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OVERTHINKING UNDERFLOOR AIR DISTRIBUTION SYSTEMS?

HOW TO ENSURE YOUR UFAD SYSTEM ACHIEVES ITS COMFORT AND ENERGY SAVINGS GOALS

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Although not noticeable at first glance, many of today's office buildings, especially those with open floor plans, have been built with raised floors, also referred to as access floor systems. For example, The New York Times Building, the Bank of America Tower and the San Francisco Federal Building are all equipped with these systems, which are made up of durable panels that are elevated above a solid substrate, often a concrete slab. Underneath the panels, unsightly cables, wiring and network hookups can be housed to provide a clean and organized appearance above.

However, office buildings aren't the only types of facilities that utilize raised floor layouts. Computer labs within schools and libraries, and even casinos may have raised floor systems in place to hide cords for laptops, monitors and slot machines. No longer are computer, phone and printer cords tangled amongst each other and creating tripping hazards. The underfloor pathway is also ideal for housing necessary heating, ventilation and air conditioning (HVAC) equipment. And because the contents underneath the panels can be easily accessed, businesses can rearrange layouts and move computers and desks without hassle, substantially reducing the cost of office "churn," or reorganization.

Typically, buildings with access floor systems also install an underfloor air distribution (UFAD) system to provide proper ventilation, heating and cooling throughout the space. The air is pushed upwards in a swirling motion through circular grilles that are regularly spaced throughout the environment. The **air** from the UFAD system creates a pool of clean conditioned air in the breathing zone and then moves to the ceiling return by convection of the space heat sources. This upward "floor-to-ceiling" flow of air helps keep the contaminated air at the ceiling and out of the occupant breathing zone, thereby enhancing indoor air quality. Not only do these systems enhance comfort, they eliminate the need for bulky overhead ductwork systems.

However, it's important for architects, engineers and building managers and owners to understand UFAD systems in detail. Over the years, there have been modifications to the design of these systems to accommodate for shortcomings. A closer look at these systems will ensure building occupants and managers are pleased with a facility's UFAD system.

THE RISE OF UFAD SYSTEMS

Why these systems are popular

UFAD systems, which have been in use since the early 1990s, have been very popular in facilities across North America. Many buildings in Silicon Valley, Vancouver, Seattle and Denver have installed access floor systems and UFAD systems to handle their HVAC needs. Buildings in major metropolitan cities such as Chicago, New York City and Calgary have also added UFAD systems underneath their raised floor panels.

SO HOW DO UFAD SYSTEMS WORK?

The system is made up of an underfloor pressurized plenum, located between the concrete slab and the raised floor panels, that supplies air up through grilles in the floor into areas where occupants and equipment are located. The plenum typically ranges from 12 to 24 inches in depth. It is up to 2 feet high because large fan-powered variable air volume (VAV) boxes and ducting are installed throughout the interior to

push air across the length of the environment and towards any windows in the space. By pushing air along the floor and then upwards through the circular grilles, the system creates a vertical gradient, or incline of air, so that people in the lower occupied breathing zone are comfortable at all times.

UFAD systems offer numerous benefits, especially when compared to traditional overhead HVAC systems, including:

• **Flexibility for work stations** - If an open office with a raised floor environment eventually wants to add walls or partitions, this won't interfere with the UFAD system. The distribution through the floor is simply modified to accommodate the loads of the newly configured spaces. With overhead systems that deliver heating and cooling to zones via ductwork, facilities may have to create offices according to the location of this ductwork to ensure maximum comfort. This drives up the cost of office churn, whereas UFAD systems make reconfiguration very simple.

• **Improved thermal comfort** - Hot air naturally rises, while colder air naturally wants to sink under the influence of gravity. These processes result in thermal stratification, or a layering of cooler, high-density air below low-density warm air. With an overhead HVAC system, the supply air, whether it's heating or cooling the room, has to be pushed through diffusers to create a mixing effect. This typically requires higher pressure drop than underfloor systems, resulting in higher energy consumption.

