Fundamentals of AMC Filtration

Entegris leverages its state-of-the-art analytical expertise and proven filter solutions to remove airborne molecular contamination (AMC) in a host of environments

Entegris

INTRODUCTION

When people think of air purification, they typically picture physical particulates. These might include airborne dust, viruses, and bacteria that can be mitigated by HEPA or MERV particle filters – a perception that was intensified by the COVID-19 pandemic. However, every environment also contains gas-phase contaminants which must be eliminated using a different type of purifier.

This chemical contamination exists within ambient air and supply gases in virtually every environment and may create problems for many industrial spaces. Having a method in place to measure and analyze AMC is vital to determining its degree of risk and potential impact. This should be the first step when attempting mitigation.

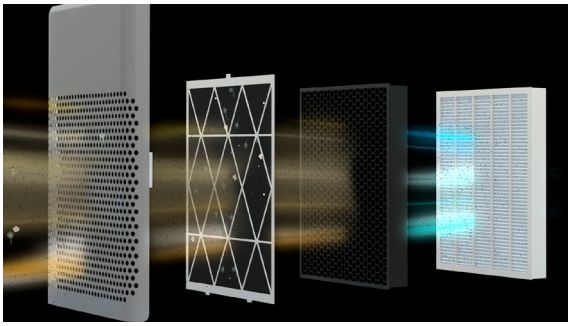

Figure 1. AMC filter airflow direction.

AMC filtration solutions, such as those developed by Entegris, are invaluable for manufacturing and industrial environments, healthcare facilities, libraries, museums, airports, and other public spaces. If not addressed, the outgassing caused by equipment, materials, humans, processes, and external sources can contribute to the degradation of materials and products.

This market brief delves into:

- Different types of AMC
- Best approaches when assessing and mitigating AMC, as appropriate
- Key industries and environments that are most sensitive to airborne gas contamination

The use cases will illustrate why Entegris is uniquely qualified to partner with you to assess your environment and help you find the best solution to mitigate the impact of AMC, while optimizing your cost of ownership (CoO).

AMC TYPES AND DETECTION

AMC is comprised of gas molecules that move with air, which is made up primarily of nitrogen and oxygen. Acids, bases, and organic contaminants represent the most common contaminants. Ozone and sulfur compounds can also be detected. These gas molecules typically have very low concentrations, so the aim in removing them is to filter one contaminant molecule from millions or billions of air molecules. This seemingly tall order is one that AMC filters were created to address.

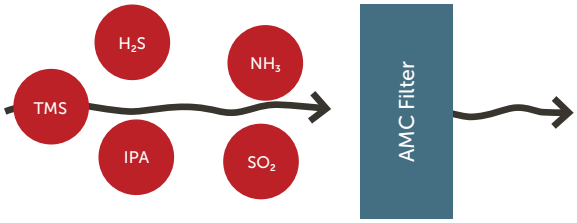

Figure 2. Air flow direction to remove contaminants.

AMC filters – more accurately termed purifiers because of their retention and removal mechanism – utilize integrated materials called adsorbents to remove gas-phase contaminants in ambient air streams. There are three main kinds of adsorbents. Physical adsorbents use intermolecular, electromagnetic forces to captures gases. While the most ubiquitous due to their low cost, they are also the weakest, and their adsorption is reversible. Catalytic adsorbents, often used with UV light, completely remove the contaminants, breaking gases down into CO_2, H_2O, or other oxides. However, they are costly to implement. Finally, chemical adsorbents remove gases by chemically reacting with them to create strong bonds that render contaminants unable to reenter the airstream.

MEETING MARKET DEMANDS

Entegris has built its portfolio of AMC control solutions using physical and chemical adsorbents, leveraging both its chemistry expertise and analytical capabilities – a combination unique to the filtration industry. The company's data-driven *"See it. Control it."* paradigm for implementing AMC filters involves two key steps:

1. *See it* – measure and identify contamination and its concentrations to define the environment.

   Entegris employs its own worldwide service laboratory for advanced AMC measurement. One of more than 30 global laboratories within Entegris, Entegris Analytical Services is ISO/IEC 17025 accredited (a competence standard for analytical labs), and provides in-field support for AMC filter products and gas purification systems. Close collaboration with the customer throughout the process – on results, applications, and implementation of AMC filtration – is key to achieving viable, repeatable solutions.

2. *Control it* – create an AMC filter for that specific environment using the data gathered during measurement.

   Because the type and makeup of airborne molecular contaminants differ from one environment to the next, one size does not fit all when it comes to mitigating them. Off-the-shelf products are insufficient for many applications. Entegris tailors its AMC control products, such as the VaporSorb™ filter, to meet the needs of each specific environment, tool, or process. Once the filter is installed, its performance can be closely monitored so that it can be modified if the environment or the process needs change. Monitoring also allows the filter to be replaced only when needed, instead of on a time-installed basis. This contributes to optimized CoO for the customer.

MARKET IMPACT AND USE CASES

While several markets represent primary drivers for AMC filtration technology, such as semiconductor manufacturing, data centers, and fuel cells, virtually any environment can benefit from AMC filtration, especially those where many people congregate in confined spaces. Each market faces its own challenges.

Figure 3. AMC concentration example.

