ASHRAE Standard 62.1: Connecting the Dots

Introduction and Background

During 2020 and the initial phases of the current Covid-19 pandemic, many industry "experts" rushed to make recommendations regarding air-conditioning systems, ventilation, filtration, or other air treatment with respect to the transmission of Covid-19, viruses, and pathogens in general. It was a needed response. Those experts included medical-based clinicians, manufacturers of air-conditioning equipment, and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). With one notable exception, the recommended range for relative humidity (RH) was 40-60%.

One of the most visible industry personalities during 2020 was Dr. Stephanie Taylor, MD, M. Arch, who possesses both a medical background as well as architectural experience. On February 2, 2020 (prior to the exponential growth of COVID-19), Dr. Taylor posted on her LinkedIn profile: *Ten years ago we learned that viruses studied as surrogates for Coronavirus, the family of SARS and Wuhan, were inactivated on surfaces when the ambient relative humidity (RH) was 40-60%. Conversely, when RH was either below 40% or above 60%, the viruses remained virulent and infectious.* Dr. Taylor continues to recommend this range as she posts, presents, and publishes on the subject.

For those that have recommended the 40-60% range, further discussion has seemed to concentrate on the lower range (0-40%). These conditions present themselves in winter climates, although for some parts of the country (i.e. New Mexico) they represent year-round conditions. There has been little discussion regarding the range above 60%, with no apparent reason. Those ranges are very common for cooling applications, especially when occupancy is high. They are compounded in the American South or other areas that experience humid climates.

ASHRAE Position Document: Why would they not take a position?

In February of 2020, the presence of virus on surfaces was of greater concern than that of airborne particles. As time passed, the transmissibility through air became of equal or greater concern. In April of 2020, ASHRAE published a *Position Document on Infectious Aerosols*. Inexplicably, there was not a position taken with respect to relative humidity. There was the better part of a typewritten page devoted to discussion of RH, including mention of the 40-60% range. There was a good deal of medical-based discussion on the merits of this range, and the risks of deviating from it. A number of academic references were made. But, in the end, ASHRAE left it to "practitioners" to make building design and operation decisions on a "case-by-case basis."

At first glance, this might seem to acknowledge a need to be flexible for various applications, and there is some validity in that interpretation. However, for an organization that elects and lobbies to be the standard bearer for indoor air quality, it also seems to be a cop-out. A look at the history of ASHRAE Standard 62.1 offers some further clarification, but it also raises many pertinent questions that seem to have increased in importance during these times.

This paper will strive to offer possible answers for these questions from the perspective of an experienced design engineer, unencumbered by association with an equipment manufacturer or diluted by a committee. The paper will also tend to focus on the humidity range that exceeds 60% and the likely reasons that little information or discussion has been offered.

History

2019: What prompted the change?

In the 2019 edition, ASHRAE Standard 62.1 was updated to remove relative humidity (RH) requirements from the standard. They were replaced with dewpoint limits. Research indicates that this change was perhaps made by addendum to the 2016 edition. What prompted the change? Why was it missed previously? What was so important to warrant a mid-cycle addendum? By coincidence I suppose, this change was made immediately prior to the COVID-19 pandemic.

The 2001 edition of ASHRAE Standard 62.1, Paragraph 5.10 read, very clearly:

2001: A definitive health concern

> *High humidities can support the grown of pathogenic or allergenic organisms (See Reference 19). … Relative humidity in habitable spaces preferably should be maintained between 30% and 60% relative humidity (See Reference 10) to minimize growth of allergenic or pathogenic organisms.*

The standard's references were well documented and were from the mid-80's, a time when many buildings had suffered from "sick building syndrome," a term often given to problematic buildings of the day. As a result, much research had been devoted to indoor air quality. The danger of high humidity levels to health, not to mention comfort and productivity, were known and documented at that time.

2004: Health concerns omitted, high limit raised

In 2004, Paragraph 5.10 underwent a significant change. First, statements that warned about the health concerns of high humidity were omitted. Second, the high limit for RH was raised to 65%, with "further complications" regarding the design conditions that it would be calculated at. A note was added to clarify that a system's peak dehumidification load may very well fall at a different time than the peak cooling load.

