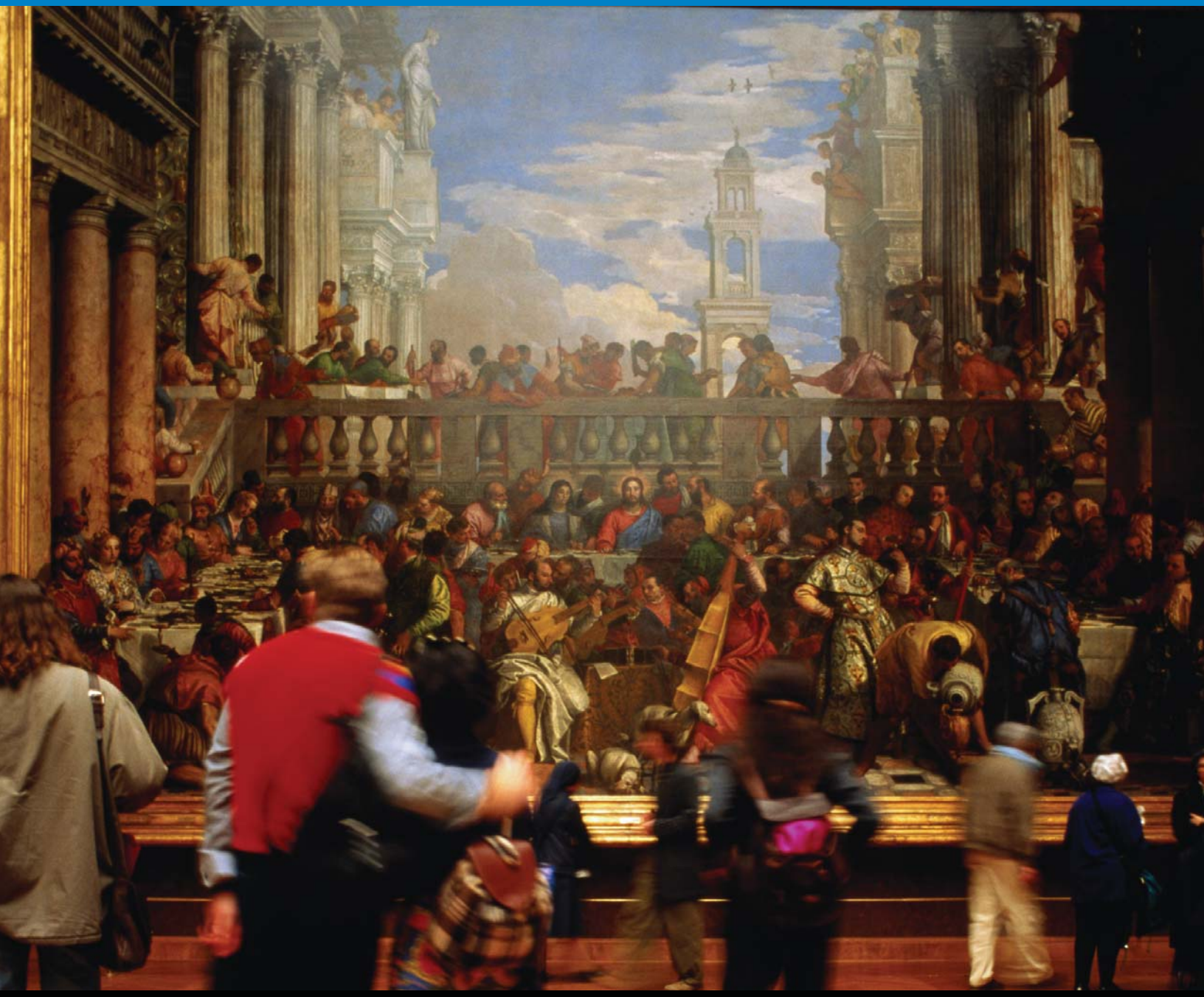

# Molecular Filtration Preserves Artifacts

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|---|---|---|
| Camfil Farr | Segment Brochure | |
| Museums, Galleries & Archives | | |
| Camfil Farr - Clean Air Solutions | | |

# The Art of Artifact Preservation

The primary function of museums, art galleries, libraries and document archives is to preserve artifacts for future generations. Artifacts need not be ancient; they may be comparatively recent, but nevertheless, sensitive objects such as government records, newspapers and microfilms. Conservation may be applied on a remedial basis (repair of existing damage), however, it is far more desirable and cost effective in the long term to prevent deterioration.
This approach is called “Preventative Conservation”. Molecular Filtration has an important role to play within Preventative Conservation.