UFAD systems take advantage of the low pressure drop, using the plenum and swirl diffusers as a distribution system, and require less brake horsepower than a traditional overhead system. UFAD systems also rely on thermal stratification to ensure that the breathing zone above the floor is provided with clean and comfortable air for occupants. Cool air is pushed out of the grilles in a

swirling motion and comes to the set point temperature in the breathing zone. Heat generated by people and machines will rise towards the ceiling to be captured, filtered and then pushed out as cold air at the floor again.

• **Improved ventilation effectiveness** - Ventilation is the process of providing clean air to a space and exhausting unclean air in order to control indoor air quality (IAQ). Underfloor systems improve ventilation effectiveness because the mixing of clean air with contaminated air is reduced compared to traditional systems. Clean air is stratified in the breathing zone and moves in a floor-to-ceiling motion. The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) confirms that underfloor systems can help reduce overall ventilation-air quantities compared to overhead systems because a UFAD system only requires ventilation of the breathing zone.

• **Improved employee productivity** - According to the Center for the Built Environment, over 90 percent of the total operating cost of commercial office buildings is attributed to the cost of employee salaries . Improvements in worker productivity can thus lead to significant cost savings. By delivering clean conditioned air directly to the breathing zone, UFAD systems improve IAQ and thermal comfort. This leads to improved productivity, thereby bringing down operational costs.

• **Visually appealing** - Overhead systems use bulky ductwork that is left exposed unless developers and engineers set aside budget to hide these components within ceilings. UFAD systems can't be seen by building occupants, since they are housed underneath the floor panels.

PROBLEMS WITH THE PERIMETER

Thermal decay causes comfort issues

UFAD systems have traditionally been configured to handle heating and cooling for the interior and the perimeter of an indoor space. Unfortunately, having a one-zone system can create comfort issues. This occurs because the interior or core of a space, defined as space at least 12 feet from the perimeter, has relatively constant heat loads. However, heat gain and heat loss at the perimeter changes much more frequently due to radiation through windows and temperature conduction on the outside of the building.

On a day with both sun and cloud cover, these heat gains and losses can occur within a relatively short period of time. A system that handles both the interior and the perimeter would have to drop the temperature of the supply air in order to reduce the temperature at the perimeter. However, this tactic would make people within the interior cold. Often, systems are not designed to vary the core temperature in order to satisfy the perimeter. Thus, people at the perimeter would overheat when the sun is present.

Thermal decay is a phenomenon that occurs when the conditioned air temperature rises. This occurs because it gains heat as it travels through the plenum below the floor tiles. The plenum air also gains heat from the ceiling of the space below, as warmer air is driven upwards. Thermal decay can result in higher airflow rates and increased fan and chiller energy consumption, which would drive up utility costs.

There are several solutions for alleviating the issue of rapid load fluctuations due to weather and solar effects. Some buildings will install a traditional radiator at the floor or wall to handle the heating and a radiant sail or panel at the ceiling to handle the cooling. Another solution is to install fan-powered VAV boxes and ductwork under the floor running towards the perimeter in order to better manage heating and cooling along windows and walls. The perimeter VAV boxes are controlled by a thermostat. Separate diffusers in the interior can be opened and closed to meet the comfort needs of each employee in their cubicle or workspace.
However, although the VAV boxes push air out of grilles along the perimeter, their ability to cool the perimeter zone is a function of the plenum temperature. If this air temperature has increased due to thermal decay, then it may not be able to handle the perimeter load as designed.
VAV boxes also reheat the cool supply air, which is not the most efficient way to heat. Critics of this solution also believe that adding ductwork can create design and installation complications, in addition to being costly and eliminating some of the flexibility the UFAD provided in the first place. There are now large ducts cutting across the floor, blocking the ability to easily reconfigure office spaces and data/power connections.

