OVERVIEW OF AIR POLLUTION CONTROL DEVICE TECHNOLOGIES

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RAMBOLL

PRESENTATION TOPICS

I. Background on Air Pollutants and Regulations
   1. Types of Air Pollutants
   2. Why Control Air Pollutants
   3. Regulatory Framework Requiring Controls

II. Control Strategy Approaches

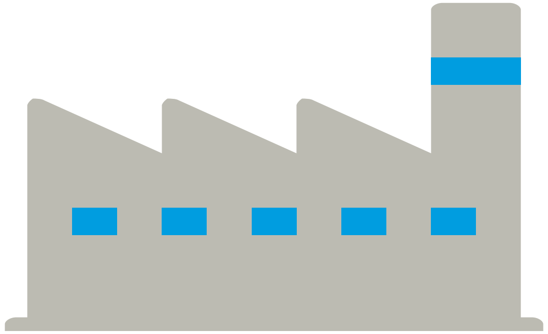
III. Common VOC/HAP Control Technologies

IV. Common PM Control Technologies

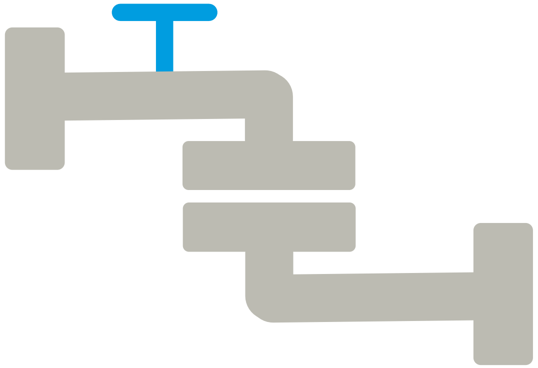
V. Common NOx Control Technologies

COMMON AIR EMISSON SOURCES

Cars/Trucks



POINT SOURCES



FUGITIVE SOURCES

Mobile Sources

Stationary Emissions Sources

TYPES OF AIR POLLUTANTS

Criteria Pollutants

- Nitrogen oxides (NO_x) – gas
- Sulfur oxides (SO_x) – gas
- Particulate matter (PM) – gas (condensable), liquid or solid
- Carbon monoxide (CO) – gas
- Lead (Pb) – solid
- Ozone (O_3) – gas
  - Volatile organic compounds (VOC) – ozone precursor – gas

Toxic / Hazardous Air Pollutants (HAPs)

- 187 Federal HAPs – solid or gas

WHY CONTROL AIR POLLUTION?

Human Health Effects

- Lung function impairment
- Cancer
- Heart, liver, other organ damage
- Birth defects

Environmental Effects

- Visibility degradation
- Wildlife and ecosystem damage
- Crop damage
- Other material damage

REGULATORY FRAMEWORK REQUIRING CONTROLS

- New Source Review (NSR) Permitting Program – Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NNSR) – Applies to Major Sources
  - PSD Program – BACT (Best Available Control Technology)
  - NNSR Program – LAER (Lowest Achievable Emission Rate)
  - Some states (like Texas) require state BACT for minor sources
- Air Toxics Regulations (Section 112 of CAA)
  - 40 CFR 61 (pre November 15, 1990 CAA Amendments)
  - 40 CFR 63 MACT (Maximum Achievable Control Technology)
  - 112g Case-by-Case MACT
- New Source Performance Standards (Section 111 of CAA)
  - New, Modified or Reconstructed facilities
- State Regulations
  - Chapter 51 (regulates LTAPs), Chapter 21 (regulates VOC), Chapter 22 (regulates NOx), etc.

CONTROL STRATEGY APPROACHES

➢ Add-on Emission Control Approach (primary focus of today's discussions)

- This approach focuses on controlling the emissions after they have been generated prior to being released to atmosphere. Typically more expensive.
  - Flares, Regenerative Thermal Oxidizers, Scrubbers, etc.

➢ Pollution Prevention Approach

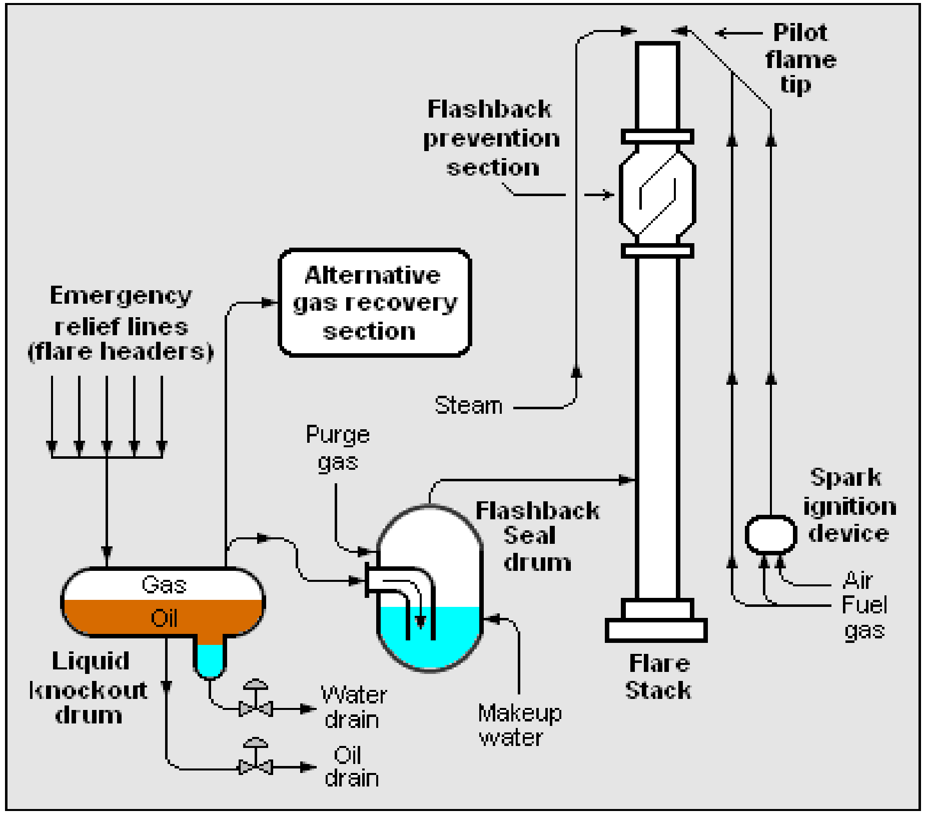
- This approach focuses on eliminating the generation of the pollutant rather than treating it once it has been generated. Preferred approach but not always technically feasible.
  - Material substitution, combustion controls, process changes, etc.

