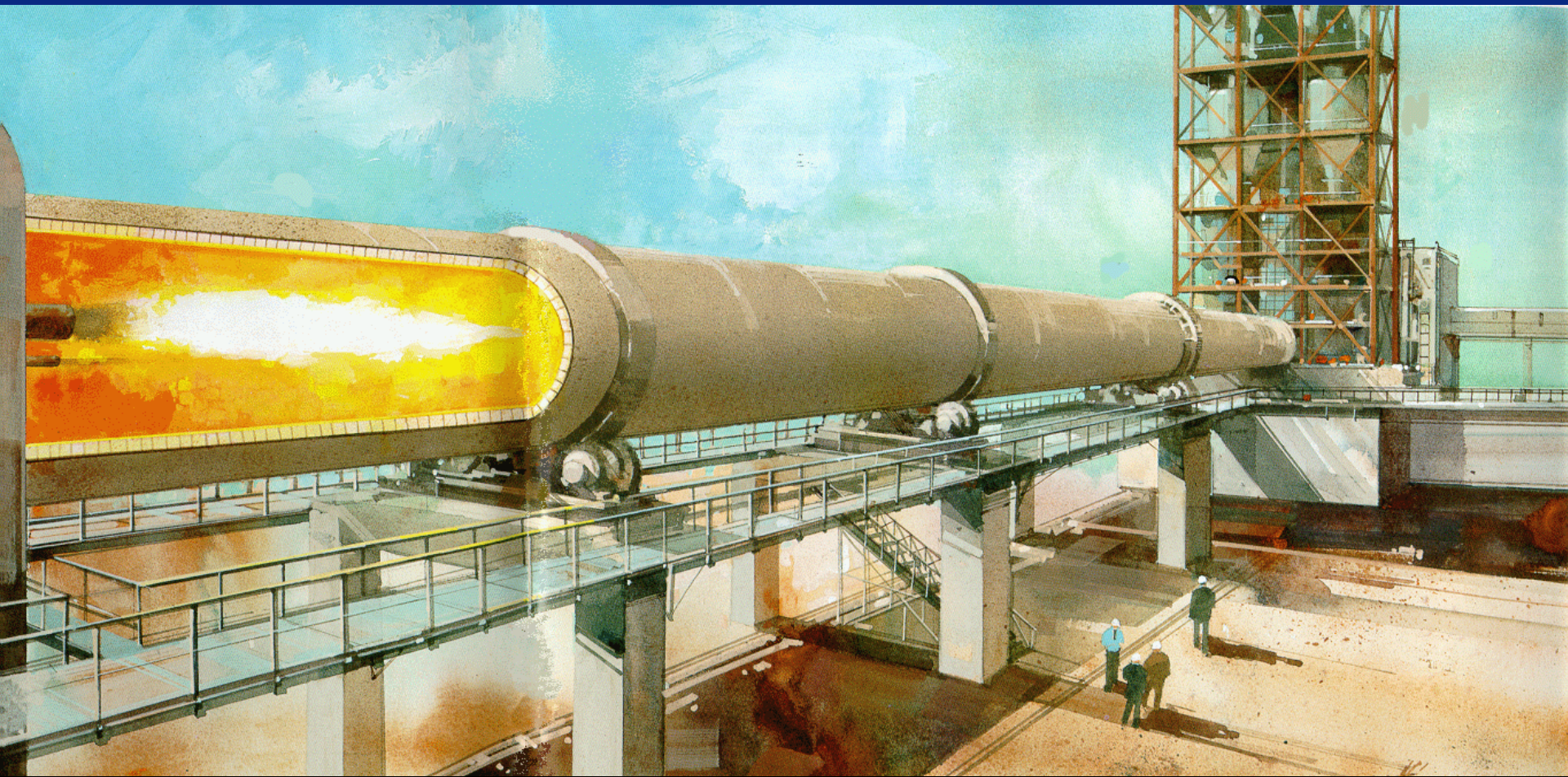


NACT 245

Cement Manufacturing



National Training Program



□ Air Pollution Problem

History

- ❑ Assyrians and Babylonians used clay
- ❑ Egyptians used lime and gypsum
- ❑ Greeks used natural cement
- ❑ Romans used slaked lime, pozzolana (volcanic ash)
- ❑ Joseph Aspdin, Leeds UK, developed Portland Cement

Portland Cement

- A fine powder, gray or white in color, that consists of a mixture of hydraulic cement materials comprising primarily of calcium silicates, aluminates and aluminoferrites.

