ASHRAE®

ADDENDA

ASHRAE Addendum a to
ASHRAE Guideline 10-2023

Interactions Affecting the Achievement of Acceptable Indoor Environments

Approved by ASHRAE on August 20, 2024.

This addendum was approved by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased on the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 180 Technology Parkway, Peachtree Corners, GA 30092. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1049-894X

SPECIAL NOTE

This Guideline was developed under the auspices of ASHRAE. ASHRAE Guidelines are developed under a review process, identifying a Guideline for the design, testing, application, or evaluation of a specific product, concept, or practice. As a Guideline it is not definitive but encompasses areas where there may be a variety of approaches, none of which must be precisely correct. ASHRAE Guidelines are written to assist professionals in the area of concern and expertise of ASHRAE's Technical Committees and Task Groups.

ASHRAE Guidelines are prepared by Project Committees appointed specifically for the purpose of writing Guidelines. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Guideline.

Development of ASHRAE Guidelines follows procedures similar to those for ASHRAE Standards except that (a) committee balance is desired but not required, (b) an effort is made to achieve consensus but consensus is not required, (c) Guidelines are not appealable, and (d) Guidelines are not submitted to ANSI for approval.

The Senior Manager of Standards of ASHRAE should be contacted for

a. interpretation of the contents of this Guideline,
b. participation in the next review of the Guideline,
c. offering constructive criticism for improving the Guideline, or
d. permission to reprint portions of the Guideline.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

Addendum a to ASHRAE Guideline 10-2023 adds moisture as an aspect of the four indoor environmental factors. Edits include addition of the various properties, measurements, effects, and interactions of moisture with the acceptability of the indoor environment, as well as associated definitions (with notes) and references.

Informative Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum a to Guideline 10-2023

Modify Section 3 as shown.

3. DEFINITIONS

absolute humidity: the weight of water vapor contained in a unit volume of air, expressed as milligrams of water vapor per cubic centimeter of air.

Note: The measurement of absolute humidity is expressed sensitive to changes with the temperature of air and atmospheric pressure. *Specific humidity* is a more accurate and useful term for the indoor environment, while *absolute humidity* is technically correct for chemical processes.

[. . .]

condensation: the conversion of water vapor in the air to liquid water on a surface that is at or below the dew-point temperature of the surrounding air.

***contaminant*:** see *pollutant*.

dew-point temperature: the temperature to which the air must be cooled to become 100% saturated with water vapor. Water vapor (humidity) will form condensation on adjacent surfaces that are at or below the dew-point temperature of that air.

dry-bulb temperature: the ambient temperature of the air as measured by using a normal thermometer freely exposed to the air but shielded from radiation and moisture.

[. . .]

equilibrium relative humidity: the relative humidity of air in contact with a surface when neither air nor surface is gaining or losing energy or moisture.

Note: Full equilibrium between surface and air does not occur in buildings, because equilibrium requires a sealed and insulated container that isolates both surface and air from external sources of energy and moisture. However, when the surface temperature of building components or furnishing and the dew-point temperature of the adjacent air is known with some certainty, converting the dew point of the air to relative humidity with respect to the temperature of the surface can be useful for assessing whether a surface might be gaining or losing moisture.

[. . .]

health risk: an interaction of the factors of the indoor environment that decreases below satisfaction the chance of developing a diagnosable disease or a definable hazard.

humidity: the presence of water vapor in the air or in a gas. The amount of water vapor in the air can be expressed in at least four different terms, each of them linked to a different way of measuring the humidity:

specific humidity: a measure of the weight of water vapor contained in a unit weight of air, expressed as grams per kilogram or grains per pound of water vapor of air.

Notes:

1. Specific humidity is the vertical axis of psychrometric charts and corresponds directly with dew point.
2. The measurement of specific humidity is not influenced by the temperature of the air or the atmospheric pressure of the air.
3. Specific humidity is more relevant to effects on materials rather than to humans.

dew-point condition: a measure of absolute humidity that is measured by cooling the air until it starts to condense or until dew forms on a cold surface.

absolute humidity: the weight of water vapor contained in a unit volume of air, expressed as milligrams of water vapor per cubic centimeter of air.