VOC/HAP CONTROLS

VOC/HAP CONTROL TECHNOLOGIES

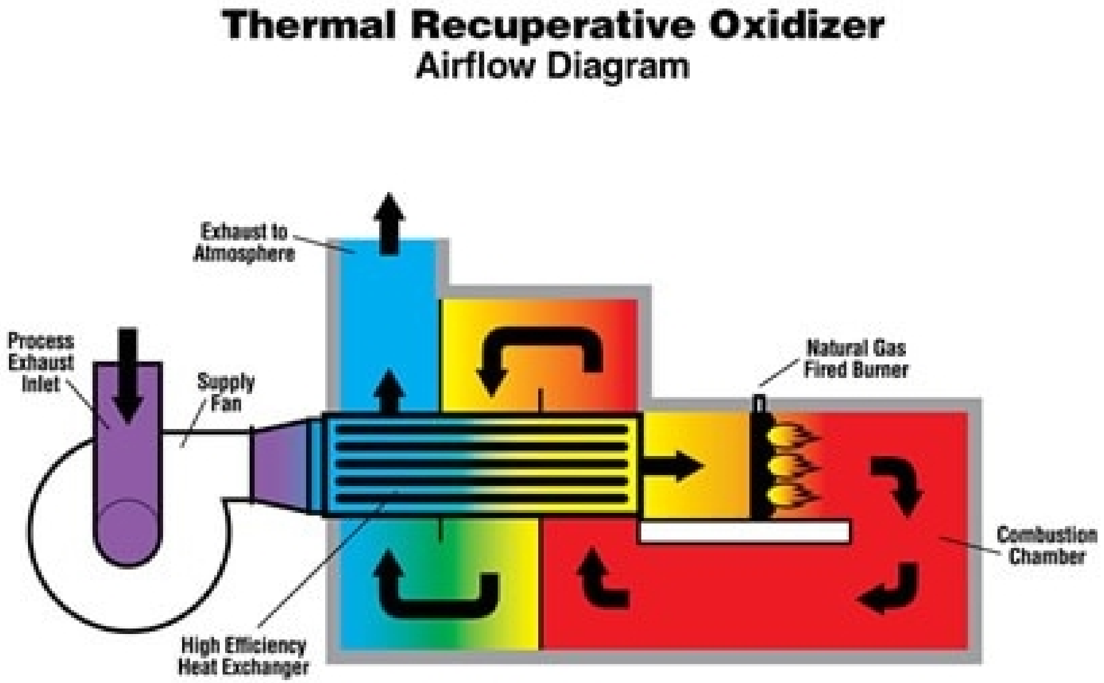
- Most common technologies
  - Thermal/Catalytic Oxidation (Flares, Regenerative Thermal Oxidizers, Catalytic Oxidizers, etc.)
    - Oxidation converts VOC/HAP to carbon dioxide (CO_2) and water (H_2O).
    - Generates combustion pollutants – NO_x, CO, PM and SO_2
  - Carbon Adsorbers
    - Adsorption – mass transfer from a gas to a solid
  - Condensers
  - Scrubbers
    - Absorption – mass transfer from a gas to a liquid
- A little overview on how they work

FLARE



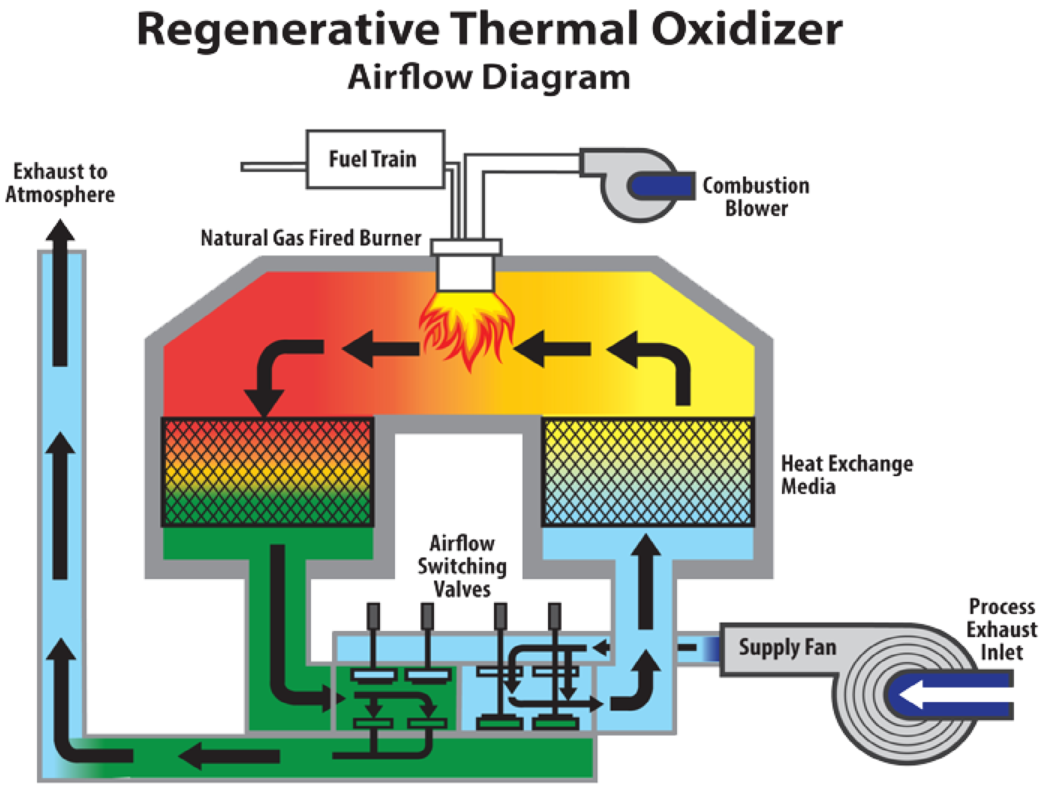
Flare requires supplemental fuel in most cases to ensure combustion temperature adequate for complete oxidation of VOC/HAP emissions.