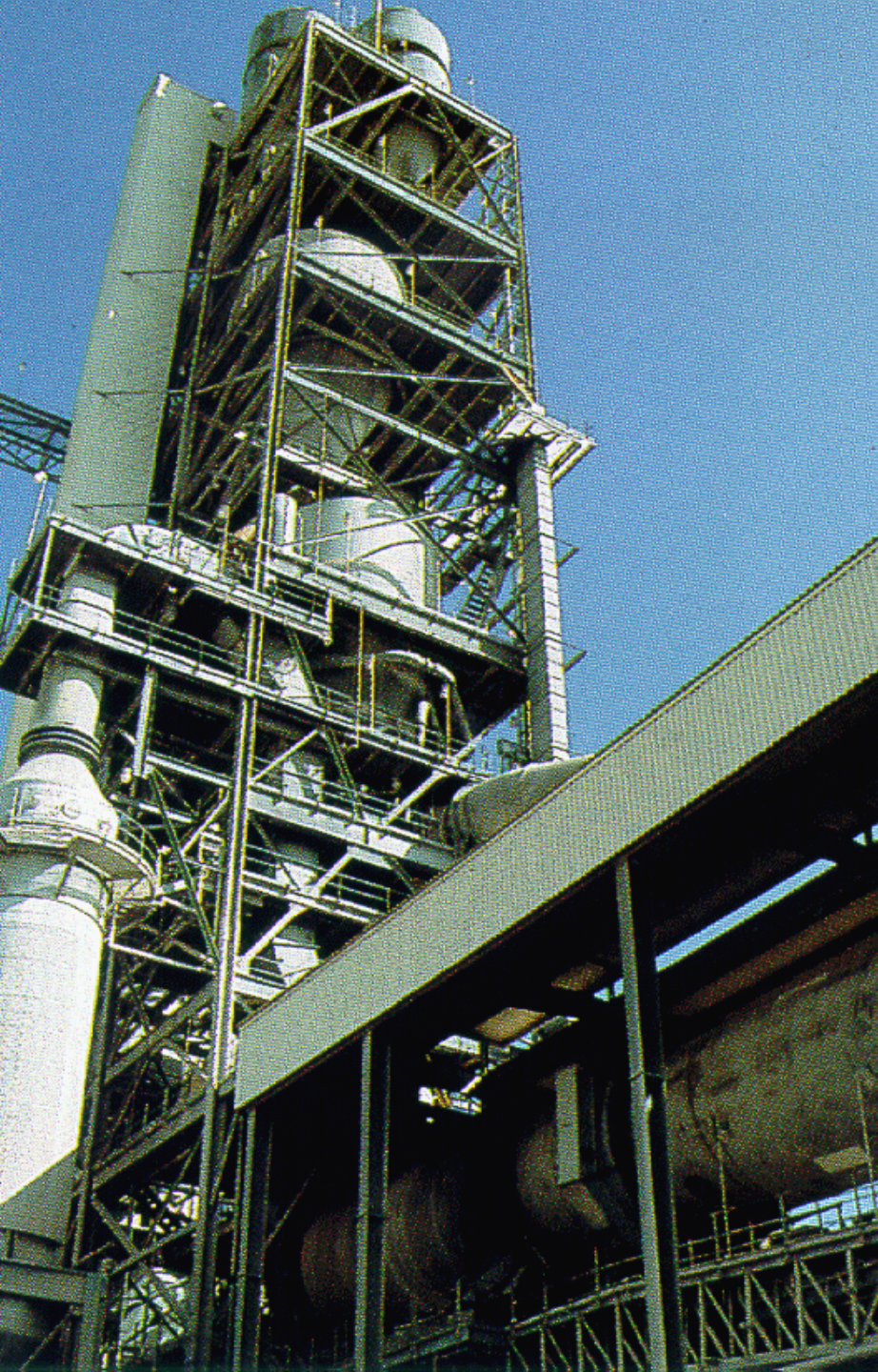
How is Cement Made?

- Limestone

- Clay

- Sand

- Iron-containing materials



Calciner Towers

- Dry pulverized material is preheated and partially calcined before entering the rotary kiln

Cement Kiln



Types of Cement Kilns

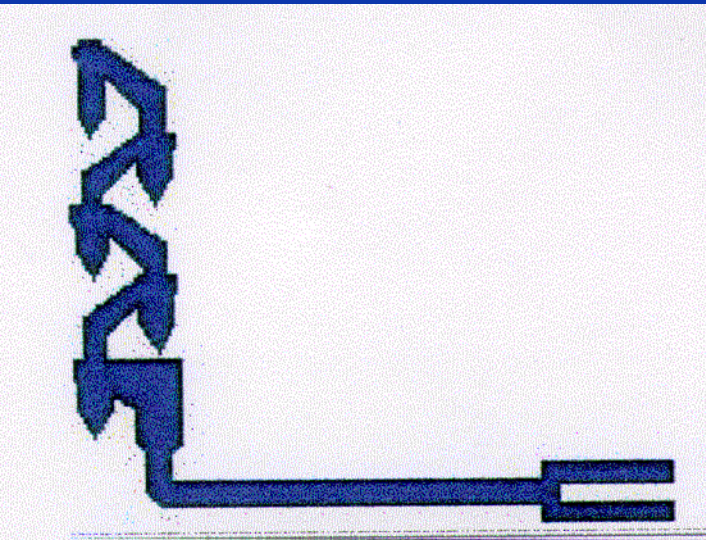
- Long Wet Kilns
- Semi-dry Kilns
- Long Dry Kilns
- Kilns with a Preheater
- Kilns with a Precalciner

Greenhouse Gas CO₂

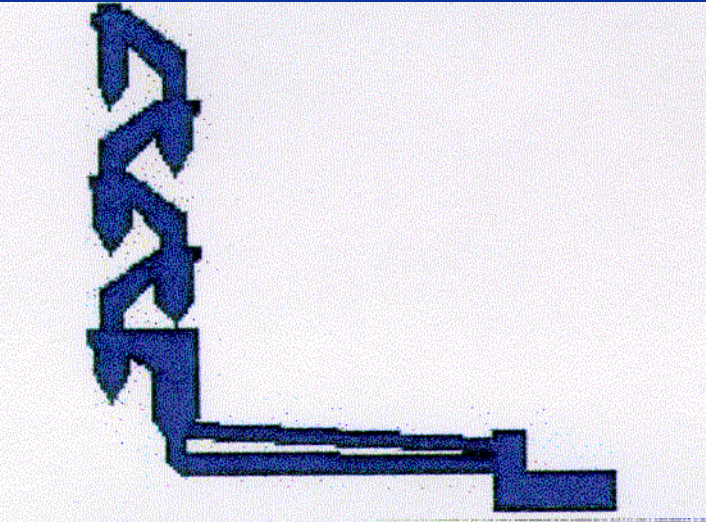
- 1997 Approximately 100 million tons of CO₂ emissions from cement kilns

Types of Calciner Towers

- ILC-E In-Line Calciner Using Excess Air
- Single string cyclone preheater kiln with a small precalciner built into the kiln riser duct.
- Combustion air for the precalciner is drawn through the kiln