Notes:

1. As pressure or dry-bulb temperatures change, the amount of water vapor in a fixed volume of air changes. At the constant temperature and pressure of standard cfm conditions, absolute and specific humidity directly correspond to each other as well as the dew point of the air.
2. The measurement of absolute humidity measures weight per volume or g/m^3 or grains/cfm. HVAC air supply conditions are usually defined in terms of volume per time (i.e., cfm/cmh); absolute humidity can be used to determine how much water needs to be added or removed to get to target conditions in terms of dry-bulb temperature/relative humidity.

relative humidity (RH): the amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.

Notes:

1. Relative humidity is more relevant to effects on humans, while dew-point temperature is more relevant to effects on materials.
2. The relative humidity as measured in the open air is not the same value as relative humidity when measured near indoor surfaces, unless both the air and the surface in question are at the same temperature.
3. Extremes of the relative humidity of indoor air can affect perception of comfort. High relative humidity supports growth of biological agents, including disease vectors such as viruses. High relative humidity also drives moisture development on cold surfaces. It can maintain the size of moisture droplets in the air with viruses/bacteria inside of them that are expelled by occupants. Heavier droplets will fall down more quickly. Low relative humidity increases the lifetime of airborne disease vectors by quickly reducing the size of droplets. It also adversely affects the human immune system in a number of ways that lead to significant increases in transmission of infectious diseases such as the flu.

[. . .]

moisture: (1) water vapor in air; (2) water liquid absorbed or adsorbed into or below the surface of a solid, such as the materials or furnishings of a building.

Notes:

1. Moisture is an aspect of the environment that is interactive, individually or collectively, as an influence of the four environmental factors that affect the acceptability of indoor environments. Moisture is active in the air as vapor (enthalpy), in materials as liquid (moisture content), or at surfaces of materials or furnishings (water activity/available water) of the indoor environment. Moisture can be considered a pollutant when excessive in air, in materials, or on surfaces of materials and potentially considered a health risk when excessive or deficient in air. Water as vapor, liquid, or solid can also contain or distribute dissolved or suspended material as Category 1, 2, or 3 water, per ANSI-IICRC S500.
2. Moisture accumulation in materials creates favorable conditions for biological growth including, but not limited to, growth of molds on surfaces and growth of disease vectors such as viruses and bacteria. Very low moisture conditions on surfaces can lead to extended life of microbiological substances. High surface moisture can lead to adverse surface reactions that increase gaseous pollutants of indoor air and, over time, can lead to health-relevant building dampness.
3. The term "moisture" is routinely used as a generic reference to the collective or inclusive use of relative humidity, specific humidity, moisture content, and water activity without differentiation.

moisture content: the weight of water in a material compared to the dry weight of that material, expressed as a percentage.

Note: Moisture content is a common metric used to assess the risk of excessive moisture accumulation in wood and other cellulosic building materials, including paper-faced gypsum board and acoustic ceiling tile. For building materials, moisture content is generally expressed as a percentage of the material when oven dried. Wood moisture equivalent (WME) is a convenient metric of moisture content, because low-cost handheld moisture meters are widely available with that calibration. WME values that imply risk of mold growth on cut wood surfaces also imply risk of mold growth and other adverse effects in the adjacent cellulosic materials and fabrics commonly found in buildings.

[. . .]

psychrometric chart: a graphical representation of the thermodynamic properties of air at various conditions.

[. . .]

visual environment: the combined effect of the spectral distribution, intensity, and direction of the visible electromagnetic energy in a space.

wet-bulb temperature: a measure of the enthalpy/energy content of the air; the measured air temperature influenced by humidity and other environmental factors.