THERMAL RECUPERATIVE OXIDIZER (TO)



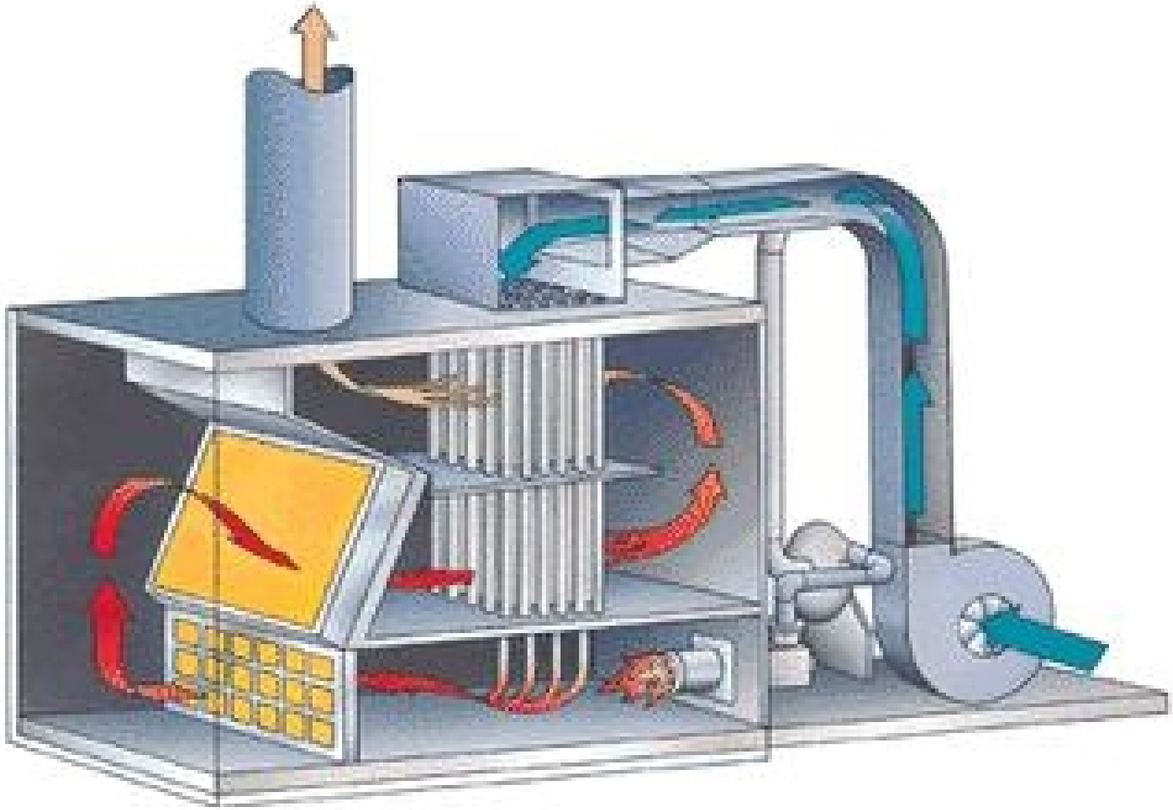
Converts VOC/HAP to CO_2 and H_2O at approximately 1500 F with 1-2 second retention time. Utilizes recuperative heat exchange to reduce fuel costs.

REGENERATIVE THERMAL OXIDIZER (RTO)



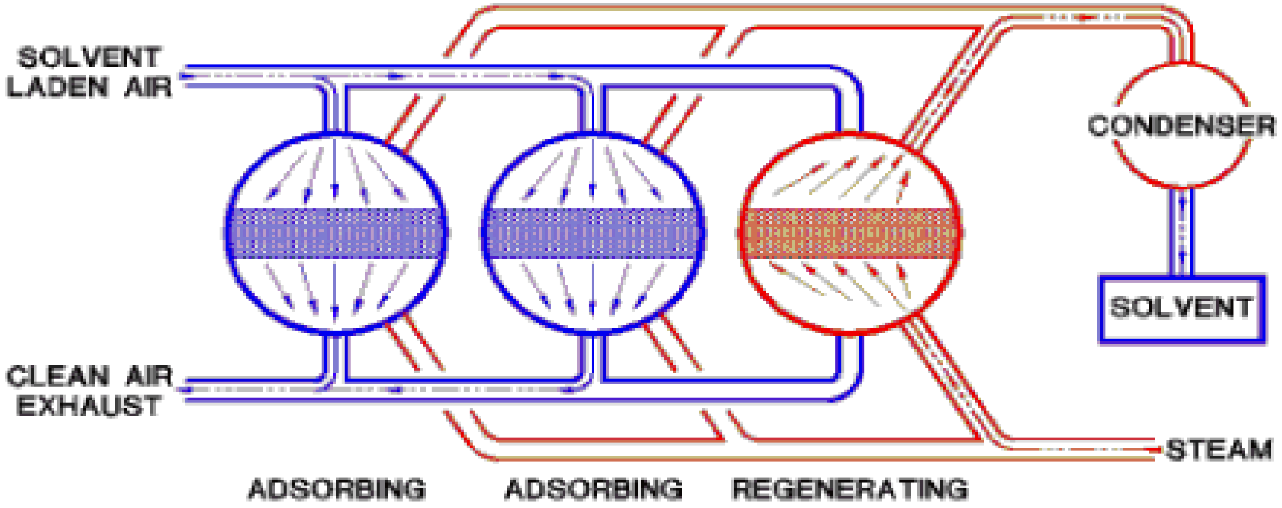
Utilizes a heat exchange media and alternating combustion chambers to preheat VOC/HAP stream.

CATALYTIC OXIDIZER



Similar to Thermal Oxidation but utilizes catalyst to lower activation energy required for oxidation so that it can be accomplished at lower temperatures, thus reducing fuel costs.

