Season1- Episode5
Airconditioning in 2023

JOURNEY

It's Friday morning, the Millers family are sitting together for breakfast. Thomas 'phone rings, it is Daniel, the family 's lifelong friend. Thomas answers and sends greetings from the kids and Xenia to him. Tonight, is Daniel's birthday party and he was inviting them to come. Thomas notes down the time and place of the party, wishes Daniel a happy birthday and hangs up. „Now let me go to work and then find a nice present for Daniel "says Thomas. Xenia says she will be doing the same and they leave to work and take the girls to school.

In the afternoon Thomas and Xenia discuss whether it would be safe and wise to go to the party or should they just celebrate with Daniel another day separately. Xenia argues „giving Daniel's nature and personality, I don't think he will be inviting too many people ". Thomas agrees and comments that Daniel booked the whole place so there would be a big space only for them. Melanie comes in to remind her parents to look up the restaurant on the internet for sanitation rating and AC air purifying technology. The whole family stares at the computer's screen eagerly, and then are happy to see that the restaurant processes a high-ranking regarding AC technology and sanitation measurements. Now they are relieved and excited about going to the party, so they go to get themselves ready and leave.

Once the family arrives and enters the restaurant, they notice the difference in the air quality between outside and inside the restaurant. „How refreshing, it's smells just like the air inside an airplane "commented little Christie. Thomas replies that they use a similar AC technology. The kids run to Daniel to give him his presents and wish him a happy birthday!

Agnes Kunkel:

We are still in the Covid-19 pandemic. The total confirmed cases have reached today 14.5 million people, but global number of casualties has now risen significantly above 600.000. Today, we have 20th of July 2020 and my name is Agnes Kunkel. I am your host and today we are happy to introduce Dr. Bahnfleth live. He is a professor of architectural engineering at Penn State University. He holds a Ph.D. in mechanical engineering and is a registered professional engineer. His research focuses on thermal and air quality control systems for buildings, a major component of his research is the Study of the Control of Indoor Microbial Air Contaminants using Ventilation, Filtration, Germicide, Ultraviolet Disinfection. He is a past president of the American Society of Heating, Refrigerating and Air Conditioning Engineers and the chair of its

Epidemic Task Force. Welcome, Dr. Banfleth. It's a great honor to have you here as guest in our podcast. When Covid-19 started, everyone was talking about washing hands and to keep everything clean. But today we have learned that also aerosols are a transmitter of Covid-19, especially in closed rooms. I guess that's one of your specialties. I think you have researched this topic.

Prof. Bahnfleth:
Yes. That's, just by coincidence, been something I've been studying for close to 20 years now. I became interested in it, when one of my graduate students back around 1998-1999 read a book, I think it was called Epidemic or something similar, but it was about a worldwide infectious disease that was killing millions of people. He read that book and became very interested in controlling airborne microorganisms, and that got me started. And we did a lot of work related to bioterrorism around 9/11 when anthrax was being made in the US and did a lot of things that are similar to what we're doing today. That was when I got started looking at germicide ultraviolet light as a disinfectant. But, all of that went away and it's been pretty quiet until Covid-19 came around. And now, suddenly everyone's concerned in a way that they never have been before.

Agnes Kunkel:
So I guess you are a quite popular interview partner at the moment.

Prof. Bahnfleth:
I'm certainly getting a lot of requests to talk to the media. I think everyone wants to know what it takes to be safe inside of a building or if the air conditioning system transmits Covid -19. Or if it can be prevented, what do I do to it, so transition doesn't happen? How do I know, if it's safe to go into a restaurant? Just lots of questions coming from different quarters, and quite understandably, because everyone's life has been disrupted by the pandemic. We're all trying to figure out how to get from where we are back to something that feels normal.

Agnes Kunkel:
Yes, hopefully. The WHO guidelines now state airborne transmissions may be possible indoors. I guess it's true, they are major source. What about ventilation and filtration to reduce the airborne concentration of the SARS-COV-2 VIRUS and the risk of transmission? Do you see it the same way as WHO does?

Prof. Bahnfleth:
Yes, actually, REHVA, the European HVAC Federation as well as ASHRAE said four or five months ago that we really thought that, based on what we had seen and reports of super

spreading events, we ought to be taking precautions to lower airborne concentrations of infectious aerosols. So, that's what those different modalities you just mentioned address: ventilation dilutes indoor air with outdoor air that's free of infectious material and filtration removes particles that may contain viruses, and we can also use other types of air cleaners to inactivate or kill them, if you will. Because the most important thing, if aerosol transmission is possible, is to keep the concentration in the air low enough that it takes a very long time to be exposed to enough of it to have a high risk of infection. So, the only thing we're trying to do is keep concentrations of a certain contaminant low indoors, using methods that we've used really for over 100 years.