Note: Wet-bulb temperature reflects the cooling effect of evaporation of water from a thermometer bulb wrapped in wet muslin, whirled in the air until the thermometer reaches a constant value. Modern digital instruments calculate web-bulb temperature from the measured values of temperature and humidity. The wet-bulb temperature can also be located on a psychrometric chart.

water activity/available water (aW): the ratio between the water vapor pressure of a surface and the vapor pressure of distilled water at the same temperature when both are in equilibrium at a constant temperature.

Note: Water activity (aW) is the decimal equivalent of the equilibrium relative humidity at the surface in question. For example, an aW value of 0.8 is the same as an equilibrium relative humidity of 80%. At high aW values, moisture at the surface of a material is available to fungus and bacteria to support growth and reproduction.

wood moisture equivalent (WME): the moisture level in any building material as if it were in close contact and in moisture equilibrium with wood, expressed as the equivalent moisture content of wood.

Note: Wood moisture equivalent (WME) can be used directly to establish if materials are in a dry, at-risk, or damp condition as the critical percent moisture content thresholds for wood are known. WME is particularly useful not only for direct comparisons but also when a material under evaluation is not directly accessible to the moisture meter.

Modify Section 4 as shown. The remainder of Section 4 remains unchanged.

4. INTRODUCTION TO THE FACTORS AND THEIR INTERACTIONS

In order to provide an acceptable indoor environment, it is necessary not only that each aspect of the environment be at a satisfactory level but also that the adverse impact of interactions between these aspects is limited. Four factors—indoor air quality (IAQ), thermal environment, acoustical environment, and visual environment—are widely regarded as the principal categories for classifying or characterizing the acceptability of an indoor environment. Each of these factors includes several separate aspects. For example, within the lighting factor are included the issues of luminance and illuminance levels, color temperature, color rendering ability, gradients or luminance ratios, discomfort glare, and disability glare. The number of possible interactions among the four factors and their several aspects, especially moisture, is therefore very large. This guideline provides a framework based on the limited available knowledge for considering these interactions and draws attention to the ones that are currently considered to be the most important.

[. . .]

4.1 The Four Factors and Building Design. There can be interactions among the four main factors that were unanticipated during building design or refurbishment. For example, to limit temperature fluctuation and improve the thermal environment, it may be decided to make use of the thermal storage provided by interior surfaces of high thermal capacity (thermal mass), such as exposed masonry ceilings or hard floors, which are also susceptible to condensation. But high-capacity materials can be deficient in sound absorption and so produce an unacceptable acoustical environment. If the acoustical engineer then recommends covering these surfaces with sound-absorbent materials, an unsatisfactory thermal environment may result. Materials with increased sound absorption often have increased absorption of moisture, which can lead to microbial growth and release of volatile organic compounds (VOCs). Likewise, buildings may be designed to make use of natural ventilation through operable windows both to control indoor temperature and maintain IAQ. If the outdoor environment is excessively noisy, ~~or~~ polluted, or humid, however, people will not open the windows, and both the indoor thermal environment and the air quality will be poor. Design and construction solutions to control one environmental variable may therefore result in problems in another variable.

To further illustrate this, acoustical control is often accomplished with high-surface-area materials (“fleecy” materials such as carpet, fibrous or highly textured ceiling tiles, and textiles) for interiors. This conflicts with what some consider to be the ideal IAQ solution of hard, durable, non-porous surface materials to reduce emissions of ~~volatile organic compounds (~~VOCs~~)~~ from the materials and to reduce “sink effects” (adsorption on surfaces) that lead to subsequent secondary emissions. Smooth surfaces are also more easily cleanable. So, if designs are to produce satisfied occupants, solutions to the acoustical environmental problem must account for the IAQ implications, and the air quality solutions must consider the acoustical environmental implications.