## Display and storage conditions in museum, gallery and archive buildings

Inappropriate environmental conditions may cause irreversible damage to vulnerable artifacts. Critical parameters include; temperature, relative humidity, lighting, particulate pollution (dust), molecular (gaseous) pollutants and pests. The stability of temperature and humidity levels are equally important. In some cases, rapid changes can be more detrimental than a stable condition, albeit at a non-ideal level. It is also known that there is a synergistic relationship between increased temperature, increased humidity, molecular pollutants and the rate of deterioration. Different categories of artifacts (e.g. paper, paintings, metals and wood) have their own specific storage requirements.

A very high level of care and expertise should be applied in the design and construction of buildings used for the storage and display of artifacts. Interestingly, in most collections only a small selection of the artifacts are on the display, the bulk of the items are actually in storage.

If different classes of artifacts are present, it is normal to provide a cell, or compartmentalised construction, within the building, in which it is possible to provide different micro-climates. All buildings must be ventilated to some degree. Since it is necessary to provide good breathing air, ventilation rates typically increase with human occupancy. Forced or natural ventilation induces external or “fresh air” into the building.

This air can contain many particulate or molecular pollutants. External pollutants may also enter the building via “fugitive” routes such as open windows, delivery bays and building defects. In addition to external sources, there are important internal sources of pollutants which may damage artifacts. Humans shed vast numbers of particles from skin and clothing. Research has shown that internal levels of particles may exceed the external street level value during daytime periods. Molecular pollution can originate from building construction and finishing materials, storage materials and the artifacts themselves.

# The Problem: Molecular Pollutants

Although there are natural sources such as hot water springs and volcanoes, atmospheric molecular pollutants can be predominantly attributed to human activity such as power generation and transport. Normally they are associated with high population density (e.g. cities).
In terms of damage to artifacts, molecular pollutants fall into two broad categories:

- those with acidic chemical properties
- those with oxidizing chemical properties

The principal acidic precursor gases are sulfur dioxide and nitrogen dioxide. These may react with atmospheric humidity to form the stronger sulfuric/sulfurous and nitric/nitrous acids. Acids cause damage by corrosion to materials such as metals and marble. Other materials susceptible to damage include leather, wool, silk, paper and photographic items.
The predominant oxidizing gases are ozone, nitric acid and other oxygen/ nitrogen compounds. These gases will cause damage mainly in organic materials and the effects can be likened to premature ageing. In some cases, ozone will lead to the breakdown of the organic material, and the formation of carboxylic acids. These acids can accelerate the deterioration rate within the affected artifact and in other artifacts in close proximity. Typical visual changes resulting from oxidation include; yellowing, brittleness, fading and tarnishing of metals.
Molecular pollutants are identified in terms of the concentration of individual chemicals or groups of chemicals.
The normal units of concentration are micrograms per cubic meter (µg/m³) and parts per billion (ppb). Typical concentrations of these gases in cities are readily available from the web sites of cognizant authorities.
Pollutant molecules act on an individual basis and for a concentration of 10 ppb (which is an extremely low ambient level), there are 25,000,000,000,000,000 molecules per cubic meter of air which are each capable of causing damage.
A summary of molecular pollutants and their effects is given in Table One.

### Particulate pollutants

Particulate pollutants arise from multiple sources, including combustion processes (industrial, power generation, vehicle exhausts, cigarette smoke), vehicle tires, building activity and human beings. Heavy particles with metallic content are abrasive and may settle on surfaces and cause scratching. Smaller particles may remain suspended and be transported by air movement to even the remotest corners in rooms and display cabinets. Here, surface deposition will lead to soiling or discoloration
Many particles, particularly those arising from combustion processes, will be oily, or sooty, and have acidic properties. These particles are particularly damaging since they are very sticky and can cause corrosion in many materials.
Particles arising from building works (concrete) have both alkaline and abrasive properties and are harmful to artifacts such as paintings and textile fibers.
Particles are specified according to their size and frequency (i.e. number per unit volume (per cubic meter)). If the level of particulate pollution is high, it may be appropriate to specify the efficiency of the filter in terms of weight, (mg/m³).