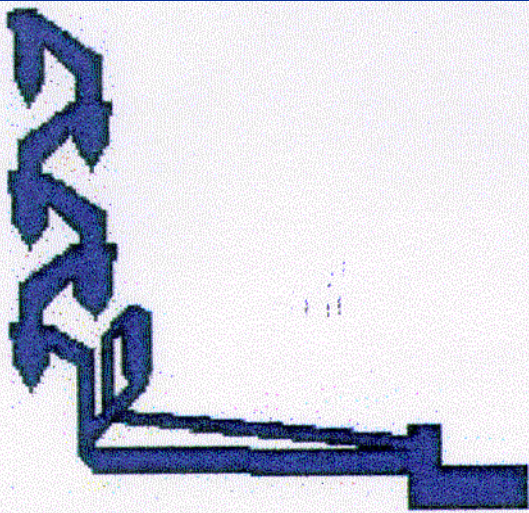
Types of Calciner Towers



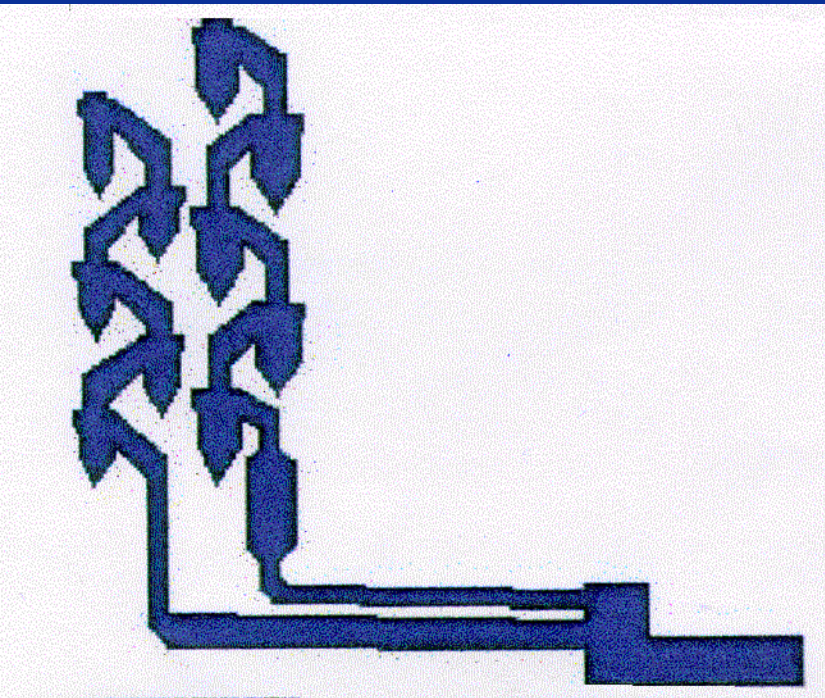
- ILCTM: In-Line Calciner
- Single-string or double-string cyclone pre-heated kiln with precalciner built into the kiln riser duct. Combustion air for the precalciner is drawn through a separate tertiary air duct between the cooler and the calciner.

Types of Calciner Towers

- SLC-D: Separate-Line Calciner-Downdraft
- Single-string or double-string cyclone preheater kiln with a combustion chamber/precalciner placed parallel to the riser duct.

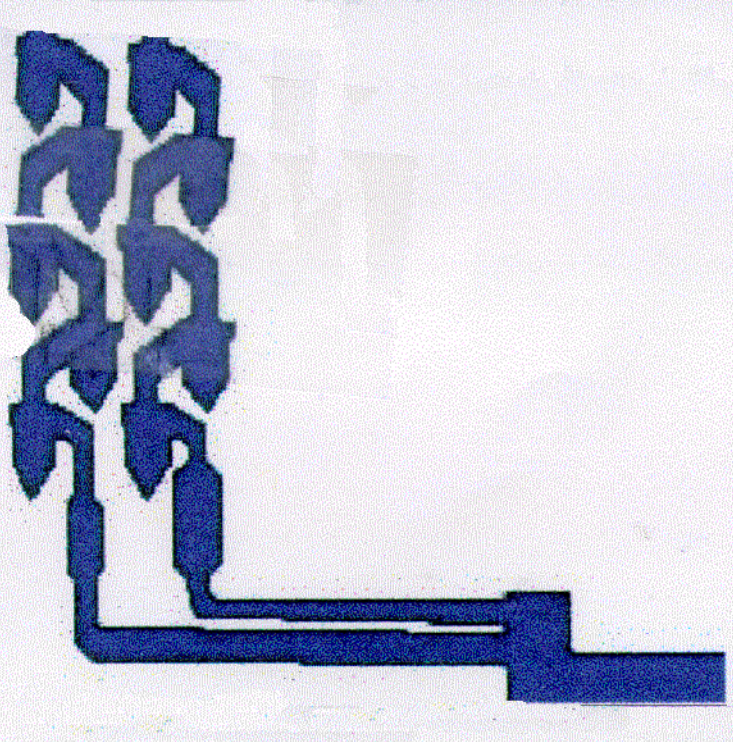


Types of Calciner Towers



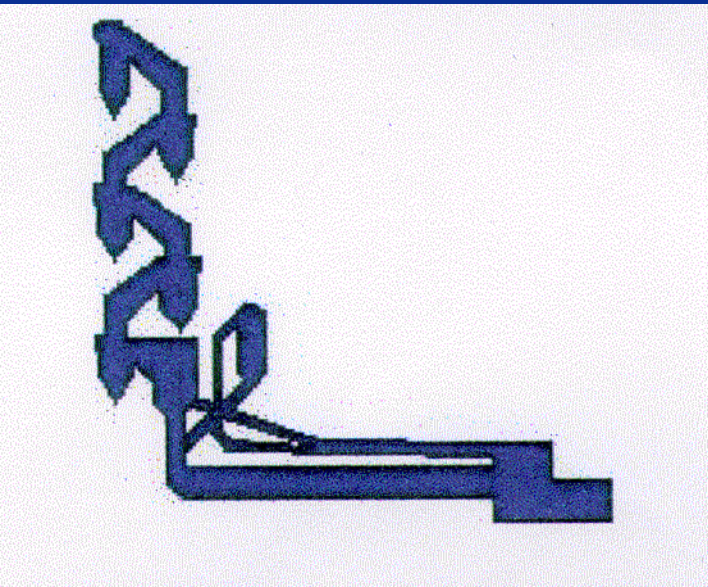
- SLC- Separate-Line Calciner
- Double-string or triple-string cyclone preheater kiln with a precalciner placed parallel to the kiln riser duct

Types of Calciner Towers



- SLC-I™: Separate-Line Calciner with In-Line Calciner
- Double string cyclone preheater kiln with a precalciner placed both within the kiln riser duct and parallel with the kiln riser duct

Types of Calciner Towers



- SLC-D-NO_xTM: Separate-Line Calciner-Downdraft Low NO_x Type
- Single-string or double-string cyclone preheater kiln with a downdraft combustion chamber and an in-line calciner built into the kiln riser duct.

