

- **Estimating Portable Toilet Counts Based on Event Attendance**

Estimating Portable Toilet Counts Based on Event Attendance   Calculating Restroom Needs for Food and Beverage Events   Mapping Portable Restroom Locations for Crowd Flow   Accessibility Considerations in Event Restroom Placement   Weather Factors that Influence Portable Toilet Positioning   Portable Restroom Spacing Rules for Outdoor Festivals   Integrating Hand Wash Stations with Restroom Layouts   Using Technology to Track Portable Toilet Utilization at Events   Reducing Line Times with Optimal Restroom Distribution   Setup Timeline for Event Portable Restroom Delivery   Coordination with Other Vendors During Restroom Placement   Post Event Evaluation of Portable Toilet Placement Effectiveness

- **Measuring the Carbon Footprint of Portable Restrooms**

Measuring the Carbon Footprint of Portable Restrooms   Benefits of Formaldehyde Free Deodorizer Solutions   Recycling High Density Polyethylene from Retired Units   Water Conservation Strategies in Portable Toilet Design   Certification Pathways for Green Portable Sanitation   Lifecycle Analysis of Standard and Deluxe Portable Toilets   Partnering with Wastewater Plants for Sustainable Disposal   Implementing Solar Lighting in Portable Restrooms   Composting Options for Biodegradable Portable Toilet Waste   Communicating Sustainability Initiatives to Event Organizers   Selecting Vendors with ISO Environmental Management Systems   Tracking Emission Reductions through Fleet Optimization

- **About Us**



participate fully and comfortably.

Thinking about ADA compliance in restroom placement means considering things like accessible routes. Can someone using a wheelchair easily get from the event entrance to the restroom area? Are there ramps where needed, and are the pathways wide enough? It also means paying attention to the restrooms themselves. Are there accessible stalls with grab bars and enough space to maneuver? Is the sink at a usable height, and are the faucets easy to operate?

Ignoring these standards isn't just a legal oversight; it sends a message that some attendees are less welcome than others. And honestly, nobody wants to unintentionally create that kind of environment. So, let's make sure that when we're planning our event

restrooms, were not just thinking about the bottom line or the shortest walk, but also about inclusivity and making sure everyone can enjoy the event with dignity and ease. Its the right thing to do, plain and simple.

# Calculating the Number of Units Needed —

- Factors Influencing Portable Toilet Requirements
- Calculating the Number of Units Needed
- Duration of the Event and Toilet Needs
- Special Considerations for Different Event Types

When planning an event, its easy to get caught up in the big picture: the music, the food, the decorations. But overlooking the smaller details, like restroom accessibility, can have a significant impact on the experience of many attendees. Thinking about accessibility features in porta potty rentals isnt just about ticking a box; its about creating a welcoming and inclusive environment for everyone.

Accessibility features in porta potties go beyond simply providing a larger space. Ramps with gentle slopes are crucial for individuals using wheelchairs or mobility aids. Inside, grab bars strategically placed near the toilet offer stability and support, making it easier and safer to use the facilities. Wider doorways allow for easier maneuverability, and ample turning space inside the unit is essential for wheelchair users to navigate comfortably.

But the considerations go further. Clear signage with tactile elements or Braille assists individuals with visual impairments. Proper lighting inside the unit is important for everyone, but especially crucial for those with limited vision. And placement matters just as much as the features themselves. Accessible porta potties should be located on level ground, close to accessible pathways, and clearly marked so they are easy to find.

Ignoring these details can inadvertently exclude individuals with disabilities, making them feel unwelcome and uncomfortable. By proactively incorporating accessibility features into porta potty rentals and thoughtfully considering their placement, event organizers demonstrate a commitment to inclusivity and ensure that everyone can enjoy the event to the fullest. Its a small effort that makes a big difference.

# Duration of the Event and Toilet Needs

Lets talk about event restroom placement and making sure everyone can actually *use* them. Were not just slapping porta-potties down and hoping for the best, right? Were thinking strategically. Were thinking about placement strategies for maximum accessibility.

What does that even mean? Well, first, it means proximity. If someones got mobility issues, or a visual impairment, or even just a really full bladder, they need those restrooms to be reasonably close. Think about high-traffic areas, food vendors, seating areas – places people already congregate. Dont tuck them away in the farthest corner of the field.

Then theres the path *to* the restrooms. Is it paved? Is it level? Are there any crazy slopes or unexpected obstacles? A slightly bumpy path might be manageable for some, but a total non-starter for others. Consider temporary ramps or level platforms if the existing terrain is challenging. Clear signage is also crucial. Not just signs, but clear, well-lit signs with universal symbols. Think about height, font size, and contrast. Can everyone, regardless of their vision, easily find their way?

And its not just about physical accessibility. Think about sensory sensitivities. A bank of restrooms right next to the main stage speakers might be a nightmare for someone with sensory overload. Can we create a slightly quieter, more secluded area for at least some of the facilities?

Finally, dont forget about the restrooms themselves. Are there accessible units available, and are they actually *usable*? Meaning, are they kept clean, well-stocked with supplies, and are the doors easy to open and close? Its no good having an accessible unit if its being used as a storage closet or if the hand sanitizer is empty.

Ultimately, smart restroom placement is about empathy. It's about putting yourself in the shoes of someone with different needs and making sure that everyone can participate fully in the event, without having to worry about something as basic as finding and using a restroom. It's about creating a welcoming and inclusive environment for all.







# Special Considerations for Different Event Types

Training Staff for Accessibility Support in Event Restroom Placement

Accessibility is a cornerstone of inclusivity, ensuring that all individuals, regardless of their abilities, can participate fully in events and activities. One critical aspect of accessibility is the thoughtful placement of restrooms, which can significantly impact the experience of attendees. Training staff for accessibility support in this area is essential to creating an environment that is welcoming and accommodating for everyone.

First and foremost, training should emphasize the importance of understanding the diverse needs of individuals who may require assistance. This includes people with mobility impairments, those who use wheelchairs, individuals with visual or auditory disabilities, and those who may need additional time or support due to cognitive or medical conditions. By fostering a culture of empathy and respect, staff can better anticipate and address the needs of all attendees.

Training should also cover the specific guidelines and regulations related to accessible restroom facilities. This includes knowledge of the Americans with Disabilities Act (ADA) and other relevant standards that dictate the design and placement of accessible restrooms. Staff should be trained to recognize the features that make a restroom accessible, such as grab bars, lower sinks, and wider doorways, and ensure that these features are present and functional.

Moreover, training should equip staff with the skills to assist individuals who may need help navigating to and using accessible restrooms. This involves not only physical assistance but also providing clear, concise directions and offering support in a manner that respects the dignity and independence of the individual. Staff should be trained to communicate effectively, using simple language and ensuring that their tone is supportive and non-patronizing.



In addition to practical skills, training should also focus on the importance of proactive communication. Staff should be encouraged to ask attendees if they need any assistance and to offer help before it is requested. This proactive approach can help prevent situations where individuals feel embarrassed or reluctant to ask for help, thereby promoting a more inclusive environment.

Finally, training should emphasize the role of staff in advocating for accessibility improvements. By providing feedback and reporting any issues with restroom accessibility, staff can help ensure that events are continually improving in their commitment to inclusivity. This advocacy can also extend to collaborating with event organizers to make necessary adjustments before the event takes place.

In conclusion, training staff for accessibility support in event restroom placement is a vital component of creating an inclusive environment. By understanding the diverse needs of attendees, adhering to accessibility guidelines, providing effective assistance, and promoting proactive communication, staff can play a crucial role in ensuring that all individuals have a positive and accessible experience at events.

