb	4.0 ppb	The average over a single calendar year of all 1-hour average SO ₂ concentrations
Nitrogen Dioxide (NO ₂)	1-hour	-	60 ppb	42 ppb	The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations
	Annual	-	17.0 ppb	12.0 ppb	The average over a single calendar year of all 1-hour average concentrations

Canada

- While the Canadian Ambient Air Quality Standards (CAAQS) are set at lower (more stringent) levels than the National Ambient Air Quality Standards (NAAQS) in the United States, direct comparisons are difficult as both countries have significantly different air quality, legislative, and regulatory frameworks.
- Additionally, under the American *Clean Air Act*, penalties can be levied on states where the NAAQS are not being met.
- Under the 1999 *Canadian Environmental Protection Act*, the CAAQS are voluntary guidelines.

Section 5. systems and equipment design requirements

- Outdoor air intakes
- Air classification
- Ventilation system controls
- Exhaust systems
- Moisture control
- Dirt control

Outdoor Air Intakes

- Location—Table 5.5.1
- Appendix B (normative)
- Rain entrainment
- Rain intrusion
- Snow entrainment

Air Classification and Recirculation (5.16)

- **Class 1:** Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.
- **Class 2:** Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.

Air Classification and Recirculation (5.16)

- **Class 3:** Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
- **Class 4:** Air with highly objectionable fumes or gases or with potentially dangerous particles, bio aerosols or gases, at concentrations high enough to be considered harmful.

Example Building Medium Office?

- What are outdoor air intake location restrictions for this building?
- Table 5.5.1 lists (partial) exhaust vents, chimneys, garage entry, loading dock, street, landscaped grade, roof, dumpster, cooling tower

What Are OA Intake Restrictions?

- Class 2 exhaust/relief outlet
- Class 3 exhaust/relief outlet
- Class 4 exhaust/relief outlet
- Chimneys and flues
- Truck loading area
- Driveway, street
- Thoroughfare with high traffic
- Garbage dumpster
- Cooling tower

Recirculation Limitations

- Class 1 air may be recirculated or transferred to any space.
- Class 3 air may be recirculated within the space of origin. Class 3 air shall not be recirculated or transferred to any other space.
- Class 4 air shall not be recirculated or transferred to any space nor recirculated within the space of origin.

Recirculation Limitations—Class 2

- **5.18.3.2.1** Recirculation of Class 2 air within the space of origin shall be permitted.
- **5.18.3.2.2** Recirculation or transfer of Class 2 air to other Class 2 or Class 3 spaces shall be permitted, provided the other spaces are used for the same or similar purpose or task and involve the same or similar pollutant sources as the Class 2 space.

Recirculation Limitations—Class 2

- **5.18.3.2.3** Transfer of Class 2 air to toilet rooms shall be permitted.
- **5.18.3.2.4** Recirculation or transfer of Class 2 air to Class 4 spaces shall be permitted.
- **5.18.3.2.5** Class 2 air shall not be recirculated or transferred to Class 1 spaces.
- **5.18.2.3** Ancillary Spaces. Redesignation of Class 1 air to Class 2 air shall be permitted for Class 1 “spaces that are ancillary to Class 2 spaces.”

Redesignation

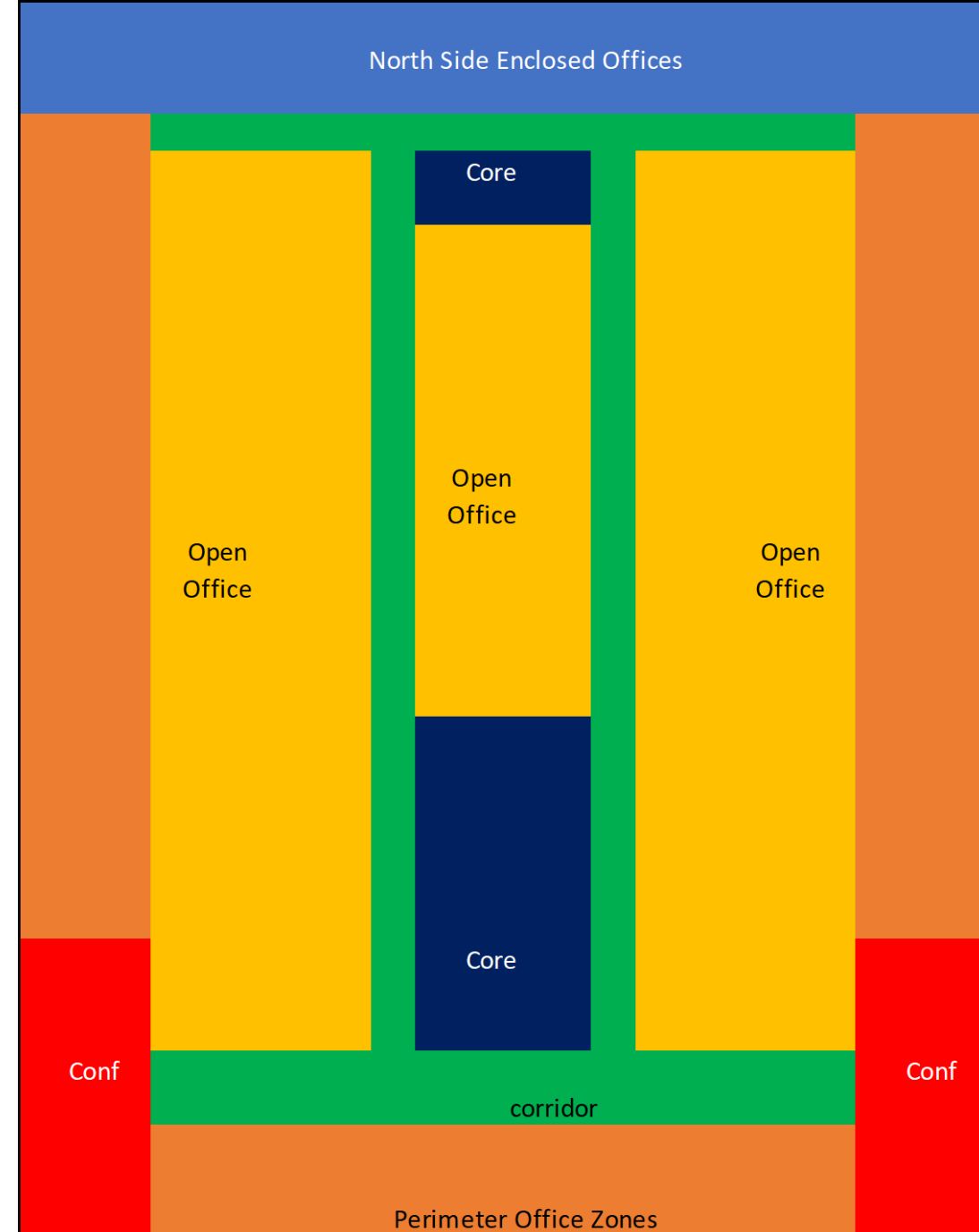
- Air cleaning may be used to reclassify
- Energy recovery air leakage limitation
 - Recirculated Class 2 air shall not exceed 10% of the outdoor air intake flow
 - Recirculated Class 3 air shall not exceed 5% of the outdoor air intake flow
 - Note that the recirculated air does not count as outdoor air
- Transfer
 - Mixtures must be classified as highest

Example – Schwedler Office Building

- Hypothetical example is based on DOE/PNNL prototype medium office building
- 53,600 square feet
- 268 people
- Location – Baltimore (Washington DC) area
- Climate Zone 4A



Office Zones - One floor out of three

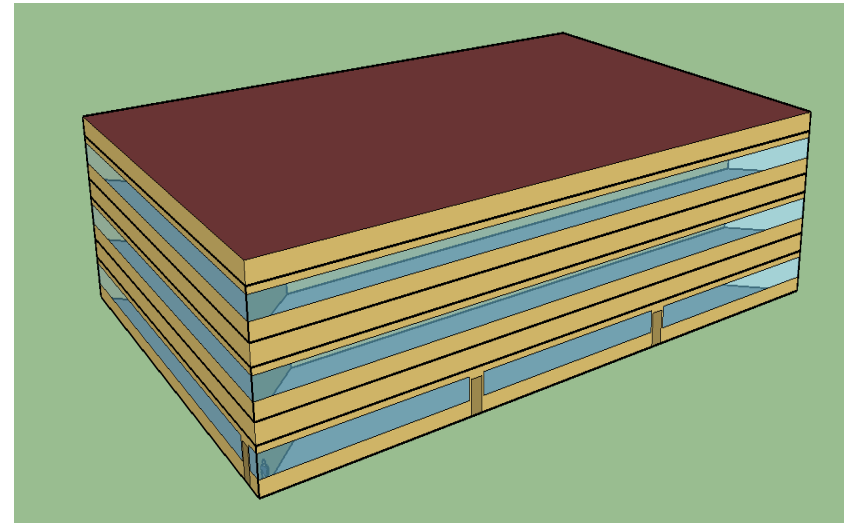


Example Schwedler Office Building

Zones	Area, ft ²	Design Population
North Enclosed Office	1650	7
Conference	1200	60
Core	1100	0
Corridor	2350	0
Perimeter Office	4350	22
Interior Open Office	6950	50
Total	17600	139