Agnes Kunkel:
And what are these methods you are typically recommending to keep the virus concentration low in indoor facilities?

Prof. Bahnfleth:
Well, certainly a good supply of outdoor air is fundamental. We bring in outdoor air for ventilation to control all sorts of indoor contaminants. There are thousands of contaminants that are inside of a building that come from building materials like the glues and resins in flooring and carpets and particulate emissions from indoor sources like candles. So, we use that as our general purpose air quality control, also human odors as well. So, that's fundamental. Particulate filtration is something that has generally been done at a relatively low level in buildings, mainly to protect air conditioning equipment, to keep it from getting dirty. The changes in requirements for buildings have been increasing the filtration requirements to levels, where we're using filters that are efficient at capturing particles that are in the size range of respiratory droplets, a term that nobody probably knew before and everyone knows now. We understand that when we breathe or speak or sing, we are producing thousands of small droplets, which may contain viruses.
And we're recommending filters that are efficient enough to remove those at a fairly high level to reduce the concentration. And to that we add methods like germicidal ultraviolet light, which is very effective for inactivating viruses on the air or on surfaces.

Agnes Kunkel:
Is ultraviolet light still used on a broad scale?

Prof. Bahnfleth:
Yeah, it's been interesting for me to talk to people from many different countries during the pandemic because I'm more accustomed to the way things are done in the US. From my point of view, we've had a fairly robust ultraviolet air and surface disinfection industry here for some

time -for one to two decades. It's not nearly at the level of the air filtration market, but we have lots of manufacturers, who produce systems not just for health care facilities, but also for office buildings and even homes. I know of companies that mainly serve a residential market. So you can get the equipment for all of these of these different types of buildings. But I would say the most common is health care. It has been studied a lot as a control for tuberculosis and has been deployed around the world as a way of reducing tuberculosis infection rates, such as in sanatoria that it might have tuberculosis patients in them. So the CDC (Centers for Disease Control and Prevention) in the US approves the use of ultraviolet for tuberculosis control in health care facilities. But, now we're seeing that technology being considered for other applications like large high density spaces that you might find in some buildings, where perhaps a concourse in a transit facility, where it's hard to keep the air clean by other methods. So, we see a lot of interest in those applications and in office buildings, as well as a way of ensuring that the areas as clean as we can get it.

Agnes Kunkel:
Do you think that these air conditioning system or UV systems will be given a higher priority in the construction of new buildings over the next few years?

Prof. Bahnfleth:
I certainly think so. In new buildings we may be seeing differences in designs that incorporate better ability to control infection risk. I think, we'll see also a lot more attention being paid to the maintenance of existing systems. That's one of the big issues with the risk posed by air conditioning and a lot of buildings have old and not well-maintained systems. The first thing we have to do, is make sure that they're performing the way they are intended to. I think, we'll see differences in how much outside air is provided and what types of air cleaners are used and perhaps the way air is distributed in buildings as well. There's been a lot of discussion about whether we should recirculate air inside of a building, because it could take infectious materials from the room, where a sick person is in and carry it to another room and infect them. That seems very unlikely to happen with Covid-19 based on the data that we have on places where there have been super spreading events. But there are other diseases like measles, that are much more contagious, so it was highly infectious. Ones that only require a few microorganisms to cause an infection might be a concern. But a lot of that has to be worked out, I think, carefully before we change standards. We're doing a lot of things right now based on what we know about Covid-19 and not necessarily about the broad spectrum of diseases. Not everything that works with Covid-19 will necessarily work with the different pathogens. So we need to take a broader view of it before.

Agnes Kunkel:

OK, not just for one pandemic, we have to think about many other germs and many other possibilities of contagious material that should be kept out by a good purification system.

Prof. Bahnfleth:
Yeah, exactly - and planning to win the last battle is not often a good plan for the future. We should think ahead.

Agnes Kunkel:
Here in Germany, and I guess it's not so different in the US, we have a big discussion about large indoor events. Such as theaters, cinemas, big restaurants, concert halls, as these areas of the economy are really near a complete collapse. I guess, in New York all the Broadway theaters are closed as well. Is there sort of obvious solutions from the air purifying side that might allow to start conventions again for some technical reasons during the pandemic? ASHRAE also must have conventions delayed at the moment. So, is there a possibility from the side of air purification systems to hold earlier such big events?