- The **semiconductor industry** needs AMC filters to protect processes in cleanrooms, where all chip designs are fabricated. Many of the hundreds of processing steps are sensitive to airborne chemicals that can alter the structure and behavior of an electronic circuit as it's created, resulting in low yield, increased waste, and higher cost.
- **Data centers** and **industrial control rooms** in polluted regions need to protect their computer and power supply equipment from corrosion by ambient air acids. Corrosion of computer equipment requires more frequent changeout and may cause data loss through equipment failures. Corroding power supply switches can be hazardous and can lead to catastrophic explosions.
- **Fuel cells** are an exponentially increasing solution for green energy, but their performance is hampered by gas-phase air pollution. Fuel cells burn hydrogen and oxygen, which comes from ambient air drawn into the fuel cell, and contains hundreds of chemicals from all kinds of sources.
- **Libraries, museums, and data archives** need to filter the air that enters and circulates through their facilities. The many humans that pass through, as well as the outside air, add gas-phase contaminants that deteriorate books, media, and sensitive artifacts. Acids degrade paper, while ammonia and organic gases build up reactive films on surfaces.
- **Airports** need chemical filters to remove the odor created by jet fuel exhausts. Every incoming and outgoing airplane creates an odor problem for airport workers and travelers in transit.
- **Hospitals and healthcare facilities** are concerned about odor and potential health impact of many chemicals used to clean and sterilize the facilities and equipment. In addition, helicopters and emergency vehicles add exhaust that is transported inside through air handlers.

- Production chemicals used in many **industrial facilities** generate emissions that can create odors and/or health problems for people working in these facilities or impact the industrial process.
- Any accumulation of people in **large buildings and confined spaces** creates contaminated air, as humans emit significant amounts of ammonia, formic and acetic acids, organic trace gases and others. "Stuffy air" is not just inconvenient; breathed in over extended periods, it negatively impacts health and individual performance.
- **Smoke emissions** from vegetation fires can significantly affect sensitive industrial processes and personnel health or wellbeing. Implementing AMC filters in air handlers and industrial environments can reduce this impact to protect processes and personnel and increase production yields.

Use case examples

- Entegris minimized cost of ownership for a **semiconductor** customer by measuring their environmental AMC concentrations and creating a chemical filter solution tailored to that environment, extending filter lifetime and preventing time-based changeout.
- By analyzing a biocide used for an **air handler swamp cooler**, Entegris provided a chemical filter solution that eliminated odors from biocide degradation. At the same time, data center equipment was protected from the resulting acid emissions.
- A control room of a **municipal water treatment plant** had odor issues from sulfur-containing gases. Entegris provided a chemical filter using a special adsorbent for targeted sulfur gas removal with high capacity, resulting in long filter lifetime.

CHALLENGES AND FUTURE OPPORTUNITIES

AMC filters typically require a compromise, as the basic performance parameters contradict each other. On one hand, the filters need a long lifetime with high capacity and removal efficiency. However, achieving increased lifetime and removal efficiency requires adding more adsorbent, which adds cost and weight to the filter, as well as pressure drop, which lowers energy efficiency.

Flow and performance are also difficult to balance. High flow, such as in air handlers, increases pressure drop, which limits the amount of adsorbent that can be added. High flow also impacts contact time, which lowers to just a few milliseconds in an AMC filter compared to an order of minutes or longer in a cartridge purifier filled with adsorbent for pressurized gas purification. And because large amounts of adsorbent can't be added to limit the pressure drop, removal efficiency automatically goes down.

With AMC filtration use on the rise for many types of applications, Entegris has identified three key areas of focus for future technology progression.

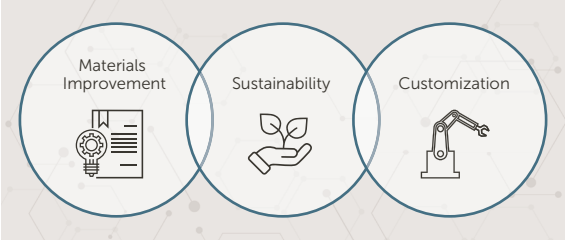

Figure 4. Three trends for AMC removal effectiveness and efficiency.

- **Materials improvements**. Materials science advancements are enabling development of new adsorbents tailored to specific needs, e.g., creating a specific pore size to capture a particular gas molecule of a specific size. Another example is identifying and implementing specific chemicals to achieve targeted reactions for chemical adsorption.
- **Sustainability**. New ways to reduce the environmental impact of AMC filtration are continually being explored. As part of its commitment to corporate social responsibility, Entegris is working on sustainable filtration media that contain fewer materials. The media can be either fully incinerated, regenerated, refilled, or decomposed. Other materials under development have much longer life spans to minimize their environmental footprint.
- **Customization**. Customized solutions are becoming even more essential to AMC filtration. Entegris provides customized contamination removal that is a 100% fit for the application and is continuing to research more advanced materials that can tackle more challenging applications.

CONCLUSION

As a premier materials company, Entegris offers a comprehensive portfolio of AMC filtration and analysis, customized products, and ongoing monitoring that is unique to many industries. No other AMC filter provider effectively addresses these requirements. New applications for these capabilities are being discovered all the time, as businesses and industries that weren't previously focused on airborne molecular contamination understand the damage it can cause and why they cannot neglect addressing AMC. Customers turn to Entegris to leverage its expertise in developing a targeted solution to mitigate AMC and its impact on people, products, and processes.

To explore how Entegris can partner with you to develop an AMC filtration and analysis solution optimized for your unique environment, contact us here, or call your local customer service office.

See it: Analytical Services

Control it: AMC Filters

Figure 5. Entegris AMC Filters.

FOR MORE INFORMATION

Please call your Regional Customer Service Center today to learn what Entegris can do for you.
Visit entegris.com and select the Contact Us link to find the customer service center nearest you.

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