Example Schwedler Office Building

- All listed spaces are Class 1
- What about auxiliary spaces?
- Which are not Class 1?
 - Toilets _____
 - Break rooms _____
 - Reception _____
 - Corridors _____
 - Storage _____



Building Systems and Equipment Requirements



Design requirements



Construction and start-up requirements



Operations and maintenance requirements



Documentation

Design—Air Requirements

- Ventilation air distribution (Section 5.1)
- Buildings with attached parking garages (Section 5.15)
- **5.3 Ventilation System Controls**
 - **5.3.1** All systems shall be provided with manual or automatic controls to maintain no less than the outdoor air intake flow (V_{ot}) required by Section 6 under all load conditions *or* dynamic reset conditions.
 - **5.3.2** Systems with fans supplying variable primary air (V_{ps}) shall be provided with any combination of control equipment, methods, or devices to maintain no less than the outdoor air intake flow (V_{ot}) required for compliance with Section 5.3.1.

Design—Air Exhaust

- Minimum exhaust rates (Table 6-2)
- Exhaust duct location (Section 5.2)
 - Negative pressure and/or sealed
- Local capture of contaminants (Section 5.6)
 - Duct directly to outdoors
- Combustion air (Section 5.8)
 - Provide sufficient combustion air
 - Adequate removal of combustion products

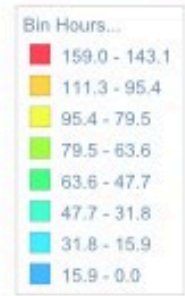
Design—Moisture Control (5.10)

- **5.10 Maximum Indoor Air Dewpoint in Mechanically Cooled Buildings.** Buildings or spaces equipped with or served by mechanical cooling equipment shall be provided with dehumidification components and controls that limit the indoor humidity to a maximum dewpoint of 60°F (15°C) during both occupied and unoccupied hours whenever the outdoor air dewpoint is above 60°F (15°C). The dewpoint limit shall not be exceeded when system performance is analyzed with outdoor air at the dehumidification design condition (that is, design dewpoint and mean coincident dry bulb temperatures) and with the space interior loads (both sensible and latent) at cooling design values and space solar loads at zero.

PSYCHROMETRIC CHART

Atlanta, Georgia USA

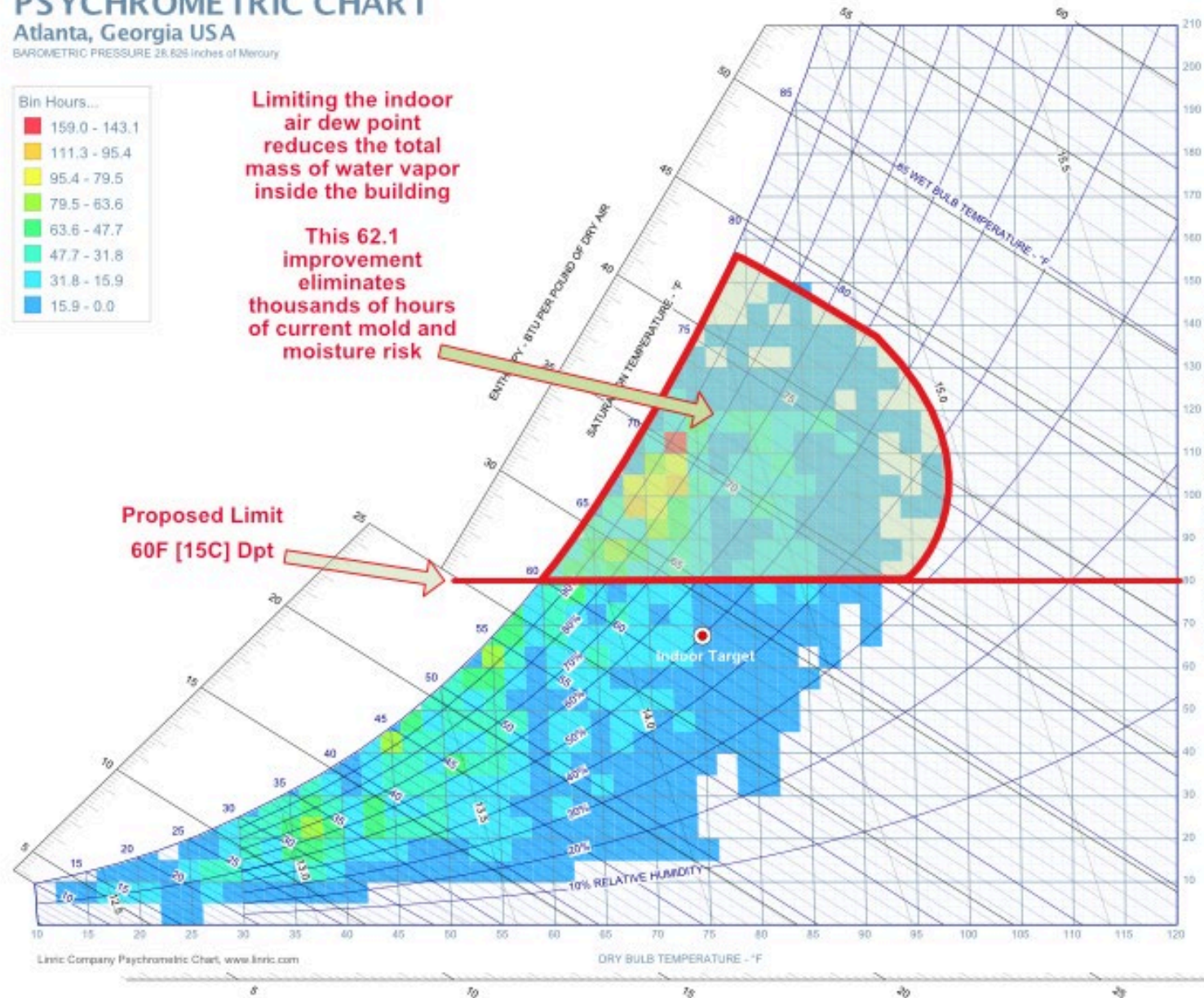
BAROMETRIC PRESSURE 28.625 inches of Mercury



Limiting the indoor
air dew point
reduces the total
mass of water vapor
inside the building

This 62.1
improvement
eliminates
thousands of hours
of current mold and
moisture risk

Proposed Limit
60F [15C] Dpt



Design—Moisture Control

- Drain pans (Section 5.12)
- Humidifier and water spray systems (Section 5.14)
- Building envelope and interior surfaces (Section 5.16)
 - Water intrusion
 - Vapor control and condensation

Design—Dirt/Mold Control

- Airstream surfaces resist mold growth and erosion (Section 5.4)
- Bird screen on intakes (Section 5.5.5)
- Filters $\geq$ MERV 8 required upstream of cooling coils and wetted surfaces (Section 5.9)
- Finned tube coil cleanable (Section 5.13)
- Access for inspection, cleaning and maintenance (Section 5.15)

Section 6. Design Procedures

- **6.1 General.** The ventilation rate procedure, the IAQ procedure, and/or the natural ventilation procedure shall be used to meet the requirements of this section.
 - **Informative Note:** Although the intake airflow determined using each of these approaches may differ significantly because of assumptions about the design, any of these approaches is a valid basis for design.

Air Quantity Requirements

- **Ventilation Rate Procedure (Section 6.2)**
 - Single-zone systems
 - 100% outdoor air systems
 - Multiple-zone recirculating systems
- **Indoor Air Quality (IAQ) Procedure (Section 6.3)**
- **Natural Ventilation Procedure (Section 6.4)**
- **Exhaust Ventilation (Section 6.5)**

Ventilation Rate Procedure— Breathing Zone Outdoor Airflow

$$V_{bz} = R_p \times P_z + R_a \times A_z \quad (6-1)$$

where:

- **A_z = zone floor area:** the net occupiable area of the ventilation zone, ft² (m²)
- **P_z = zone population:** the number of people in the ventilation zone during typical usage
- **R_p = outdoor airflow rate required per person,** as determined from Table 6-1
- **R_a = outdoor airflow rate required per unit area,** as determined from Table 6-1

Table 6-1

- R_p , R_a
- Default occupant density
- Air class
- ***Informative Notes:***
 - 2. The rates in Table 6-1 are based on all other applicable requirements of this standard being met. If other requirements of the standard are not met, then the rates do not apply.

