

# Installing drives in an air stream

## Proper application of a drive

Variable frequency drives (VFDs) are often installed in locations widely considered to be a plenum. Each of these plenum locations have their own advantages, challenges, and in some locations additional UL/NFPA standards apply. The following technical note will review best practices for installing drives in different sections of the plenum along with addressing standards.

### Air handler unit mounted drives

There are five locations on an air handler unit (AHU) to mount a drive:

- Isolated vestibule
- Outside of the AHU
- Return air section
- Supply air section
- Exhaust air section

The mounting locations in the supply air (SA), return air (RA), and exhaust air (EA) sections would be part of a plenum. Drives mounted on the outside of an AHU would not be in the plenum unless the AHU itself was mounted in a plenum, such as a ceiling cavity. Drives are typically not installed in the outside air (OA) section of an AHU due to direct exposure to the OA conditions. Drives are typically not installed in the mixed air section due to limited space within the AHU, along with the potential to be exposed to 100% OA in certain operating conditions.

Mounting drives in the SA, RA, or EA sections of the AHU provide unique environmental challenges to the drive. Drives, like any piece of electronic equipment, operate at their peak performance with best longevity when they are kept at a reasonable temperature, clean, and dry. A conditioned mechanical room would be the preferred mounting location to meet those three conditions. However, sometimes site conditions require the drives to be mounted in the AHU, potentially in the SA or RA section.

There is a common misconception that installing drives in the SA section of an AHU is ideal, due to the fact the section is conditioned around 55° F. However, this section is considerably more environmentally stressful than the RA section. The following are concerns and recommendations to keep in mind when installing drives in a SA section:

#### Coil blow-off

Whether a chilled water coil or evaporator, condensation forms on the cooling coil. That moisture has the potential to be blown onto the drive in the form of a water droplet. AHU designs with the SA fan after the coil, will typically experience less distance to the blow-off. The drive should be mounted as far from the coil as possible to reduce the likelihood of water droplets blowing from the coil to the drive. Drives must not be installed within range of the blow-off.

#### Condensation due to AHU maintenance

The drive is exposed to a conditioned, often 55° F, environment during typical steady state operation. As a result, many portions of the drive will be at a cooler temperature, except for certain heat producing electronic components within the drive.

Consider the scenario of a hot and humid day where the AHU is shut down briefly for preventative maintenance. The access door is opened on the AHU to check the condition of the belt between the motor and fan. Opening the access door results in a sudden rush of hot and humid air into the SA section of the AHU, immediately resulting in condensation forming on all cool components within the AHU, including portions of the drive. Condensation could also form on the metal above the drive and then drip onto the drive. (Poor access door seals can also create this same condition.)

In this scenario, the AHU should be left powered off until all signs of condensation have evaporated. Labels and documentation must be clear to this fact, supported by proper training. Without documentation and training, the maintenance technician will naturally re-apply power to the AHU to get the unit up and running as soon as possible after maintenance is completed. Worst case, a failure would occur, due to a wet circuit board that "shorts out" upon re-application of power. Conformal coating on circuit boards provides a degree of protection against moisture but will not fully protect against this condition.

#### Condensation due to SA temperature swings

The SA temperature may not always be a fixed 55° F. The swing in SA temperature is typically slower in chilled water systems, as the chilled water valve can be slowly adjusted. There is also a small amount of thermal storage in the chilled water itself after the valve is closed. Direct expansion (DX) coil AHU designs have SA temperature swings that can be more extreme.

Consider the scenario of a DX AHU supplying conditioned air to a shopping complex. This AHU supply fan is always running due to the need to bring in a minimum amount of fresh outside air. The AHU is in cooling mode for most of a hot humid day. However, there will be short periods where the space is satisfied, and the cooling command is removed from the AHU. The DX coil stops cooling and hot, humid air now flows through the AHU sections that were previously at 55 °F. There is minimal thermal storage in the coil itself which in turn causes a fast increase in the SA temperature and humidity (moisture content) levels. This scenario creates the risk of condensation forming on parts of the drive or forming above the drive and exposing it to droplets falling from above.

In this scenario, there is no drive installation technique to solve this issue. Design and control scheme adjustments can help reduce the frequency of the above situation from occurring and reduce the magnitude/frequency of the SA temperature swing. For example, a dual stage DX design with a higher SA setpoint for the low cooling stage would be helpful from the drive's point of view, as the AHU will be more likely to stay in a mechanical cooling mode. While no small feat, this could be accomplished based on coordination of coil sizing, fan speed, and system needs.