IAQ, thermal environment, acoustical environment, and visual environment are all interconnected in the indoor environment. An effective design process integrates the numerous considerations across factors and aspects to produce a total indoor environment acceptable to occupants. Building designers should therefore consider potential conflicts at an early stage of design or refurbishment so that an indoor environment can be provided that is acceptable with regard to all four main factors and their interactions while—in line with ASHRAE policy—making minimal demands on energy and environmental resources.

The combination of architecture and mechanical/electrical design of buildings will normally serve to define the performance of the interior spaces, and it is important to have a high level of occupant satisfaction with the building indoor environmental quality (IEQ) factors. Traditionally, visual aspects of design have been the leading factors in decision making on architecture, and now green performance, climate, and moisture management ~~is~~ are becoming ~~an~~ increasingly influential factors. The challenge is to find compatibility between aesthetic, green, climate, moisture, and other environmental qualities to ensure a healthy, comfortable, and productive environment for the building occupants and users.

Efforts to make buildings more energy efficient often incorporate improved insulation of the envelope, improvements to windows, and reductions in uncontrolled infiltration in the building that leads to tighter buildings with significantly lower cooling and heating loads. As a result, humidity control becomes more important, especially in the warm and humid climates typical for the eastern United States. Traditional condensing technologies are designed to primarily remove sensible loads. As a result, DX units often need to reheat highly humid air, especially during unoccupied periods. Absorption-based desiccant technologies can improve moisture management in buildings by allowing for moisture removal without cooling down the building and thereby deliver air with lower relative humidity (RH) levels of about 50% (70°F dry-bulb, 55°F dew-point).

Occupant satisfaction surveys such as those reported by Huizenga et al. (2006) indicate that normal building design/construction/operation have not been entirely successful relative to occupant satisfaction for several of the primary IEQ factors. This is confirmed by the results of more than 400 building surveys encompassing more than 45,000 building occupants (Brager and Baker 2009), summarized in Figure 1.

As Figure 1 shows, indoor environmental performance is often less than desirable, which suggests that design professionals should pay specific attention to each of the four main factors as well as to their interactions to ensure better performance in future building design.

Studies also show that higher humidity and higher levels of PM2.5 that can significantly impact health do not necessarily reduce occupant-reported satisfaction (Allen et al. 2015). Research shows significant links between unplanned sickness-related absenteeism and especially dry conditions during flu periods. Low ventilation is also correlated with reduced decision making quality and other cognitive factors. Even small effects can have a significant impact on performance of people in the space with an impact several times that of the total energy cost (Colton et al. 2014; NRC 2007; Singh et al. 2010).

[. . .]

4.3 Acceptability and Human Adaptability. People are not passive receptors of their environment but interact continuously with it. Given the opportunity, people will adjust themselves to their environment and their environment to themselves. Problems associated with the interactions among the factors and of aspects within each factor can therefore sometimes be circumvented by providing the occupants suitable control over their environment. People then perform their own optimization, balancing one factor against another, as their requirements vary from time to time and from task to task.

For example, consider the thermal environment. The principal aspects within this factor are the temperature of the air, thermal radiation from surrounding surfaces, and the movement of the air and its moisture content (specific humidity), while the principal personal aspects are relative humidity, the thermal insulation of the clothing, the degree of activity, and the physiological status of the individual. Providing control for local air temperature, air movement, or thermal radiation and adequate freedom in the choice of clothing will usually ensure thermal satisfaction. People establish their own optimization, balancing the several aspects of the thermal environment. The balance chosen may differ from person to person and may vary with the time of day or the climate and culture, and it may be that once a satisfactory balance is established, no further adjustments take place. Nevertheless, the awareness that controls are available for use could be important for overall satisfaction.

[. . .]

4.5 Human Response to the Environment: Physiological and Psychological Interactions.

[. . .]

In addition to considering the four main environmental factors—IAQ, thermal environment, acoustical environment, and visual environment—it is necessary, when exploring their effects, to consider the physiological and the psychological dimensions of each. Some authors identify social and institutional factors separately from psychological factors. These factors mediate human responses through psychological mechanisms. For example, occupants' attitudes toward other occupants (employers, supervisors, peers) can create stress that can alter the body's normal reactions to the environment.