A BETTER SOLUTION FOR

IMPROVING UFAD SYSTEMS

A closer look at trench systems

Thankfully, there is an alternative to installing VAV boxes and ductwork along the perimeter. Low-H_2O, or low-water content trench heating and cooling solutions are being used with increasing frequency at the perimeter of buildings with raised floor and UFAD systems. The units are placed so that the grilles are flush with the floor at the perimeter, and can be installed as a continuous grille to offer a sleek and clean look.

TRENCH HEATING AND COOLING SOLUTIONS OFFER NUMEROUS BENEFITS.

Installing these units decouples the interior zone from the perimeter zone, solving the issues that arise when one system is expected to handle heating and cooling for an entire space. Rather than the system being dependent upon the plenum air temperature to do the cooling at the perimeter, the trench units use chilled water to effectively handle the perimeter load. Trench systems also help eliminate the need for higher cubic feet per minute (cfm) per square foot at the perimeter.

As these units rely upon hot or chilled water to provide thermal comfort, small (maximum 3/4 inch diameter) pipes are connected to them. These trench convectors are incredibly efficient when combined with a low voltage fan and require very little water content. Because there is less water to heat, the reaction time is much faster. The unit transfers heat immediately into the room when needed and can stop emitting heat quickly when temperature changes are detected on the skin of the building. This means that occupants won't be uncomfortable when solar rays shine through windows or on days when cold drafts attempt to sneak inside.

The units also have the ability to increase core air-side economizer hours. Air-side economizers bring outdoor air inside when the conditions are favorable in order to reduce costs. Trench units help because they are able to work well with warmer air temperatures. No longer do buildings have to reduce supply air temperatures in order to compensate for thermal decay at the perimeter.

COST EFFECTIVE

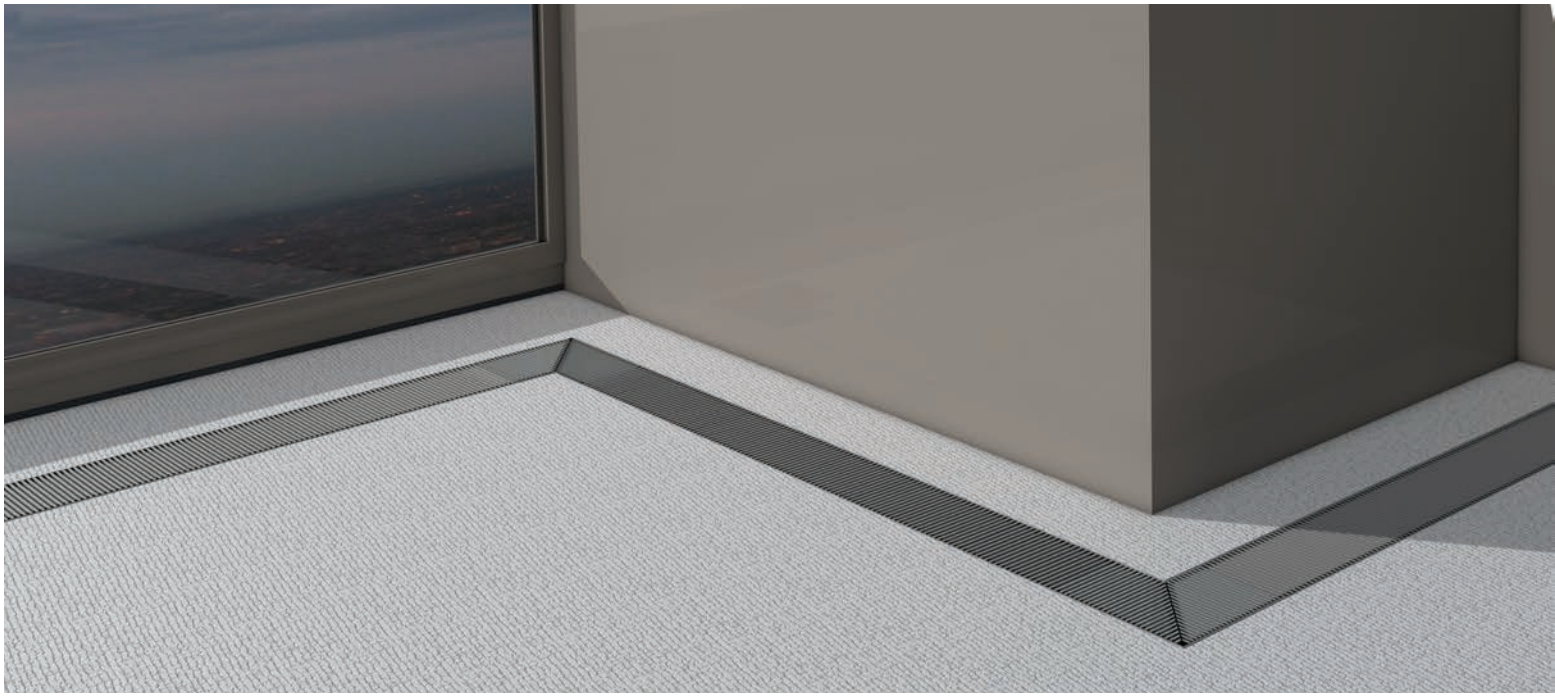
Trench units require less under-floor component maintenance compared to fan-powered VAV boxes, which require floor disruption in order to conduct maintenance. Trench solutions are more cost effective than running ducts and VAV boxes along the perimeter of the environment when sheet metal and installation costs are considered. The units are quite small, roughly 4 inches deep and 7 inches wide. However, they are powerful because they are equipped with energy-saving EC motor fans (operating at 24VDC) that consume less than one-tenth the electrical power of conventional motors in service today. Plus, because they are more responsive to temperature changes and can fully modulate with a 0-10V signal, trench convectors help save energy.