Prof. Bahnfleth:
It would help if we knew more about how infective SARS-COV-2 actually is. One of the problems with being able to say this is really a safe space, is that we don't know as much as we would like to know about how much infectious material an infected person puts out, when they're speaking or singing or playing a musical instrument and what the dose is to cause an infection. So, if you don't really know very accurately what the source is and you don't know very accurately the dose is that you're concerned about, then all you can do is try to be conservative. And, I certainly think that some of the air cleaning options that are available could be helpful. So something like a concert hall is a place where you could use so-called upper room ultraviolet germicidal irradiation to provide protection. That's actually a very good way of applying it. We talk in terms of how much outdoor air it's equivalent to - perhaps 10 air changes per hour or more, which is a very high level.

Agnes Kunkel:
That's great. But it sounds a little bit like science fiction. How does this work? What do you mean by upper air?

Prof. Bahnfleth:
Well, yeah, germicidal ultraviolet light is produced by mercury vapor lamps, the same technology as fluorescent lamps, which LEDs are now replacing them for lighting or for buildings. Mercury vapor lamps produce a lot of UVC, which is the germicide. So, an ordinary ultra-fluorescent lamp has a glass tube with a phosphor on it and the U.V, that's produced in the

lamp is absorbed by that phosphor and radiates as visible light. However, if we have a tube made of quartz, then the germicide is limited and what it does is damage the DNA or RNA of bacteria or viruses. If there's enough damage, then they can't reproduce. It's a very well understood and simple process and we're simply trying to deploy this UV in a way that's safe. You can't shine a mercury vapor germicide, a lamp on a person because they are the equivalent of a bad sunburn from it in their eyes will be irritated as well. So we put it in the upper space in a room. The air circulates there and it's disinfected, but the people aren't exposed and are safe.

Agnes Kunkel:
So, it's when you have a high concert hall, you would put it up on the ceiling or in a separate room, if you have a ceiling that's lowered and between it and the upper room, you install the special light.

Prof. Bahnfleth:
Yeah, if a space has a ceiling that's at least perhaps three meters tall, then you can safely install these lamps there. You may not put it all the way in the top of a huge concert hall because you actually want to treat the air that's down, where the people are but above where they're sitting. One thing that I mentioned in a discussion with some performing arts center people in the US last week was that these fixtures do give off a little bit of blue light. And I wonder how they feel about having something in their concert hall during a performance glowing blue with it might be a little distracting, if that's what it takes to actually be able to have image.

Agnes Kunkel:
I would guess people would accept this when they start doing concerts and performances and shows.

Prof. Bahnfleth:
And of course, you know, the air is often supplied under the seat because you're in these big high ceiling rooms and you can also put UV into the air conditioning system and treat the air that is supplied. So, you're getting cleaner air. There are a lot of different ways to do it. It's not magic. Although, I remember the first time I heard about light disinfecting things, I thought that sounded like it was questionable.

Agnes Kunkel:
Are you doing research on these ideas?

Prof. Bahnfleth:

Yes, I have a project going right now that has two parts to it. In one, we're actually studying coronaviruses in the laboratory and testing them with germicidal light to determine what their susceptibility is. In order to be able to design a system, we need to know for a specific pathogen, what dose it takes to reduce its concentration by a large amount. We're working with a surrogate coronavirus right now, one the causes colds in people. But within the next few weeks, we're going to be looking at source code to itself, which we don't expect to be different by very much, but it still needs to be confirmed.The other part is doing studies of application of UV in typical space. We're studying what is the best way to apply it in combination with filtration and outdoor air so that we get a good result, with low energy use and cost effectively, which is part of the thinking when engineers design systems. Something may work very effectively, but if it is so expensive no one can afford to do it, then it's not going to be widely adopted.

Agnes Kunkel:
Ok, so, when we think about the short narrative at the beginning of our episode, it was talking about a visit to a restaurant and not asking for the quality of the dessert, but asking about the quality of the air conditioning and, if it's safe. Do you think this high interest in your search of this field of research that it will last and that really in two to three or five years? Let's say will it be a point of interest, what air cleaning system a building has? Does it bring in fresh air? Does it kill germs? Maybe people get more demanding by saying, I don't want to get cold (laughs) and we don't want to get other influenza viruses in our buildings and all that stuff. Do you think that the interest will stay?