A Yale study identified links between relative humidity levels indoors and the human respiratory system. The mucus barrier and ciliary clearance of the respiratory system, and the response by T and B cells, protect against infection and more severe disease resulting from the flu. (Kudo et al. 2019).

It is important to note physiological and psychological factors, for not only are occupants likely to influence their environments by purposeful behavioral adaptations, but there are also responses at a less deliberate level. The body heat, ~~moisture~~ perspiration, and odor emissions from occupants affect the temperature, humidity, and quality of the air; if sound absorption is increased people tend to converse more quietly, further reducing the sound pressure levels. There are certainly characteristics of indoor environments that are appropriate or even desirable for certain occupancy types that may make another occupancy type unacceptable. Loud music or conversation, the odor of alcohol, or other characteristics of a typical night club would be unwelcome in a classroom or office. The preferred temperature for a gymnasium differs from that of a conference room.

[. . .]

4.8 Limits to Reliance on Existing Standards and Previous Guidelines. Because of their combined effects on the diverse population of building occupants, interactions among the factors can sometimes result in unacceptable IEQ even where the design conforms to the standards and guidelines for the four major environmental factors. For example, an odor that may be acceptable when thermal conditions are cool and dry may be annoying or even sickening when thermal conditions are warm and humid but still within the thermal comfort zone. Particles that may not be annoying when relative humidity is at normal levels may be irritating to the eyes or upper respiratory tract when relative humidity is very low.

[. . .]

Modify Section 5 as shown. The remainder of Section 5 remains unchanged.

5.1.1 The PMV Index. The principal aspects of the thermal environment that affect the subjective warmth of the occupant are the temperature, speed, and relative humidity (RH) of the air and the thermal radiation exchange between the occupant and the surroundings. The principal "personal" thermal aspects are the level of physical activity and the thermal insulation of the clothing. ASHRAE Standard 55 (ASHRAE 2020a) combines all these aspects in the Predicted Mean Vote (PMV) index, which is a numerical value on a seven-point scale of subjective warmth. The PMV index quantifies the offsetting of one thermal aspect against another, thus incorporating their interactions on the basis of their effect on human heat exchange.

[. . .]

5.1.4 Interaction between Metabolism and Thermal Environment.

[. . .]

The PMV index works best when assessing the effects of the interactions of the various thermal aspects in moderate indoor temperatures with low air movement (Humphreys and Nicol 2002). To assess the effects of the thermal interactions on the acceptability of higher temperatures with substantial air movement, particularly if the relative humidity is high, an alternative index such as the Standard Effective Temperature (SET) index (ASHRAE 2021, Chapter 9) may be preferred. Values of the thermal sensation predicted by either index can be calculated using the CBE Thermal Comfort Tool (CBE 2022). Figure 2 shows paired evaluations for thermal environments drawn from the ASHRAE database of field studies of thermal comfort (de Dear and Brager 1998). Each point represents a separate indoor environment. Those environments assessed as neutral or warmer by either method have been included (0 = neutral, 1 = slightly warm, 2 = warm, 3 = hot). The scatter is attributable to the different quantifications of the interactions by the two indices.

[. . .]

5.2.2 Temperature and Perception of Air Quality. The sense of smell is more acute at warmer temperatures, so both pleasant and unpleasant odors become more perceptible. Substantial research has shown that changes in the thermal environment can cause changes in perceptions of the air quality. Changes in temperature or relative humidity affect human responses to, and perceptions of, the chemical content of the air. Several laboratory studies have found that subjects describe air as more stuffy, odorous, and stale when the air temperature is elevated, the relative humidity is increased, or both (Berglund and Cain 1989; Fang et al. 1998a, 1998b, 1999). This relationship holds true at both low activity levels and at the levels attained when walking or jogging (Berglund and Cain 1989).

[. . .]

