SKAA 3913 ENVIRONMENTAL MANAGEMENT 2015/2016 Semester 2

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AIR POLLUTION CONTROL: MECHANISM

- Definition
  - Air pollution control refer to steps taken to maintain a standard of purity of air for good public health; for protection of plant and animal life, and property; for visibility; and for safe ground and air transportation (OECD, 1997)

- Air pollution control of removal mechanism can be divided into:
  - Control of gaseous emission
  - Control of particulates emission

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AIR POLLUTION CONTROL: GASEOUS EMISSION

- The major collection mechanism for gaseous pollutants are:
  - Absorption
  - Adsorption
  - Combustion
  - Condensation

- The applicability of each technique depends on the physical and chemical properties of the gaseous pollutant and the gas stream

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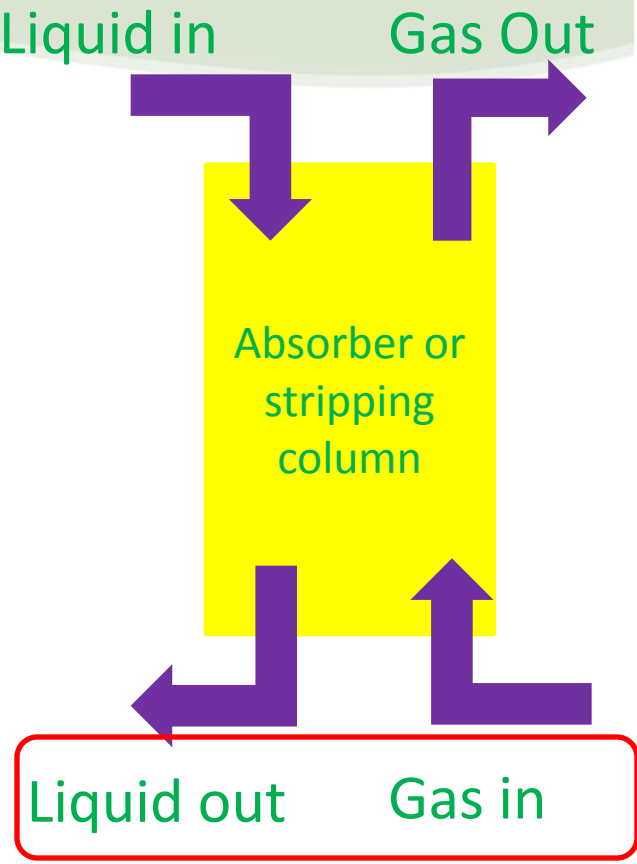
AIR POLLUTION CONTROL: GASEOUS EMISSION

Gas removal mechanism include:

1) Absorption

- The transfer of gaseous pollutant from the air into a contacting liquid such as water.
- A gas is dissolved in a liquid, where the contaminants diffuses from gas phase into the liquid phase
- Gas absorbers are designed to provide sufficient mixing of the gas and liquid phases



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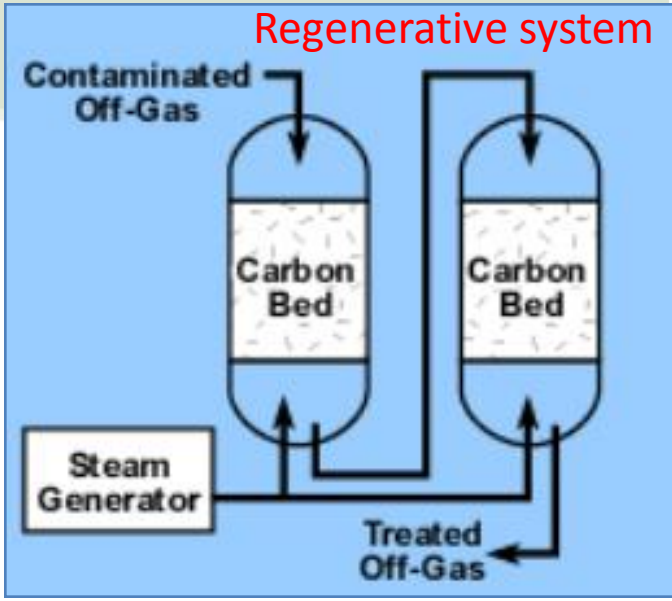
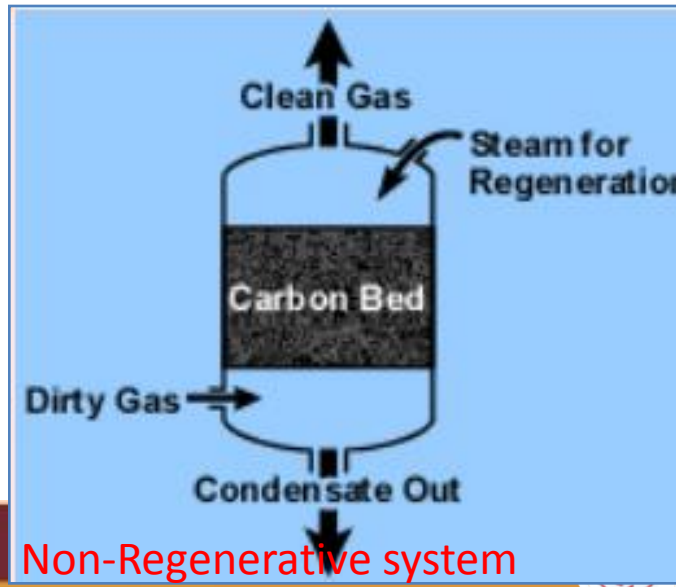
AIR POLLUTION CONTROL: GASEOUS EMISSION

2) Adsorption

- Contrasted with absorption, adsorption is a surface phenomenon
- Gas adheres to the surface of a solid bodies with which they are in contact, not destroyed but stored on the adsorbent surface until it is removed by desorption
- Activated **carbon** (heated charcoal)is commonly used as an adsorbent materials.





AIR POLLUTION CONTROL: GASEOUS EMISSION

3) Combustion

- Rapid, high temperature, gas phase oxidation where the VOCs and other gaseous hydrocarbon pollutants is oxidized and converted to CO_2 and water vapor

- Incineration usually is accomplished in a special incinerator called an afterburner. Afterburners are used to control odors, destroy toxic compounds, or reduce the amount of photo-chemically reactive substances released into the air.

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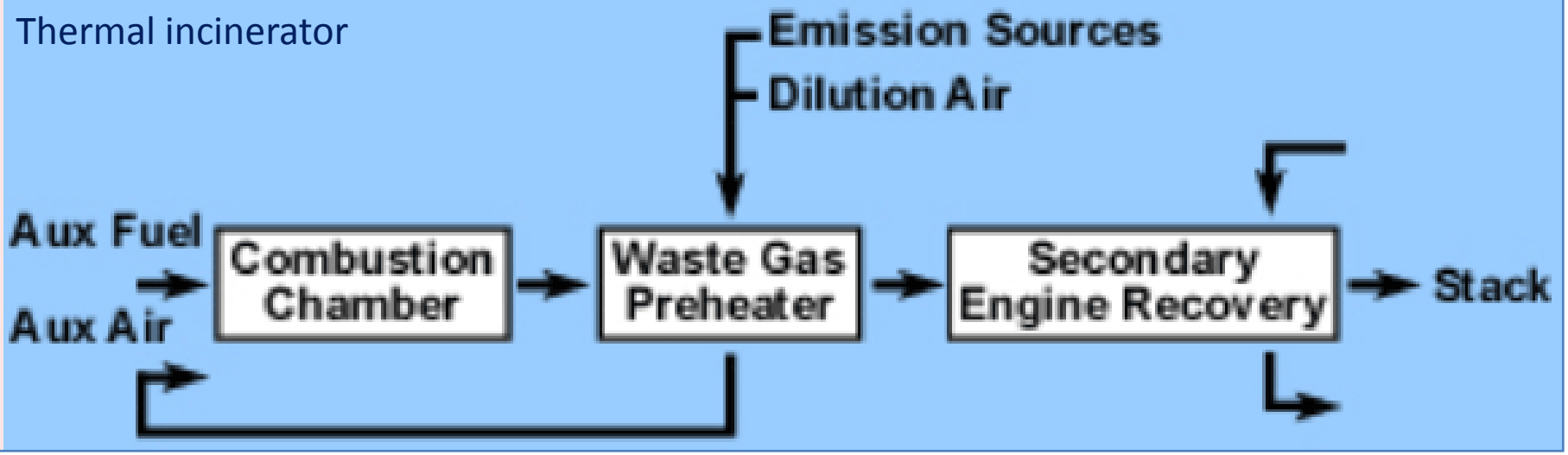
Thermal incinerator



