AIR QUALITY AND ENVIRONMENTAL CONTROL:

KEY CONSIDERATIONS FOR THE CONSUMABLES INDUSTRY

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Redefining Air Dispersion

While air quality and environmental control are important for any operation, they are critical for facilities that create or handle food and other consumables. Certainly, these types of facilities need to keep workers comfortable and productive through seasonal challenges such as heat stress in summer and cold, dry air in winter.

However, temperature is just one of many considerations. Depending on the specific process, many food industry facilities may also have to maintain or eliminate micro-climate areas with various levels of humidity, while almost all consumables operations must follow strict government protocols curtailing microbial growth. Like cleanrooms and bio-labs, food-processing plants must be kept as sterile as possible. Since poorly filtered air systems can circulate bacteria, they hamper these efforts and can compromise product quality.

Heating, ventilation and air conditioning (HVAC) systems are thus every bit as important to sanitary design in this sector as floors, walls, ceilings and equipment. Understanding the importance of temperature, humidity, ventilation and air filtration are keys to establishing an effective air quality and environmental control system for a consumables industry facility.

This whitepaper will examine the role of fabric ductwork and air diffusers in such systems.

Consumables Industry Overview

The consumables industry is one of the fastest growing sectors of the U.S. economy. It is generally defined as encompassing all areas of food and beverage production, including manufacturing, processing, packaging and growing, as well as food service, restaurants and retail (grocery).

- Food Processing: Food processing facilities are strictly regulated by state and federal bodies such as the U.S. Food & Drug Administration and the U.S. Department of Agriculture. From the preparation of meats to the cold storage of vegetables, food processing facilities must retain consistent environmental control.
- Food Packaging/Bottling: An extension of processing, food packaging and beverage bottling areas need to balance employee comfort and safety with product integrity and increased productivity demands.
- Growing Facilities: Grow facilities are a particularly fast-growing sector of the consumables industry. While they have traditionally centered on fruits, vegetables, flowers and other natural products, many are now engaged in the emerging medical grade and recreational cannabis/hemp industry. Strict rules are in development to regulate this new industry.
- Beverage Production: Similar to food, beverage production is highly regulated and requires sterile conditions and precise environmental control.
- Restaurants/Food Service/Grocery Stores: At the intersection of product and people, restaurants, commercial kitchens, 3rd party storage, and food retailers require sophisticated air distribution (including exhaust systems) and other environmental controls to keep staff and customers happy while also maintaining the integrity of food products on the shelf or in the freezer.

Regulatory Bodies & Codes

Whether an organization is engaged in the processing, packaging, serving or selling of consumable goods, its management must keep up-to-date with a host of dense and continually changing regulations to ensure compliance, along with consumer protection worker safety and product integrity. Below is an overview of the most prominent regulatory bodies and regulations, as well as selected industry organizations and protocols that impact the consumables industry.

U.S. Department of Agriculture (USDA)
The United States Department of Agriculture (USDA) sets forth federal regulations each year to control and protect agricultural consumables and consumers. Specifically, the USDA's Food Safety and Inspection Service (FSIS) is focused on auditing and improving the processes of production facilities to ensure safe preparation, packaging, and delivery of inventory. Facility managers should specifically stay up-to-date regarding the FSIS's Sanitation Performance Standards when it comes to air distribution and food safety.

Section 416.2(d) of the Sanitation Performance Standards covers ventilation requirements. The code states that in situations where condensation is expected as a result of certain operations, facilities should, "take action to ensure that the condensation does not adulterate product or create insanitary conditions. Such actions must be documented in the establishment's Sanitation Standard Operating Procedures (Sanitation SOP's). Most often, establishments will control such condensation by cleaning and sanitizing, on a daily or as-needed basis, the surface(s) where the condensation is expected to form." These surfaces could include, but are not limited to:

1. The inside or outside of stainless production chutes.
2. Ceilings over open kettle cooking areas and over poultry chill vats.
3. The outside of stainless-steel ice vats or ice chutes in chill areas.

Section 416.2(d) additionally outlines the following Food Codes for ventilation and air distribution.

4-301.14 Ventilation Hood Systems, Adequacy
Ventilation hood systems and devices shall be sufficient in number and capacity to prevent grease or condensation from collecting on walls and ceilings.

6-202.12 Heating, Ventilating, Air Conditioning System Vents
Heating, ventilating, and air conditioning systems shall be designed and installed so that make-up air intake and exhaust vents do not cause contamination of food, food-contact surfaces, equipment, or utensils.

