



THE ESSENTIAL ROLE OF CLEANROOM COATINGS IN FOOD AND BEVERAGE PRODUCTION

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For flooring, walls, ceilings and even fire protection, coating systems are critical to controlling conditions in food and beverage environments.

By Feraas Alameh, Market Segment Manager – Food & Beverage, Sherwin-Williams Protective & Marine

Cleanrooms are increasingly being adopted in food and beverage facilities to help ensure food safety, regulatory compliance, product quality and a safe working environment for personnel.

Technologies used in these facilities allow for control over environmental conditions, including temperature, static electricity, humidity and air pressure. Along with strict and specialized sanitizing regimes, cleanrooms and clean zones help minimize contamination with advanced air filtration for dust, particulates and microbes – crucial for ensuring consumer safety.

In food processing environments, there are many contamination risks – including chemical residues and physical particulates – all of which can lead to foodborne illnesses or product recalls. Maintaining an effective cleanroom requires utilization of protective coatings that not only resist microbial contamination, but which can also endure repeated exposure to harsh cleaning agents and high-moisture conditions.

Choosing the correct coating is fundamental – for walls, floors, ceilings and fireproofing – to serve as barriers against contamination while withstanding the demanding conditions inherent to controlled spaces. Key requirements of coating systems are properties like non-particle shedding and non-outgassing, which are essential for stopping the entry of particulate matter and volatile organic compounds (VOCs). These solutions also help companies meet strict requirements and maximize their operations.

By partnering with experienced coating professionals, facility owners can help ensure the materials utilized in their cleanrooms are both suitable and effective for maintaining peak cleanliness, product quality and safety. Throughout a facility's life cycle, coating experts provide valuable support, from helping to choose the ideal coating systems tailored to specific cleanroom needs, to considering cleanliness standards, environmental factors and regulatory adherence.

CLEAN ENVIRONMENT ASSURANCE

In food-processing cleanrooms, controlling contamination is a central focus.

Cleanrooms play a critical role in preventing the growth of bacteria, molds and other potential pathogens. Microbial contamination can lead to foodborne illnesses, which pose significant health risks to consumers and can result in costly recalls and damage to a company's reputation.

The sterile environment of a cleanroom minimizes the risk of contamination and helps to ensure the safety, shelf life, and integrity of food products. These facilities help mitigate risks by providing a controlled environment where air quality, temperature, humidity, and particulate levels are tightly regulated. This is essential in processes such as the packaging, filling, and handling of ready-to-eat foods, dairy products, beverages, and other perishable items.

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Determining the appropriate type of cleanroom to meet these guidelines hinges on a range of factors, including industry standards, regulations, cleaning feasibility, particulate concentration and more.

The International Organization for Standardization (ISO) has established specific cleanroom classifications to suit various cleanliness needs under the ISO 14644-1 standard. These nine classification levels are based on the maximum number and size of particulates allowed per cubic meter, with a Class 1 designation being the cleanest. Food and beverage cleanrooms typically adhere to ISO Class 7 or 8 standards, balancing the need for cleanliness with practical considerations for food production environments.

Surfaces within these cleanrooms are often treated with antimicrobial coatings that prevent the growth and spread of harmful microorganisms. Continuous monitoring of microbial load and airborne particulates ensures that the cleanroom environment remains within acceptable limits.

Adhering to ISO standards helps promote compliance with food safety regulations, which are essential for successful food and beverage operations. In the United States, the Food Safety Modernization Act (FSMA) – enacted and enforced by the U.S. Food and Drug Administration (FDA) – focuses on preventing contamination rather than responding to it. Properly constructed and operated cleanrooms – ones that implement preventive controls, including maintaining sanitary conditions, proper hygiene practices and environmental monitoring – are instrumental in adhering to the FSMA.

Many operations adopt an approach centered on Hazard Analysis and Critical Control Points (HACCP), a systematic approach to food safety that identifies potential hazards and implements critical control points to mitigate risks.

