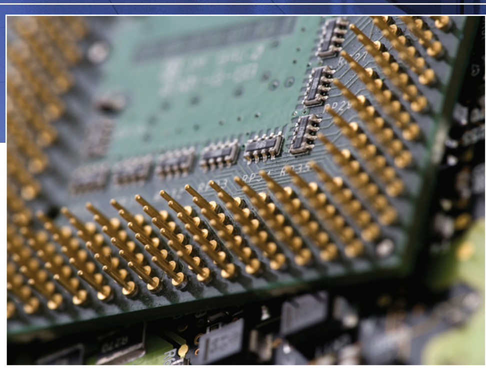
THE WORLD LEADER IN CLEAN AIR SOLUTIONS



Airborne Contaminant Control for Data Center Environments

PARTICULATE AND GASEOUS FILTRATION SOLUTIONS

AAF® INTERNATIONAL

AAF has an in-depth understanding of the
challenges and opportunities for data center environments.
This understanding and technical ability makes
AAF the preferred partner in
maintaining equipment reliability.

Protecting Data Center Environments

In 2003, the European Union (EU) passed the Restriction of Hazardous Substances (RoHS) Directive. The directive restricts six substances—mercury, lead, hexavalent chromium, cadmium, polybrominated biphenyls, and polybrominated diphenyl ethers. Circuit board manufacturers therefore had to remove lead-based solder to comply with this directive. Many electronic equipment manufacturers switched from lead solder to other materials that were more susceptible to gaseous corrosion. These types of connections can fail quickly in mild and moderate environments that were previously thought to cause problems only after long periods of time.

An immersion silver (ImAg) finish was chosen by many manufacturers as an RoHS solution, due to its ease of application and appealing cost. However, manufacturers found that environments containing sulfur could cause failures when using this finish in short periods of time. Testing of various materials showed that ImAg suffers corrosion failures in moderate environments. Common failure times for ImAg were 2–4 months for products in industrial atmospheres, such as rubber manufacturing facilities, pulp and paper mills, and water treatment plants. Electronic equipment in urban areas also experienced failures, as pollution from automobile traffic consists of the same reactive contaminants, including sulfur dioxide and ozone.

Electronic control equipment has been used for several decades to control processes and enhance yields in industrial facilities. Control rooms housing electronic equipment typically classify the environment by the ISA-71.04-1985 standard for environments with electronic control equipment. This served the industry well for a period of time.

Starting in 2009, the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) investigated the topic of corrosive, gaseous, and other environmental effects that may damage RoHS-compliant electronics, and published "2011 Gaseous and Particulate Contamination Guidelines for Data Centers." Later in 2013, ISA-71.04 was modified to account for the increased sensitivity of RoHS-compliant electronics.

AAF understands the need to provide gas-phase and particulate filtration systems for data center environments. Employing such systems can:

- **Eliminate contaminant caused equipment failures**
- **Maintain high level of electronic equipment dependability**
- **Reduce unplanned shutdowns to avoid potentially large business and financial losses**
- **Help protect equipment warranty claims**

Particulate Contamination and Control

Failures due to dust are generally classified as:

- Mechanical effects, including obstruction of cooling airflow, interference of moving or optical parts, and deformation of surfaces.
- Chemical effects, including corrosion of electrical components, due to dust comprised of sulfur and chlorine bearing salts.
- Electrical effects, including impedance changes and electronic circuit conductor bridging.

Most dust harmful to a data center falls into two size groups: coarse (2.5–15 μm) and fine (0.1–2.5 μm). Coarse dust particles tend to settle out of the air after a few days, and are generally derived of mineral or biological origins. Fine dust particles can stay airborne for years. Sources of fine dust are fossil fuel burning, volcanic activity, forest fires, humidifier feed water, or sea salt spray. Component failures are accelerated when dust absorbs moisture and gets wet. When wetted, dust can more easily contribute to corrosion.

Corrosion of Electronics

Corrosion of electronics due to ambient air pollution has been documented for many years. Historically, the problem occurred only at industrial sites, such as pulp and paper mills and petrochemical refineries. These industrial facilities produce relatively high levels of sulfur content—hydrogen sulfide, sulfur dioxide, mercaptans, or sulfur laden particulates. Therefore, electronic components in these plants are subject to corrosion, due to reactions with environmental sulfur and humidity.

