CHANGE THE AIR FOUNDATION

Learn How Your House Operates as a System

with Chris Hughes & Steve Rogers

SPEAKERS
Kendra Seymour, Steve Rogers, Chris Hughes

SR
Steve Rogers
00:00
We've mentioned the dew point, but let me explain why the dew point is important to know and important to keep track of. The reason dew point is important is because, if there are any surfaces in the home that routinely get below the dew point of the air around it, water will condense. It'll sweat, just like a cold beverage on a warm, humid day, and anytime we have moisture condensing on a cool surface, that's an opportunity for it to stay wet long enough to start having biological growth, mold, mildew and other things like that, that can be dangerous to health and even dangerous to the building materials.

KS
Kendra Seymour
00:51
Welcome to the HVAC plus D mini class series brought to you by Change the Air Foundation. This series is made possible thanks to the generosity of our sponsor, Santa Fe Dehumidifiers, we are deeply grateful for their support, which helps us continue raising awareness and providing free resources so that more families can breathe safe indoor air. A quick reminder, this 12 part mini class series offers a consumer friendly overview of common HVAC plus D topics. It is not a replacement for professional advice. You can watch the full series on our YouTube channel or by visiting ChangetheAirFoundation.org, and clicking on our resources tab. Welcome to episode three. Learn how your house operates as a system with Chris Hughes and Steve Rogers. In this episode, we'll talk about water vapor basics, including dew point, moisture drivers in a home, and some action items for homeowners. This information lays the foundation for understanding how your house operates as a system. A bit of background on our presenters. Steve Rogers is the president of The Energy Conservatory, makers of the Minneapolis Blower Door, the Minneapolis Duck Blaster and the True Flow. He has over 25 years of experience working in flow and

pressure management at The Energy Conservatory and at Dwyer and Emerson. Steve earned his mechanical engineering degree from Brigham Young University, and is involved in multiple committees for the ASME, the ISO and ASHRAE. Chris Hughes is an experienced HVAC professional from the heart of Louisiana with 20 years of experience in the industry. In addition to his previous hands on experience as an HVAC mechanical contractor, Chris has further honed his expertise through his time at The Energy Conservatory, where he continues to fine tune his skills and stay abreast of the latest advancements in HVAC and building science technology.

CH

Chris Hughes

02:37

Okay, so what, what we wanted to present today is we kind of titled this, The HVAC Starts with the House. And Steve and I, of course, at The Energy Conservatory, we focus a lot like our flagship product is the Minneapolis Blower Door. So of course, we look at the shell of the home, but we've kind of dove deep into HVAC too. And that's kind of a big reason, I guess I'm on board is kind of look at the HVAC tied into the house, but you got to look at it all together, right? And so we're going to kind of take you down through two parts that kind of segue together. There's going to be a part three and a part four. So if you really want to get the full meat and potatoes of what we're going to discuss, part three and part four, kind of handshake. They'll lace together. So this particular presentation, I developed this kind of with the idea of AJ Callegan in mind, you know, AJ, I've watched the Change the Air Foundation. I watched AJ presentation, and I know he had a huge health issue with mold. And so, you know, the question is, why is my house growing, microbial growth, and where does it start from, and and how do I address it, and how do I fix it for the long haul, not just remediate it, but how do I take care of it? And it kind of starts with moisture drivers in the home and things like that. But at its core, it's all about moisture transfer, right? There's moisture outside, there's moisture in the house. There's things that remediate, like our take moisture out of the home. There's things that bring moisture in the home. And so we thought we'd do like a high level overview of kind of like, the moisture transfer between inside and outside, to help understand the principles of that. And that's what this presentation is about. Okay, so we're going to break this down into like three learning objectives. We're going to talk about a very, very basic water vapor basics overview. Then we're going to talk about moisture drivers, and then we're going to talk about action items that we should be maybe asking our mechanical contractors to take care of for us to try to remediate some of these things. So let's get started with water vapor basics. So, a pints a pound the world around. Steve, tell them what that means.

SR

Steve Rogers

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It just turns out that a pint of water weighs almost exactly a pound. And we're going to be talking about sort of a day in the life of that pint of water today. And talking about, you know, that water moving into your home and hopefully out of your home, because you want some water in the air in your home, but you don't want too much,

CH

Chris Hughes

05:10

That's right. And so the big message of why we're starting with this, like high level overview, is to kind of understand grains of moisture. So there's 7000 grains in a pint of water, and that's a little nerdy, and that's not something you gotta memorize. But when an HVAC technician is coming to your home and you're trying to do a moisture balance transfer on a home to make sure that the right amount of moisture is in your home or not in your home, or do you have too much, it really starts with boiling down, of having to know how much water is in your home, and you relate that to grains as like an absolute measurement. You know, as technicians, when we do snapshots in time on a home, we'll use temperature and relative humidity. And probably a lot of homeowners hear us talk about like, oh, the humidity is high in here, or the temperature is really high, but the humidity is okay. But you know that relative humidity number is exactly what it is. It's relative and you're going to see that in this presentation. And so a big driver that we should be paying attention to is dew point, because dew point could go up even though the relative humidity is going down due to the temperature in the home. And so we're going to drive that message, which stems from grains of moisture.