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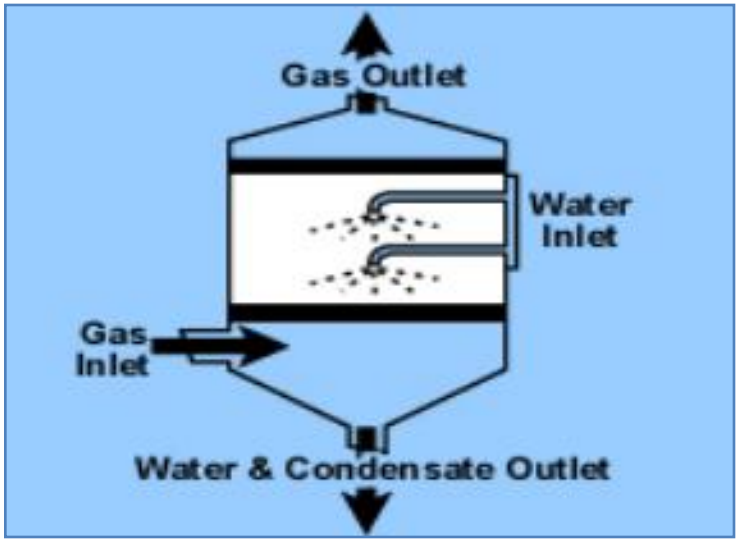
AIR POLLUTION CONTROL: GASEOUS EMISSION

4) Condensation

- Volatile contaminant gases are removed from a gas stream by adjusting the gas stream temperature until the gas changes into a liquid.

- Condensation devices (condenser) are often used in combination with other control devices , located before absorber, adsorber or incinerator.



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AIR POLLUTION CONTROL: PARTICULATES EMISSION

- Particulates pollutants are collected using applied force

- Particle removal mechanisms include separation by:
  - Gravity
  - Centrifugal force
  - Impaction
  - Diffusion
  - Electrostatic precipitation

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AIR POLLUTION CONTROL: PARTICULATES EMISSION

Particle removal mechanisms:

1) Gravity

- Large particles move slowly through the gas stream are overcome by gravity, and collected at the bottom of control device

2) Centrifugal force

- The shape or curvature of the collector causes the gas stream to rotate in a spiral motion

- The particles lose their kinetic energy as they strike the wall of the collector and are separated from the gas stream

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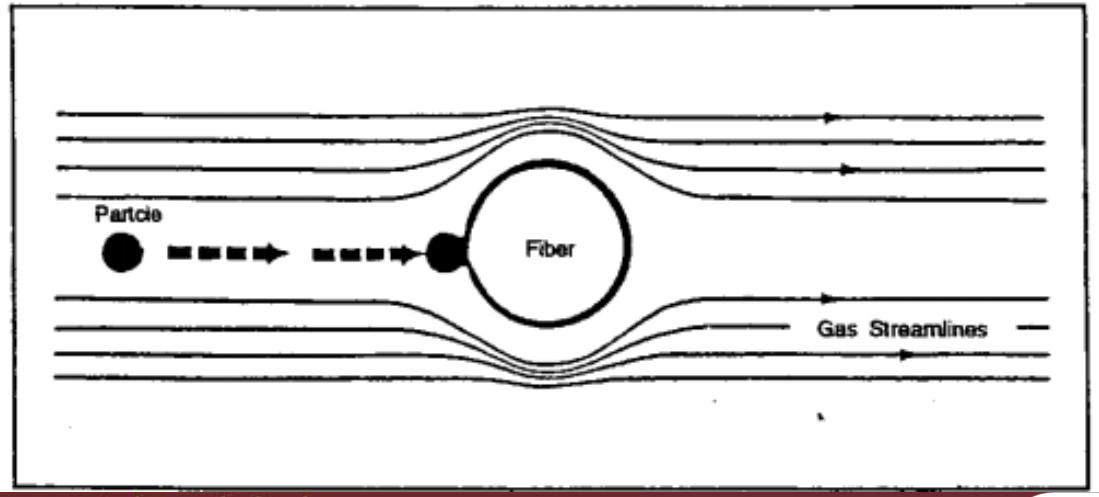
AIR POLLUTION CONTROL: PARTICULATES EMISSION

3) Impaction

- Involves direct contact between particle and object

- The particles is too large to follow the gas stream lines around the filter fiber, so its strikes the fiber and left at collection surface



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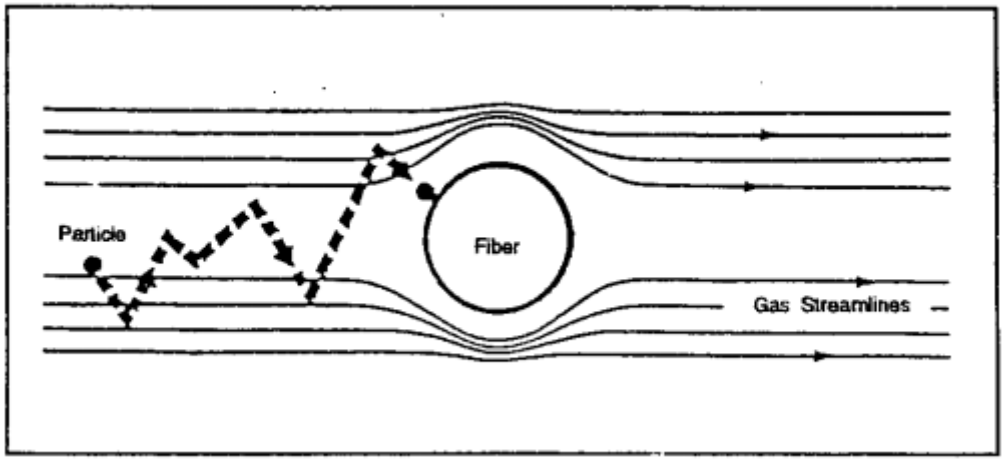
AIR POLLUTION CONTROL: PARTICULATES EMISSION

4) Diffusion

- Small pollutant particles are continually and regularly bombarded gas molecules, causes the particles to move in an erratic, zigzag manner

- The particles move through the gas stream until they strike an object such as a fiber in a fabric filter system.

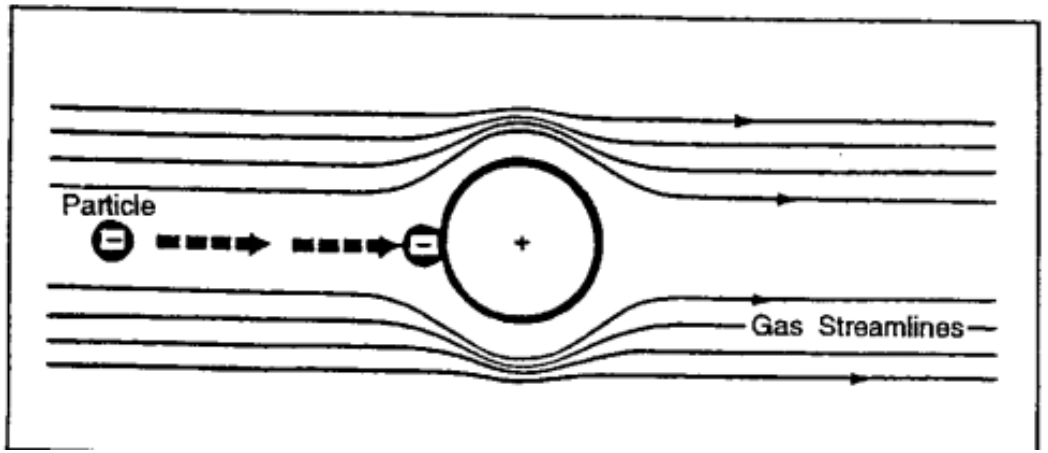


AIR POLLUTION CONTROL: PARTICULATES EMISSION

5) Electrostatic Precipitation

- Uses electrostatic forces. Particles can be charged by being subjected to a strong electrical field.

- The charged particle migrate to an oppositely charged collection surface and attached



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AIR POLLUTION CONTROL: DEVICES

- The best way to reduce the emission of pollutants is by changing to cleaner fuels and processers
- However, pollutants that not eliminated in this way must be collected or trapped by appropriate air cleaning devices; as they are generated and before it release into the atmosphere.
- Air quality management sets the tools to control air pollutant emissions. Control measurements describes the equipment, processes or actions used to reduce air pollution.
- The extent of pollution reduction varies among technologies and measures.

