CIRCUL-AIRE INC.

Multi-Mix® Chemical Media

CONTAMINANT & APPLICATIONS HANDBOOK

MULTI-MIX® CHEMICAL MEDIA

An Introduction to Multi-Mix® Chemical Media

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Chapter 1

Circul-Aire Multi-Mix® Media

A Brief Introduction to Gas Phase Filtration and Multi-Mix® Media

Circul-Aire offers a wide variety of chemical media to provide continuous purification of corrosive, odorous and toxic contaminants in both industrial and commercial environments. Depending on the pollutants involved, Circul-Aire's chemical filters will use different processes to remove unwanted gases from contaminated air-streams. More specifically, four primary removal mechanisms are employed by Circul-Aire's Multi-Mix® media to eliminate most airborne chemical contaminants: **ad**sorption, **ab**sorption, **chemi**sorption, and catalysis.

Gas Phase Filtration Processes

In order to abate any confusion, the following definitions will help to clarify some of the subtle differences and popular misconceptions between each of the gas phase filtration processes mentioned above:

There is a classic example used to illustrate the difference between adsorption and absorption; ADsorption is like getting a pie in the face, while ABsorption is like getting pie in your mouth.

Adsorption

Adsorption is a physical process that occurs when a contaminant (liquid, gas, or suspended matter) adheres to the surfaces of, or in the pores of, an adsorbent material. Adsorption is a reversible process, which occurs without a chemical reaction.

Absorption

Absorption is a process where a contaminant actually penetrates into the structure of another substance. This is different from **ad**sorption, in which one substance adheres to the surface of another substance.

Chemisorption

Chemisorption is a process related to physical adsorption, except that a chemical reaction occurs once the contaminant comes into contact with a reagent on the surface of adsorbent material. Chemisorption is usually considered to be an irreversible process.

Catalysis

Catalysis is a process where the catalyst assists a chemical change in another substance. The change (usually inducing **or** accelerating a chemical reaction) removes the contaminant without the catalyst itself undergoing any change.

Classification of Chemical Media

The following table indicates some of the overlapping processes, which can occur with different types of chemical media:

Two specialty blends of chemical media that may be unfamiliar to most are MM-200, *a carbon dioxide (CO_2) absorbent* and MM-100, *a carbon monoxide (CO) catalyst*.

Absorbent	Adsorbent	Chemisorbent	Catalyst
MM-200	**MM-3000**	*MM-200*	**MM-100**
	MM-3000C	**MM-1000**	*MM-1000*
	MM-3000LP[*]	**MM-1000SP**	*MM-1000SP*
	MM-9000	**MM-7000**	*MM-9000*
	MM-9000LP[*]	**MM-8000**	*MM-9000LP*[*]
		MM-9000	
		MM-9000LP[*]	

Table 1-1 Circul-Aire Multi-Mix® media formulations classifiied with respect to specific gas-phase filtration processes.

NOTE: A **bold font** indicates a primary process associated with the media in question. An *italic font* indicates a secondary process, which may also be associated with the media.

For example: The above table indicates that the primary process associated with MM-9000 media is that of **chemisorption**, which is correct. However, the table also indicates that *adsorption* is a secondary process affiliated with MM-9000, which is also true. The chemisorbent MM-9000 media relies on the adsorptive forces of the activated substrate to initiate contact between the chemical reagent and the contaminant.

These designations and distinctions will become clearer later in the chapter.

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[*] LP denotes a low-pressure drop formulation for special applications; the reduced pressure drop is achieved by altering the *physical* characteristics of the chemical media. The types of contaminants removed by the media are not effected.

How to Read Chemical Media Specifications

Any meaningful discussion related to chemical media will rely on an understanding of the basic chemical and physical properties found in most general specifications (*see* Appendix A: Material Safety Data Sheet for more detailed information). The easiest way to acquire this fundamental knowledge is to deconstruct the general format of a media specification and to examine each property separately.

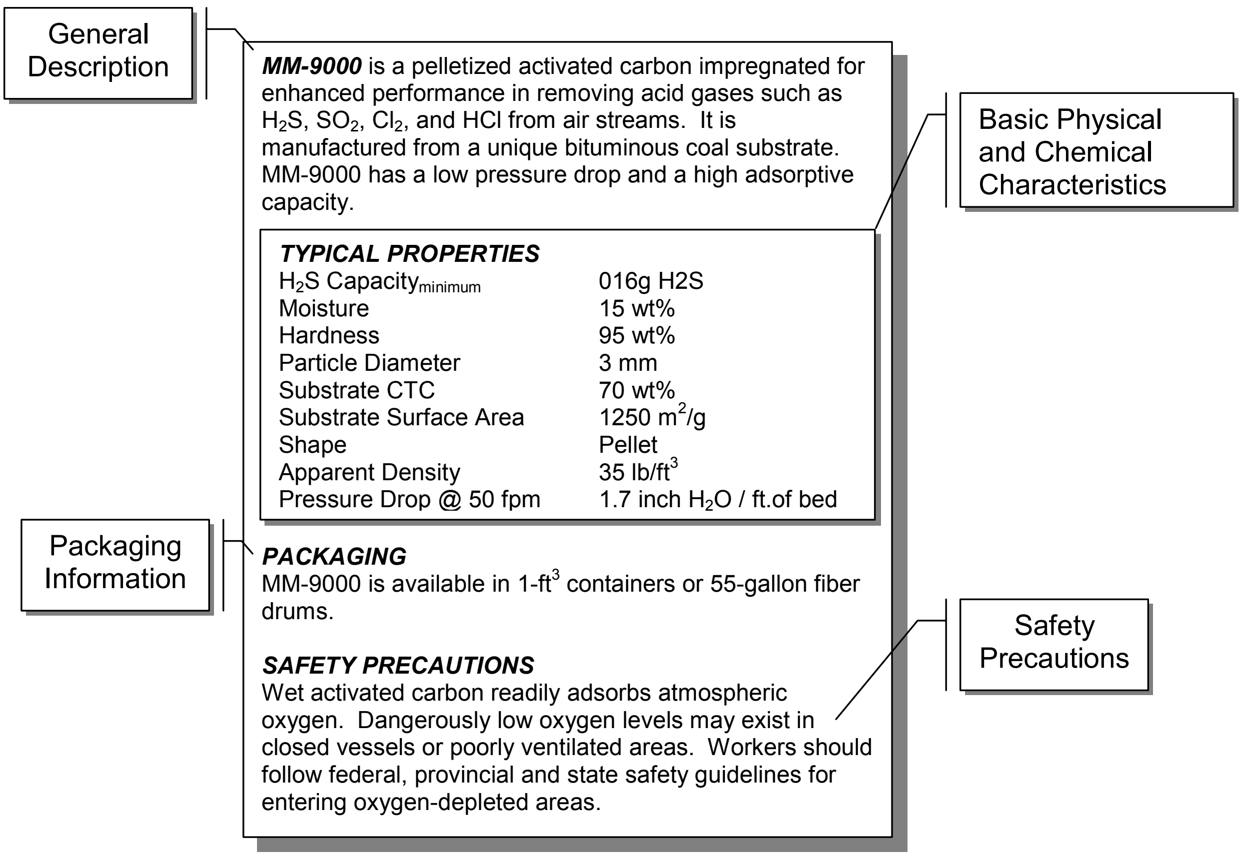

Figure 1-1 Typical media specification.

Capacity

Capacity refers to the ability of the media to remove a specific contaminant. The capacity is usually expressed as a percentage of either the weight-to-weight or volume-to-volume ratio. For example, media with an H_2S capacity of 15% wt/wt means that the media is capable of adsorbing 15% of it's own weight of H_2S.

Moisture
Moisture is simply the amount of water contained in a substance. Typically, the moisture content of chemical media is determined by drying the media and expressing the weight lost as a percentage of the weight of the original sample.

Hardness
Hardness is a generic term, which refers to the media's general resistance to breakage. Hardness does not determine a chemical filter's real-life resistance to degradation; however, it is still a useful tool for relative comparisons between similar grades of media.

Particle Diameter
Particle diameter is simply the nominal diameter of the carbon pellet expressed in millimeters. This property becomes significant when pressure drop across the bed is critical.

Substrate Carbon Tetrachloride (CTC Activity)
The CTC is a standard test used to measure the porosity of activated carbon. The adsorptive capacity is determined by testing the activated carbon against saturated **c**arbon **t**etra**c**hloride (CCl_4) vapour. The results of this test are presented as a ratio (expressed as a percentage) of the weight of CCl_4 adsorbed by the activated carbon with respect to the weight of the activated carbon under saturated conditions. Other measurements of porosity rely on different test gases such as iodine and butane.

NOTE: Both porosity and surface area are used as indicators of activity level. In both cases the assumption is that a greater surface area indicates a higher adsorptive capacity.

Substrate Surface Area (BET N_2)
Substrate surface area is the total area of the activated carbon substrate calculated by the B.E.T. equation for nitrogen (N_2) adsorption. This is often considered to be one of the primary indicators of the activity level.

Shape
Shape is a description of the actual physical form of the activated carbon (i.e. powder, pellet, chip, etc.).

Apparent Density
Apparent density or bulk density represents the packed density of a media bed. This property is important when sizing and designing air filtration equipment. The apparent density of the carbon becomes lower as the adsorption capacity increases.

Pressure Drop
Pressure drop is a measurement of the pressure across a media bed, usually expressed as inches of water per foot of bed depth. The most important physical characteristics related to pressure drop are the size and shape of the activated carbon media. It is important to note that the pressure drop across a bed of chemical filtration media does **not increase** as the media is being spent (as one would expect with a particulate filter). For this reason it is important to have the media periodically examined by a qualified laboratory to ensure timely media change-out.

Activated Carbon

Activation

Activated carbon is **"activated"** when the raw material (usually coal, wood, or shell-based carbon) undergoes a high temperature (or chemical) process to remove impurities from the internal structure of the base material. This activation process is what creates the large and intricate pore structure necessary to produce an effective adsorbent structure (see Figure 1-2); the resulting porosity and large surface area is essential for the physical adsorption process to occur.

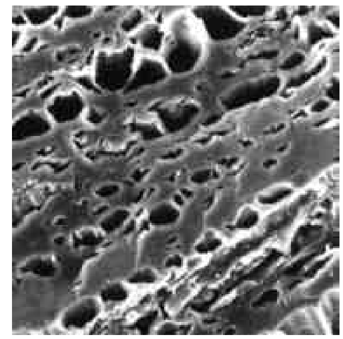

Figure 1-2 Magnification of pore structure.

