Week Ten: Air Pollution Control and Prevention - Part 1

**AIR QUALITY MANAGEMENT:**

**APPROACHES FOR AIR POLLUTION CONTROL AND PREVENTION**

The subject of management of air quality is treated under two parts: **Outdoor Air Quality Management** and **Indoor Air Quality Management.** These topics will be sequentially dealt in next four weeks under different modules, starting from this week.

**PART ONE:** **Outdoor Air Quality Management**

The air quality management under Part One consists of different modules and each module covers different management approaches and these are driven by the 1990 Federal Clean Air Act and its amendments.  These will be discussed in next three weeks, starting from this week.

**Module A:** **Strategies for Outdoor Air Quality Management**

**1.0** **Introduction**

As you have studied in the past few weeks, air pollution caused by emissions of toxic pollutants by both anthropogenic industrial and natural sources have drastically changed the quality of air, impacting human health and welfare, natural resources, climate and consequently economies. Although we cannot fully and cost-effectively mitigate the pollution problems created by the natural sources, such as volcanic activities, we can certainly do a great deal to either minimize or eliminate the pollution problems arising from anthropogenic industrial activities through sound management approaches.

Generally, developing and implementing a source specific ***Integrated Pollution Management Program,*** and meeting all institutional, staffing, training and equipment requirements could be a viable approach for ***Management of Air Quality.*** Some elements of this integrated management program are:

-         Monitoring and assessment of point- and non-point source air pollution

-         Projecting emissions growth through models

-         Assessing the air pollution impacts on health and environmental resources

-         Adopting best management practices and technological options

Management of air quality with viable and implementable strategies is an effective system of maintaining the present and future air quality of our nation.  Air quality management system (AQMS) refers to the activities that are directed toward promoting cleaner air and maintaining it. Management activities are governed by regulatory policies, requirements and standards, including ambient and source air quality monitoring, developing permitting programs, enforcement activities, and establishment of economic incentives to reduce air pollution. Air quality management, through the CAA, prescribes a set of responsibilities and relationships among federal, state, tribal and local agencies.

The basics of AQMS are presented in the following steps:

**1: Based on the standards, set Air quality Goals** **--->  2: Determine necessary reductions** **---> 3: Take Measures to achieve the reduction goals** **---> 4: Monitor and evaluate the results-- If the results meet the expectations** **---> 5: Implement the Emission Reduction Programs--- If the results do not meet the expectations** **---> Go to # 2**

For successfully implementing the AQMS, several approaches are considered and these include:

* Compliance with Emission Standards
* Technology-Based Approaches
* Economic-Based Approaches
* Market-Based Approaches

### These approaches are applicable not only to stationary sources but also non-stationary sources, such as transportation motor vehicles (e.g., cars, trucks, airplanes, farm equipment etc.).  These are dealt in different modules in next four weeks, starting from this week.

### 2.0 The Role of the Federal and State Government Agencies

As part of its responsibility to protect the environment and human health, EPA promotes and helps to implement methods of controlling air pollution. These control methods include voluntary and enforced reduction in the use of ozone-depleting substances, phasing out the use of certain toxic chemicals, developing treatment methods for polluted areas, and introduction of ***cleaner alternatives.*** The Agency enacts these various controls through targeted grants, in cooperation with state and local governments, in partnership with industry, and through the enforcement of environmental regulations.

Although the 1990 Clean Air Act covers the entire country, the states do much of the work to carry out the requirements of the Act. For example, a state air pollution agency holds a hearing on a permit application by a power or chemical plant or fines a company for violating air pollution limits.  The law allows individual states to have stronger pollution controls, but states are not allowed to have weaker pollution controls than those set for the whole country.

#### 2.1 State Implementation Plans (SIPs)

***You have learned a bit about this during week seven.***

The State Implementation Plan defines the combination of local, state and federal actions and emissions control needed for an area to meet ambient air quality standards and for an area that has attained the NAAQS to maintain compliance and **prevent significant deterioration (PSD)** of air quality. The first step in developing a SIP is to divide the state into geographical regions known as **Air Quality Control Regions (AQCRs)**. An AQCR could be a metropolitan area or a county. Using the AQCRs for management purposes, the states could devise their own requirements for controlling air pollution related to specific local needs. This could include the control of both ***new and existing sources of air pollution***. An example of a common measure taken by states within their SIPs is the requirement that all motor vehicles be regularly inspected and tested for air emissions control.

The SIP is developed by state and local officials, and is approved by EPA. Once approved, it becomes legally enforceable on both the state and federal levels. To supplement the SIPs, federal regulatory and support programs are also in place. In one support program, EPA establishes **control techniques guidelines (CTG)** for controlling air pollutants for specific industries. These CTGs provide states with information on existing control technologies referred to as ***reasonably available control technology (RACT)***. RACT represents control techniques commonly in use in a specific industry. To date, EPA has promulgated over 60 CTGs. On the other hand, a regulatory program that supplements the SIPs is the **New Source Performance Standard (NSPS)**.

States have to develop **State Implementation Plans (SIPs)** that explain how each state will do its job under the Clean Air Act. A state implementation plan is a collection of the regulations a state will use to clean up polluted areas. The states must involve the public, through hearings and opportunities to comment, in the development of each state implementation plan.  EPA must approve each SIP, and if a SIP isn't acceptable, EPA can take over enforcing the Clean Air Act in that state.

**3.0** **Federal Programs**

The United States government, through EPA, assists the states by providing scientific research, expert studies, engineering designs and financial resources to support clean air programs.  Examples of such programs given in the following:

#### 3.1 Program for Compliance with New Source Performance Standards (NSPS)

New Source Performance Standards (NSPS) are federal standards promulgated for major and minor sources on a category-category basis. NSPS are national emission standards that are progressively tightened over time to achieve a steady rate of air quality improvement ***without unreasonable economic disruption.*** The NSPS imposes uniform requirements on new and modified sources through out the nation. These standards are based on the **best demonstrated technology (BDT)**. BDT refers to the best system of continuous emissions reduction that has been demonstrated to work in a given industry, considering economic costs and other factors, such as energy use. In other words, any new source of air pollution must install the best control system currently in use within that industry.

The format of the standard can vary from source to source. It could be a numerical emission limit, a design standard, an equipment standard, or a work practice standard. Primary enforcement responsibility of the NSPS rests with EPA, but this authority may be delegated to the states. States can adopt an NSPS or impose limitations of their own, as long as the state requirements are not in excess of the federal requirements.

***3.2 Program for Prevention of Significant Deterioration (PSD) and New Source Review (NSR)***

Major new stationary sources of air pollution and major modifications to major stationary sources are required by the Clean Air Act to obtain an air pollution permit before beginning construction. The process is called **New Source Review (NSR)** and this is applicable to sources, whether they are new major source or the sources with modification plans, where the national ambient air quality standards (NAAQS) are exceeded (non-attainment areas) or a source where air quality is acceptable (attainment and unclassifiable areas). Permits for sources in attainment areas are referred to as **prevention of significant air quality deterioration (PSD) permits** while permits for sources located in non-attainment areas are referred to as **NAA permits**. The entire program, including both PSD and NAA permit reviews, is referred to as the NSR program.