CARBON ADSORBERS (REGENERATIVE)

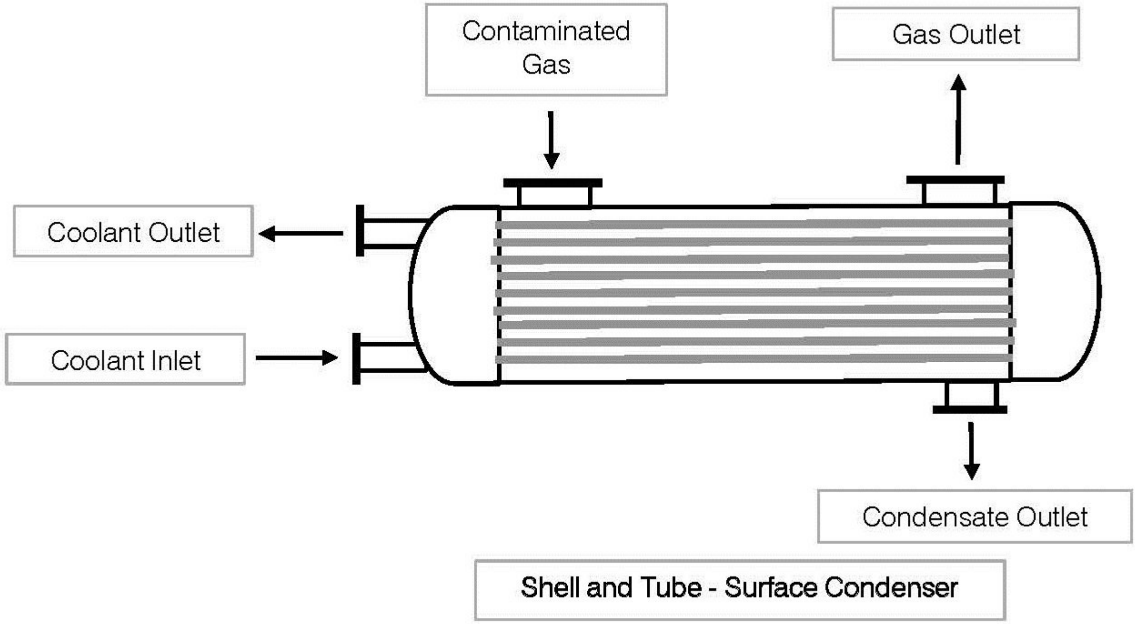


Utilizes activated carbon or other media to adsorb/bind VOC/HAP. Media is pollutant specific. Spent media can be cleaned/regenerated using steam and recovered VOC/HAP can be recycled, treated onsite or sent offsite for disposal.

CARBON ADSORBERS (ONE-TRIP)

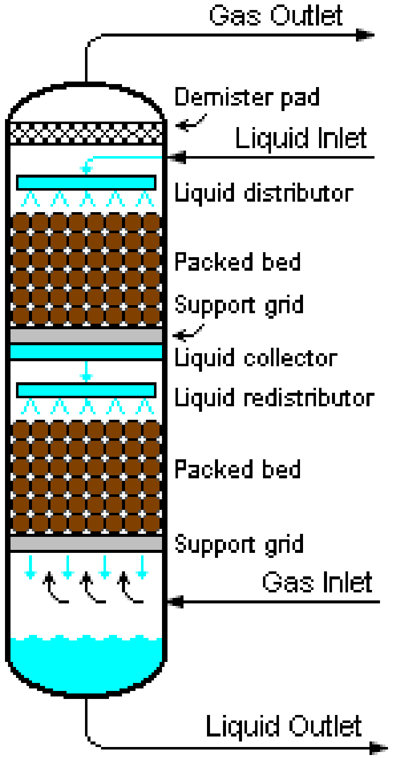
Spent drums are replaced when media is saturated and sent off-site for treatment or regeneration. Not cost effective for high VOC/HAP streams.

CONDENSERS



Condenser uses coolant (typically water from cooling water tower) to condense VOC/HAPs in gas to liquid. The condensed VOC/HAP liquid stream must be recycled, treated or disposed of offsite.

PACKED BED SCRUBBERS



Scrubber uses scrubbant (water/solvent) and packed bed to capture VOC/HAP emissions through solubility or through chemical reaction. The spent scrubbant must be shipped offsite for treatment or treated onsite.

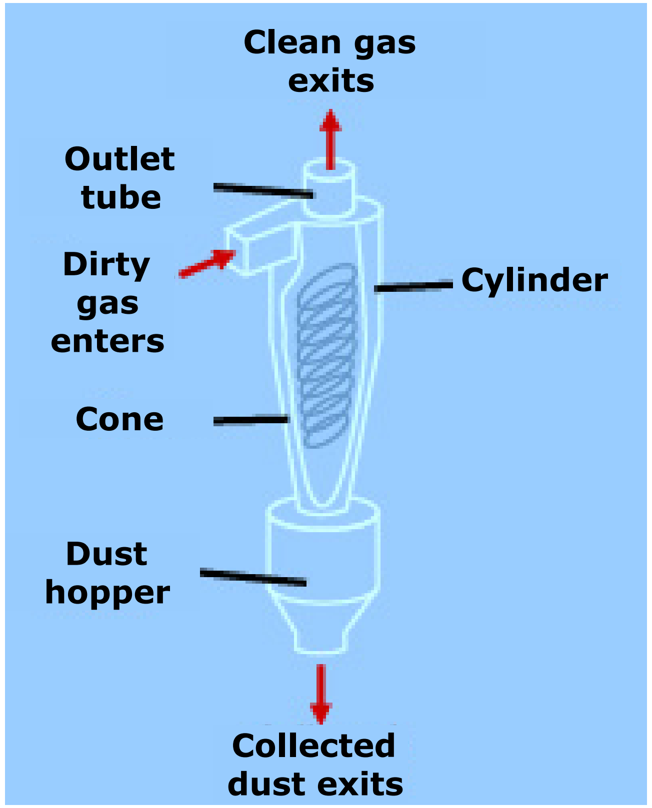
PM CONTROLS

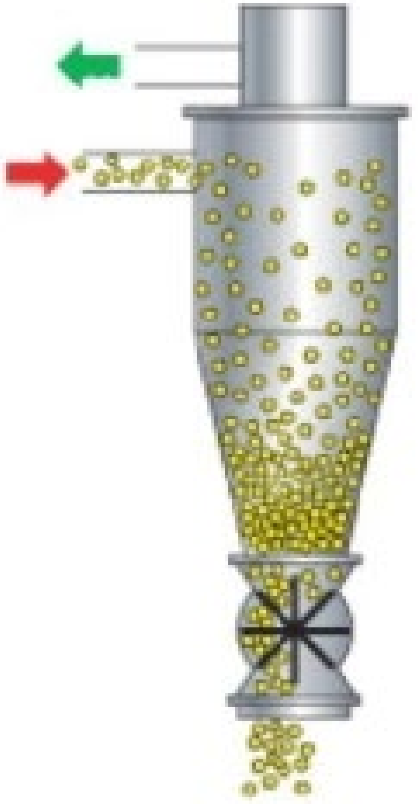
PM CONTROL TECHNOLOGIES

- Most common technologies
  - Cyclones
  - Fabric Filter – Baghouses
  - Electrostatic Precipitators (ESPs) – Wet and Dry ESPs
  - Venturi Scrubbers