Prof. Bahnfleth:
Well, I certainly hope so. We have several examples where there's been a serious epidemic, though, and the memory has been very short. Once things are over and we go back to normal, the public forgets all about it, then people start saying, well, that would be nice, but it's very expensive. I think that perhaps we've suffered so much personal and economic damage on such a scale from this pandemic, that we have a longer window of opportunity to do something. But, I'm not feeling comfortable that we have a long time to make changes. So, I think we're going to have to work very hard after the pandemic is over. We need to have our thoughts in order about how to change design standards and what to recommend as far as technology for making buildings safer. Fortunately, there are a number of things coming together here. One is the whole wellness movement in buildings. The public has become aware of that. And, I think we tie in infection control when there's a pandemic with simply making buildings healthier all the time. I think cost effective solutions will be there if our technology keeps developing. And the other thing is resilience. There's been a lot of discussion about designing buildings to adapt to climate change. If the climate keeps getting warmer or it's getting humid or wetter, that affects the way that HVAC systems have to function, so, we've been thinking about that as well.

Dealing with a pandemic is essentially having resilient systems in your buildings to control infection. I'm hopeful, but it will be interesting to see how far we can go with some of the things that are under discussion now. As far as restaurants, a lot of people ask the question, how do I know if the air quality is good or if it's safe? It's very hard to tell. It's easy to tell when air quality is bad because of odors, than to tell if it's good. It's really hard to look at it and say, well, there's a lot of PM 2.5 and smaller particles in the air. They're not really visible. So, you can't tell from looking at the air whether the filters are good. Some people are talking about taking carbon dioxide monitors into restaurants and trying to judge from the CO2 concentration whether there is good ventilations. Maybe in the future we will have personal air quality monitors. Something on your phone you could test the air in the space that you're in. There are there are apps like that now, actually, but not everyone is using them. I think another approach that would really be helpful would be air quality certifications for buildings. We have energy regulation for buildings. Why shouldn't they be certified as to the quality of their air and their safety equipment?

Agnes Kunkel:
I could imagine people demand that. Even if it's not mandatory, if it's just a free choice of the owner of a restaurant or a gym for instance. That’s something you can add to your service showing that you have good air conditioning. And, as we discussed in the beginning, I guess maintaining air conditioning systems or heating, refrigerating and cleaning systems is a big point.

Prof. Bahnfleth:
A building that's working satisfactorily for many maintenance organizations that have limited budgets is one that people aren't complaining about. Yeah, and often when you actually look at them, there are lots of things wrong, and not just with indoor air quality, but with energy as well. It's been said throughout my career that if we could just get all of the systems to work the way they're supposed to, we would immediately reduce their energy use by 15 to 30 percent. So, that's great energy expense that we're just living with.

Agnes Kunkel:
That's amazing. Here in Germany, we always think about stricter regulations on the official side. I guess in your country it's more about a free service that people expect. What do you think it will cost to upgrade a restaurant or concert hall. What amounts of money are we talking about if you want to level it up to a standard where you can filter out viruses?

Prof. Bahnfleth:
Well, my organization, ASHRAE, that is producing guidance on building updates for COVID -19, is only recommending an update to what we call in the US, a 13 filter. I'm not sure exactly, what

that is in ISO or European standards, but it's a filter of good efficiency, but not a HEPA filter like you might find in laboratories or hospitals. Those filters might cost twice as much as the ones, that are being specified by minimum standards now. So, it's an expense, but not a huge one. And, they don't necessarily have larger pressure drops through them than the less efficient filters, So, there may not be an operating cost. In fact, increasing outside air, depending on the type of system that you have, may simply be a matter of adjusting the controls to reduce the amount of error that recirculates and to bring in more from outside. That doesn't have an equipment cost with it. And to mitigate that impact, you might want to put energy recovery devices in your system. But again, it's a moderate cost. If you're using an upper room system in US dollars per square meter, the equipment might be thirty or forty dollars per square meter plus installation. So, an upper room system is pretty expensive, but you see below ten dollars per square meter for a system that was put inside of an air handling unit. So, these are not insignificant costs, but there are costs that a lot of facilities could afford. When you think of the other side of the ledger, the health effects and loss of business that people suffer, there's no comparison. Those costs are ten to one hundred times the cost of the equipment and energy.