PSD permits mandate the installation of pollution controls that represent the **best available control technology (BACT)**. BACT is defined as an emission limit based on the maximum degree of reduction of each pollutant subjected to regulation under the Clean Air Act. BACT is done on a case-by-case basis, and considers energy, environmental, and economic impacts.

The idea behind the **PSD** program is that if the air in an area is clean, it should stay clean. If a major source will be locating in an attainment area, it is subject to the PSD program. (If the source is trying to locate in a non-attainment area, it is subject to the NSR program discussed below.)

The CAA defines three classes or areas for PSD. Each has a so-called "increment" (actually decrement) in the NAAQS for SOx, NOx, and PM10. These classes are:

a) Class I is national parks larger than 6,000 acres, national wilderness areas and national memorial parks larger than 5,000 acres, and other areas designated as Class I by local governments.

b) Class II is all areas that are not Class I and that have not been designated Class III by a state governor.

c) Class III is areas designated by a state governor as requiring less protection than Class II areas. Not surprisingly, there are no Class III areas.

Table 1 lists the increments for the three classes of PSD and, for comparison, the NAAQS, which apply outside of the PSD areas.

**Table 1
PSD Increments, Concentrations in µg/m3**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pollutant**  | **PSD Class I**  | **PSD Class II**  | **PSD Class III**  | **NAAQS**  |
| SOx  |    |    |    |    |
| Annual  | 2  | 20  | 40  | 80  |
| 24 hours  | 5  | 91  | 182  | 365  |
| 3 hours  | 25  | 512  | 700  | 1300  |
| PM10 annual  | 4  | 17  | 34  | 50  |
| PM10 24 hours  | 8  | 30  | 60  | 150  |
| NOx annual  | 2.5  | 25  | 50  | 100  |

Source: Adapted from Erbes (1997, 125).

For a proposed new source to obtain a permit, the source must demonstrate that the NAAQS and the PSD increments for the area will not be exceeded. Regardless of the predicted ambient air quality of a PSD area, the new source must install ***Best Available Control Technology (BACT)***.

Unlike PSD, the NSR applies to **major modifications** that increase the emissions more than a threshold amount. The thresholds are potential emissions greater than 250 tons per year of any one criteria pollutant. A major modification is one with the potential to increase the emissions of criteria pollutants of an existing major source by more than 0.6 tons to 100 tons per year for lead and CO, respectively. Other criteria pollutant thresholds are in between.

There are published thresholds for non-criteria pollutants, which vary and can be as small as "any amount." ***For example***, the threshold is any amount of a pollutant that could cause greater than a 1 µg/m3 increase in a PSD Class I area, or when the source is located within 10 km of a Class I area.

NSR in a non-attainment area requires that the new source obtain offsets and install ***Lowest Achievable Emission Requirement (LAER)***. An offset is a reduction from an existing source of at least the amount of pollution the new source will emit. Offsets are obtained in any number of ways, from modifying existing plants to buying out another source and closing the facility. Sometimes these credits can be purchased; the price can run into hundreds or thousands of dollars per pound per day emitted. Offset credits not used can be "banked" for later use by arrangement with the permitting authority.

The amount of the offset depends on the degree of non-attainment. Table 2 lists the offset ratios. However, if attainment or SIPs are not reached or submitted by the deadlines, the offset ratio goes to 2:1.

**Table 2 Emission-offset Ratios for
Non-attainment (NA) Designations**

|  |  |
| --- | --- |
| **NA Designation**  | **Offset Ratio**  |
| Marginal  | 1.1:1  |
| Moderate  | 1.15:1  |
| Serious  | 1.2:1  |
| Severe  | 1.3:1  |
| Extreme  | 1.5:1  |

Source: Erbes (1997, 148).

### 3.3 Program for Acid Rain Control

Congress established the Acid Rain Program under Title IV of the 1990 Clean Air Act Amendments. The program called for major reductions in electric-generating facilities emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx) - the key components of acid rain - while establishing a new approach to environmental protection through the use of ***market incentives.***

The amendments encourage this approach as a way to reduce the costs of compliance with air pollution standards. For example, the Act includes a system of emission allowances for SO2 emissions. Industries that produce emissions below the standard for SO2 can build up a supply of ***allowances, or credits***, which can be sold to other companies. This creates a market where industries can trade or ***"bank" their emissions***, thereby establishing a market-based approach to encouraging companies to reduce air pollution.

### 3.4 Program for Reduction of Ozone Depleting Emissions

The 1990 Clean Air Act Amendments, in concert with the 1987 Montreal Protocol, established a U.S. regulatory program for the states to reduce the production of ozone depleting emissions for protecting the stratospheric ozone layer-***“the Protective Blanket”.*** The amendments require the industries to completely phase out emissions of chlorofluorocarbons (CFCs) and other ozone-depleting pollutants. As such, productions of some halons ended in January 1994.  Iin January 1996, U.S. industrial production of many ozone-depleting substances virtually ended, including CFCs, carbon tetrachloride, and methyl chloroform.

***3.5    Pollution Prevention and Minimization Program***

Pollution prevention is given new emphasis in the 1990 CAAA under both Title I and III. The amendments require EPA to conduct research and development for pollution prevention technologies. Also, provisions were included requiring consideration of cross-media impacts, substitution and other modifications to reduce HAP volumes, the potential for process changes, eliminating emissions entirely, sale of cleaner reformulated gasoline, and phase out of CFCs and halons.

***3.6 Other Programs***

The other programs include the following:

1. NOx Budget Reduction and Trading Program
2. Motor Vehicle emission Control Program
3. Stationary Source emission Control Program
4. Air Quality Monitoring, Auditing and Enforcement Program

***Reading Assignments:***

Please read Sections 8.2, 8.4 and 8.5 of the textbook.

***Review Check Questions***

- What are the elements of an Integrated Pollution Management Program (IPMP) and the program objectives?

- Can you outline the basics of AQMS?

- Can you describe the State Implementation Plans for Air Quality management?

- What are various Federal Programs designed for Air Quality management?

- What are PSD and NSR and their implications to air quality management?

- Can you define BACT and LAER?

If your answer is a ***resounding yes*** for the above questions, then you have realized this week's objectives.

Have a pleasant week!

Week Eleven: Air Pollution Control Management: Parts 2 and 3

**AIR POLLUTION CONTROL MANAGEMENT: Part 2**

**Outdoor Air Pollution Control Technologies**

As I mentioned earlier, Air Quality Management is built upon air quality monitoring or sampling of air pollutants and taking emission inventories. Monitoring data are a critical part of the nation's air program infrastructure. Ambient air data are used to determine progress in meeting the National Ambient Air Quality Standards (NAAQS). Such data forms a basis for establishing baseline air quality conditions for a given area before new sources are constructed and to develop air dispersion models. Local to regional air quality data from the nation's ambient air monitoring networks is used to:

- Inform the public of air quality and exposure levels

- Establish the compliance status of industries, cities and their suburban areas

- Track air quality trends and evaluate progress of emission control programs

- Support development of emission control and air quality research programs

In the following modules, I will discuss about various air pollution control technologies that pertains to Stationary Sources and Mobile Sources.