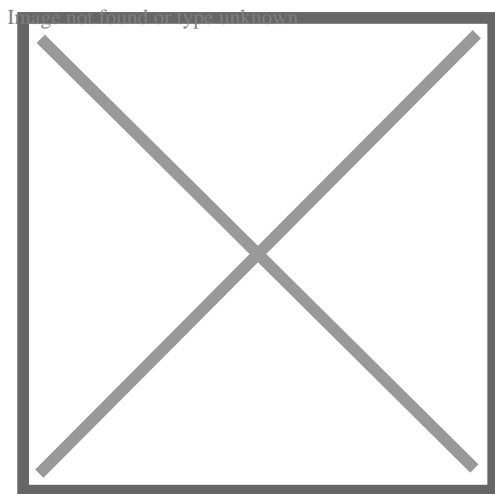
## **About Toilet paper**

Toilet tissue (often called toilet/bath/bathroom cells, or toilet roll) is a cells paper product mainly made use of to clean the rectum and bordering region of feces (after defecation), and to clean the external genitalia and perineal area of pee (after urination). It is commonly supplied as a lengthy strip of perforated paper wrapped around a cylindrical paperboard core, for storage in a dispenser within arm's reach of a commode. The bundle, or roll of toilet paper, is particularly called a toilet roll, bathroom roll, or bog roll (in Britain). There are other usages for toilet tissue, as it is a readily available family product. It can be used for blowing the nose or cleaning the eyes (or various other uses of facial cells). It can be utilized to wipe off sweat or absorb it. Some people might utilize the paper to absorb the bloody discharge that

comes out of the vagina during menstrual cycle. Toilet tissue can be made use of in cleansing (like a less abrasive paper towel). As an adolescent trick, "bathroom papering" is a kind of short-lived vandalism. Most modern-day toilet tissue in the developed world is developed to decompose in septic systems, whereas some other restroom and facial cells are not. Damp bathroom tissue rapidly disintegrates in the atmosphere. Toilet tissue can be found in different numbers of plies (layers of density), from one- to six-ply, with even more back-to-back plies supplying greater strength and absorbency. A lot of contemporary domestic bathroom tissue is white, and embossed with a pattern, which enhances the surface area of the paper, and therefore, its performance at removing waste. Some people have a preference for whether the alignment of the roll on a dispenser should more than or under. Making use of paper for hygiene has been recorded in China in the 6th century AD, with particularly manufactured bathroom tissue being mass-produced in the 14th century. Modern industrial toilet tissue come from the 19th century, with a patent for roll-based dispensers being made in 1883.

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### About Soap dispenser



A **soap dispenser** is a device that, when manipulated or triggered appropriately, dispenses soap (usually in small, single-use quantities). Soap dispensers typically

dispense liquid soap or foam soap. They can be automatic or manually operated by a handle and are often found in public toilets or private bathrooms.

## **Manual**

[edit]

The design of a manual soap dispenser is generally determined by whether the soap comes in liquid, powder or foam form.

# **Liquid soap**

[edit]

When soap is dispensed in liquid form, it is generally in a squeeze bottle or pump. The most popular soap dispensers of this type are plastic pump bottles, many of which are disposable.

William Quick patented liquid soap on August 22, 1865. Minnetonka Corporation introduced the first modern liquid soap in 1980 and bought up the entire supply of plastic pumps used in their dispensers to delay competition entering the market.<sup>[1]</sup>

## **Parts**

[edit]

- Actuator – This is the top of the pump from which is pressed down to get the liquid out
- Closure – Closure is the bottle that is fastened to the bottle's neck. it has a smooth or ribbed surface
- Outer gasket – Made up of plastic or rubber, it is fit inside the closure and prevents leakage

- Housing – The main pump that keeps the other components in the right place and sends liquid to the actuator from the dip tube
- Dip tube – This is the visible tube that carries liquid from the bottom of the bottle up to the housing
- Interior components – A spring, ball, piston or stem that helps move the liquid to the actuator

## **Operation**

[edit]

The handwash bottle acts much like an air suction device that draws liquid upwards to the user's hands against the force of gravity. When the user presses down the actuator, the piston compresses the spring and upward air pressure pulls the ball upward, along with the liquid product into the dip tube and then reaches the housing. When the user releases the actuator, the spring returns the piston and actuator to the normal position and the ball returns to its earlier position to stop the backflow of the liquid back to the bottle. This process is called 'priming' and is only used when the handwash is put in the bottle.

When the user presses the bottle again, the liquid in the housing is drawn from there and is released out of the actuator. The housing is again filled up with the handwash from the bottle, and the process goes on.

## **Dry soap**

[edit]



A vertical stainless steel tube, mounted on a wall, with a crank handle on the side at the bottom

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A soap mill in a public washroom.

A moulded bulge protruding from the underside of a moulded plastic surface; at the base of the

Image not found or type unknown

A train-washroom built-in soap mill from below.

When the black spokes are rotated with one finger, the spiral blades rotate against the soap bar visible behind them and flakes of soap fall out the bottom of the device into the other hand.

Some soap dispensers grate, plane<sup>[2]</sup> or grind solid soap bars to flakes or powder as they are dispensed. About 40 grams (1.4 oz) fresh weight of soap is equivalent to 1 liter (0.22 imp gal; 0.26 U.S. gal) of liquid soap, providing soap for up to 400 handwashings.

Soap mills are common in public washrooms in Germany.<sup>[3]</sup> **Soap graters** made specifically for home use<sup>[4]</sup><sup>[2]</sup> can be wall-mounted or free-standing (like a pepper grinder) and waterproof for use in a shower.<sup>[5]</sup><sup>[6]</sup> Some graters take specially dimensioned soap bars, others will take a range of ordinary soap bar sizes.<sup>[3]</sup><sup>[2]</sup>

Dispensers of pre-powdered soaps, such as borax, often take the form of a metal box with a weighted lever; when the lever is pressed, a handful of soap is released. Ground soap is also used to wash laundry.<sup>[7]</sup>

## Foam soap

[edit]

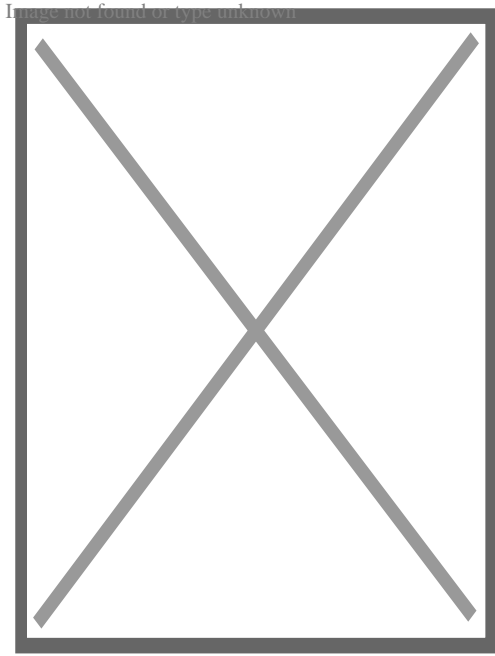
Foam soap dispensers have dual foam pumps that when used, move both air and soap, injecting both together through small openings to create a lather. They can be found in both manual and automatic varieties.

Manual dispensers of foam soap often consist of a large button that squeezes the foam out of a tube. Many liquid soap dispensers operate in this way as well. A few dispensers operate with a lever that pulls forward and squeezes the soap out.

The majority of manual foam soap dispensers have the soap in a bladder in the dispenser in liquid form, as the pump is pressed the liquid soap is pushed through a small foaming nozzle which foams the soap.