There are various types of electronic circuitry corrosion, including whisker growth and creep corrosion. Stricter environmental guidelines have forced many manufacturers to replace lead-based solders with lead-free solutions, which are more susceptible to corrosion from airborne gaseous and particulate contaminants. These forms of corrosion can cause failure by either impeding the flow of electricity or forming unintended circuit paths. Figure 1 demonstrates silver whisker growth on surface mounted components of a circuit board. Silver whisker growth will cause failures by forming unintended circuit paths on a circuit board. The growth of silver whiskers is the notable indicator to server manufacturers that sulfur contamination exists in their equipment.

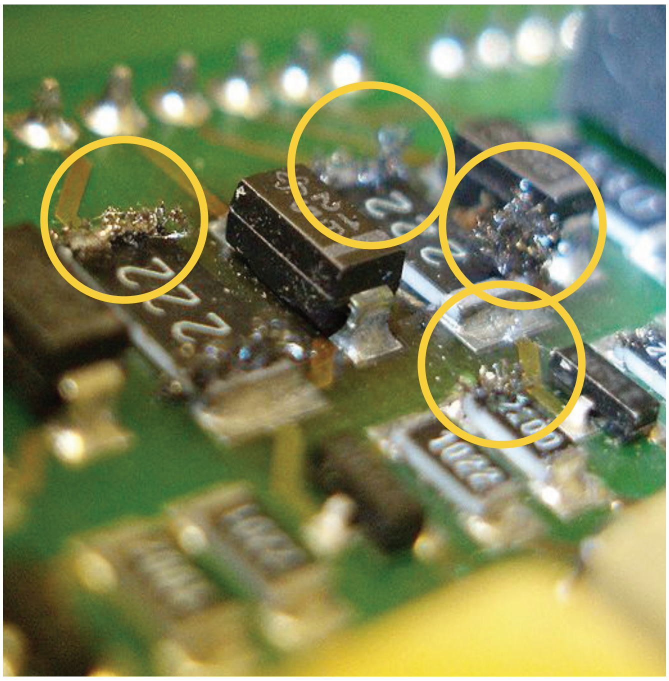


Figure 1 – The Restriction of Hazardous Substances (RoHS) directive, which originated in the European Union, restricts dangerous substances commonly used in electronics. The photograph above shows silver whiskers growing out of RoHS compliant circuit board components

In response to these problems, the industry has developed a standard to classify control rooms and process control environments. Most equipment manufacturers require that the control room environment meets the ISA G1—Mild classification to maintain a reliable communication network in industrial environments. The only way to meet this requirement in many industrial environments is to protect the control room with gas-phase and particulate filtration.

ASHRAE TC 9.9-2011

Gaseous and Particulate Contamination Guidelines for Data Centers

ASHRAE developed a technical guideline for modern data center facilities. Sources of particulate and gaseous contamination should be monitored and controlled at all times.

TC 9.9 recommends that data centers be kept clean to ISO Class 8 of ISO Standard 14644-1. Every effort should be made to filter out particulates and relative humidity less than the maximum allowable relative humidity in the data center. The gaseous contamination should be within the modified severity level G1 (see Table 1).

For data centers without economizers, the ISO Class 8 cleanliness level may be achieved simply by specifying ISO coarse or ISO ePM10 (EN779: G4–M5) filters for air recirculated inside the data center, and ISO ePM2,5 (EN779: M6 or F7) filters for air entering a data center.

For data centers utilizing free air cooling or air-side economizers, the choice of filters to achieve ISO class 8 level of cleanliness depends on the specific conditions present at that data center.

ISA 71.04-2013 Standard

Environmental Conditions for Process Measurement & Control Systems: Airborne Contaminants

The International Society of Automation (ISA) standard covers airborne contaminants and biological influences that affect industrial process control equipment, electronic office equipment, and data center and network equipment. This standard establishes airborne contaminant classes for fixed installations during normal operation, or during transportation and storage.

Air Filtration Solutions for Data Centers

Air quality within Information Technology (IT) data centers is more important today than ever. Data centers have unique requirements and strict regulations, compared to a typical commercial site. Particulate and corrosive gaseous contaminants have become a serious problem for data centers and server rooms. In some cases, corrosion of electronic components has resulted in catastrophic failures of equipment within data centers, due to environmental conditions like low concentrations of corrosive gases. These contaminants enter data centers in a variety of ways, including outdoor ventilation systems, adjacent interior areas, and with individuals entering and exiting the data center.

