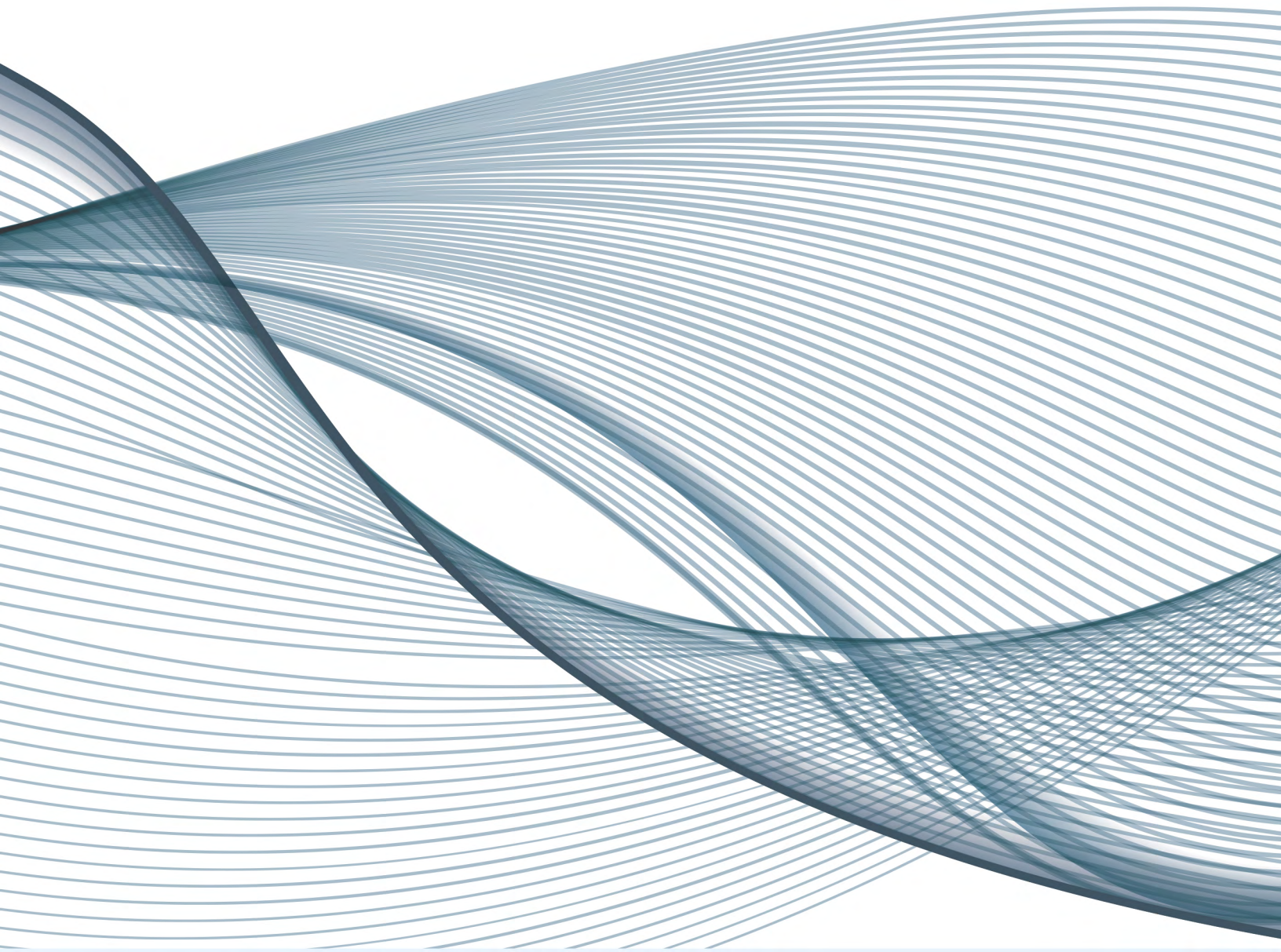
Humidity



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Background

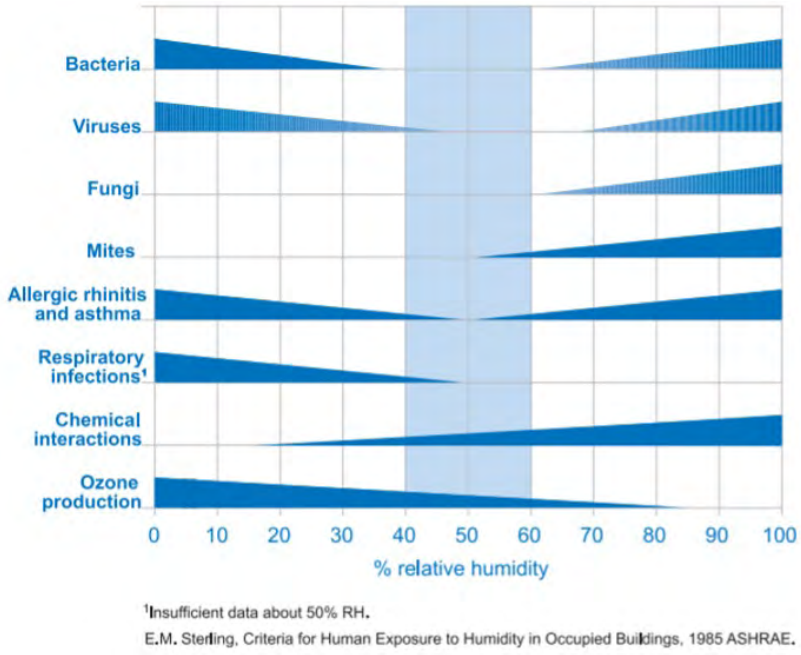
Humidity is defined as the quantity of water vapour in the air. Vapour is the gaseous form of water, and the amount of humidity in each air volume depends on the temperature and pressure of the system. There are three measurements used to determine air humidity: absolute humidity, specific humidity, and relative humidity. **Relative Humidity (RH)** is the ratio of how much water vapour is in the air to how much water vapour the air could maximally contain at a given temperature. RH is expressed as a percentage.

In the context of **Indoor Air Quality (IAQ)**, RH is the most commonly used metric because it has a direct effect on the indoor built environment as well as human comfort and health.

Indoor Relative Humidity

Indoor relative humidity can be generally divided into three zones: low, optimal, and high. The Sterling Chart (Figure 1) shows an example of how various indoor risk factors are affected by different levels of relative humidity.[1]

Figure 1: Relative humidity vs risk factor based on various topics.



At low percent relative humidity (typically below 30% RH), the air is considered dry. Humans might experience sore and dry throat, nosebleeds, allergies, asthma, irritated skin, and/or an impaired respiratory immune system. Airborne water-based particles containing viruses also shrink faster by evaporation and can be carried longer distances as they are lighter. The decay rate for some viruses is slower at low humidity, leaving a higher percentage of viable viruses in the air over time.

Under optimal RH conditions (typically between 40% - 60% RH), throat skin irritation can be expected

[1] ASHRAE, "Thermal Environmental Conditions for Human Occupancy," 2017.

to be lower.[2] Studies have shown that the infectivity of the SARS-CoV-2 virus is lower when the RH is between 40 - 60%.[3] The impact of RH on virus or bacterial decay varies based on the species. For example, the viability remains high across all RHs for the H1N1 flu virus.[4]

High RHs compromise occupants' ability to tolerate elevated temperatures and often make people feel uncomfortable. Higher RH (above 60%) could also cause mold growth, which might lead to unpleasant odours and, in the long run, could cause or exacerbate respiratory problems, including allergies and asthma.[5,6] Long-term exposure to high levels of relative humidity could also result in condensation on material surfaces and inside building enclosures, causing material deterioration and even structural damage.[7]