### Automatic

[edit]



Automatic soap dispenser

Main article: Automatic soap dispenser

An automatic soap dispenser is specifically a hands-free dispenser of liquid or foam soap, and generally can be used for other liquids such as hand sanitizers, shampoos or hand lotions. They are often battery-powered-powered. Hands-free dispensers for water and soap/hand sanitizer have particular virtues for operating theatres and treatment rooms.

## Mechanism

[edit]

The touch-free design dispenses the liquid when a sensor detects motion under the nozzle. The electronic components of an automatic soap dispenser allow for a timing device or signal (sound, lights, etc.) which can indicate to the user whether they have washed their hands for the correct amount of time or not.

**See also**

[edit]

- Foam pump
- Hand washing
- Soapdish

## References

[edit]

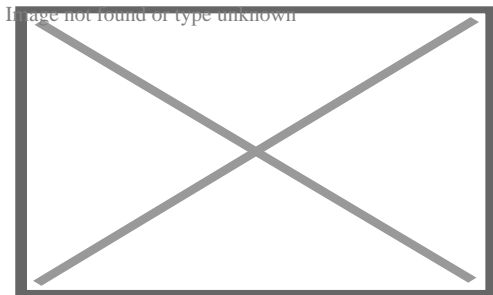
1. ^ *"The History of Soap and Detergent". Archived from the original on July 14, 2012.*
2. ^ **a b c** *"Trockenseifenspender SoapPlaner". SoapPlaner (in German).*
3. ^ **a b** Morwood, Peter. *"Trockenseifenspender (dry soap dispenser)".*
4. ^ John Brownlee (12 January 2011). *"Bar soap dispenser will double as cheese grater in a pinch". Geek.com.*
5. ^ *"Soap Grater Looks Practical". Cool Things. January 11, 2011.*
6. ^ *"Soap Flakes - Soap Bar Dispensers". The Green Head - Finds Cool New Stuff!.*
7. ^ *"How To Make Classic DIY Laundry Detergent With NO Grating!". Farming My Backyard. 10 April 2018.*



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Wikimedia Commons has media related to ***Soap dispensers***.

## About Ventilation (architecture)



An Ab anbar (water reservoir) with double domes and windcatchers (openings near the top of the towers) in the central desert city of Naeen, Iran. Windcatchers are a form of natural ventilation.<sup>[1]</sup>





This article's lead section **may need to be rewritten**. Please review the lead guide and help improve the lead of this article if you can. *(July 2025) (Learn how and when to remove this message)*

**Ventilation** is the intentional introduction of outdoor air into a space. Ventilation is mainly used to control indoor air quality by diluting and displacing indoor effluents and pollutants. It can also be used to control indoor temperature, humidity, and air motion to benefit thermal comfort, satisfaction with other aspects of the indoor environment, or other objectives.

The intentional introduction of outdoor air is usually categorized as either mechanical ventilation, natural ventilation, or mixed-mode ventilation.<sup>[2]</sup>

- Mechanical ventilation is the intentional fan-driven flow of outdoor air into and/or out from a building. Mechanical ventilation systems may include supply fans (which push outdoor air into a building), exhaust<sup>[3]</sup> fans (which draw air out of a building and thereby cause equal ventilation flow into a building), or a combination of both (called balanced ventilation if it neither pressurizes nor depressurizes the inside air,<sup>[3]</sup> or only slightly depressurizes it). Mechanical ventilation is often provided by equipment that is also used to heat and cool a space.
- Natural ventilation is the intentional passive flow of outdoor air into a building through planned openings (such as louvers, doors, and windows). Natural ventilation does not require mechanical systems to move outdoor air. Instead, it relies entirely on passive physical phenomena, such as wind pressure, or the stack effect. Natural ventilation openings may be fixed, or adjustable. Adjustable openings may be controlled automatically (automated), owned by occupants (operable), or a combination of both. Cross ventilation is a phenomenon of natural ventilation.
- Mixed-mode ventilation systems use both mechanical and natural processes. The mechanical and natural components may be used at the same time, at different times of day, or in different seasons of the year.<sup>[4]</sup> Since natural

ventilation flow depends on environmental conditions, it may not always provide an appropriate amount of ventilation. In this case, mechanical systems may be used to supplement or regulate the naturally driven flow.

Ventilation is typically described as separate from infiltration.

- Infiltration is the circumstantial flow of air from outdoors to indoors through leaks (unplanned openings) in a building envelope. When a building design relies on infiltration to maintain indoor air quality, this flow has been referred to as adventitious ventilation.<sup>[5]</sup>

The design of buildings that promote occupant health and well-being requires a clear understanding of the ways that ventilation airflow interacts with, dilutes, displaces, or introduces pollutants within the occupied space. Although ventilation is an integral component of maintaining good indoor air quality, it may not be satisfactory alone.<sup>[6]</sup> A clear understanding of both indoor and outdoor air quality parameters is needed to improve the performance of ventilation in terms of occupant health and energy.<sup>[7]</sup> In scenarios where outdoor pollution would deteriorate indoor air quality, other treatment devices such as filtration may also be necessary.<sup>[8]</sup> In kitchen ventilation systems, or for laboratory fume hoods, the design of effective effluent capture can be more important than the bulk amount of ventilation in a space. More generally, the way that an air distribution system causes ventilation to flow into and out of a space impacts the ability of a particular ventilation rate to remove internally generated pollutants. The ability of a system to reduce pollution in space is described as its "ventilation effectiveness". However, the overall impacts of ventilation on indoor air quality can depend on more complex factors such as the sources of pollution, and the ways that activities and airflow interact to affect occupant exposure.

An array of factors related to the design and operation of ventilation systems are regulated by various codes and standards. Standards dealing with the design and operation of ventilation systems to achieve acceptable indoor air quality include the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards 62.1 and 62.2, the International Residential Code, the International

Mechanical Code, and the United Kingdom Building Regulations Part F. Other standards that focus on energy conservation also impact the design and operation of ventilation systems, including ASHRAE Standard 90.1, and the International Energy Conservation Code.

When indoor and outdoor conditions are favorable, increasing ventilation beyond the minimum required for indoor air quality can significantly improve both indoor air quality and thermal comfort through ventilative cooling, which also helps reduce the energy demand of buildings.<sup>[9]</sup><sup>[10]</sup> During these times, higher ventilation rates, achieved through passive or mechanical means (air-side economizer, ventilative pre-cooling), can be particularly beneficial for enhancing people's physical health.<sup>[11]</sup> Conversely, when conditions are less favorable, maintaining or improving indoor air quality through ventilation may require increased use of mechanical heating or cooling, leading to higher energy consumption.

Ventilation should be considered for its relationship to "venting" for appliances and combustion equipment such as water heaters, furnaces, boilers, and wood stoves. Most importantly, building ventilation design must be careful to avoid the backdraft of combustion products from "naturally vented" appliances into the occupied space. This issue is of greater importance for buildings with more air-tight envelopes. To avoid the hazard, many modern combustion appliances utilize "direct venting" which draws combustion air directly from outdoors, instead of from the indoor environment.