6-304.11 Mechanical
If necessary to keep rooms free of excessive heat, steam, condensation, vapors, obnoxious odors, smoke, and fumes, mechanical ventilation of sufficient capacity shall be provided.

In addition to ventilation requirements, the Sanitation Performance Standards share best practices for the sanitation of both food-contact and non-food-contact equipment throughout all production processes.

USDA United States Department of Agriculture

Section 416.4 (b) states that, "Non-food-contact surfaces of facilities, equipment, and utensils used in the operation of the establishment must be cleaned and sanitized as frequently as necessary to prevent the creation of insanitary conditions or the adulteration of product." This non-contact equipment as it pertains to air distribution includes A/C units, ductwork, and all diffusers, particularly if the equipment is positioned above or near production lines.

Additionally, Food Code 4-601.11 outlines that "non-food-contact surfaces of equipment shall be kept free of an accumulation of dust, dirt, food residue, and other debris." The air distribution outlined in the above section is to be regularly cleaned to prevent not only condensation but also all other harmful particulate, including mold, mildew and other airborne contaminants that can lead to disease or illness.

United States Food and Drug Administration (USFDA)
The USFDA is an agency of the United States Department of Health and Human Services, one of the United States federal executive departments. It is responsible for protecting and promoting public health through the control and supervision of food safety, tobacco products, dietar supplements, prescription and over-the-counter pharmaceutical drugs (medications), vaccines, cosmetics, animal foods and feed and veterinary products, among other things.

Food Safety Modernization Act (FSMA)
One of the USFDA's most sweeping regulations pertaining to consumables is the Food Safety Modernization Act (FSMA). Passed in 2011, it was the first major piece of federal legislation on food safety since 1938, and gave the USFDA increased authority to regulate the way foods are grown, harvested and processed, with particular emphasis on prevention of foodborne illnesses. It was also the first piece of legislation to address food tampering.

FSMA regulations – including rules on preventive controls, sanitary transportation and food defense – have significant implications for food industry facilities from freezers, coolers and other internal process areas to shipping and receiving.

Considering that the Centers for Disease Control estimates nearly 60 million Americans get sick from contaminated food every year, the FSMA regulations are a step in the right direction. While food facilities face a wide variety of challenges to product integrity, facility managers should understand the specific facets of FSMA that relate to air distribution.

FSMA & Air Distribution
Preventive Controls for Human Food were the first regulations to take effect, phasing in for general businesses on August 1, 2016 and small businesses on August 1, 2017. Per this regulation, covered facilities must establish and implement a written food safety plan that includes:

- A hazard analysis, which must consider known or reasonably foreseeable biological, chemical and physical hazards
- Preventive controls, which are required to ensure that hazards will be minimized or prevented
- Oversight and management of preventive controls, including monitoring, corrective actions and verification

FSMA's Sec. 105, which covers Standards for Produce Safety, establishes science-based minimum standards for the safe production and harvesting of fruits and vegetables that are raw agricultural commodities. These strict rules apply to the entire process, including growing, harvesting, sorting, packing, and storage operations. As it relates to airflow, facility managers must understand the rules set forth related to hygiene, temperature controls, and condensation in the production process.

Additionally, cold storage facilities must now put verifiable frost and condensation control measures in place or risk losing FDA registration. Building defects are no longer an excuse. This includes droplets from refrigeration units, moisture near docks, or drops from the ceiling, all which can be impacted by a facility's air distribution system.

Industry Organizations, Guidelines and Protocols

FSMA has not been the only factor in re-shaping what are considered "best practices." A number of nationally and internationally recognized food industry guidelines and protocols have also become more stringent.

Current Good Manufacturing Practices (cGMPs) play a major role in FSMA, especially as it relates to FSMA's preventive controls for human food. Education and training in cGMPs is now a requirement – a plant's management must ensure all employees who manufacture, process, pack or hold food have the education, training and/or experience to be considered up to code.

The Safe Quality Food Institute (SQFI) update of its SQF Code is a wholly different certification standard, and it is becoming more prevalent across the industry. Edition 8 of the SQF was redesigned in 2017 for use by all sectors of the food business, from primary production to storage and distribution. The SQF System is an assurance that a site's food safety plans have been implemented in accordance with the Hazard Analysis and Critical Control Points (HACCP) method, as well as applicable regulatory requirements. It also ensures the site uses a system that is verified and effectively manages food safety. As of January 2, 2018, sites with existing SQF certification will be required to upgrade their systems to meet the requirements outlined in the new edition of the SQF code.