SR

Steve Rogers

06:26

Yeah, there's a nice relationship between the grains of moisture and the dew point. If you know the dew point, there will be exactly the same number of grains of moisture in the air regardless of its temperature, so that the dew point tells you, like, how many molecules of water are in the air. The relative humidity doesn't tell you that unless you also know the temperature.

CH

Chris Hughes

06:50

The next slide here is a pint of water vapor, roughly is in your bedroom. And what I'm trying to address with this slide is a couple things. One, the average bedroom, like, we're all having this conversation right now, in a room, right if you're in a room, and that room's like, let's say roughly 10 by 10, eight foot ceilings, and somewhere close to that, for example, 175 square feet, or 1400 or 1500 cubic feet, then you roughly have about one bottle of water in the vapor state in that room, if that room is at design conditions. And what I mean by design conditions is 75 degrees Fahrenheit with 50% relative humidity. So when a technician does a load calculation for you, for your home, they're inputting that as the indoor design conditions they're trying to maintain. And there's a lot I could say around that homeowners will a lot of times argue with technicians to say, well, I want my house at 72 or 70 degrees. That doesn't mean that your house won't get there. That's just the design conditions. And if we had hours of content, we'd really dive deep into how that can be accomplished. But just know that programs are designed to run with those numbers of 75, 50 that's very commonplace, and it works.

SR

Steve Rogers

08:18

And I'll just point out that if you think you need your house to be at 72 it's probably because you haven't had a house that's at 50% relative humidity. You'll find that if the humidity is where it should be, a higher temperature is comfortable. But a lot of homes are not getting proper dehumidification in humid parts of the country, and so usually, or frequently, you'll find that you need it to be at 72 or you want it to be at 72 because your humidity is at 60% which is really too high.

CH

Chris Hughes

08:49

I'll expand just a little bit further. Maintaining a house at 50% relative humidity in a very humid climate can sometimes the house sneaks away from you, from subtle things. They're not exactly driven by the box that's taking the humidity out of the air. It could be bedroom pressures or mild duct leakage, or just very subtle things happening around the house that's driving up that humidity, which is making you want to run that air conditioner a little bit lower to make you feel a little bit more comfortable. And so we're going to get into those though. So you know, a pint of water is in the vapor state. It's kind of what you have in your bedroom. And that would be kind of normal. So taking that one step further, if you have a house, and a house is, let's say, roughly 2000 square feet, given the average ceiling height, somewhere around 10 feet, you're going to have somewhere in the neighborhood of a 16,000 cubic foot house, and that house would hold at design conditions, roughly about half a case of water, right, to be exact, 10.8 bottles of water, for this example, which correlates to 75,000 grains of moisture. And that's our absolute measurement. But we, you'll see we have our our design temperatures down below but what's important is looking at that dew point. That dew point is 55 degrees Fahrenheit. Now, what does that mean? That means if, for instance, if my walls are below 55 degrees, that means they're going to sweat right moisture is going to accumulate, stick to that wall, and we're going to have issues, and that dew point is kind of the source of knowledge that we're going to use to know if microbial growth is going to start to grow, because we all we know when water sits on something, we're going to start to grow micro growth on it. So that dew point's a very important number. We're going to keep sourcing back to

SR

Steve Rogers

10:38

Alright, so we've mentioned the dew point, but let me explain why the dew point is important to know and important to keep track of. The reason dew point is important is because, if there are any surfaces in the home that routinely get below the dew point of the air around it, water will condense. It'll sweat, just like a cold beverage on a warm, humid day, and anytime we have moisture condensing on a cool surface, that's an opportunity for it to stay wet long enough to start having biological growth, mold, mildew and other things like that, that can be dangerous to health and even dangerous to the building materials of your home, if it goes on long enough. So we should be tracking the dew point. And in this example, you know this is design conditions. So the dew point in the home would be about 55 degrees. So you'd ask yourself, are there surfaces in my home that are cooler than 55 degrees? Because if there are, and they're routinely that temperature, then they will condense and start to accumulate moisture. So that's normally not a problem, because we don't have a lot of surfaces that are that cold in our home. But what if the dew point in my house is 70 degrees? Well, that means any surface that's cooler than 70, you know, if I've got a tile floor on the you know, that's on a concrete slab that might be cooler than 70. If I've got water pipes, water could be cooler than 70. The ducts and grill registers from my HVAC, those are going to be cooler than 70. So if the dew point in your home is up as high as 70 or even 65 then there's going to be lots of surfaces where moisture could be condensing, and that could be causing problems. So that's why dew points important. If the surface gets below the dew point, moisture will condense, yeah. So keep tracking that number through these next few slides, because that dew point is going to be probably the most important number, and it will help you to get a sense of you know, what's what's a dangerous dew point, and what's an okay dew point to have in your house?