Module A: Stationary Sources Air Pollution Control Technologies

***1.0 Overview***

***Introduction***

As far as the Clean Air Act (CAA) is concern, many **stationary sources** are major contributors of hazardous air pollution (HAPs); therefore, they are called major sources.  For HAPs, a ***major source*** is defined in the Act as any stationary source or group of sources within a contiguous area (sometimes called an "***area source***") that emits at least 10 tons per year of a single HAP or 25 tons per year of any combination of HAPs, both after controls. For ***New Source Review*** (NSR) purposes, a major source is one that has the ***"potential to emit"*** criteria pollutants in amounts greater than certain thresholds.

Many major sources are big, such as electricity-generating utility plants, petroleum refineries and  grain milling and handling operations. As an **example**, consider typical emission control systems for a coal-fired utility boiler that would invariably have a very large emission control installation. Not all stationary sources have such large emission control installations. Most stationary sources have some sort of mechanical and /or electrical device or devices to clean the emissions before discharge. The design and operation of control equipment assumes that a source can be reduced to the regulatory level. The engineers designing and operating pollution control equipment must know the physical and chemical data for the process and its emissions. The engineers and environmental managers must know the applicable regulations regarding the construction, operation, and efficacy of the equipment.

Generally, air quality management sets the technology tools to control air pollutant emissions. The **control technologies** describe the equipment, processes or actions used to reduce air pollution. The extent of pollution reduction varies among technologies and measures. In general, control technologies and measures that do the best job of reducing pollution will be required in the areas with the worst pollution. ***The selection of control technologies depends on environmental conditions, engineering design criteria, economic factors and pollutant type***.

Techniques to minimize or eliminate air pollutant emissions ***without using add-on controls include***:

***1. Pollution Prevention (P2) program:***This program is regulated by the Pollution Prevention Act of 1990 and incorporated into the CAA Amendments of 1990, as measure of realizing the air quality goals.  This P2 program is mainly made up of ***Process equipment changes*** and ***Process material changes by substitution.***  Under the P2 program, the industries have to utilize ***Clean Technologies*** to enhance the efficiency of plant operations and reduce the pollutant emissions.  These control methods work equally well for gaseous and particulate pollutants. ***An example*** of a process material change might be the conversion from a power source using fossil fuel to one using solar or hydroelectric power. Solar and hydroelectric power generators produce less air pollution than do generators that burn fossil fuels. ***An example*** of a change in fuel would be to use coal with low sulfur content, rather than coal with high sulfur content. ***This would reduce the amount of sulfur dioxide emissions. Another example*** of a fuel change would be to replace coal with natural gas, a less polluting fuel. Another ***good example*** is the reduction in the amounts of dioxins emitted from a boiler or incinerator by controlling the furnace and exit gas temperatures. Similarly, control of furnace temperature and gas velocities can also reduce the amount of NOx emissions.

***2. Good operating practices:***These include common sense measures, such as good housekeeping and proper maintenance. ***An example*** is the use of a regular inspection and maintenance system to ensure that volatile organic compounds are not emitted by leaking equipment in a chemical plant. Equipment leaks can be a large source of volatile organic compound emissions. ***A regular inspection program*** using simple leak detection devices, coupled with a prompt repair and maintenance system, can greatly reduce this source of emissions. In addition to reducing emissions, good housekeeping and maintenance practices can also result in cost savings to a plant by reducing losses of valuable materials.

***3. Plant shutdowns:***Shutdowns are an effective pollution reduction technique. Plant shutdowns might be necessary in extreme cases, such as during an air pollution episode. Replacing old and outdated plants with modernized facilities is also effective in reducing air pollution. In this unit we will describe some techniques used to control particulate and gaseous pollutants from stationary sources and pollutants from mobile sources.

#### 2.0 Control of particulate pollutants from stationary sources (Source: [*http://www.epa.gov/air/oaqps/eog/course422/ce6a5.html*](http://www.epa.gov/air/oaqps/eog/course422/ce6a5.html))

Control techniques for particles focus on capturing the particles emitted by a pollution source. Several factors must be considered before choosing a particulate control device. Typically, particles are collected and channeled through a duct or stack. The characteristics of the particulate exhaust stream affect the choice of the control device. These ***characteristics include the range of particle sizes, the exhaust flow rate, the temperature, the moisture content, and various chemical properties such as explosiveness, acidity, alkalinity, and flammability.***

The most commonly used control devices for controlling particulate emissions include:

-         Electrostatic precipitators,

-         Fabric filters,

-         Venture scrubbers,

-         Cyclones, and

-         Settling chambers.

In many cases, more than one of these devices is used in a series to obtain the desired efficiency of emission controls. ***For example***, a settling chamber can be used to remove larger particles before a pollutant stream enters an electrostatic precipitator.

***2.1 Electrostatic Precipitators (ESPs)***

An electrostatic precipitator (ESP) is a particle control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates. The ESP places electrical charges on the particles, causing them to be attracted to oppositely charged metal plates located in the precipitator.(see the attached Figure 1)

|  |
| --- |
|  |

**Figure 1:**Electrostatic precipitator components

The particles are removed from the plates by "rapping" and collected in a hopper located below the unit. The removal efficiencies for ESPs are highly variable; however, for very small particles alone, the removal efficiency is about 99 percent.

**2.2 Fabric Filters**  (see Figure 2 attached)

Fabric filters, or bag-houses, remove dust from a gas stream by passing the stream through a porous fabric. The fabric filter is efficient at removing fine particles and can exceed efficiencies of 99 percent in most applications. The selection of the fiber material and fabric construction is important to bag-house performance. The fiber material from which the fabric is made must have adequate strength characteristics at the maximum gas temperature expected and adequate chemical compatibility with both the gas and the collected dust. One disadvantage of the fabric filter is that high-temperature gases often have to be cooled before contacting the filter medium.

**Figure 2:**Fabric filter (bag-house) components

**2.3** **Venturi Scrubbers** (see Figure 3 attached)

Venturi scrubbers use a liquid stream to remove solid particles. In the venturi scrubber, gas laden with particulate matter passes through a short tube with flared ends and a constricted middle. This constriction causes the gas stream to speed up when the pressure is increased. A water spray is directed into the gas stream either prior to or at the constriction in the tube. The difference in velocity and pressure resulting from the constriction causes the particles and water to mix and combine. The reduced velocity at the expanded section of the throat allows the droplets of water containing the particles to drop out of the gas stream. Venturi scrubbers are effective in removing small particles, with removal efficiencies of up to 99 percent. One drawback of this device, however, is the production of wastewater.

**Figure 3:**Venturi scrubber components

**2.4** **Settling Chambers**(see Figure 4 attached)

Settling chambers use the force of gravity to remove solid particles. The gas stream enters a chamber where the velocity of the gas is reduced. Large particles drop out of the gas and are recollected in hoppers. Because settling chambers are effective in removing only larger particles, they are used in conjunction with a more efficient control device.