COMBINE TWO SYSTEMS INTO ONE

The size of the units also provide additional advantages. Because they are small and do not require much depth, trench solutions allow architects to reduce the height of the lower plenum. The system no longer requires duct work to run from the VAV boxes to the perimeter, thus saving lots of vertical height. The space savings in the floor can either provide greater ceiling height, or allow developers to add another floor to the same vertical footprint. A trench convector setup is also more cost effective than a system with a floor or wall radiator and radiant sail or panel at the ceiling because it combines two systems into one.

Trench units are also much quieter systems, which ensure that employees in open office spaces and conference rooms won't be disrupted by noisy heating and cooling outputs throughout the day.

Some experts have argued that although hydronic perimeter systems like chilled beams and radiant slabs have lower transport energy, they require more mechanical cooling, thus making them less efficient than systems with air-side economizers. However, fan-powered trench units enable significantly more output in a small space and require less mechanical cooling energy. In climates where one can take advantage of "free air," air-side economizers can still be utilized for the interior zones. The trench units properly handle heat loads at the perimeter and won't require any additional equipment due to the powerful fans within the units



TIPS FOR SELECTION

How to choose trench solutions

When considering trench solutions, developers and engineers should look for units that:

• **Operate on DC voltage** - Engineers should look for heating and cooling solutions that utilize direct current (DC) voltage. Just as LED lights save energy compared to incandescent bulbs, DC-powered solutions can reduce the amount of energy required to heat and cool a space, helping buildings reduce utility costs. Buildings are already looking at providing DC connections for devices likes laptops and lighting, so it makes sense to have DC connections for the perimeter heating and cooling devices as well.

• **Are low flow, require low heating water temperature and operate at low pressure** - Many installers and engineers incorrectly assume that copper or metal pipes are required with hydronic trench solutions. This is not the case as these units can operate at very low heating water temperatures, making them well-matched for PEX pipes. Recent advances in PEX pipes have made them incredibly cost effective, especially with regards to pre-insulated solutions when water below 56 degrees Fahrenheit is flowing through the pipes.

• **Are accessible from the top** - Units that can be opened from the top are easier to clean and ensure that no floor tiles have to be removed to access the units for maintenance.