Why were statements about health concerns omitted? Why was there a requirement to limit RH in the first place, if the health concerns were not present? Why was the limit raised? This edition of 62.1 may have been the initial point at which the standard, and ASHRAE Society, started down a slippery slope of favoring equipment design over public health. This was likely a function of committee makeup, as manufacturers are much better poised to devote effort and cost to committee participation than system designers. It is also in their interest to limit directives from supposedly independent bodies that may impact their economic cost or success.

Once again, in 2007, the wording of Paragraph 5.10 was changed. The upper limit of 65% was maintained, and the wording of the "further complications" was slightly simplified and rearranged. The reasoning for limiting RH remained unexplained. However, there was an added "note" that, looking back, seems quite interesting:

2007: …may challenge system performance

> *System configuration and/or climatic conditions may adequately limit space relative humidity at these conditions without additional humidity-control devices. The specified conditions challenge the system dehumidification performance with high outdoor latent load and low space sensible heat ratio.*

This additional note immediately provokes a "huh?" from most readers. It does seem to recognize that there is a "system" that exists. However, it is worded in a questionable manner by first stating "that it may work" and then subtly mentioning that it "might be challenged under certain conditions." In humid climates, meeting the "further complications" of a peak dehumidification load at conditions of no space solar load is very difficult with anything other than a hydronic (chilled water) system. It was an inferred acknowledgement that equipment being offered by the industry may not be able to perform at a level to meet the requirement. I believe that this was another step down the slippery slope that was mentioned earlier.

Fast forward to 2016 and Paragraph 5.10 has become 5.9, but it is basically identical to 2007. So, for nine years, Standard 62.1, Paragraph 5.10 /.9 essentially remained the same.

2019: Use dewpoint metric, but further raised humidity limits

Now for 2019 (and beyond?), the standard takes an entirely different position. It attempts to evaluate indoor humidity by dewpoint temperature, not relative humidity. The stated limit is 60-degrees F dewpoint. The typical note of "further complications" remains. One of the "informative notes" (for the exception, not the overall requirement) does add back an acknowledgment that the requirement "reduces the risk of microbial growth in buildings and their interstitial spaces." Still, there is no direct reference, as existed in 2001, that high humidity is a threat to the health of building occupants.

If one gains access to the public review draft of the Addendum, the foreword seems to suggest the limits were redefined and raised for reasons of unoccupied periods and that mold may not grow if it does not condense. It leaves out reasons, other than "microbial growth" that RH should be limited. Perhaps a chance for further research, but the justifications simply doesn't seem to be strong. Our opinion is that the change has occurred to justify the marketing of VRF technology which in its current form is even less capable of adequately addressing dehumidification for many occupied spaces, especially at part load.

We can be sick - if we do it economically!

One's confidence diminishes quickly when the fourth paragraph of the foreword states "This specific limit is a compromise between energy and microbial growth concerns." A later sentence refers to the "affordable balance between the equally important concerns of reducing energy consumption…"

With these statements, ASHRAE has taken the position that health can be compromised if economic concerns are in place. Again, one more step down that slippery slope!

Analysis

It is helpful to look at what 60-degrees dewpoint really represents. A dewpoint temperature represents an absolute or constant level of moisture in the air. If you breathe moist air into a plastic bag and then seal the bag, the moisture inside will remain constant. As the temperature of the air in the bag changes, the relative humidity of that air will change. It is not an easy concept for the layperson, but one condition will open the eyes of anyone - at a temperature below the dewpoint temperature, some amount of moisture will condense out and become water. The bag will include droplets of moisture. At higher temperatures, the moisture reverts into a vapor again. The science of this is called psychrometrics, familiar to many mechanical and chemical engineers as well as meteorologists.

OK, enough of the hard stuff. The following chart tabulates relative humidity values for various temperatures at a constant 60-degree dewpoint temperature.

70°/70% - It is acceptable to ASHRAE!