Pore Distribution

An important concept associated with porosity and surface area, is the idea of pore size distribution. Although not one of the primary indicators used to contrast and compare different grades of carbon, pore size and pore size distribution is an important, if often overlooked concept related to contaminant migration and efficient adsorption.

Pore size is usually classified as follows:

Macropores	**(r > 25 nm)**	***Large***
Mesopores	**(r = 1 to 25 nm)**	***Medium***
Micropores	**(r < 1 nm)**	***Small***

In an ideal system: the macropores are used by the contaminant to enter the carbon base, the mesopores are used to transport the contaminant deeper within the structure, and the micropores are used to adsorb the contaminant out of the air stream. In general, approximately one-third distribution among each pore-class is usually desired in HVAC applications.

van der Waals Adsorption

The magic of gas-phase filtration with activated carbon relies on the process of physical adsorption or, more specifically, the **van der Waals adsorption,** which occurs between a solid and a gas. The attraction between two non-polar atoms or molecules (not surprisingly called the **van der Waals attraction**) arises from a fluctuating dipole moment in one molecule, which causes a fluctuating dipole moment in another molecule. This essentially creates an internal "charge" which enables the gaseous contaminant to precipitate out of the air stream onto the surface of the adsorbent material.

MM-3000

Coal Based Activated Carbon

MM-3000 is a pelletized activated carbon for removing a variety of odour causing organic compounds and volatile organic compounds (VOCs) through physical adsorption. It is manufactured and activated from a unique bituminous coal substrate. MM-3000 has a low-pressure drop and high adsorptive capacity.

Typical Physical and Adsorptive Characteristics	
Moisture	2 wt%
Hardness	95 wt%
Particle Diameter	3 mm
Substrate CTC	70 wt%
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	30 lb/ft^3
Pressure Drop @ 50 fpm (0.25 m/s)	1.7" of water/ft of bed (900 Pa/m)

Packaging

MM-3000 is available in 1 cu.ft. boxes, pails and 6 cu.ft. or 20 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated areas. Workers should follow federal, provincial and state safety guidelines for entering oxygen-depleted areas.

MM-3000C

Coconut Shell Based Activated Carbon

MM-3000C is a pelletized activated carbon for removing a variety of organic compounds through physical adsorption. It is manufactured and activated from a coconut shell base. MM-3000C is ideally suited for low molecular weight contaminants and has a low-pressure drop and high adsorptive capacity.

Typical Physical and Adsorptive Characteristics	
Moisture	2 wt%
Hardness	95 wt%
Particle Diameter	4 x 8 mesh or 4 x 6 mesh
Substrate CTC	60 wt%
Substrate Surface Area	1000 m^2/g
Shape	Chips
Apparent Density	30 lb/ft^3

Packaging

MM-3000C is available in 1 cu.ft. boxes, pails and 6 cu.ft. or 20 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated areas. Workers should follow federal, provincial and state safety guidelines for entering oxygen-depleted areas.

MM-3000LP

Low Pressure Drop Coal Based Activated Carbon

MM-3000LP is a pelletized activated carbon for removing a variety of odour causing organic compounds and volatile organic compounds (VOCs) through physical adsorption. It is manufactured and activated from a unique bituminous coal substrate. MM-3000LP has been enhanced for a lower pressure drop and high adsorptive capacity.

Typical Physical and Adsorptive Characteristics	
Moisture	2 wt%
Hardness	95 wt%
Particle Diameter	4 mm
Substrate CTC	70 wt%
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	30 lb/ft^3
Pressure Drop @ 50 fpm (0.25 m/s)	1.1" of water/ft of bed (900 Pa/m)

Packaging

MM-3000 is available in 1 cu.ft. boxes, pails and 6 cu.ft. or 20 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated areas. Workers should follow federal, provincial and state safety guidelines for entering oxygen-depleted areas.

Impregnated Activated Carbon (and Activated Alumina)

If there is a specific contaminant that cannot be readily removed by an existing formulation of Multi-Mix® chemical media, Circul-Aire's in-house laboratory and production facilities can custom-impregnate their media to accommodate your needs.

Impregnation and Physical Adsorption

Physical adsorption, which occurs due to the large and intricate pore structure of an activated base material, is often indiscriminate when removing odors, toxic gases, or other harmful contaminants; specific gases cannot be targeted for removal because adsorption is a **purely physical process.**

Fortunately, impregnation can be used to improve the affinity of an activated base for removing specific gases. The process of impregnation involves enhancing the inherent properties of a substrate by finely distributing certain chemical reagents on the surface of an adsorbent. This process alters the **primary** removal mechanism from physical adsorption to chemisorption.

The following table summarizes the impregnates used on Circul-Aire Multi-Mix® chemical media, and the specific contaminants targeted for removal:

Multi-Mix®	Substrate	Impregnate	Target Contaminants*
MM-1000	Activated Alumina	Potassium Permanganate ($KmnO_4$)	Hydrogen Sulfide, Sulfur Dioxide, Nitrogen Dioxide
MM-1000SP	Activated Alumina	Potassium Permanganate ($KMnO_4$)	Ethylene, Formaldehyde
MM-7000	Activated Carbon	Phosphoric Acid ($H_3P\ O_4$)	Ammonia, Amines
MM-8000	Activated Carbon	Iodine (I_2)	Mercury Vapour
MM-9000, MM-9000SP	Activated Carbon	Potassium Hydroxide (KOH)	Hydrogen Sulfide, Sulfur Dioxide, Chlorine, Hydrochloric Acid

Table 1-2 Circul-Aire Multi-Mix® media, impregnates and target contaminants.

* This is a representative sample only, please see the following section concerning contaminant removal for a full discussion of applications and media selection as they relate to Multi-Mix® media.

Acid/Base Impregnated Carbons

Base *(alkali/caustic)* impregnated carbons *(MM-9000)* are used to remove acid contaminants *(hydrogen sulphide)*, and acid impregnated *(MM-7000)* carbons are used to remove base contaminants *(ammonia)*.

Generally, there is a three-fold removal process involved when filtering contaminants with impregnated carbons:

Adsorption

The first part of the process uses adsorption like a non-impregnated carbon. The impregnate plays no useful role during this step; in fact, the impregnate necessarily lowers the capacity for straight physical adsorption by taking up adsorption sites within the carbon structure. For instance, chemical reagents almost exclusively occupy the pore structure of the MM-7000 media so that barely any adsorptive forces are being exerted on the contaminant.

Neutralization

Once the contaminant comes into contact with the impregnate, a neutralization reaction occurs:

The combination of adsorption and at least one chemical reaction, like oxidation or acid-base neutralization, creates a chemisorptive process.

Acid-Base Reaction

Acid + Base → Salt + Water

Oxidation

Finally, the contaminant can be oxidized by a catalytic reaction between the impregnate, the oxygen in the air stream and the contaminant.

Activated Alumina and Chemical Oxidation

Activated alumina impregnated with potassium permanganate is primarily a chemical oxidant (i.e. classified as a chemisorbent), although a catalytic reaction will also occur to a lesser degree.

Oxidation Reaction

Oxidant + Contaminant + Oxygen → Carbon Dioxide + Water

NOTE: The permanganate goes through several oxidation stages before its useable life is expended. As the permanganate on the outer surface is reduced, the original purple color of the pellet begins to turn brown. The color changes from light to dark brown, beginning on the surface, and eventually extending to the core. When the pellet first turns brown, approximately 80% of the pellets affective life remains.

MM-1000

Activated Alumina Impregnated with Potassium Permanganate

MM-1000 is a pelletized activated alumina impregnated with potassium permanganate for enhanced performance in removing Hydrogen Sulfide (H_2S), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Mercaptans from air streams. MM-1000 is a chemisorbent that has a low-pressure drop and a high affinity for certain contaminants species.

Typical Physical and Chemical Characteristics	
H_2S Capacity	10 wt%
Moisture	15 wt%
Crush Test	32 wt%
Particle Diameter	3.5 mm (6 mesh)
Substrate Surface Area	250 m^2/g
Shape	Spherical Pellet
Apparent Density	55 lb/ft^3
Pressure Drop @ 50 fpm	1.0” of water/ft of bed

Packaging

MM-1000 is available in 1 cu.ft. containers, 55 gallon fiber drums and 20 cu.ft. super sacks.

Safety Precautions

Do not heat or rub in contact with easily oxidizable matter. Keep away from heat and flammable materials. Handle in a well-ventilated area. Store in a cool dry area away from incompatible materials.

MM-1000SP

Special Activated Alumina Impregnated with Potassium Permanganate

MM-1000SP is a pelletized activated alumina impregnated with potassium permanganate for enhanced performance in removing Ethylene (C_2H_4), Formaldehyde (HCHO), and a large variety of odour compounds and potentially toxic vapour. MM-1000SP is a chemisorbent which has a low pressure drop and a high affinity for certain contaminants species.

Typical Physical and Chemical Characteristics	
Potassium Permanganate	5% wt/wt min.
Moisture	15 wt%
Particle Diameter*	3.5 mm (6 mesh)
Substrate Surface Area	250 m^2/g
Shape	Spherical Pellet
Apparent Density	55 lb/ft^3
Pressure Drop @ 50 fpm	1.0" of water/ft of bed

* Other sizes are available on request.

Packaging

MM-1000 is available in 1 cu.ft. containers, 55 gallon fiber drums and 6 cu.ft. or 20 cu.ft. super sacks.

Safety Precautions

Do not heat or rub in contact with easily oxidizable matter. Keep away from heat and flammable materials. Handle in a well-ventilated area. Store in a cool dry area away from incompatible materials.

MM-7000

Activated Carbon Impregnated with Phosphoric Acid

MM-7000 is a pelletized activated carbon impregnated with phosphoric acid for enhanced performance in removing Ammonia (NH_3) and caustic gases from air streams. MM-7000 is a chemisorbent manufactured from a unique bituminous substrate. MM-7000 has a low pressure drop and a high removal capacity.

Typical Physical and Chemical Characteristics	
NH_3 Capacity	5.5 wt%
Moisture	15 wt%
Hardness	95 wt%
Substrate Carbon Tetrachloride	70 wt%
Particle Diameter	4 mm
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	35 lb/ft^3
Pressure Drop @ 100 fpm	0.4" of water/in. of bed

Packaging

MM-7000 is available in 1 cu.ft. containers, 55 gallon fiber drums and 6 cu.ft. or 20 cu.ft. super sacks. Unless otherwise specified, MM-7000 is supplied in 1 cu.ft. boxes.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may result in closed vessels or poorly ventilated areas. Workers should follow federal, state and local safety guidelines for entering oxygen-depleted areas.

