Chapter 13

Introduction to Control Technology

Introduction to Control Technology

- Carbon adsorption
- Incineration
- Condensation
- Bioreaction

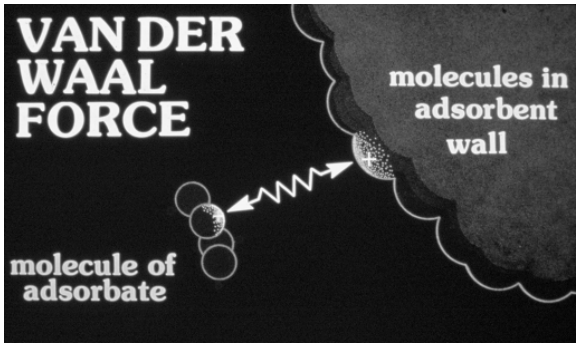
Carbon Adsorption

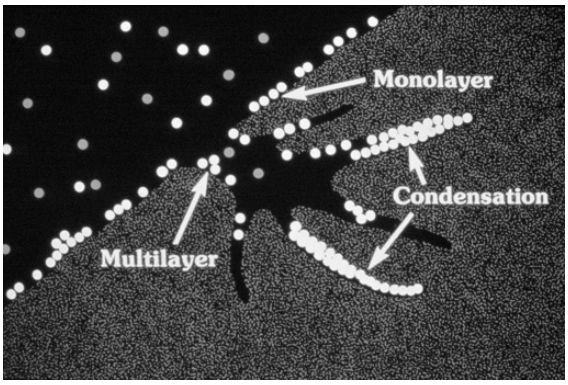
Activated Carbon

- A class of materials
- Produced from coal, wood, nut shells and petroleum-based products
- Activation process
  - Heat material to ~1,100°F without oxygen
  - Use stream, air or CO_2 to increase pore structure