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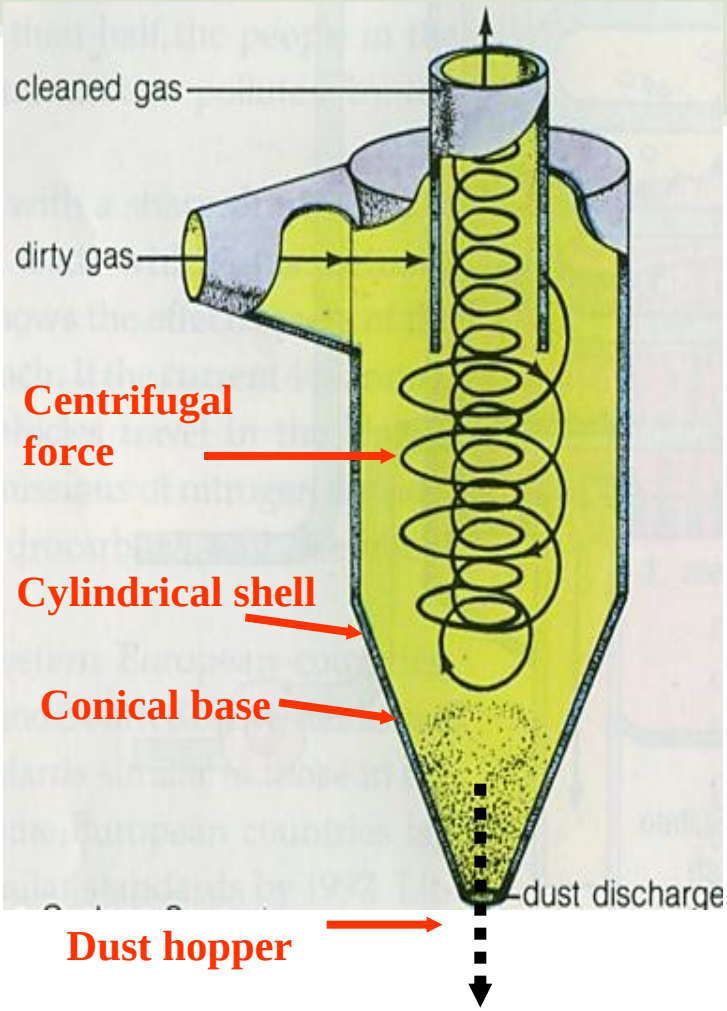
CYCLONE SEPARATOR

1.Dirty airstream flow in a spiral path inside a cylindrical chamber

2. From a tangential direction at the outer wall of the device, forming a vortex as it swirls within the chamber

3. The larger particulates move outward and are forced against the chamber wall



5. The cleaned air swirls upward in a narrower spiral through an inner cylinder and emerges from an outlet at the top

4. Slowed by friction with the wall surface, large particulates slide down the wall into a conical dust hopper at the bottom of the cyclone.

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CYCLONE SEPARATOR

- **Advantages** of cyclone separator
  - Low capital cost
  - Easy operation and maintenance
  - Efficient for particle size greater than 10µm

- **Disadvantages** of cyclone separator
  - Not very efficient for particles less than 10µm
  - Not adequate to meet stringent air pollution regulations

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HOW A CYCLONIC DUST COLLECTOR WORKS

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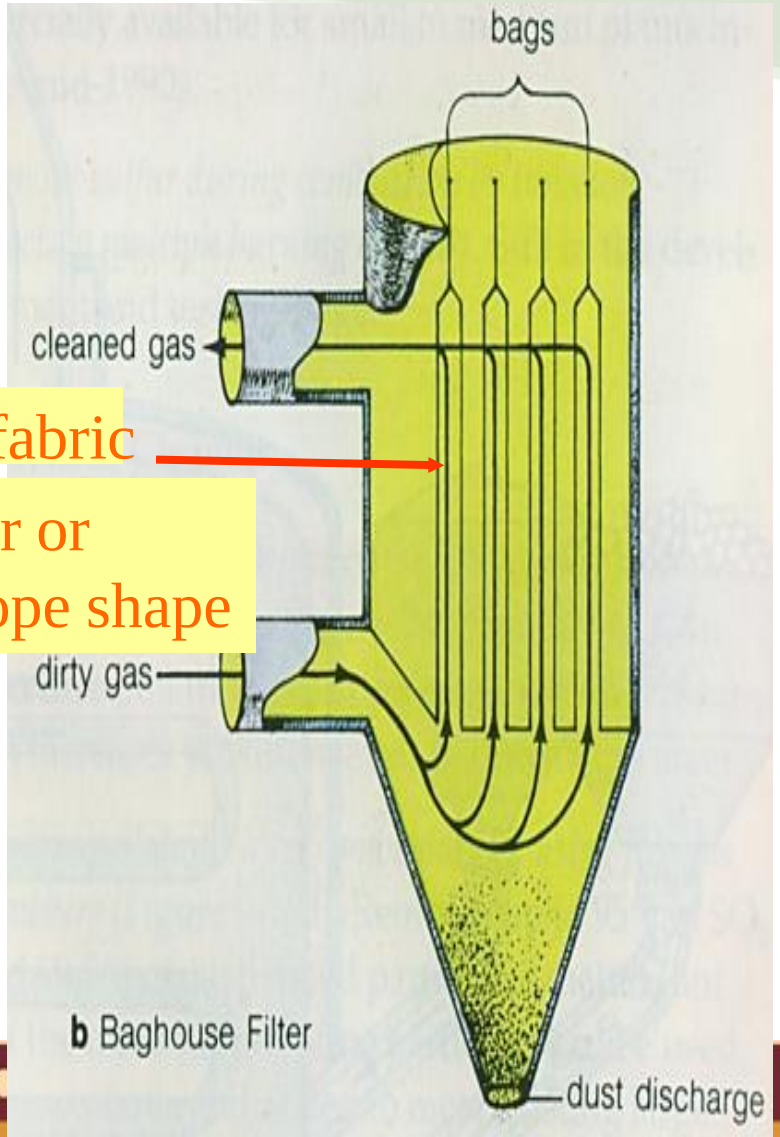
BAGHOUSE FILTER

1. A typical baghouse comprises an array of long, narrow bags that are suspended upside down in a large enclosure



2. Dust-laden air is blown upward through the bottom of the enclosure by fans.

3. Particulates are trapped inside the filter bags, while the clean air passes through the fabric and exits at the top of the baghouse.

4. The bags are cleaned by removing the excess layer of surface dust. After removed, it falls into a hopper below and can be collected for disposal or further use

BAGHOUSE FILTER

- **Advantages** of baghouse filter
  - High collection efficiencies even for very small particles (< 5µm)
  - Can operate on a wide variety of dust types
  - Modular design and can be pre-assembled at the factory

- **Disadvantages** of baghouse filter
  - Require large floor areas
  - Fabrics can be harmed by high temperatures or corrosive chemicals
  - Cannot operate in moist environments; reduce efficiencies
  - Potential for fire & explosion
  - High capital cost

BAGHOUSE BASICS

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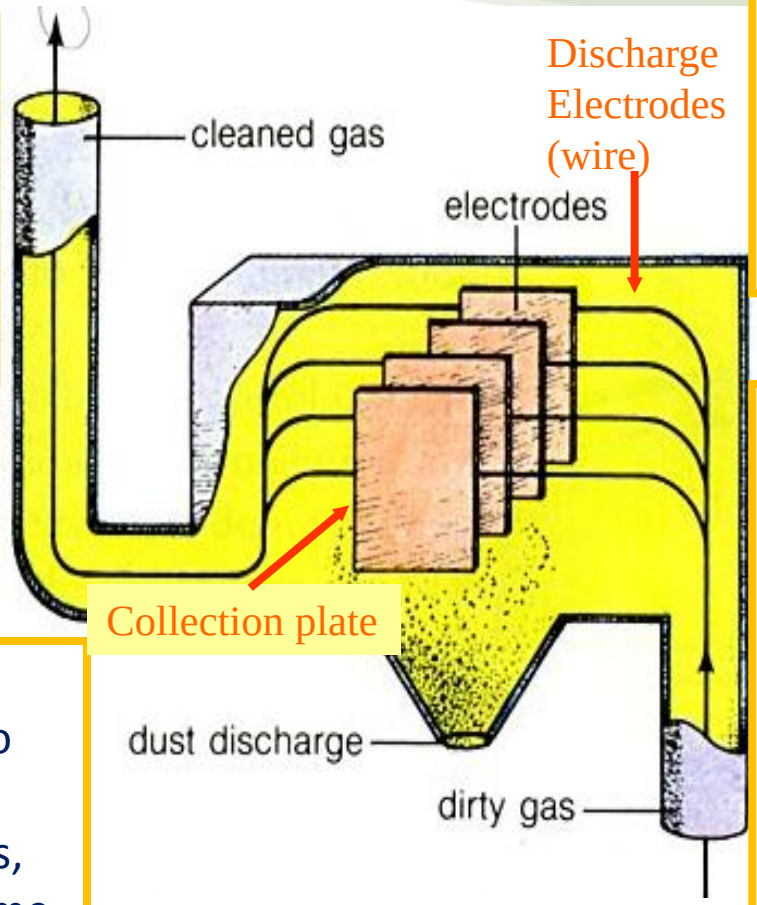
ELECTROSTATIC PRECIPITATOR