Ventilation Rate Procedure— Zone Outdoor Airflow

$V_{oz} = V_{bz}/E_z$ (6-2)

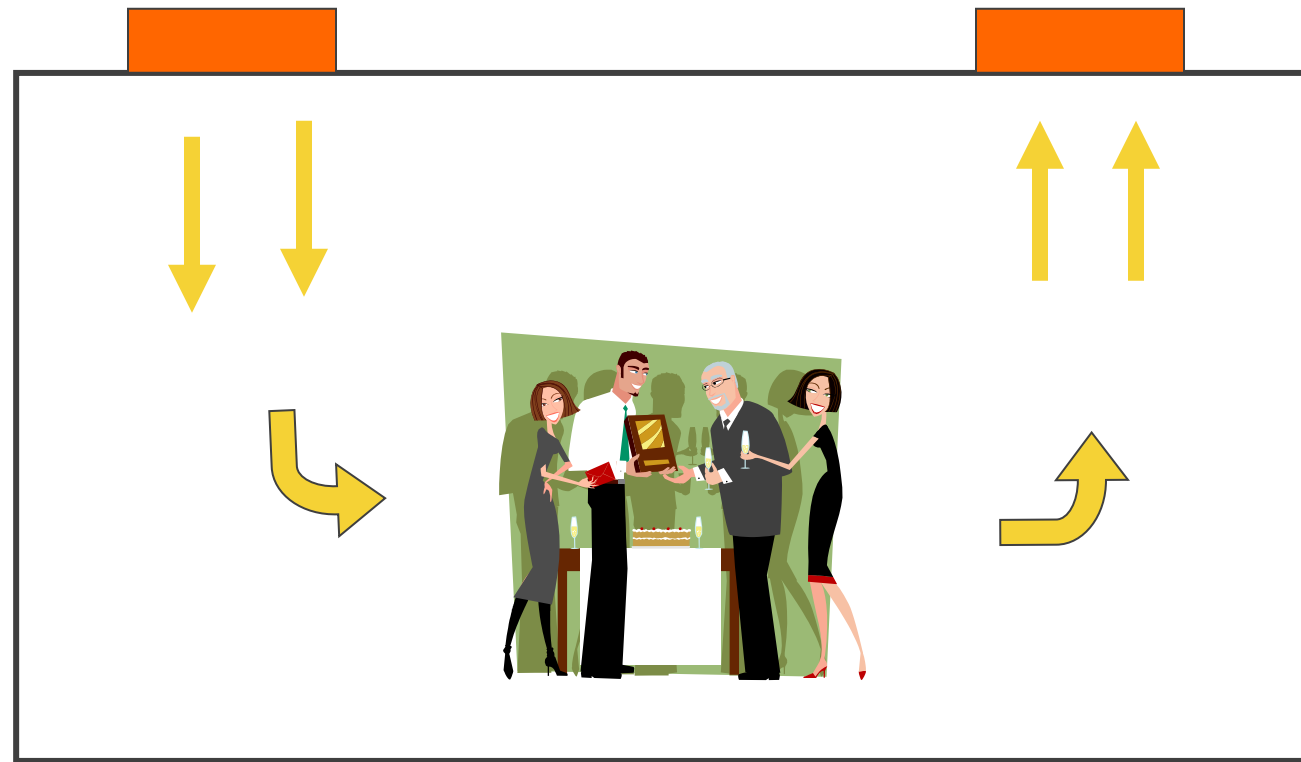
- (E_z) The zone air distribution effectiveness shall be determined in accordance with Table 6-4 or Normative Appendix C. (part of table shown below)

Table 6-4 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Well-Mixed Air Distribution Systems	
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8

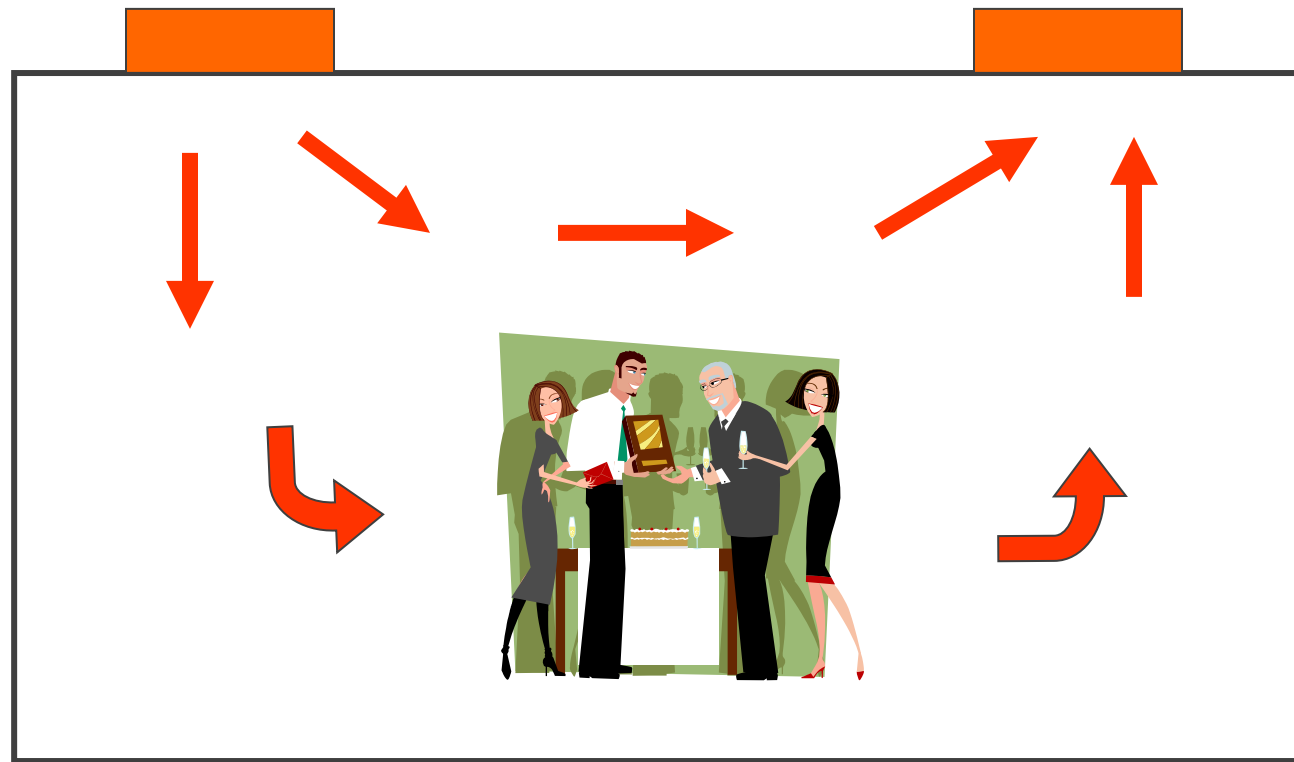
Zone Air Distribution Effectiveness

$$E_z = 1.0$$



Zone Air Distribution Effectiveness

$$E_z = 0.8$$



Ventilation Rate Procedure— Outdoor Airflow Single Zone

$$V_{ot} = V_{oz} \quad (6-3)$$

- **Single-Zone Systems.** For ventilation systems wherein one or more air handlers supply a mixture of outdoor air and recirculated air to only one ventilation zone, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-3.

Ventilation Rate Procedure— Outdoor Airflow—100% OA

$$V_{ot} = \sum_{all\ zones} V_{oz} \quad (6-4)$$

- **100% Outdoor Air Systems.** For ventilation systems wherein one or more air handlers supply only outdoor air to one or more ventilation zones, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-4.

Example Schwedler Office Building

Zones	Area, ft ²	Design Population
North Enclosed Office	1650	7
Conference	1200	60
Core	1100	0
Corridor	2350	0
Perimeter Office	4350	22
Interior Open Office	6950	50
Total	17600	139

Breathing Zone Ventilation

$$V_{bz} = R_p P_z + R_a A_z \quad (6-1)$$

- North offices: 1650 ft², 7 people
- Table 6-1:
 - $R_p = 5$ cfm/person
 - $R_a = 0.06$ cfm/ft²
- $V_{bz} = 134$ cfm

Zone Outdoor Airflow

$$V_{oz} = V_{bz}/E_z \quad (6-2)$$

- E_z : The zone air distribution effectiveness
- Assume overhead air heating for the building
- EXAMPLE
- $E_z = 0.8$ in heating mode. Why?
- $V_{oz} = 168$ cfm

Schwedler Building

Zones	ft ²	Population	R_a	R_p	V_{bz}
North Office	1650	7	0.06	5	134
Conference	1200	60	0.06	5	372
Corridor	2350	0	0.06	0	141
Perimeter Office	4350	22	0.06	5	371
Interior Office	6950	50	0.06	5	667

Why is the core omitted?