Therefore, controlling relative humidity in indoor environments is important for the comfort, health, and safety of building occupants.

SARS-CoV-2 and Relative Humidity

As discussed earlier, for occupant comfort and to reduce mold growth, an indoor relative humidity of 40%-60% should be maintained. During winter conditions, it may be difficult to maintain an RH of 40%; therefore, the recommendations are usually between 30% to 50%.[8,9] For airborne infectious disease control, relative humidity control may help, depending on the type of pathogen, but should always be used in combination with improved ventilation and filtration. It is worth noting that ventilation can adversely affect humidity levels, but minimum ventilation requirements should not be compromised to improve humidity. Filtration can improve indoor air quality without any significant effects on humidity.[10,11]

Humidification

Humidification can generally be divided into three physical methods: Vaporization, Atomization, and Evaporation.[12]

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[9] ASHRAE, "Thermal Environmental Conditions for Human Occupancy," 2017.

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[11] ASHRAE, "Standards 62.1 & 62.2." Accessed: Feb. 23, 2024. [Online]. Available: https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2

[12] ASHRAE, "Standard 90.1-2022-Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings," 2022.

Vaporization: Isothermal Humidifiers

The term isothermal humidification has been established to describe a steam humidification process in which the air temperature essentially remains constant. The steam is generated by boiling water using electricity or gas, and is injected into the air stream via a central air unit or an injector manifold.

Some of the advantages of isothermal humidifiers are that they promote hygiene precision and short absorption distances. The high temperature of the steam in isothermal humidifiers eliminates contaminants, making it inherently beneficial for hygiene.[13] Isothermal humidifiers allow for precise control of humidity levels, making them suitable for sensitive environments. Lastly, they can controllably approach complete saturation of the airstream with relatively short absorption distances.