Dewpoint Temperature (F)	Space Temperature (F)	Relative Humidity (%)
60	80	50.5
60	78	53.9
60	75	59.6
60	72	65.9
60	**70**	**70.6**
60	68	75.6
60	66	81.0

Table 1 - Relative Humidity Values at Constant 60 Degree Dewpoint

These RH values vary between 50% and 81%. While the values of 80 degrees and 66 degrees are outside normal spaces temperatures, each of the remaining temperatures represent conditions that reasonable, ordinary people choose to place their thermostat at in the cooling mode. Many are likely set between 68 and 72, an area where the relative humidity is allowed to be between 66 and 75%! These values far exceed RH limits of past ASHRAE 62.1 requirements! Not only that, even a lay-person knows better. Maybe that is why the smoke and mirrors of dewpoint have been used in ASHRAE 62.1-2019. Most would express a 50% value as optimal, and state that values summarized above are unacceptable. Why would ASHRAE allow conditions that make people uncomfortable and encourage sickness, according to other published sources?

Now, the standards committee is likely to say that those are high limits, one can design to lower values and probably should. The problem is that by setting limits that high, they are endorsing those as acceptable. I don't think that they are acceptable. They might also refer to energy codes that say that indoor temperatures should be set at 75 degrees - looking at the resultant RH, we arrive just under that limit. One problem with that - just sneaking under the limit is not a place to be designing to. Also, the "system" is not going to perform as well in later years as it does on day one.

The real problem is that the industry is not manufacturing equipment that can provide dehumidification levels which can comply with professionally accepted limits.

Systems Inadequacy

During the 1980's, the use of chilled water systems, especially for high density occupancy (schools, churches, etc.) was much more common than today. Most of these systems had the ability to dehumidify in all but the most demanding applications. However, since that time, the use of packaged equipment has increased to the point where it is the majority in place by an overwhelming margin.

For humid climates, most of the packaged equipment manufactured today is inappropriate to apply where there are any types of medium or high occupancy spaces. Churches, theaters, training rooms, and school classrooms are the most common examples. Yet many of these applications today see that equipment utilized.

Two characteristics define a system's ability to adequately dehumidify a space:

1) Coil sensible heat ratio
2) System performance at part load

The coil sensible heat ratio (SHR) is really a measure of how much latent (moisture) heat a system is capable of removing. If a certain latent load is present, then the coil should be able to at least meet that load, if not exceed it by a small amount. These latent loads are best evaluated at 50% RH, not higher values accepted by ASHRAE 62.1.

Today's equipment can marginally provide a 60º dewpoint - what a coincidence!

It is interesting to note that the leaving air dewpoint temperature of today's equipment is usually closer to 60 degrees dewpoint than 55 degrees or lower. Often, one must search somewhat harder to compile this data - performance data is being minimized in many cases, especially VRF equipment.

Coils adequate for dehumidification generally require a minimum depth, or number of rows, to meet performance requirements. There are other variables, but coil depth is the most influential. This all assumes that the coil is sufficiently cold. With chilled water systems, the water temperature defines the "coldness." For a refrigerant based system (DX), the operating saturated suction temperature (SST) defines this.

If one can achieve the proper SHR at peak load, then the part load performance of a system coil must still be evaluated. Chilled water systems maintain dehumidification capability best, as the coil is always very near the fluid temperature. Unfortunately, DX systems always have some portion of time where the compressor has either cycled off, or the quantity of refrigerant has been reduced, causing the coil leaving air temperature to rise, often to a point that no dehumidification can occur.

For DX systems, the logical reaction might be to add a row or rows to the coil to make up for the inherent dehumidification compromises that occur in a refrigerant based system. This is possible and it does occur in some larger and/or more specialized systems. However, it rarely occurs in most smaller equipment - the equipment that makes up most of the air conditioning capacity that is installed today. In fact, the opposite is occurring. Variable refrigerant flow (VRF) technology has been introduced over the last ten years or so in America and it generally offers coils that subtract rows, not add them. The dehumidification performance of these systems is usually awful. While the root technology could be promising, most manufacturers have imported the technology and products from Asia with little to no re-engineering for local operating conditions.

For more information regarding the performance of various coils, please refer to our white paper *Cooling Coils: A Comparison of Dehumidification Performance*, available on our website (www.appeng.com/editorial)

Many manufacturers are encouraging the use of dedicated outside air systems (DOAS) as a response to the inadequacy of packaged equipment. A full discussion of DOAS is beyond the scope of this paper, but the idea is to remove the outside air load from the packaged unit that is inadequate for the application. DOAS units are very expensive and often omitted from projects during VE (value extraction) phases post design. They are often never utilized by owners that aware that they can be turned off to save utility cost.