## **Design of air flow in rooms**

[edit]

The air in a room can be supplied and removed in several ways, for example via ceiling ventilation, cross ventilation, floor ventilation or displacement ventilation.<sup>[*citation needed*]</sup>

## Ceiling ventilation

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## Ceiling ventilation

### Cross ventilation

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### Cross ventilation

### Floor ventilation

○

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### Floor ventilation

### Displacement ventilation

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## Displacement

### ventilation

Furthermore, the air can be circulated in the room using vortexes which can be initiated in various ways:



## Tangential flow vortices, initiated horizontally

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Tangential flow  
vortices, initiated  
horizontally

Tangential flow vortices, initiated vertically

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Tangential flow  
vortices, initiated  
vertically

Diffused flow vortices from air nozzles

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Diffused flow  
vortices from air  
nozzles

Diffused flow vortices due to roof vortices

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Diffused flow  
vortices due to roof

vortices

## Ventilation rates for indoor air quality

[edit]

The examples and perspective in this article **deal primarily with the United States and do not represent a worldwide view of the subject**. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. *(April 2024) (Learn how and when to remove this message)*

The ventilation rate, for commercial, industrial, and institutional (CII) buildings, is normally expressed by the volumetric flow rate of outdoor air, introduced to the building. The typical units used are cubic feet per minute (CFM) in the imperial system, or liters per second (L/s) in the metric system (even though cubic meter per second is the preferred unit for volumetric flow rate in the SI system of units). The ventilation rate can also be expressed on a per person or per unit floor area basis, such as CFM/p or CFM/ft<sup>2</sup>, or as air changes per hour (ACH).

## Standards for residential buildings

[edit]

For residential buildings, which mostly rely on infiltration for meeting their ventilation needs, a common ventilation rate measure is the air change rate (or air changes per hour): the hourly ventilation rate divided by the volume of the space (*I* or *ACH*; units of 1/h). During the winter, ACH may range from 0.50 to 0.41 in a tightly air-sealed house to 1.11 to 1.47 in a loosely air-sealed house.<sup>[12]</sup>

ASHRAE now recommends ventilation rates dependent upon floor area, as a revision to the 62-2001 standard, in which the minimum ACH was 0.35, but no less than 15 CFM/person (7.1 L/s/person). As of 2003, the standard has been changed to 3 CFM/100 sq. ft. (15 L/s/100 sq. m.) plus 7.5 CFM/person (3.5 L/s/person).<sup>[13]</sup>

# Standards for commercial buildings

[edit]

## Ventilation rate procedure

[edit]

Ventilation Rate Procedure is rate based on standard and prescribes the rate at which ventilation air must be delivered to space and various means to the condition that air.<sup>[14]</sup> Air quality is assessed (through CO<sub>2</sub> measurement) and ventilation rates are mathematically derived using constants. Indoor Air Quality Procedure uses one or more guidelines for the specification of acceptable concentrations of certain contaminants in indoor air but does not prescribe ventilation rates or air treatment methods.<sup>[14]</sup> This addresses both quantitative and subjective evaluations and is based on the Ventilation Rate Procedure. It also accounts for potential contaminants that may have no measured limits, or for which no limits are not set (such as formaldehyde off-gassing from carpet and furniture).

### Natural ventilation

[edit]

Main article: Natural ventilation

Natural ventilation harnesses naturally available forces to supply and remove air in an enclosed space. Poor ventilation in rooms is identified to significantly increase the localized moldy smell in specific places of the room including room corners.<sup>[11]</sup> There are three types of natural ventilation occurring in buildings: wind-driven ventilation, pressure-driven flows, and stack ventilation.<sup>[15]</sup> The pressures generated by 'the stack effect' rely upon the buoyancy of heated or rising air. Wind-driven ventilation

relies upon the force of the prevailing wind to pull and push air through the enclosed space as well as through breaches in the building's envelope.

Almost all historic buildings were ventilated naturally.<sup>[16]</sup> The technique was generally abandoned in larger US buildings during the late 20th century as the use of air conditioning became more widespread. However, with the advent of advanced Building Performance Simulation (BPS) software, improved Building Automation Systems (BAS), Leadership in Energy and Environmental Design (LEED) design requirements, and improved window manufacturing techniques; natural ventilation has made a resurgence in commercial buildings both globally and throughout the US.<sup>[17]</sup>

The benefits of natural ventilation include:

- Improved indoor air quality (IAQ)
- Energy savings
- Reduction of greenhouse gas emissions
- Occupant control
- Reduction in occupant illness associated with sick building syndrome
- Increased worker productivity

Techniques and architectural features used to ventilate buildings and structures naturally include, but are not limited to:

- Operable windows
- Clerestory windows and vented skylights
- Lev/convection doors
- Night purge ventilation
- Building orientation
- Wind capture façades

## **Airborne diseases**

[edit]



Natural ventilation is a key factor in reducing the spread of airborne illnesses such as tuberculosis, the common cold, influenza, meningitis or COVID-19.<sup>[18]</sup> Opening doors and windows are good ways to maximize natural ventilation, which would make the risk of airborne contagion much lower than with costly and maintenance-requiring mechanical systems. Old-fashioned clinical areas with high ceilings and large windows provide the greatest protection. Natural ventilation costs little and is maintenance-free, and is particularly suited to limited-resource settings and tropical climates, where the burden of TB and institutional TB transmission is highest. In settings where respiratory isolation is difficult and climate permits, windows and doors should be opened to reduce the risk of airborne contagion. Natural ventilation requires little maintenance and is inexpensive.<sup>[19]</sup>

Natural ventilation is not practical in much of the infrastructure because of climate. This means that the facilities need to have effective mechanical ventilation systems and or use Ceiling Level UV or FAR UV ventilation systems.

Ventilation is measured in terms of air changes per hour (ACH). As of 2023, the CDC recommends that all spaces have a minimum of 5 ACH.<sup>[20]</sup> For hospital rooms with airborne contagions the CDC recommends a minimum of 12 ACH.<sup>[21]</sup> Challenges in facility ventilation are public unawareness,<sup>[22]</sup><sup>[23]</sup> ineffective government oversight, poor building codes that are based on comfort levels, poor system operations, poor maintenance, and lack of transparency.<sup>[24]</sup>

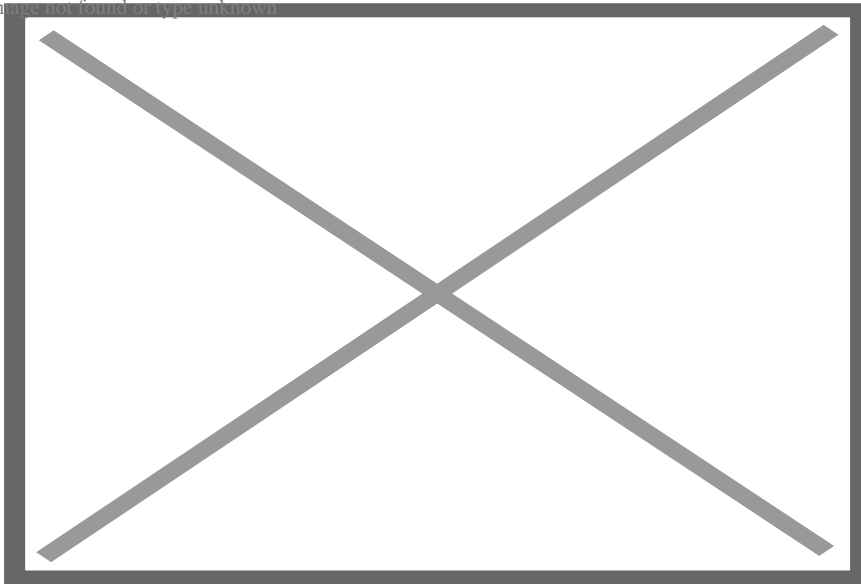
Pressure, both political and economic, to improve energy conservation has led to decreased ventilation rates. Heating, ventilation, and air conditioning rates have dropped since the energy crisis in the 1970s and the banning of cigarette smoke in the 1980s and 1990s.<sup>[25]</sup><sup>[26]</sup> *better source needed*

## **Mechanical ventilation**

[edit]

Main article: HVAC

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An axial belt-drive exhaust fan serving an underground car park. This exhaust fan's operation is interlocked with the concentration of contaminants emitted by internal combustion engines.