Classes of Cement

- Clays
- Common Limes
- Hydraulic Limes
- Natural Cements
- Pozzolana Cements

Characteristics of Clays

- ❑ Chiefly aluminum silicate
- ❑ Can be used alone or with other substances
- ❑ Formed by disintegration of minerals
- ❑ Requires no preliminary processing
- ❑ Do not harden in water

Characteristics of Common Limes

- ❑ Do not set under water
- ❑ Require processing
- ❑ Must be heated before water is added
- ❑ Produced from calcium carbonate, CaCO_3

Characteristics of Hydraulic Limes

- An hydraulic hydrated lime is the hydrated, dry cementitious product obtained by calcining a limestone containing silica and alumina to a temperature short of incipient fusion, so as to form sufficient free lime (CaO) to permit hydration.....

Natural Cements

- Hydraulic cementitious materials
- Each raw materials contains compounds of silicon, aluminum, and calcium
- Preparation includes crushing and grinding material into smaller size
- Main use is for concrete

Pozzolana Cements

- ❑ Originally produced by the Romans
- ❑ Hydrated lime and finely ground volcanic materials containing aluminum, silicon, sodium, and potassium
- ❑ Named for a town in Italy, Pozzolana
- ❑ Requires two raw material components: Calciate limestone and finely ground Pozzolana