Schwedler Building - Heating Condition

Zones	ft ²	Population	V_{bz}	E_z	V_{oz}
North Office	1650	7	134	0.8	168
Conference	1200	60	372	0.8	464
Corridor	2350	0	141	1	141
Perimeter Office	4350	22	371	0.8	464
Interior Office	6950	50	676	1	667

Why are some zones $E_z = 0.8$ and other zones $E_z=1$?

Single Zone Systems - Heating

Zones	ft ²	Population	V_{oz}	V_{ot}
North Office	1650	7	168	168
Conference	1200	60	464	464
Corridor	2350	0	141	141
Perimeter Office	4350	22	464	464
Interior Office	6950	50	667	667
Total				1904

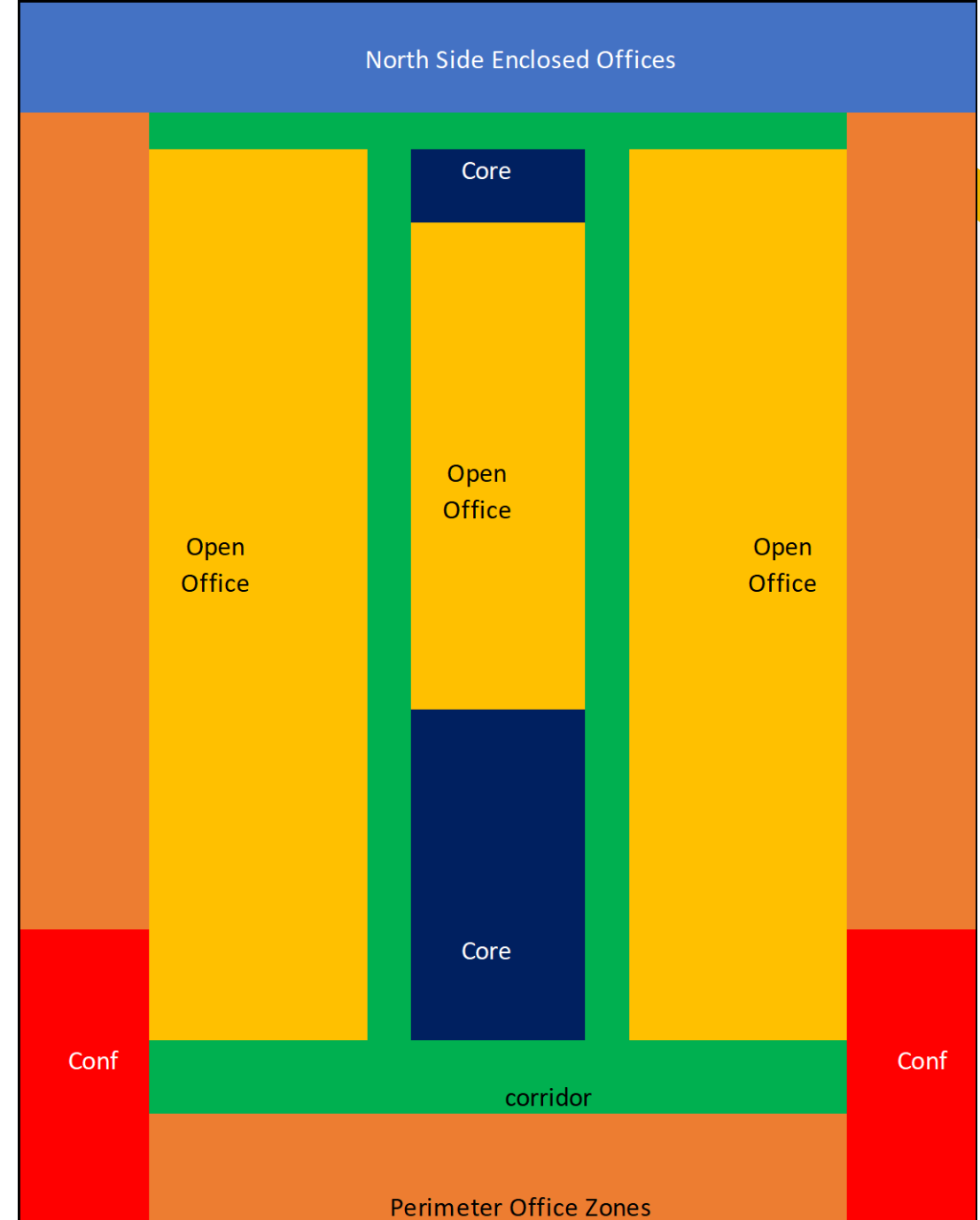
100% Outdoor Air System

Zones	ft ²	Population	V_{bz}	E_z	V_{oz}
North Office	1650	7	134	1	134
Conference	1200	60	372	1	372
Corridor	2350	0	141	1	141
Perimeter Office	4350	22	371	1	371
Interior Office	6950	50	676	1	667
Total					1685

Assume heating is from another system – not from the DOAS

Summary Single Zone and 100% OA

- Five (or more) single-zone systems:
Total 1904 cfm for floor
- One 100% dedicated OA system:
Heating and cooling from other systems
Total 1685 cfm for floor



Multiple-Zone Recirculating Systems

- For ventilation systems wherein one or more air handlers supply a mixture of outdoor air and recirculated air to more than one ventilation zone, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Sections 6.2.4.1 through 6.2.4.4.
- **System Ventilation Efficiency.** The system ventilation efficiency (E_v) shall be determined in accordance with Section 6.2.4.3 Simplified Procedure or Normative Appendix A for the Alternative Procedure.

Multiple-Zone Recirculating Systems

- **6.2.4.4 Outdoor Air Intake.** The design outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-10.

$$V_{ot} = V_{ou}/E_v \quad (6-10)$$

Multiple-Zone Recirculating Systems—Uncorrected OA Intake

- **6.2.4.1 Uncorrected Outdoor Air Intake.** The uncorrected outdoor air intake (V_{ou}) shall be determined in accordance with Equation 6-5:

$$V_{ou} = D \sum_{all\ zones} (R_p \times P_z) + \sum_{all\ zones} (R_a \times A_z) \quad (6-5)$$

Multiple-Zone Recirculating Systems

- The occupant diversity ratio (D) shall be determined in accordance with Equation 6-6 to account for variations in population within the ventilation zones served by the system.

$$D = P_s / \sum_{all\ zones} P_z \quad (6-6)$$

where the system population (P_s) is the total population in the area served by the system.

- For the Example Building sum of all P_z is 139 people. However, it is determined that when the conference room(s) are full some people will not be occupying their offices. The estimate for P_s is 88 people. The value of D will be 0.63

Simplified Procedure

- **6.2.4.3.1 System Ventilation Efficiency.** System Ventilation Efficiency (E_v) shall be determined in accordance with Equation 6.2.5.4.1A or B.

$$E_v = 0.88 * D + 0.22 \quad \text{for } D < 0.60 \quad (6-7)$$

$$E_v = 0.75 \quad \text{for } D \geq 0.60 \quad (6-8)$$

- **6.2.5.3.2 Zone Minimum Primary Airflow.** For each zone, the minimum primary airflow (V_{pz-min}) shall be determined in accordance with equation 6.2.5.3.2.