Mechanical ventilation of buildings and structures can be achieved by the use of the following techniques:

- Whole-house ventilation
- Mixing ventilation
- Displacement ventilation
- Dedicated subaerial air supply

## Demand-controlled ventilation (DCV)

[edit]

Demand-controlled ventilation (**DCV**, also known as Demand Control Ventilation) makes it possible to maintain air quality while conserving energy.<sup>[27]</sup><sup>[28]</sup> ASHRAE has determined that "It is consistent with the ventilation rate procedure that demand control be permitted for use to reduce the total outdoor air supply during periods of less occupancy."<sup>[29]</sup> In a DCV system, CO<sub>2</sub> sensors control the amount of ventilation. [

<sup>30</sup>][<sup>31</sup>] During peak occupancy, CO<sub>2</sub> levels rise, and the system adjusts to deliver the same amount of outdoor air as would be used by the ventilation-rate procedure.<sup>[32]</sup> However, when spaces are less occupied, CO<sub>2</sub> levels reduce, and the system reduces ventilation to conserve energy. DCV is a well-established practice,<sup>[33]</sup> and is required in high occupancy spaces by building energy standards such as ASHRAE 90.1.<sup>[34]</sup>

## Personalized ventilation

[edit]



This section needs to be **updated**. Please help update this article to reflect recent events or newly available information. (*September 2024*)

Personalized ventilation is an air distribution strategy that allows individuals to control the amount of ventilation received. The approach delivers fresh air more directly to the breathing zone and aims to improve the air quality of inhaled air. Personalized ventilation provides much higher ventilation effectiveness than conventional mixing ventilation systems by displacing pollution from the breathing zone with far less air volume. Beyond improved air quality benefits, the strategy can also improve occupants' thermal comfort, perceived air quality, and overall satisfaction with the indoor environment. Individuals' preferences for temperature and air movement are not equal, and so traditional approaches to homogeneous environmental control have failed to achieve high occupant satisfaction. Techniques such as personalized ventilation facilitate control of a more diverse thermal environment that can improve thermal satisfaction for most occupants.

## Local exhaust ventilation

[edit]

See also: Power tool

Local exhaust ventilation addresses the issue of avoiding the contamination of indoor air by specific high-emission sources by capturing airborne contaminants before they are spread into the environment. This can include water vapor control, lavatory effluent control, solvent vapors from industrial processes, and dust from wood- and metal-working machinery. Air can be exhausted through pressurized hoods or the use of fans and pressurizing a specific area.<sup>[35]</sup>

A local exhaust system is composed of five basic parts:

1. A hood that captures the contaminant at its source
2. Ducts for transporting the air
3. An air-cleaning device that removes/minimizes the contaminant
4. A fan that moves the air through the system
5. An exhaust stack through which the contaminated air is discharged<sup>[35]</sup>

In the UK, the use of LEV systems has regulations set out by the Health and Safety Executive (HSE) which are referred to as the Control of Substances Hazardous to Health (CoSHH). Under CoSHH, legislation is set to protect users of LEV systems by ensuring that all equipment is tested at least every fourteen months to ensure the LEV systems are performing adequately. All parts of the system must be visually inspected and thoroughly tested and where any parts are found to be defective, the inspector must issue a red label to identify the defective part and the issue.

The owner of the LEV system must then have the defective parts repaired or replaced before the system can be used.

## **Smart ventilation**

[edit]

Smart ventilation is a process of continually adjusting the ventilation system in time, and optionally by location, to provide the desired IAQ benefits while minimizing energy consumption, utility bills, and other non-IAQ costs (such as thermal

discomfort or noise). A smart ventilation system adjusts ventilation rates in time or by location in a building to be responsive to one or more of the following: occupancy, outdoor thermal and air quality conditions, electricity grid needs, direct sensing of contaminants, operation of other air moving and air cleaning systems. In addition, smart ventilation systems can provide information to building owners, occupants, and managers on operational energy consumption and indoor air quality as well as a signal when systems need maintenance or repair. Being responsive to occupancy means that a smart ventilation system can adjust ventilation depending on demand such as reducing ventilation if the building is unoccupied. Smart ventilation can time-shift ventilation to periods when a) indoor-outdoor temperature differences are smaller (and away from peak outdoor temperatures and humidity), b) when indoor-outdoor temperatures are appropriate for ventilative cooling, or c) when outdoor air quality is acceptable. Being responsive to electricity grid needs means providing flexibility to electricity demand (including direct signals from utilities) and integration with electric grid control strategies. Smart ventilation systems can have sensors to detect airflow, systems pressures, or fan energy use in such a way that systems failures can be detected and repaired, as well as when system components need maintenance, such as filter replacement.<sup>[36]</sup>

## **Ventilation and combustion**

[edit]

Combustion (in a fireplace, gas heater, candle, oil lamp, etc.) consumes oxygen while producing carbon dioxide and other unhealthy gases and smoke, requiring ventilation air. An open chimney promotes infiltration (i.e. natural ventilation) because of the negative pressure change induced by the buoyant, warmer air leaving through the chimney. The warm air is typically replaced by heavier, cold air.

Ventilation in a structure is also needed for removing water vapor produced by respiration, burning, and cooking, and for removing odors. If water vapor is permitted to accumulate, it may damage the structure, insulation, or finishes. <sup>[citation needed]</sup>

When operating, an air conditioner usually removes excess moisture from the air. A dehumidifier may also be appropriate for removing airborne moisture.

### Calculation for acceptable ventilation rate

[edit]

Ventilation guidelines are based on the minimum ventilation rate required to maintain acceptable levels of effluents. Carbon dioxide is used as a reference point, as it is the gas of highest emission at a relatively constant value of 0.005 L/s. The mass balance equation is:

$$Q = G / (C_i - C_a)$$

- Q = ventilation rate (L/s)
- G = CO<sub>2</sub> generation rate
- C<sub>i</sub> = acceptable indoor CO<sub>2</sub> concentration
- C<sub>a</sub> = ambient CO<sub>2</sub> concentration<sup>[37]</sup>

### Smoking and ventilation

[edit]

ASHRAE standard 62 states that air removed from an area with environmental tobacco smoke shall not be recirculated into ETS-free air. A space with ETS requires more ventilation to achieve similar perceived air quality to that of a non-smoking environment.

The amount of ventilation in an ETS area is equal to the amount of an ETS-free area plus the amount V, where:

$$V = DSD \times VA \times A/60E$$

- V = recommended extra flow rate in CFM (L/s)
- DSD = design smoking density (estimated number of cigarettes smoked per hour per unit area)

- VA = volume of ventilation air per cigarette for the room being designed ( $\text{ft}^3/\text{cig}$ )
- E = contaminant removal effectiveness<sup>[38]</sup>