| Gas | Formula | Source | Susceptible Artifacts | Type of Damage |
|---|---|---|---|---|
| Sulfur Dioxide | $SO_2$ | External, traffic fumes, power generation | Metals, marble/limestone, paper<br>Old paintings, particularly the natural pigments (organic & inorganic) | Acidic corrosion<br>Blackening due to sulfide formation |
| Oxides of nitrogen, particularly nitrogen dioxide | $NO_x$, $NO_2$ | External, traffic fumes | Metals, marble/limestone. | Acidic corrosion |
| Ozone | $O_3$ | External, atmospheric. | Paper, fabrics | Oxidation (aging) |
| Hydrogen sulfide | $H_2S$ | External — industry, waste water treatment Internal — leather items | Old paintings, particularly the natural pigments (organic & inorganic) | Blackening due to sulfide formation |
| Organic acids — formic or methanoic acid, acetic or ethanoic acid | HCOOH<br>$CH_3COOH$ | Internal — wooden fixtures, wood and paper products | Metals & organic based materials | |
| Organics i.e. phenol, formaldehyde | $C_6H_5OH$ | Internal, construction & furnishing materials | Various | Aging |

Table One: Gaseous pollutants, their sources & effects.

## 1 CamCarb Metal Cylinders

A robust solution, in an easy to install canister, that can be filled with the appropriate adsorbent. CamCarb Metal Cylinders provide long contact times, long life and extremely high efficiency. Stainless steel cylindrical cartridges may be refurbished by refilling with new media. CamCarb is particularly suited to make-up air applications.

## 2 CamCarb Plastic Cylinders

An eco-friendly version of the above, these plastic cylinders are a single-use solution suitable for disposal and may be incinerated.

Both versions may be installed in built-up bank holding frames or side-access housings.

## 3 CF Panels & Housings

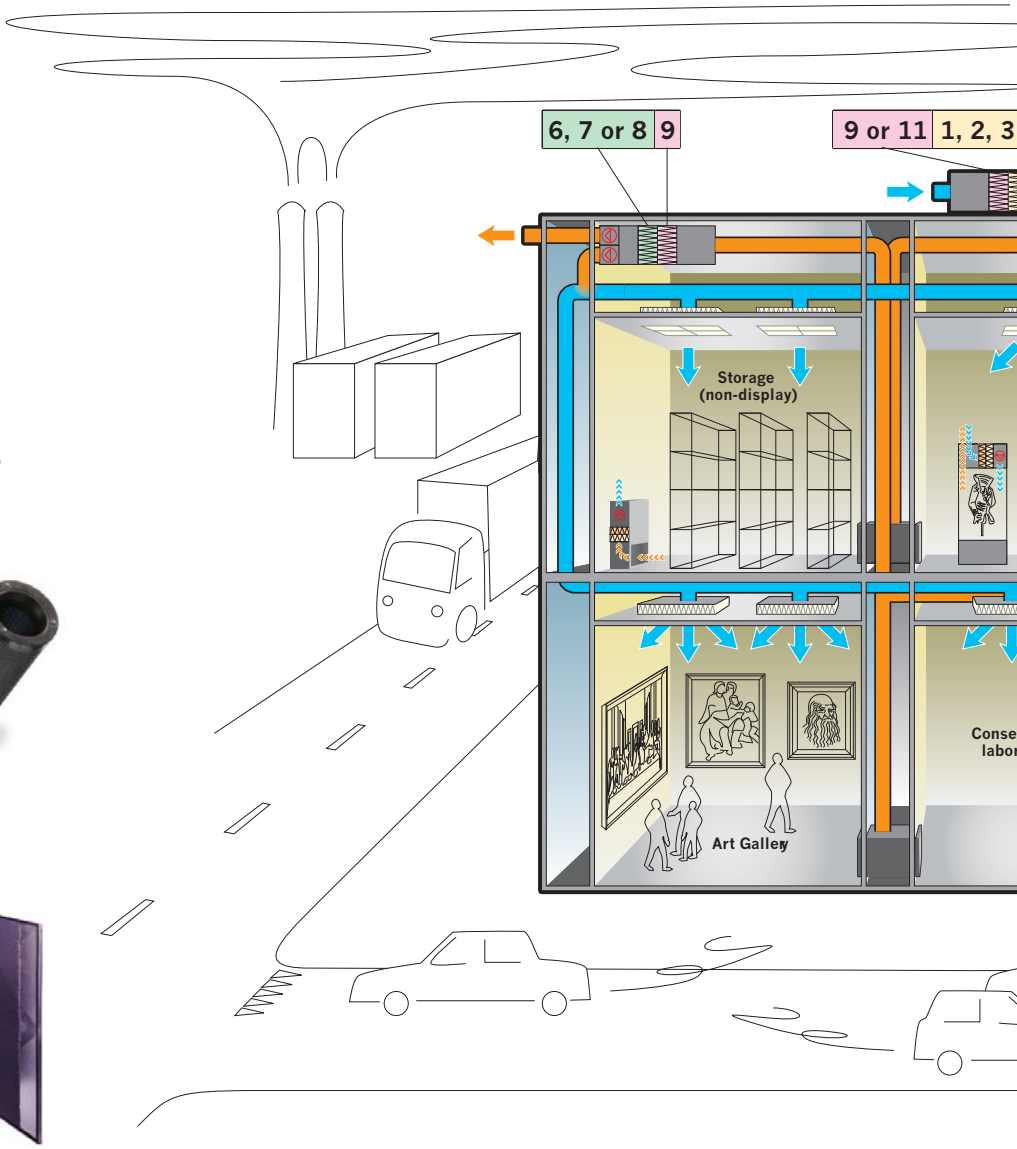
A standard for over 40 years, Camfil Farr CF panels are a 1-inch flat panel and tray solution that may be used with a variety of adsorbents. CF panels provide long contact times, long life and very high efficiency. CF panels may be installed in built-up bank modules or side access housings.