In addition, the ISO 22000 standard specifies the requirements for a food safety management system up to the point of final consumption. Cleanrooms help organizations meet these ISO requirements by maintaining stringent control over environmental conditions and implementing robust cleaning and sanitation protocols.

By adhering to these guidelines, laws and standards, facilities can ensure their cleanrooms are effective and compliant. This proactive approach not only safeguards public health but also enhances a facility's operational efficiency and credibility.

CLEANROOM COATING SYSTEMS

In food and beverage cleanrooms, the choice of coatings is critical to maintaining a hygienic environment.

Antimicrobial coatings contain agents that disrupt the cellular functions of microorganisms, effectively preventing their growth on walls, floors and other surfaces. This is particularly important in areas where food contact is possible, as it helps maintain a sanitary environment.

Coatings certified for food contact surfaces meet stringent safety standards and are free from harmful substances that could contaminate food. Regulatory agencies, including the FDA, provide guidelines and approvals for such coatings, ensuring they are safe for use in these environments.

These coatings are also formulated to withstand rigorous and frequent cleaning protocols – often with strong disinfectants – and maintain their integrity and effectiveness over time. Cleaning processes also often involve high-pressure washdowns for thorough sanitation, demanding that coatings resist degrading or peeling.

Coatings must also prevent cross-contamination from allergens, which is a significant concern in food processing. This involves using non-porous, easy-to-clean coatings that do not harbor residues. In addition to allergens, coatings should act as barriers against pathogens. Smooth, seamless coatings that eliminate crevices where bacteria and other microorganisms can hide are ideal.

By selecting coatings that meet these specific requirements, food and beverage facilities can ensure their cleanrooms remain compliant with industry standards, safe for processing and effective in maintaining a contaminant-free environment.

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FOOD-SAFE FLOORING

Flooring systems play a pivotal role in maintaining a sanitary environment – and ensuring the safety of both products and personnel – while enduring the harsh conditions typical in product processing areas.

Subjected to frequent cleaning with strong disinfectants and detergents, flooring must be resistant to chemical exposure to prevent degradation, ensuring a long-lasting hygienic surface.

Smooth, seamless resinous flooring systems – including epoxies, urethanes and combinations of the two – must be impervious to moisture to prevent water ingress. With no crevices or joints where dirt and microbes can accumulate, these systems facilitate easy and thorough cleanings without suffering long-structural damage.

A key component often utilized in food and beverage cleanroom flooring systems is a cove base, which creates



Figure 1. Cove bases provide a seamless transition between floors and wall surfaces, ensuring ease of cleaning by eliminating gaps or crevices where dirt, debris or microbial contaminants could accumulate.

a seamless transition between the floor and wall surfaces. This feature not only enhances aesthetic appeal but facilitates an ease of cleaning by ensuring that no gaps or crevices are present at wall-to-floor transitions.

In wet and potentially slippery environments, flooring must offer slip resistance to protect personnel from accidents. Textured or specially coated surfaces can

provide the necessary traction to prevent slips and falls. Some cleanrooms require a moisture vapor barrier (MVB) as a line of defense against moisture vapor transmission that can be detrimental to the safety and integrity of a cleanroom environment.

Scratch resistance is also a key quality that promotes longevity, reducing the potential for surface damage that could compromise cleanliness standards. This resilience contributes to the overall durability of the cleanroom environment. By cutting down on repairs and replacements, these systems also help save costs and promote sustainability efforts.

Flooring systems should be made from materials that are safe for food contact and free from harmful substances that could leach into food products. As processing often involves rapid temperature changes, improper flooring can crack or delaminate. Appropriate flooring needs to withstand thermal shock to maintain its integrity.

High-solids epoxies are ideal for food and beverage cleanrooms with stringent cleanliness standards. Robust and long-lasting – and preferred for their chemical resistance and durability – these coatings are formulated to withstand heavy foot traffic and equipment movement.

However, epoxies have longer cure times, requiring more downtime during installation. They are also less suitable for environments with extreme temperature fluctuations due to brittleness at low temperatures and softening at high temperatures.