CH

Chris Hughes

12:43

And just for anybody listening, dew point isn't like this super complicated like math problem you have to go figure out. You can download very easy calculators, probably for free, anywhere online, on your phone, and you can get a simple calculator where you enter, you know, two points of you know, you could enter temperature, relative humidity, and, you know, find the dew point. You know, it's not hard to calculate with an easy tool online. Okay, so that's just a really kind of easy, deep dive into water vapor basics. Now we're going to get into moisture drivers, right? Like, what is causing potential high relative humidity, or might look like low relative humidity, but high moisture content in the house, and we kind of bundled all those up as moisture drivers. And of course, I have this picture of a kitchen hood. So being a mechanical contractor most of my life, this one hits home for me, like, really, really hard, especially in the deep South. I don't know why, if this is Steve, you tell me, I don't know if this is widespread where you're at, but where I live, everybody loves to build a big old Acadian style home, and they buy the biggest range hood they can find and the biggest, biggest kitchen hood they can find. And I have personally witnessed this and walked into an appliance store and have had the salesman tell me, oh, you want this thing it moves 1200 cfm. I have one in my house. If I cook a steak inside my house, it all that smell just goes up and right through the kitchen hood. It works awesome. And that may be true, but what's the side effects of that, like, do you really need 1200 cfm moving through a kitchen hood inside your home? So we're going to, we're going to dive into that and decide if that's a good idea.

SR

Steve Rogers

14:32

Yeah. So the example we're using doesn't use a 1200 cfm hood. It uses a much smaller, more reasonable hood. Let me, let me tell you just a little quick personal anecdote that explain how much do you really need, and do you really should you consider the 1200 cfm hood? So a few years ago, I replaced a really bad over the range microwave range hood, which I think was probably not moving much more than about 100 cfm, and I replaced it with a new one, which was moving, you know, I actually was able to test it, and it was moving more like 350 or 400 cfm. And I like to cook. I cook a lot. And what I found is that when I changed the hood from 100 cfm to 350 I had to change the way I cooked, because I realized I was depending on being able to smell the cooking food to know when I had to stop cutting something up and go back and stir the food that was cooking. And when I upgraded to the 350, 400 cfm range hood, I could no longer smell it from 10 feet away at the counter, from the from the the cooker. And so that tells me that 350, 400 cfm is moving enough to get most of the pollutants from cooking out of your house.

CH

Chris Hughes

15:53

Alright, so let's expand on this a little bit. I've had not one but two engineers in my life tell me this. And I think Steve, you were maybe the second of the first, I'm not sure, but you told me, houses are not squishy, they suck. You, I'm going let you take this one, because I think he's you describe it well.

SR

Steve Rogers

16:12

Yeah, so I my, mine is a little different. It's very closely related to this. Houses are not squishy, they suck. Which means that if you take 1200 cfm out of your house, you can guess that 1200 cfm goes back in your house, exactly 1200 cfm. And how do we know that? Because houses are not squishy, and if you turn on your range hood and you go outside and watch your house, it doesn't implode. Ever! So that tells us that you can't be taking 1200 cfm out and not be putting 1200 cfm back in, because otherwise your house would literally implode.

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Chris Hughes

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All right, so we, we know we're bringing outside air in, or maybe even attic area in which is kind of outside air too. And we're going to kind of deep dive into that a little bit. So let's cover a quick need to know about this. There's one or two things that will happen when you turn a kitchen hood on. Either one, the kitchen hood will draw air from outside, which, as Steve just discussed. Or if you have a really tight house, which is a good thing, the kitchen hood turned on will actually just reduce the amount of airflow that it's actually going to pull and send through the house. So if you starve the fan for air because you have such a tight home, you're just going to reduce what that kitchen hood is designed to do.

SR
Steve Rogers
16:50
Yeah, and you'll all, you'll always have some of both of those things happening. But in a leaky house, it will mostly be number one, and in an airtight house, it'll be more of number two, of reducing the airflow.

CH
Chris Hughes
17:46
So getting to the equation, right? So let's play out the scenario. You got a kitchen hood, and it's running, and let's say, for this example, we're doing 400 cfm, and the reason we're doing that is because there's a lot of like normal, your normal run of the mill hood is probably sized for 400 cfm, so it's very common. And let's say this hood is moving 400 cfm outside of the shell of the home, right? We're throwing that air outside. Is it a problem? Well, the first thing we need to understand is the conditions, right? So inside the home, we're trying to maintain 75, 50 so 75 degrees Fahrenheit, 50% relative humidity. That's a design home, right? We talked about that's a comfortable home. We've paid money to condition that air to keep it comfortable, right? So we've paid that's expensive air, okay. Outside air is expensive to treat, to bring it into the home. It's not expensive because we haven't paid to treat it yet. And at, let's just say, where I'm at, my design conditions are 93 and 50, right? And so as that air is hot outside, it's going to hold a lot more moisture.