Types of Adsorption Processes

- Chemical adsorption
- Physical adsorption

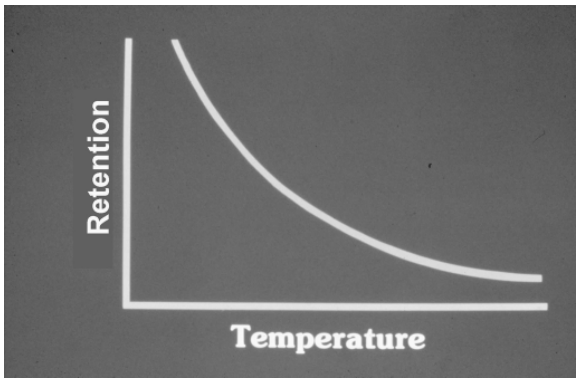


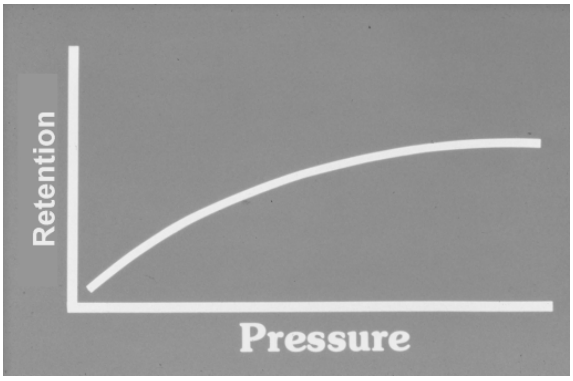


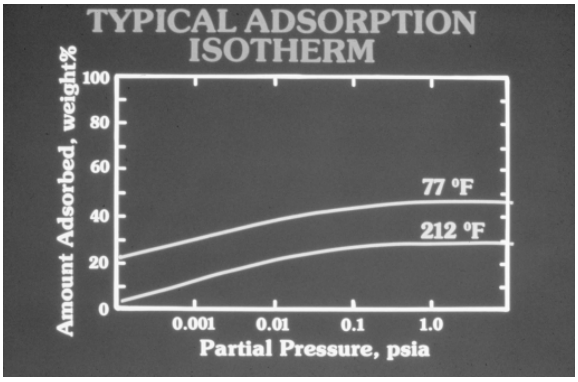
Adsorption Capacity

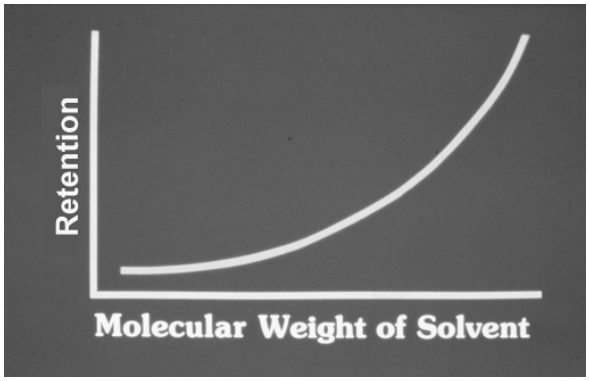
Retention

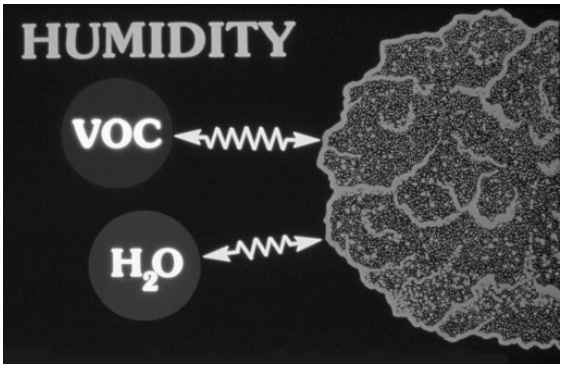
- Lbs of VOC adsorbed per 100 lbs of carbon
- Weight percent

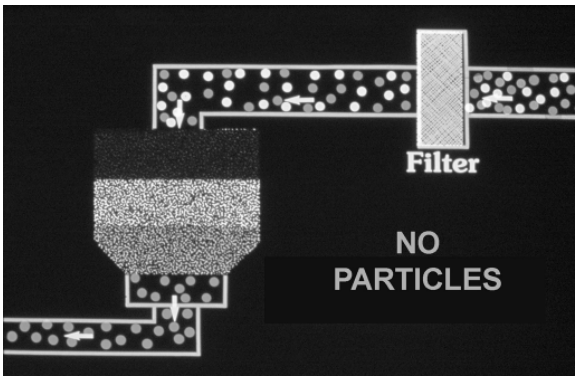



Retention
Pressure


TYPICAL ADSORPTION ISOTHERM
Amount Adsorbed, weight%
100
80
60
40
20
0
77 °F
212 °F
0.001
0.01
0.1
1.0
Partial Pressure, psia