Urethanes offer a flexible and versatile alternative. While not as chemically resistant as epoxies, urethanes provide durability and can handle moderate to heavy traffic common in food processing plants. Their flexibility accommodates substrate movement and minor cracks, maintaining coating integrity. Additionally, urethanes cure faster, minimizing downtime and reducing operational disruption.

The superior UV light resistance of urethanes also makes them suitable for cleanrooms exposed to natural or artificial light – providing long-term protection against discoloration and degradation, including from high-intensity UV-C light used for sterilization. Two-component acrylic urethane systems, particularly with broadcast systems, offer the best UV resistance.

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Water-based urethanes and polymer hybrid combinations of urethane and epoxy resins provide versatile solutions for various cleanroom applications in the food and beverage industry. A complementary acrylic clearcoat, low in VOCs and UV-resistant, can offer additional protection while maintaining environmental standards.

Different coatings have specific advantages and limitations. Choosing the appropriate flooring solution depends on the specific requirements of the food and beverage cleanroom, budgetary considerations and installation timelines.

ESD FOR FOOD AND BEVERAGE FACILITIES

Electrostatic dissipative (ESD) flooring can play a significant role in cleanrooms within the food and beverage industry, contributing to both safety and product integrity.

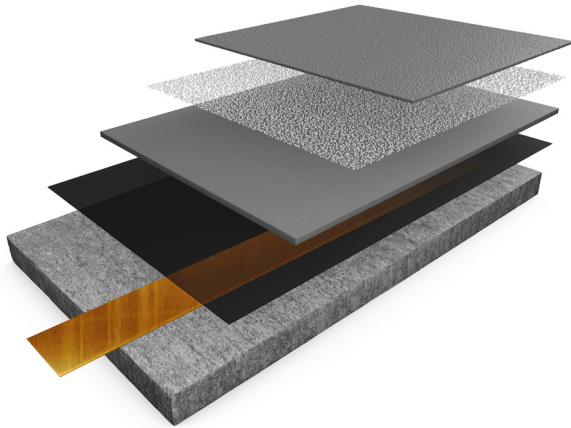


Figure 2. A common electrostatic dissipative (ESD) flooring system includes the following layers applied on top of the concrete substrate:

1. Copper earthing tape
2. An ESD primer coat
3. An ESD epoxy build coat
- 4/5. An ESD urethane with a high wear additive

ESD flooring helps reduce the risk of contamination. By minimizing static electricity, ESD flooring prevents the attraction and retention of dust, particles and microbes, which can compromise cleanliness. This is crucial, especially in facilities involved in the production

of sensitive items like dairy products, chocolates and an assortment of beverages, where maintaining product quality is essential.

Static electricity can also pose safety hazards in food and beverage facilities, where flammable materials or powders are often used. ESD flooring mitigates these risks by dissipating static charges, which reduces the potential for sparks that could lead to flash fires or explosions.

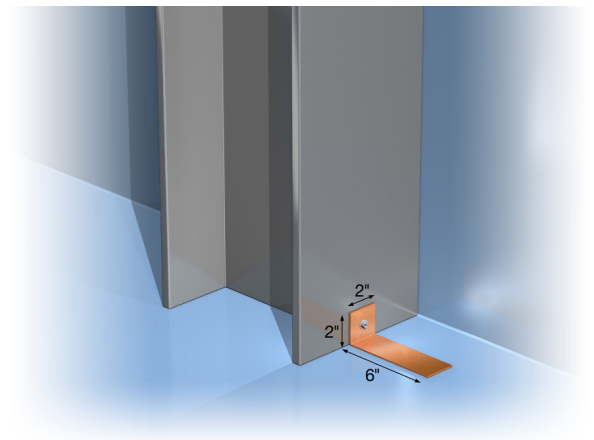
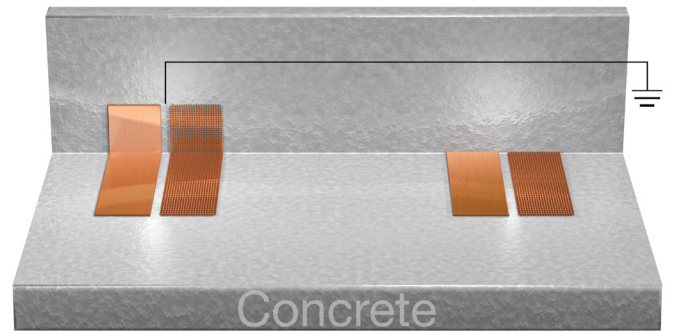


