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1. Introduction to Indoor Air Quality (IAQ)

Over the years, the HVAC residential industry has focused on temperature control in the home and basically regarded all other aspects of Indoor Air Quality (IAQ) as non-essential.

IAQ is an ever-growing concern to the population and is a far reaching subject that we as comfort specialists must get a better grasp on in the very near future. With our customers being bombarded with products that make claims to do everything from cleaning 99.9% of all dust in the air to killing all airborne germs and viruses, our customers look to us to make sense of it all.

There is a reason corporations are spending millions on infomercials and advertising these products; our customers are looking for something to make the air in their homes cleaner and fresher. The market is out there. We, as specialists in HVAC, are in a front line position to grow our companies as well as provide our customers with the solutions to their IAQ issues.

The information in the industry is sporadic at best; so, we must turn to the agencies that monitor it for guidance. The Environmental Protection Agency (EPA), American Medical Association (AMA), and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) are such agencies we depend on for the best possible information.

The EPA has stated that:

- An HVAC system that is *properly designed, installed, maintained, and operated* is essential to providing healthy indoor air; a poorly maintained system can generate and disperse air pollutants.

- *Control of pollutants at its source* is the most effective means of promoting IAQ.

- *An adequate supply of outdoor air* is essential to diluting indoor pollutants.

- *Air cleaning is an important part of an HVAC system, but is not a substitute for source control or ventilation.* All air cleaners must be properly sized and maintained to be effective.
The American Medical Association has stated that:

- Most people spend 80 to 90% of their time indoors.
- 50% of all illnesses are caused or aggravated by polluted indoor air.

The EPA states that there are three main areas of concern for IAQ:

1) Source control

2) Ventilation

3) Filtration

Let’s take a closer look at each.

1) **Source control** eliminates the problem or reduces the problem at its source. Examples of this would be: cleaning the evaporator or ductwork, providing adequate combustion air for furnaces, ductwork repair/replacement and adding or removing humidity. Source control can involve humidification or circulation (ductwork).

2) **Ventilation** brings in fresh air from outside to dilute the stale air inside the tightly constructed home. This is done by installing Energy Recovery Ventilators (ERVs) and Heat Recovery Ventilators (HRVs), fresh air ducts or ductwork repair/replacement. By doing these things we can help to reduce odors, dilute the toxins such as volatile organic chemicals (VOCs) and bio-aerosols, and reduce pressurization problems. Ventilation can involve circulation, ERVs and HRVs, and filtration at the fresh air source.

3) **Filtration** cleans the circulated air that is in the home. We generally consider filtration as removing the dust that is in the air, but in the last few years filtration products have evolved into sterilizing biological organisms with ultraviolet light (UV) and removing odors with catalytic cells. Filtration can involve particulate, odor and bio-contaminate reduction, and circulation (continuous fan).
2. Elimination/Source Control – Humidification

Humidity is measured in Percentage of Relative Humidity (%RH) or the amount of moisture in the air compared to how much moisture the air can hold at any given temperature. The warmer the air is the more moisture it can hold before producing condensation (dew point).

If you had a 100 gallon container and filled it ¾ full with water it would be similar to a 100 degree day at 75% RH. Similarly, Relative Humidity is the amount of water in the air compared to how much it can hold.

If you then reduced the container size to 75 gallons and placed the same amount of moisture in the container, your container would be 100% full. Similarly, on a 75-degree day, if the air contained the same amount of moisture as it did on the 100-degree day, relative humidity would be 100%. The air would now be completely saturated with water.

If you lower the temperature any more, the air will not be able to hold it and it will condense on objects. This is what we call “dew point” - the temperature at which moisture will condense from the air.

High humidity makes us uncomfortable in the cooling season. We all know that. However, high humidity can also make us feel warmer in the heating season as well. Remember that moisture in the air is a form of heat (latent heat). Therefore, it must be controlled in order to maintain comfort.

Using the heat index below in the winter in Albany, NY, if the temperature in the home is 70 degrees and the Relative Humidity is 10%, your body feels like the temperature is 65 degrees. Simply adding humidity to the air and raising it to 40% will make it feel as if it is 68 degrees. Your customer will feel more comfortable.
In Orlando, FL, in the summer, with an indoor temperature of 80 degrees, and a Relative Humidity of 90%, it can feel like 88 degrees. If we lower the humidity to 40%, it feels almost 10 degrees cooler.