## 4 GDM 300

An industrial strength solution that may be applied with a variety of Campure medias.

## 5 GDM 440

A economical replacement for existing commercial systems that offers a low pressure loss solution when used with Campure medias.



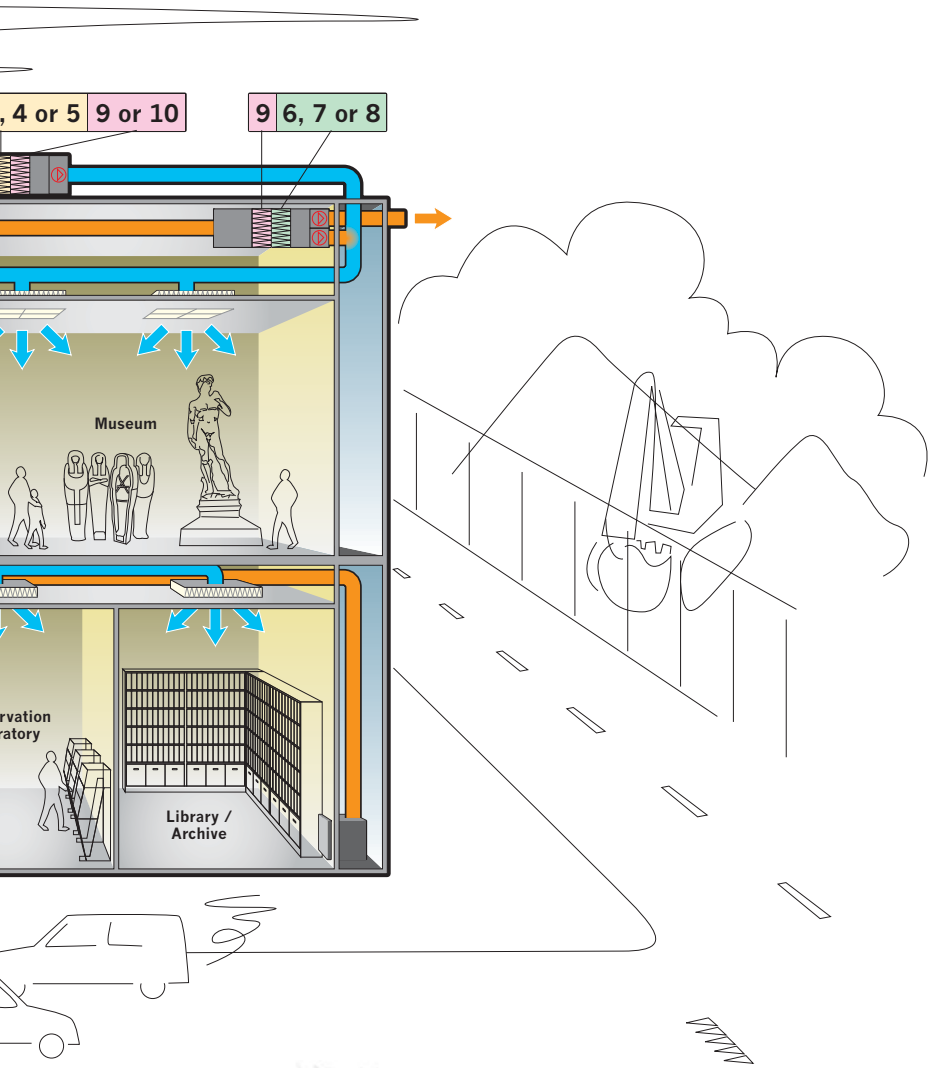

## 6 RigaCarb

A compact and practical solution aimed at low concentration (predominantly recirculating air applications). RigaCarb uses a very finely divided adsorbent and provides Rapid Adsorption Dynamics (RAD). Three versions are available, one with very high quality broad spectrum adsorbent, one with impregnated activated carbon to target acidic gases, and one with impregnated activated adsorbents that target aldehydes gases and diesel emissions.

## 7 CityCarb

Two versions are available, one with very high quality broad spectrum adsorbent and one with impregnated activated carbon to target acidic gases. The CityCarb includes an integral MERV 15 layer that provides high efficiency particle filtration.

# from Camfil Farr




## Solid pollutants (particle filtration)

For effective preservation, artifacts must be protected from small, aggressive particles. Such particles, which are often acidic in nature, originate from combustion processes and are in the sub-micron size range. They can also block adsorbent pore space, decreasing its ability to adsorb contaminants. Therefore, molecular filters must be used in conjunction with high efficiency particulate filters. The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) recommends, at a minimum MERV 7 prefiltration and MERV 13 final filtration. To ensure filter performance throughout the life of the filters, Camfil Farr recommends that specifiers add the caveat that particulate filters also be evaluated in accordance with Appendix J of ASHRAE Standard 52.2. Filters that do not meet both MERV and MERV-A may drop in particle capture efficiency, increasing the likelihood of damaging sub-micron particle damage to artifacts.

To avoid microbial growth, the ventilation system should be designed so that the relative humidity (R.H.) always stays below 90% and the average R.H. for a three-day period is less than 80% in all parts of the system, including the air filtration plenum. If these requirements are impractical, it is recommended that the filters be changed frequently.