Figure 3. ESD flooring mitigates shock risks by dissipating static charges through the flooring via a direct, uninterrupted connection between copper tape embedded within the flooring and an existing electrical outlet (top) or another grounding point such as a steel post (bottom).

Many facilities also use sensitive electronic equipment for processing, packaging and quality control. ESD flooring helps protect this equipment from damage caused by static discharge, ensuring reliable operation and reducing the risk of costly downtime or repairs.

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HYGIENIC WALL SOLUTIONS

In food and beverage cleanrooms, walls must withstand various forms of wear and tear, including exposure to moisture, impacts, abrasion and chemicals.

High-performance wall systems are crucial for protecting against long-term damage in these environments. They provide essential functions such as imperviousness, ease of cleaning, and resistance to moisture and microbial growth.



Figure 4. In sterile environments such as food and beverage cleanrooms, wall systems must be highly cleanable to minimize contamination risks and durable enough to endure rigorous cleaning protocols, impacts and abrasions.

Fiber-reinforced epoxy resin systems create a protective barrier against contaminants. Specifically designed for application to walls and ceilings, these systems offer exceptional durability, ease of application and excellent performance – including resistance to UV light, which is not typical of traditional epoxy systems.

Smooth wall coating systems with no pinholes or gaps are relatively easy to sanitize and maintain, with options for power washing and resistance to vaporized hydrogen peroxide (VHP). Seamless surfaces eliminate crevices where grime can accumulate, inhibiting the collection of dust, dirt, fluids and microbes.

These systems should consist of multiple layers, including epoxy and urethane topcoats, engineered to resist the cleaning regimens required. They help control humidity, minimize outgassing and prevent particle infiltration by being impermeable. Fiberglass-reinforced coatings can be included for added impact resistance.

Cleanroom ceilings should also offer the resilience to withstand daily washdowns. These systems may include two-component, water-based urethanes and a single-component, low-VOC, UV-resistant acrylic clearcoat, providing protection against corrosion from sanitizing agents.

A breathable, water-based epoxy intermediate coat on ceilings can enhance durability and longevity. These ceiling coatings proactively address maintenance needs, helping to minimize downtime and ensure continuous compliance with food safety standards.

FIREPROOFING CONSIDERATIONS FOR CLEANROOMS

Fire safety is a critical aspect of maintaining safe and compliant food and beverage facilities. Given the potential presence of flammable ingredients, high-heat equipment and various other fire hazards, implementing effective fireproofing measures is of utmost importance. These measures must not only protect against fire risks but also ensure they do not compromise food safety.

Many food processing operations involve the use of flammable ingredients, such as oils, alcohols and certain chemicals used in cleaning or preservation. Additionally, ovens, fryers and stoves can pose significant fire risks if not properly managed.

When constructing or renovating food and beverage facilities, using fire-resistant building materials – such as fire-rated drywall, ceilings and flooring – can provide an additional layer of protection. Utilizing fire-resistant insulation and barriers around high-risk areas can prevent the spread of fire to other parts of a facility.

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Steps taken to fireproof cleanrooms mainly focus on protecting the steel structure. The selection and application of fireproofing materials and systems should not introduce contaminants that could jeopardize sensitive food- and beverage-related processes.

These materials must be non-toxic, especially in environments where they might come into contact with food or food-preparation surfaces. Materials should be chosen that do not emit harmful fumes or leave residues that could contaminate food products.

Traditional cementitious spray-applied fire-resistive materials (SFRMs) – while commonly used in other environments – can pose challenges in food and beverage facilities due to the risk of creating dust. Generally, epoxy coatings are cleaner and more effective in these settings. Unlike SFRMs, epoxy coatings do not outgas or release airborne particulates, thus minimizing contamination risks.