$$V_{pz-min} = V_{oz} * 1.5 \quad (6-9)$$

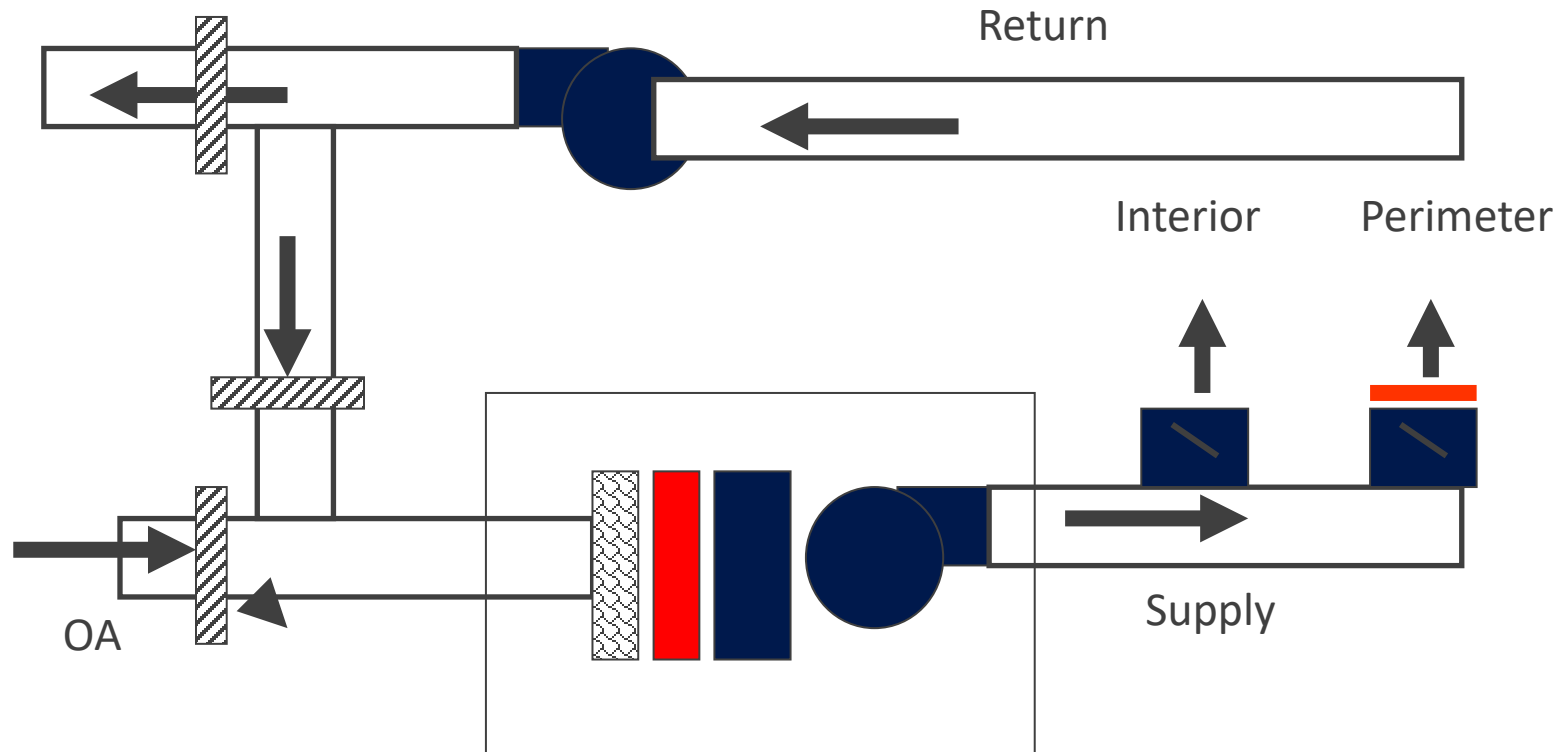
Example Schwedler Office Building

Zones	Area, ft ²	Design Population
North Enclosed Office	1650	7
Conference	1200	60
Core	1100	0
Corridor	2350	0
Perimeter Office	4350	22
Interior Open Office	6950	50
Total	17600	139

Different Multiple-Zone Systems

- Multiple configurations, including *ASHRAE Journal* articles about
 - Single zone and dedicated OA (Oct 2004)
 - Changeover bypass VAV (Nov 2004)
 - Single-path multiple zone (Jan 2005)
 - Dual-path multiple zone (May 2005)

BUILDING HVAC



Multiple-Zone Recirculating Systems

- **6.2.5.4 Outdoor Air Intake.** The design outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-10:

$$V_{ot} = V_{ou}/E_v \quad (6-10)$$

- **Note:** The uncorrected outdoor air intake (V_{ou}) is adjusted for diversity but uncorrected for ventilation efficiency.

System Ventilation Efficiency

- Why do we make this adjustment?
- Where do the numbers come from?

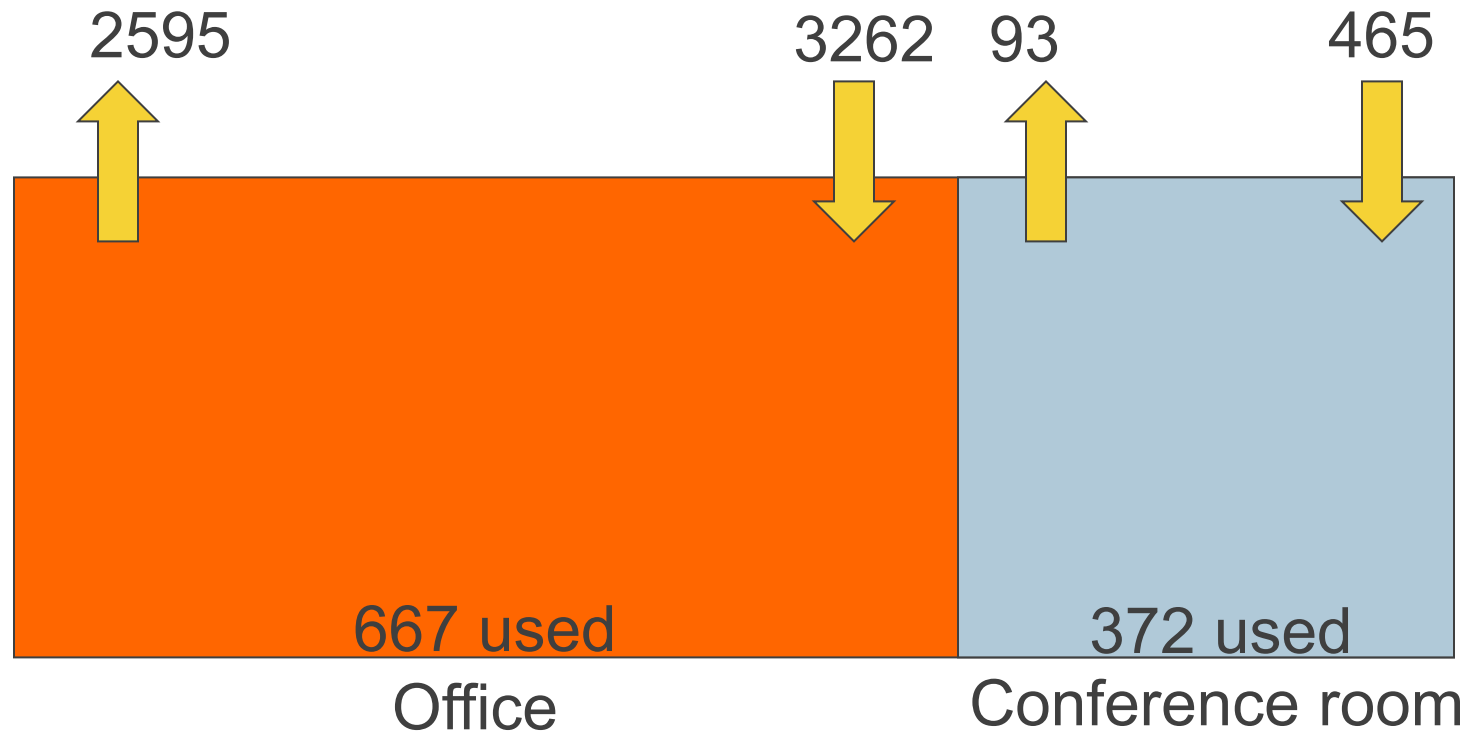


Example—Multiple Zones

Assume heating $E_z = 1.0$, 0.8	Interior Offices	Conference
V_{bz}	667	372
V_{oz}	667	465
$V_{pz \text{ max}}$	4865	698
% outdoor air required	14%	67%

Outdoor Air Provided at 67%

$$5563 \text{ cfm} \times 67\% = 3727 \text{ cfm outdoor air}$$



Multiple-Zone Recirculating System

- The largest % load in the conference room requires 67% outdoor air
- But providing 67% outdoor air oversupplies the offices by 2595 cfm
- Should we get credit for unused outdoor air that is recirculated? _____

Multiple-Zone Recirculating System

- If the only zones are the North offices and the conference room(s)
- Assume $D = 1$ (*most conservative assumes that no one from offices is in conference rooms*)
- From Equation 6-8, $E_v = 0.75$

Multiple-Zone Recirculating System

- If the only zones are the two we considered (Interior offices and Conference):

$$V_{ou} = D \sum_{all\ zones} (R_p P_z) + \sum_{all\ zones} (R_a A_z)$$

- Assume $D = 1$
- $V_{ou} = 1 * [(60 * 5) + (50 * 5)] + [6950 * 0.06 + 1200 * 0.06] = 1039\text{ cfm}$
- $E_v = 0.75$ from previous slide
- $V_{ot} = V_{ou} / E_v = 1039 / 0.75 = 1385\text{ cfm}$
- Compare to 3727 cfm

Example Building - Cooling Condition

Zones	ft ²	Population	V_{oz}	V_{pz-min}	V_{pz-max}
North Office	1650	7	134	201	1155
Conference	1200	60	372	558	1800
Corridor	2350	0	141	212	705
Perimeter Office	4350	22	371	557	4350
Interior Office	6950	50	667	1014	4865
			1685	2541	13,275

Assumes all $E_z=1$, V_{pz-min} from equation 6-9, V_{pz-max} from load calculation

Multiple-Zone Recirculating System

- For the full floor

$$V_{ou} = D \sum_{all\ zones} (R_p P_z) + \sum_{all\ zones} (R_a A_z) \quad (6-5)$$

- Assume $D = 0.63$
- $V_{ou} = 0.63 * (139 * 5) + (16500 * 0.06) = 1430 \text{ cfm}$
- $E_v = 0.75$ from equation 6-8
- $V_{ot} = V_{ou} / E_v = 1430 / 0.75 = 1907 \text{ cfm}$

Appendix A

- This appendix presents an alternative procedure for calculating the system ventilation efficiency (E_v) for multiple zone recirculating systems that must be used when Section 6.2.4.3 is not used. In this alternative procedure, E_v is equal to the lowest calculated value of the zone ventilation efficiency (E_{vz}) (see Equation A-2 below
- **A.1 System Ventilation Efficiency.** For any multiple-zone recirculating system, the system ventilation efficiency (E_v) shall be calculated in accordance with Sections A1.1 through A1.3.