ENERGY COST INDEX

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### Durafil® ES

High efficiency V-Bank filters with efficiencies of MERV 11 to MERV 16 when evaluated per ASHRAE Standard 52.2. The Durafil provides high efficiency particulate removal and maintains its published efficiency, ensuring consistent particle capture efficiency over the life of the filter.

The Durafil can also reduce facility energy usage significantly when compared to other filter configurations.

8

### City-Flo

A member of the prestigious Hi-Flo bag filter family, the City-Flo includes a layer of very high performance broad spectrum activated carbon media.

11

### Opti-Pac®

A short-depth (4") high efficiency filter available in efficiencies of MERV 11, MERV 13 and MERV 14. The Opti-Pac has a corresponding MERV-A, matching its published efficiency ensuring consistent particle capture efficiency over the entire life of the filter.

ENERGY COST INDEX

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### Hi-Flo®

High efficiency bag filters with efficiencies of MERV 9 to MERV 15 when evaluated per ASHRAE Standard 52.2. The Hi-Flo provides high efficiency particulate removal and is available in various pocket depths and dimensions. The Hi-Flo has a corresponding MERV-A, matching its published efficiency, ensuring consistent particle capture efficiency over the life of the filter.

### 30/30® (not shown in diagram)

An excellent prefilter to extend the life of particulate final filters and adsorbers. The 30/30 is guaranteed to last longer and maintain its efficiency over the life of the product. Prefilters may be used in any location where extended life of final filters is desired.

ENERGY COST INDEX

For more information on Energy Cost Index product ratings contact Camfil Farr.

# Safe Concentrations of Molecular Pollutants

It can be argued that because each individual molecule is potentially capable of causing change or damage to an artifact, the only safe concentration of molecular pollutants is zero. This however is an impractical proposition. Even without budget constraints, the optimum combination of all control factors is unlikely to produce the desired result. In any event, damage to artifacts is dose-based behavior. Not only is the concentration important, but the exposure time must also be taken into account.