Isothermal humidifiers also have disadvantages, such as high energy consumption as well as microbial growth. Isothermal humidifiers require a significant amount of energy to create steam, which ultimately needs to be added to the airstream, leading to higher electricity or gas usage.[14] While isothermal humidifiers have minimal concerns over microbial growth, they may still require proper maintenance to prevent any potential issues.[15]

Atomization and Evaporation: Adiabatic Humidifiers

Adiabatic humidification injects water, not steam, directly into the air, and the heat from the surrounding air causes the water to evaporate. Ultrasonic humidifiers use a metal diaphragm vibrating at high frequency to spray mist into the air. Impeller humidifiers use a rotating disk to spray mist into the air. Often, ultrasonic and impeller humidifiers are referred to as cool-mist humidifiers.

Evaporative humidifiers use a fan to pull air through a wetted wick. A typical home auxiliary humidifier (furnace attached) is an adiabatic humidifier where a wick is wet with water, and hot air flows through the wick and absorbs the water.

The water supply to isothermal humidifiers requires treatment (soft water) to reduce calcium buildup. Generating steam is also an expensive process where energy is required.

The advantages of adiabatic humidifiers, according to several studies,[16] are precise humidity control, ease of installation and retrofitting, as well as simplicity. Adiabatic humidifiers are easy to install and retrofit, making them convenient for various applications. These humidifiers are based on proven and simple technology, ensuring reliability. The disadvantages can include longer absorption distances, the

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[16] Z. Ding, P. M. Thibado, C. Awo-Affouda, and V. P. LaBella, "Electron-beam evaporated cobalt films on molecular beam epitaxy prepared GaAs(001)," *Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures Processing, Measurement, and Phenomena*, vol. 22, no. 4, pp. 2068–2072, Jul. 2004, doi: 10.1116/1.1771674.
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need to preheat the air supply, and the inefficiency of the filters.[17] Adiabatic humidifiers may require more length in an air handling unit due to longer absorption distances and only 10% of the supplied water will result in steam/gas form (resulting in increased RH). Additionally, most of the water needs to be recirculated. Often, the recirculated water must be disinfected by biocides, which may become airborne and negatively affect the occupants in the room.

Use Considerations

Use of humidifiers requires a significant amount of maintenance, which can be costly, in addition to high energy costs. Ultrasonic or cool mist humidifiers can significantly increase the level of particulate matter in the air when they are not used with distilled water. Additionally, they can aerosolize bacteria and mold that may be present in the water reservoir. Improper use of these devices can have adverse effects on indoor air quality.[18] For this reason, we strongly recommend the use of steam or evaporative humidifiers. If using an ultrasonic humidifier, it is recommended to use distilled water to reduce occupant exposure to increased particle concentrations. Furthermore, it is important to frequently disinfect and clean these humidifiers to mitigate the risk of biological growth.

Dehumidification

Humidity control also includes dehumidification, the removal of humidity. When the humidity is higher than 60% RH indoors, some humidity must be removed to avoid moisture issues. One way of removing humidity from an indoor space is by bringing fresh, dry air into the building, typically using a **Heat Recovery Ventilator (HRV)** in winter.[19] This is not feasible when the air outdoors is more humid than the indoor space in most cooling climates.

Another method of dehumidification is mechanical cooling. The air is cooled to a much lower temperature, and the water vapour in the air condenses on the coil, leaving the air. The moisture is then drained away, and the air returning is drier. There are different levels of mechanical cooling dehumidification processes, and they vary by the size, complexity, and reliability of the results.

A third way of removing humidity is desiccant dehumidification. In this process, the reactivation air passes through a spinning desiccant material wheel that captures moisture from the air, removes it by exhausting the moist air, and returns dry air into the space. Desiccant dehumidification is considered the most energy-efficient way to remove moisture from air.

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[17] H. and R. I. Air-Conditioning, “Humidifiers.” Accessed: Mar. 13, 2024. [Online]. Available: https://www.ahrinet.org/scholarships-education/education/contractors-and-specifiers/hvacr-equipmentcomponents/humidifiers

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[19] ASHRAE, “Standard 90.1-2022-Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings,” 2022.