4. Particles that stick to the collection plates are removed periodically when the plates are shaken, or rapped



2. A high voltage of direct current as much as 100,000 volts, is applied to the discharge electrodes to charge the particles

1. In an electrostatic precipitator, particles suspended in the airstream are given an electric charge as they enter the unit and are then removed by the influence of an electric field

3. Charged particles then are attracted to oppositely charged collection electrodes, on which they become trapped.

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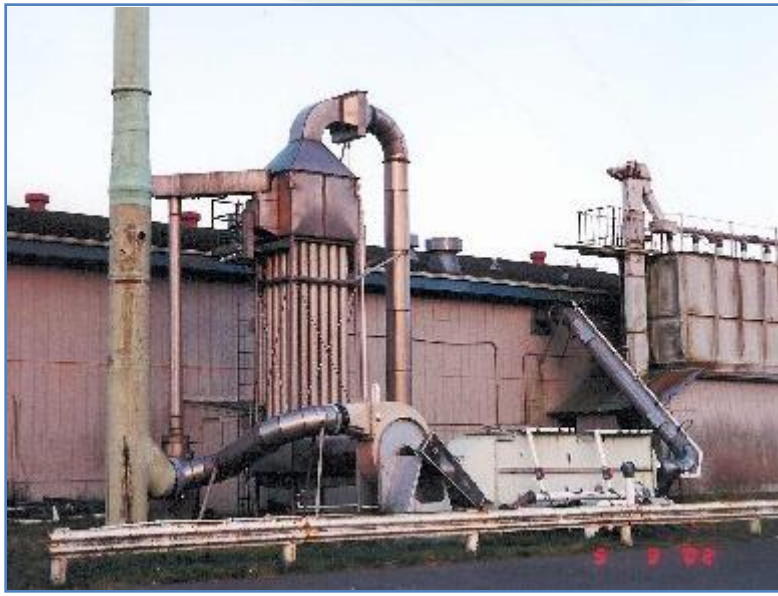
ELECTROSTATIC PRECIPITATOR

- **Advantages** of electrostatic precipitator
  - Very high efficiencies, even for small particles
  - Can handle large volume of gases
  - Can be designed for a wide range of gas temperature

- **Disadvantages** of electrostatic precipitator
  - High capital cost
  - Cannot control gaseous emissions
  - Once installed the unit is not very flexible to changes in operating conditions
  - Requires large floor areas
  - Might not work on particulates with very high electrical resistivity



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WORKING PRINCIPLE OF ELECTROSTATIC PRECIPITATOR

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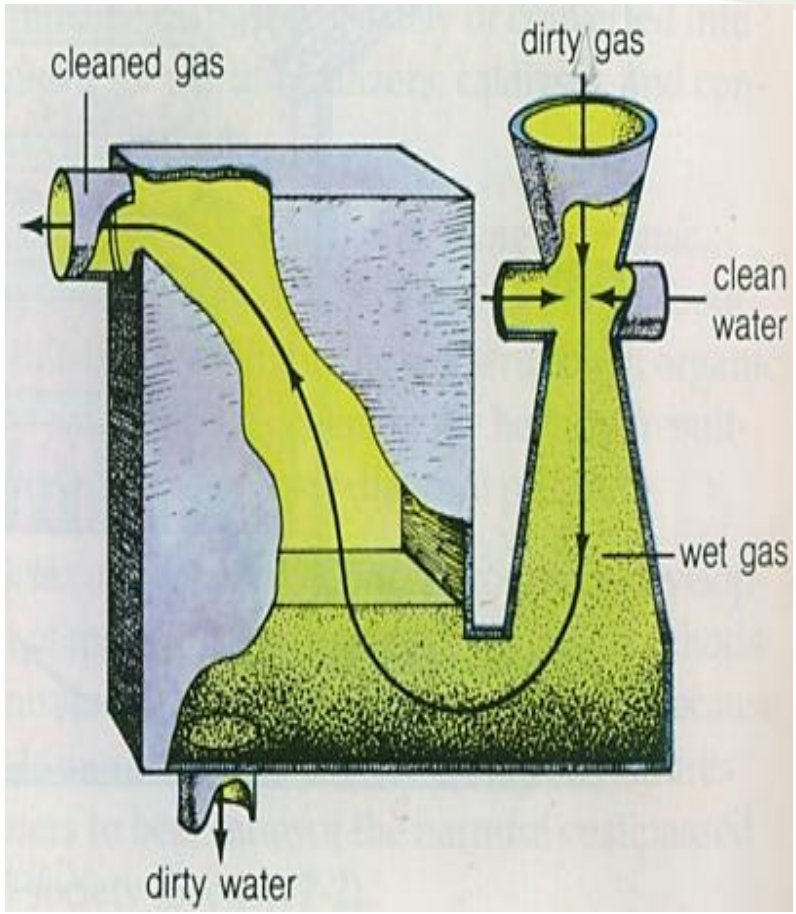
WET SCRUBBERS

1. Wet scrubbers trap suspended particles by direct contact with a spray of water or other liquid



2.In a spray-tower scrubber, an upward-flowing airstream is washed by water sprayed downward from a series of nozzles.

3. In orifice scrubbers and wet-impingement scrubbers, the air-and-droplet mixture collides with a solid surface.

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WET SCRUBBERS

- **Advantages** of wet scrubber
  - Can handle flammable and explosive dust with little risk
  - Provide gas absorption and dust collection in a single unit
  - Can handle mist or moist type pollutants
  - Provide cooling of hot gases
  - Acidic gases and dust can be neutralized

- **Disadvantages** of wet scrubber
  - High potential for corrosive problems
  - High capital cost
  - Effluent liquid can create water pollution problems

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WET SCRUBBER WORKING ANIMATION

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STANDARDS AND REGULATIONS

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AIR POLLUTANT INDEX (API)

- API- reporting the quality of air or level of air pollution at any particular area
- Developed in easily understood ranges of values, instead of using the actual concentrations of air pollutants.
- It is calculated based on 5 major air pollutants :
  - Sulphur Dioxide ($SO_{2)}$
  - Nitrogen Dioxide ($NO_{2)}$
  - Carbon Monoxide (CO)
  - Suspended particulate matter of less than 10microns size (PM_{10})
  - Ground Level Ozone (O_3)

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National Air Quality Monitoring Network

Automatic

52 automatic stations

Continuous Air Quality Monitoring Station (CAQM)

Located at strategic places:

- Industrial;
- Urban
- Sub-Urban; and
- Rural area

Manual

14 manual stations

Manual sampling (High Volume Sampler, HVS)

Measured in ppm (parts per million) or µg/m3 (micrograms per cubic meter)