Retention
Molecular Weight of Solvent

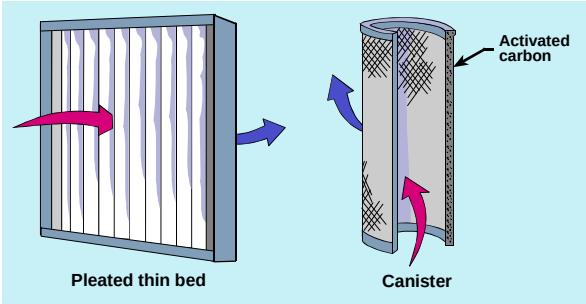




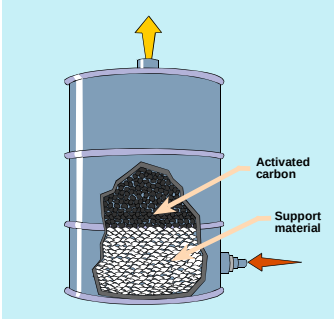
Types of Adsorption Systems

- On-site regeneration
- Off-site regeneration

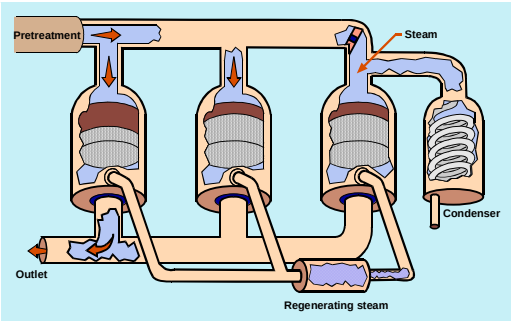
Off-Site Regeneration Adsorbers

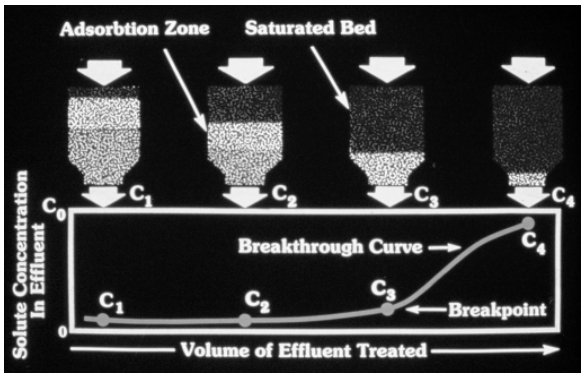


Canister Adsorber



On-Site Regeneration Fixed-Bed System

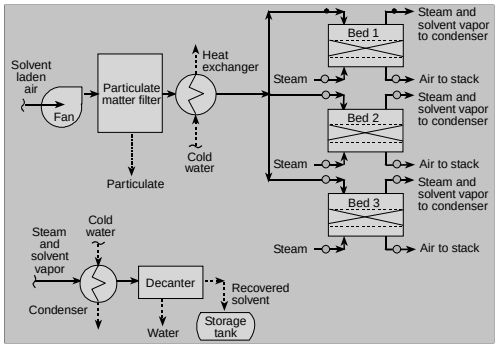




Regeneration Methods

- Thermal swing
  - Steam
  - Hot gas
- Pressure swing

Steam Regeneration



Regeneration Methods

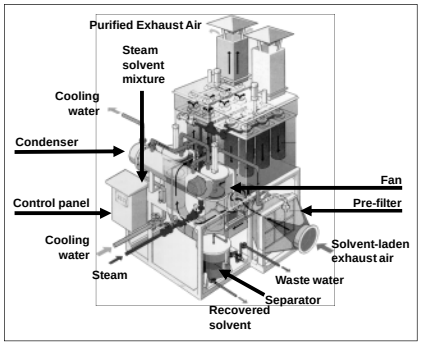
- Thermal swing
  - Steam
  - Hot gas
- Pressure swing

Regeneration Methods

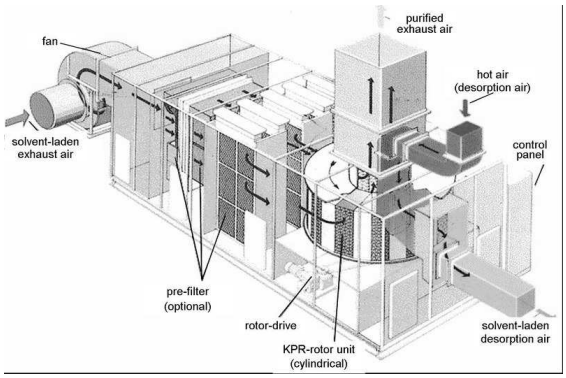
- Thermal swing
  - Steam
  - Hot gas
- Pressure swing