The SQF program has been recognized by the Global Food Safety Initiative (GFSI) since 2004. The GFSI is itself not a standard, but it references standards and safety programs from other organizations as benchmarks. The BRC Global Standards, which is the most popular food safety standard in England and is gaining acceptance in North America, is another example of a GFSI benchmark. In fact, some of its requirements exceed those listed in FSMA. For example, Section 4.16 Dispatch and Transport states, "Documented procedures to maintain product safety and quality during loading and transportation shall be developed and implemented. These may include, as appropriate: controlling temperature of loading dock areas." Even if not classified as a transporter or carrier, facility managers shoulder the compliance throughout a food facility.

In almost all cases, compliance and/or certification begins with analysis and planning and places a heavy emphasis on training, maintenance and documentation.

While these standards and regulations have already been enacted and are being enforced (or will go into effect soon), one that has yet to be realized – an Integrated Food Safety System (IFSS). Mandated by FSMA, IFSS is a strategy of joining food safety efforts at all levels of government into a unified network. This has been the vision of the Association of Food and Drug Officials (AFDO) – which aims to streamline and simplify regulations – since its inaugural meeting in 1998. The idea of IFSS is for food-related organizations to collaborate and collectively share information as an integrated network to ultimately identify and practice more effective food illness prevention protocols, while also controlling and containing foodborne outbreaks and disasters.

AIB International, formerly the American Institute for Baking, provides training and consolidated standards for inspection across ten industries. Facility managers should understand the five key categories that an AIB International inspection would cover:

- Operational Methods and Personnel Practices – the receipt, storage, monitoring, handling, and processing of raw materials to manufacture and distribute safe final product. Facilities need to be confident that people, processes, and conditions do not introduce a food safety concern.
- Maintenance for Food Safety – the design, upkeep, and management of equipment, buildings, and grounds to provide a sanitary, efficient, and reliable manufacturing environment. AIB standards here provide best practices for optimizing the design and care of the facility and equipment so that they are easy to manage and do not create sanitation issues.
- Cleaning Practices – the cleaning and sanitizing of equipment, utensils, and buildings to provide a wholesome and safe processing environment. The AIB inspection will look at the methods of cleaning, the types of chemicals used, the frequency of cleaning activities, and the control of microbes.
- Integrated Pest Management – the assessment, monitoring, and management of pest activity to identify, prevent, and eliminate conditions that could promote or sustain a pest population. The inspection considers both removal of any pests and measures to prevent pests from ever having the opportunity to thrive in a food environment.
- Adequacy of Prerequisite and Food Safety Programs – this standard is largely about documentation. AIB wants to ensure that all departments are working together to deliver a safe product. It is not enough to have programs in place, the programs must be formalized through designing, planning, management, documentation, and review.

Underwriters Laboratories (UL) develops standards to guide safe, sustainable commercialization of evolving technologies. UL 2518, specifically, is the most comprehensive compliance requirement assembled for air dispersion system materials (fabric and non-fabric) to ensure that facility equipment meets a high level of safety, quality, and performance.

UL 2518 requires a variety of performance tests, including mold growth and humidity, temperature, and pressure. Installation instructions are also clearly outlined to ensure that any equipment with holding the UL classification is structurally safe for facilities. A surface burning characteristics test is also performed on any air distribution materials to gauge flammability, which is essential for the safety of facilities in which air handling equipment runs throughout a space.

Facility managers should look for UL classifications when implementing or upgrading air distribution equipment to promote facility safety and efficiency.

Common Airborne Environmental Control Challenges

While no two consumables industry facilities are the same, there are a variety of common air-flow related environmental challenges that they face, particularly as it relates to mold and bacterial growth. These challenges are accentuated by the perishable nature of consumable products, as well as increasing consumer expectations in terms of quality, convenience, and delivery time.

Condensation
The sanitation cycle in food facilities is essential to keeping operations and product clean and safe throughout the supply chain. However, that same necessary cycle introduces unwanted condensation into the processing area, which—left unmanaged—can lead to bacteria growth, mold, and product spoilage.

According to Manufacturing.Net, "One of the first steps of the sanitation cycle involves using pressurized hot water to clean and remove excess material from production lines." Unfortunately, foaming and disinfectant methods that typically suffice in other industries are not fully effective when, excess proteins and lipids are present.

These sanitation steps, especially in a cool environment, lead to unwanted condensate on the overhead surfaces, such as metal ductwork in a production facility. As these surfaces are often neglected in the cleaning process (which focuses on food contact surfaces), the remaining condensate will absorb harmful bacteria. Drops from this condensation can spoil food and beverage products if left unaddressed.