Appendix A—Single Supply

- **A.1.2.1 Single-Supply Systems.** For “single-supply” systems, wherein all of the ventilation air supplied to each ventilation zone is a mixture of outdoor air and system-level recirculated air, zone ventilation efficiency (E_{vz}) shall be determined in accordance with Equation A-2. Examples of single-supply systems include constant-volume reheat, single-duct VAV, single-fan dual-duct, and multizone systems.

$$E_{vz} = 1 + X_s - Z_{pz} \quad (\text{A-2})$$

where the average outdoor air fraction (X_s) for the system is determined in accordance with Equation A-2 and the primary outdoor air fraction (Z_{pz}) for the zone is determined in accordance with equation A-3.

$$Z_{pz} = V_{oz}/V_{pz} \quad (\text{A-3})$$

Appendix A—Single Supply

- **A.1.1 Average Outdoor Air Fraction.** The average outdoor air fraction (X_s) for the ventilation system shall be determined in accordance with Equation A-1:

$$X_s = V_{ou}/V_{ps} \quad (A-1)$$

- Where the uncorrected outdoor air intake (V_{ou}) is found in accordance with Section 6.2.4.1, and the system primary airflow (V_{ps}) is found at the condition analyzed.
- **Note:** For VAV system design purposes, V_{ps} is the highest expected system primary airflow at the design condition analyzed. System primary airflow at design is usually less than the sum of design zone primary airflow values, because primary airflow seldom peaks simultaneously in all VAV zones.

Example Building

Appendix A—single supply

- Single Supply Systems. $E_{vz} = 1 + X_s - Z_{pz}$ (A-2)

- Calculate $X_s = V_{ou}/V_{ps}$

$$V_{ou} = D * \sum R_p * P_z + \sum R_a * A_z = 1430 \text{ cfm}$$

$$D = 0.63,$$

$$\sum R_p * P_z = 5 * 139 = 695$$

$$\sum R_a * A_z = 0.06 * 16500 = 990$$

$$V_{ps} = 13,275 \text{ cfm}$$

$$X_s = V_{ou}/V_{ps} = 0.11$$

Example Building.

Appendix A—Single Supply

- For North offices in cooling season, calculate:

$$Z_{pz} = V_{oz}/V_{dzm} = 134/201 = 0.67$$

$$V_{oz} = 134 \text{ cfm}$$

$$V_{dzm} = 201 \text{ cfm}$$

$$E_{vz} = 1 + X_s - Z_{pz} = 1 + 0.11 - 0.67 = 0.44$$

$$Z_{pz} = 0.67$$

$$X_s = 0.17$$

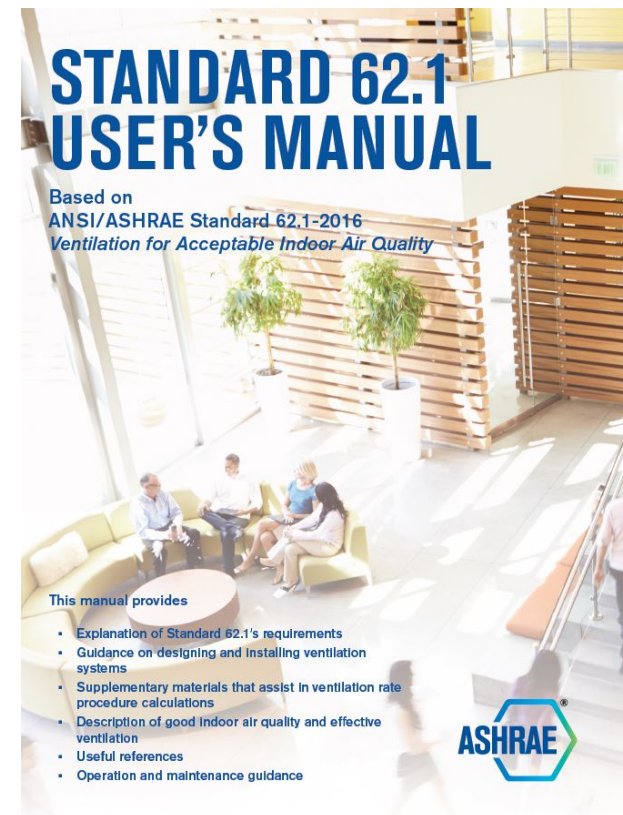
Building

Appendix A—Single Supply

- Single Supply Systems: $E_{vz} = 1 + X_s - Z_{pz}$ (A1.2.1)
- Compute E_{vz} for each zone:
 - $E_v = \text{minimum } (E_{vz})$ (A1.3)
 - $V_{ot} = V_{ou}/E_v$ (6.2.5.4)

Ventilation Rate Procedure Spreadsheet

- Spreadsheet provided with *Standard 62.1 User's Manual*
- 62MZCalc



Building

- Heating and cooling have different conditions, so we must calculate both seasons
- Zone air distribution effectiveness (E_z) is different
- Also, minimum primary airflow (V_{pz}) may be different in heating and cooling season

Calculate Different Ventilation Rates for Example Schwedler Office Building

Using:

- E_v from Simplified Procedure cooling condition
- E_v from Simplified Procedure heating condition
- E_v from Appendix A equations—cooling condition
- E_v from Appendix A equations—heating condition

Outdoor Air Required, V_{ot}

- 8 single-zone systems: 1904 cfm
- 100% OA system: 1685 cfm
- Single-path multiple zone
 - Simplified Procedure—cooling 1907 cfm
 - Simplified Procedure—heating 1907 cfm
 - Calculated E_v —cooling* 3242 cfm
 - Calculated E_v —heating* 2744 cfm
- *Note that this uses the values calculated in the previous slide value of $E_v = 0.44$ (cooling) where the simplified procedure uses a default of $E_v = 0.75$
Modifications to the multiple zone system design can reasonably reduce the minimum V_{ot} to less than 1800 cfm using dual path systems. These are covered in the next course.

Indoor Air Quality Procedure

- Performance-based design approach
- Designs shall comply with the following:
- **6.3.1 Contaminant Sources.** Contaminants or mixtures of concern for purposes of the design shall be identified. For each contaminant or mixture of concern, indoor sources (occupants and materials) and outdoor sources shall be identified, and the emission rate for each contaminant of concern from each source shall be determined.

Indoor Air Quality Procedure

- **6.3.2 Contaminant Concentration.** For each contaminant of concern, a target concentration limit and its corresponding exposure period and an appropriate reference to a cognizant authority shall be specified.
- **6.3.3 Perceived Indoor Air Quality.** The design level of indoor air acceptability shall be specified in terms of the percentage of building occupants and/or visitors expressing satisfaction with perceived IAQ.