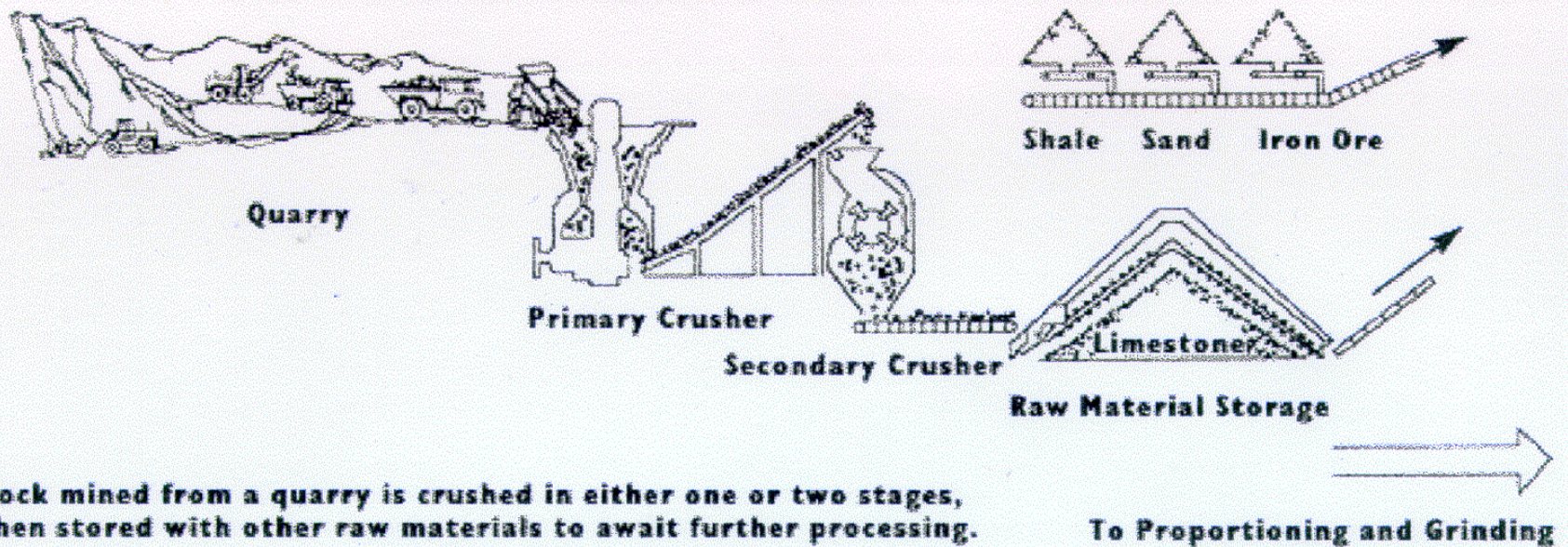
Raw Materials

- Calcium
- Silicon
- Aluminum
- Iron

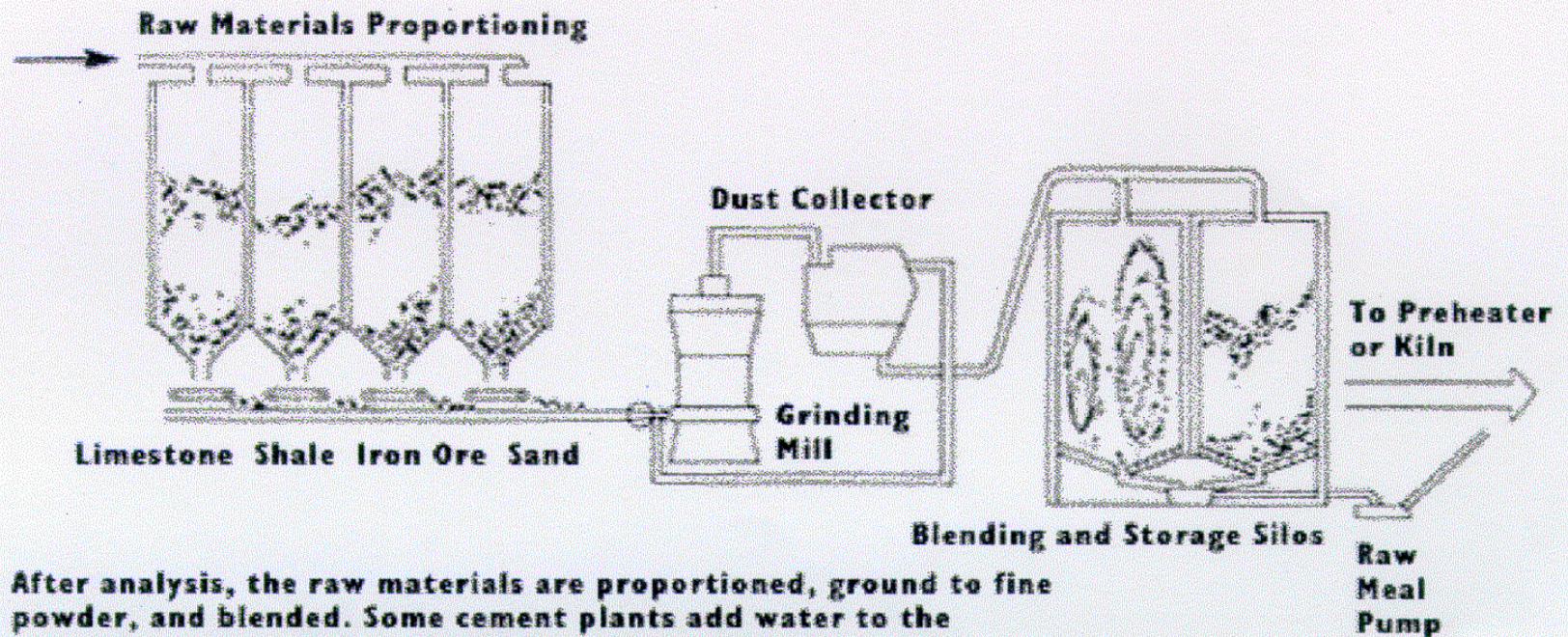
Raw Materials



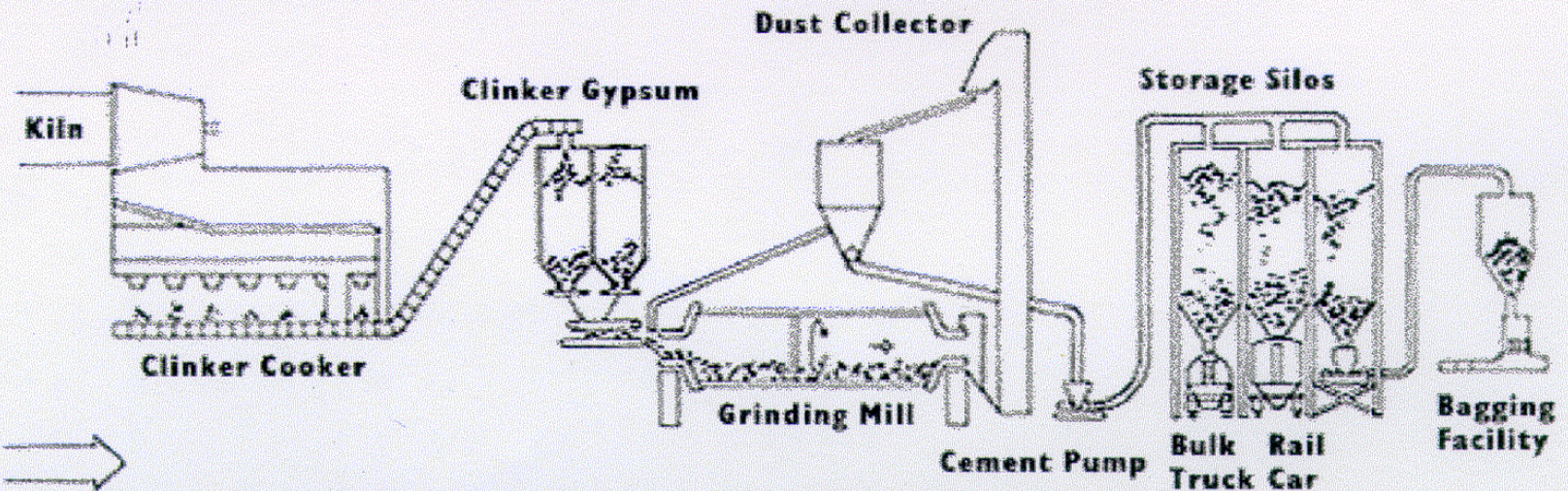
Raw Material Process



Raw Material Proportioning



Clinker Process



Once cooled, the clinker is ground with a small amount of gypsum.
It's now portland cement-ready to be bagged or shipped in bulk.

Raw Materials

- Sand
- Bauxites
- Alumina-rich flint clays

Raw Materials for Lime

- Aragonite
- Calcite
- Limestone
- Marl
- Shale

Raw Materials for Iron

- Blast furnace flu dust
- Clay
- Iron ore
- Mill scale
- Shale

Raw Materials for Silica

- SiO_2
- Calcium silicate
- Clay
- Marl
- Sand
- Shale

Raw Materials for Alumina

- Al_2O_3
- Aluminum ore refuse
- Clay
- Fly ash
- Shale

Raw Materials for Gypsum

- $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
- Anhydrite
- Calcium sulfate
- Gypsum

Raw Materials for Magnesia

- MgO
- Cement rock
- Limestone
- Slag

Major Components of Portland Cement Clinker

- Tricalcium silicate
- Dicalcium silicate
- Tricalcium aluminate
- Tetracalcium aluminoferrite

Factors to be Considered

- ❑ Composition
- ❑ Uniformity
- ❑ Physical Characteristics
- ❑ Manual page 200-9

Factors (Continued)

- Overburden
- Quantity
- Location, Topography, and Transportation Methods

Types of Cement

- Type I – normal, general purpose
- Type IA – normal, air entraining
- Type II – moderate sulfate resistant
- Type IIA – moderate heat of hydration and moderate sulfate resisting and air entrained.
Low alkaline

Types of Cement

- Type III – high early strength
- Type IIIA – high early strength and air entraining
- Type IV – low heat of hydration
- Type V – high sulfate resistance

Focus

- Processes and equipment
- Regulation requirements
- Inspection procedures

Four Step Process

- ❑ Acquisition of raw material
- ❑ Preparation of the raw materials for pyro-processing
- ❑ Pyro-processing of the raw material to form Portland cement clinker
- ❑ Grinding of the clinker to Portland cement

Layout

- Quarry
- Preliminary Grinding and Mixing
- Kilning and Clinkering
- Finish and Fine Grinding
- Storing, Packaging, and Shipping

Inspector's View

- ❑ Is the facility operating within it's PTO?
- ❑ Have all the emission points been identified?
- ❑ What is 40 CFR 266?
- ❑ What is MACT - NO_x emissions
- ❑ Are all possible mitigation measures being implemented?

Quarry



Blast!