DOA Systems are not an efficient or economical answer for small tonnage systems.

Unfortunately, there are not sufficient air distribution devices available to support DOAS. For example, a single-occupant office requires a fresh air flow rate of about 15 cubic feet per minute (cfm). Manufacturers do not make grilles or registers that have industry certifications for such flow rates! Duct sizes to support them are less than 3-inch sizes - more like vacuum cleaner hoses! The *ASHRAE Design Guide for Dedicated Outside Air Systems* fails to even address air distribution systems for DOAS. So, for us DOAS is "DOA."

What is the result of using packaged equipment on higher occupancy applications? Will it cool effectively? The answer to that question is yes - throw enough tonnage to a space and it will cool. However, if the coil sensible heat ratio is too high, or if the coil surface temperature is too high, which it generally will be, then the space will see increased humidity levels. We are back to ASHRAE 62.1-2007 and that slippery slope!

Energy codes have made the problem worse...

It is interesting to note that energy codes have made the problem worse. The impact on energy codes has been such that overall space sensible loads have been reduced, while latent loads have generally remained constant. Latent loads have increased in terms of percentage, requiring equipment with lower sensible heat ratios. This makes the conflict of space loads and available equipment to meet them even greater. With all of the industry press for "green" design over the last 10 - 15 years, the industries ultimate unwillingness or inability to change equipment is downright disappointing. It is also quite obvious that this was recognized in 2007!

Simply stated, today's packaged air-conditioning equipment is not designed with enough coil depth, sufficiently cold surfaces, or both. As a result, it cannot provide adequate dehumidification to spaces that have modest to high occupant levels, such as classrooms, theaters, or churches.

Practical Results from the Use of Packaged Equipment

If the space humidity of say, a school classroom, rises excessively because of the use of a small packaged unit, then what results when complaints ensue? Usually, the fresh air damper is closed, either partially or completely. This reduces the dehumidification load on the unit from humid outside air. The ventilation to each occupant is now compromised! Unfortunately, this is not often a tangible item for a lay person to sense. They may blame their sleepiness on the teacher, or they may blame their allergies on recess. In reality, the classroom is to blame.

Don't worry, just close the outside air damper...

To make matters worse, today's manufacturers are providing thermostats that include internal routines that will disable ventilation automatically when the unit is "unable to keep up." Following is an excerpt from a major manufacturer's programmable thermostat manual that instructs users how to do so. Ventilation can be disabled at outside temperatures above 80 degrees F when cooling and less than 50 degrees F during when heating, for units that "can't keep up." For this range, ventilation will be disabled at all but the most pleasant outside weather conditions.

Outdoor Air Temperature Ventilation Override	[Disable]. Enable	Select whether an outdoor temperature ovrerride is allowed (Outdoor air temperature sensor must be connected and enabled to allow this setting to be selected)
Ventilation — Minimum Outdoor Air Temperature	-10°F to 50°F [0°F]	Select the minimum outdoor temperature that ventilation is allowed
Ventilation — Maximum Outdoor Air Temperature	80°F to 110°F [0°F]	Select the maximum outdoor temperature that ventilation is allowed

Figure 1 - Programming a Thermostat to Disable Ventilation

These thermostat settings are often used by performance-based energy contractors who promise energy savings to school systems. While the savings are eagerly accepted, indoor air quality and the health of the students are compromised. The best measure of this is the frequency at which many school systems must close for a period of days to weeks each winter for influenza spread. This has only become frequent in the last ten years or so; in prior years it rarely occurred. Something has certainly occurred to cause such closings. We are not going in the right direction!

Conclusion

Maintaining spaces at 40 to 60% RH is a contributor to the wellness and attentiveness of building occupants. Ample research and documentation exists for adoption of these values. Unfortunately, ASHRAE Society and its Standard 62.1 are failing to provide the performance metrics that would result in buildings that achieve these goals.

As a result, equipment manufacturers are failing to respond or innovate, enabled by the generous margins offered by ASHRAE Standards. In fact, their response has been just the opposite, embedding controls that are contributing to sickness and spread in many buildings.

References

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applied
engineering

405 Erin Drive
Knoxville, TN 37919
www.appeng.com

For more information:
Contact: Jack Hopkins, P.E. Principal
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