**If the Relative Humidity is too high, we can have moisture problems. Fungus can grow, dust mites thrive, and a host of other undesirable conditions can occur.**

**If the Relative Humidity is too low, we lessen those detrimental effects but then can have static electricity, skin disorders, nose bleeds, etc. - another group of issues we must consider.**

Dry air is also easier to heat and cool than moist air. In the dry air of the desert for example, temperatures range from a high of 110 degrees during the day to a low of 40 degrees at night. If your home is too dry in the winter, it may feel drafty because the dry conditions are conducive to wide ranges of temperature.

In the swampy Florida Keys it may get to 98 degrees during the day but only drop to 90 degrees at night. In these high humidity conditions, even if we lower the temperature, a customer can still feel uncomfortable.
With this in mind and knowing moisture is a form of heat, does it not make sense to add moisture to the air on a dry winter day adding latent heat to the home as well as keeping the temperature swing from being so great? We can do this with a humidifier.

Conversely, if moisture is heat, we do not want it in our homes in the summer; therefore, it must be removed by a dehumidifier or our air conditioner coils.

The human body has a very small window of comfort level with too much or too little heat and too much or too little moisture. Our job is a balancing act to maintain that small window of comfort.

For example, the winter comfort level is about 63 to 71 degrees while the summer comfort level is 66 to 75 degrees. This is close enough, but factor in the humidity range for comfort being between 30 and 70 percent and the HVAC technician has quite a challenge.

**Lennox has determined that 25-50 percent is the optimum range for Relative Humidity. However, there can be conditions when we must deviate from these parameters so we do not create other problems in the residence.**

**Situation: Less Than 25% RH**

- Static electricity
- Dry itchy skin
- Sore throats
- Nose irritation or bleeding
- Viruses
- Bacteria
- Respiratory infections

**Solutions**

- Humidifier
- Sealed combustion furnaces
- Ensure proper pressurization of home

**Situation: Over 50% RH**

- Bacterial growth
- Viruses
- Fungi
- Dust mites
- Asthma
- Chemical interactions (VOCs)

**Solutions**

- Ensure proper pressurization of home
- Dehumidifier
- 2 stage air conditioner
- Variable speed air handler
- Proper size air conditioner (Possibly too big)
- Proper airflow (CFM)
- Proper size ductwork or grills (Possibly too small)
- Proper refrigerant charge in air conditioner
- Proper attic or crawlspace ventilation
- UV Lights
3. Ventilation – Dilution

As homes have become more energy efficient, in part due to tighter construction, indoor air quality has declined. This is caused by fewer air changes, or the lack of air ventilation. It is estimated by the EPA that the air inside the home is 40 to 100 times more polluted than outdoor air.

Inside today’s tighter homes, both moisture and pollutants are being formed. The moisture comes from cooking, washing clothes and dishes, showers, and even our breathing. Live plants in the home convert CO2 into much needed oxygen. But, they also add large amounts of moisture to the air and can become breeding grounds for fungus that spread into the air we breathe.

When the moisture inside the home reaches excessive levels, mold, mildew, fungi, dust mites, and bacteria can grow. When this occurs, moisture (condensation) can be found on windowsills and black spots (fungi) can form on walls, bathrooms, and on ductwork.

The net result – additional moisture – adds to the latent heat of the HVAC equipment while doing nothing to overcome the pollutants.

One pollutant that is common in modern homes is carbon monoxide (CO). CO is produced by cigarette smoke, candles, unvented cooking products, unvented fire logs, leaky chimneys, idling cars in attached garages, and wood burning fireplaces or stoves.

Other pollutants include the very materials from which the home is constructed. Examples are: insulation, plywood, particleboard, foam sealants, caulk, paints, carpets and glues. All of these products, when exposed to higher temperatures or humidity, will off-gas at higher rates. Off-gassing is when these products let off VOCs (Volatile Organic Compounds) into the air we breathe. But, it does not end there. The foam cushions in our furniture and even the chemicals in our cleaning products all contribute to the contamination of our indoor air.