SR
Steve Rogers
18:58
We should probably explain design conditions. What does that mean? You said design conditions, or 93, 50 design conditions are what is the typical a really hot day in your area, and that's the conditions that the HVAC technician should be designing the equipment for. They shouldn't design it for the worst day ever. They should design it for a pretty common but really hot day. So we had actually the 1% level is what they design at, meaning that they design it where 99% of the days of the year are going to be cooler than that temperature, and only 1% of the days would ever be hotter than that temperature of 93 and you know, at 50% really humidity. So that's what Chris means by design conditions.

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Chris Hughes
19:45
That's a that's a really interesting point, Steve. I'm expand a little bit on what Steve's getting at it. There's days where it's hotter than 93 degrees here. It might hit 97 degrees. Let's just say, if you added up all of

those that time throughout an entire year, let's just say it equates to five hours. If that is your new design selection, you essentially oversize the air conditioner for that home, and that's not a good thing to do, and so for five hours, that customer might be just mildly uncomfortable in their home, but for the other 99% of the runtime hours of that air conditioner, or, you know, minus the winter time, they're going to be way more comfortable if you size it properly. So you don't want to size it for that aggressive few hours of the year.

SR

Steve Rogers

20:32

Yeah, it's about making sure you're comfortable and controlling the humidity properly during 99% of the time. Because if you design for like the 99.9 or 99.99% of the time, you're way oversized most of the time, and dehumidification is not as effective when you do that. And so and really, most people don't notice. Even when you go hotter than the design conditions, your indoor temperature might slip one or two degrees. Most people don't notice.

CH

Chris Hughes

21:03

Yeah, and, and we're getting probably really nerdy here, but like, the tighter you make a home when you build it, that problem really kind of goes away. You don't have to worry about that as much. But that's really deep diving. So getting back to the kitchen hood with my little tombstone remark at the bottom that says, moisture driver, one, right? That's going to keep us on track so we don't lose the topic of what we're at here, like this is all about the first moisture driver, the kitchen hood. So we've got our indoor conditions, and we've got our unconditioned outside air, you know, peak load design conditions, and we're doing a 400 cfm exchange, 400 cfm goes in the house while we dish 400 cfm out of the house. Well, let's talk about what those conditions look like if they're absolute moisture. And that's where we go back to grains per pound. That's why we did the whole pint of water, you know. And what does that look like in grains? So when we're calculating the moisture that's being increased in the home, we break that down, the grains. So inside the home, at those conditions, we have 65 grains per pound. Now outside, at those conditions, we have 117 grains per pound. So we almost have double the amount of moisture in one pound of air outside than we do inside. And it costs money to take moisture out of the air. So

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Steve Rogers

22:21

Even though the relative humidity, in this case, happens to be the same at 50% so the relative humidity doesn't tell you how much water is in the air, unless you know the temperature as well. So we can, we can see that the dew point of the outdoor air will be much higher even though the relative humidity is 50% inside and outside.

CH

Chris Hughes
22:42
And so if we ran that kitchen hood for one minute, just one minute, we would increase the moisture inside the home by not very much, right, two tenths of a bottle of water. So not a lot of impact to the home. If we were to kind of drive this absolute moisture measurement, back to a design of temperature and relative humidity, we would see that the actual home goes up to 75.5 and a 50.2 relative humidity, almost not. Like no homeowner is going to feel that or notice that.

SR
Steve Rogers
23:15
Yeah, the dew point went up only one degree. Yeah.

CH
Chris Hughes
23:18
Like, this is almost something that you know, if you're using some DIY temperature measuring tools, this will almost be in the noise of the measurement, right? So not super noticeable. But we don't run our kitchen hoods for one minute. We run them longer. So what happens when we run the kitchen hood for one hour? Now, I'm going to dive into this a little deep, but I need to say this at first, we are not running the air conditioner right now. We should be. But to understand this problem, we have to really paint one side of the picture, and we're painting the moisture load increase. We are not equating for what the air conditioner is going to do, because it's going to be running right now, and it's going to take water out. We're going to get to that, but right now we're just showing the impact of load that's happening to the house. So bear with me. That's we're going to come full circle toward the end. But so we have one hour run time on the kitchen hood, and this is kind of the impact to the home. Now the home gets up to 17 bottles of water. So a lot of water is now being injected into the home. That's a lot of load on the HVAC system to deal with. Okay, now we are going to talk about that. Like I said we're going to talk about how we deal with that water, but just understand, like, that's a lot of problem. That's a whole lot of moisture that's that's huge for the air conditioner to deal with. So what does that look like from a temperature and dew point standpoint? So, you know, without the air conditioner running, we get up to 89 degrees, 51% relative humidity, you know? And our dew point goes up to 69 right? We're just like again, showing that one side of the equation. Now moving on to a second moisture driver. This is duct leakage to outside.