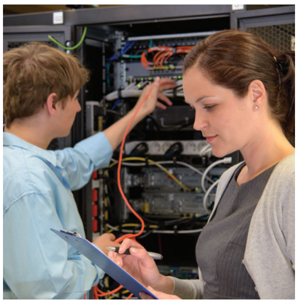
While the connection between contamination and hardware failures is often overlooked, the need to maintain a high level of equipment dependability in data centers is not. AAF is experienced in the prevention and control of particulate and gaseous contamination, as well as air quality testing and analysis in mission critical applications.

AAF provides custom air filtration products and solutions to meet the most demanding airflow and efficiency requirements for controlling temperature, humidity, and air purification for any type of data center. AAF products are designed with energy efficiency in mind. Offering you the highest efficiency products with the lowest energy requirements, AAF has the filtration solutions to provide clean air and reduce operating costs.

Gaseous Contamination and Control

Sulfur-bearing gases, such as sulfur dioxide (SO_2) and hydrogen sulfide (H_2S), are the most common gases that cause corrosion of electronic equipment. Once introduced in a data center or server room environment, these gaseous contaminants lead to deterioration of copper surfaces and silver solder used on computer circuit boards, leading to intermittent and hard failures.

Leading computer manufacturers have adopted The International Society of Automation (ISA) standard S71.04 and require that customers meet this guideline, limiting corrosive gaseous levels in their data centers. Elimination of corrosive contaminants is essential to maintain data center equipment reliability. A very convenient and quantitative way to determine



the corrosivity of air in a data center is the so-called “reactive monitoring” method described in ISA-71.04. This method exposes a copper coupon to the environment for one month, and analyzes the accumulated corrosion product thickness and chemistry using coulometric reduction, to classify the environment into one of four severity levels, described in Table 1.

According to ISA-71.04, the copper corrosion rate should be less than 300 Å/month for an environment where corrosion will not be a factor in determining equipment reliability. However, the use of copper coupons alone has two major limitations: copper is not sensitive to chlorine, a contaminant particularly corrosive to many metals, and copper corrosion is overly sensitive to relative humidity. The inclusion of a silver coupon helps differentiate the corrosive contributions of gaseous contaminations and relative humidity.

It is now common practice to include silver coupons along with copper coupons to gain greater insight into the chemistry of the corrosive gases in the environment. Silver corrosion rates in data centers that have reported corrosion-related hardware failures are above 200 Å/month, whereas those with no reported corrosion-related hardware failures have silver corrosion rates below 200 Å/month. Copper corrosion rates, on the other hand, show significant overlap for data centers both with and without corrosion-related hardware failures. In general, though, copper corrosion rates are higher in data centers with corrosion-related hardware failures.

Table 1 – Recommended Gaseous Corrosivity Levels

ISA-71.04-2013 Classification Scheme

Classification	Copper Angstroms /30 days	Silver Angstroms /30 days	Reliability Statement Summary
G1 Mild	< 300	< 200	Sufficiently well controlled
G2 Moderate	< 1000	< 1000	Effects of corrosion are measurable
G3 Harsh	< 2000	< 2000	High probability that corrosive attack will occur
GX Severe	≥ 2000	≥ 2000	Only specially designed and packaged equipment would be expected to survive

Particulate Filtration Solutions

Pleated Panel Filters

The AAF pleated panel filter line provides the industry's broadest selection of high performance, high capacity filters, including specialty and standard capacity options. This enhanced line of filters offers consistent air quality, improved process performance, social responsibility, and optimized Total Cost of Ownership.