Poor Airflow and Uneven Temperature
Temperature is the leading variable in product integrity. In all food and beverage consumables facilities, strategic airflow is essential to maintaining an even, well-distributed indoor environment. However, facility managers face daily air movement challenges due to large warehouse spaces, unique layouts, and specific product requirements.

The air diffusers found in traditional metal ductwork are typically placed sporadically across the length of the duct. This means airflow is concentrated every 10 feet on average, which yields an uneven temperature pattern in a facility space – and can potentially lead to the growth of mold, mildew and bacteria. What's more, large warehouse facilities that have uneven temperatures due to poorly designed equipment are forced to rotate inventory frequently. As food and beverage products require a highly-regulated environment, this could spell disaster for managers attempting to reduce spoilage.

Cross-Contamination
Another challenge facing consumables facilities is keeping microscopic contaminants in one area from moving to another. From food allergens and aerosols to bacteria and condensation droplets, these unseen particles of "cross-contamination" can have dangerous ripple effects if not adequately separated. Airborne contamination can not only cause foodborne illness, it can contribute to the spoilage of many different foods.

In spaces with poorly designed air distribution systems, air will flow from contaminated areas to clean areas, transferring particles between otherwise isolated processes and products. This is important for company's aiming to control allergens. When processing powders that tend to suspend and float between spaces easily, air handling equipment and airflow design is integral in the control and dispersion of these potentially hazardous allergens.

Cross-contamination can also occur from mismanaged air currents caused by pedestrian traffic and operating equipment. According to Food Engineering, “these air currents can cause atomization and microbial cross-contamination as they pass over the stagnant water in drains and drain ‘p’ traps.” Condensation or drain trays under ductwork or diffusers can collect condensation if not addressed. Facility managers must consider the flow of not only their equipment and employees, but also their facility’s air.

Air Handling Hygiene Issues
Airborne contamination and hygiene issues can originate from myriad of sources, including raw materials, cooking, allergens, dust, packaging, people, poorly designed systems, and equipment. Dangerous particles harboring bacteria, fungi and other problematic microbes can travel through air handling systems, vents and ductwork settle on and around flat or enclosed surfaces.

Fungal growth problems may be exacerbated by issues with other plant equipment, such as leaky roofs or inefficient ventilation systems. Left unclean, this build-up of particles at the critical intersection points of an air distribution system can increasingly contaminate clean air particles as they pass through the facility’s air handling equipment. Neglected interior air systems can be a leading contributor to sick building syndrome, human health problems, and possible contamination.

Metal Shed
Even facilities that diligently follow the regular cleaning schedules mandated by the FDA may experience problems with air distribution equipment as the corrosive effects of bleaches, detergents and other cleaning-related chemicals may cause metal surfaces to degrade. The insulated particulate that results (“ducting shed”) then enters the air supply and spoils consumable inventory.

Air Handling Solutions: The Advantages of Fabric

When evaluating and implementing air handling equipment, facility managers have traditionally been limited to metal options. However, thanks to the evolution of custom fabric dispersion technology technology, facility managers now have a host of other options – many of which are more efficient, more aesthetically appealing, easier to install/clean, and less expensive than metal ductwork.

Condensation is a largely unavoidable biproduct of most operations in a consumables facility. From sanitary washdowns to temperature-specific production processes, moisture and condensate particles are regularly introduced into a space. Traditional metal ductwork is widely susceptible to the forming of condensation droplets along the length of the duct. As air handling systems regularly run overtop and near production lines, the droplets, which often harbor bacteria, can damage inventory and cause harmful spoilage.

Fabric ductwork eliminates this issue for facility managers. Due to the fact that the entire duct is comprised of breathable fabric material, condensation is not able to form or rest on the exterior of the duct. Better yet, antimicrobial fabric options actively work to eliminate microscopic bacterial threats that pass through the fabric air handling equipment.

Targeted Air Dispersion is a significant benefit when comparing metal and fabric air handling equipment. In open ceiling architecture, traditional metal duct systems discharge air through side mounted metal diffusers. The air is directed to specific zones resulting in less efficient mixing of air in the occupied space and often causes drafting and hot or cold spots. This lack of temperature control can lead to spoilage.