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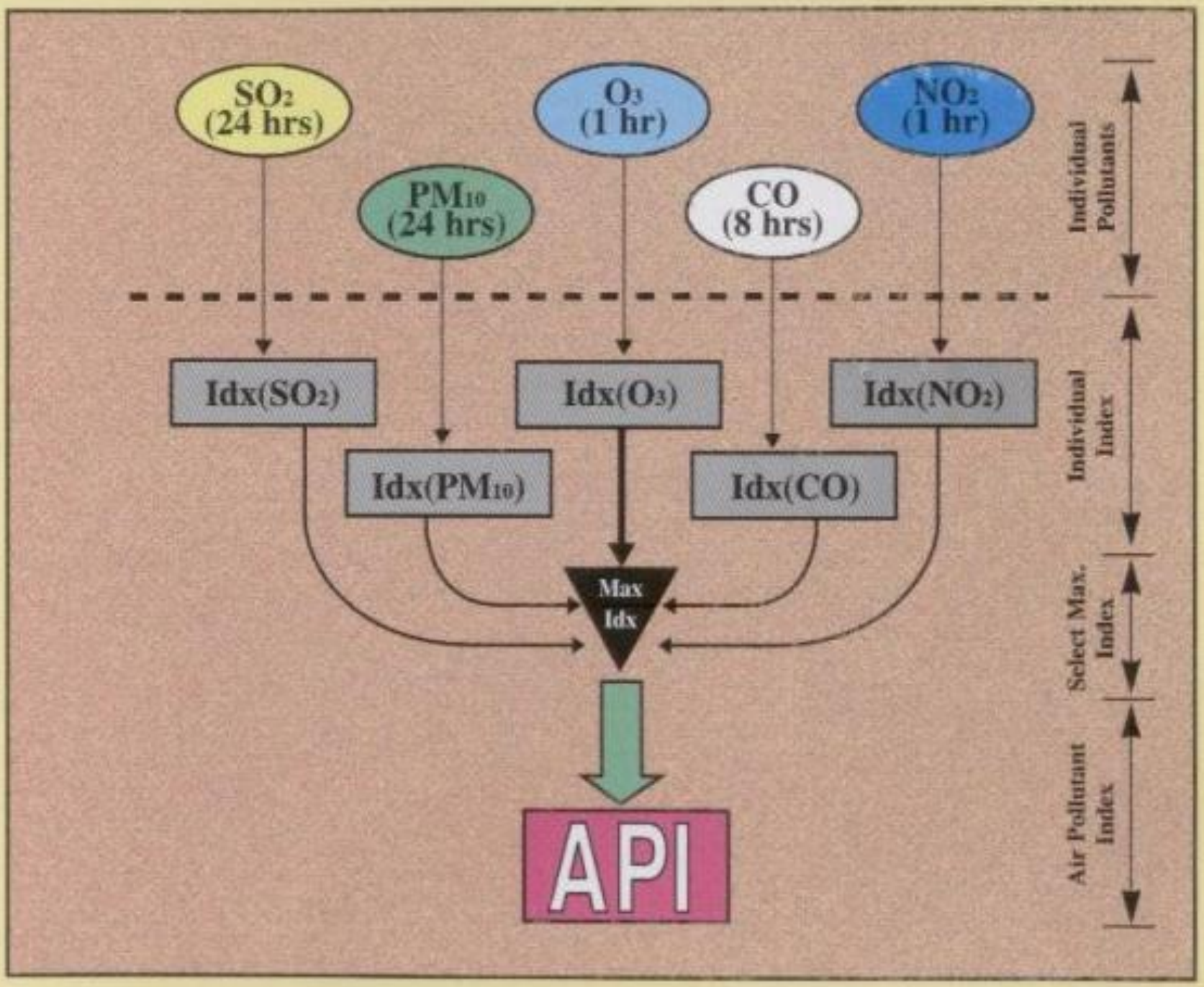
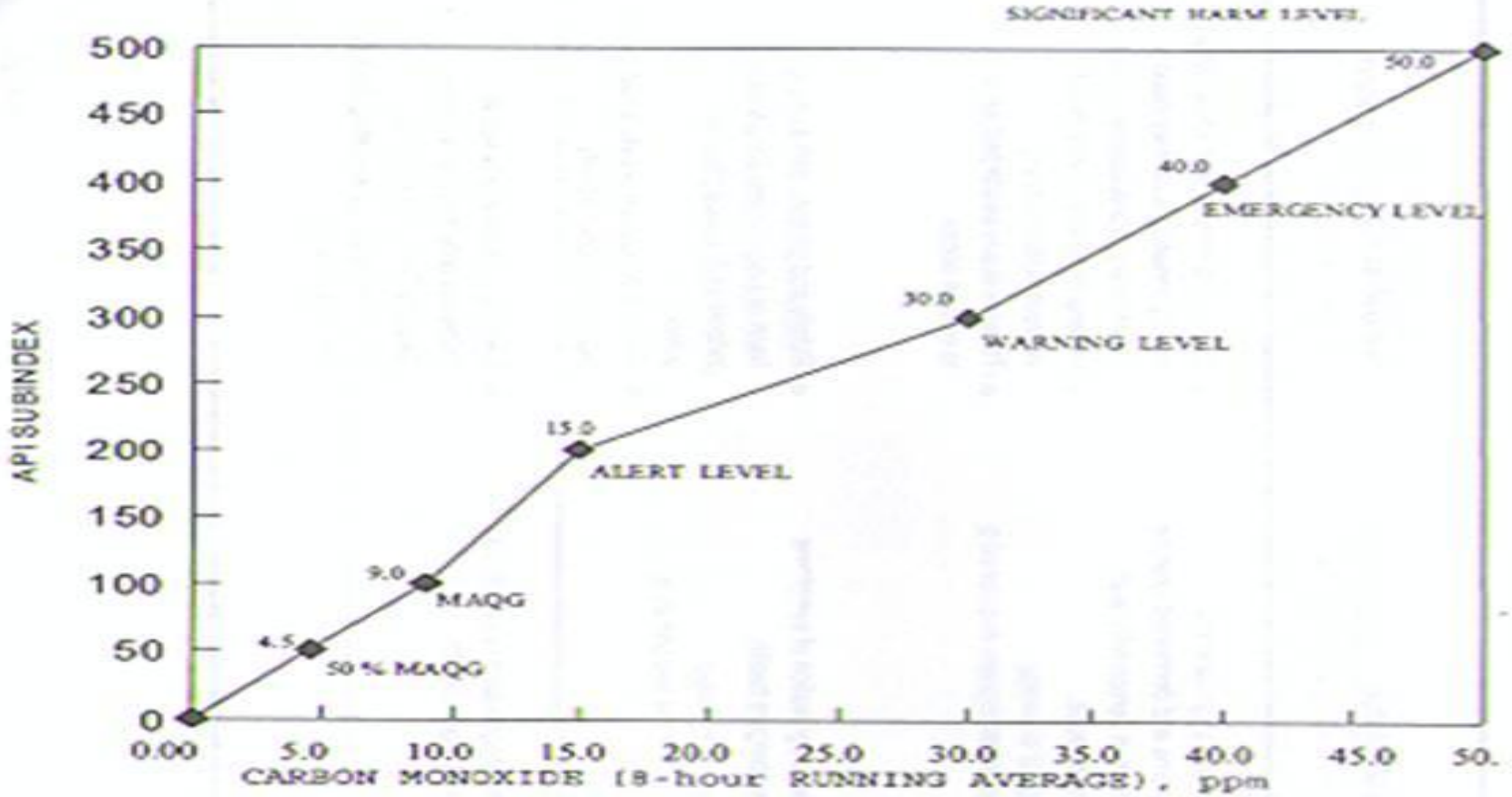

SO2 (24 hrs)
O3 (1 hr)
NO2 (1 hr)
PM10 (24 hrs)
CO (8 hrs)
Idx(SO2)
Idx(O3)
Idx(NO2)
Idx(PM10)
Idx(CO)
Max Idx
API
Individual Pollutants
Individual Index
Select Max. Index
Air Pollutant Index