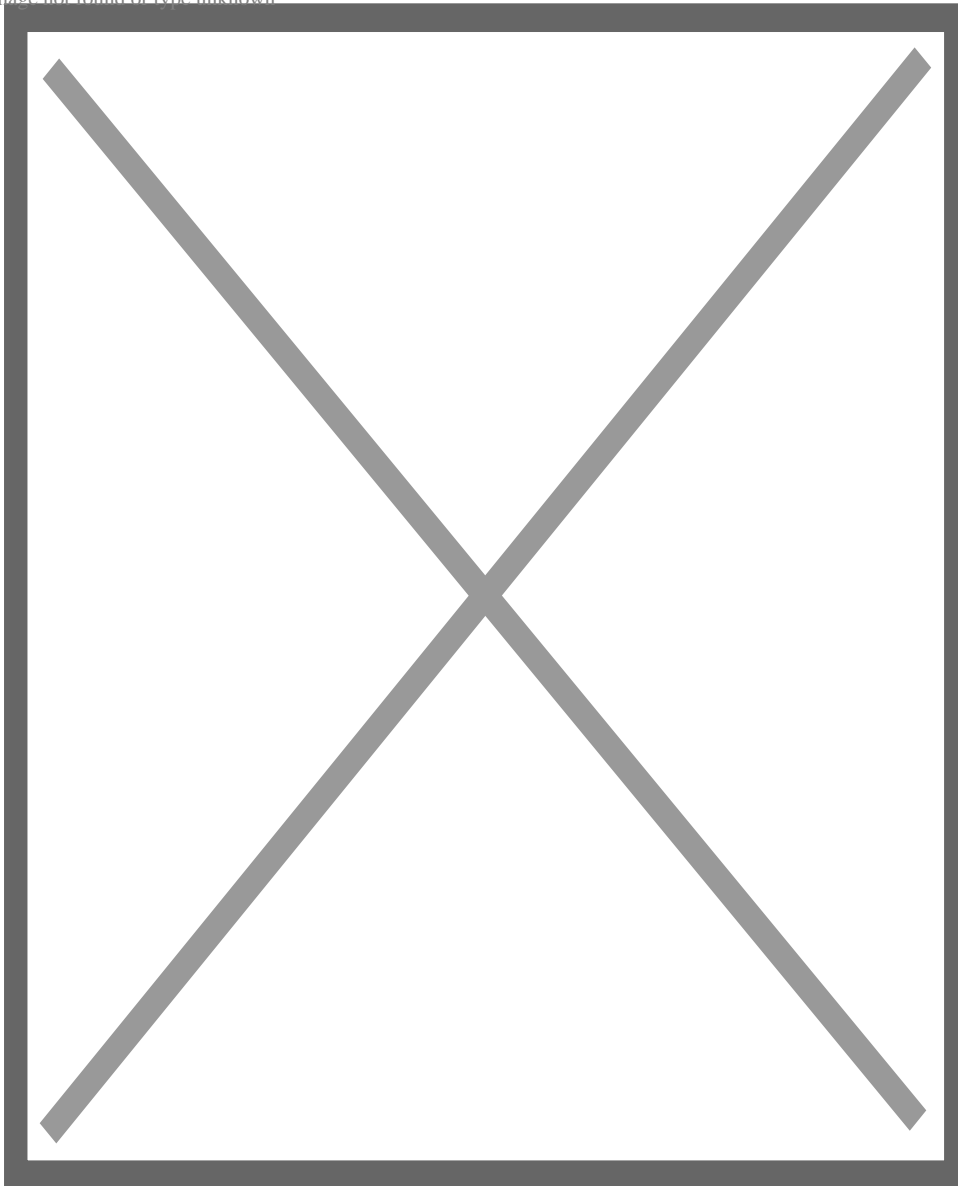
## History

[edit]

**This section needs expansion.** You can help by adding to it. *(August 2020)*

[icon] Image:Microsection of Rome

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This ancient Roman house uses a variety of passive cooling and passive ventilation techniques. Heavy masonry walls, small exterior windows, and a narrow walled garden oriented N-S shade the house, preventing heat gain.

The house opens onto a central atrium with an impluvium (open to the sky); the evaporative cooling of the water causes a cross-draft from atrium to garden.

Primitive ventilation systems were found at the Pločnik archeological site (belonging to the Vinča culture) in Serbia and were built into early copper smelting furnaces. The furnace, built on the outside of the workshop, featured earthen pipe-like air vents with hundreds of tiny holes in them and a prototype chimney to ensure air goes into the furnace to feed the fire and smoke comes out safely.<sup>[39]</sup>

Passive ventilation and passive cooling systems were widely written about around the Mediterranean by Classical times. Both sources of heat and sources of cooling (such as fountains and subterranean heat reservoirs) were used to drive air circulation, and buildings were designed to encourage or exclude drafts, according to climate and function. Public bathhouses were often particularly sophisticated in their heating and cooling. Icehouses are some millennia old, and were part of a well-developed ice industry by classical times.

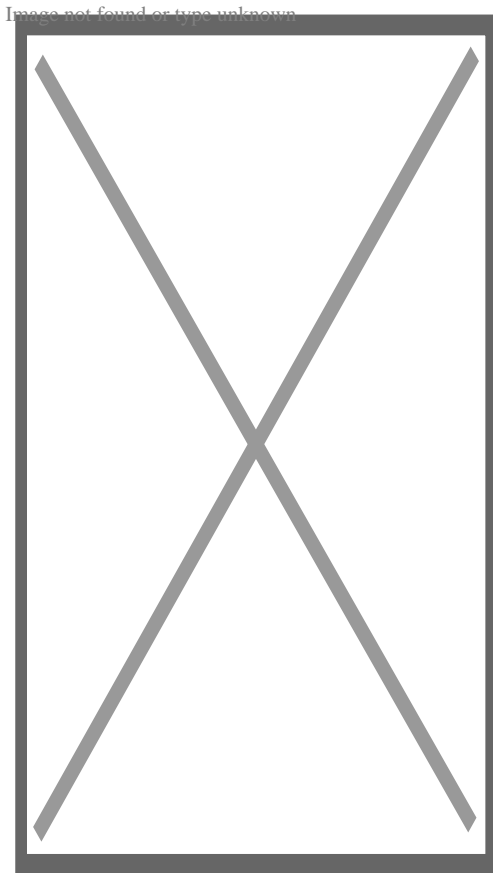
The development of forced ventilation was spurred by the common belief in the late 18th and early 19th century in the miasma theory of disease, where stagnant 'airs' were thought to spread illness. An early method of ventilation was the use of a ventilating fire near an air vent which would forcibly cause the air in the building to circulate. English engineer John Theophilus Desaguliers provided an early example of this when he installed ventilating fires in the air tubes on the roof of the House of Commons. Starting with the Covent Garden Theatre, gas burning chandeliers on the ceiling were often specially designed to perform a ventilating role.

## Mechanical systems

[edit]



Further information: Heating, ventilation, and air conditioning § Mechanical or forced ventilation



The Central Tower of the Palace of Westminster. This octagonal spire was for ventilation purposes, in the more complex system imposed by Reid on Barry, in which it was to draw air out of the Palace. The design was for the aesthetic disguise of its function.<sup>[40]</sup><sup>[41]</sup>

A more sophisticated system involving the use of mechanical equipment to circulate the air was developed in the mid-19th century. A basic system of bellows was put in place to ventilate Newgate Prison and outlying buildings, by the engineer Stephen Hales in the mid-1700s. The problem with these early devices was that they required constant human labor to operate. David Boswell Reid was called to testify before a Parliamentary committee on proposed architectural designs for the new House of Commons, after the old one burned down in a fire in 1834.<sup>[40]</sup> In January 1840 Reid was appointed by the committee for the House of Lords dealing with the construction of the replacement for the Houses of Parliament. The post was in the

capacity of ventilation engineer, in effect; and with its creation there began a long series of quarrels between Reid and Charles Barry, the architect.<sup>[42]</sup>

Reid advocated the installation of a very advanced ventilation system in the new House. His design had air being drawn into an underground chamber, where it would undergo either heating or cooling. It would then ascend into the chamber through thousands of small holes drilled into the floor, and would be extracted through the ceiling by a special ventilation fire within a great stack.<sup>[43]</sup>

Reid's reputation was made by his work in Westminster. He was commissioned for an air quality survey in 1837 by the Leeds and Selby Railway in their tunnel.<sup>[44]</sup> The steam vessels built for the Niger expedition of 1841 were fitted with ventilation systems based on Reid's Westminster model.<sup>[45]</sup> Air was dried, filtered and passed over charcoal.<sup>[46]</sup><sup>[47]</sup> Reid's ventilation method was also applied more fully to St. George's Hall, Liverpool, where the architect, Harvey Lonsdale Elmes, requested that Reid should be involved in ventilation design.<sup>[48]</sup> Reid considered this the only building in which his system was completely carried out.<sup>[49]</sup>