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Steve Rogers
25:03
So ducts that move the air from the air conditioner into your home are not perfectly hermetically sealed ever. In fact, most of the time they're really pretty leaky, and that can be a real problem if your ducts are outside of what we call the thermal envelope, which is the part of your house that we want to keep warm

and cool with our HVAC system. So if your attic is, you know, if you got your insulation on the ceiling and you're there's no insulation on, you know, under your roof, then that means your attic is unconditioned. You might also have a home that's on a crawl space where the crawl space is unconditioned. And so you might have sometimes the HVAC system is in a garage that's not conditioned. And so if your ducts are in any of those spaces and they leak air, that means we might have a situation where the HVAC system is moving more air out of your house than it's bringing back in, or it might be putting more air into your house than it's taking back out, you know. So the air is supposed to come into your house from the supply grills, that's where the warm or cold air comes in, and the return grills are going to take that unconditioned air back into the system, so that the air is intended to just circulate through your home without losing any but if you have ducts, duct leakage in an attic, for example, now you have a problem where the system might be moving 1000 cfm out of your house, but it's only moving 800 cfm back into your house. And now you're going to stop me, and you're going to say, wait a minute, Steve, you said that my house would implode if I did that. Well, your house has a funny way of fixing that problem, and that's by letting air leak in, just like happens with your range hood. This does exactly the same thing. If I if the HVAC system is moving 1000 cfm out and only putting 800 back in, then the other 200 cfm that it needs to prevent your house from imploding is just going to get sucked in from any leaks in your house. So it will always be in balance. But we don't really want to be sucking extra air from outside into the house every time we run the air conditioner. We just explain the impact of running a range hood. Well, if you have a really leaky duct from the supply, it's doing exactly the same thing, except not just for an hour while you cook your meal. It's doing it anytime the air conditioner runs. And so this can be a big driver of bringing moisture into your house, moisture that you don't want into your house.

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Kendra Seymour

27:51

Can I ask a question and kind of add some context for those listening? Because I think as I've gotten to understand building science more. I think what stands out to me as a homeowner is we're then pulling air in from some pretty dirty spaces, right? Like, if you've ever done any kind of construction, you've opened up a wall, like, behind your wall, like, that's not a there's dust and sometimes mouse droppings and everything else. If it's pulling from your attic and you have a problem in your attic or your crawl space or anything like that that is dirty, contaminated air, and to your point, with that, it brings in moisture. And I've seen pictures being in the remediation side of things where you start to get mold growth on in between some of these walls and behind building materials because of that leak. Am I explaining that correctly?

SR
Steve Rogers
28:42
Yep, that's exactly right. You know, if you don't know where the air is coming in, then some of it's coming from places you don't want air to be coming in either, because it's contaminated air that you really don't want to breathe. Like, I mean, you can be sucking in, you know, the the lawnmower gasoline vapors from the garage, if that's, you know, if you've got an attached garage, the other thing it can do that Kendra mentioned is it can suck air into the the wall cavity or the floor cavity of the house, and cause moisture accumulation to be growing in those spaces.

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Chris Hughes
29:16
So, you know, this is kind of geared toward the southern region here, but a lot of times our houses are on slabs, and we pull a lot of air straight from the vented attic space, which is kind of funny you brought that up because, like, that's kind of where we're headed in the presentation is to dive deep into that whole attic air situation, which is a lot of times the path of least resistance of where we're going to get our airflow from. So like, if we have 80 cfm of air exchange, for example. And I just picked that number because I think I ran when I presented this example on this house, it was like 2000 square foot. There's a duct leakage standard to this, which we're going to get into, I believe, in part four. So 80 cfm of air exchange. And like you say, the air, sometimes isn't, like Steve was saying, it doesn't always come from outside. It comes from, say, the attic.

SR
Steve Rogers
30:05
Let me just interject something here, Chris. The the 80 cfm, that's an important number because that if you have a 2000 square foot home that's conditioned by one system, or even, even if it's conditioned by two systems, that's how much you are allowed to leak by code, in most states. They're going to allow your house, a 2000 square foot house, would be allowed to leak 80 cfm. Which you know, if you're leaking over 80, that's worse, but we're going to find out even leaking 80 is not awesome.

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Chris Hughes
30:36
So in this example, with 80 cfm of duct leakage that is outside the air barrier of the home we're going to get into that. I think that's a part four one as well. So for this example, I, instead of design, I pulled actual conditions and said, well, what if the attic is at 125 degrees Fahrenheit and a 20% relative humidity. And you think, well, maybe not as impactful, because the relative humidity is really low, right? But it's still very humid. Like our grains per pound is 118 our house is still at 65 but we're basically at the same grains of

moisture per pound, even though the relative humidity looks really low, and it's because that hot air can hold a lot more moisture in it, because it's in a hot attic. So you know, you can't look at temperature and relative humidity and make that the determination, unless you can do the moisture calculation based off that in your head. And if you can, that's impressive. All right, so what does that look like after, you know, one hour run time, and it looks like we take the house from 10.8 bottles of water to 12.8 bottles of water. Okay, so a little bit of an increase, little bit of an impact, you know. So where does that put us? That puts us at a 60 degree dew point the house is 88 degrees, 39% relative humidity.