**Figure 4:** Settling chambers

**2.5 Cyclones** (see Figure 5 attached)

Cyclones provide a low-cost, low-maintenance method of removing larger particulates from a gas stream. The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream. The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper. The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral. Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.

Because the particulate control devices discussed above capture the pollutants but don't destroy them, proper disposal of the collected material is needed. Collected solid particles are most often disposed of in a landfill. Wastewater generated by scrubber must be sent to a wastewater treatment facility. When possible, collected particle matter is recycled and reused.

**Figure 5:** Cyclone Collector

**2.6 Wet Scrubbers**  (see Figure 6 attached)

Wet Air Scrubber is designed to remove both heavy and light airborne particulate matter from industrial exhaust systems, as well as flue and process gasses. The scrubber is a completely self contained unit that needs only to be connected to normal plant electrical, water and air systems.  They use a high-energy liquid spray to remove aerosol and gaseous pollutants from an air stream. **Figure 6** shows an example of a wet scrubber.

**Figure 6:**Wet Scrubber Unit

A summary of advantages and disadvantages of some of the particulate technologies are given in **Table 1.**

**Table 1:**A summary of particulate pollution control technologies, and their advantages and disadvantages

|  |  |  |  |
| --- | --- | --- | --- |
| **Technology**  | **Description**  | **Advantages**  | **Disadvantages**  |
| Gravity settlers  | PM settles under gravity in an enlarged cross section (settling chamber) as the air velocity is reduced. It is a conventional technology. Baffles increase settling efficiency.  | Simple designLow initial costLow maintenance costLow pressure lossNo energy requirement  | Less efficient for particles smaller than 40 µM in size  |
| Cyclones  | Particulates are forced outward toward the wall by creating a vortex of the contaminated air. Due to inertia and friction, they settle into the hopper bottom of the tank.  | Removes both solid and liquid PMSimple designLow initial costLow maintenance costLow pressure lossDry collection and disposalCompact size  | Cannot handle tacky materialLow removals for particles smaller than 15 µM in size  |
| Wet scrubbers  | Contaminated air is brought into intimate contact with a fine spray of water or other liquid. PM from gas stream is removed and captured by the liquid or water stream. Venturi scrubbers are commonly used. (See figure 7-3.)  | Low initial costCompact sizeSimple to operateHigh collection efficiency (up to 98 percent for >0.5 µM)Can handle tacky, flammable, or corrosive matterSimultaneous collection of PM and     gasesNo secondary dust  | High maintenance costHigh pressure dropWastewater treatment and disposalEnergy consumption  |
| Electrostatic precipitators (ESP)  | ESP is commonly used for removing small particles such as fly ash in power plants. Particles are imparted with a negative charge as they enter the unit and removed under the influence of an electrical field.  | Low operating costHigh collection efficiency (up to 99 percent for >1 µM)Can handle tacky, flammable, or corrosive matterDry collection and disposalLow pressure dropSuitable for high pressure/vacuum,     temperature, and velocity streams  | High initial costLarge space requiredSkilled personnel are required to operate the equipmentPotential hazards due to high voltageSensitive to particle loadingConditioning of resistive PM may be requiredOzone may be produced  |
| Fabric filters  | These are commonly used devices. When PM-laden air is blown through the fabric filters, PM is trapped within the filters. Filters can be cleaned using shakers, reverse flow, or pulse-jet cleaning.  | Very high collection efficiency (up to 100 percent for >1 µM)Moderate pressure dropSimple to operateDry collection and disposalReadily available in many configurations  | High operation and maintenance costPre-cooler required for influent air above 550o FLower fabric life with acidic or alkaline PMFlammableHighly humid or oily streams   may clog fabric  |
| High efficiency particulate air (HEPA) filters  | HEPA filters are commonly used in medical, research, and manufacturing facilities requiring 99.9 percent or greater PM removal. HEPA filters are made of paper that can be pleated back and forth to form a compact filter element to fit in a housing. Generally, a vacuum is applied to draw air through filters.  | Very high collection efficiency (up to 99.97 percent for >0.3 µM)Simple to operateDry collection and disposalReadily available in many configurationsCan remove asbestos  | High operation and maintenance costHigh pressure dropLower filter life with acidic or alkaline PMFlammableHighly humid or oily streams may clog filter  |

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#### 3.0 Control of gaseous pollutants from stationary sources (Source: <http://www.epa.gov/air/oaqps/eog/course422/ce6b.html>)

The most common method for controlling gaseous pollutants is the addition of **add-on control devices** to recover or destroy a pollutant. There are four commonly used control technologies for gaseous pollutants: absorption, adsorption, condensation, and incineration (combustion). The choice of control technology depends on the pollutant(s) that must be removed, the removal efficiency required, pollutant gas stream characteristics, and specific characteristics of the site. Absorption, adsorption, and condensation all are recovery techniques while incineration involves the destruction of the pollutant.

**3.1 Absorption** (see Figure 7 attached)

The removal of one or more selected components from a gas mixture by absorption is probably the most important operation in the control of gaseous pollutant emissions. Absorption is a process in which a gaseous pollutant is dissolved in a liquid. Water is the most commonly used absorbent liquid. As the gas stream passes through the liquid, the liquid absorbs the gas, in much the same way that sugar is absorbed in a glass of water when stirred. Absorption is commonly used to recover products or to purify gas streams that have high concentrations of organic compounds. Absorption equipment is designed to get as much mixing between the gas and liquid as possible.

Absorbers are often referred to as scrubbers, and there are various types of absorption equipment. The principal types of gas absorption equipment include spray towers, packed columns, spray chambers, and venture scrubbers. The packed column is by far the most commonly used for the absorption of gaseous pollutants. The packed column absorber has a column filled with an inert (non-reactive) substance, such as plastic or ceramic, which increases the liquid surface area for the liquid/gas interface. The inert material helps to maximize the absorption capability of the column. In addition, the introduction of the gas and liquid at opposite ends of the column causes mixing to be more efficient because of the counter-current flow through the column. In general, absorbers can achieve removal efficiencies grater than 95 percent. One potential problem with absorption is the generation of waste-water, which converts an air pollution problem to a water pollution problem.

 **Figure 7:** Typical Packed Column Diagram

**3.2** **Adsorption** (see Figures 8 and 9 attached)

When a gas or vapor is brought into contact with a solid, part of it is taken up by the solid. The molecules that disappear from the gas either enter the inside of the solid, or remain on the outside attached to the surface. The former phenomenon is termed absorption (or dissolution) and the latter adsorption. Adsorption is the binding of molecules or particles to a surface. In this phenomenon molecules from a gas or liquid will be attached in a physical way to a surface. The binding to the surface is usually weak and reversible. The most common industrial adsorbents are **activated carbon, silica gel, and alumina,** because they have enormous surface areas per unit weight.