MM-8000

Activated Carbon Impregnated with Iodine

MM-8000 is a pelletized activated carbon impregnated with iodine for enhanced performance in Mercury Vapours. MM-8000 is a chemisorbent manufactured from a unique bituminous substrate. MM-8000 has a low-pressure drop and a high removal capacity.

Typical Physical and Chemical Characteristics	
Impregnate	3% Iodine
Capacity	2.3% wt/wt
Moisture	2 wt%
Hardness	95 wt%
Substrate Carbon Tetrachloride	70 wt%
Particle Diameter	4 mm
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	31 lb/ft^3
Pressure Drop @ 50 fpm	1.1" of water/ft. of bed

Packaging

MM-8000 is available in 1 cu.ft. boxes, and 6 cu.ft. or 20 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may result in closed vessels or poorly ventilated areas. Workers should follow federal, state and local safety guidelines for entering oxygen-depleted areas.

MM-9000

Activated Carbon Impregnated with Potassium Hydroxide

MM-9000 is a pelletized activated carbon impregnated with potassium hydroxide for enhanced performance in removing acid gases like H_2S, SO_2, Cl_2, and HCl from air streams. MM-9000 is a chemisorbent manufactured from a unique bituminous substrate. MM-9000 has a low-pressure drop and a high removal capacity.

Typical Physical and Chemical Characteristics	
H_2S Capacity	0.16 H_2S/cc
Moisture	15 wt%
Hardness	95 wt%
Substrate Carbon Tetrachloride	70 wt%
Particle Diameter	3 mm
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	35 lb/ft^3
Pressure Drop @ 50 fpm	1.7" of water/ft. of bed

Packaging

MM-9000 is available in 1 cu.ft. containers, 55 gallon fiber drums and 6 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may result in closed vessels or poorly ventilated areas. Workers should follow federal, state and local safety guidelines for entering oxygen-depleted areas.

MM-9000LP

Low Pressure Drop Activated Carbon Impregnated with Potassium Hydroxide

MM-9000LP is a pelletized activated carbon impregnated with potassium hydroxide for enhanced performance in removing acid gases like H_2S, SO_2, Cl_2, and HCl from air streams. MM-9000LP is a chemisorbent manufactured from a unique bituminous substrate. MM-9000LP has an enhanced, low pressure drop while maintaining a high removal capacity.

Typical Physical and Chemical Characteristics	
H_2S Capacity	0.16 H_2S/cc
Moisture	15 wt%
Hardness	95 wt%
Substrate Carbon Tetrachloride	70 wt%
Particle Diameter	4 mm
Substrate Surface Area	1250 m^2/g
Shape	Pellet
Apparent Density	35 lb/ft^3
Pressure Drop @ 50 fpm	1.1" of water/ft. of bed

Packaging

MM-9000LP is available in 1 cu.ft. containers, 55 gallon fiber drums and 6 cu.ft. super sacks.

Safety Precautions

Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may result in closed vessels or poorly ventilated areas. Workers should follow federal, state and local safety guidelines for entering oxygen-depleted areas.

Custom Blends of Multi-Mix® Chemical Media

Depending on the application and the contaminants involved, a special blend of chemical media may be required for optimal performance and media life. These custom mixes are designated by the following nomenclature:

MM-**X** <u>Y</u> ***X%*** <u>*Y%*</u>

Where,

X denotes the first digit of the identifying number of the first Multi-Mix® media selected

Each application is unique and requires careful consideration before a blend can be recommended.

X% corresponds to the first digit of the percentage of Multi-Mix® **X** in the blend

Y denotes the first digit of the identifying number of the second Multi-Mix® media selected

Y% corresponds to the first digit of the percentage of Multi-Mix® Y in the blend

For example: A popular blend of chemical media (especially for airport applications) is **MM-1355**. In this case,

- **1** represents MM-**1**000,
- **3** denotes MM-**3**000;
- **5** indicates that **5**0% of the blend should be MM-1000,
- **5** indicates that the other **5**0% of the blend should be MM-3000.

The mixture combines the adsorptive and chemisorptive properties of both media, normally requiring two beds, into a single bed. In the case of MM-1355, the MM-1000 pellets are also protected from “blinding” or crystallization.

Please note: To ensure optimal media combinations and correct media weightings, the laboratory should verify the specific blend of chemical media.

A brief summary of some of Circul-Aire’s combinatorial media immediately follows.

MM-1355

(50% MM-1000 / 50% MM-3000)

MM-1355 provides enhanced performance in controlling compounds usually controlled by MM-1000 and MM-3000 with the added benefit of protecting the MM-1000 pellets from "blinding" or crystallization. Please refer to the specifications for MM-1000 and MM-3000 for a full product description. The combined benefits of both media may be realized in one bed.

Combined Properties	
Average Density	42.5 lb/ft^3
Pressure Drop @ 100 fpm	0.3" of water/in. of bed

Other blends that have also been furnished by Circul-Aire are MM-1346, MM-1364. Not all combinations are listed. The final media selection is application specific.

MM-1373

(70% MM-1000 / 30% MM-3000)

MM-1373 provides enhanced performance in controlling compounds usually controlled by MM-1000 and MM-3000 with the added benefit of protecting the MM-1000 pellets from "blinding" or crystallization. Please refer to the specifications for MM-1000 and MM-3000 for a full product description. The combined benefits of both media may be realized in one bed.

Combined Properties	
Average Density	47.5 lb/ft^3
Pressure Drop @ 50 fpm	1.2" of water/ft. of bed

MM-1973

(70% MM-1000 / 30% MM-9000)

MM-1973 provides enhanced performance in controlling compounds usually controlled by MM-1000 and MM-9000. Please refer to the specifications for MM-1000 and MM-9000 for a full product description. The combined benefits of both media may be realized in one bed.

Combined Properties	
Average Density	49 lb/ft^3
Pressure Drop @ 50 fpm	1.2" of water/ft. of bed

MM-1955

(50% MM-1000 / 50% MM-9000)

MM-1955 provides enhanced performance in controlling compounds usually controlled by MM-1000 and MM-9000. Please refer to the specifications for MM-1000 and MM-9000 for a full product description. The combined benefits of both media may be realized in one bed.

Combined Properties	
Average Density	45 lb/ft^3
Pressure Drop @ 100 fpm	0.4" of water/in. of bed

Specialty Media

MM-100 and MM-200

Circul-Aire also offers specialty media for unique applications: removing carbon monoxide and carbon dioxide from air streams.

MM-100

Carbon Monoxide (CO) Catalyst

MM-100 is a special high surface area alumina based catalyst impregnated with copper chloride, palladium chloride and nickel oxide. This catalyst converts carbon monoxide (CO) to carbon dioxide (CO_2) in the treated air stream. The metallic salts act as a catalyst and therefore are never consumed. However, the media life can be diminished due to various types of poisoning which may occur.

Typical Characteristics	
Appearance	Bluish green beads
Shape	Spherical
Particle Diameter	2.8 mm
Apparent Density	25-30 lb/ft^3
Pressure Drop @ 50 fpm	1.0" of water/ft. of bed

MM-200

Carbon Dioxide (CO_2) Absorbent

MM-200 consists of hydrated lime ($Ca(OH)_2$), sodium hydroxide (NaOH) and potassium hydroxide (KOH), specially mixed with a carefully controlled moisture content.

The media is specially processed into pellets to allow the greatest exposure area for the absorbent surface. The granules permit free inter-granular circulation of gases. The hardness of the pellets makes them highly resistant to powdering and breakage.

Quality Control and Media Production

Quality Control (QC) for Multi-Mix® Media

All starting material used in the production of Circul-Aire Multi-Mix® must pass stringent test requirements before it can be used in media production. At several stages during the manufacture of the media, tests are also performed on the intermediate product, where properties like percentage moisture, percentage impregnate, pellet strength and bulk density are measured. The results of these tests are used to fine tune manufacturing criterion, and to ensure optimal media production.

Quality Assurance (QA) for Multi-Mix® Media

To guarantee the satisfaction of the end-user, the in-house laboratory also performs certain quality assurance protocols. Each production run is given a batch number, and each box filled from that batch is coded with the batch number and a number corresponding to its position in the batch.

Samples are randomly taken from each pallet at specified intervals (the interval varies depending on the media in question) and tested by the Quality Assurance Lab. Final quality assurance testing covers all aspects of the final product, and includes an examination of:

I Physical Properties

Appearance: Uniform in color, uniform in size.

Density: Weight per cubic foot.

Size: Percentage of desired mesh size, percentage of undesired mesh size.

Dusting: Percentage of losses due to attrition.

II Chemical Properties

Moisture: Percentage of water.

Impregnate: Percentage of impregnate.

III Performance

Removal Efficiency: Tested against the appropriate contaminant.

The actual test procedures used by the Quality Assurance Laboratory are outlined in the Circul-Aire QA Manifesto and include but are not limited to the following tests:

Laboratory and Production Test Procedures

Apparent Density, lb/ft^3
ASTM 2854, *Apparent Density for Activated Carbon*

CATM, *Apparent Density for MM-1000 Media*

Moisture, %
ASTM D2867, *Moisture in Activated Carbon*

CATM-001, *Moisture Content in MM-1000 Media*

Particle Diameter, mm
CATM-011C, *Particle Size Distribution of Circul-Aire Activated Carbon*

CATM-011P, *Particle Size Distribution of Circul-Aire MM-1000 Media*

Performance
CATM-013, *Circul-Aire Media Performance Test: 50 PPM Challenge*

Potassium Permanganate, %
CATM-002, *Determination of Potassium Permanganate in MM-1000*

Pressure Drop, inch H_2O / ft of bed
PITAH-38.25, *Pressure Drop Across Chemical Media Beds*

Substrate CTC Activity, %
ASTM D3467, *Carbon Tetrachloride Activity of Activated Carbon*

Substrate Hardness
ASTM D3802, *Ball-Pan Hardness of Activated Carbon*

CATM-012, *Compaction Test for MM-1000 Media*

Substrate Surface Area, m^2/g
BET N_2: Based on the *Brunauer, Emmett and Teller equation* for nitrogen adsorption.

XX, Capacity, %
ASTM Dxxxx, *1% Capacity Test, H_2S*

Chapter 2

Contaminants and Applications

Circul-Aire's Guide to Gaseous Contaminant Removal and Appropriate Media Selection

For the novice, making media selections is often one of the most difficult aspects of the gas-phase filtration design process; when confronted with an unusual situation, it is best not to panic.