SR

Steve Rogers

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Yeah, so not as impactful. But again, we just want to clarify, again, this is assuming that the HVAC system wasn't running. So this is what would happen if you turned on your fan, but didn't have the air conditioner running, right, which is why you shouldn't do that.

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Chris Hughes

32:18

But now we are going to look at the other side of the equation, right? We do have an air conditioner. The air conditioner does run. So let's talk about what it normally does for water removal capacity. So, you know, typically, this is kind of like a just an example, but on a 2000 square foot home in the south and I don't want to generalize this, or say rules of thumb, or and all that, because really a load calculation is and a blower door number and all that is how you're going to size the air conditioner. But generally speaking, you're going to cover more than 500 square foot per ton on most houses today. You're, you know, in my experience, where I'm at on a normal design house, normal windows, nothing crazy. I may be covering seven to eight hundred square foot per ton, right? That's just generally a good assumption, not saying you should just go do that with a rule of thumb, but you'll probably be close to that. You may be higher. And if you did put a three ton, this is some data straight from a unit that I was looking at for expanded performance data that tells me, like, how many BTUs it can produce, what's the sensible heat factor, which lets me know how much of the coil will do water removal, and how much of the coil will actually work on bringing the temperature down in the house, and how many cfm, you know, It will move a minute through the system. So just some data that, as an HVAC designer needs to know to design an air conditioner to handle the basic moisture load of the load calculation designed for the house. If that were the case, this system will remove about six bottles of water in that scenario based on certain temperature conditions. Okay. Now, this gets a little nerdy, and I'm just going to throw this out there. Things change a little bit based on the conditions inside the home. So the conditions inside the home will change, and some other factors will change how much water the air conditioner will remove. So this is just kind of like one snapshot in time, right? That's pretty basic, and this, in this example, it removes about six bottles of water. Now, in my Manual J if you're sizing the air conditioner for the home. You don't probably want to do that to where it's just perfect, right? So if my Manual J calls for five bottles of water, of water removal, then maybe I'm designing the air conditioner to remove six. That way I got a little bit of buffer, as you've seen, because you're going to have a kitchen hood that's going to run momentarily. It's not going to run all the time. You're going to have a lot of other things we're not talking about. You're going to have a kitchen hood or exhaust fan in your bathroom that's going to run sometimes. You're going to run your dryer. And we're running dryers probably a lot more than we used to, because nobody has clotheslines anymore. So there's a lot of moisture drivers we didn't even get into they're going to move air out of the house. So having a little bit of buffer of water removal capacity is a good thing. And so typically, a designer will design for a little bit of extra water removal capacity. Not a bad idea to even also have a backup unit, like a dehumidifier for a southern home, to have that extra water removal capacity, and that we're getting kind of little nerdy again, but like as air conditioners become more efficient, and that's the direction they're headed, the water removal capacity of the air conditioner is going down by design, so dehumidifiers are becoming more important today than they used to. So it's not a bad idea to have a dehumidifier in a home.

KS

Kendra Seymour

36:06

And I'll jump in to say we're gonna have part seven is all on dehumidification with Tim De Stasio, and so we're gonna have that be its own thing, because we know it's a big deal.

CH

Chris Hughes

36:16

Yes,

SR

Steve Rogers

36:17

I'll also point out that when the when the HVAC company does the load calculation, what are they figuring about where that moisture comes from? They should be figuring based on how leaky your house is, because some of water comes in from outside, if your house is leaky, more if it's leakier, less if it's not leaky. But also, they're accounting for humidity that gets generated indoors. When somebody takes a shower, it puts humidity indoors, just humans breathing, add humidity to the air that has to be removed. And those things are taken account of in the load calculation. But as Chris said, normally, they're not taking into account a kitchen range hood or a bath fan, because those things don't run all the time.

KS

Kendra Seymour

37:05

Yeah, I'll just add Steve for listeners, we're going to get into, like, Manual J, S, D and T in like a two parter. And in Part five, there'll be an A and B, where we'll we'll unpack that. So if you're listening and you're not quite sure what they're talking about, we're going to get into that, I promise.