Activated carbon is the universal standard for purification and removal of trace organic contaminants from liquid and vapor streams. **Carbon adsorption** uses activated carbon to control and/or recover gaseous pollutant emissions. In carbon adsorption, the gas is attracted and adheres to the porous surface of the activated carbon. Removal efficiencies of 95 percent to 99 percent can be achieved by using this process. Carbon adsorption is used in cases where the recovered organics are valuable. For example, carbon adsorption is often used to recover perchloroethylene, a compound used in the dry cleaning process.

Carbon adsorption systems are either **regenerative or non-regenerative**. A **regenerative system** usually contains more than one carbon bed. As one bed actively removes pollutants, another bed is being regenerated for future use. Steam is used to purge captured pollutants from the bed to a pollutant recovery device. By "regenerating" the carbon bed, the same activated carbon particles can be used again and again. Regenerative systems are used when concentration of the pollutant in the gas stream is relatively high. **Non-regenerative systems** have thinner beds of activated carbon. In a non-regenerative adsorber, the spent carbon is disposed of when it becomes saturated with the pollutant. Because of the solid waste problem generated by this type of system, non-regenerative carbon adsorbers are usually used when the pollutant concentration is extremely low.

**Figure 8:** Regenerative Carbon Adsorption System                  **Figure 9:** Non-Regenerative Carbon Adsorption System

**3.3** **Condensation**  (see Figures 10 and 11 attached)

Condensation is the process of converting a pollutant gas or vapor to liquid. Any gas can be reduced to a liquid by lowering its temperature and/or increasing its pressure. The most common approach is to reduce the temperature of the gas stream, since increasing the pressure of a gas can be expensive.

Condensers are typically used as pretreatment devices. They can be used ahead of adsorbers, absorbers, and incinerators to reduce the total gas volume to be treated by more expensive control equipment. Condensers used for pollution control are **contact condensers and surface condensers** **(see Figures 10 and 11).**In a contact condenser, the gas comes into contact with cold liquid. In a surface condenser, the gas contacts a cooled surface in which cooled liquid or gas is circulated, such as the outside of the tube. Removal efficiencies of condensers typically range from 50 percent to more than 95 percent, depending on design and applications.

**Figure 10:** Contact condenser                          **Figure 11:** Surface condenser

**3.4** **Incineration** (see Figures 12  and 13 attached)

Incineration is also known as combustion.  It is used to control the emissions of organic compounds from process industries. This control technique refers to the **rapid oxidation** of a substance through the combination of oxygen with a combustible material in the presence of heat. When combustion is complete, the gaseous stream is converted to carbon dioxide and water vapor. **Incomplete combustion** will result in some pollutants being released into the atmosphere. Smoke is one indication of incomplete combustion. There are two types of incinerators: **thermal incineration** and **catalytic incineration(see Figures 12 and 13** respectively). **Choosing the proper incinerator** depends on many factors, including type of hazardous contaminants in the waste stream, concentration of combustibles in the stream, process flow rate, control requirements, and an economic evaluation.

In **thermal incinerators** the combustible waste gases pass over or around a burner flame into a residence chamber where oxidation of the waste gases is completed. For thermal incineration, it is important that the vapor stream directed to the thermal incinerator have a constant combustible gas concentration and flow rate. These devices are not well-suited to vapor streams that fluctuate, because the efficiency of the combustion process depends on the proper mixing of vapors and a specific residence time in the combustion chamber. The **residence time** is the amount of time the fuel mixture remains in the combustion chamber. Energy and heat produced by the incineration process can be recovered and put to beneficial uses at a facility. **Thermal incinerators can destroy gaseous pollutants at efficiencies of greater than 99 percent when operated correctly**.

**Figure 12:**Thermal incinerator

**Catalytic incinerators** are somewhat similar to thermal incinerators. The main difference between the two is that after passing through the flame area, the gases pass over a catalytic bed. A **catalyst** is a substance that enhances a chemical reaction without being changed or consumed by the reaction. A catalyst promotes oxidation at lower temperatures, thereby reducing fuel costs. **Destruction efficiencies greater than 95 percent are possible using a catalytic incinerator.** Higher efficiencies are possible if larger catalyst volumes or higher temperatures are used. Catalytic incinerators are best suited for emission streams with low VOC content.

**Figure 13:** Catalytic incinerator

Table 2 summarizes the advantages and disadvantages of gaseous air pollution control technologies