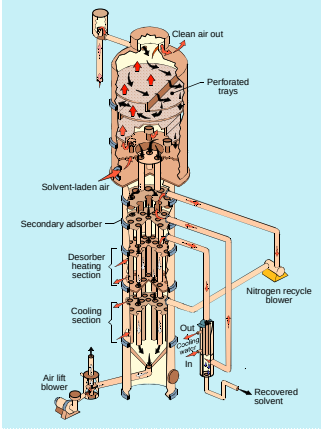
Other Adsorber Designs

Carbon Fiber Adsorber



Rotary Bed Adsorber



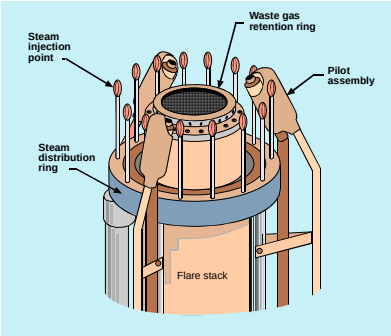


Fluidized Bed Adsorber

Incineration

- Flares
- Thermal oxidizers
- Catalytic oxidizers

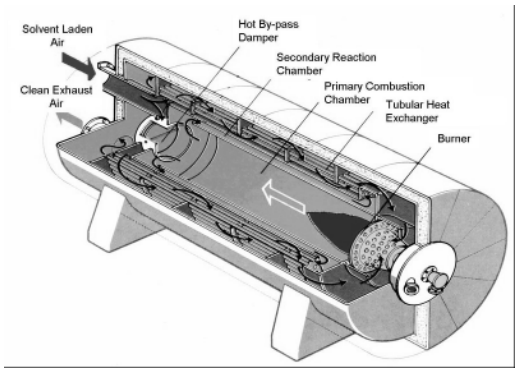
Flare



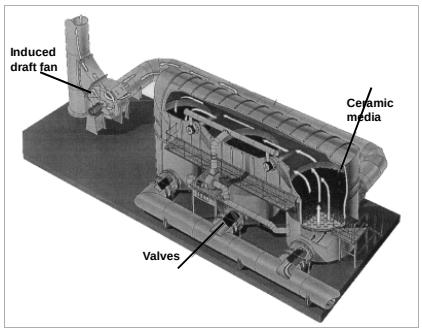
Thermal Oxidizer

- Refractory-brink lined chamber with one or more oil or gas burners
- Temperature: 1,300-1,800°F
- Residence time: 0.3-0.5 seconds

Recuperative Thermal Oxidizer



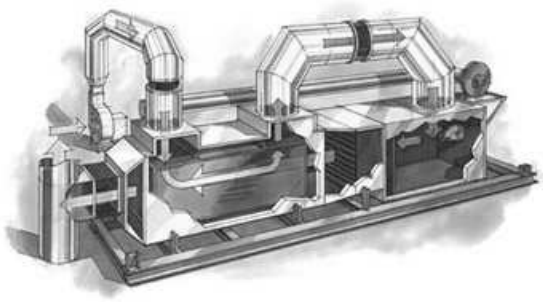
Regenerative Thermal Oxidizer



Process Heaters and Boilers

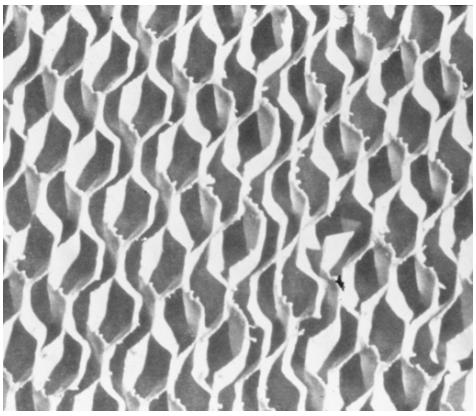
- Boiler must operate at 40-100% of full load
- Contaminated gas stream flow rate should be small portion of total
- Nothing corrosive or that causes deposits