Specialized passive fire protection (PFP) solutions, including intumescent fire-resistive materials (IFRMs), are often preferred choices for their cleanliness and effectiveness.



Figure 5. Intumescent fire-resistive materials (IFRMs) comply with outgassing, low dusting and environmental tolerance requirements that are essential for food and beverage cleanroom environments.

In addition, the coatings can be applied off-site,



Figure 6. Off-site application of epoxy intumescent fireproofing before constructing a food and beverage cleanroom environment eliminates potential numerous on-site challenges.

enhancing the quality of applications, minimizing overlap with other trades at the construction site and enabling faster project completions.

By integrating effective fireproofing strategies and materials that prioritize both fire safety and food safety, facility owners can significantly reduce the risk of fire-related incidents. This dual focus ensures the protection of personnel, the facility and the food products themselves, maintaining a safe and compliant operation.

PARTNERING WITH PROFESSIONALS

Partnerships with coating experts can help facilities ensure compliance with mandatory standards, which is essential for avoiding fines, shutdowns and audits. Non-compliance can lead to regulatory scrutiny and severe consequences.

These industry insiders, often from large coating manufacturers and distributors, offer a specialized approach to selecting and applying coatings, which can offer significant advantages and enhance operational performance. Starting from the specification and CapEx stage of planning, these experts can provide assistance and offer access to tailored features that emphasize cost-efficiency, performance and compliance with industry standards.

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Coating professionals understand the unique challenges and needs of food and beverage environments.

They possess in-depth knowledge of the various regulations and standards, such as the FSMA, HACCP and ISO 22000. Coating experts can also recommend customized coating solutions that are tailored to specific operational conditions, such as exposure to high humidity, frequent cleaning and the presence of food acids or other reactive substances.

While high-quality, food-safe coatings may have a higher initial cost, specialists can help identify options that offer long-term cost savings through improved durability and reduced maintenance needs – helping minimize downtime and ensure that production schedules are maintained.

Specialists also stay on top of the latest developments and innovations in coating technologies. By working with these professionals, facilities can benefit from the most advanced solutions available, which may offer enhanced performance and compliance features.

Investing in cleanroom standards compliance also strengthens a company's competitive edge by demonstrating reliability and consistency in delivering high-quality products and services.

Beyond the initial selection and application, experts with specialized knowledge in food-facility coatings provide ongoing support and consultation. This includes regular inspections, maintenance advice and updates on new regulations or technological advancements.

Teaming with experienced coating suppliers helps facilities stay on the right side of the rules, reduces risks and sets up companies for lasting success.

OPERATIONAL EXCELLENCE

Cleanroom coatings are foundational to efforts to promote hygiene by providing easy-to-clean surfaces that ensure production areas remain sanitary.

These coatings prevent microbial growth, withstand harsh cleaning regimens, ensure regulatory compliance, and control allergens and pathogens. Investing in the right cleanroom coatings helps facilities meet and exceed food safety standards, protecting consumers, maintaining product quality and mitigating regulatory risks.

Flooring, wall and ceiling systems form strong barriers against contaminants, making surfaces easy to clean and resistant to microbial growth. ESD flooring prevents static discharge, protecting delicate equipment and personnel. Engineered wall systems offer insulation and shield against contaminants, with moisture barriers enhancing reliability.

Prioritizing these coatings leads to operational excellence and a competitive edge. The right coatings are the cornerstone of cleanroom success, safeguarding quality, efficiency and peace of mind across an array of industries.

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ABOUT THE AUTHOR

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Feraas Alameh is the Market Segment Manager – Food & Beverage for Sherwin-Williams Protective & Marine. Alameh is a seasoned business professional with nearly 15 years of experience in the coatings industry, leading various market segments with an emphasis on front-end innovation and business and market strategy. Alameh earned his bachelor's degree from Cleveland State University and has completed continuing education programs at the Weatherhead School of Management at Case Western Reserve University and the Fisher College of Business at the Ohio State University.

FIGURES AND CAPTIONS

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