Blast Results



Crusher



Cone Crusher



Secondary Crusher



Raw Mill



Raw Feed Mill



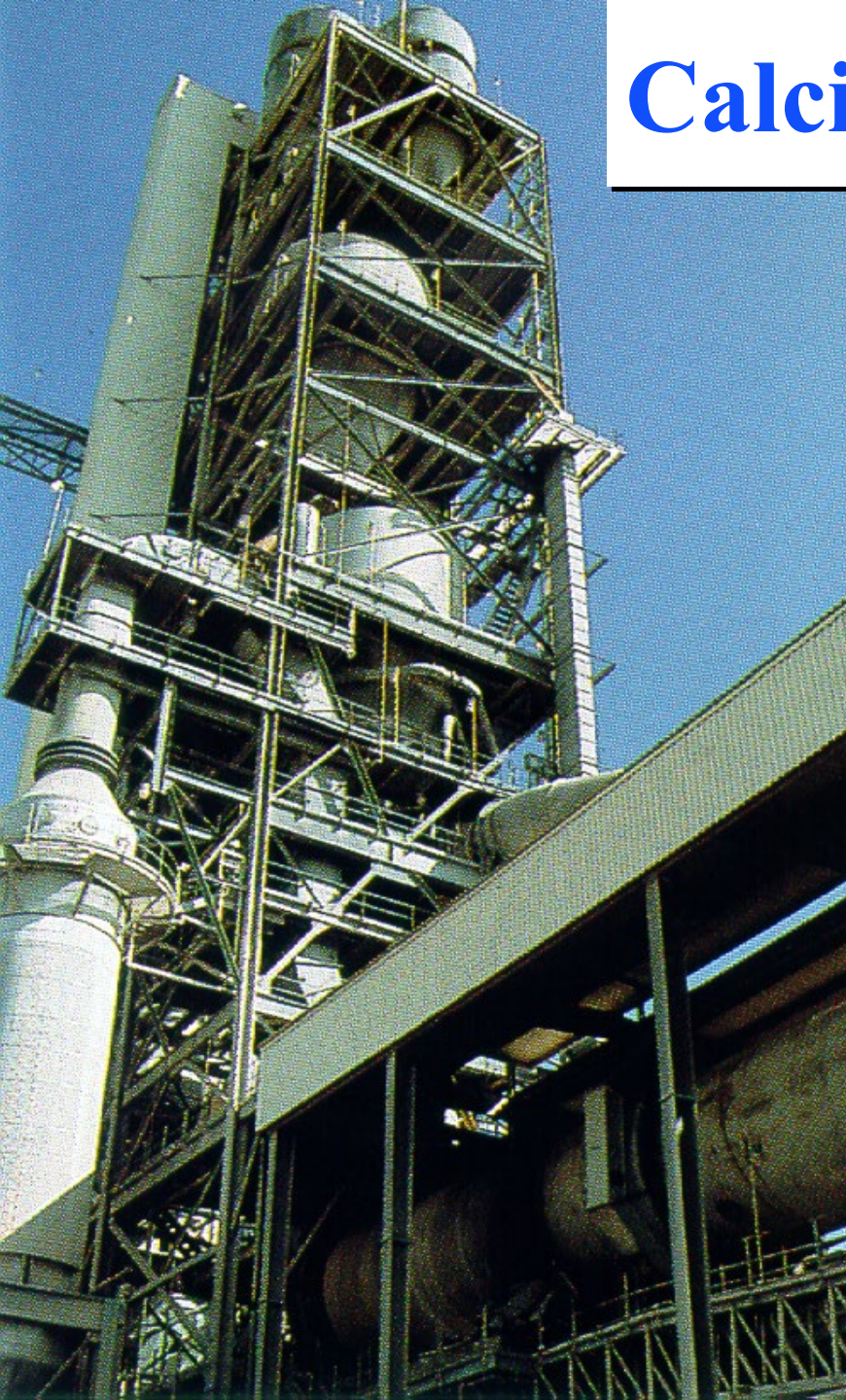
Radial Stacker



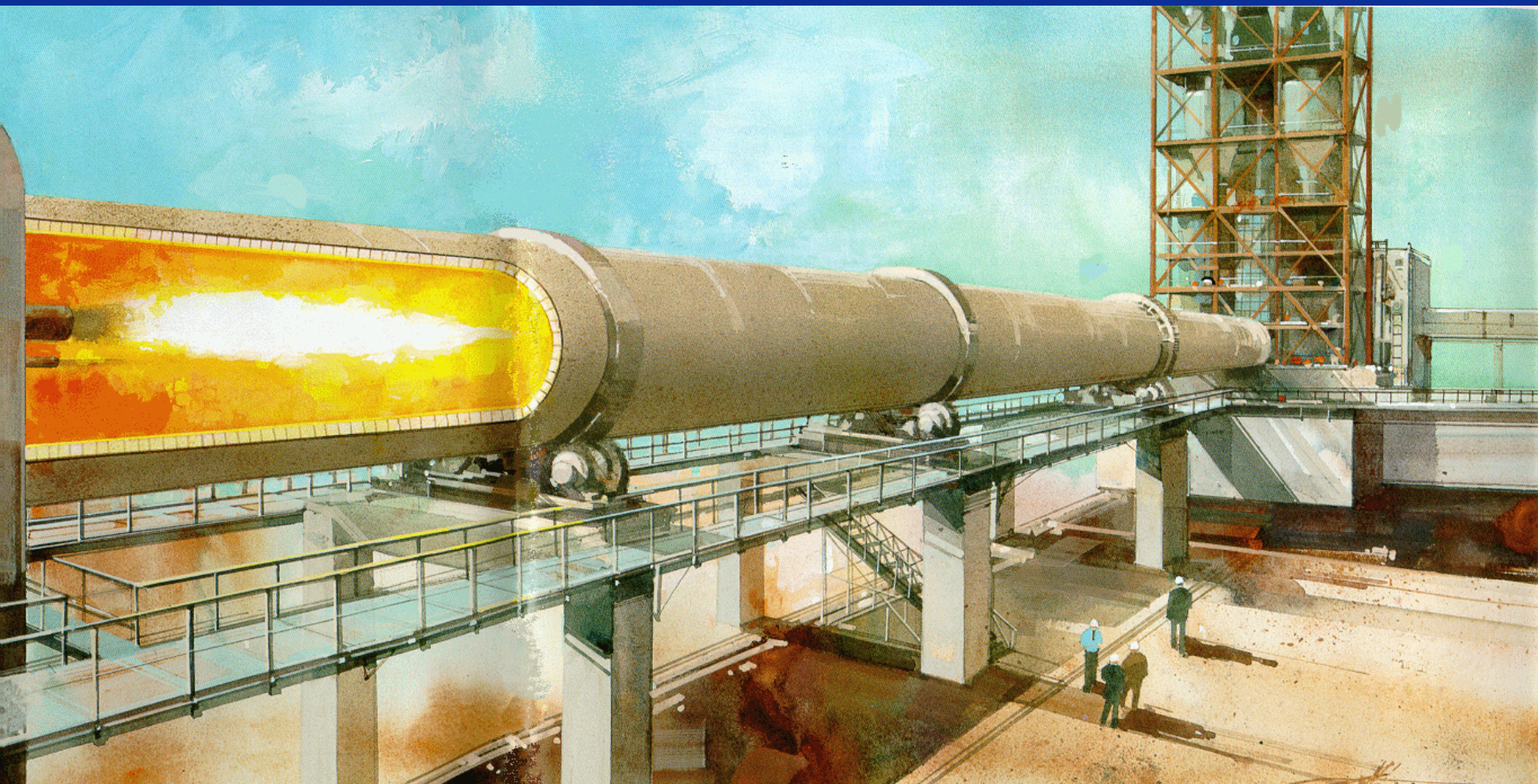
Pyro-processing

- Dry Process
- Dry Process w/Preheater
- Precalciner
- Semi-dry Process

Calciner Towers



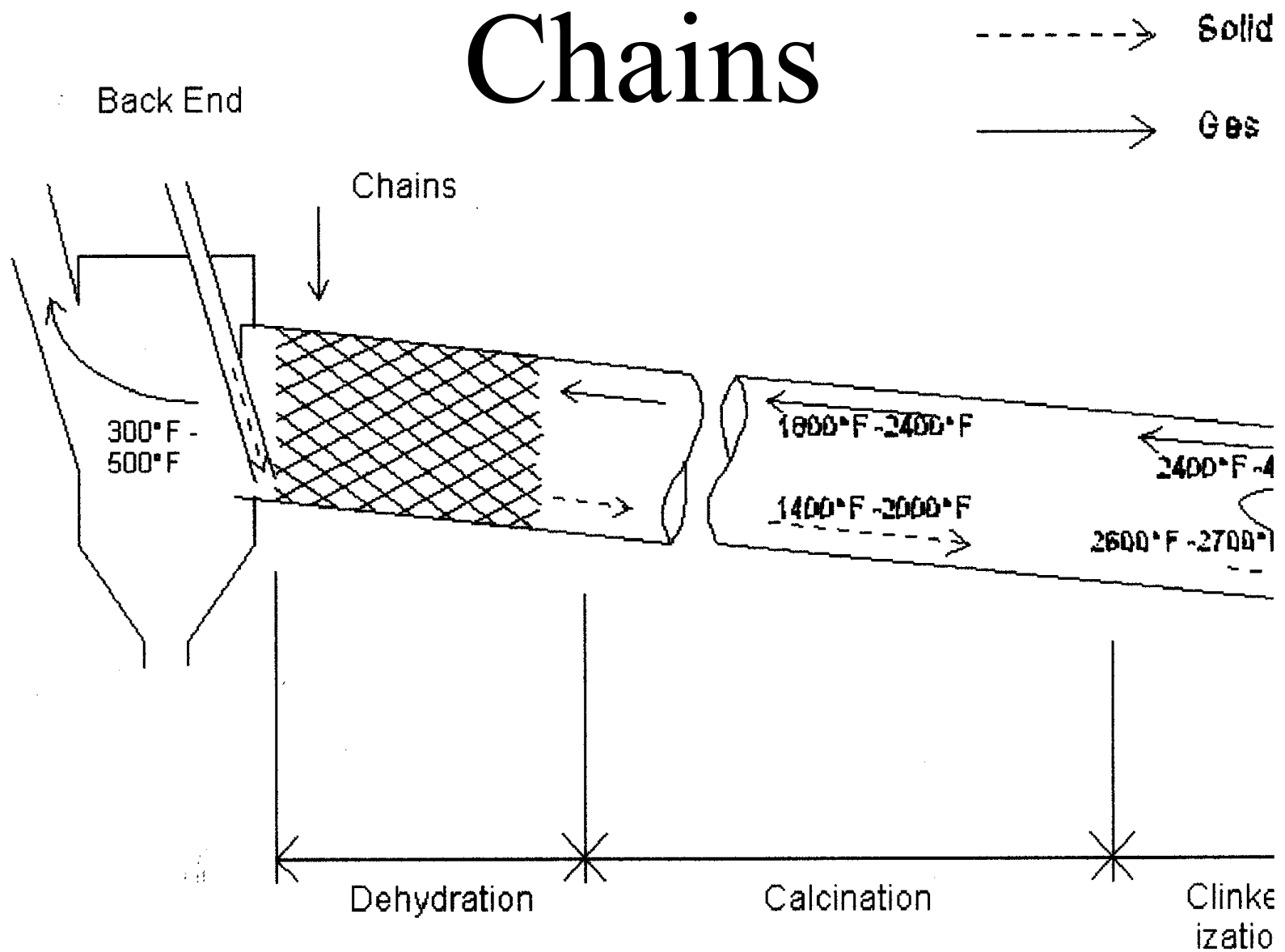
Conversion by Fire



Kiln

- ❑ Chamber of combustion
- ❑ Flue for gases and vapors
- ❑ Conveyor
- ❑ Heat exchanger and dryer
- ❑ Calciner
- ❑ Mixer
- ❑ Transformer

Chains



Schematic Flow Diagram of a
Straight Rotary Cement Kiln

Kiln



Wet Process

- ❑ Wet slurry
- ❑ 40 – 50% Water
- ❑ More energy required to remove water

Dry Process

Zones and Temperatures

□ Drying/Preheating	60-1,480 °F
□ Calcining	1,480-2,192°F
□ Upper-transition	2,192-2,552°F
□ Sintering	2,552-2,750°F
□ Cooling (lower transition)	2,750-2,350°F