The recommended methods for controlling these VOCs are to:

1) Remove products from the living space (source control)

2) Ventilate
Since we do not want to completely destroy our homes to eliminate contaminants, our only option is to dilute the VOCs with fresh air. Ventilation is the answer.

Ventilation is achieved by bringing in fresh air from outdoors to dilute the stale air indoors. In some applications however, we could unknowingly bring in air that is hotter, colder, wetter, dirtier, or drier than the air we are removing. We could then create a situation that is worse than when we started.

Because we do not want to bring in air that is worse, we can use an HRV (Heat recovery Ventilator) or an ERV (Energy Recovery Ventilator). They temper the incoming air by running it side by side, with the exhaust air, through a heat exchanger core. This is done after the incoming air is filtered and in the case of the ERV, dehumidified through a desiccant wheel. A good ERV or HRV can be 85% efficient.

**HRV is typically used in northern climates because it will not dehumidify the incoming fresh air.**

**ERV is typically used in southern climates where we must dehumidify the fresh air being brought into the home.**

**Situations Requiring Ventilation**

- Air is being pulled from the attic or basement when exhaust fans are turned on
- Home is built very tight
- Cabinets or furniture are made of particle board
- Home is newer construction with adhesives for flooring or treated wood in walls or floor
- If customers use: aerosol sprays, cleaning products, cigarettes, candles, air fresheners, paints, nail products, etc.
Solutions

- ERV
- HRV
- Fresh air duct to return air
- Continuous fan products
4. Cleaning – Filtration

**Particulate** is a fancy name for dust. It is basically anything that becomes airborne, that we can breathe in inside our home. We breathe in dust every day, but our bodies have built-in filtration systems. The hairs in our nose and the mucus membrane help filter out this dust and keep our lungs clear. The first problem occurs when the dust becomes so small (around .3 microns) that our bodies cannot do an adequate job of filtering it out.

The second problem is that the air in our homes contains tremendous amounts of this very fine dust that can pose respiratory problems in adults, but more often in children.

It is not just dust; it is what is in the dust that can be a problem: viruses, pollen, mold spores, lead paint dust, pet dander and a group of other potentially harmful items, all going in and out of our air conditioner, and in and out of our bodies.

*It is our job once again to solve all the problems associated with dust. We do this with filtration, and/or filters.*

To do our jobs correctly, we must be able to identify what is a good or poor filter. Until recently this was a very difficult thing to do.

4.1. History of ASHRE Standard 52

Originally there was ASHRE Standard 52-1968, developed by the Air Filter Institute and the National Institute of Standards. The primary measuring standard for purity was outside air, which seemed fine for the day. Outside air was clean and breathable. Large metal mesh and fiber mesh filters were the standard and allowed fine dust to travel through the system.

After standard 1968, ASHRE Standard 52.1-1992 brought about changes to the testing procedures. Filters were now rated on best-case scenarios capturing large particle dust and tested again using small particle dust. As a filter loads up, the more dust capturing ability it has, the dirtier it gets the better it performs removing particulates. (Keep in mind the dirtier it gets the less air your system can move.)

*The large dust captured by the filter was rated as Average Arrestance Efficiency.* If a filter captured 90% of the large dust, over a given time, it was given a 90% Arrestance Efficiency.
The small dust captured by the filter was rated as the Average Dust Spot Efficiency. If a filter captured 30% of the fine dust, over a given time, it was given a 30% Dust Spot Efficiency.

As you can see, by testing this way you can only tell how good the filter is over the life of the filter (average), not how well it will do with a particular size dust when the filter is brand new or least efficient.

During the latter part of the 20th century, health concerns in office spaces became more prevalent. Computer systems had to be kept free of dust as they would fail if they got hot or dirty. Manufactures were using the Arrestance % and Dust spot %; however, it made their product look better. Given all the different ways a manufacturer could test under 52-1 1992, they could make any filter look good if they left it in long enough, or increased the final resistance high enough. The numbers were too easy to manipulate to get a desired effect. The technicians in the industry had a hard time deciphering the information so it became harder to recommend the proper filtration for a customer’s needs.

Enter ASHRE Standard 52.2-1999. Filter testing under this new method uses specific particles of 0.3 to 10 microns. This standard is specifically designed to test “High Efficient Filters” for discriminating homeowners, labs, hospitals etc.