Agnes Kunkel:
I have seen a figure of about sick days when the air conditioning or the heating cooling system is not working. Well, that was tremendous, what a good climate in the office building can mean for or even when it's not good working.

Prof. Bahnfleth:
Sick days, productivity, performance of children in school; there's just piles and piles of evidence that we could do better without really spending a lot more on our buildings.

Agnes Kunkel:
To derive some conclusions, at the moment there is some discussion going on. A big point is the maintenance of the existing systems. It would not only mean we have better air quality in the rooms, we would also save a lot of energy just by a regular cycle of maintenance, changing the filters, have a look if the regulation systems are working properly. What I was positively surprised with, I thought upgrading an air conditioning system would be very expensive, but now I understood, upgrading mainly means installing new filters. So, just by changing your filter the system is already upgraded.

Prof. Bahnfleth:
Yes, and of course, it's important to point out that not every air conditioning system can be upgraded to a certain level. They may have limitations in terms of the size of the filter racks, or there may be limitations in terms of how much pressure the fan can produce. And, if you were

going to go as far as is being suggested, you might have to make some physical modifications to the system. But in my own home years ago, simply because I want to get better air quality, I change the filters from very inefficient ones to the highest that I could put in, which is of MERV 11, which is close to what we're recommending. It caused no operating problems exist at all and it keeps the air cleaner in the house. So, I think it's affordable.

Agnes Kunkel:
Now I have these air cleaners, and I have air purifiers on HEPA level in all my rooms. And, it wasn't expensive as I guess in China, they have it for the air pollution. Of course, you have to change the filters from time to time. But it was really not expensive. And, for the rest, are you expecting some sort of Apps or small measure units where you can go to a place and check the CO2 concentration.

Prof. Bahnfleth:
Yeah, these already exist and I just foresee that people will want to have them and the technology will get better. So, you have a sensor that you plug into your mobile phone and the app will tell you what the measurements mean in terms of air quality. I certainly see that happening.

Agnes Kunkel:
What type of sensors are these? Maybe our listeners are interested to plug in some sensor to go to their office (laughs).

Prof. Bahnfleth:
Sure. You have things that are normally measured in an overall assessment of air quality - particles in the fine size range that we know has health effects and carbon dioxide, because it's sort of an indicator of how good ventilation is. The other thing that is sometimes sensed would be volatile organic compounds, which are the things that would be given off by building materials that are another component of indoor air pollution. Those are the main three things that I would expect to be represented and maybe temperature and humidity would be rolled in there as well.

Agnes Kunkel:
Ok, and I guess nowadays these sensors are not so expensive that it would not be able for a private person to buy it.

Prof. Bahnfleth:
Oh, yeah. If someone's really interested, it's something that they could afford.

Agnes Kunkel:
OK, so it's a little bit more expensive. Ok, but maybe the more people are asking for it, the cheaper it becoms. And, so maybe in two or three years it's normal to have your own air quality sensor.

Prof. Bahnfleth:
I think it could be.

Agnes Kunkel:
So hopefully if you are very successful with your research on Covid-19 germs and can help to solve these problems, maybe for services and concert halls and all, that's a hard-hit community. In the end, we always ask our guests in this podcast about their personal experience, what changes you have in your life and your research. Maybe the next semester will be online in your Pennsylvania state. What do you think you have changed during the pandemic and you will keep in the next years?

Prof. Bahnfleth:
Well, given that I'm an academic and teaching is part of my responsibilities, I think there will be big changes in teaching. I think, we found out that it's actually easier than we thought to do remote education. Universities were trying to go in that direction to build a larger audience for their classes already, so, I think this will accelerate. I also think that probably like a lot of other businesses, the university may be less concerned about whether we work from home. We've been getting by since the middle of March with the campus shut down. We finished the spring semester online. We're going to try to do some live instruction in the fall. But, I think most of us are mainly going to be doing remote instruction with a little bit of contact, partly because when you distance the students in the classes, we don't have enough rooms that can hold some of the larger classes. It'll be interesting to see what happens because things could change. If the pandemic really heats up in my part of the US, then we could be shut down again by August or September.

Agnes Kunkel:
Let's not hope for this to happen. I was sure our talk would be interesting, but it was even more interesting (laughs). And, I'm really thinking about buying a sensor to find out about the quality of air in my house and where I'm working. Thanks a lot, we wish you well, and that you have a lot of fun in your experience in online teaching.

Prof. Bahnfleth:

Yes, thank you very much. It was my pleasure! Bye bye.