CH

Chris Hughes

37:19

Okay, so that's a deep dive into our moisture drivers kind of stemming to show where that problem comes from. So I wanted to kind of talk a little bit about action items, like, if I'm a homeowner and or renting a home and I want my house to be more comfortable, what should I be asking for to kind of resolve some of these issues we've talked about. And so the first one I'm going to get into is controlling the fan speed. So the air conditioner, there's factors that will change how the air conditioner removes water, and basically, one of the biggest factors that you can control is how fast the fan moves the air across the evaporator coil. The evaporator coil is the apparatus that takes the moisture out of the home as you move air across it. And so you know, ideally, you know you want to have that. You want the house to be comfortable and you want the house to be efficient. And for this example, I'm just picking an arbitrary number of 400 cfm per ton. That may be 350 cfm per ton to be comfortable and efficient, and it might be the best you can do. And 450 may be too high. 450 may mean you're efficient, but you're not comfortable because you left too much water in the air. So as you move the fan faster, you will have a more efficient air conditioner, but you may leave a lot of water in the house. Okay? So that's a balancing act that needs to be kind of thought out and set properly. Jumping into the makeup hood. So one action item you can take is rather than letting your kitchen hood run and just letting your house leak from who knows where, and like we said, maybe attic air, which is pulling through can lights and such, which is dirty air, you could bring a makeup duck, a path of least resistance, straight to the kitchen hood, very close to it, just like you would see in, like, a restaurant, you know, typically a restaurant has a large kitchen exhaust with a makeup air fan that blows air right next to it. Not saying you'd want to put a booster fan in the makeup duck, but running a duck for an easy point of access for that air exchange wouldn't be the worst idea. Now, a couple things you'd want to think about is having, like, some some type of motorized damper that way they duck is not just open, because if it is now, you just have a penetration through your air barrier that's open all the time. So you'd want to have something that, you know, some type of control that isolates that makeup duck only when needed. And there's controls out there for that,

SR

Steve Rogers

39:58

Yeah, a technician can set it up so that that damper that lets the air, the makeup air in only opens when it detects that the fan is on. They can set it up that way.

KS

Kendra Seymour

40:09

Should that duct? Should that be filtered air? Should it be dehumidified air? Or is it just air as it's coming in from outside?

CH

Chris Hughes

40:19

Yes, like

SR

Steve Rogers

40:21

I think it depends.

CH

Chris Hughes

40:24

No, I think it's just a, you know, to add this to someone's home is going to be expense, and it's all in, it's all about, like, what is the homeowner want to pay for. You know, does the homeowner want to pay for a filter in their makeup duct for their kitchen hood, and then, great, yeah, give it to them. If they, you know, would you have to make it bigger to account for the pressure drop across the filter. You've reduced that path of least resistance a little bit. So, because now it's harder to get air through it, because there's a filter in the way. So maybe it has to grow and get bigger and become a bigger filter media, and that's part of the design. Not saying it's bad idea, but it costs more money to do that. So it's a conversation of how much air, how many times are we going to use it? And do I want to afford it?

SR

Steve Rogers

41:07

And it depends a little bit on your climate too, you know, if you're designing makeup air and you want to bring it in, you know, it's actually really effective if you can bring it in near the stove, like some people will have it, so that the air comes in below the cooking range. So that means that the air is you're going to feel, you know, in the summertime, maybe some warm humid air that's coming in by your toes, but most of that warm, humid air is going out with the cooking stuff. And so that's a really effective way to do it. But if you're in Minneapolis, where I'm at, you know, you maybe don't want 10 degree air coming in at your toes whenever you cook the in the winter. So maybe you do want to temper it, or maybe you want to just dump it into a mechanical room. So it depends on your climate. Depends on how much if you really got to have that 1200 cfm range hood, well, then you definitely need makeup air, and you might need to be tempering it. Might need to be cooling it. You might need need to be dehumidifying it if you're in a really humid climate. So

CH

Chris Hughes

42:03

And just for the record, nobody needs in their home a 1200 cfm rangehead! Okay, going on to ceiling ducts. This one's very straightforward. When you know, if you have leaky ducts, you have what we nicknamed whammy number one, you're losing this expensive air. Which drives whammy number two, which we've kind of been talking about a lot, which we're going to drive infiltration, right? So if we want to kill whammy number one and whammy number two, we just need to seal the ductwork, right? We need to just get that tight. And you can measure that with tools. Right? We have a tool that measures airflow through a duct system, and you can, you know, take a benchmark and do some air sealing, and then measure your benchmark after your air sealing and see if you did a good job.

SR

Steve Rogers

42:47

Let me explain what the double whammy is. So when Chris says there's a double whammy, what we didn't explain is that the duct leakage outside affects your system in two ways. The first way is that you paid to cool that expensive air, and then all of it didn't get back into the house, so you just lost it. So if you're conditioning 1000 cfm and only 800 cfms getting back into the house, that means 20% of the expensive air you paid to cool down just got lost. It just blew out your attic. But the other thing that happens is that we talked about the warm, humid air that has to get sucked in from any leaks in your house because of the imbalance. You know, the house has to get back into balance. Well, that 200 cfm of outdoor air coming in through all the leaks, that actually means there's more cooling and more dehumidification that has to happen. So the load of your home went up at the same time that you lost capacity. And so that's why we call it a double whammy.

