THE WORLD LEADER IN CLEAN AIR SOLUTIONS

Controlling Tobacco Smoke Haze and Odors

SAAF TECHNOTE

Tobacco Smoke Composition

Tobacco smoke contains a **wide mixture** of contaminants. The burning end of a tobacco product (cigarettes, cigars, and pipes) produces both **gaseous** and **particulate** contaminants, as the superheated vapors rise, condense, and agglomerate. Laboratory studies have found more than 4,700 compounds in tobacco smoke, making it a broad group of gases and particulates to remove.

Studies have found that tobacco smoke particle size ranges from 0.01 to 1.0 microns, with median diameters being in the 0.3 micron range (examples shown in Table I).

Gaseous contaminants may include carbon monoxide, hydrogen cyanide, butane, ammonia, toluene, polycyclic aromatic hydrocarbons (PAHs), N-nitrosamines, aromatic amines (4-aminobiphenyl), aldehydes (formaldehyde), and miscellaneous organic chemicals, such as benzene and vinyl chloride. Table II shows an example of cigarette contaminant generation rates for some of these compounds.

Table I:
Tobacco Smoke Particle Sizes Found in Various Studies

Description	Particle Size (µm)
Cigarette - inhaled (count median diameter)	0.15 - 0.17
Cigarette - exhaled (count median diameter)	0.22 - 0.27
ETS* overall size range	0.01 - 1.0
ETS mass median diameter	0.3

**Environmental Tobacco Smoke* — **Environmental Tobacco Smoke*

Table II:
Typical Cigarette Smoke Major Contaminant Generation Rates

Contaminant	Generation Rate (µg/Cigarette)
Carbon monoxide	55,101
Ammonia	4,148
Acetaldehyde	2,500
Formaldehyde	1,330
Hydrocarbons by FID	27,810
Respirable Particles	13,674

Proper Filtration for Tobacco Smoke

Proper filtration to reduce haze and odors from tobacco smoke includes both particulate and gas-phase filtration. Particulate filtration will remove the tobacco smoke particulate and haze, as well as protect the gas-phase media. If the gas-phase media becomes coated with sticky tobacco aerosols, it will become ineffective for the removal of odors.

The **particulate filtration** needs to target the wide range of 0.01 - 1.0 micron particles in tobacco smoke. This is best done with a 3-stage particulate filtration system; a low efficiency filter (MERV 6-8) for large particles, followed by a high efficiency filter (MERV 14-16) to remove the majority of the 0.3 - 1.0 micron size particles, followed by HEPA final filtration to remove the 0.3 micron and smaller particles. The system should be arranged and filters chosen, such that the prefilters and high efficiency filters can be changed frequently, to remove odor generating aerosols out of the airstream. The HEPA filters can be left in for a longer period of time, because they are protected by the other filters. In some ducted applications, it may be impractical to include HEPA filtration, due to system limitations. In such cases, MERV 14-16 may suffice, as this efficiency can remove tobacco smoke particulates in the 0.3 micron range, with the best choice being the MERV 16 (see Table III for information on particulate size efficiencies).

Table III:
Particle Filter Efficiency Related to Tobacco Smoke Median Size Range

Filter Efficiency Rating	Typical Efficiency 0.3-0.4 µm
MERV 14	60-70%
MERV 15	70-82%
MERV 16	≥95%
HEPA	≥99.97%

AAF INTERNATIONAL

BETTER AIR IS OUR BUSINESS®

Controlling Tobacco Smoke Haze and Odors

The **gas-phase filtration** must target the wide range of odorous and irritant gases. This is accomplished by using both activated carbon and potassium permanganate impregnated media, through the mechanisms of adsorption and chemisorption. **Adsorption** on the activated carbon targets the larger organic components of the tobacco smoke, mainly by surface adhesion in its pore structure (Figure 1).

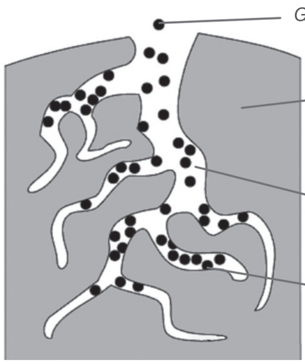

Figure 1 *- Adsorption taking place on activated carbon*

Chemisorption on the potassium permanganate impregnated media targets the smaller reactive compounds, by forming chemical bonds via reaction with the potassium permanganate within its pore structure. Figure 2 shows the results of such chemical reactions taking place on the media.

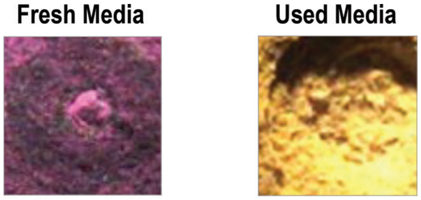

Figure 2 *- Cross sections of permanganate media; (A) fresh permanganate media before reacting with contaminants; (B) used permanganate media after forming chemical bonds with contaminants.*

By using this media combination, the gas-phase filtration system can target a large percentage of the odor producing and irritating contaminants found in tobacco smoke. Table IV shows examples of which contaminants each media targets for removal.

Table IV:
Examples of Tobacco Smoke Components Targeted by Activated Carbon and Permanganate Media

Media	Tobacco Smoke Component
activated carbon	aromatic amines benzene hydrocarbons PAHs N-nitrosamines toluene
potassium permanganate impregnated media	acetaldehyde formaldehyde hydrogen cyanide

The AAF Filtration System

AAF offers filtration equipment which provides all the filtration components identified previously, including prefilters, high efficiency filters, HEPA filters, and gas-phase filtration. For optimal media life and contaminant removal, filtration systems can be provided with separate passes of AAF's activated carbon (SAAFCarb™) and potassium permanganate impregnated media (SAAFOxidant™), and replace each as it becomes spent. Systems may also use AAF's blended media in a single pass (SAAFBlend™ GP), but this will cause a quicker time to odor or irritant breakthrough than the separate media passes.

References Used:

ASHRAE. (2009). ASHRAE Handbook Fundamentals. Atlanta, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc..

Martin, P., Heavner, D. L., Nelson, P. R., Maiolo, K. C., Risner, C. H., Simmons, P. S., Morgan, W. T., & Ogden, M. W. (1997). Environmental tobacco Smoke (ETS:) A market Cigarette Study. Environmental International, 23(1), 75-89.

McGrath, C., Warren, N., Biggs, P., McAughey, J. (2009). Real-time Measurement of Inhaled and Exhaled Cigarette Smoke: Implications for Dose. Journal of Physics: Conference Series. doi: 151 012018.

Office of the Surgeon General. (2007). The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General, U.S. Department of Health and Human Services: Secondhand Smoke Is Toxic and Poisonous. Retrieved from: www.hhs.gov

9920 Corporate Campus Drive, Suite 2200, Louisville, KY 40223-5690
888.223.2003 Fax 888.223.6500 | www.aafintl.com

GPF-8-103A 08/15