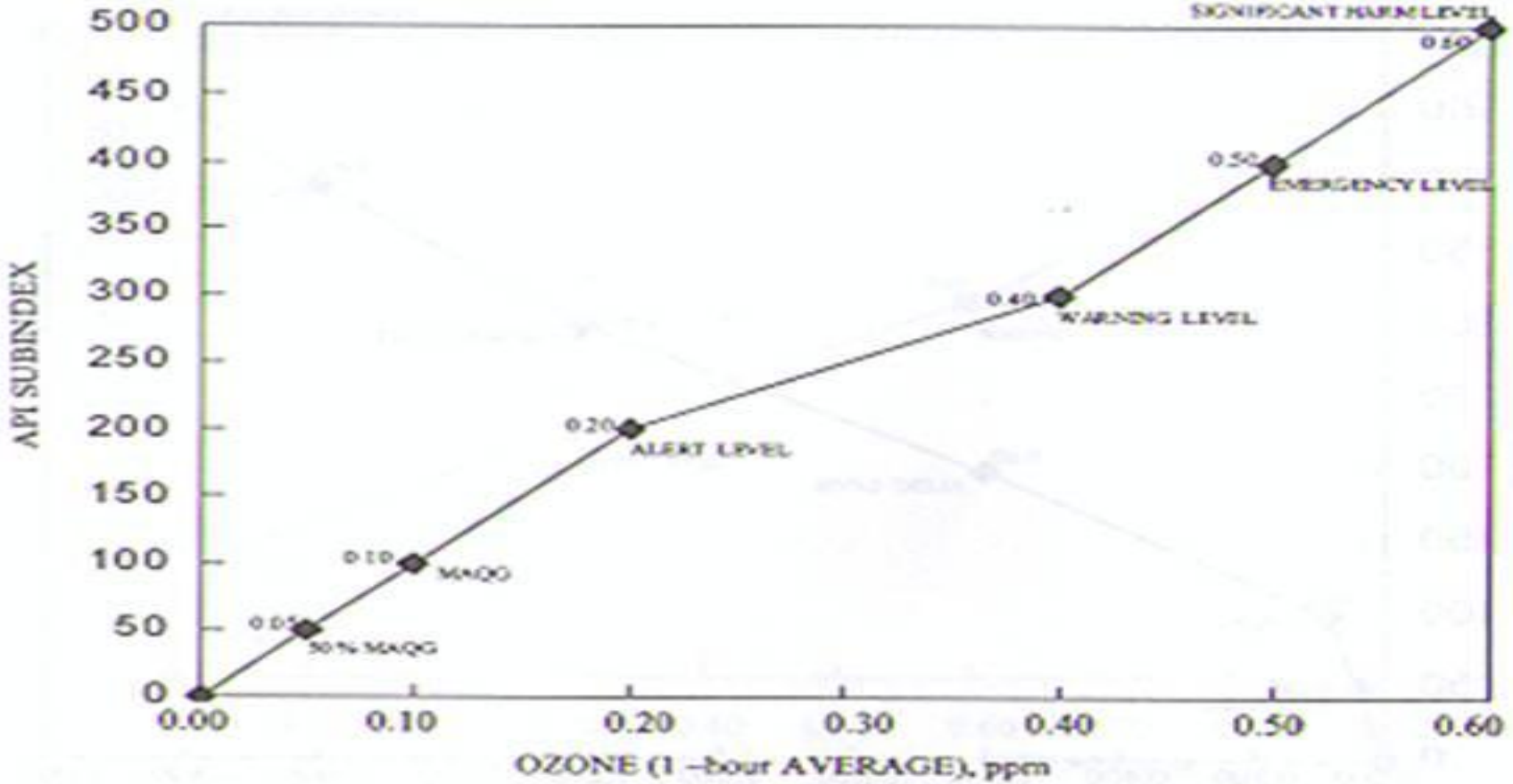
Figure 1 : API subindex function for carbon monoxide



Equation for the calculation of API based on 8– hour average concentration:

conc < 9 ppm	API = conc. x 11.11111
9 < conc. < 15	API = 100 + {[conc. – 9] x 16.66667}
15 < conc. < 30	API = 200 + {[conc. – 15] x 6.66667}
conc. > 30 ppm	API = 300 + {[conc. – 30] x 10}

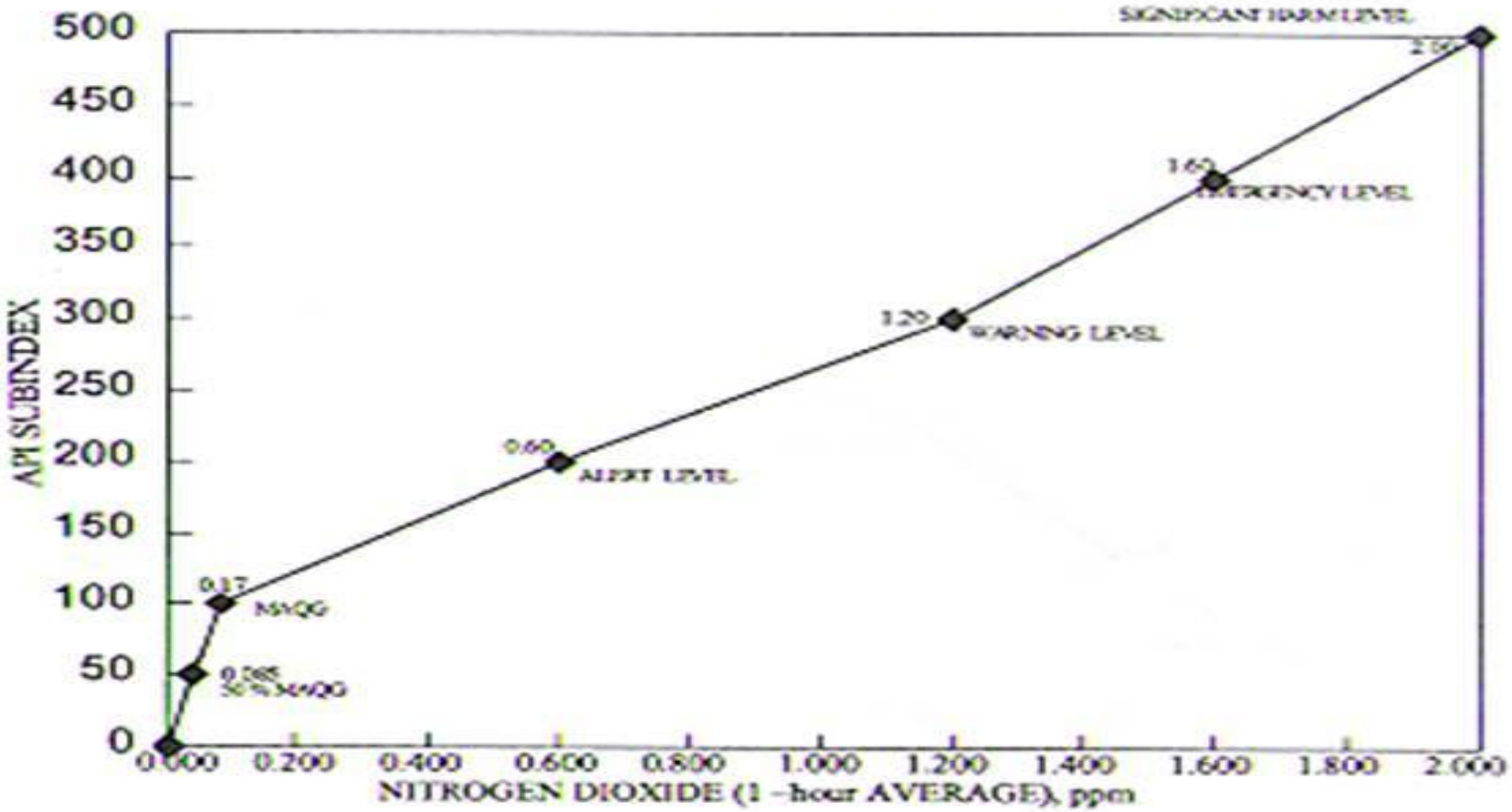
Figure 2 : API subindex function for ozone



Equation for the calculation of API based on 1– hour average concentration:

•conc < 0.2 ppm	API = conc. x 1000
0.2 < conc. < 0.4	API = 200 + {[conc. – 0.2] x 500}
conc. > 0.4 ppm	API = 300 + {[conc. – 0.4] x 1000}