CH

Chris Hughes

43:52

And that's our presentation. So that's our conversation of the moisture transfer. And I think if you can wrap your head around you know that grains of moisture in versus grains of moisture going out, understanding those snapshots in time and relating that to absolute moisture, you can kind of put some type of bearing on where you need to be.

KS

Kendra Seymour

44:14

Yeah, this has been really helpful because they I we want people to understand the home as a system. Every time I do something as simple as turn on my bathroom fan or run my dryer or my kitchen range hood. It changes what's going on in my home. I think is kind of the takeaway. This has been incredibly helpful. Is there anything that before we wrap up that you didn't say or a point you want to reiterate before we say goodbye to everyone for part three.

CH

Chris Hughes

44:41

I would like to add this in context. We talked about a lot of snapshots in time here, but one thing to consider is, if you're if you're listening this, and you go out and buy some DIY sensors and do some calculations, there may be moments in time where your dew points really high, and that's okay if it's just for a short little bit of time. This is not something where you go, oh, I just cooked in my house for an hour, oh, my gosh, the dew points out of control. That's gonna happen. That's normal. That's living in your home. Now it's the trending. It the importance of data logging, I guess, is what I'm saying. It's what is it like all the time? If your dew points high all the time, well, then you have what's called a problematic house, and you need to address it, and someone needs to come investigate these moisture drivers. But if there's just like these random short little peaks, and you catch it once, that doesn't mean you're needing to do stuff and start working on your home. If it stays level, you're okay and you're not living in a problematic house.

SR

Steve Rogers

45:44

Yep. That's a super important point, Chris, because anybody who gets a temperature and humidity sensor is going to find out that they probably do get over 70% humidity, but that happens once in a while, and it doesn't last long. That's fine. It's Where are you getting to most of the time, but it's going to be up and down, and up and down, which means temperature and humidity sensor that actually logs the data, so you kind of know what's happening all 24 hours of the day, not just when you happen to look at it. Because we don't want people to get the idea that, oh, I saw a 70 on there one time. I got a bad house. Because that's not the right conclusion.

KS

Kendra Seymour

46:20

Yeah, and homeowners and renters, you can buy like there are cheap hygrometers online that are battery operated, and that will give you a snapshot when you look at it. And I encourage you to have a hygrometer in your home on multiple floors. Pay attention to it, but there are fancier systems now that you know can talk to your phone and log that data over time, which I think is what you're speaking to.

SR

Steve Rogers

46:40

Yeah, there's some that I found on Amazon. I won't mention the brand, but they cost $17 and they record, you know, 24/7 every minute. And then you can Bluetooth to your phone and see the graphs of, you know, what was humidity doing for the last 24 hours for the last week?

CH

Chris Hughes

46:56

I would tell you, if you're a homeowner and you're gonna spend $17 the idea of maybe going just a step further, and let's just say we're spending maybe $200 and getting to see a lot more data or around IAQ, yeah, might be worth it for the extra data you're going to get outside of just temperature and relative humidity, which will tell you a lot more about your house. Some of these $17 meters do measure decently well, but you can have probably more confidence in your $200 meter, but you're also going to get a lot more data. And being this is, you know, Change the Air Foundation, I know y'all are bigger on IAQ, so like having a meter that could look at, you know, CO, in case you have appliances, you know, things like that, or or even CO2, or anything, you know, like, a lot more of that information would be pretty cool, you know, just.

SR

Steve Rogers

47:46

Yeah, I'm and I'm not sure if anybody does everything, but if you're in the part of the country where people have basements and it's a and there's radon. Radon is one of the most important pollutants that you should be monitoring. If you have combustion appliances inside the home, you should have carbon monoxide monitors. So there's lots of different things to consider.

KS

Kendra Seymour

48:07

I'm glad you brought both those up. We have great episodes on radon and carbon monoxide that I'll link to in the show notes, for people who want to take a detour and learn about that, because it's super important, and something we want all homeowners and renters thinking about at some point. Well, thank you both so much for being here.

SR
Steve Rogers
48:22
Happy to be here.

CH
Chris Hughes
48:24
Yep.

KS
Kendra Seymour
48:24
So for everyone listening, thank you so much for joining us. I hope you'll come back for part four, because Chris and Steve are going to return, and we're going to talk about testing our home and HVAC system. We're going to get to things like blower door testing and duct leakage and true flow grid and more. So I don't want you to miss it if you happen to miss parts one and two and you want to just stay in the loop, here's what you can do. Hit like and follow us on YouTube, or you can head on over to ChangetheAirFoundation.org, click on our resource tab, and there you're going to see all of our mini class videos. And do me a favor while you're on the website, be sure to sign up for our newsletter, because it really is the best way to get great information like this directly to your inbox. Until next time, breathe easy and we'll see you for part four.