- A little overview on how they work

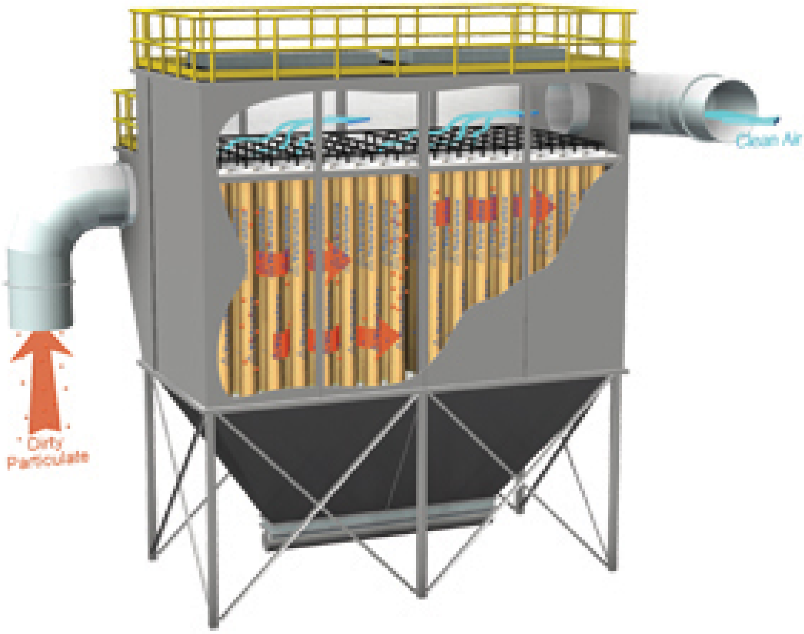
CYCLONES





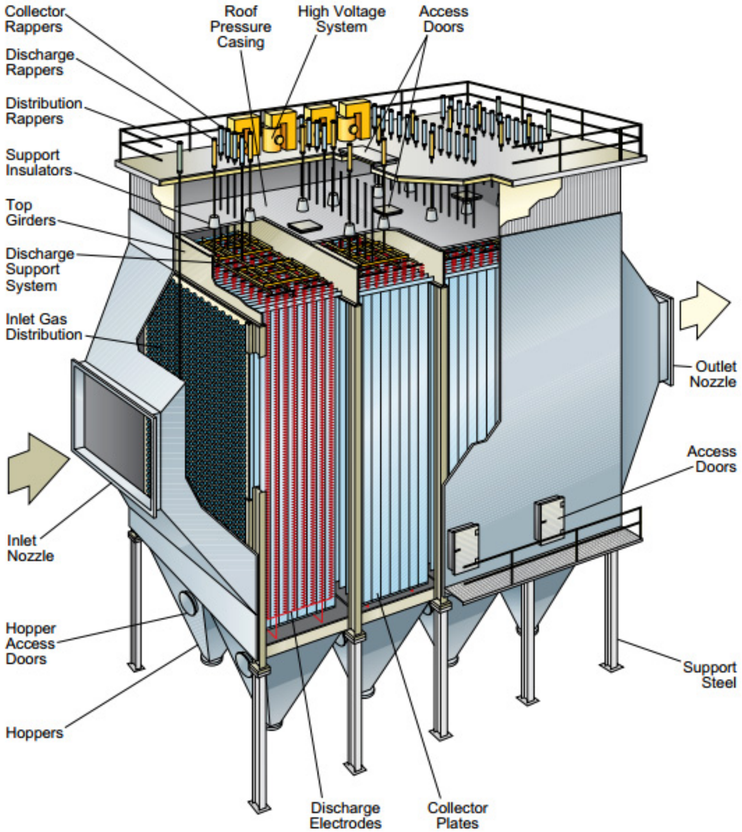
Cyclone uses cyclonic flow to force PM to walls of vessel and down to the dust hopper while clean air goes up through the center of the cyclone.

FABRIC FILTERS (BAGHOUSES)



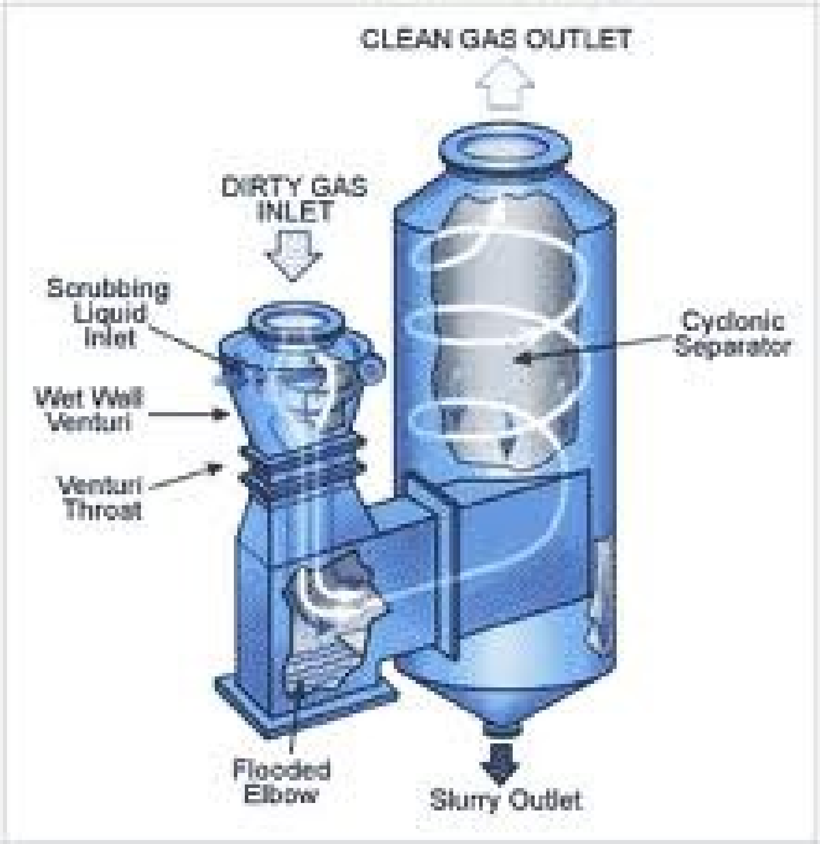
Baghouse uses fabric filters to collect/remove PM from exhaust stream. Bags are periodically cleaned either by mechanical shaker, reverse air or pulse jet. Loose dust cake falls into hopper for recycling or offsite treatment.