> **"What have you got to remove 3-methyl-2-butanone?"…Pause…"Um, could you hang on a second?"**

Building on the foundations of the previous chapter, we will begin by examining chemical compounds in general (mostly for vocabulary and to ensure a common footing in basic chemistry). Then, appropriate media selections for specific contaminants will be presented; finally, a discussion of some frequently encountered applications will bring everything into focus.

Classes of Chemical Compounds

Organic Compounds

Generally, an **organic compound** is any compound that contains a carbon atom. The simplest organic compound contains both hydrogen and carbon; these are referred to as **hydrocarbons (HC)**. Hydrocarbons are familiar to most people in the air purification industry, particularly those involved with outdoor air filtration in urban environments. What most people do not know, however, is that the term hydrocarbon is a very broad definition of a huge part of organic chemistry. What is usually meant in most air purification literature, when hydrocarbons are mentioned, are pure hydrocarbons (i.e. those compounds that are entirely composed of hydrogen and carbon molecules, ***only***).

Note: There are over one million compounds that contain carbon. This is due to the property of catenation (the ability of carbon compounds to form large chains or rings).

Species of Pure Hydrocarbons

Note: The easiest way for a layperson to identify chemical families is by examining the prefix and/or suffix of the contaminant in question. However, the lab should verify all media selections based on this type of identification.

ALKANES

Alkanes are saturated (i.e. carbon-carbon bonds are single bonds) hydrocarbons of the form C_nH_{2n+2} (where n is the number of carbon atoms). The alkane series is also called the methane series because methane is the simplest alkane of the series.

Some examples of compounds contained in this group are summarized below:

meth**ane** (CH_4), eth**ane** (C_2H_6), prop**ane** (C_3H_8), but**ane** (C_4H_{10}), pent**ane** (C_5H_{12}), hex**ane** (C_6H_{14}), hept**ane** (C_7H_{16}), oct**ane** (C_8H_{18}), non**ane** (C_9H_{20}), dec**ane** ($C_{10}H_{22}$).

Notice that many of these compounds are quite familiar (i.e. methane, propane, butane, octane) and notice that the suffix **-ane** makes any member of the alk**ane** family easily identifiable.

CYCLOALKANES (CYCLICALKANES)

Cycloalkanes are saturated ring compounds having the general formula C_nH_{2n}. Some examples of cylcoalkanes are:

cycloprop**ane** (C_3H_6), methyl**cyclo**but**ane** (C_5H_{10}), **cylco**but**ane** (C_4H_8), **cyclo**pent**ane** (C_5H_{10}).

Cycloalk**anes** are similarly easy to identify because the **cyclo-** prefix and **-ane** suffix are usually contained somewhere within in the chemical name.

ALKENES (OLEFINS)

Alkenes are unsaturated (i.e. carbon-carbon bonds are double or triple bonds) having the general formula C_nH_{2n} . Chemically, the formula for cycloalkanes and alkenes are quite similar, the only difference between them are chemical structure and bonding. Fortunately, members of the alk**ene** family can be identified by the **-ene** suffix. As can be seen the following partial list of alk**enes**:

eth**ene** [ethyl**ene**, **olefiant** gas] (C_2H_4), prop**ene** (C_3H_6), 1,2-pentadi**ene** (C_5H_{10}), butyl**ene** (C_4H_8).

Note: To effectively design gas-phase filtration equipment it is essential to gather as much information as possible about the contaminants involved: chemical name and or formula, CAS number, concentrations, etc.

ALKYNES

Alkynes have a triple bond of the form C_nH_{2n-2}. When naming alk**yne**s the **-ane** suffix of the alk**ane** (single bond, saturated) group is replaced by **-yne**. As in:

> eth**yne** [welding gas] (C_2H_2), and 2-but**yne** (C_4H_4).

AROMATIC HYDROCARBONS (AROMATICS)

All aromatic hydrocarbons contain at least one ring of carbon atoms, held together by delocalized electrons. With this definition, it is difficult to qualify those compounds that fall under this category, especially since many of these compounds end with the -ene suffix that we have used to identify the alkene family. The best approach would probably be to memorize the most popular compounds of the aromatic species of hydrocarbons. Like:

> toluene (C_7H_8), ethylbenzene (C_8H_{10}), propylbenzene (C_9H_{12}), xylene ($C_{24}H_{30}$), naphthalene ($C_{10}H_8$), anthracene ($C_{14}H_{10}$), aspirin [acetylsalicyclic acid] ($C_9H_8O_4$), 2,4,6-trinitritiluene [TNT] ($C_7H_5N_3O_6$), dichlorodiphenyltrichloroethane [DDT] ($C_{12}H_9Cl_5$).

The following table reiterates the sub-species, or families of hydrocarbons that contain only hydrogen and carbon:

Hydrocarbon Summary (HC's Containing Hydrogen and Carbon Only)			
Family	**General Formula**	**Textual Identification**	**Miscellaneous**
Alk**ane**s	C_nH_{2n+2}	**-ane**	single bond
Cycloalk**ane**s	C_nH_{2n}	**cyclo-; -ane**	single bond
Alk**ene**s	C_nH_{2n}	**-ene**	double bond
Alk**yne**s	C_nH_{2n-2}	**-yne**	triple bond
Aromatics	-	-	ring structure

Hydrocarbons Containing Oxygen

HYDROXY COMPOUNDS (ALCOHOLS)

Hydroxy compounds, or alcohols, have a hydroxl group **-OH** attached to the alkyl group. They are named by dropping the **-e** of the alk**ane** series and adding the **-ol** suffix.

Consider the following examples of alcoh**ol**s that use the **-ol** naming convention:

> methan**ol** (CH_4O), ethan**ol** (C_2H_6O), **phenol** (C_6H_6O), ethyl alcoh**ol** (C_2H_6O), isopropyl alcoh**ol** (C_3H_8O), methyl alcoh**ol** [rubbing alcohol] (C_3H_8O).

CARBOXYLIC ACIDS (ORGANIC ACIDS)

All organic acids have the carboxyl group. The carboxylic acid group is usually written as **-COOH**. The **-e** in the chain name is dropped and **-oic** plus the word "**acid**" is added, making them fairly easy to identify. More common forms replace **-oic** with **-ic** suffix added.

Examine the following organic acids and notice the patterns:

> methan**oic acid** [form**ic acid**] (CH_2O_2), ethan**oic acid** [vinegar, acet**ic acid**] ($C_2H_4O_2$), benz**oic acid** ($C_7H_6O_2$), butyr**ic acid** ($C_4H_8O_2$), isovaler**ic acid** ($C_5H_{10}O_2$).

ALDEHYDES

The functional group of aldehydes is similar to the carboxyl group. Identifying **aldehydes** can be achieved by spotting the **-al** or **-aldehyde** suffix.

For example, examine the suffixes in the following chemical names:

> methan**al** [form**aldehyde**] (CH_20), ethan**al** (C_2H_4O), propan**al** (C_3H_6O), butan**al** (C_4H_8O), benz**aldehyde** (C_7H_6O), acet**aldehyde** (C_2H_4O).

KETONES

Obeying a now familiar pattern, the ket**one** family of hydrocarbons uses the **-one** suffix to name compounds.

To illustrate examine the following chemical names for some ketones:

propan**one** [acet**one**] (C_3H_6O), diphenylmethan**one** ($C_{13}H_{10}O$), methylethylket**one** (C_4H_8O).

ESTERS

Esters are formed from organic acids, hence, the **-ic** suffix from the acid name is dropped and the **-ate** is substituted in it's place.

Refer to the following examples for clarification:

ethyl propano**ate** ($C_5H_{10}O_2$), methyl benzo**ate** ($C_8H_8O_2$).

ETHERS

Ethers have the general formula R-O-R in which an oxygen atom is joined to two separate hydrocarbon groups (where R represents a hydrocarbon group). Ethers are named as **-oxy-** derivatives of hydrocarbons.

Notice the introduction of the **-oxy-** string in the naming conventions of the following ethers:

meth**oxy**ethane (C_3H_8O), meth**oxy**benzene (C_7H_8O).

Hydrocarbon Summary (HC's Containing Oxygen)		
Family	**General Formula**	**Textual Identification**
alcohols	R-OH	**-ol**
organic acids	R-carboxyl group	**- oic acid**
aldehydes	R-carbonyl group	**-al**
ketones	w/ cabonyl group	**-one**
esters	w/ carboxyl group	**-ate**
etrshe	R-O-R	**-oxy-**

Halogen Derivatives of Hydrocarbons (Alkyl Halides, Halocarbons, Halo Alkanes, Halogenated Hydrocarbons)

By replacing a hydrogen atom with a halogen atom in a typical hydrocarbon, a halogen derivative of a hydrocarbon is created. A halogen atom is defined as a member of the halogen series on the periodic table, namely: -F, **fluoro**; -Cl, **chloro**; -Br, **bromo**; and -I, **iodo**. These compounds are also known as alkyl halides. Specific examples of halo alkanes usually contain the string indicative of the halogen contained in the compound: i.e. 1-**chloro**propane (C_3H_7Cl), 1,4-di**bromo**benzene ($C_6H_4Br_2$).

Nitrogen Containing Hydrocarbons (Ammonia Derivatives)

Ammonia (NH_3) is an inorganic compound, as it does not contain a carbon molecule. However, when one, two, or three of the hydrogen atoms in the ammonia molecule is replaced by a hydrocarbon, the result is an organic nitrogen containing hydrocarbon. These are commonly referred to as **amines** (e.g. ethyl**amine**): primary amines, secondary amines, and tertiary amines. Other classes of nitrogen containing organic compounds are **amides** (e.g. ethan**amide**), **amino acids** (e.g. 2-**amino**propanoic **acid**), **nitriles** (e.g. butane**nitrile**), and **nitro** compounds (e.g. **nitro**benzene).

Sulfur Containing Hydrocarbons (Hydrogen Sulfide Derivatives)

Similar to the inorganic derivation of amines, organic sulfur containing compounds are derived from the inorganic hydrogen sulfide. (H_2S) When organic compounds are derived from sulfur compounds, may be referred to as **mercaptans** [i.e. butyl **mercaptan** ($C_4H_{10}S$), ethyl **mercaptan** (C_2H_6S), methyl **mercaptan** (CH_4S)].