#### Humidity

The industry standard drive rating for maximum relative humidity (RH) is 95%, non-condensing. The 55° F SA is often at/near 100% RH. Air at cooler temperatures cannot hold as much moisture content as warmer air, however this 100% RH value is outside of the drive's recommended rating. The previous example of the DX AHU supplying outside air, but without a cooling command present, could result in levels exceeding 95% RH but at warmer temperatures, thus containing a considerable amount of moisture content.

#### Air flow and mounting

Conventional wisdom is to mount a drive vertically, as heat rises, and the drive's cooling fan blows from the bottom to the top of the drive. However, depending on where the drive is mounted in the SA section, and how the SA is discharged from the AHU, mounting the drive horizontally may be a better option. From the drive's viewpoint, it is undesirable to have the drive's cooling fan significantly fight the natural SA flow.

The design of the drive itself should be evaluated as drive designs differ between drive families and drive manufacturers. For example, if the bottom of a drive is open (IP20), and the drive potentially could be exposed to blow-off, then mounting that drive horizontally would not be recommended. Or if the side of the drive has cooling vents, thus exposing the electronics to water droplets dripping from above, then mounting the drive horizontally would not be recommended. Clearance (free space) past the drive's cooling fan is also important for proper cooling, as the drive should not be mounted snugly against the AHU roof or wall that could restrict the air flow through the drive.

### Access to the drive

A drive should be mounted in a readily accessible location. The access may be required for commissioning, troubleshooting, operating in hand (manual) mode, preventative maintenance, or replacement. Some of these tasks require accessing the drive itself, so the drive must be installed in a location easily and safely reached by a technician. For example, installing a drive in a dark and semi-confined location, very close to a bottom discharge duct, could put a technician in an unsafe position. Drives mounted in the SA section should have the drive's control panel mounted on the outside of the AHU. The control panel allows programming, control, and access to drive data without requiring the technician to enter the AHU. The control panel should be mounted using a UV rated NEMA 4 (or similar) cover or kit.

### Vibration

AHUs experience a degree of vibration, especially when operating at full speed. The size and number of fans, along with the overall design of the AHU, impact the magnitude and frequency of the vibration. Mounting a drive on a piece of vibrating equipment results in the vibrations transferring through to the drive. Over time, connections within the drive could come loose. The best engineering practice is to use vibration dampening isolators between the drive and the AHU. A robust preventative maintenance plan should be in place when dampening isolators were not used. Proper grounding practices should be in place such that the isolators do not impact the drive's grounding.

Another overlooked source of vibration is due to transportation. AHUs are transported via tractor-trailer from the AHU factory to the job site. This distance may exceed 1000's of miles and include stretches of pothole filled roads. The resulting shock/vibration may result in loose connections, or in extreme cases, mechanical stress to the electrical components. Before start-up of any AHU mounted drive, the drive should be inspected. Be aware that certain failure modes are difficult to identify, such as a partially damaged solder joint or a cracked surface mount component. Alternatively, drives could be shipped loose to a job site, and mounted at the site. Drive's shipped loose typically have shipping materials and methods designed to protect the drive.

### Wiring practices

Drives produce a pulse width modulated voltage waveform to the motor. This type of signal is known to generate a degree of electrical noise. Ideal installation conditions use metal conduit or VFD cable all the way from the drive to the motor, thus greatly reducing radiated electrical noise. However, some AHU designs bundle and route the wires without conduit or shielding. ABB recommends using metal conduit or VFD cable, but if this is not followed, then routing the motor wiring away from control wiring is critical. Unshielded motor wires can induce noise into control signals. Examples of control wiring would include discharge air temperature sensors and humidity sensors.

The RA section of an air handler has better environmental conditions for a drive than the supply air section. In comparison to the SA section, the RA section is:

- Not exposed to coil blow-off
- Not exposed to condensation due to maintenance
- Not exposed to condensation due to temperature swings
- Not/rarely exposed to humidity levels exceeding 95%

However, the RA section has similar concerns with:

- Airflow and mounting
- Access to the drive
- Vibration
- Wiring practices

Mounting a drive in the RA section, while still maintaining proper airflow and access to the drive, may not be practical for some AHU designs. The space available in the RA section may be quite small, thus designers often prefer to place the drive in the SA section, even though the environment in the SA section may be far from ideal. Typical RA temperature is around 80° F. Drives will have a longer lifespan when installed in a dry and stable 80° F environment than in a 55° F typical environment that occasionally becomes warmer and moist. AHU designs with a powered EA section will have similar environmental conditions as the RA section.