ELECTROSTATIC PRECIPITATORS



Discharge electrodes apply a <u>negative</u> charge to particles passing through strong electrical field. The charged particles then migrate to a collecting electrode having an opposite or <u>positive</u> charge. PM collected on collector plates is removed by periodic mechanical rapping.

VENTURI SCRUBBERS



PM is collected by inertial impact with water droplets and then water/PM slurry is removed by cyclone.

NO_X CONTROLS

NITROGEN OXIDE FORMATION

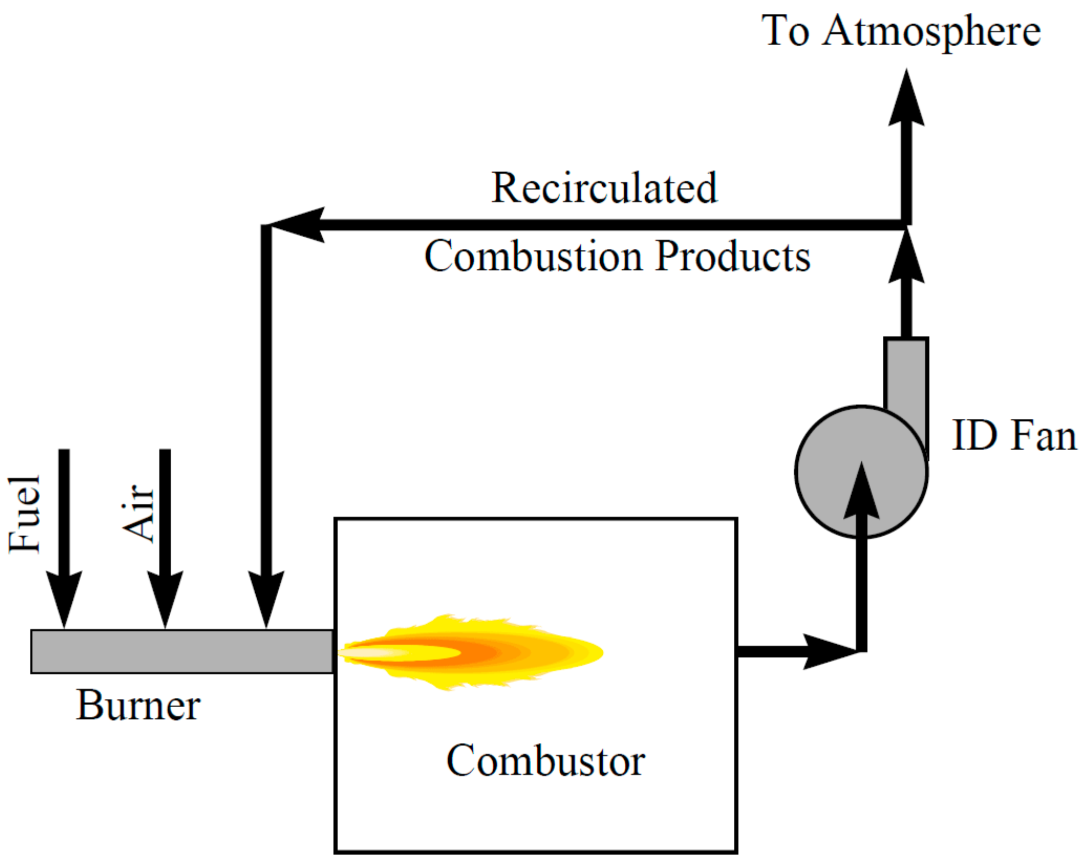
- NO_x is formed by two primary mechanisms
  - Thermal NO_x
    - Forms at high flame temperatures when dissociated nitrogen from combustion air combines with oxygen atoms to produce NO_x
    - Formation of Thermal NO_x increases exponentially with combustion temperature
    - Control strategy – reduce flame temperature and excess oxygen
  - Fuel-bound NO_x
    - Fuel-bound NO_x formation is not limited to high temperatures, but is dependent upon the nitrogen content in fuel
    - Control strategy – use low nitrogen containing fuels

NO_x CONTROL TECHNOLOGIES

- Most common technologies
  - Combustion Controls – Reduce NO_x by altering or modifying the firing conditions under which combustion occurs
    - Flue Gas Re-circulation (FGR)
    - Low NO_x burners (internal staged combustion)
    - Steam or water Injection
  - Post Combustion Controls – Remove NO_x from exhaust stream after it is formed
    - Selective non-catalytic reduction (SNCR)
    - Selective catalytic reduction (SCR)
  - Combination of Combustion Controls and Post Combustion Controls (will not review today)
- A little overview on how they work

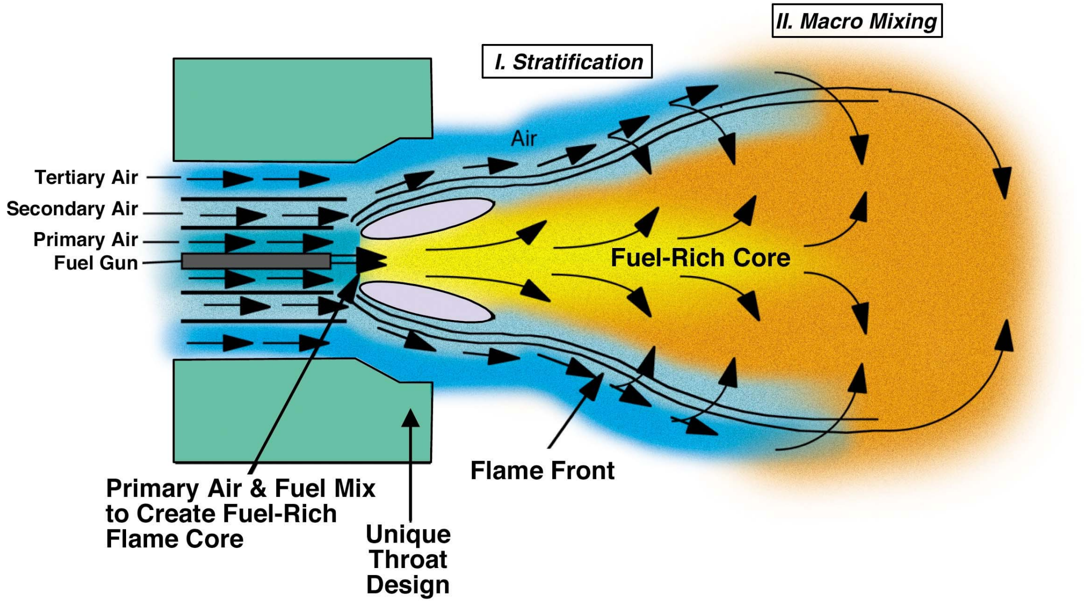
NO_X COMBUSTION CONTROLS

FLUE GAS RECIRCULATION



The recirculated flue gas dilutes the combustion air and thus reduces oxygen content of the combustion air and cools the flame.