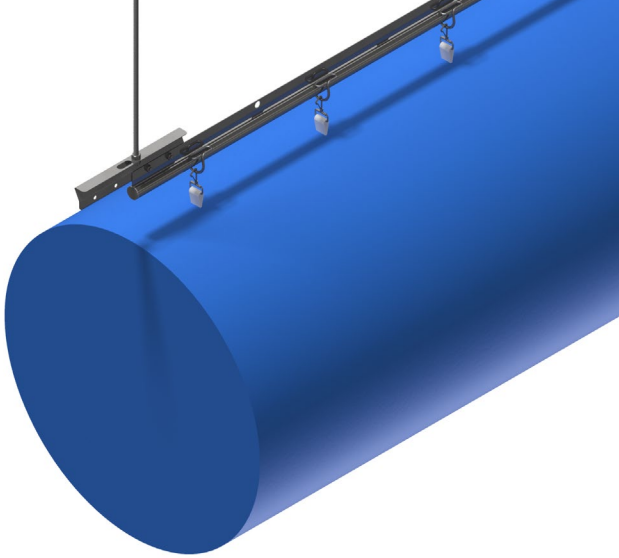
Additionally, this targeted air dispersion helps prevent condensation on walls, ceilings, floors and production equipment. Controlling condensation in the hard to reach or manage places of a facility helps managers reduce the risk of dangerous bacteria buildup.

Alternatively, custom fabric systems are designed to provide uniform air dispersion through a combination of air-porous fabrics, linear vents, nozzles and orifices. This method allows for a system to heat or cool spaces faster and more uniformly to satisfy temperature set points.

Hygiene is a critical variable for all USDA-inspected environments. For any food-grade facility aiming to keep non-food-contact equipment free from bacteria, residue, and other debris as outlined in the list of regulations, regular sanitation of the air handling system is a must.

For metal ductwork, the looming condensation concern presents a dilemma, as pressurized water and chemicals use to wash down the ceiling-mounted ducts can cause them to degrade. Fabric ductwork features a zippered section design to allow for the outer, lightweight fabric sections to be removed, commercially laundered, and re-installed. In addition to meeting access point regulations, easy access is available every 10 ft. on average. As the anti-microbial fabric works daily to eliminate bacteria when mounted, this type of washdown flexibility allows managers to remain compliant with all sanitation practices without introducing additional risk factors into the space.

Customized Airflow Application For Fabric Systems



R-Track suspension method

Not every food-grade facility is the same. Fortunately, fabric duct and air dispersion systems are highly customizable, putting a myriad of options at a facility manager's disposal as they consider air distribution plans alongside floor layouts, retrofitting projects, or regulatory compliance.

Fabric type is typically the first variable to consider. Given the strict sanitation regulations and product integrity demands they operate under, the most common fabric choices for food-grade facilities are anti-microbial, anti-shed, and/or anti-static options.

Anti-microbial fabric comprised of polyester yarns that are treated with antimicrobial which controls the growth and transmission of harmful bacteria, fungi, and molds that can be found in food processing environments. It's also proven to be effective after 75 wash cycles. Anti-shed is typically clean room grade fabric that helps prevent any particulate from dropping into sensitive production areas. Finally, a permanent anti-static, such as a carbon grid woven into the fabric, dissipates static electricity created by air friction so that debris would be less likely to stick to the fabric.

Suspension is another important consideration for the layout of a fabric air handling system. Whether horizontal, vertical, or angled, round fabric ducts are available in a variety of traditional suspensions to adapt to any facility layout. For applications where the fabric duct is mounted against a flat surface (wall, ceiling, or both), the surface mount offers flexibility for shape, configuration, and inlet position (end, top, back). There are two suspension systems that can be used with mounted fabric ductwork, all of which use track or cable.

- Hangers (3 x 1 and 4 x 2) offer simple installation that employs an external hanger to support the fabric duct.
- A 1-, 2- or 3-row system is the most cost-efficient method of suspension as a series of cables or tracks run the length of the duct to support the lightweight fabric.

There are also four distinct designs for air dispersion by fabric duct systems.