A filter is subjected to 6 stages of loading, from Clean to Maximum pressure drop.

After each stage, the filter is tested with test dust from 0.3 to 10 microns to see how well it removes dust at each different stage of loading. This gives a clearer picture of how well a filter is doing at each stage rather than on an average, as was the case in the older standards.

The resulting efficiencies to the test are now given a number from 1-20 (which could increase later as needed) called the Minimum Efficiency Reporting Value (MERV). This number tells the user under the least efficient conditions (usually brand new) how well this filter will work.

The chart below shows the typical size of some common household particulates.
For the sake of example, these are some typical MERV ratings and how they correspond to the Dust Spot efficiencies of past Standards.
<table>
<thead>
<tr>
<th>MERV</th>
<th>Type of Filter</th>
<th>Avg Arrestance</th>
<th>Avg Dust Spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERV 1-4</td>
<td>Fiberglass, Disposable Panel, Washable metal/synthetic, Self charging (Passive)</td>
<td>60-80%</td>
<td>&lt; 20%</td>
</tr>
<tr>
<td>MERV 5-8</td>
<td>Pleated, Media panel, Cube</td>
<td>80-95%</td>
<td>&lt; 20-35%</td>
</tr>
<tr>
<td>MERV 9-12</td>
<td>Extended pleated</td>
<td>&gt; 95%</td>
<td>40-75%</td>
</tr>
<tr>
<td>MERV 13-16</td>
<td>Electronics</td>
<td>&gt; 98%</td>
<td>80-95%</td>
</tr>
<tr>
<td>MERV 17-20</td>
<td>HEPA</td>
<td></td>
<td>99.9%</td>
</tr>
</tbody>
</table>

During a test done in Canada, twenty homes were fitted with several types of filters under a variety of conditions. Some of the basic things they found during normal running conditions in the FAN ON position were:

- Dust levels in the home were not reduced much (9 to 30%) during active hours because of opening doors, walking on carpeting stirring up dust, folding clothes etc.

- Dust levels in the home were reduced (13 to 75%) during inactive times by an approximate level of the dust spot efficiency tests.

Electronic filters were also tested and found to emit ozone into the living space. Ozone is generated in nature at much higher levels than those found in the homes with electronic air cleaners, but be aware that some customers have a higher sensitivity to it.

The current guidelines for ozone are 120 ppb (parts per billion) per hour but levels as low as 15ppb could provoke health conditions. Levels tested in the test homes averaged 10 ppb with a range of 2 to 19 ppb. Also found was that ozone emissions were not reduced significantly after the cleaning of the media.

Note that the HEPA filter cannot be used with the standard residential blower, because the static pressure drop across this media is too high. It is typically used in a stand-alone, or HEPA bypass application. The stand-alone versions do not do a good enough job for the whole house to be recommended by Lennox at this time.
HEPA bypass is a very good way of removing dust of all sizes from the environment. Being in the MERV 17-20 range, this style of filter uses a bypass around the unit’s air handler to remove dust from the air. Utilizing its own blower, it can overcome resistance that a typical residential blower cannot.

**Lennox has chosen to use a MERV 8 as its target minimum for recommendations.**

**Situations Requiring Filtration/Cleaning**

- Dirty interior of ductwork
- Dirty blower wheels
- Dirty Evaporator
- Dirty secondary heat exchanger
- Dust/pollen allergies
- Dust level high in the home
- Cooking or bathroom odors
- Pet odors

**Solutions**

- 3” pleated filters
- 4” pleated filters
- 6” pleated filters
- Electronic Air Cleaner
- Pleated with UV
- HEPA Bypass
- Pleated with UV and Catalyst (PureAir)
- Variable speed continuous fan products

- UV light
5. Circulation

Circulation of air through the ductwork falls under three headings:

- Source control, for proper humidification or dehumidification.
- Ventilation, the ERV and HRV are needed to tie into tightly sealed ductwork to be effective.
- Filtration, because if the air is not moving across the filter it cannot clean it, and if the ductwork is leaking it will draw dust in from undesirable sources.