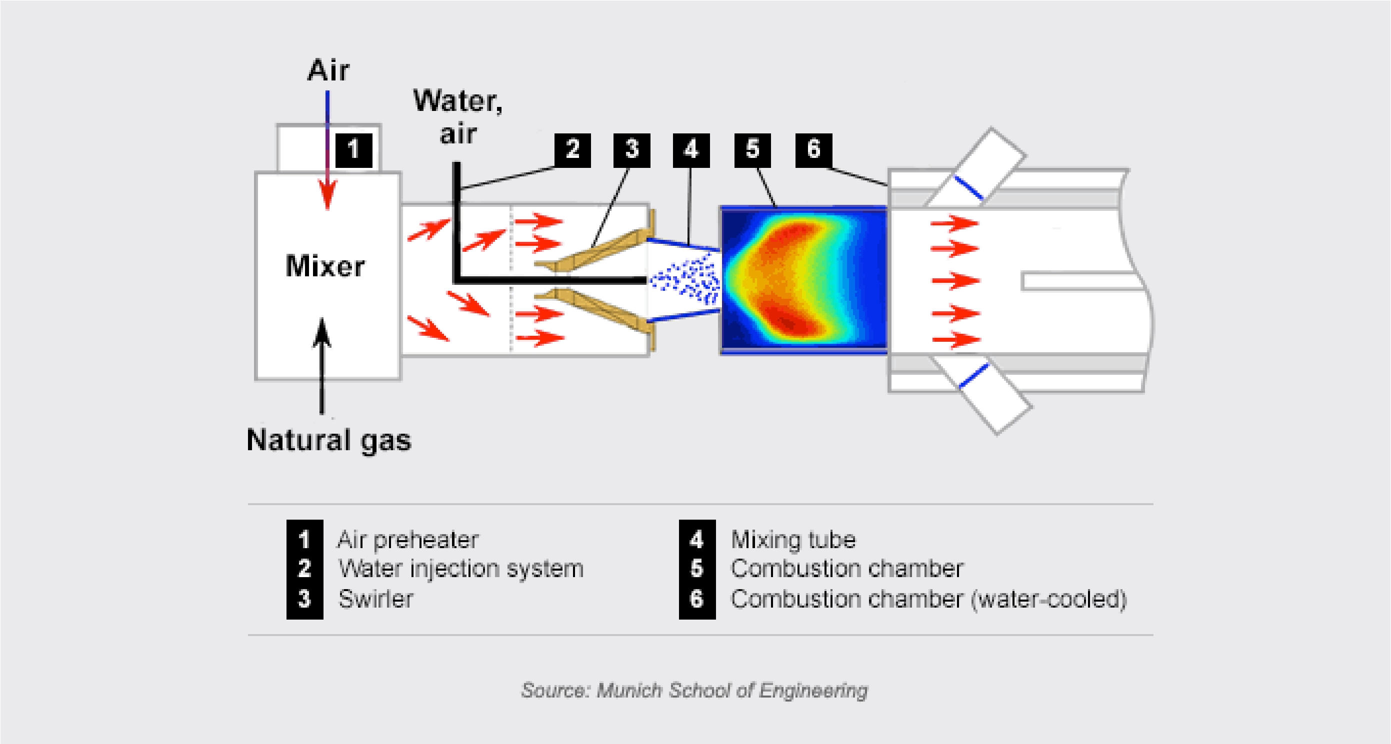
LOW NOX BURNER



Low NO_x burner design results in staged fuel and air across the burner and creates fuel-rich and fuel-lean combustion zones.

- **Fuel-rich – Results in lower temperature and oxygen**
- **Fuel-lean – Results in lowered flame temperature**