## Fans

[edit]

With the advent of practical steam power, ceiling fans could finally be used for ventilation. Reid installed four steam-powered fans in the ceiling of St George's Hospital in Liverpool, so that the pressure produced by the fans would force the incoming air upward and through vents in the ceiling. Reid's pioneering work provides the basis for ventilation systems to this day.<sup>[43]</sup> He was remembered as "Dr. Reid the ventilator" in the twenty-first century in discussions of energy efficiency, by Lord Wade of Chorlton.<sup>[50]</sup>

# History and development of ventilation rate standards

[edit]

Ventilating a space with fresh air aims to avoid "bad air". The study of what constitutes bad air dates back to the 1600s when the scientist Mayow studied asphyxia of animals in confined bottles.<sup>[51]</sup> The poisonous component of air was later identified as carbon dioxide (CO<sub>2</sub>), by Lavoisier in the very late 1700s, starting a debate as to the nature of "bad air" which humans perceive to be stuffy or unpleasant. Early hypotheses included excess concentrations of CO<sub>2</sub> and oxygen depletion. However, by the late 1800s, scientists thought biological contamination, not oxygen or CO<sub>2</sub>, was the primary component of unacceptable indoor air. However, it was noted as early as 1872 that CO<sub>2</sub> concentration closely correlates to perceived air quality.

The first estimate of minimum ventilation rates was developed by Tredgold in 1836.<sup>[52]</sup> This was followed by subsequent studies on the topic by Billings <sup>[53]</sup> in 1886 and Flugge in 1905. The recommendations of Billings and Flugge were incorporated into numerous building codes from 1900–the 1920s and published as an industry standard by ASHVE (the predecessor to ASHRAE) in 1914.<sup>[51]</sup>

The study continued into the varied effects of thermal comfort, oxygen, carbon dioxide, and biological contaminants. The research was conducted with human subjects in controlled test chambers. Two studies, published between 1909 and 1911, showed that carbon dioxide was not the offending component. Subjects remained satisfied in chambers with high levels of CO<sub>2</sub>, so long as the chamber remained cool.<sup>[51]</sup> (Subsequently, it has been determined that CO<sub>2</sub> is, in fact, harmful at concentrations over 50,000ppm<sup>[54]</sup>)

ASHVE began a robust research effort in 1919. By 1935, ASHVE-funded research conducted by Lemberg, Brandt, and Morse – again using human subjects in test chambers – suggested the primary component of "bad air" was an odor, perceived by the human olfactory nerves.<sup>[55]</sup> Human response to odor was found to be logarithmic to contaminant concentrations, and related to temperature. At lower, more comfortable temperatures, lower ventilation rates were satisfactory. A 1936 human test chamber study by Yaglou, Riley, and Coggins culminated much of this effort, considering odor, room volume, occupant age, cooling equipment effects, and recirculated air implications, which guided ventilation rates.<sup>[56]</sup> The Yagle research has been validated, and adopted into industry standards, beginning with the ASA code in 1946. From this research base, ASHRAE (having replaced ASHVE) developed space-by-space recommendations, and published them as ASHRAE Standard 62–1975: Ventilation for acceptable indoor air quality.

As more architecture incorporated mechanical ventilation, the cost of outdoor air ventilation came under some scrutiny. In 1973, in response to the 1973 oil crisis and conservation concerns, ASHRAE Standards 62–73 and 62–81) reduced required ventilation from 10 CFM (4.76 L/s) per person to 5 CFM (2.37 L/s) per person. In cold, warm, humid, or dusty climates, it is preferable to minimize ventilation with outdoor air to conserve energy, cost, or filtration. This critique (e.g. Tiller<sup>[57]</sup>) led ASHRAE to reduce outdoor ventilation rates in 1981, particularly in non-smoking areas. However subsequent research by Fanger,<sup>[58]</sup> W. Cain, and Janssen validated the Yagle model. The reduced ventilation rates were found to be a contributing factor to sick building syndrome.<sup>[59]</sup>

The 1989 ASHRAE standard (Standard 62–89) states that appropriate ventilation guidelines are 20 CFM (9.2 L/s) per person in an office building, and 15 CFM (7.1 L/s) per person for schools, while 2004 Standard 62.1–2004 has lower recommendations again (see tables below). ANSI/ASHRAE (Standard 62–89) speculated that "comfort (odor) criteria are likely to be satisfied if the ventilation rate is set so that 1,000 ppm CO<sub>2</sub> is not exceeded"<sup>[60]</sup> while OSHA has set a limit of 5000 ppm over 8 hours.<sup>[61]</sup>

## Historical ventilation rates

Author or source	Year	Ventilation rate (IP)	Ventilation rate (SI)	Basis or rationale
Tredgold	1836	4 CFM per person	2 L/s per person	Basic metabolic needs, breathing rate, and candle burning
Billings	1895	30 CFM per person	15 L/s per person	Indoor air hygiene, preventing spread of disease
Flugge	1905	30 CFM per person	15 L/s per person	Excessive temperature or unpleasant odor
ASHVE	1914	30 CFM per person	15 L/s per person	Based on Billings, Flugge and contemporaries
Early US Codes	1925	30 CFM per person	15 L/s per person	Same as above
Yaglou	1936	15 CFM per person	7.5 L/s per person	Odor control, outdoor air as a fraction of total air
ASA	1946	15 CFM per person	7.5 L/s per person	Based on Yaglou and contemporaries
ASHRAE	1975	15 CFM per person	7.5 L/s per person	Same as above
ASHRAE	1981	10 CFM per person	5 L/s per person	For non-smoking areas, reduced.
ASHRAE	1989	15 CFM per person	7.5 L/s per person	Based on Fanger, W. Cain, and Janssen

ASHRAE continues to publish space-by-space ventilation rate recommendations, which are decided by a consensus committee of industry experts. The modern descendants of ASHRAE standard 62-1975 are ASHRAE Standard 62.1, for non-residential spaces, and ASHRAE 62.2 for residences.

In 2004, the calculation method was revised to include both an occupant-based contamination component and an area-based contamination component.<sup>[62]</sup> These two components are additive, to arrive at an overall ventilation rate. The change was made to recognize that densely populated areas were sometimes overventilated (leading to higher energy and cost) using a per-person methodology.

### **Occupant Based Ventilation Rates,<sup>[62]</sup> ANSI/ASHRAE Standard 62.1-2004**

<b>IP Units</b>	<b>SI Units</b>	<b>Category</b>	<b>Examples</b>
0 cfm/person	0 L/s/person	Spaces where ventilation requirements are primarily associated with building elements, not occupants.	Storage Rooms, Warehouses
5 cfm/person	2.5 L/s/person	Spaces occupied by adults, engaged in low levels of activity	Office space
7.5 cfm/person	3.5 L/s/person	Spaces where occupants are engaged in higher levels of activity, but not strenuous, or activities generating more contaminants	Retail spaces, lobbies
10 cfm/person	5 L/s/person	Spaces where occupants are engaged in more strenuous activity, but not exercise, or activities generating more contaminants	Classrooms, school settings
20 cfm/person	10 L/s/person	Spaces where occupants are engaged in exercise, or activities generating many contaminants	dance floors, exercise rooms

### **Area-based ventilation rates,<sup>[62]</sup> ANSI/ASHRAE Standard 62.1-2004**

<b>IP Units</b>	<b>SI Units</b>	<b>Category</b>	<b>Examples</b>
0.06 cfm/ft <sup>2</sup>	0.30 L/s/m <sup>2</sup>	Spaces where space contamination is normal, or similar to an office environment	Conference rooms, lobbies