The goal of preventative conservation is to ensure that collections remain stable over reasonably long time scales (hundreds to thousands of years). There are no absolute definitions of acceptable concentrations of molecular pollutants, because the sensitivity of different artifacts varies, and the harmful effects are influenced by other factors such as temperature and humidity. Nevertheless, guidelines exist for critical gas concentrations that support an environment that is acceptable for long-term storage, see Table Two.

| Molecular Pollutant | Acceptable Concentration | Recommended Control Method | Source* |
|---|---|---|---|
| Sulfur dioxide | <10 µg/m³ | Activated carbon or activated alumina | British Standard BS5454 2000 |
| Oxides of nitrogen | <10 µg/m³ | Activated carbon or activated alumina | British Standard BS5454 2000 |
| Ozone | < 2 µg/m³ | Activated carbon | International Centre for the Study for Preservation and Restoration of Cultural Property (ICCROM) |

Table Two

* For more information see:
Appendix 1 and 2 "*Monitoring for Gaseous Pollutants in Museum Environments*"
Cecily Grzywacz, Getty Publication, 2006

## The solution to Molecular Pollutants

Molecular filtration provides a cost effective method of controlling the harmful pollutants, thereby ensuring safe storage and display conditions. Various types of solutions are available depending on the types and concentrations of gaseous pollutants, the type of artifact to be protected and the layout of the ventilation system.

Molecular filtration may be applied in either the fresh air make-up or recirculation air units. Solutions for make-up air applications need to reflect the high external concentrations and one-pass operation. Solutions for recirculation applications reflect lower ambient concentrations and multi-pass systems.

## Adsorbents

Adsorbents are available to control the complete range of harmful gases. The adsorbents operate with either a “broad spectrum” behaviour towards a very wide range of gases (particularly sulfur dioxide and organic vapors), or they use a chemical adsorption mechanism to target one specific gas or group of gases (e.g. acids or formaldehyde).

| Base material | Material type | Grade name | Removal mechanism | Target gases |
|---|---|---|---|---|
| Activated carbon | Coconut shell activated carbon | CFS-201-4 (LGS048 & LGS612) | Broad spectrum/ physical adsorption | Sulfur dioxide, organic vapors, ozone |
| | Coal activated carbon | CFS-201-E (CEX002 & CEX003) | Broad spectrum/ physical adsorption | Organic vapors, ozone |
| | Coal activated carbon impregnated with caustic potassium hydroxide | CFS-202-E (CEX003/A6) | Chemical adsorption | Organic and inorganic acid gases (high capacity), organic vapors, ozone |
| Activated alumina | Activated alumina impregnated with potassium permanganate | Campure 6XL or Campure 8 | Chemical adsorption | $SO_X$, $NO_X$, other inorganic and organic acid gases (high capacity), formaldehyde, organic vapors |
| | Blend of activated carbon and activated alumina impregnated with potassium permanganante | Campure 6XL & CFS-201-E | Chemical adsorption / broad spectrum physical adsorption | Organic vapors, ozone, acidic gases, organic acids, formaldehyde |
| | Blend of caustic impregnated activated carbon and activated alumina with potassium permanganate | Campure 6XL & CFS-202-E | Chemical adsorption / broad spectrum physical adsorption | Best solution for organic vapors, ozone, acidic gases including $SO_x$ and $NO_x$, organic acids, formaldehyde |

## Support Services and R&D

Gigacheck

Camfil Farr offers a comprehensive range of support services to ensure that users achieve the maximum benefit from the molecular filtration installation. In particular, it is essential to have confidence in the air quality within the enclosed space and to be able to predict the end of the useful service life, before the filter efficiency drops to an unacceptable level and eventually fails.

The Gigacheck and Campure Coupon passive sampling devices offer convenient and economic methods of determining concentrations of various gases in ventilation systems or enclosed spaces.

More sophisticated measurements can be obtained continuously in real time with ISA Check. The Gigamonitor techniques are used to analyze samples of used molecular filtration media to determine the adsorbed contamination. A series of analyses at appropriate times allows the residual life to be monitored and replacements planned in advance of a failure. This is an essential part of the preservation strategy for any artifact.

Camfil Farr operates a unique molecular filtration test facility in which full-scale products can be tested at a wide range of temperature and humidity values to mimic actual application conditions. The test filter can be challenged with a wide variety of gases and vapors. Sophisticated detection equipment upstream and downstream of the filters provide realistic initial efficiency and efficiency/lifetime curves and are provided to the user for guidance.


Campure Coupon

ISA Check

# On world standards...

Camfil Farr is the global leader in clean air technology and energy efficient air filter solutions with product development, R&D and local representation in the Americas, Europe and Asia-Pacific region.

We supply high quality products and services with the aim of making our customers' operations more sustainable, energy efficient and productive.

Our vision of sustainability is a global approach combining consideration for people, environmental protection and business performance.

Camfil Farr is a member of the United Nations Global Compact Program and follows the Global Reporting Initiative's (GRI) sustainability reporting framework.

## www.camfilfarr.com


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