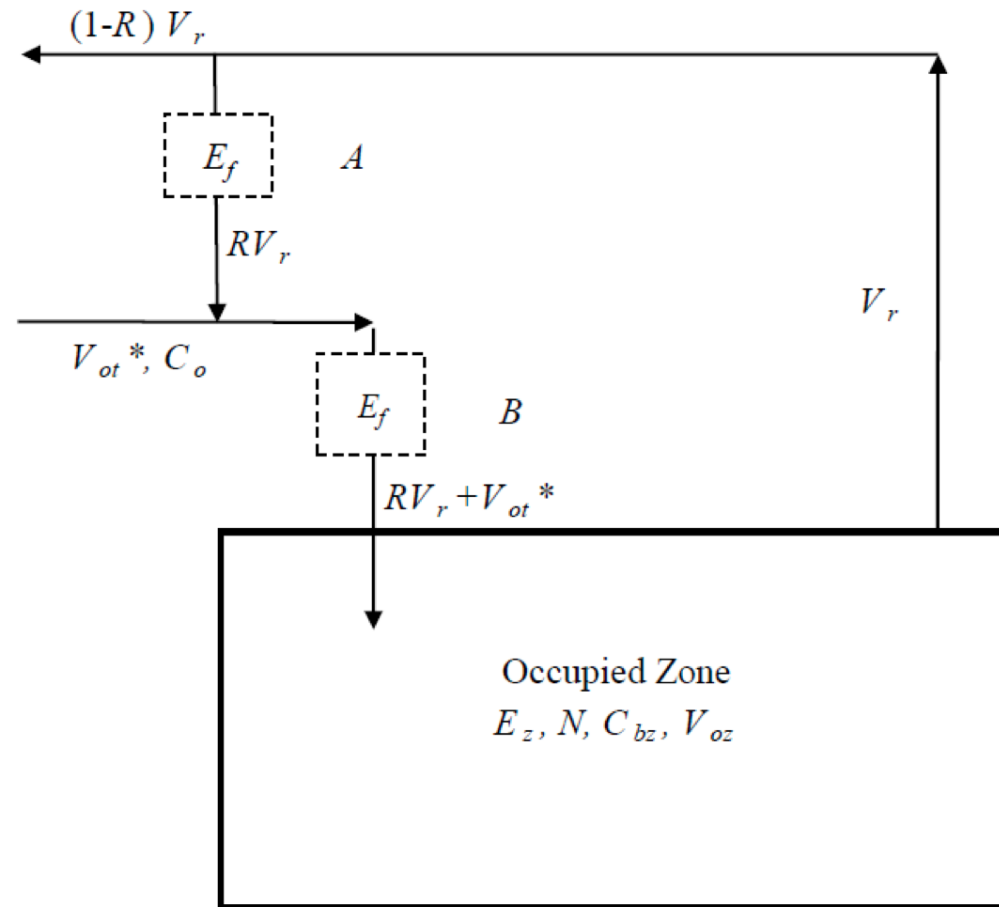
Design Approach

- **6.3.4 Design Approach.** Zone and system outdoor airflow rates shall be the larger of those determined in accordance with Section 6.3.4.1 and either 6.3.4.2 or 6.3.4.3, based on emission rates, concentration limits and other relevant design parameters (e.g., air cleaning efficiencies and supply airflow rates).
 - **6.3.4.1 Mass Balance Analysis**
 - **6.3.4.2 Subjective Evaluation**
 - **6.3.4.3 Similar Zone**

Mass Balance Analysis

- **6.3.4.1 Mass Balance Analysis.** Using a steady-state or dynamic mass-balance analysis, determine the minimum outdoor airflow rates required to achieve the concentration limits specified in Section 6.3.2 for each contaminant or mixture of concern, within each zone served by the system.
- **Informative Notes:**
 1. Informative Appendix E includes steady-state mass-balance equations that describe the impact of air cleaning on outdoor air and recirculation rates for ventilation systems serving a single zone.
 2. In the completed building, measurement of the concentration of contaminants or mixtures of concern may be useful as a means of checking the accuracy of the design mass-balance analysis, but such measurement is not required for compliance.

Ventilation System Schematic



For Constant-Volume System with Filter in Location A in schematic

$$V_{oz} = \frac{N - E_z R V_r E_f C_{bz}}{E_z (C_{bz} - C_o)}$$

Subscript: *o* (outdoor)

Subscript: *r* (return)

Subscript: *b* (breathing)

Subscript: *z* (zone)

Subjective Evaluation Requirements

- **6.3.4.2 Subjective Evaluation.** Using a subjective occupant evaluation conducted in the completed building, determine the minimum outdoor airflow rates required to achieve the level of acceptability specified in Section 6.3.3 within each zone served by the system.
- **6.3.4.3 Similar Zone.** The minimum outdoor airflow rates shall be no less than those found in accordance with Section 6.3.4.2 for a substantially similar zone
- (i.e., in a zone with identical contaminants of concern, concentration limits, air-cleaning efficiency, and specified level of acceptability, and with similar contaminant sources and emission rates).

Natural Ventilation (6.4)

- **6.4 Natural Ventilation Procedure.** Natural ventilation systems shall comply with the requirements of either Section 6.4.1 or Section 6.4.2. Designers shall provide interior air barriers, insulation, or other means that separate naturally-ventilated spaces from mechanically-cooled spaces, to prevent high dew point outdoor air from coming into contact with mechanically cooled surfaces

Natural Ventilation (6.4)

6.4.1 Prescriptive Compliance Path. Any zone designed for natural ventilation shall include a mechanical ventilation system designed in accordance with Section 6.2, Section 6.3, or both.

Exceptions:

1. Zones in buildings that have all of the following:
 - a. natural ventilation openings that comply with the requirements of Section 6.4.1,
 - b. controls that prevent the natural ventilation openings from being closed during periods of expected occupancy or natural ventilation openings that are permanently open,
2. Zones that are not served by heating or cooling equipment.

Natural Ventilation (6.4)

- **6.4.1.2 Floor Area to Be Ventilated.** The naturally ventilated area in zones or portions of zones shall extend from the openings a distance determined by Sections 6.4.1.3, 6.4.1.4, or 6.4.1.5. Openings shall meet the requirements of Section 6.4.1.6. For zones where ceilings are not parallel to the floor, the ceiling height shall be determined in accordance with Section 6.4.1.1.
- **6.4.1.3 Single Side Opening.** For zones with openings on only one side of the zone, the naturally ventilated area shall extend to a distance not greater than two times the height of the ceiling from the openings.
- **6.4.1.4 Double Side Opening.** For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling.

Natural Ventilation (6.4)

- **6.4.1.6 Location and Size of Openings.** Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The minimum flowrate to the zone shall be determined in accordance with 6.2.2.1. This flowrate shall be used to determine the required openable area of openings, accounting only for buoyancy-driven flow. Wind-driven flow shall be used only where it can be demonstrated that the minimum flowrate is provided during all occupied hours. Openings shall be sized in accordance with Section 6.4.1.6.1 (Path A) OR Section 6.4.1.6.2 (Path B).
- **6.4.3 Control and Accessibility.** The means to open required openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to properly coordinate operation of the natural and mechanical ventilation systems.

Natural Ventilation (6.4)

- **6.4.1.6.1 Sizing Openings – Path A**
- Where the zone is ventilated using a single opening or multiple single openings located at the same elevation, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6.4.1.6.1.1. Where the zone is ventilated using two openings located at different elevations or multiple pairs of such openings, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6.4.1.6.1.2.

Improvement: Same window area regardless of window type in previous versions of the standard

$$A_1 \neq A_1$$

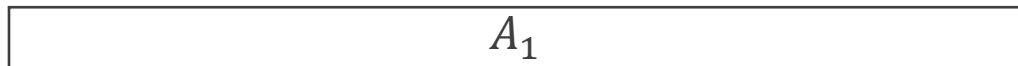


Table 6.4.1.6.1.1: Minimum Openable Areas: Single Openings

$V_{bz} / A_z \leq$ (L/s per m ²)	$V_{bz} / A_z \leq$ (cfm per ft ²)	Total Openable Areas in Zone as a Percentage of A_z		
		$H_s/W_s \leq 0.1$	$0.1 < H_s/W_s \leq 1$	$H_s/W_s > 1$
1.0	0.2	4.0	2.9	2.5
2.0	0.4	6.9	5.0	4.4
3.0	0.6	9.5	6.9	6.0
4.0	0.8	12.0	8.7	7.6
5.5	1.1	15.5	11.2	9.8

Engineered System Compliance Path

For an engineered natural ventilation system, the designer shall:

- a. Determine hourly environmental conditions including outdoor air dry-bulb temperature, dew-point temperature, outdoor concentration of contaminants including PM2.5, PM10 and ozone where data is available, wind speed and direction, and internal heat gains during expected hours of natural ventilation operation.
- b. Determine the effect of pressure losses along natural ventilation airflow paths on the resulting flowrates, including inlet openings, air transfer grills, ventilation stacks and outlet openings during representative conditions of expected natural ventilation system use.
- c. Quantify natural ventilation airflow rates of identified airflow paths accounting for wind- and thermally-induced driving pressures during representative conditions of expected natural ventilation system use.
- d. Design to provide outdoor air in quantities sufficient to result in acceptable indoor air quality as established under 6.2.2.1 or 6.3 during representative conditions of expected natural ventilation system use.

Natural Ventilation (6.4)

- **6.4.3 Control and Accessibility.** The means to open required openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to properly coordinate operation of the natural and mechanical ventilation systems.
- **6.4.4 Documentation.** Where the Natural Ventilation Procedure is used, the designer shall document the values and calculations that demonstrate conformance with the compliance path and the controls systems and sequences required for operation of the natural ventilation system including coordination with mechanical ventilation systems. Where the Prescriptive Compliance Path is used for buildings located in an area where the national standard for one or more contaminants is exceeded, any design assumptions and calculations related to the impact on indoor air quality shall be included in the design documents.

Exhaust Ventilation (6.5)

- The prescriptive compliance path or the performance compliance path shall be used to meet the requirements of this section.
- Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air, or transfer air.