Volatile Organic Compounds (VOCs)

Volatile organic compounds are not really a family of organic compounds from a strictly chemical perspective. In the air quality industry, however it useful to define some organic compounds with respect to certain physical properties. The definition of a VOC is as follows:

> **A Volatile Organic Compound (VOC) is a compound which contains at least one carbon atom and has a vapor pressure of at least 0.01kPa at 25 Deg.C, excluding carbon monoxide and carbon dioxide.**

To elaborate, the **vapour pressure** is a measure of how readily something **evaporates**. Therefore, for a compound to be classified as volatile, it must readily vaporize (evaporate) at room temperature and standard pressure. Volatile organic compounds can be members of any of the families of organic compounds, provided it meets the criteria of the definition.

> Some examples of **volatile organic compounds** are: **gasoline** (-), **benzene** (C_6H_6), **toluene** (C_7H_8), **xylene** ($C_{24}H_{30}$), **formaldehyde** (CH_2O), **varsol** (-), **acetone** (C_3H_6O), **chloroform** ($CHCl_3$), **butane** (C_4H_{10}), **propane** (C_3H_8) and **napthalene** ($C_{10}H_8$).

Inorganic Compounds

Categorizing inorganic compounds according to specific sub-species, or families, as was done with organic compounds is a little more difficult. Inorganic compounds do not lend themselves to neat categories and definitions.

To contrast the difference between the two types of compounds it is probably wise to examine the difference between organic chemistry and inorganic chemistry.

> Generally, **organic chemistry** is the study of the composition, reactions, and properties of carbon-chain or carbon-ring compounds and mixtures thereof.
>
> Whereas **inorganic chemistry** is the study of chemical reactions and properties of all the elements and their compounds, with the **exception** of hydrocarbons, and usually **including** carbides, oxides of carbon, metallic carbonates, carbon sulfur compounds, and carbon nitrogen compounds.

The following tables list some commonly occurring inorganic compounds.

Inorganic Nitrogen Compounds

ammonia (NH_3), cyanogen (C_2N_2), hydrasine (N_2H_4), nitric acid (HNO_2), nitrous oxide (N_2O)

oxides of nitrogen (NO_X): nitrogen monoxide (NO), nitrogen dioxide (NO_2), nitrogen trioxide (NO_3)

Inorganic Sulfur Compounds

hydrogen sulfide (H_2S), sulfuric acid (H_2SO_4), sulfur monobromide (S_2Br_2)

oxides of sulfur (SO_X): sulfur dioxide (SO_2), sulfur trioxide (SO_3)

Inorganic Carbon Compounds

carbon disulfide (CS_2), carbon suboxide (C_2O_2), carbon oxychloride [a.k.a. phosgene] ($COCl_2$)

oxides of carbon (CO_X): carbon monoxide (CO), carbon dioxide (CO_2)

Inorganic Chlorine Compounds

chlorine (Cl_2), hydrochloric acid (H_2SO_4), chloric acid ($HClO_2.7H_2O$), chlorosulfonic acid ($HO.SO_2.Cl$)

Miscellaneous Inorganic Compounds

hydrofluoric acid [hydrogen fluoride] (HF)

phosphine (PH3)

ozone (O3)

Multi-Mix® Media Recommendations for Common Gaseous Contaminants*

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Acetaldehyde	●	○		
Acetic Acid	●			○
Acetic Anhydride	●			○
Acetone	●			
Acetylene	●			
Acalylane	○	●		
Acrolam	○	●		
Acrolein	●	○		
Acrylaldehyde	●	●		
Acrylic Acid	●			○
Acronitrile	○	●		
Acrylonrole	●	○		
Allyl Chloride		●		○
Allyl Sulfide	●	○		
Ammonia (NH_3)			●	
Amyl Acetate	○	●		
Amyl Alcohol	●	○		
Amyl Ether	●	○		
Aniline	○	●		
Arsine	●			
Benzene		●		
Borane	●	○		
Bromine		●		
Butadiene (1,3-)	●	○		
Butane		●		
Butane Diamine	○	●		
Butanone (2-)	●	○		

● A column with a solid dot implies that it is a primary media selection for the contaminant indicated.

○ A column with an open dot implies that it is a secondary media selection for the contaminant indicated.

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Butyl Acetate	●	○		
Butyl Alcohol	○	●		
Butyl Cellosolve	○	●		
Butyl Chloride		●		
Butyl Ether		●		
Butyl Mercaptan	○	●		
Butylene	○	●		
Butyne	○	●		
Butyraldehyde	○	●		
Butyric Acid		●		○
Cadaverine	○	●		
Camphor		●		
Caproic Acid		○		●
Caprylic Acid		○		●
Carbolic Acid		○		●
Carbon Dioxide (CO_2)	***MM-200***			
Carbon Disulfide	○	●		
Carbon Monoxide (CO)	***MM-100***			
Carbon Tetrachloride		●		
Cellosolve	○	●		
Cellosolve Acetate	○	●		
Chlorine (Cl_2)				●
Chlorobenzene		●		
Chlorobutadiene	○	●		
Chloroform		●		
Chloronitropropane		●		
Chlorophenol	○	●		
Chloropicrin		●		
Chloroprene	○	●		
Creosote	●	○		
Cresol		●		
Crotonaldehyde	○	●		
Cyclohexane		●		
Cyclohexanol	○	●		
Cyclohexanone	○	●		
Cyclohexene		●		
Decane		●		
Diborane	●			

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Dibromomethane		●		
Dichloroethane (1,2-)		●		
Dichloromonofloromethane		●		
Dichloronitroathene		●		
Dichloropropane		●		
Dichlorotetrafluoroethane		●		
Dichlorothyelether	○	●		
Diethylamine	○	●		
Diethyl Ketone	○	●		
Dimethylamine		●	○	
Dimethylaniline	○	●		
Dimethyl Disulfate		●		
Dimethyl Sulfate	●			○
Dioctyl Phthalate		●		
Dioxane	●	○		
Dipropyl Ketone	●			
Ethanol	●	○		
Ether	●	○		
Ethyl Acetate	○	●		
Ethyl Alcohol	○	●		
Ethylamine		●	○	
Ethylbenzene		●		
Ethyl Bromide		●		
Ethyl Chloride	●	○		
Ethylene (C_2H_4)	●			
Ethylene Chlorhydrin	●			
Ethylene Oxide	●	○		
Ethyl Ether	○	●		
Ethyl Formate	○	●		
Ethyl Mercaptan	●			○
Ethyl Silicate		●		
Fluorotrichloromethane		●		
Formaldehyde (HCOH)	●			
Formic Acid				○
Gasoline	●			
General Hydrocarbon (HC)*	○	●		

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
*General VOC***	○	●		
Halocarbons		●		
Heptane		●		
Hexane		●		
Hexylene	○	●		
Hexyne	○	●		
Hydrogen Bromide		○		●
Hydrogen Chloride		○		●
Hydrogen Cyanide	●			
Hydrogen Fluoride (HF)	●			●
Hydrogen Iodide	○			
Hydrogen Selenide				
Hydrogen Sulfide (H_2S)	●			●
Indole		●		
Iodine		●		
Iodoform	○	●		
Isophorone	○	●		
Isoprene	○	●		
Isopropanol		●		
Isopropyl Acetate	○	●		
Isopropyl Alcohol	○	●		
Isopropyl Ether	○	●		
Isovaleric Acid	●			
Kerosene		●		
Lactic Acid		●		
Menthol	○	●		
Mercury Vapour	*MM-8000*			
Methanol	○	●		
Methyl Acetate	●	○		
Methyl Acrylate	○	●		
Methyl Alcohol	●			
Methyl Bromide		●		
Methyl Butyl Ketone	●	○		
Methyl Cellosolve	●	○		

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Methyl Cellosolve Acetate	○	●		
Methyl Chloride		●		
Methylchloroform		●		
Methylcyclohexane		●		
Methylcyclohexanol		●		
Methylcyclohexanone		●		
Methylene Chloride		●		
Methyl Ether	○	●		
Methyl Ethyl Ketone		●		
Methyl Formate	○	●		
Methyl Isobutyl Ketone	○	●		
Methyl Mercaptan	●			
Methyl Pyrrolidine	○	●		
Methyl Sulfide	●			
Methyl Vinyl Ketone	○	●		
Monochlorobenzene		●		
Monoflorotrichloromethane	●			
Monomethyl Amine		○	●	
Naphtha		●		
Naphthalene		●		
Nicotine	●	○		
Nicotinic Acid	○	●		
Nitric Acid				●
Nitric Oxide (NO)	●			○
Nitrobenzene		●		
Nitroethane		●		
Nitrogen Dioxide (NO_2)	●			○
Nitroglycerine	○	●		
Nitromethane	●			
Nitropropane	●			
Nitrotoluene	●	○		
Nitrous Oxide				●
Nonane	○	●		
Octalene	○	●		
Octane	○	●		
Ozone (O_3)	○	●		
Palmitic Acid	○	●		
Paradichlozbenzene		●		

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Pentane	○	●		
Pentanone (3-)	●	○		
Pentylene	○	●		
Pentyne	○	●		
Perchloroethylene	●			
Perchloroethylene	●			
Peroxy Acetyl Nitrate (PAN)		●		
Phenol	○	●		
Phosgene	○	●		
Phosphine	●			
Propanol	○	●		
Propionaldehyde	●	○		
Propionic Acid	●	○		
Propyl Acetate	●	○		
Propyl Alcohol	○	●		
Propyl Chloride		●		
Propyl Ether	○	●		
Propyl Mercaptan	○	●		
Propylene		●		
Propyne		●		
Putrescine	●	○		
Pyridine	●			
Skatole	○	●		
Silane	●			
Stoddard Solvent	●			
Stibine	●			
Styrene	○	●		
Styrene Monomer	○	●		
Sulfur Dioxide (SO_2)	●			●
Sulfur Trioxide (SO_3)	●			●
Sulfuric Acid		○		●
Tetrachloroethane		●		
Tetrachloroethylene	○	●		
Toluene		●		
Toluidine	○	●		
Triarylphosphate	○	●		
Triethylamine		○	●	
Trichlorethylene		●		

Gaseous Contaminants	Gaseous Contaminants			
	MM-1000	MM-3000	MM-7000	MM-9000
Trichloroethane	●	○		
Trihalomethanes	○	●		
Trimethylamine		○		
Turpentine	○	●		
Urea	○	●		
Uric Acid	●			○
Valeric Acid	●			
Valeric Aldehyde	●	○		
Vinyl Chloride		●		
Xylene		●		

For a quick reference to Circul-Aire media recommendations with respect to some of the more commonly occurring contaminants, please consult Appendix B: Circul-Aire Quick Reference Guide-Sheet.