Drives can also be mounted on the outside of an AHU. In most cases, this drive mounting location is not considered to be part of the plenum, thus is outside the scope of this document. However, there are some scenarios where the AHU is mounted in a plenum. In these scenarios, mounting the drive on the outside of the AHU results in the drive being mounting inside of a plenum. The two most common scenarios for this situation are:

- AHU mounted in the ceiling cavity that is also acting as a plenum
- AHU mounted in a mechanical room/space that is part of an open plenum

The above two mounting locations typically have temperature and humidity environmental conditions that are suitable for drives. However, mounting a drive in a ceiling cavity plenum does have UL and NFPA 90A implications, which will be covered later in this document. Accessing drives/equipment in a ceiling cavity may be a challenge. The access challenges include:

- Working from a height
- Possible special equipment and safety gear required to reach to location
- Coordination or temporary relocation of items below AHU/drive location

#### Mechanical Rooms / Spaces

Some mechanical rooms are designed to be part of the return air plenum. A mechanical room is usually the ideal mounting location for a drive. Mechanical room ambient temperature is typically the biggest installation concern for the drive, as a small percentage of mechanical rooms are unconditioned with temperatures exceeding a 104 °F ambient. However, if the mechanical room is part of the plenum, it would be rare for the ambient to reach or exceed that level. Mechanical rooms may have limited space available, so care should be taken to make sure the drive is installed with appropriate clearance around the drive to allow the drive to properly cool itself. On installations where wall space is at a premium, a taller but narrower drive package is often recommended. Drives should not be installed under locations where condensation could form on uninsulated chilled water pipes, as those pipes could have condensation that drips onto the drive.

There are also designs for large HVAC systems, such as ones for data centers, where entire rooms are designed to mimic one stage of an air handler. In those cases, the series of physical rooms within the building are combined to essentially form the function of an air handler. Due to the physical size of these spaces, and the consistent loading of the HVAC system, there are several locations where the drive can be installed in an ideal environment.

#### Plenum installations and code compliance

The previous portion of this Technical Note 012 focused on environmental and installation concerns related to drive longevity. Now the discussion transitions to plenum installations from a code and compliance viewpoint. NFPA 90A breaks down plenums into (4) categories:

1. Air handling room plenum – an individual room containing an air-handling unit(s) used to gather air from various sources and combine the air within the room before returning it to the air-handling unit.
2. Apparatus casing plenum – a sheet metal construction attached directly to a fan enclosure, fan coil unit, air-handling unit, or furnace bonnet for the purpose of connecting distribution ducts.
3. Ceiling cavity plenum – the space between the top of the finished ceiling and (either) the underside of the floor above or the roof, and used to supply air to the occupied area or to return air to or exhaust air from the occupied area.
4. Raised floor plenum – the space between the top of the finished floor and the underside of the raised floor, and used to supply air to the occupied area or to return air to or exhaust air from the occupied area.

Drive standards UL508C and UL61800-5-1 both reference UL2043, the *Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*, for drives with non-metallic enclosures being installed in plenums. NFPA 90A identifies which plenum categories require UL2043 compliance, which are the ceiling cavity plenum and raised floor plenum types. Exposed ABB base drives (such as ACH580-01) do not meet UL2043 testing requirements, thus they should not be installed as a stand-alone solution within a ceiling cavity or raised floor plenum. However, by installing the drive inside a metal enclosure, now UL2043 is no longer applicable, and the drive may be mounted in a ceiling cavity plenum or raised floor plenum. Due to the challenges of servicing products installed in ceiling cavities or raised floors, installing a drive in either of these locations should be considered only as the last option.

Following NFPA 90A's guidelines on UL2043 testing requirements, ABB drives are suitable (rated) for installation in air

handling room and apparatus casing plenums. Installing a drive in a ceiling cavity plenum or raised floor plenum does require additional considerations, ultimately resulting in the drive packaged in a metal enclosure.

#### Summary

Drives are installed in a variety of different locations. Too often these locations are chosen based on convenience and ease of installation, with minimal thought given to the longevity of the drive. Drives, like all electronic devices, last longer when installed in clean and conditioned spaces. Drives are sometimes installed in areas considered to be a plenum. Some of the plenum locations, such as the supply air section of an AHU, provide environmental challenges that require consideration for drive mounting. Other plenum locations, such as ceiling cavities, have code requirements that impact how the drive must be packaged. Contact your local ABB representative or ABB Application Engineering with any questions on drive installations.