Air distribution is the ability to move air in the right quantity, at the proper speed, at a designed temperature, keeping in mind moisture problems, noise, and cleanliness. So you see, it is more than blowing air into a room. The size and location of ducts, grills, and registers is critical to the proper airflow required by the higher efficiency equipment. Also, the homeowner wants the system to move air quietly, without a large temperature change, without drafts from air moving too fast, and without hot or cold spots from stratified air. Going beyond just comfort, proper airflow can affect personal health and the health of the home. These IAQ problems fall under the jurisdiction of the EPA and include problems like mildew and mold radon and other pollutants.

The air distribution system does not create air; it simply circulates the same air through the residence over and over again. Everyone has heard of someone getting sick because they flew on planes that re-circulate the air and germs from other passengers. The same holds true in the residence. If the air is contaminated by dirt, pollen, dust, or any other problematic sources, the result is the circulation of these products throughout the home. All of the air in your home can be completely circulated through your system in 8-16 minutes. This is the same air, dirt, and germs going around in your home.

Often overlooked in this industry is the circulation system of the air. As long as the air was coming out of the registers it seemed to be OK. If the room was too cool or too hot, another duct was added to bring in more air with little regard to the source or origin of that air.

Leaking air from the supply side of the system can cause the whole house to go into a negative pressure. When a home goes into a negative pressure, air is being sucked into every crack and crevice of the home, through electrical fixtures, sill plates, windows, and doors. This air is not conditioned air; it is often very hot or cold and with varying degrees of moisture content and dirt. This can cause higher
electric bills as well as dust problems. If the air is very humid, the interior of the walls can reach dew point and mold issues can develop where it is not visible, but is potentially dangerous to the occupants.

**Leaking air into the return side** of the system, depending on from where it is being drawn, can have the opposite effect on the home. It will place the structure in a positive pressure. When a home goes positive it forces the clean, conditioned air out from all the same places, again costing the homeowner money. If it is a very dry climate, the moisture level drops in the residence causing low humidity issues like static electricity, dry itchy skin, nose bleeds, etc. If in a wet climate, humidity levels can be increased.

**Symptoms of Circulation Problems**

- Humidity, high or low
- Not cooling or heating in home
- Not cooling or heating in certain rooms
- Dust in home
- Noisy supply or return ducts or grills
- Drafty rooms
- Sweating ductwork
- Moisture around grills
- Musty odors
- Air blows too cold or too hot
- Home pressure changes when blower turns on

**Solutions**

- Variable speed blower
- Repair duct leaks
- Replace ducts
- Add additional ducts
- Enlarge return grills
- Replace or add insulation
- Two-stage gas furnace
- Clean ductwork
- UV light
6. Review Questions

1) What is the primary difference between an ERV and a HRV?
   a) HRV removes moisture and an ERV does not
   b) ERV removes moisture and an HRV does not
   c) HRV is predominantly used in southern states
   d) ERV is predominantly used in northern states

2) Particulates are removed by what primary method?
   a) HRV
   b) Filtration
   c) Positive pressure in the home
   d) Humidification

3) Dust mites and fungus thrive under what conditions?
   a) Cold, low humidity
   b) Dusty, low humidity
   c) Warm, low humidity
   d) Warm, high humidity
4) What does the MERV ratings signify the efficiency of?

a) An ERV  

b) A HRV  

c) A Filter  

d) A Ductwork system

5) Which one of the following is not a recommendation for IAQ?

a) Source Control  

b) Filtration  

c) Refraction  

d) Ventilation

6) According to the EPA, indoor air can be 40 to 100 times more polluted than:

a) Sewage disposal site  

b) Outdoor air  

c) City dump  

d) Car exhaust

7) Static electricity is an indication of what condition?

a) High humidity  

b) Television screen is creating dust  

c) Low humidity  

d) Home is in a positive pressure
8) How would CO or VOCs best be diluted in the home?
   a) Filtration
   b) Circulation
   c) Ventilation
   d) Humidification

9) What would be the minimum MERV rating you should recommend to your customer?
   a) 4
   b) 8
   c) 12
   d) 16

10) Leaking air from the supply ductwork into an attic or crawlspace will have what affect on the home?
    a) The home will go into a positive pressure
    b) The system will force high humidity out of the ductwork
    c) The home will force air out of the windows and doors
    d) The home will go into a negative pressure