Commercial Applications*

COMMMERCIAL APPLICATION	CONTAMINANTS AND/OR CONTAMINANT SPECIES	MULTI-MIX® MEDIA
Airport Terminals *(Ground Side)*	ETS, fumes, food odors	MM-3000/MM-1000
Airport Terminals *(Air Side)*	NO_X, SO_X, O_3, VOC, HC, mercaptans	MM-3000/MM-1000
Animal Holding Rooms	urine, excreta, pet odors	MM-1000/MM-7000
Art Studios	multiple organics & inorganics	MM-3000/MM-1000
Athletic Clubs	body odors, Valeric Acid	MM-3000/MM-1000
Auditoriums	multiple organics & inorganics	MM-3000/MM-1000
Autopsy Rooms	formaldehyde	MM-1000/MM-1000
Banks (customer area)	formaldehyde, multiple organics & inorganics	MM-3000/MM-1000
Banks (vault area)	formaldehyde	MM-1000/MM-1000
Banquet Rooms	ETS, body odors, food odors	MM-3000/MM-1000
Barber Shops	ETS	MM-1000/MM-1000
Bars	ETS, body odors, perfume	MM-3000/MM-1000
Beauty Salons	multiple organics & inorganics	MM-3000/MM-1000
Bingo Halls	ETS	MM-3000/MM-1000
Brasseries	ETS, food odors, body odors	MM-3000/MM-1000
Bus Terminals	ETS	MM-3000/MM-1000
Cafeterias	ETS, kitchen fumes	MM-3000/MM-1000
Casinos	ETS	MM-3000/MM-1000
Clinics	multiple organics & inorganics	MM-3000/MM-1000
Cocktail Lounges	ETS, food odors	MM-3000/MM-1000
Conference Rooms	ETS, body odors, furn off gasing	MM-3000/MM-1000

* This table summarizes some of the most common contaminants, which may be present in certain commercial applications. Please be advised that **each application is unique**, and that the greatest effort should be made to determine the actual contaminants involved in each specific application. These tables should only be used as a guide, actual field conditions may vary.

COMMMERCIAL APPLICATION	CONTAMINANTS AND/OR CONTAMINANT SPECIES	MULTI-MIX® MEDIA
Correctional Facilities	ETS, body odors	MM-3000/MM-1000
Darkrooms	multiple organics & inorganics	MM-3000/MM-1000
Decal Application	multiple organics & inorganics	MM-3000/MM-1000
Dentists' Offices	multiple organics & inorganics	MM-3000/MM-1000
Dining Rooms	food odors, ETS	MM-1000/MM-1000
Doctors' Offices	multiple organics & inorganics	MM-3000/MM-1000
Drafting Areas	multiple organics	MM-1000/MM-7000
Drafting Areas (w/ BPM)	ammonia, mutiple organics	MM-3000/MM-1000
Dry Cleaners (dust area)	multiple organics & inorganics	MM-3000/MM-1000
Embalming Rooms	formaldehyde, multiple organics	MM-3000/MM-1000
Factories (office area)	ETS, furniture	MM-3000/MM-1000
Fertilizer Plants (office)	ammonia, ETS	MM-1000/MM-7000
Fish Markets	tri-methyl amine	MM-1000/MM-1000
Florists	floral scents	MM-3000/MM-9000
Fruit & Vegetable Storage Areas	ethylene, multiple organics	MM-3000/MM-1000
Funeral Homes	ETS, body odors, furniture	MM-3000/MM-1000
Garbage Disposal Areas	multiple organics & inorganics, acidic compounds	MM-1000/MM-9000
Geriatrics	body odors, urine, excreta	MM-3000/MM-1000
Greenhouses	ethylene, multiple organics	MM-3000/MM-1000
Grocery Stores	multiple organics & inorganics	MM-3000/MM-1000
Hospitals	multiple organics & inorganics, body odors	MM-3000/MM-1000
Hospitals (autopsy)	formaldehyde	MM-1000/MM-1000
Hotels (smoking, renovation)	ETS, particulates, paint	MM-3000/MM-1000
Institutions (psychiatry)	ETS, body odors, urine	MM-3000/MM-1000
I.C.U.'s	multiple organics & inorganics	MM-3000/MM-1000

COMMMERCIAL APPLICATION	CONTAMINANTS AND/OR CONTAMINANT SPECIES	MULTI-MIX® MEDIA
Kitchen Exhausts	odorous fumes	MM-3000/MM-1000
Laboratories (research)	multiple organics & inorganics from solvent, etc.	Consult Office
Libraries	multiple hydrocarbons	MM-3000/MM-1000
Locker Rooms	moldy odors, Valeric Acid	MM-3000/MM-1000
Lounges	ETS	MM-3000/MM-1000
Lunch Rooms	multiple odors, ETS, food	MM-3000/MM-1000
Morgues	formaldehyde	MM-1000/MM-1000
Motels	furnishings, ETS	MM-3000/MM-1000
Museums	multiple contaminants	MM-3000/MM-1000
Night Clubs	ETS, body odors, perfume	MM-3000/MM-1000
Nurseries	multiple organics & inorganics	MM-3000/MM-1000
Office Buildings	ETS, paint fumes, furniture	MM-3000/MM-1000
Paint Shops	toluene, xylene, multiple organics	MM-3000/MM-1000
Painted Rooms	paint fumes	MM-3000/MM-1000
Penal Institutions	ETS, body odors	MM-3000/MM-1000
Pet Shops	urine, animal odors	MM-1000/MM-7000
Pharmacies	multiple contaminants	MM-3000/MM-1000
Photo Stores	multiple hydrocarbons	MM-3000/MM-1000
Photographic Studios	multiple hydrocarbons	MM-3000/MM-1000
Physiotherapy	multiple hydrocarbons	MM-3000/MM-1000
Printing Plants	hydrocarbons & ammonia	MM-3000/MM-7000
Projection Booths	hydrocarbons, ETS, food odors	MM-3000/MM-1000
Psychiatric Wards	ETS, body odors	MM-3000/MM-1000
Public Toilets	urine, excreta, body odors	MM-3000/MM-1000
Recreation Halls	multiple contaminants	MM-3000/MM-1000
Rendering Plants	multiple organics	MM-3000/MM-1000
Restaurants	food odors, ETS	MM-3000/MM-1000
Segregated Smoking Rooms	ETS, body odors, perfume	MM-3000/MM-1000
Storage Rooms	multiple organics & inorganics	MM-3000/MM-1000
Stores	multiple organics & inorganics	MM-3000/MM-1000
Theaters	ETS, food odors	MM-3000/MM-1000
Veterinary Hospitals	animal odors, urine	MM-1000/MM-7000
Waiting Rooms	ETS	MM-3000/MM-1000

Industrial Applications

INDUSTRIAL PROCESS	ANTICIPATED GASEOUS CONTAMINANTS		MULTI-MIX® MEDIA*
	CHEMICAL NAME	CHEMICAL FORMULA	
Aluminum Manufacturing	chlorine	Cl_2	MM-9000
	hydrogen chloride	HCl	MM-9000
	hypochlorous acid	HOCl	MM-9000
	hydrogen fluoride	HF	MM-9000
	sulphur oxides	SO_X	MM-1000
	nitrogen oxides	NO_X	MM-9000
	hydrocarbons	HC	MM-3000
Battery Manufacturing	sulphur oxides	SO_X	MM-1000
	acid gases	**	**
Fertilizer Manufacturing	ammonia	NH_3	MM-7000
	hydrogen fluoride	HF	MM-9000
	hydrocarbons	HC	MM-3000
	ethylene	CH_4	MM-1000

* Generally recommended Multi-Mix® media for the contaminant in question.

** Consult head office for appropriate media selection.

INDUSTRIAL PROCESS	ANTICIPATED GASEOUS CONTAMINANTS		MULTI-MIX® MEDIA
	CHEMICAL NAME	CHEMICAL FORMULA	
Food Processing	***Organic acids***	**	**
Paint Manufacturing	***Consult head office***	**	**
Perfume / Fragrance Manufacturing	***Consult head office***	**	**
Petroleum Refining	**hydrogen sulphide**	H_2S	**MM-9000**
	sulphur oxides	SO_x	**MM-1000**
	mercaptans	**	**
	organics	**	**
	hydrocarbons	**HC**	**MM-3000**
Plastics Manufacturing	**ammonia**	NH_3	**MM-7000**
	sulphur dioxide	SO_2	**MM-1000**
	aldehydes	**	**
	alcohols	**	**
	organics	**	**
Power Generation	**sulphur oxides**	SO_x	**MM-1000**
	nitrogen oxides	NO_x	**MM-9000**
	hydrocarbons	**HC**	**MM-3000**

INDUSTRIAL PROCESS	ANTICIPATED GASEOUS CONTAMINANTS		MULTI-MIX® MEDIA
	CHEMICAL NAME	CHEMICAL FORMULA	
Pulp and Paper Manufacturing	chlorine	Cl_2	MM-9000
	hydrogen chloride	HCl	MM-9000
	hypochlorous acid	HOCl	MM-9000
	hydrogen sulphide	H_2S	MM-9000
	sulphur oxides	SO_X	MM-1000
	mercaptans	**	**
	hydrocarbons	HC	MM-3000
Rubber Manufacturing	hydrogen sulphide	H_2S	MM-9000
	elemental sulphur	S_8	MM-1000
	mercaptans	**	**
Sewage Treatment Facilities	hydrogen sulphide	H2S	MM-9000
	ammonia	NH3	MM-7000
	hydrocarbons	HC	MM-3000
	organics	**	**
Steel Manufacturing	hydrogen chloride	HCl	MM-9000
	hydrogen sulphide	H_2S	MM-9000
	hydrogen fluoride	HF	MM-9000
	sulphur oxides	SO_X	MM-1000
	nitrogen oxides	NO_x	MM-9000

Chapter 3

An Introduction to Circul-Aire's Multi-Mix® Media Services

A summary of services offered by Circul-Aire to refine selection, enhance performance and improve the operation of equipment utilizing Multi-Mix® media.

To ensure that all Multi-Mix® chemical filters perform properly, Circul-Aire has developed a number of media services to refine and optimize selection, to monitor and enhance media performance, and to guarantee the ongoing efficacy of all equipment containing Circul-Aire's gas phase filtration media.