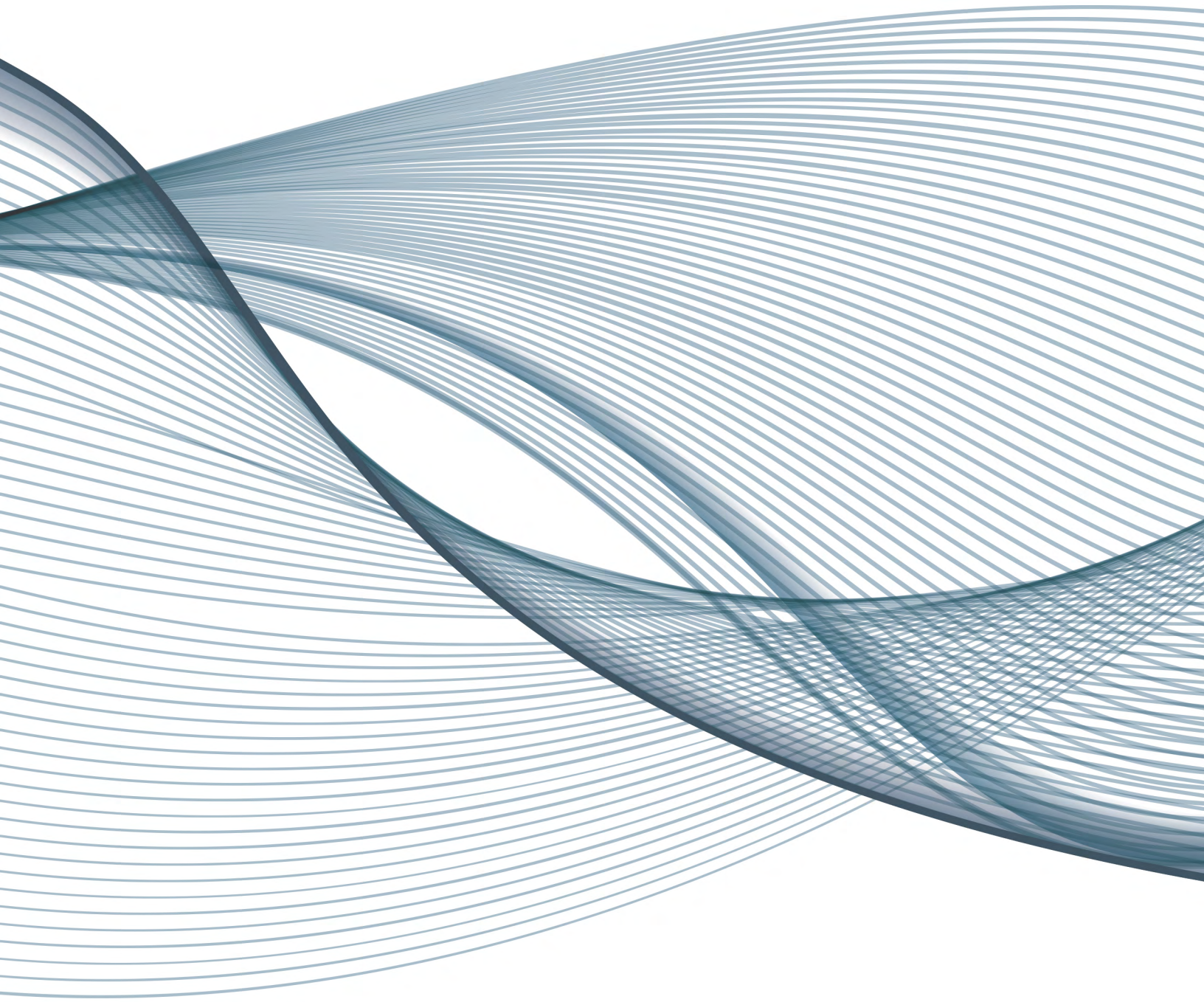
Commercial Humidity Control

Humification and dehumidification processes in a commercial indoor environment are critical to ensuring that occupants' thermal comfort is maintained and providing a healthy environment. Larger HVAC systems are designed with humidity control equipment built in. However, building standards such as **ASHRAE 55-2017** only have a maximum RH requirement of 60%, but do not specify a minimum RH requirement for thermal comfort.[20]

Residential Humidity Control

Single occupancy homes are typically equipped with a gas furnace, and some furnaces have a duct-mounted humidifier. This type of humidifier is equipped with a wet evaporator pad, where side-stream air passes through and moisture is added to the air. This type of humidifier is typically equipped with a stand-alone duct-mounted humidistat. Some newer thermostats are equipped today with the ability to control external humidifiers and control humidity levels using cooling cycles. Multitenant residential units are typically equipped with a fan coil unit not capable of adding humidity to spaces. In addition, many homeowners use stand-alone humidifiers or dehumidifiers that have controls built in.[21]

[20] ASHRAE, “Thermal Environmental Conditions for Human Occupancy,” 2017.
[21] ASHRAE, “Standard 90.1-2022-Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings,” 2022.
[21] H. and R. I. Air-Conditioning, “Humidifiers.” Accessed: Mar. 13, 2024. [Online]. Available: https://www.ahrinet.org/scholarships-education/education/contractors-and-specifiers/hvacr-equipmentcomponents/humidifiers



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