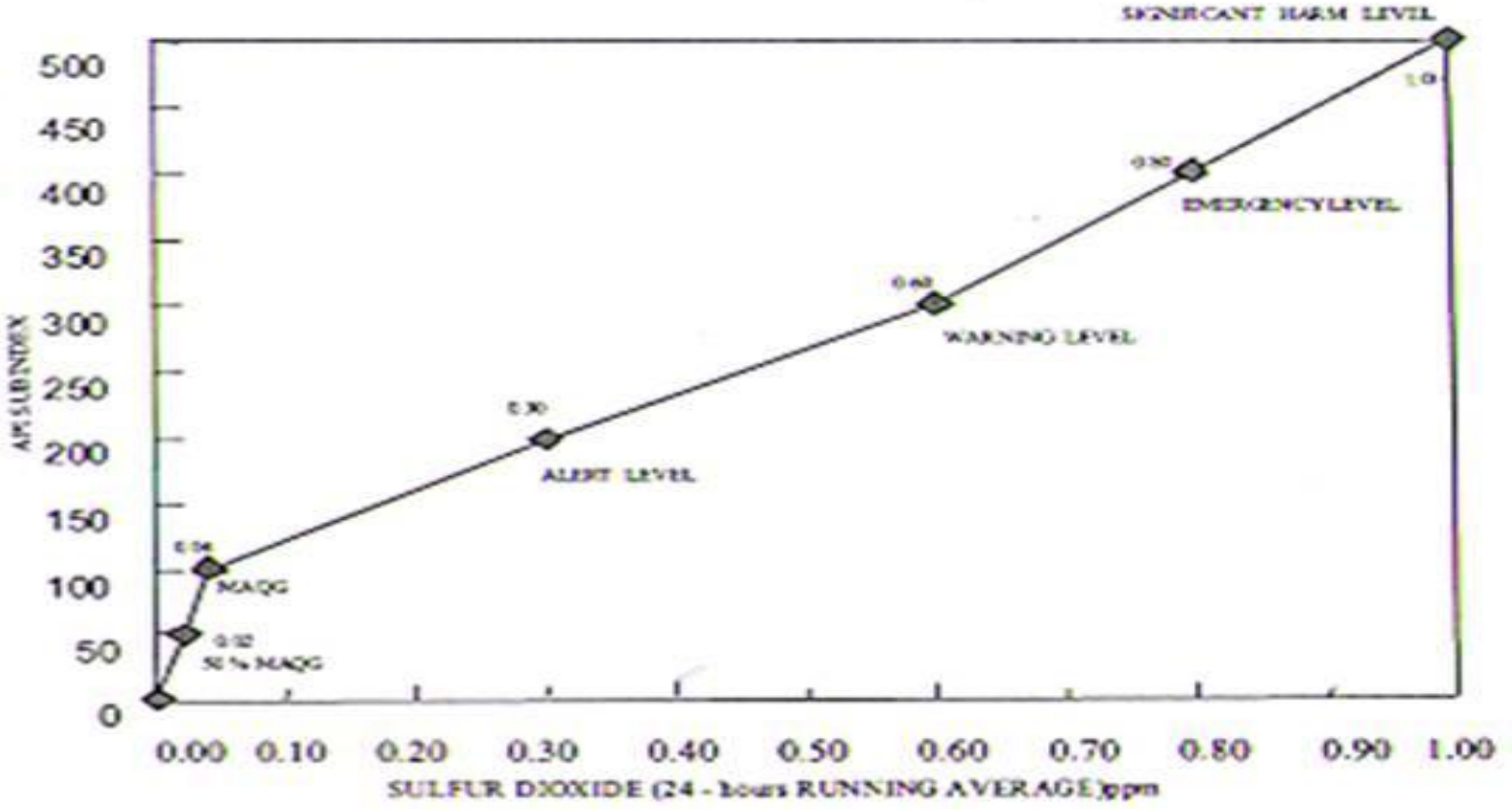
Figure 3 : API subindex function for nitrogen dioxide



Equation for the calculation of API based on 1– hour average concentration:

•conc < 0.17 ppm	API = conc. x 588.23529
•0.17 < conc. < 0.6	API = 100 + {[conc. – 0.17] x 232.56}
0.6 < conc. < 1.2	API = 200 + {[conc. – 0.6] x 166.667}
conc. > 1.2 ppm	API = 300 + {[conc. – 1.2] x 250}

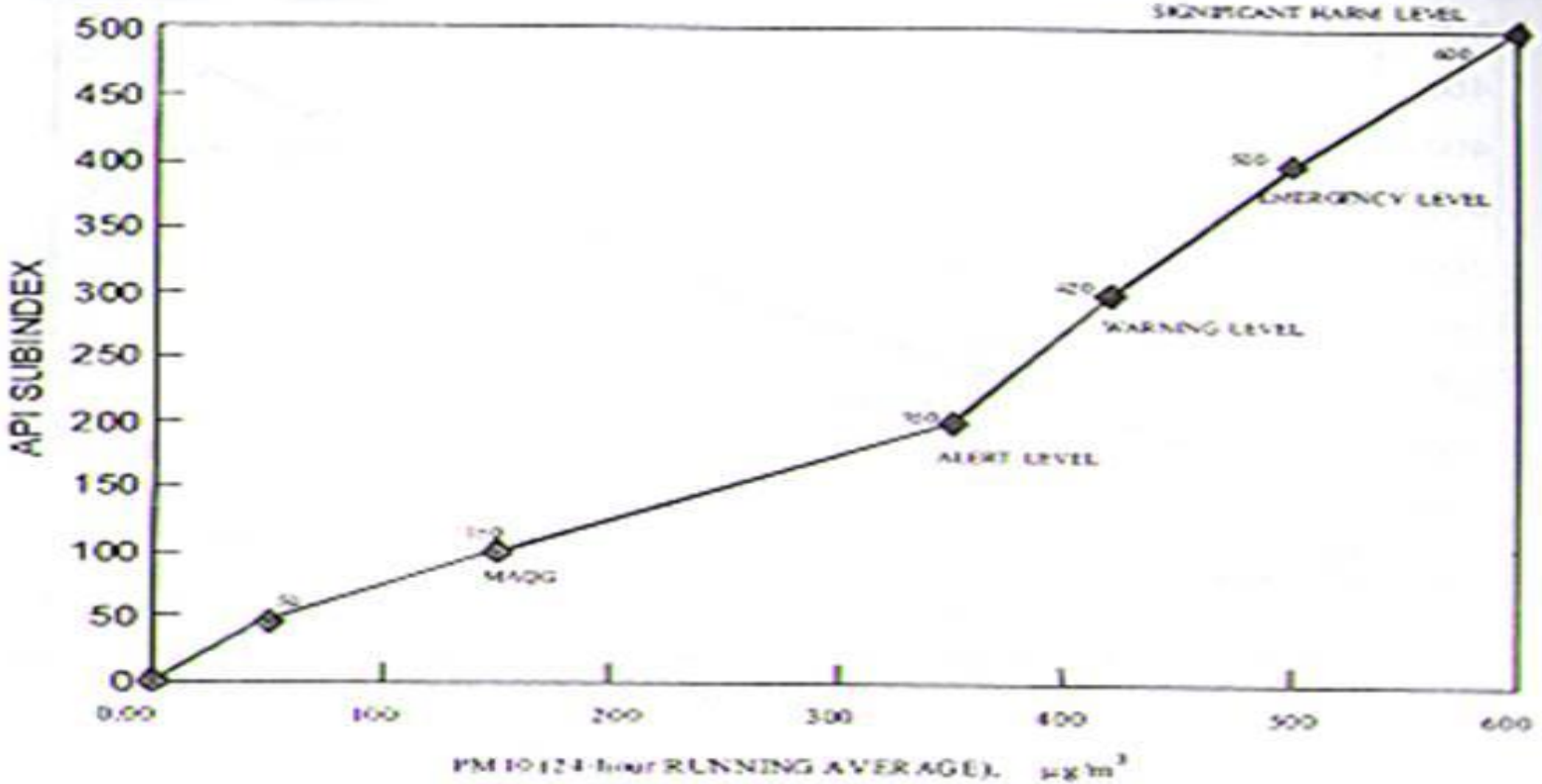
Figure 4 : API subindex function for sulfur dioxide



Equation for the calculation of API based on 24 – hour average concentration:

•conc < 0.04 ppm	API = conc. x 2500
•0.04 < conc. < 0.3	API = 100 + {[conc. – 0.04] x 384.61}
0.3 < conc. < 0.6	API = 200 + {[conc. – 0.3] x 333.333}
conc. > 0.6 ppm	API = 300 + {[conc. – 0.6] x 500}

Figure 5 : API subindex function for PM10



Equation for the calculation of API based on 24 – hour average concentration:

conc < 50 µg/cu.m	API = conc.
50 < conc. < 350	API = 50 + {[conc. – 50] x 0.5}
350 < conc. < 420	API = 200 + {[conc. – 350] x 1.4286}
420 < conc. < 500	API = 300 + {[conc. – 420] x 1.25}
conc. > 500 µg/cu.m	API = 400 + [conc. – 500]

Table 3: API values, in steps of 5, from 5 to 500

API	Gravimetric Units					Volumetric Units			
	CO mg/m3	O3 µg/m3	SO2 µg/m3	NO2 µg/m3	PM10 µg/m3	CO ppm	O3 ppm	SO2 ppm	NO2 ppm
5	0.50	10	5.25	16.00	7.50	0.45	0.005	0.002	0.009
10	1.00	20	10.50	32.00	15.00	0.90	0.010	0.004	0.017
15	1.50	30	15.75	48.00	22.50	1.35	0.015	0.006	0.026
20	2.00	40	21.00	64.00	30.00	1.80	0.020	0.008	0.034
25	2.50	50	26.25	80.00	37.50	2.25	0.025	0.010	0.043
30	3.00	60	31.50	96.00	45.00	2.70	0.030	0.012	0.051
35	3.50	70	36.75	112.00	52.50	3.15	0.035	0.014	0.060
40	4.00	80	42.00	128.00	60.00	3.60	0.040	0.016	0.068
45	4.50	90	47.25	144.00	67.50	4.05	0.045	0.018	0.077
50	5.00	100	52.50	160.00	75.00	4.50	0.050	0.020	0.085
55	5.50	110	57.75	176.00	82.50	4.95	0.055	0.022	0.094
60	6.00	120	63.00	192.00	90.00	5.40	0.060	0.024	0.102
65	6.50	130	68.25	208.00	97.50	5.85	0.065	0.026	0.111
70	7.00	140	73.50	224.00	105.00	6.30	0.070	0.028	0.119
75	7.50	150	78.75	240.00	112.50	6.75	0.075	0.030	0.128
80	8.00	160	84.00	256.00	120.00	7.20	0.080	0.032	0.136
85	8.50	170	89.25	272.00	127.50	7.65	0.085	0.034	0.145
90	9.00	180	94.50	288.00	135.00	8.10	0.090	0.036	0.153
95	9.50	190	99.75	304.00	142.50	8.55	0.095	0.038	0.162
100	10.00	200	105.00	320.00	150.00	9.00	0.100	0.040	0.170
105	10.35	210	139.75	360.50	160.00	9.30	0.105	0.053	0.192
110	10.70	220	174.50	401.00	170.00	9.60	0.110	0.066	0.213
115	11.05	230	209.25	441.50	180.00	9.90	0.115	0.079	0.235
120	11.40	240	244.00	482.00	190.00	10.20	0.120	0.092	0.256