**Table 2:** A summary of gaseous air pollution control technologies, and their advantages and disadvantages

|  |  |  |  |
| --- | --- | --- | --- |
| **Technology**  | **Description**  | **Advantages**  | **Disadvantages**  |
| Wet scrubbers  | Scrubbers remove gases or vapors through absorption. Gas-liquid contact is provided in spray, tray, or packed towers. (See figure 7.3.) Scrubber liquid can be water for soluble contaminants or a reactive liquid (for example, lime slurry used in flue gas desulfurization). Scrubber liquid is introduced as fine spray into gas stream in spray towers. Spray towers are also used as a pretreatment to cool off hot gases. In tray towers, gas travels upward through orifices in the trays and contacts liquid flowing down across the trays. Gas-liquid contact in packed towers occurs in thin films of liquid formed on the packing material.  | Well establishedLow capital costCompact sizeSimple to operateTypically achieves 90?95 percent removalCan handle tacky, flammable, or corrosive matterSimultaneous collection of PM and gasesNo secondary dustModerate pressure loss  | High maintenance costLiquid waste disposal requiredLess efficient at low flow rates  |
| Adsorption  | Granular activated carbon (GAC) is the most commonly used [adsorbent](http://tychoarc.umuc.edu/0006_enmt340/Modules/M2-Module_2/S3-Commentary.html)for toxic organic removal. Other adsorbents such as silica gel, activated alumina, and so on are used to adsorb certain corrosive gases and inorganics. GAC has a finite adsorption capacity; once the capacity is reached, GAC can be regenerated to remove adsorbed contaminants and restore its capacity.  | Effective in removing a wide range of organics to extremely low levels (up to 99 percent removal)Simple to operateEasy to automateInsensitive to flow rate and concentration changesEffective for low organic concentrations[Adsorbate](http://tychoarc.umuc.edu/0006_enmt340/Modules/M2-Module_2/S3-Commentary.html)recovery for recycling possibleLow initial costWell developed  | High maintenance cost[Regeneration](http://tychoarc.umuc.edu/0006_enmt340/Modules/M2-Module_2/S3-Commentary.html) or disposal of spent carbon required; regeneration is an energy-intensive processHigh humidity reduces the effectivenessOrganic compounds with too low of a molecular weight do not adsorb readilyOrganic compounds with too high of a molecular weight do not desorb readily  |
| Condensers  | Condensers liquefy contaminant vapors or gases from the air stream. Condensation is achieved by lowering the temperature or increasing the pressure of a gas stream.  | Can be used as a pretreatment step to reduce concentrations to be treatedCompound recovery for recycling possible  | High operational costRelatively low removal efficiencySensitive to process parameters  |
| Flares  | Flares are open flame combustion devices for burning waste gases that have some fuel value. Flares are used when it is not economically feasible to recover the heating value of the waste gases. Upon complete burning, the waste gas or vapor is transformed to CO2 and water.  | Can achieve over 98 percent destruction of organicsInnocuous by-products  | High capital costsIncomplete combustion may produce potentially more toxic pollutants  |
| Thermal combustion  | This process is also known as thermal incineration, thermal oxidation, or after burner. Pollutant-laden air passes around or through a burner and into a refractory lined residence chamber, where the oxidation takes place. This process operates at 1,300?1,500o F temperature and 0.3?.0.5 second residence time. Upon complete oxidation, the waste contaminant is transformed to CO2 and water.  | Proven and well established technologyEffective for a wide range of organic compoundsNo waste disposalDestruction and removal efficiency (DRE) is typically over 98 percentInnocuous by-productsFacilitates heat recovery from off-gas  | High capital costOften supplemental fuel is requiredIncomplete combustion may produce potentially more toxic pollutantsHalogenated organics require higher temperatures and longer residence times  |
| Catalytic combustion  | Contaminant-laden air is heated and passed through a catalyst bed that promotes the oxidation at a lower temperature. Catalytic combustion operates at 600?900o F.  | All advantages of thermal combustionRelatively lower auxiliary fuel requirementCatalysts that can handle chlorinated solvents are emerging  | Halogens and sulfur-containing compounds, certain heavy metals such as mercury, arsenic, lead, and so on foul the catalystIncomplete combustion may produce potentially more toxic pollutants  |
| High energy corona (HEC)  | This emerging process uses high voltage electricity to destroy organics at room temperature. A HEC reactor is a glass tube filled with glass beads through which contaminated air is passed. A high voltage electrode is placed along the center of the tube and a grounded metal screen is attached to the outer wall of the tube. A high voltage power supply is attached across the electrodes to provide 0?50 mA current at 30kV voltage.  | Effectively destroys most VOCs and SVOC, including chlorinated solvents and potentially NOx and SOxGenerally 95 to over 99 percent DRE is achievedProvides a portable means of treating off-gas producedLittle or no maintenance  | Technology under developmentCurrently available on experimental scale for low flow ratesRelatively high initial costPotential hazards due to high voltageFurther treatment may be required to remove HCl when treating chlorinated solvents  |
| Bio-filtration  | Bio-filtration is an innovative technology to treat biodegradable organics in off-gases. Contaminant-laden air is passed through a bed of biologically active material (for example, soil). In this process biodegradable organics are adsorbed on the adsorbent material and are available for biodegradation into innocuous end products.  | Available for full-scale applicationsVery effective for non-halogenated organics and fuel hydrocarbonsSO2, NOx, and H2S can be treatedLow initial cost and low maintenance costRegeneration not requiredContaminants are destroyed as opposed to phase transfer  | Less effective for halogenated organicsExtensive monitoring and control of pH, moisture content, gas humidity, and so on are required to keep bio-filtration process activeIneffective in cold weather; heating may be requiredRequires large areaFugitive fungi may be a problemPM may clog soil beds  |
| Membrane separation  | This is an emerging technology to separate organic contaminants from air. Specialty nonporous gas membranes allow preferential transport of contaminants through diffusion. High pressure is applied on the influent side of the membrane by pressurizing the contaminated air. Concentrated stream (permeate) is collected on the effluent side. Treated air is discharged to atmosphere.  | Compound recovery for recycling possibleVOC removal efficiencies up to 95 percentUseful as pretreatmentApplicable where GAC cannot be usedLow initial and low operational costs  | Limited data availableNot a complete treatment technologyParticulates and inorganics may foul the membraneCorrosive gases may degrade the membranesSensitive to moistureMembrane replacement required every three years  |

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#### Module B: Mobil Source Air Pollution Control Technologies

#### 1.0  Overview

Since the earliest days of the Clean Air Act (CAA), mobile sources have been recognized as one of the most important sources of air pollution and, as a result, have been a prime target for emission control. The 1970 CAA required automobile manufacturers to reduce by 90% the pollutant emissions from new vehicles by 1975. Specific limits were set for emissions of carbon monoxide, hydrocarbons, and oxides of nitrogen from automobiles. This forced the automobile industry to develop new technologies for emission control. Currently, a wide variety of mobile sources are subjected to control under the CAA. Strategies used to control mobile-source emissions include the new-source certification programs that specify emission standards applicable to new vehicles and motors; in-use technological measures and controls that include specification for fuel properties, vehicle inspections, maintenance programs, and retrofits to existing vehicles; and non-technological measures to control usage or activity.

The term **mobile source** refers to any moving source of air pollution that can be licensed to travel on a public roadway, such as cars, trucks, and motorcycles. Mobile sources include airplanes but not off-road construction and farm vehicles. However, these vehicles may be regulated if the EPA administrator determines that some degree of emission reduction is necessary. Mobile sources emit large quantities of CO, VOCs and NOx, all leading to increases in criteria pollutants. Over the years, the statutory emission limits have been reduced in several steps.

**2.0** **Mobil Source Air Pollution Control Approaches and Technologies**

To achieve on-road mobile source emission control an integrated approach has been used. This integrated approach includes technological advances in vehicle and engine design together with cleaner, high-quality fuels plus the addition of vapor and particulate recovery systems and the development of auto inspection and maintenance (I/M) programs.  Some highly recommended mobile air pollution technologies are briefly described in the following:

**2.1 Cleaner fuels technology**

One of the ways to reduce air pollution from cars and trucks is to use a gasoline that is designed to burn clean. This cleaner burning gasoline, called **reformulated gasoline** or ***RFG***, is essential in cities with the worst smog pollution, but other cities with smog problems may choose to use RFG. Reformulated gasoline contains less volatile organic compounds (VOCs), and will contain oxygen additives to make the fuel burn more efficiently. In addition, all types of gasoline have to contain detergents, which, by preventing build-up of engine deposits, keep engines working smoothly and burning fuel cleanly.

**Methyl tertiary-butyl ether (MTBE)** is the oxygen additive most commonly used by the petroleum industry to satisfy the two percent oxygen mandate in the RFG program. MTBE is used in approximately 87 percent of RFG, with ethanol being the second most commonly used additive. Oxygenates increase the combustion efficiency of gasoline, thereby reducing vehicle emissions of carbon monoxide. On the other hand, EPA encourages the development and sale of **alternative fuels** such as alcohols, liquefied petroleum gas (LPG) and natural gas in order to lower fuel emissions.

**2.2 Cleaner cars**

In response to tighter standards, manufacturers equipped new cars with even more sophisticated emission control systems. These systems generally include a "three-way" catalyst (which converts carbon monoxide and hydrocarbons to carbon dioxide and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen), plus an on-board computer and oxygen sensor. This equipment helps optimize the efficiency of the catalytic converter. The catalytic converter is an anti-pollution device located between a vehicle's engine and tailpipe. Catalytic converters work by facilitating chemical reactions that convert exhaust pollutants such as carbon monoxide and nitrogen oxides to normal atmospheric gases such as nitrogen, carbon dioxide, and water.