Circul-Aire Chemical Media Services

To date there are six services provided by Circul-Aire, to ensure the continuous satisfaction of our customers:

- The Tech-Chek™ Program
- Qualitative Media Selection Service
- **S**ealing **I**ntegrity **V**erification (SIV)
- Passive Hydrogen Sulfide Monitoring
- **Re**activity **Mo**nitoring Coupons (REMO)
- Surveyor and Surveyor +

The Tech-Chek™ Program

A Free Service Provided by Circul-Aire

With the Tech-Chek™ program, samples are periodically taken from filtration equipment containing gas phase media and sent to Circul-Aire's in-house laboratory for analysis. The lab tests the samples using both ASTM standard test methods, and test methods developed by Circul-Aire, to determine the life expended for the samples in question. In this way, the laboratory can ensure optimum media change-out and performance. The test procedures used are a reflection of the requirements of each client's specific application.

The program is offered on an ongoing basis with samples usually taken every three to four months. For the best results, several samples (at least three) should be taken for each bed during the sampling period. The samples should be taken from different locations (bottom, middle, and top) along the media bed and in the direction of air flow.

These samples should be placed in the media sample bag (provided by Circul-Aire) and correctly labeled with the date, the system it was obtained from, and the location (i.e. bottom, middle, and top) from where the sample was taken.

With this valuable information, the lab can determine the consumption rate of the media bed, and determine the optimum time for change-out, before the bed reaches saturation. A written report will attest to the lab's findings, but in the case of an emergency, the lab will contact you immediately.

Qualitative Media Selection

Controlled Odor Replication and Media Selection

In some cases, the chemicals responsible for certain nuisance odors are not easily discerned. Many complex reactions may be involved in generating a single odor. As an alternative to a costly, quantitative analysis, Circul-Aire's in-house laboratory can replicate the odor in question instead. Once the offending scent is properly duplicated (to be verified by the client), Circul-Aire will qualitatively test various Multi-Mix® formulations against the odor, and determine the optimal selection for the best single pass odor removal efficiency.

Sealing Integrity Verification (SIV)

Effective Leakage Area and Room Pressurization

Circul-Aire's Sealing Integrity Verification (SIV) measures a protected area where process control equipment may be located. Building enclosures can never be perfectly sealed. Leakage allows contaminated air, often in significant quantities, to infiltrate into the protected space, even to the extent of preventing required room pressurization.

The blower door apparatus measures both room differential pressure and airflow pressure to determine leakage profiles. The values are used to calculate effective leakage area and geometry in order to implement proper sealing procedures.

The data can be used to determine appropriate equipment selection and media quantities required for effective filtration.

Passive Hydrogen Sulfide Monitor

Monitoring Breakthrough

For systems that have hydrogen sulfide as the primary component of a contaminated air stream, Circul-Aire offers a passive monitor for hydrogen sulfide detection. This monitor is mounted on the side of the unit, so that it is exposed to air in the filter bed at a set location. This allows the operator to monitor a portion of the filter bed, and to determine whether there is breakthrough of hydrogen sulfide occurring through that portion of the bed. This gives the operator a visual indication of the consumption of the chemical media.

The monitor consist of a fitting to attach to the filter vessel, a flow meter with valve to control air sample flow rate, sensing chamber with window and a lead acetate indicator in the sensing chamber.

The monitor works by exposing a piece of lead acetate paper to the sample air stream. The lead acetate reacts with hydrogen sulfide, changing the paper's color from white to brown and eventually to black. The color of the paper is a function of the concentration in the air stream and the length of the exposure period. (i.e. the total quantity of hydrogen sulfide that the paper is exposed to.)

Extending the time period for exposure allows the monitor to detect very low concentrations of the contaminant. The monitor can also act as an accumulator, giving the total quantity of hydrogen sulfide breaking through the segment of the media bed over long periods of time.

Reactivity Monitoring Coupons

Corrosion Control for Critical Environments

Diagnose the environment to accurately determine the extent of its corrosion potential. Circul-Aire's Reactivity Monitoring Service is a proven method that produces a normalized one-month evaluation of a given environment's corrosion potential.

REMO coupons contain 99.9% pure copper and silver strips that react with the environment when installed on strategic areas for periods of 30 to 90 days. After exposure, the coupons are analyzed to determine film thickness and chemical composition. The data is used to determine the normalized one-month value for ISA (Instrument Society of America) classification (G1 to GX) and further to determine chemical media (MULTI-MIX®) selection. The silver coupon is also analyzed to evaluate the presence of chlorine and humidity levels.

Reactivity Monitoring Coupons are an inexpensive way to insure the area under filtration remains a corrosion free environment. Circul-Aire uses pure copper strips to give the environmental classification based on ISA standards. To monitor for the presence of reactive chlorine compounds and to see the effect that relative humidity level has on the classification Circul-Aire adds a pure silver strip to the Reactivity Monitoring Coupon.

Coupons mounted in the air stream right after the filter bed insure that the filter bed is removing all possible contaminants that may lead to corrosion of equipment. A coupon mounted near the equipment is an excellent way to insure that no contaminants are bypassing the filtration system and entering the area through some other means.

Surveyor and the Surveyor +

Real Time Environmental Classification

To monitor the ISA environmental classification on a real time basis Circul-Aire also offers the Surveyor and Surveyor+ systems. The Surveyor monitors the corrosion rate of a copper strip, using sophisticated electronics, and calculates the environmental classification based on the ISA standard. The Surveyor+ uses both a copper strip and a silver strip to give a wider spectrum on the corrosion potential of the environment. The Surveyor+ also includes temperature and relative humidity sensors for total monitoring of the environment.

The Surveyor family can be used like the Reactivity Monitoring Coupons to insure the function of a filtering system and/or the ISA classification of an area.

Chapter 4

Frequently Asked Questions about Circul-Aire Multi-Mix® Chemical Media

Circul-Aire responds to common questions concerning Multi-Mix® chemical media and Gas Phase Filtration

In order to clarify some aspects of gas phase filtration and Multi-Mix® chemical media, Circul-Aire has compiled some of the most common questions asked of the applications department, the laboratory and our representatives.

Please note: If you have any questions which has not already been considered, or are not included in this section, please feel free to contact the head office where our staff will be more than happy respond to any inquiries.

What is the proper media selection for air purification when considering a museum application? Is activated carbon adequate all by itself?

Looking at the primary contaminants which are to be controlled (i.e. SO_2, NO_X, O_3) and the temperature and relative humidity conditions, activated carbon alone will not do the job.

Activated carbon does work well against ozone (O_3). It can also work against oxides of nitrogen (NOx) to a limited degree. The main area where the filter system is going to fail is against sulfur dioxide (SO_2). Some select carbons have shown, under high relative humidity conditions, that they can remove SO_2. However, if the relative humidity never goes over 45%, even one of the few select carbons mentioned above would not be able to remove sulfur dioxide.

It is recommended that a mixture of activated carbon and activated alumina pellets impregnated with potassium permanganate be used in museum applications. The addition of the impregnated alumina pellets will insure that the chemical media will be able to remove the NO_X and SO_2 to below design conditions. There is the added bonus in using the mixture as well; it will also remove other contaminants, which may be present (and unaccounted for) that have the potential to be harmful. A partial list of such contaminants would be Hydrogen Chloride, Acetic Acid, and Formaldehyde.

Circul-Aire can supply such a mixture with the percentages of each component adjusted to the specifically to the application in question. Circul-Aire will fine-tune the mixture for the customer using the results from sample testing; the sample testing is part of Circul-Aire's free TECH-CHEK™ service.

When disposing of spent media, is it advisable to use an incinerator?

The majority of our customers use industrial landfill to dispose of their used chemical filters. If incineration is to be considered, it must be noted that the used carbon will contain elemental sulfur and sulfur compounds resulting in the possibility of producing sulfur dioxide.

What type of carbon is MM-9000 media made from? How are the physical characteristics of the MM-9000 media maintained?

MM-9000 is an extruded carbon manufactured from a unique bituminous coal substrate. At the time of manufacturing, each and every pellet is made to conform to a preset diameter. To further ensure a uniform, dust-free product, Circul-Aire further screens the MM-9000 after the addition of the base impregnate.

What is the difference between MM-9000 and MM-9000LP?

Circul-Aire offers two base impregnated carbons: MM-9000, a three-millimeter carbon pellet; and MM-9000LP, a four-millimeter carbon pellet. MM9000LP is used wherever a lower pressure drop is required.

Is it difficult to perform an analysis to determine the expended life on special blends chemical media? What are the advantages of performing such an evaluation?

No, it is not difficult for Circul-Aire to perform a Life Expended Analysis on a mixture of chemical media (i.e. MM-1355). For the analysis, the two components of the mixture are separated, and tested separately.

By determining the expended life for each component of a blend, we can see if the mixture needs to be adjusted. Adjustment of a blend occurs when original contaminant concentrations used at the design stage are no longer valid, or if certain contaminant species were unaccounted for or misrepresented at the design stage.

Change-out occurs in a blend when one component, at least, becomes saturated. Ideally, both components should be consumed at the same rate. However, without adjustment the total mixture may have to be replaced earlier than necessary. Periodic adjustment allows the Circul-Aire teams to fine tune the consumption rate, and thus minimizes waste, while ensuring that the chemical media performs as it was designed.

How does relative humidity effect the moisture content of Multi-Mix® chemical media?

Let us examine how the moisture level fluctuates with respect to relative humidity by referring to the particular case of MM-9000 chemical media:

The moisture level of MM-9000 naturally comes to equilibrium with the relative humidity of the ambient air, everything else being equal. The moisture level goes up with higher relative humidity and down with lower relative humidity. When relative humidity is constant then the moisture level of MM-9000 will adjust, either up or down, until it reaches equilibrium level. Once at equilibrium the moisture level will remain constant.

Tests in the laboratory have shown that the moisture level of MM-9000 will range between 5 to 30 % with relative humidity ranging between 10 to 95 %. It may be of interest to note that testing indicates that the removal efficiency is increases with higher relative humidity.

What are the contaminants involved when considering air filtration for a sewage treatment plant? What media would work best to combat these contaminants?

For a sewage treatment application the contaminants are usually Hydrogen Sulfide, Mercaptans and other large, odorous, organic compounds. MM-9000 is ideally suited for this application.

The base material is a 70% Carbon Tetrachloride carbon. (Average carbon has a Carbon Tetrachloride number of 55% to 60%). This insures that MM-9000 has a large capacity to contain the odorous compounds found in most sewage treatment plants. Furthermore, the addition of **potassium hydroxide**, as an impregnate, further enhances its performance against Hydrogen Sulfide and Mercaptans.

Speaking of impregnates, I heard that other companies use sodium hydroxide, instead of potassium hydroxide to impregnate their media. Does this effect the media in any way? And also, what is "carbonate bloom"?

