**Lecture 21. Urban photochemical smog.**

## Part3: Monitoring and controlling smog

Objectives:
1. Monitoring and controlling urban pollution.
2. Alternative fuels.

Readings: Turco: p.174-180, 215- 221; Brimblecombe: p.

## 1. Monitoring and controlling urban pollution.

Photochemical smog has become a serious problem in the major cities of the developed nations as well as the developing countries.

The monitoring of air pollution involves the most advanced technology available in scientific instrumentation.

Pollutant concentrations are determined in the following ways:

⇒ Carbon monoxide (CO) is typically measured by using an **infrared gas analyzer**. With this instrument the absorption of infrared radiation by CO in the sample of air stream is compared with absorption in a reference gas of known CO concentration. This method allows continuous measurements of CO in the sampled air.

⇒ Sulfur dioxide ($SO_2$) is generally measured by **ultraviolet (UV) emission spectrometers**. This approach is based on the principle that $SO_2$ emits a measurable flux of radiation when irradiated with intense UV from a light source in the spectrometer.

⇒ Nitrogen oxides (NOx) are measured by **chemiluminescence**. Two sequential chemical reactions involving ozone are used. First, NO is measured, then $NO_2$. Infrared radiation is emitted during oxidation of NO and $NO_2$ by ozone introduced into instrument. The amount of radiation (chemiluminescence) produced is proportional to the NO concentration in the air stream. To measure NO2, a catalyst is used to reduced all $NO_2$ in the air stream to NO, whose subsequent reaction with ozone permits the indirect determination of $NO_2$.

⇒ Ozone ($O_3$) concentrations are generally measured by using **UV absorption spectrophotometers**, although chemiluminescent-type instruments are also used.

⇒ Nonmethane hydrocarbons (NMHCs) are measured using such instruments as a **gas chromatograph.** Hydrocarbons are generally more difficult to measure than most other pollutants, and often require greater operator involvement in the measurement process.

⇒ Particulates (PM10) are measured using a **high-volume air sampler** situated outside the trailer or van. In this type of instrument , a known volume of air is continuously drawn through several paper filters. The filters collect particles of different size ranges. The amount of particulate matter is each size range is determined by measuring the weight change of the filter over a specified period of time, such as 24 hours. Chemical analysis, such as determination of lead, may also be done.

- The legislative basis for air pollution abatement in the United States is the 1963 Clean Air Act (major amendments were added in 1970, 1977, and 1990).

Strategy: **pollution prevention**

Table 21.1 Examples of industrial pollution prevention.

| **Previous action and result** | **New action and result** |
|---|---|
| One company painted steel joists by dipping them into open vats of paint, releasing large amounts of fumes. | Vats were layered with ping pong balls, which cut emissions without interfering with the dipping of joists. |
| A facility had storage tanks containing volatile organic chemicals. Large amounts of fumes were escaping. | Floating roofs were placed in the tanks. Because they float directly on the liquid, there is no room for vapor to form. VOC emissions to the air were greatly cut. |
| An electric power plant used end of pipe control to capture the sulfur dioxide that was formed as coal was burned. | The plant began buying coal that had been treated to remove much of its sulfur, resulting in lower sulfur dioxide emissions. |

Table 21.2 Examples of pollution prevention in the motor vehicle industry.

| **A manufacturer designs a vehicle that** | **The result is** |
|---|---|
| has reduced tailpipe emission | reduced air pollution |
| has better fuel mileage | reduced air pollution<br>reduced use of gasoline (conservation) |
| is lighter weight, but still safe | reduced air pollution<br>reduced use of gasoline |
| uses fewer toxic chemicals in its manufacture | reduced worker exposure to chemicals<br>reduced hazardous waste generation |
| can be disassembled at the end of its life | reduced solid waste generation<br>reuse of vehicle component parts |

Table 21.3 Individual Example of pollution prevention.

| **YOU** |
|---|
| Purchase a car with good fuel economy and maintain it to keep that economy. |
| Use energy-efficient light bulbs and turn them off when not in use. |
| Turn down the thermostat at night and turn off appliances that are not being used. |
| Practice water conservation in the home an yard. |

NOTE: examples above and more discussion on pollution prevention you can find in Hill M. "Understanding environmental pollution". Cambridge Univ. Press, 1997.

## 2. Alternative fuels.

### "Clean" gasoline mixture:

**Advantages:**

1) Immediate reduction in air pollution emissions;
2) Fuel-distribution system in place
3) Requires no engine modifications

**Disadvantages:**

1) Net environmental benefits uncertain;
2) Fuel is more expensive;
3) Dependence on important crude oil;
4) No reduction in carbon dioxide emissions;

### Ethanol:

**Advantages:**

1) Higher octane than regular or premium gasoline;
2) Renewable resources (based on corn or sugar cane);
3) Reduce carbon dioxide emissions;
4) Lowers CO emissions for gasoline mixtures;

**Disadvantages:**

1) Less energy per gallon;
2) Expensive;
3) Causes smog when used with gasoline;

## Methanol:

**Advantages:**

1) Higher octane than gasoline;
2) Overall reduction in hydrocarbon emissions;
3) Reduces carbon dioxide emissions;
4) Lowers total airborne toxics, except for formaldehyde;

**Disadvantages:**

1) Less energy per gallon;
2) Can be dangerous to handle;
3) Corrosive;
4) Cold engine starts difficult;

## Natural gas:

**Advantages:**

1) Abundant supplies;
2) Currently inexpensive;
3) Lower hydrocarbon emissions than gasoline;
4) Reduces CO emissions;
5) Small reduction in carbon dioxide emissions;
6) Distribution system largely in place;

**Disadvantages:**

1) Clumsy fuel tank;
2) Must refuel every 100 miles, and refueling time is greater by 2-3 times;

## Electricity:

**Advantages:**

1) Quiet;
2) Virtually no vehicle emissions;

**Disadvantages:**

1) Technology is about 5-10 years away;
2) Currently, less than 100 miles per charge;
3) Maximum speeds 30-65 MPH today;
4) Recharge 6-8 hours;
5) Environmental impact varies with source of electricity;

## Solar-generated hydrogen:

**Advantages:**

1) Renewable energy source;
2) Virtually emission free;
3) Does not contribute to global warming;

**Disadvantages:**

1) Technology is at least 20 years away;