0.12 cfm/ft <sup>2</sup>	0.60 L/s/m <sup>2</sup>	Spaces where space contamination is significantly higher than an office environment	Classrooms, museums
0.18 cfm/ft <sup>2</sup>	0.90 L/s/m <sup>2</sup>	Spaces where space contamination is even higher than the previous category	Laboratories, art classrooms
0.30 cfm/ft <sup>2</sup>	1.5 L/s/m <sup>2</sup>	Specific spaces in sports or entertainment where contaminants are released	Sports, entertainment
0.48 cfm/ft <sup>2</sup>	2.4 L/s/m <sup>2</sup>	Reserved for indoor swimming areas, where chemical concentrations are high	Indoor swimming areas

The addition of occupant- and area-based ventilation rates found in the tables above often results in significantly reduced rates compared to the former standard. This is compensated in other sections of the standard which require that this minimum amount of air is delivered to the breathing zone of the individual occupant at all times. The total outdoor air intake of the ventilation system (in multiple-zone variable air volume (VAV) systems) might therefore be similar to the airflow required by the 1989 standard.

From 1999 to 2010, there was considerable development of the application protocol for ventilation rates. These advancements address occupant- and process-based ventilation rates, room ventilation effectiveness, and system ventilation effectiveness[63]

## Problems

[edit]

- In hot, humid climates, unconditioned ventilation air can daily deliver approximately 260 milliliters of water for each cubic meters per hour (m<sup>3</sup>/h) of outdoor air (or one pound of water each day for each cubic feet per minute of outdoor air per day), annual average.<sup>[citation needed]</sup> This is a great deal of moisture and can create serious indoor moisture and mold problems. For example, given a 150 m<sup>2</sup> building with an airflow of 180 m<sup>3</sup>/h this could result in about 47 liters of water accumulated per day.

- Ventilation efficiency is determined by design and layout, and is dependent upon the placement and proximity of diffusers and return air outlets. If they are located closely together, supply air may mix with stale air, decreasing the efficiency of the HVAC system, and creating air quality problems.
  - System imbalances occur when components of the HVAC system are improperly adjusted or installed and can create pressure differences (too much-circulating air creating a draft or too little circulating air creating stagnancy).
  - Cross-contamination occurs when pressure differences arise, forcing potentially contaminated air from one zone to an uncontaminated zone. This often involves undesired odors or VOCs.
  - Re-entry of exhaust air occurs when exhaust outlets and fresh air intakes are either too close, prevailing winds change exhaust patterns or infiltration between intake and exhaust air flows.
  - Entrainment of contaminated outdoor air through intake flows will result in indoor air contamination. There are a variety of contaminated air sources, ranging from industrial effluent to VOCs put off by nearby construction work.<sup>[64]</sup>
- A recent study revealed that in urban European buildings equipped with ventilation systems lacking outdoor air filtration, the exposure to outdoor-originating pollutants indoors resulted in more Disability-Adjusted Life Years (DALYs) than exposure to indoor-emitted pollutants.<sup>[65]</sup>

## See also

[edit]

- Architectural engineering
- Biological safety
- Cleanroom
- Environmental tobacco smoke
- Fume hood
- Head-end power
- Heating, ventilation, and air conditioning
- Heat recovery ventilation
- Mechanical engineering



- Room air distribution
- Sick building syndrome
- Siheyuan
- Solar chimney
- Tulou
- Windcatcher

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# Air Infiltration & Ventilation Centre (AIVC)

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# International Energy Agency (IEA) Energy in Buildings and Communities Programme (EBC)

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- Publications from the International Energy Agency (IEA) Energy in Buildings and Communities Programme (EBC) ventilation-related research projects–annexes:
  - EBC Annex 9 Minimum Ventilation Rates
  - EBC Annex 18 Demand Controlled Ventilation Systems
  - EBC Annex 26 Energy Efficient Ventilation of Large Enclosures
  - EBC Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems
  - EBC Annex 35 Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (HYBVENT)
  - EBC Annex 62 Ventilative Cooling

## **International Society of Indoor Air Quality and Climate**

[edit]

- Indoor Air Journal
- Indoor Air Conference Proceedings

## **American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)**

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- ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality
- ASHRAE Standard 62.2 – Ventilation for Acceptable Indoor Air Quality in Residential Buildings
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## Heating, ventilation, and air conditioning

### **Fundamental concepts**

- Air changes per hour (ACH)
- Bake-out
- Building envelope
- Convection
- Dilution
- Domestic energy consumption
- Enthalpy
- Fluid dynamics
- Gas compressor
- Heat pump and refrigeration cycle
- Heat transfer
- Humidity
- Infiltration
- Latent heat
- Noise control
- Outgassing
- Particulates
- Psychrometrics
- Sensible heat
- Stack effect
- Thermal comfort
- Thermal destratification
- Thermal mass
- Thermodynamics
- Vapour pressure of water



- Absorption-compression heat pump
- Absorption refrigerator
- Air barrier
- Air conditioning
- Antifreeze
- Automobile air conditioning
- Autonomous building
- Building insulation materials
- Central heating
- Central solar heating
- Chilled beam
- Chilled water
- Constant air volume (CAV)
- Coolant
- Cross ventilation
- Dedicated outdoor air system (DOAS)
- Deep water source cooling
- Demand controlled ventilation (DCV)
- Displacement ventilation
- District cooling
- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling

## **Technology**

- Air conditioner inverter
- Air door
- Air filter
- Air handler
- Air ionizer
- Air-mixing plenum
- Air purifier
- Air source heat pump
- Attic fan
- Automatic balancing valve
- Back boiler
- Barrier pipe
- Blast damper
- Boiler
- Centrifugal fan
- Ceramic heater
- Chiller
- Condensate pump
- Condenser
- Condensing boiler
- Convection heater
- Compressor
- Cooling tower
- Damper
- Dehumidifier
- Duct
- Economizer
- Electrostatic precipitator
- Evaporative cooler
- Evaporator
- Exhaust hood
- Expansion tank
- Fan
- Fan coil unit
- Fan filter unit

**Measurement  
and control**

- Air flow meter
- Aquastat
- BACnet
- Blower door
- Building automation
- Carbon dioxide sensor
- Clean air delivery rate (CADR)
- Control valve
- Gas detector
- Home energy monitor
- Humidistat
- HVAC control system
- Infrared thermometer
- Intelligent buildings
- LonWorks
- Minimum efficiency reporting value (MERV)
- Normal temperature and pressure (NTP)
- OpenTherm
- Programmable communicating thermostat
- Programmable thermostat
- Psychrometrics
- Room temperature
- Smart thermostat
- Standard temperature and pressure (STP)
- Thermographic camera
- Thermostat
- Thermostatic radiator valve

**Professions,  
trades,  
and services**

- Architectural acoustics
- Architectural engineering
- Architectural technologist
- Building services engineering
- Building information modeling (BIM)
- Deep energy retrofit
- Duct cleaning
- Duct leakage testing
- Environmental engineering
- Hydronic balancing
- Kitchen exhaust cleaning
- Mechanical engineering
- Mechanical, electrical, and plumbing
- Mold growth, assessment, and remediation
- Refrigerant reclamation
- Testing, adjusting, balancing
- AHRI
- AMCA
- ASHRAE
- ASTM International
- BRE

**Industry  
organizations**

- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC

**Health and safety**

- Indoor air quality (IAQ)
- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

## See also

- ASHRAE Handbook
- Building science
- Fireproofing
- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Fire protection
- Template:Home automation
- Template:Solar energy

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