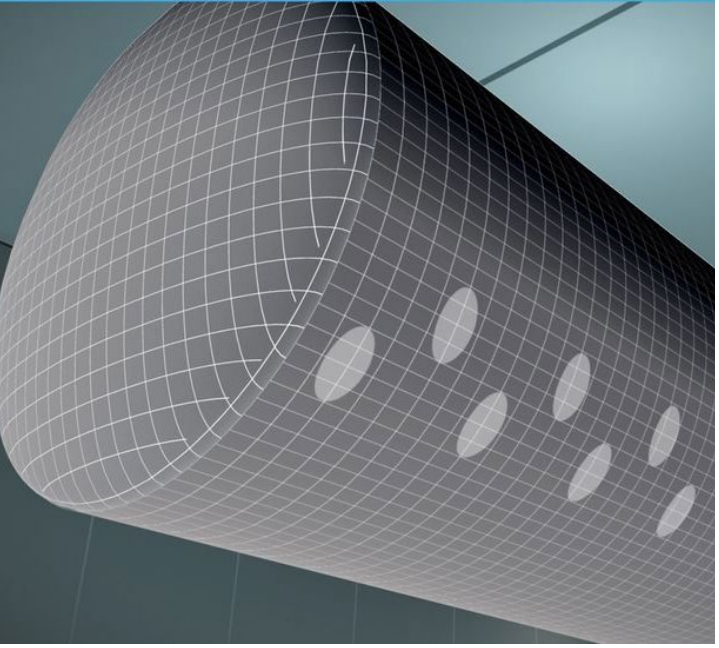
- Linear dispersion delivers airflow through precision cut orifice patterns along the length of the duct. This provides unlimited flexibility in designing vent size and location for optimum airflow control depending on the needs of a facility. Flow rate through fabric is controlled by weave and pressure can be adjusted from 2 to 165 FPM.

- For applications requiring more targeted airflow, orifices can be customized along the length of air porous ducts. Ideal for situations in which greater throw is needed than linear vents will allow, the directed pores release air towards product, production lines, or other temperature-controlled areas.

- A third air dispersion customization is nozzles. Available in both adjustable or fixed options, both are ideal for applications in which facility managers need additional control over airflow direction and status. Adjustable nozzles provide 360-degree rotation and 10 different angles, including a closed setting. Fixed nozzles provide a jet-type airflow with a closed/open plug option.

- Air porous fabric allows air to pass through with the airflow rate controlled by the fabric weave and the internal static pressure. Air can be delivered exclusively through the porous fabric or can be combined with various venting options to achieve desired airflow. This option is a commonly used alternative to exposed double wall duct as it creates no condensation and reduces dust collection.

Fabric diffusers are an ideal fit for spaces where air distribution is necessary but fabric ductwork isn't feasible. In applications that require low velocity airflow, a directional displacement diffuser is an option. Engineered to create optimal airflow patterns, the 360 degrees of even air dispersion is designed to not disturb particulates that may reside on surfaces, such as allergens or chemicals that cannot mix with other inventory or spaces.



Opti-X Fabric from DuctSox provides an anti-microbial, anti-static, and/or non-shed clean room grade duct option.

The C-Series fabric diffuser from DuctSox provides 360 degrees of even air dispersion in facility spaces that cannot use ductwork for physical or financial reasons.

The F Series from DuctSox is ideal for freezer spaces as the fabric product can be fitted to existing or new equipment operating with frosted coils.

Kitchen and restaurant spaces commonly implement fabric diffusers. Industrial kitchens are filled with necessary equipment, which limits the space for ceiling mounted fabric ducts. Instead, the fabric diffuser is designed for applications with fume hoods or other airflow-sensitive environments. Air passes through specialized fabric panels, resulting in uniform, low velocity, radially diverging air patterns with little if any turbulence. Complete with a snap frame attachment for easy removal and cleaning, kitchen applications are able to stay compliant and efficient with their airflow.

Food processing facilities are also switching to ceiling mounted diffusers with 360-degrees of air-porous openings. Compared to metal, the round fabric diffuser brings the occupied space to temperature 22% faster while offering a lower ceiling load. A diffuser like this presents facility managers struggling with budget or space limitations the same level of food-grade sanitation and airflow benefits of fabric ductwork.

Freezer spaces require precise temperature control in order to preserve product integrity. However, this puts increased responsibility on the air distribution equipment. Frosted coils inside a freezer can be fitted with a fabric sleeve. This fabric solution collapses when the cooling unit goes into a heated defrost cycle, which keeps the heat inside the unit to speed the thaw cycle time and reduce the amount of heat and energy that would normally escape into the freezer.

This fitted sleeve, in turn, reduces unintended product thawing in the freezer while the air porous fabric will not condensate during operation.

Key Take-Aways

Although the consumables industry spans a wide variety of facilities, operations, and processes, efficient air distribution is necessary in all of them, from both a best-practice and legal compliance standpoint. As food safety regulations continue to evolve, fabric ductwork and air dispersion technology will as well – giving facilities a wide range of options to stay compliant, while helping protect employees, consumers, and products.

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