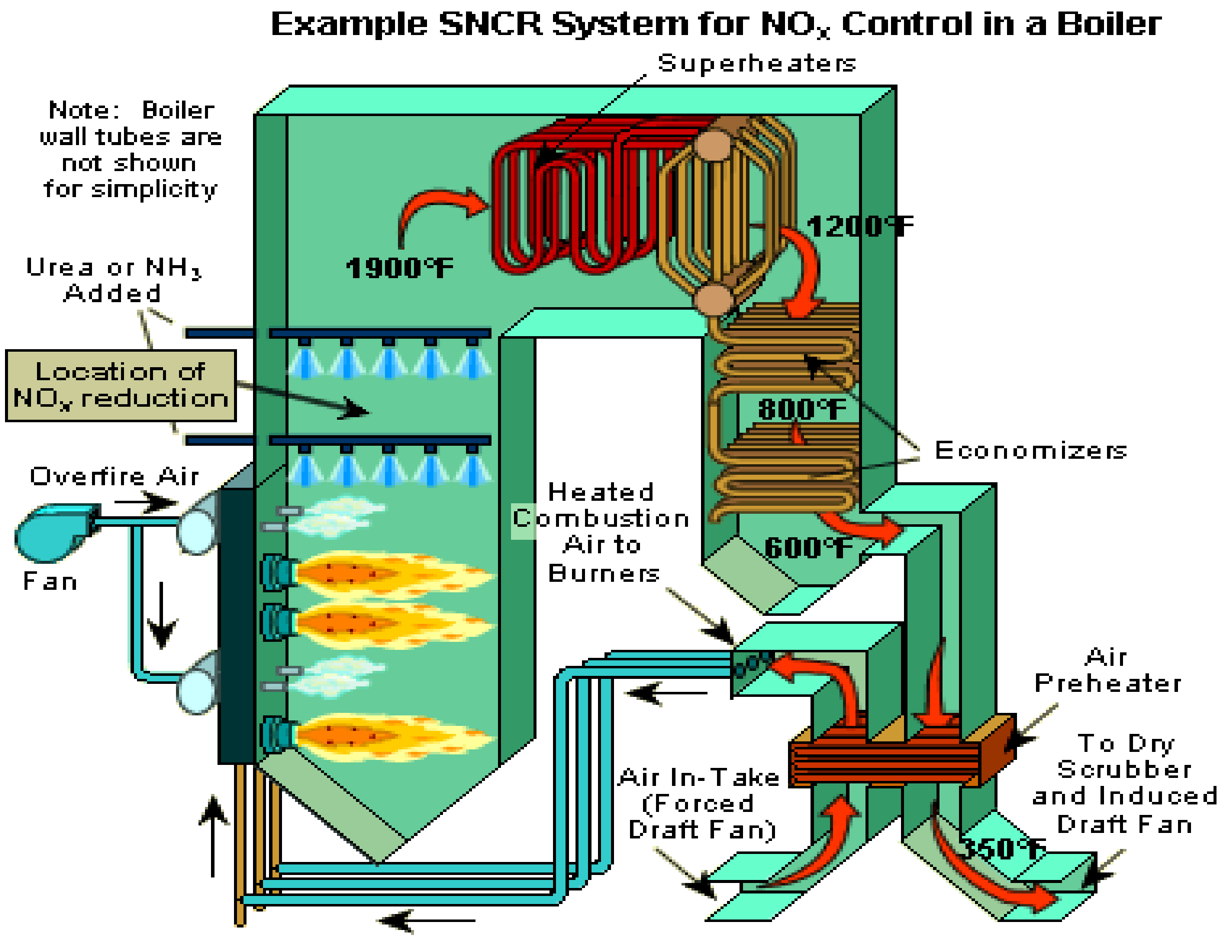
STEAM/WATER INJECTION



Injecting a small amount of water or steam into combustion zone reduces flame temperature.

NO_X POST COMBUSTION CONTROLS

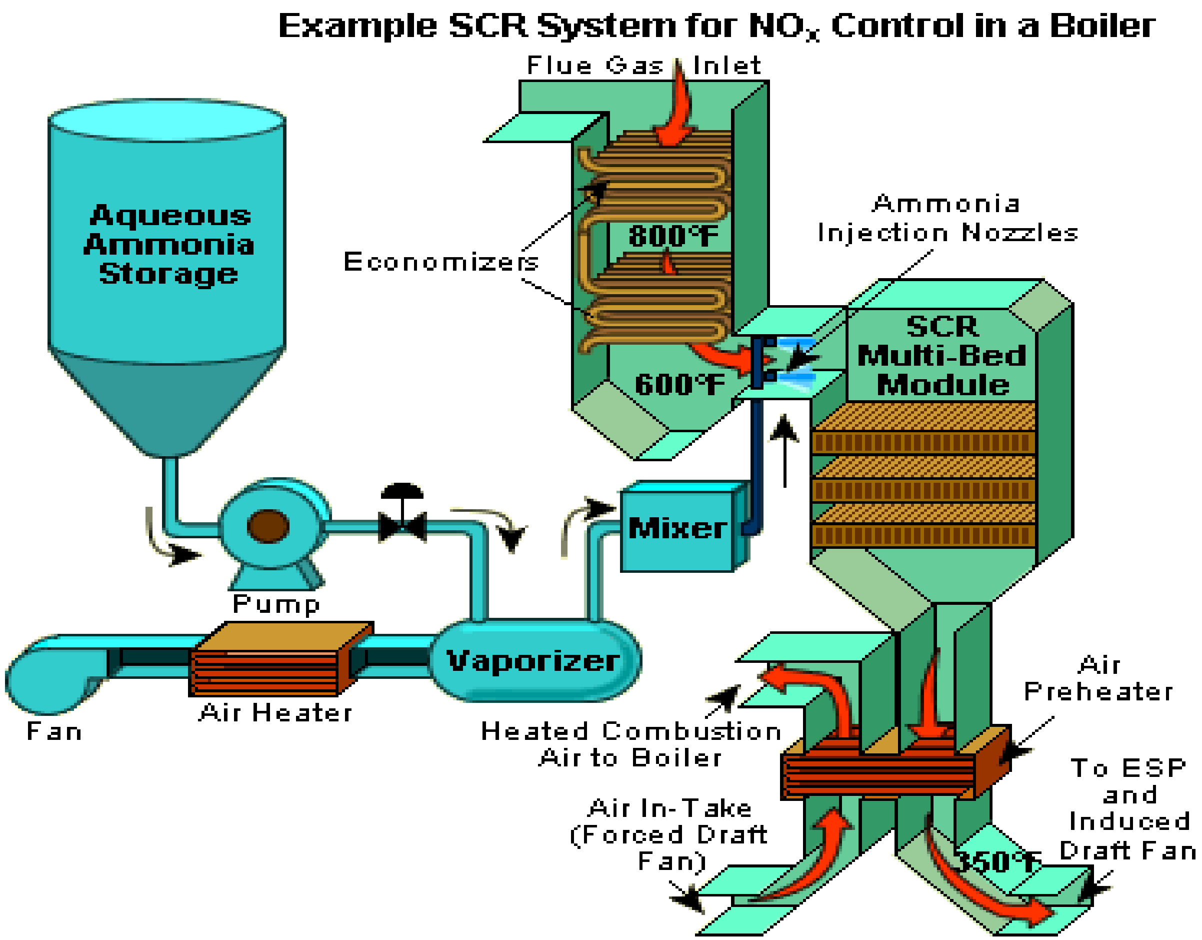
SNCR SYSTEM



SNCR involves the injection of reducing agent (ammonia or urea) into flue gas at temperature range of 1500 to 2100 F. This converts NO_x to nitrogen and water vapor

- **At <u>lower temperatures</u>, the reaction rate decreases, resulting in higher NO_x emissions and ammonia slip (un-reacted ammonia.)**
- **At <u>higher temperatures</u>, the effectiveness of the reagent reaction with NO_x emissions diminishes and increased NO_x levels may occur due to oxidation of reagent.**

SCR



Similar to SNCR but relies on reaction between the reagent and NO_x on the surface of a catalyst.

- **Temperature range is much lower than SNCR.**
- **Sensitive to catalyst poisoning and requires low PM flue gas.**

THANK YOU