Design for Varying Operating Conditions

If it is known that peak occupancy will be of short duration and/or ventilation will be varied or interrupted for a short period of time, the design may be based on the average conditions over a time period T determined by Equation 6-11a or 6-11b:

$$T = 3v/V_{bz} \quad (\text{I-P}) \quad (6-11a)$$

where

T = averaging time period, (min)

v = the volume of the zone for which averaging is being applied, (ft³)

V_{bz} = the breathing zone outdoor airflow calculated using
Equation 6-1 and the design value of the zone population P_z , (cfm)

Short-Term Conditions

Assume that for some reason the conference room can only be used for one hour per day

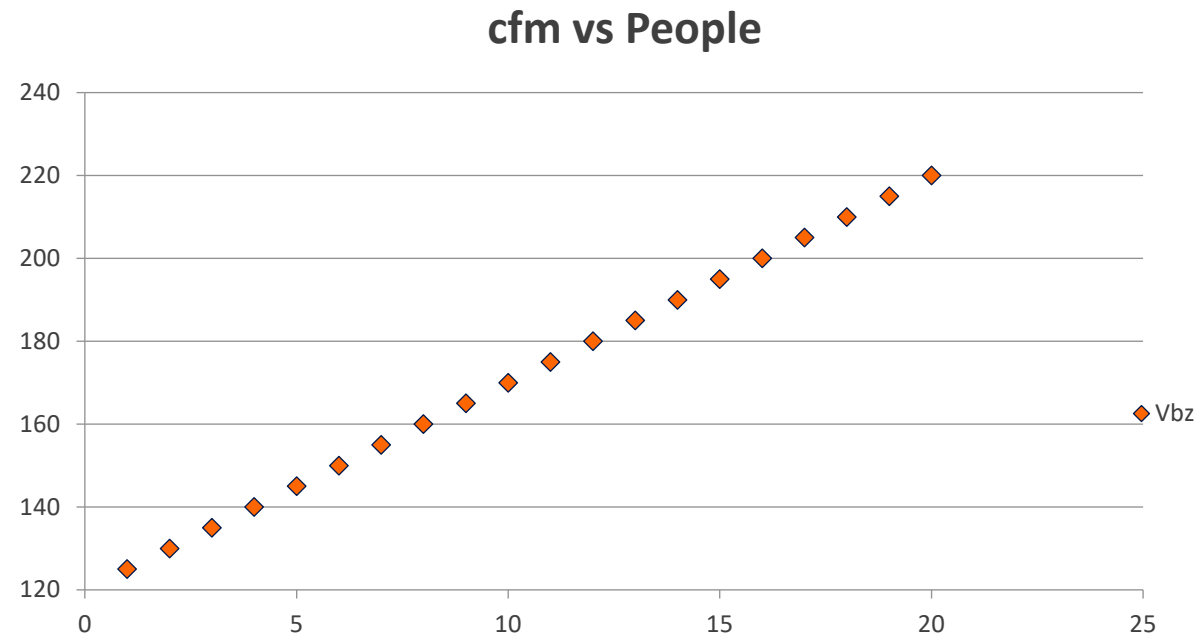
$$T = 3v/V_{bz} \quad (6.2.6.2-1) \text{ (I-P)}$$

- $v = 1000 \text{ ft}^2 \times 10 \text{ ft ceiling}$
- $V_{bz} = 310 \text{ cfm}$
- $T = 96 \text{ min} \approx 1.5 \text{ h}$
- Population average: $50/1.5 = 33$

Demand Control Ventilation

- **6.2.7.1.2** The breathing zone outdoor airflow (V_{bz}) shall be reset in response to current occupancy and shall be no less than the building component ($R_a * A_z$) of the DCV zone.
- Examples of reset methods or devices include population counters, carbon dioxide (CO₂) sensors, timers, occupancy schedules, or occupancy sensors.

People Counter Method



CO₂ DCV Method

- Assumes sensor is located in a manner representative of average (well-mixed) concentration in breathing zone
- Assumes CO₂ generation rate is accurate in terms of mets and body mass
- Assumes feedback into an air volume controller (not damper position)
- Assumes single zone

CO₂ DCV for Multiple Spaces

- Simple approaches do not work for multiple spaces
- No current published method for using CO₂ for DCV in multiple spaces
- Subject of multiple ASHRAE research projects

Sections 7 and 8

Construction and System Start-Up (7)

Operations and Maintenance (8)

- Air requirements
- Water control
- Dirt/mold control

Air Requirements

- Air duct system construction (Section 7.1.5)
- Air balancing ventilation system (Section 7.2.2)
- Outdoor air damper testing (Section 7.2.5)
- Ventilation system operated (Sections 8.1, 8.3)
- Sensor calibration (Section 8.2)
- Outdoor airflow verification (Section 8.2)
- Floor drains (are not air intakes) (Section 8.2)

Water Control

- Protect materials during construction (Section 7.1)
- Test drain pans at start-up (Section 7.2.3)
- Inspect drain pans during operation (Section 8.2)
- Cooling tower water treatment (Section 8.2)
- Water intrusion (Section 8.2)

Dirt Control

- Filters in place during construction (Section 7.1)
- Protection of occupied areas (Section 7.1)
- Ventilation system start-up (Section 7.2)
- Maintain filters and air cleaning devices (Section 8.2)
- Clean humidifiers, dehumidification coils, outdoor air intakes (Section 8.2)

Specify System Filtration Requirements during construction

- Installed ductwork that had been unprotected during on-site storage and after installation



Photo courtesy of Wayne Thomann

Documentation Requirements

- Outdoor air quality investigation (Section 4.3)
- Air balancing and assumptions regarding air distribution and ventilation rates (Section 5.1)
- Classification of air other than table values (Section 5.16)
- Other outdoor air contaminants (Section 6.2)
- IAQ procedure (if selected) (Section 6.3)
- Design criteria and assumptions (Section 6.6)
- Provided to owner: drawings, T&B, controls info, O&M manual, design criteria (Section 7.2)
- O&M manual requirements (Section 8.2)

4. Wrap-Up and Descriptions of More Advanced Courses

LEARNING OBJECTIVES

At the end of this course the attendee should be able to

- Explain the three major types of contaminants in the air and give an example of a source for each.
- List the five major requirement sections of ASHRAE Standard 62.1-2019
- Understand that different approaches to HVAC design using the Ventilation Rate Procedure result in different quantities of outside air at the outside air intake
- Contrast the Ventilation Rate Procedure, the Indoor Air Quality Procedure, and the Natural Ventilation Procedure

What's Next?

- V in HVAC – Energy Savings using the 62.1 Ventilation Rate Procedure – 3 hour (Intermediate)
- V in HVAC – Energy Savings using Natural Ventilation. – 3-hour (Advanced)
- V in HVAC - Energy Savings using the Indoor Air Quality Procedure – 6-hour (Advanced)
- V in HVAC – Design Options for Advanced Energy Savings – 3 hour (Advanced)

These courses provide background, techniques, and skills for resilient and sustainable ventilation system design.

Charles E. Gulledge III, P.E., HBDP, LEED AP, Fellow ASHRAE, 2020-2021 ASHRAE President



[ashrae.org/president](https://www.ashrae.org/president)

Read more about Chuck's life, career and his Society year theme,
The ASHRAE Digital Lighthouse and Industry 4.0.



Download these resources at www.ashrae.org/president:

- Bio
- Abstract
- Full Manuscript
- Presidential Presentation
- Live Video Recording from President's Luncheon
- Building Operational Excellence Resource List



“Like” Chuck on facebook.com/ashraepresident

Evaluation and Certificate

- ASHRAE values your comments about this course. All course registrants will receive a separate email from ALI-Education (edu@ashrae.org) allowing access to the Course Survey and Certificate of Attendance. Once the Course Survey is complete, you will be directed to the Certificate of Attendance. Questions should be sent to edu@ashrae.org.
- A copy of the presentation is available at: https://www.ashrae.org/vinhvac_2021fallonline
- If you have any questions about ASHRAE Certificates, please contact Kelly Arnold, Coordinator Professional Development, at karnold@ashrae.org.
- If you have any questions about ASHRAE courses, please contact Tiffany Cox, Course Administrator, tcox@ashrae.org.

Explore ASHRAE Learning Institute Courses



<https://www.ashrae.org/instructor-led-courses>

Find a Topic that Fits You:

- Commissioning
- Energy Efficiency
- Environmental Quality
- HVAC&R Applications
- Standards and Guidelines
- CoV-2 Mitigation

See all the ways to learn and grow with ASHRAE at
<https://www.ashrae.org/professional-development/learning-portal>

ASHRAE Certification



Visit www.ashrae.org/certification to learn more:

- ✓ More than 3,000 certifications earned to-date
- ✓ Elevate your reputation among peers, in the workplace and among clients
- ✓ NEW! Digital Badging:



- Embedded [metadata](#) uniquely linked to you
- Shareable in electronic media, including LinkedIn and email
- Instant recognition, with real-time, third-part verification