Some companies impregnate their carbons with sodium hydroxide instead of potassium hydroxide. This has no effect on the capacity for the removal of sulfur compounds like Hydrogen Sulfide, as it is the hydroxide (OH) that is the active ingredient (i.e. most important for removal).

The difference between the two impregnates is the potential for the formation of what is commonly known as **"carbonate bloom".** Both impregnates react with carbon dioxide to form a carbonate. In the case of sodium hydroxide, the resulting sodium carbonate is only slightly soluble in water, this can lead to large crystals forming either in the carbon pores or on the surface of the pellet.

The crystal that forms in the pores, can block the pores, or fracture the pellet. This reduces removal capacity and creates dusting. The crystals that grow on the outside of the pellet form bridges between the pellets, resulting in a solid mass with reduced void spaces. This reduces airflow and increases pressure drop. The **"carbonate bloom"** also makes the removal of the used carbon very difficult.

In the case of potassium hydroxide, the carbonate byproduct is very soluble in water. It therefore remains in solution within the pellet were it is available to react further with Hydrogen Sulfide. **MM-9000** has **never** had a **"carbonate bloom"** problem.

How do you dispose of used MM-9000 media from a sewage treatment application? What are the by-products?

In North America spent MM-9000 is normally disposed of as non-hazardous industrial waste. The by-products that are normally found on consumed MM-9000 (from a sewage treatment application) are not considered hazardous. Used MM-9000 normally consists of: carbon, moisture, elemental sulfur, inorganic salts, and organic matter. The elemental sulfur and the inorganic salts are the by-products of the reactions with sulfur contaminants. The organic matter consists of the organic compounds, from the sewage, that were removed from the air stream.

How can we determine when the media has reached saturation, and subsequently, when the media requires a change-out?

Circul-Aire provides a free service called the Tech-Chek™ program, for verifying media performance and consumption rates. The media is verified on a quarterly basis (every three to four months) by the Circul-Aire laboratory. When it has been determined that the media has been consumed, the Circul-Aire lab report will recommend a change-out.

Can the Circul-Aire chemical media be regenerated?

Circul-Aire activated carbon (MM-3000) can be regenerated. Chemical media containing an impregnate can also be regenerated, but it is not recommended. When chemical media containing an impregnate (i.e.: potassium hydroxide, KOH) is regenerated, the media must be re-impregnated after it is cleaned. The cost of re-impregnation eliminates the benefit of regeneration, therefore it is not cost effective to regenerate impregnated activated carbons.

It is important to note that after every regeneration attempt, a portion of the original pore structure will no longer be available for physical adsorption. The retentivity characteristic of the carbon causes contaminants to remain on the surface of the substrate. Thus, regenerating any chemical media can only be done a few times. Shorter periods of time will occur between every successive regeneration attempt, until it is no longer feasible to continue.

Activated alumina impregnated with potassium permanganate (MM-1000) cannot be regenerated due to the nature removal mechanisms employed to remove odours.

Does the reaction of chlorine gas with CIRCUL-AIRE MM-9000 media (activated carbon impregnated with potassium hydroxide) generate an exothermic reaction?

The reaction:

$$Cl_2 + 2KOH \rightarrow 2KCl + H_2O + \frac{1}{2} O_2 \quad [\approx +75.06 \text{ kcal / mole}]$$

chlorine + potassium hydroxide → potassium chloride + water + oxygen

is exothermic. In fact, the heat generated by the reaction helps to accelerate the adsorption process, which eventually neutralizes the contaminant. It is important to note that the heat generated easily transferred via forced convection (air flow across the media) and through conduction (transmission through equipment housing).

Is there H_2O generated from the reaction of Cl_2 with KOH? If so, will it impede the media's adsorptive process?

Yes, water is generated by the reaction between chlorine and potassium hydroxide. However, the amount of water generated is not significant enough to actually effect the media's performance. Moreover, the presence of moisture is essential; in order for the media to function properly, the reactions must take place in an aqueous solution.

How does Circul-Aire determine the expected life of chemical media at the design stage?

In order to determine the quantity of media required to last a set period of time (example six months) one must know the total weight of contaminant(s) that the media will be required to remove. In order to determine how long a set quantity of media will last then one must know the mass flow rate(s) of the contaminant(s) (weight/unit time).

The method to determine either total weight or weight flow rate depends on the information that is available. The weight of contaminant(s) going into a system is known and the percentage of contaminants that will enter the waste stream to be filtered is estimated, then either total quantity or flow rate can be calculated using the following equations:

$$\text{mass flow rate} = \frac{\text{weight into system}}{\text{time put into system}} \times \frac{\text{percentage to waste stream}}{100}$$

$$\text{total quantity} = \text{mass flow rate} \times \text{time}$$

If the concentration(s) of contaminant(s) in the air stream is known by weight/volume (example micrograms per meter cubed [$\mu g/m^3$]) then the following equation can be used:

$$\text{mass flow rate} = (\text{weight/volume}) \times (\text{volume/time})$$

If the concentration(s) of contaminant(s) in the air stream is known by volume/volume (example: parts per million ppm) then the following equations can be used to get the total weight.

NOTE: The following equation assumes all vapors present behave as ideal gases.

$$\text{total volume} = \text{system volumetric flow rate} \times \text{total time}$$

$$\text{total volume of contaminant} = \text{total volume} \times \text{concentration}$$

$$\text{total weight of contaminant} = \frac{\text{total volume of contaminant}}{\text{molar volume}\,*} \times \text{molecular weight of contaminant}$$

* molar volume is the same for all ideal gases and can be taken to be …

$$\text{mass flow rate} = \frac{\text{total weight of contaminant}}{\text{total time}}$$

If more than one contaminant is present the calculation must be performed separately for each contaminant. Once the total weight of contaminant is known the media required is calculated by using the following equations:

$$\text{media required (weight)} = \frac{\text{total weight of contaminant} \times 100}{\text{capacity \% wt / wt}}$$

$$\text{media required (volume)} = \frac{\text{media required (weight)}}{\text{density of media}}$$

Once the mass flow rate is known then the time that a quantity of media will last is calculated by using the following equations.

$$\text{total weight of media} = \text{total volume} \times \text{density of media}$$

$$\text{media life} = \frac{\dfrac{\text{total weight of media} \times \text{capacity \% wt / wt}}{100}}{\text{mass flow rate}}$$

What are the required parameters necessary for design purposes?

In order to be able to design an air purification system properly it is necessary to determine the requirements and the operating conditions for such a system. Continuous consultation with our previous clients have shown that the design parameter can be divided in three broad categories:

- **application description**
- **contaminants**
- **operating conditions**

To ensure the proper selection of the air purification system that will meet the requirement set forth by the client, it is essential to answer certain fundamental questions in each category.

Application description

Question #1: Why do we need an air purification system?

By answering this question, we will establish the requirements of the system and determine our goals.

Typical answers

We have been audited by the Environmental Protection Agency (EPA) and they have pointed out that air emission levels are surpassing governmental regulations. We need an air purification system to meet the requirements of the regulations.

The employees in our manufacturing area have been complaining about the air quality. We need a system that will purify the air to a level that is comfortable for the employees.

We have a processing area in our production plant that requires a very low level of airborne and gaseous contaminants. The level of these contaminants will effect the percentage of usable product. The air purification device will lower the level of contaminants, thus increasing the percentage of usable finish product.

Some artifacts in our museum will deteriorate rapidly if it is exposed to contaminants found in an urban area (i.e. SO_x, NO_x , O_3 and VOC's). The air purification system will purify the air where these exhibits are stored. This will protect the artifact from excessive deterioration.

Contaminants

Question #2: What are the contaminants in the air?

Contaminants can be identified by their names:

Alchols, Aldehydes, Alkaloids, Amines, Aromatics, Esters, Ethers, Ketones, Mercaptans, Olefins, Organic acids, Oxides, Phenols, Sulphides

Contaminants can be identified by their chemical formulas:

H_2S, SO_x, NO_x, C_6H_6, CH_3-CHOH, C_3H_5O, KOH, H_2SO_4, etc.

They can also be identified by their trade mark:

Borax, Muriatic acid, Bleach, Salt peter etc.

The more we know about the contaminants present in the air stream the better our selection of the media will be. Thus enhancing the performance of the purification system.

Question #3: What are the concentrations of the contaminants?

Typical concentration nomenclature used in air purification systems.

Part per million (ppm)

Part per billion (ppb)

Milligrams per meters cube (mg/m^3)

The concentration of the contaminants in the air to be treated will have the greatest influence on the effective life of the purifying media. Foreknowledge, of the contaminant concentration will allow the determination of the media life in an air purifying system. However, contaminant concentration are not always easy to determine or readily available. In most cases the help of an air quality consultant is required to establish these concentrations in the areas of concern.

Operating conditions

Question #4: What is the condition of the air to be treated?

Important parameters to be established.

Volumetric Flow Rate	e.g. 2000 CFM, or
	14942 USgal/min, or
	944 L/s, or
	3398 m^3/h
Dry Bulb Temperature	e.g. 20°C, 68°F
Relative Humidity	e.g. 70% R.H.

Question #5: What is the operating time of the air purification system?

Typical operating times encountered.

8 hours per day, 5 days per week.

8 hours per day, 7 days per week.

24 hours per day, 365 days per year.

Summary

The more accurate the answers to these questions are, the more suitable and cost effective is the air purification system selection for the specific application.

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Appendix A: Material Safety Data Sheet

Appendix B: Quick Reference

Media Selection

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CIRCUL-AIRE QUICK REFERENCE MEDIA GUIDE-SHEET

MULTI-MIX®	CONTAMINANT														
	NH_3	CO	CO_2	Cl_2	C_2H_4	HCOH	HC	VOC	HF	H_2S	H_2SO_4	HCl	NO_x	O_3	SO_x
MM-100		●													
MM-200			●												
MM-1000					●	●									●
MM-3000							●	●						●	
MM-7000	●														
MM-9000				●					●	●	●	●	●		
MM-1355					●	●	●	●						●	●
MM-1955				●					●	●	●	●	●		●

Where,

NO_x - Oxides of Nitrogen
SO_x - Oxides of Sulphur
CO - Carbon Monoxide
CO_2 - Carbon Dioxide

H_2S - Hydrogen Sulphide
H_2SO_4-Sulphuric Acid
HF - Hydrogen Fluoride
HCOH - Formaldehyde

HC - General Hydrocarbon
VOC - General VOC
HCl -Hydrochloric Acid
C_2H_4 - Ethylene

NH_3 - Ammonia
Cl_2 -Chlorine
O_3 - Ozone