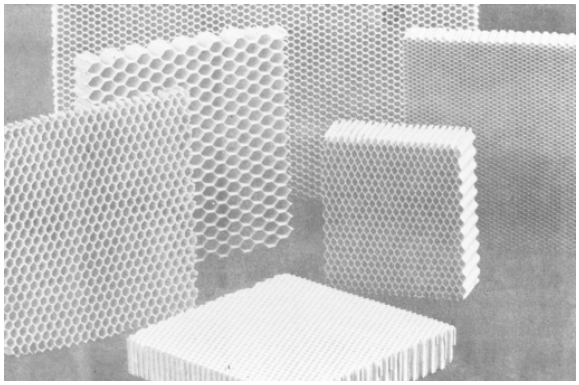
Catalytic Oxidizer



Catalyst Materials

- Noble metal oxides
  - Platinum
  - Palladium
  - Rhodium
- Base metal oxides
  - Vanadium
  - Titanium
  - Manganese





Temperature

- ~100°F above catalyst light-off temperature
- Typical inlet temperature: 500-600°F
- Typical outlet temperature: 700-900°F
- Maximum outlet temperature: 1,100-1,200°F

Space Velocity

$$\text{Space Velocity} = \frac{Q}{BV}$$

Q = standard flow rate (60°F)

BV = catalyst bed volume

Typically 30,000-40,000 hr^{-1} for noble metals

10,000-15,000 hr^{-1} for base metals

Catalyst Performance Problems

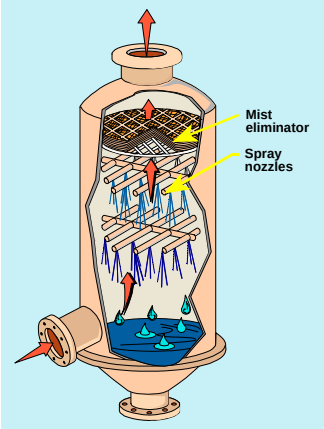
- Fouling
- Poisoning
- Masking
- Thermal aging