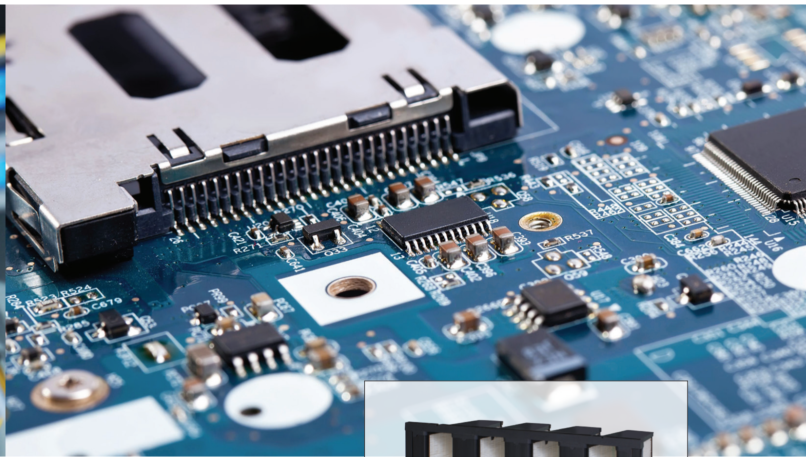
High Efficiency Extended Surface Filters

These rigid, extended surface filters are ideal for use in all high efficiency applications. The supported pleat filters provide strength and integrity in high flow, turbulent, and variable airflow conditions.

These filters are designed to remove airborne biological contaminants in critical areas, such as data centers and other environments with unique requirements and strict regulations.

The Pleated Panel Filter line features:

- Filter classes G2–M5 (EN779:2012)
- ISO coarse to ePM10 (ISO 16890)
- Industry's lowest life cycle pressure drop and highest Dust Holding Capacity (DHC) reduces energy consumption and total operating costs
- Highest performing self-supported pleated filter on the market
- High efficiency pleated filter supports achievement of LEED® credits by significantly improving Indoor Air Quality (IAQ) and reducing energy consumption
- Filter options for high temperature and high velocity environments



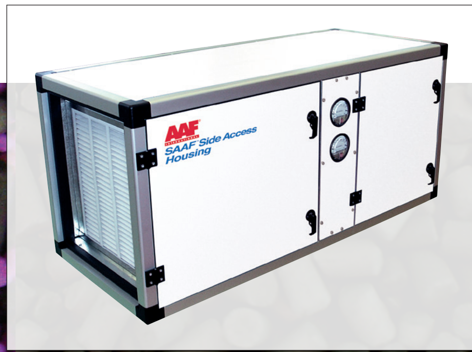
The High Efficiency Extended Surface Filter line features:

- Filter classes M6–E10 (EN779:2012; EN1822:2009)
- ISO ePM2,5 to ePM1 (ISO 16890)
- Patented Impress® Technology delivers a higher DHC and a lower pressure drop for greater energy efficiency
- Heavy-duty construction and high performance in tough operating conditions
- Dual density media increases DHC and reduces operating costs
- 100% separatorless and self-supporting microglass filters for easy disposal
- Inline space-saving designs for high efficiency without having to compromise space

Gaseous Filtration Solutions

AAF has assumed an industry leading position with the development of its innovative SAAF™ (pronounced as "SAFE") product line, designed to reduce or eliminate harmful gaseous contaminants. In combination with our expertise in airborne particulate filtration, SAAF products and solutions allow us to develop unique and effective total filtration solutions to protect people, processes, and equipment.

No other company offers this combination of experience, expertise, innovation, and capability to combat airborne contaminants, particulate and/or gaseous, and deliver the best clean air solutions.



The SAAF product line features:

- Patented chemical media cassettes with superior sealing and energy savings. These cassettes also fit in most legacy units. The housings are designed for quiet operation and durability.
- Complete chemical media line – adsorbents, oxidants, and blends configured by and produced under the supervision of our world-class global research and development teams
- Environmental Measurements related to the ISA Standard S71.04: "Environmental Conditions for Process Measurement and Control Systems. Airborne Contaminants to determine types of contaminants and their relative concentrations"
- RoHS compliant Corrosion Control
- Comprehensive, industry leading software – SAAF Tech Tools analyzes applications, develops solutions, configures equipment and media, and delivers a complete technical proposal
- Full line of gas-phase equipment, including side access housings, air purification systems, and machine intake filter systems

Additional Recommendations

In data centers with air-side economizers, supplemental real-time monitoring, like AAF's SAAFShield Technology, is recommended to enable quick reaction to outdoor events that may introduce corrosive gases into the data centers. Real-time monitoring is also recommended in data centers with gas-phase filtration air cleaning systems, in order to track the efficiency of the filters.

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