5.2.4 Hygro-Thermal Conditions and Biological Contaminants. Thermal conditions strongly affect the potential survival, growth, and distribution of microbial contaminants in indoor environments. Cold surfaces, for example, are susceptible to condensation, which can contribute to microbial growth. The higher the ~~air humidity,~~ dew-point temperature, the higher the potential water activity (aW) at the surface. ~~, and water activity is, by definition, a strong determinant of the ability of a surface to support microbial growth.~~ At high aW values, moisture at the surface of a material is available to fungus and bacteria to support growth and reproduction. The ~~water activity~~ aW level is not measured directly but is a function of the ~~air~~ specific humidity and the moisture content of the material immediately below the surface (Prezant et al. 2008; Harriman et al. 2001).

Providing a comfortable thermal environment may result in pressure differences among various spaces within a building, resulting in migration of gases and particles from one space to another. The movement may be horizontal, vertical, or both. Movement is normally from areas of higher pressure to those of lower pressure. Most mechanically ventilated commercial buildings are designed to be intentionally pressurized relative to the outdoors to prevent unwanted intrusion of unconditioned/contaminated air from outdoors from entering through cracks or other gaps in a building enclosure. Humid outdoor air may enter and condense on interior surfaces, ultimately leading to microbial growth, deterioration of building materials, and occupant health effects.

Indoor air often has higher ~~moisture content (absolute humidity)~~ specific humidity than outdoor air in cold climates. In cold climates, water vapor in heated buildings tends to migrate through the materials of the building envelope toward the outdoors. Moisture migration in the opposite direction can occur when buildings are cooled and dehumidified in warm humid climates. Condensation and elevated specific humidity, ~~of the moisture~~ as it migrates through the envelope assemblies, can result in increased moisture content and aW of cellulosic materials, resulting in mold growth and decay of building materials (ASHRAE 2020c; 2021b). The increased moisture content of the inaccessible interior materials of the building envelope is described as the wood moisture equivalent (WME) based on that of the interior and exterior assessable materials. ~~Moisture migration in the opposite direction can occur when buildings are cooled and dehumidified in warm humid climates.~~

Implications: Microbial organisms—fungi, bacteria, and viruses—are among some of the most significant contaminants of indoor air (dust mites and especially their feces are also important, although presumably more so in residences than in nonresidential environments). The absence of these organisms at harmful concentrations is a criterion for acceptability. There is a lack of specific guidelines on acceptable or harmful concentrations. ~~It is current practice to compare indoor concentrations to outdoor concentrations and consider indoor levels above outdoor levels as an indicator of a source or amplification site in the building. This~~ Microbial amplification is the result of ~~is usually accompanied by~~ excessive moisture in the building, either from leaks or spills or from condensation. Eliminating the moisture source will reduce or eliminate the growth of these organisms indoors. Careful attention to the pressure relationships between a building and the outdoors as well as the differences between spaces is important to avoid unwanted movement of contaminants.

5.2.5 Humidity and Particulate Matter. As the ~~absolute~~ specific humidity of the air decreases (more commonly determined by measuring relative humidity), so do upper respiratory defense mechanisms based on bodily tissue moisture and mucociliary removal action. Particles then may penetrate deeper and stay longer, resulting in increased effects for a given particle concentration. The irritation and discomfort of "dry nose," "dry throat," "itchy nose," and "scratchy throat" feelings, as well as effects on other mucous-membrane-protected surfaces (such as the eye), are potentially exacerbated by low humidity (Wyon 1991) or higher chemical concentrations in the air (Sundell 1994). Also, drier air will result in reduction in airborne particle size and mass of particles generated by exhaled breath, talking, coughing, and sneezing, resulting in longer airborne suspension times and greater likelihood of particles being inhaled (WHO 2009).

5.2.6 Heating Equipment and Particulate Matter.

[. . .]