MALAYSIAN AMBIENT AIR QUALITY GUIDELINES

Pollutant	Averaging	Malaysian Guidelines (Concentration)	
	Time	ppm	(µg/m³)
Ozone	1 Hour 8 Hour	0.10 0.06	200 120
Carbon Monoxide**	1 Hour 8 Hour	30.0 9.0	35 10
Nitrogen Dioxide	1 Hour 24 hour	0.17 0.04	320 10
Sulphur Dioxide	1 hour 24 Hour	0.13 0.04	350 105
Particulate Matter (PM_{10})	24 Hour 12 Month		150 50
Total Suspended Particulate (TSP)	24 Hour 12 Month		260 90
Lead	3 Month		1.5

Note :
**(mg/m³)

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AIR POLLUTANT INDEX: HEALTH EFFECT

API	Status	Health Effect	Health Advice
0-50	Good	Low pollution without any bad effect on health	No restriction for outdoor activities to the public. Maintain healthy lifestyle
51-100	Moderate	Moderate pollution that does not pose any bad effect on health	No restriction for outdoor activities to the public. Maintain healthy lifestyle
101-200	Unhealthy	Worsen the health condition of high risk people who is the people with heart and lung complications	Limited outdoor activities for the high risk people. Public need to reduce the extreme outdoor activities

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AIR POLLUTANT INDEX: HEALTH EFFECT

API	Status	Health Effect	Health Advice
201-300	Very Unhealthy	Worsen the health condition and low tolerance of physical exercises to people with heart and lung complications. Affect public health.	Old and high risk people are advised to stay indoor and reduce physical activities. People with health complications are advised to see doctor
>300	Hazardous	Hazardous to high risk people and public health	Old and high risk people are prohibited for outdoor activities. Public are advised to prevent from outdoor activities
>500	Emergency	Hazardous to high risk people and public health	Public are advised to follow orders from National Security Council and always follow the announcement in mass media

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RECENT CRISIS: HAZE (15 SEPTEMBER 2015)

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ENVIRONMENTAL QUALITY ACT 1974

OBJECTIVE

- **Prevent**, **Remove**, **Control** pollution and **Improve** the environment

RELATED SECTION

- **SECTION 22 :** Restrictions on Pollution of the Atmosphere
- **SECTION 29A :** Prohibition on Open Burning
- **SECTION 29AA :** Exclusion from "Open Burning"
- **SECTION 29B :** Owner / Occupier of Premises Liable for Open Burning

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EQA 1974 : SECTION 22

(1) No person shall, unless licensed, emit or discharge any environmentally hazardous substances, pollutants or wastes into the atmosphere in contravention of the acceptable conditions specified under section 21.

(2) Without limiting the generality of subsection (1), a person shall be deemed to emit or discharge wastes into the atmosphere if -

(*a*) he places any matter in a place where it may be released into the atmosphere;

(*b*) he causes or permits the discharge of odours which by virtue of their nature, concentration, volume or extent are obnoxious or offensive;

(*c*) he burns any wastes of the trade, process or industry; or

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EQA 1974 : SECTION 22 (CONT')

(*d*) he uses any fuel burning equipment not equipped with any device or control equipment required to be fitted to such equipment.

(3) Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable to a fine not exceeding one hundred thousand ringgit or to imprisonment for a period not exceeding five years or to both and to a further fine not exceeding one thousand ringgit a day for every day that the offence is continued after a notice by the Director General requiring him to cease the act specified therein has been served upon him.

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EQA 1974 : SECTION 29A

(1) Notwithstanding anything to the contrary contained in this Act, no person shall allow or cause open burning on any premises.

(2) Any person who contravenes subsection (1) shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding five hundred thousand ringgit or to imprisonment for a term not exceeding five years or to both.

(3) For the purposes of subsection (1) -

"open burning" means any fire, combustion or smouldering that occurs in the open air and which is not directed there through a chimney or stack;

"premises" includes any land.

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ENVIRONMENTAL QUALITY (CLEAN AIR) REGULATIONS 1978

- Came into force on the 1st October 1978
- Apply to :
  - any premises used for any industrial or trade purposes,
  - any facility or process that discharged or is capable of discharging air impurities into open air;
  - every chimney;
  - every industrial plant; and
  - every fuel burning equipment.

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ENVIRONMENTAL QUALITY (CLEAN AIR) REGULATIONS 1978

"air impurities" includes smoke, soot, dust, ash (including flyash), cinders, grit, solid particles of any kind inclusive of particulates, gases, fumes, mist, odours and radioactive substance which are generated as a result of combustion of fuel and the like, or a result of the use of electricity as a heat source, or a result of synthesis, resolution or any other treatment and any other substance which may be designated by the Minister as those which are liable to affect adversely the human health or the living environment;

"Ringelmann Chart" means the Ringelmann scale for grading the density of smoke published by the latest British Standard in BS 2742 series or equivalent Malaysian Standard, or any chart, recorder, indicator, or device for the measurement of smoke density which is approved by the Director-General as the equivalent of the said Ringelmann scale;

"incinerator" means any device, apparatus, equipment or structure used for destroying, reducing or salvaging or waste heat recovery by fire or by burning any material or substance including refuse, rubbish, garbage, trade waste, debris or scrap or a facility for cremating human or animal remains;

ENVIRONMENTAL QUALITY (CLEAN AIR) REGULATIONS 1978

(a) any premises used for any industrial or trade purposes, or on which matter is burnt in connection with any industrial or trade purposes including burning of waste, irrespective of whether such premises are prescribed under section 18 of the Act or not;

(b) any facility or process that discharges or is capable of discharging air impurities into open air;

(c) every chimney;

(d) every industrial plant; and

(e) every fuel burning equipment.

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ENVIRONMENTAL QUALITY (PRESCRIBED ACTIVITIES) (OPEN BURNING) ORDER 2000

"open burning" means any fire, combustion or smouldering that occurs in the open air and which is not directed there through a chimney or stack;

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ENVIRONMENTAL QUALITY (PRESCRIBED ACTIVITIES) (OPEN BURNING) ORDER 2000

List of **PRESCRIBED ACTIVITIES** for open burning :

- ✓ Burning of any diseased plants
- ✓ Burning of carcasses of infected animal, bird
- ✓ Burning of solid or liquid fuels in the course of carrying out research into the causes and control of fires
- ✓ Burning of plant from a land clearing for the cultivation of food crops
- ✓ Burning of paddy stalks prior to replant
- ✓ Burning of sugar cane leaves prior to harvest in an area < 20 hectares

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List of **PRESCRIBED ACTIVITIES** for open burning : (CONT')

- ✓ Burning of plants for land clearing for the purpose of planting or replanting plant crops in area < 2 ha/day
- ✓ Burning of pineapple stumps prior to replant, which is dry prior to burning, in area < 6 ha/day
- ✓ Burning of any articles as part of religious rites or worshipping activities
- ✓ Cremation
- ✓ Camp fire which is not carried out at any peat soil (tanah gambut) area
- ✓ Outdoor grilles, barbecues which is not carried out at any peat soil area

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List of **PRESCRIBED ACTIVITIES** for open burning : (CONT')

- ✓ Burning of agricultural plant for land clearing for the purpose of planting or replanting of plant crops by subsistence farmers in rural areas which is not carried out at any peat soil area
- ✓ Burning of leaves, tree branches and yard trimmings in villages in rural areas which is not carried out at any peat soil area
- ✓ Burning of flammable gases where the industrial flare is properly operated

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THAT'S ALL...

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