In diesel exhaust, the addition of a **particulate filter** as an anti-pollution device traps particles in the exhaust before they can escape into the atmosphere. A **vapor recovery system**, also an anti-pollution system, captures gasoline vapors that would otherwise escape into the atmosphere from hot vehicle engines and fuel tanks.

Finally, auto makers are required to manufacture some cars that use clean alternate fuels, including ethanol and alcohol.  In addition, they are encouraged to produce **Electric cars and "hybrid**" vehicles, which are low-pollution vehicles, currently being used as clean cars. Hybrid vehicles can more than double the gas mileage of conventional gasoline or diesel-powered cars and cut emissions significantly.

**2.3** **Auto Inspection and Maintenance (IM) Programs**

Under the 1990 Clean Air Act, auto manufacturers will build cleaner cars, and cars will use cleaner fuels. However, to get air pollution down and keep it down, a third program is mandated: **vehicle inspection and maintenance (IM)**, which ensures that cars are being maintained adequately to keep pollution emissions low. The 1990 Clean Air Act includes very specific requirements for inspection and maintenance programs.

Auto inspection and maintenance programs require the testing of motor vehicles in parts of the country with unhealthy air and the repair of those that do not meet standards. I/M tests use special equipment to measure the pollution in car exhaust. These tests check that the car's key emission controls are installed as designed and then analyze the exhaust to check acceptable control of carbon monoxide and hydrocarbons. Advanced tests also check nitrogen oxide emissions.

**Reading Assignment:**

**Chapter 10** – Sections 10.1 – 10.1.4; Sections 10.2, 10.3 and 10.4. Also **Chapter 9-**-Sections 9.1.1.2, 9.1.1.3, 9.1.1.4, Section, 9.2 and 9.3. Pay particular attention to Figures 9.2 and 9.7.

**Review Check Questions:**

--- What are the major categories of approaches to minimize or eliminate air pollutant emissions without using add-on controls?

--- Can you briefly describe the particulate pollution control technologies by giving their advantages and disadvantages?

--- Can you briefly describe the gaseous pollution control technologies by giving their advantages and disadvantages?

--- Did you understand the terminologies of the control technologies?

--- Can you briefly explain the approaches and techniques for controlling or minimizing air pollution from mobile sources?

**AIR POLLUTION CONTROL MANAGEMENT: Part 3**

**Management of Indoor Air Quality**

**1.0  Introduction**

Indoor air pollutants are harmful materials in the air. They range from dusts to chemicals to radon. Generally for the purpose of indoor air quality management, the indoor air pollutants can be broadly divided into four groups: **particles, gases, radon and its progeny, and biological pollutants.**  For effectively mitigating the indoor pollution and managing the indoor air quality one has to identify the sources of indoor air pollution. As you have learned about various sources of indoor air pollution in the previous classes, the following are some important sources:

* Smoking indoors, smoke drifting in from outdoors, or smoke being carried indoors on clothing
* Things that burn, like oil, gas, kerosene, charcoal briquettes, wood or candles
* Central heating, cooling or humidifying systems
* New or recently installed building materials and furnishings, including carpets and certain wood pressed products
* Household cleaning and maintenance products
* Personal care products, like hair spray or soaps
* Too much moisture in the house causing molds & mildews
* Pesticides and pollens in on shoes and clothes
* Improper circulation of fresh, outside air (ventilation)

**2.0 What are the strategies for managing indoor air quality?**

Generally, there are three basic strategies to manage and improve indoor air quality. These include:

- Source control

- Improved ventilation, and

- Use of air cleaners

**2.1 Source Control**

Usually the most effective ways to manage the indoor air quality is to eliminate individual sources of pollution or to reduce their emissions. Some sources, like those that contain asbestos, can be sealed or enclosed; others, like gas stoves, can be adjusted to decrease the amount of emissions. In many cases, source control is also a more cost-efficient approach to protecting indoor air quality than increasing ventilation because increasing ventilation can increase energy costs. **For most indoor air quality problems in the home, source control is the most effective solution.**

**2.2 Improved Ventilation**

Another strategy to lowering the concentrations of indoor air pollutants in your home is to increase the amount of outdoor air coming indoors. Most home heating and cooling systems, including forced air heating systems, do not mechanically bring fresh air into the house. Intermittently opening windows and doors, operating window or attic fans, when the weather permits, or running a window air conditioner with the vent control open increases the outdoor ventilation rate. Local bathroom or kitchen fans that exhaust outdoors can effectively remove contaminants directly from the room where the fan is located and also increase the outdoor air ventilation rate.  It is particularly important to take as many of these steps as possible while you are involved in short-term activities that can generate high levels of pollutants.  For **example**, activities such as painting, paint stripping, heating with kerosene heaters, cooking; engaging in maintenance and hobby activities (such as welding, soldering and sanding) can enhance the indoor air pollutants and deteriorate the air quality.  **Advanced designs of new homes** are starting to feature mechanical systems that bring outdoor air into the home. Some of these designs include **energy-efficient heat recovery ventilators** (also known as air-to-air heat exchangers).

**2.3 Air Cleaners**

Air cleaners are devices that attempt to remove such pollutants from the indoor air you breathe. The typical furnace filter installed in the ductwork of most home heating and/or air-conditioning systems is a simple air cleaner. This basic filtering system may be upgraded by using another filter to trap additional pollutants or by adding additional air-cleaning devices. An alternative to upgrading the induct air cleaning system is using individual room, portable air cleaners. Air cleaners generally rely on filtration, or the attraction of charged particles to the air cleaning device itself or to surfaces within the home, for the removal of pollutants. The use of "**air cleaners**" to remove pollutants from the air in homes/buildings is **in its infancy stage.**

There are many types and sizes of [air cleaners](http://www.epa.gov/iaq/pubs/airclean.html), which range from relatively inexpensive table-top models to sophisticated and expensive whole-house systems. Some air cleaners are highly effective at particle removal, while others, including most table-top models, are much less so. Air cleaners are generally not designed to remove gaseous pollutants.

The effectiveness of an air cleaner depends on how well it collects pollutants from indoor air (expressed as a **percentage efficiency rate**) and how much air it draws through the cleaning or filtering element (expressed in cubic feet per minute). A very efficient collector with a low air-circulation rate will not be effective, nor will a cleaner with a high air-circulation rate but a less efficient collector. The long-term performance of any air cleaner depends on maintaining it in accordance with the manufacturer's directions.

Another important factor in determining the effectiveness of an air cleaner is the strength of the pollutant source. Table-top air cleaners, in particular, may not remove satisfactory amounts of pollutants from strong nearby sources. People with sensitivity to particular sources may find that air cleaners are helpful only in conjunction with concerted efforts to remove the source.

Over the past few years, there has been some publicity suggesting that house plants have been shown to reduce levels of some chemicals in laboratory experiments. According to EPA, there is currently no evidence.  However, that a reasonable number of house plants remove significant quantities of pollutants in homes and offices. Indoor house plants should not be over-watered because overly damp soil may promote the growth of microorganisms which can affect allergic individuals.