Implications: The designer of a mechanical ventilation system should consider a higher efficiency filter (such as MERV 13) for heated spaces designed for operation at low relative humidity (e.g., <20% RH). MERV is the Minimum Efficiency Reporting Value—a single-number designation derived from the composite curve data product of ASHRAE Standard 52.2, *Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size* (ASHRAE 2017). The test method determines the minimum efficiency of particulate filters at 12 specific particle size fractions ranging from 0.3 µm, or microns, to 10 µm. The MERV 13 level of efficiency is necessary to control the smaller particles (0.3–1 µm) that impact human health. Refer to Chapter 12, "Air Contaminants," in *ASHRAE Handbook—Fundamentals* (ASHRAE 2021b) and Chapter 28, "Air Cleaners," in *ASHRAE Handbook—HVAC Systems and Equipment* (ASHRAE 2020b) for more fundamental information on gaseous and particulate contaminants.

[. . .]

Modify Section 6 as shown. The remainder of Section 6 remains unchanged.

6.1 Interactions. There are usually hundreds of organic compounds in most indoor environments. While none of these individual compounds might exceed concentrations known to cause odor, irritation, or toxicity, in some cases, combinations of chemicals may have adverse effects that are not indicated by their individual properties.

It may be necessary, under normal conditions of temperature and humidity, to modify the operational procedures of the ventilation system to increase ventilation or to modify the system to provide more ventilation to accommodate these interactive effects. If outdoor specific humidity is high, then introducing more outdoor air requires control of the dew-point temperature indoors ~~humidity~~ to limit its potential contribution for microbial growth by preventing condensation, ~~or~~ and control of relative humidity (RH) for ~~to~~ occupant discomfort. In the case of low outdoor ~~air~~ specific humidity, increasing outdoor airflow may result in a very dry environment with various potential effects on occupants and on the electrostatic environment. In very cold climates, bringing in too much outdoor air can result in very dry indoor air and potential eye, skin, and throat irritation (Jaakkola et al. 1991a, 1991b). Finally, if volatile organic compounds (VOCs), inorganic pollutants, or particle concentrations are higher outdoors than indoors, increasing ventilation will increase indoor concentrations of these pollutants.

6.2 Control of Pollutant Sources and Ventilation to Remove Pollutants. Indoor sources of pollutants include occupants, building materials, interior finishes, furnishings, equipment, maintenance products and procedures, and consumer products. Outdoor sources include combustion products, agricultural processes, and exhaust from neighboring buildings and vehicles. These and other factors affect the quality and ~~moisture content~~ specific humidity of the outdoor air, which in turn affect the quality of the indoor air via ventilation and infiltration.

[. . .]

6.3.5 Formaldehyde and Other Indoor Air Pollutants.

[. . .]

Implications: Designers should strive to use low-emitting materials in buildings. This is a form of source control and is usually both cost-effective and easily achievable. *Low-emitting materials* refers to products that have been formulated to emit little to no VOCs after installation. Information on low-emitting materials can be found in Objective 5 of *Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning* (ASHRAE 2009).

Emissions of VOCs from most materials are strongest when they are new and decrease dramatically over time, but many emissions continue at lower levels for months and even years. Ventilation affects emission rates, and increased ventilation is associated both with higher emissions and with lower airborne concentrations. Extra ventilation during the early life of new materials accelerates the emissions decay process.

Where materials are replaced in existing buildings, the replacement work should be performed during unoccupied periods and with maximum outdoor air ventilation. Designers should recommend that operators run the HVAC system on all outdoor air in order to flush out pollutants prior to new or renovated buildings being occupied. A flush-out typically occurs for four days to a week, although the length of the flush-out depends on the amount of outdoor air that can be supplied and properly conditioned for acceptable indoor thermal temperature, specific humidity, and dew-point temperature. ~~and humidity.~~ Flushing out to achieve 100 complete air changes might be a more useful guideline. The number of hours is less important than the total number of air changes after the application of new finishes and before occupancy or re-occupancy. (Tichenor 1996).

[. . .]