Condensation

- Conventional systems
- Refrigeration systems
- Cryogenic systems

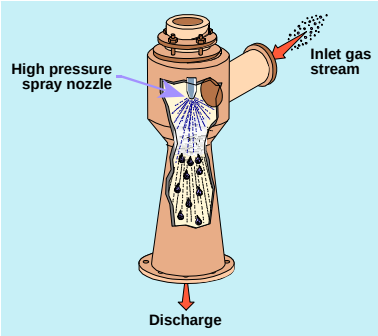
Types of Condensers

- Direct contact condensers
- Surface condensers

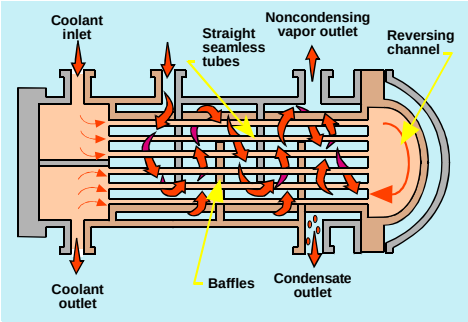


Direct Contact Condenser

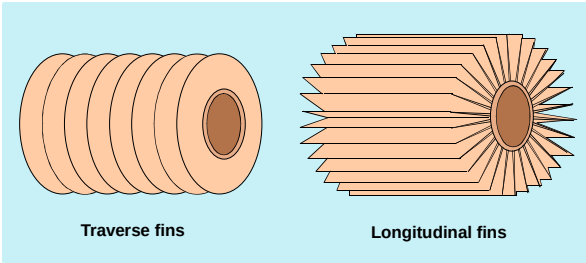
Ejector Condenser



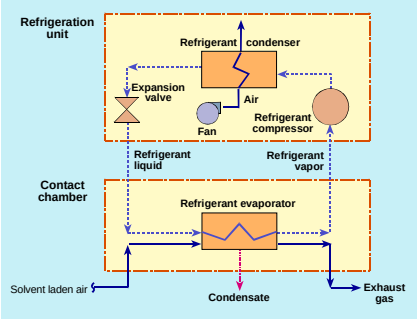
Shell and Tube Condenser



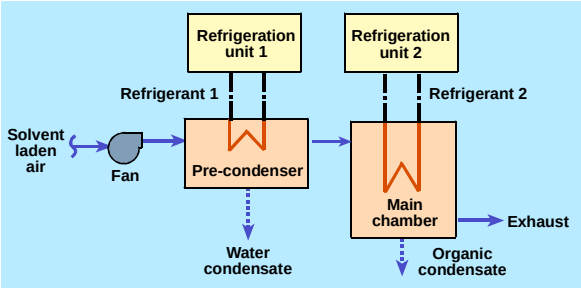
Tube and Fin Condenser



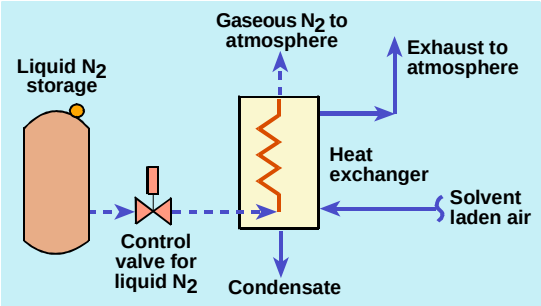
Refrigeration Cycle



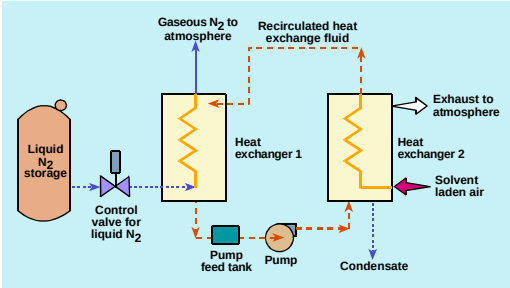
Refrigeration System



Single Heat Exchanger Cryogenic System



Dual Heat Exchanger Cryogenic System



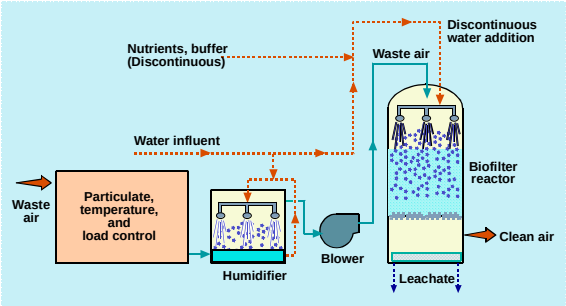
Bioreaction

- Biofilters
- Biotrickling filters
- Bioscrubbers

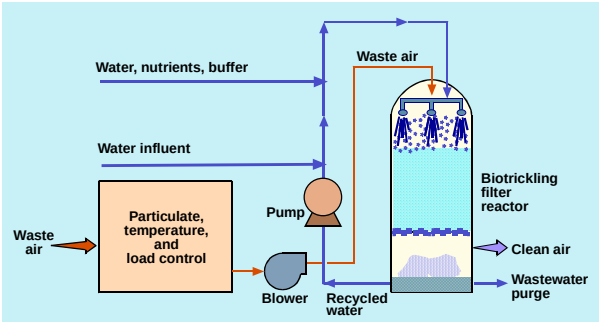
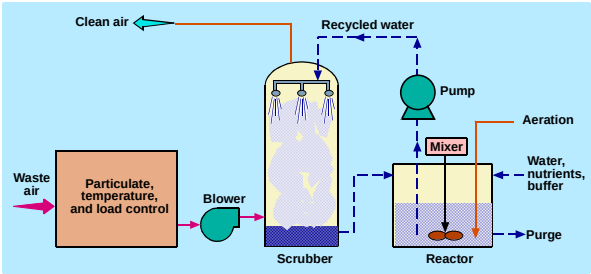
Microbial Population Requirements

- Sufficient moisture
- Sufficient nutrients
- Temperature of 60°F to 85°F
- pH of 6 to 8

Biofilter System



Biotrickling Filter System



Bioscrubber System