**Ozone-generating air cleaners** are marketed to homeowners as well as business establishments ostensibly to remove odors and other contaminants from indoor air. **Indoor Environmental Management Board (IEMB)** has characterized ozone and oxides of nitrogen (NOx) emissions from these devices in full-scale environmental chamber tests. To date, findings demonstrate that, for those models tested, ozone generation rates are generally within the ranges stated by the manufacturers and some models have the capacity to generate ozone concentrations of **200 parts per billion (ppb)** in the test house, **well above EPA's 8-hour ambient ozone standard of 80 ppb**. Additionally, ozone and nitrogen dioxide emission rates by these air cleaners increase with decreasing relative humidity.  IEMB concluded that these devices are capable of producing ozone concentrations well above those of accepted health guidelines.

At present, EPA does not recommend using air cleaners to reduce levels of ***radon and its decay products***. The effectiveness of these devices is uncertain because they only partially remove the radon decay products and do not diminish the amount of radon entering the home. EPA plans to do additional research on whether air cleaners are, or could become, a reliable means of reducing the health risk from radon.

Because many factors need to be considered in determining whether use of an air cleaner is appropriate in a particular setting, the decision whether or not to use an air cleaner is left to the individual. EPA has not taken a position either for or against

**3.0 What are the specific management approaches for improving the indoor air quality?**

**3.1. Managing biological and chemical pollution sources**

* Don't smoke indoors.
* Circulate fresh, outdoor air through your home every day to remove stale air and move pollutants out.
* Wipe feet off before coming inside, and take shoes off in the house in order to keep out pesticide contamination.
* Replace or clean furnace and air filters when they are dirty. Check them regularly, at least every two months. Use a "high efficiency particulate filter" (HEPA).
* Use ventilating fans over the stove and in the bathroom and be sure they are vented to the outside of the house.
* Keep ventilating fans clean.
* If you have mold, or areas that develop mold, see the section below titled, "Keeping your home healthy and free of mold during the wet seasons."
* Use safe cleaning products, those without any of the signal words ("danger", "warning" or "caution"). If you do not use safe household products, read the label and follow the directions carefully.
* Vacuum carpets well and stuffed furniture well, wash linens weekly and dust regularly to keep the allergen "dust mites" to a minimum. Dust mites are microscopic bugs that live in the dust and our sloughed off skin.

**3.2. Managing combustible pollutants in your home/buildings, like natural gas**

* Don't smoke indoors.
* Assure the gas flame in all appliances is blue, without much yellow. If there is a strong smell of natural gas, open the windows, leave the house, and call the gas company.
* Be sure to have good ventilation in rooms with working fireplaces and gas or wood stoves.
* Do not burn charcoal or kerosene heaters indoors. Please see the following sites:

[www.metrokc.gov/health/disaster/carbmono.htm](http://www.metrokc.gov/health/disaster/carbmono.htm)

[www.epa.gov/iaq/pubs/combust.html](http://www.epa.gov/iaq/pubs/combust.html)

**3.3. Keeping your home/buildings healthy and free of molds and mildews during the wet seasons**

Mold and mildew are a form of fungi. Mold is found in every moist indoor and outdoor environment year round. It grows naturally indoors, and can also enter your home on shoes, clothing, bags, animals, windows and ventilation systems. There is always a little mold in the air and on many surfaces. The mere presence of molds does not necessarily lead to symptoms. Mold may become a problem where there is **excessive moisture**, such as leakage in roofs, pipes, walls, plant pots, or where there has been flooding.  Too much moisture can lead to mold and mildew. Although mold exposure does not always cause health problems, daily exposure has been known to cause respiratory problems, headaches, watery eyes, dizziness, lethargy, rashes and other reactions. Mold and other biological contaminants can trigger asthma, too.  Here are some approaches for keeping buildings/homes clear of molds:

**Get excess moisture out of your home**

* Flush the air two or three times a day (for three to four minutes, open all the doors and windows and let fresh air circulate through the home).
* Ventilate the bathroom and the kitchen with an exhaust fan.
* Keep shower curtain or bathtub sliding door open after bathing to increase air circulation.
* Assure that the dryer vents freely to the outside.
* Heat all the rooms in your home to keep moisture from forming on the walls and other surfaces of unheated areas.

**Stop moisture from coming in**

* Stop any leaks from the roof, poorly-drained gutters and plumbing.
* Stop water from entering basements and crawl spaces.
* Properly insulate walls and ceilings.
* Grade ground so that it drains surface water away from home.

**Other preventive measures**

* Use easy to clean paint and wallpaper, especially in bathrooms.
* Install a timer switch on your bathroom fan, and leave the fan on for 15 minutes after showering.
* When cooking, try to minimize simmering of liquids and foods.
* Keep furniture away from outside walls where mold might grow.
* Replacing carpet with wood or vinyl floor tiles will prevent some of the problems with carpeting.

**Steps to eliminate existing mold in the home**

**1.** Clean up mold growing on surfaces by scrubbing it with regular soap and water.

**2.** Next, apply a bleach solution on the effected area (one part chlorine bleach to four parts water).

**3.4 Residential/building Radon Mitigation Standard of Practice**

EPA recommends the **Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings**\* for residential/building radon mitigation. This consensus-based standard was developed and issued by the American Society for Testing and Materials International, and is identified as **ASTM E-2121**. The Agency first cited **ASTM E-2121** in 2003 as a national consensus standard appropriate for reducing radon in homes as far as practicable below the national action level of 4 picocuries per liter (pCi/L) in indoor air.  As of May 2006, EPA no longer recommends, and will no longer distribute its own, superseded Radon Mitigation Standards (EPA 402-R-93-078, Revised April 1994).

(source: <http://www.epa.gov/iaq/radon/construc.html>)

The techniques may vary for different foundations and site requirements, but the basic elements are:

**A. Gas Permeable Layer:** This layer is placed beneath the slab or flooring system to allow the soil gas to move freely underneath the house. In many cases, the material used is a 4-inch layer of clean gravel.

**B. Plastic Sheeting:**Plastic sheeting is placed on top of the gas permeable layer and under the slab to help prevent the soil gas from entering the home. In crawl spaces, the sheeting is placed over the crawl space floor.

**C. Sealing and Caulking:**All openings in the concrete foundation floor are sealed to reduce soil gas entry into the home.

**D. Vent Pipe:** A 3- or 4-inch gas-tight or PVC pipe (commonly used for plumbing) runs from the gas permeable layer through the house to the roof to safely vent radon and other soil gases above the house.

**E. Junction Box:** An electrical junction box should be installed in case an electric venting fan is needed later.

**Reading Assignment**

Please read the following Sections of the textbook:

**Sections 11.7.1, 11.7.2 and 11.8**

**Review Check List of Questions**

- Can you recall various important sources of indoor pollution?

- Can you describe various strategies for managing indoor air quality?

- What are the specific management approaches for improving the indoor air quality?

- Do you know how to mitigate indoor radon problems?

**Please Note: The entire Air Pollution Trading Programs will be covered in week 12 instead of covering a portion of it this week, and like wise the Introduction to Air Pollution Modelling.**

Have a productive week!

Dr. Sayala

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