6.6 Indoor Air Quality—Acoustical Environment. The primary ways to achieve IAQ include the use of ventilation, either mechanically with equipment or passively through window openings. Mechanical ventilation is often accompanied by the noise of fans, airflow through duct elbows and branches, mixing boxes, dampers, and diffusers or even the sounds of air leakage from the ductwork or other system components. This HVAC noise will generally be dominated by low-frequency sound, which may in extreme cases induce secondary vibration in walls, floors, and other surfaces (in addition to that caused by improperly isolated or mounted equipment). See *Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning* (ASHRAE 2009) for a more detailed discussion.

If ventilation equipment is noisy, it may not be used as intended by the designer. For example, teachers tend not to operate noisy unit ventilators in their classrooms, resulting in reduced outdoor air ventilation and increased indoor source pollutants. Home occupants tend not to operate noisy bathroom or kitchen fans, resulting in a buildup of all aspects of moisture, combustion gases, or other products and by-products of activities conducted in the home. Because of this interaction, Standard 62.2 (2019b) requires quiet fans to achieve its IAQ objective.

[. . .]

Modify Section 9 as shown. The remainder of Section 9 remains unchanged.

9. REFERENCES AND BIBLIOGRAPHY

The following sources were either cited in this guideline or consulted by the project committee in the preparation of this guideline.

[. . .]

Arundel, A.V., E.M. Sterling, J.H. Biggin, and T.D. Sterling. 1986. Indirect Health Effects of Relative Humidity in Indoor Environments. *Environ Health Perspect.* 65:351–61. doi: 10.1289/ehp.8665351. www.ncbi.nlm.nih.gov/pmc/articles/PMC1474709/.

[. . .]

ASHRAE. 2020c. *Damp Buildings, Human Health, and HVAC Design.* Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021a. *ASHRAE Handbook—Fundamentals*. Peachtree Corners, GA: ASHRAE.

ASHRAE. 2021b. ASHRAE Positions on Limiting Indoor Mold and Dampness in Buildings. Peachtree Corners, GA: ASHRAE. www.ashrae.org/file%20library/about/position%20documents/pd_limiting-indoor-mold-and-dampness-in-buildings-2021.pdf.

[. . .]

IIRC. 2021. ANSI/IICRC S500, *Standard for Water Damage Restoration, Institute of Inspection Cleaning and Restoration Certifications*. Las Vegas, NV: Institute of Inspection Cleaning and Restoration Certification.

[. . .]

Kudo, E., E. Song, L.J. Yockey, and A. Iwasaki. 2019. Low Ambient Humidity Impairs Barrier Function and Innate Resistance Against Influenza Infection. Biological Sciences 116(22):10905–10. doi: https://doi.org/10.1073/pnas.19028401.

[. . .]

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ASHRAE · 180 Technology Parkway · Peachtree Corners, GA 30092 · www.ashrae.org

About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

To stay current with this and other ASHRAE Standards and Guidelines, visit www.ashrae.org/standards, and connect on LinkedIn, Facebook, Twitter, and YouTube.

Visit the ASHRAE Bookstore

ASHRAE offers its Standards and Guidelines in print, as immediately downloadable PDFs, and via ASHRAE Digital Collections, which provides online access with automatic updates as well as historical versions of publications. Selected Standards and Guidelines are also offered in redline versions that indicate the changes made between the active Standard or Guideline and its previous edition. For more information, visit the Standards and Guidelines section of the ASHRAE Bookstore at www.ashrae.org/bookstore.

IMPORTANT NOTICES ABOUT THIS GUIDELINE

To ensure that you have all of the approved addenda, errata, and interpretations for this Guideline, visit www.ashrae.org/standards to download them free of charge.

Addenda, errata, and interpretations for ASHRAE Standards and Guidelines are no longer distributed with copies of the Standards and Guidelines. ASHRAE provides these addenda, errata, and interpretations only in electronic form to promote more sustainable use of resources.

8/24