• **Maintain safety** - The units should be constructed with grilles that are spaced close together so that there is no fear of a shoe heel or chair getting caught in the space between the grilles.

• **Complement the space** - Companies that offer numerous grille options, such as wood-grain and aluminum, can help match the grilles to the floor so that the perimeter units blend in well with the space.

• **Are active, not passive** - Passive chilled beams can be used to handle perimeter zone loads. However, these systems are more susceptible to flow path concerns and convective turbulence than active chilled beam systems. Look for an active chilled beam system that has condensate pans to eliminate concerns around relative humidity.

When trench convectors are used, the system will typically require two small ¾ inch PEX pipes to the perimeter. The units will also need to be raised up from the concrete slab with pedestals. This is the case because the trench convectors are only 4 inches in depth, while the plenum is deeper due to the heating and cooling equipment for the interior being taller than 4 inches. A six-valve setup is recommended with trench solutions at the perimeter, as this configuration makes it easy to control the units.

SUCCESS WITH TRENCH SYSTEMS

Notable buildings using trench solutions

There are numerous examples of trench solutions being integrated into UFAD systems with great success. The Telus Towers Garden Offices are located in Vancouver's bustling downtown area. Sustainability was a critical design aspect of the 22-story building, so the developers needed a heating and cooling system to meet a high level of energy-efficiency. They also required a solution that could work with the onsite district energy system—meaning it must function at extremely low heating water temperatures and condensing chilled water temperatures. Lastly, they wanted a solution that was compact in size but would still offer maximum comfort for building occupants in the varying Vancouver climate.

To meet the multiple needs of the Telus Tower Garden Offices, developers installed more than 1900 of Jaga's Clima Canal Hybrid heating and cooling units throughout the building. The Clima Canals were integrated seamlessly by installing the units into a raised floor around the perimeter of the offices. The units work in conjunction with the low temperature heating water generated from waste heat from an onsite server farm to help reduce overall energy consumption in the offices. No other heating solution was able to offer significant output with the low water temperatures from this regenerated heat setup.

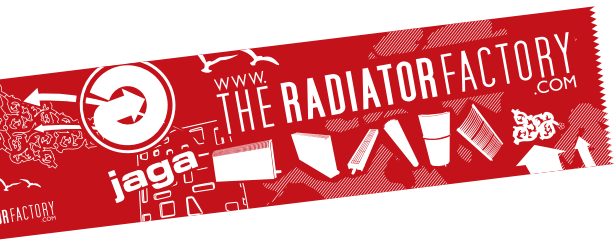
Since the Clima Canal Hybrid units are built into the floor, there is no obstruction of the panoramic views of Vancouver's mountains that the building provides to occupants. The space saving design of the units allows for additional furniture or conference room seating in offices and the continuous aluminum grille, which features just six millimeters of open spacing, prevents objects from getting caught or falling through to the area below the floor panels.

Most importantly, since the unit operates at low-water temperatures, it is able to react quickly to temperature changes. Not only does this keep occupants comfortable regardless of internal or external heat loads, in conjunction with the Telus Towers' onsite energy system, the fast-acting units also help the building reduce energy demand by an estimated 80 percent.

NOT JUST A FAD

Why trench solutions are here to stay

It's easy to understand why many buildings, including those with office environments, have installed raised floor systems and UFAD systems. These setups provide greater design flexibility, hide unsightly HVAC equipment below floor panels and keep occupants more comfortable than overhead HVAC systems. In order to maximize their UFAD systems, developers and engineers are increasingly turning to trench convectors to handle the changing loads at the perimeter of the building. By being more responsive to fluctuations in heat gains and losses, trench solutions maintain ideal temperatures for occupants and can contribute to energy and cost savings. Because the units have less depth than traditional duct work, they also help to save space, which can translate into higher ceiling heights or additional floors in a building. It's no wonder why trench solutions are here to stay. They're aesthetically pleasing, safe, quiet, energy-efficient and extremely responsive to the ever changing temperatures at the perimeter.



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