Drying/ Pre-heating Zone



Cooling Zone



Cooling Zone



Cooling Zone



Grinding Mill



Storage Silos



Transportation



Additional Storage Structures

- Limestone
- Clay
- Preblend Dome
- Clinker
- Cement
- Coal and Iron

Raw Material Storage



The Problem



The Case for Waste

- ❑ Cement manufacturing is energy intensive
- ❑ Requires between 3 and 6 million BTUs per ton
- ❑ Requires fuels with high “heat value”
- ❑ Waste material can provide enough heat

Tire Derived Fuel

- ❑ One pound of tires has a heat value of 1.5 pounds of sub-bituminous coal
- ❑ Average tire has 15000 BTU per pound compared to approx 10,000 per pound of coal

Advantages of Waste Fuels

- ❑ Utilizes the energy value of the waste as fuel which would otherwise be lost
- ❑ It contributes to the public good by keeping these recyclable materials from being buried in landfills, incinerated or injected into underground wells
- ❑ It reduces the need for fossil fuels
- ❑ It reduces stack emissions by replacing coal with cleaner burning waste fuels
- ❑ It reduces operating costs

Hazardous Wastes

- Organic
- Inorganic

What Metals are Regulated by EPA?

☐ Antimony

☐ Arsenic

☐ Barium

☐ Beryllium

☐ Cadmium

Chromium

Lead

Mercury

Silver

Thallium

What they can not burn

- ❑ PCBs
- ❑ Dioxins
- ❑ Pesticides
- ❑ Radioactive wastes

Emissions

- Particulate Matter
- Total Organic Gases

Fugitive Dust



Emissions

- Oxides of Nitrogen
- Oxides of Sulfur
- Carbon Monoxide

Emissions

- ❑ **Incomplete combustion**
- ❑ **Flame configuration**
- ❑ **Raw materials**
- ❑ **Types of fuels**

Mercury

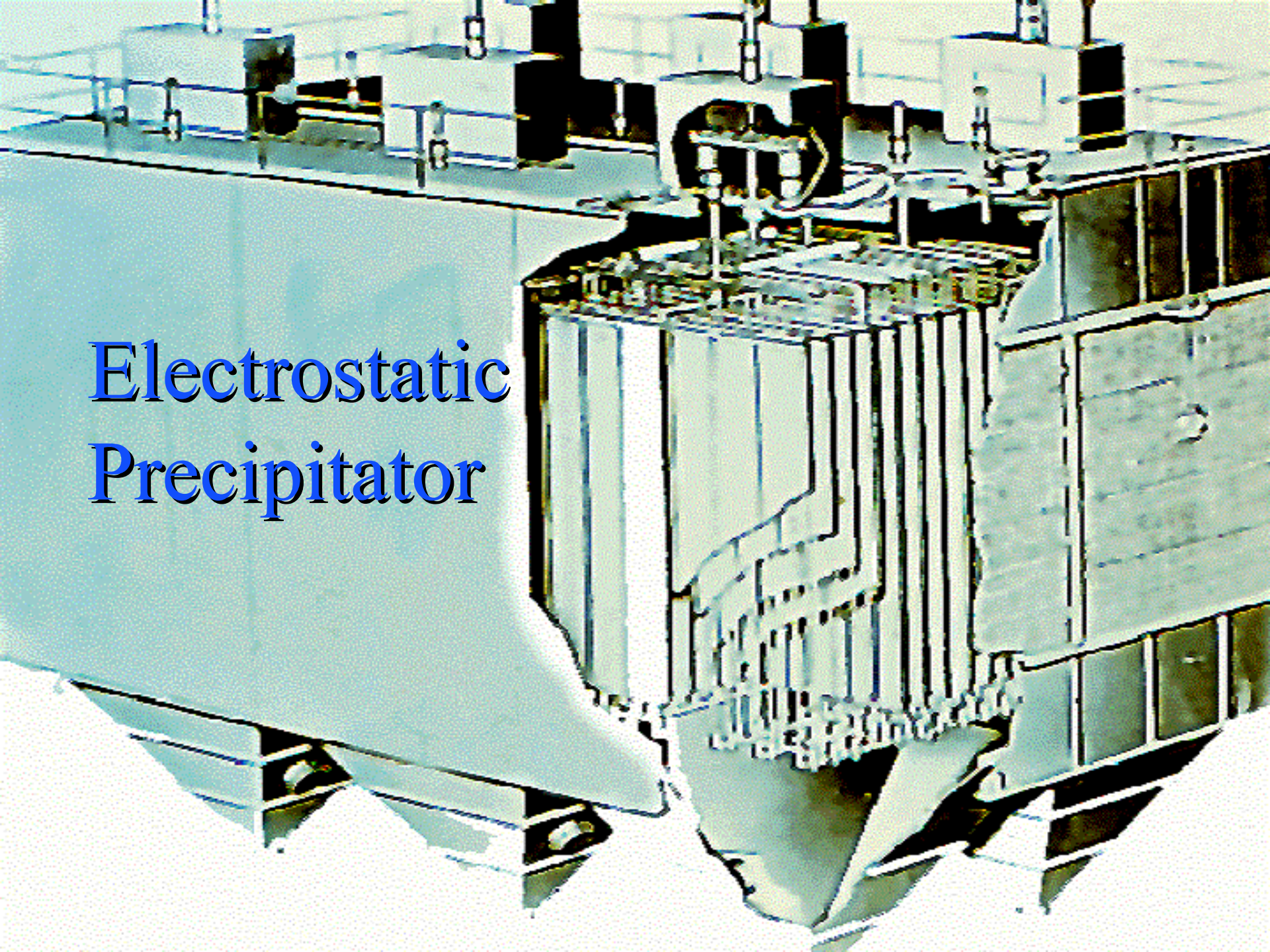
- ❑ Coal burning median mercury concentration in US coals 0.03-0.24 ppm by weight
- ❑ EPA considering 90% removal for regulated combustion sources
- ❑ Human health concern

What Kind of Control?

- Electrostatic Precipitators

- Baghouses

Electrostatic Precipitator



Electrostatic Precipitator Hopper



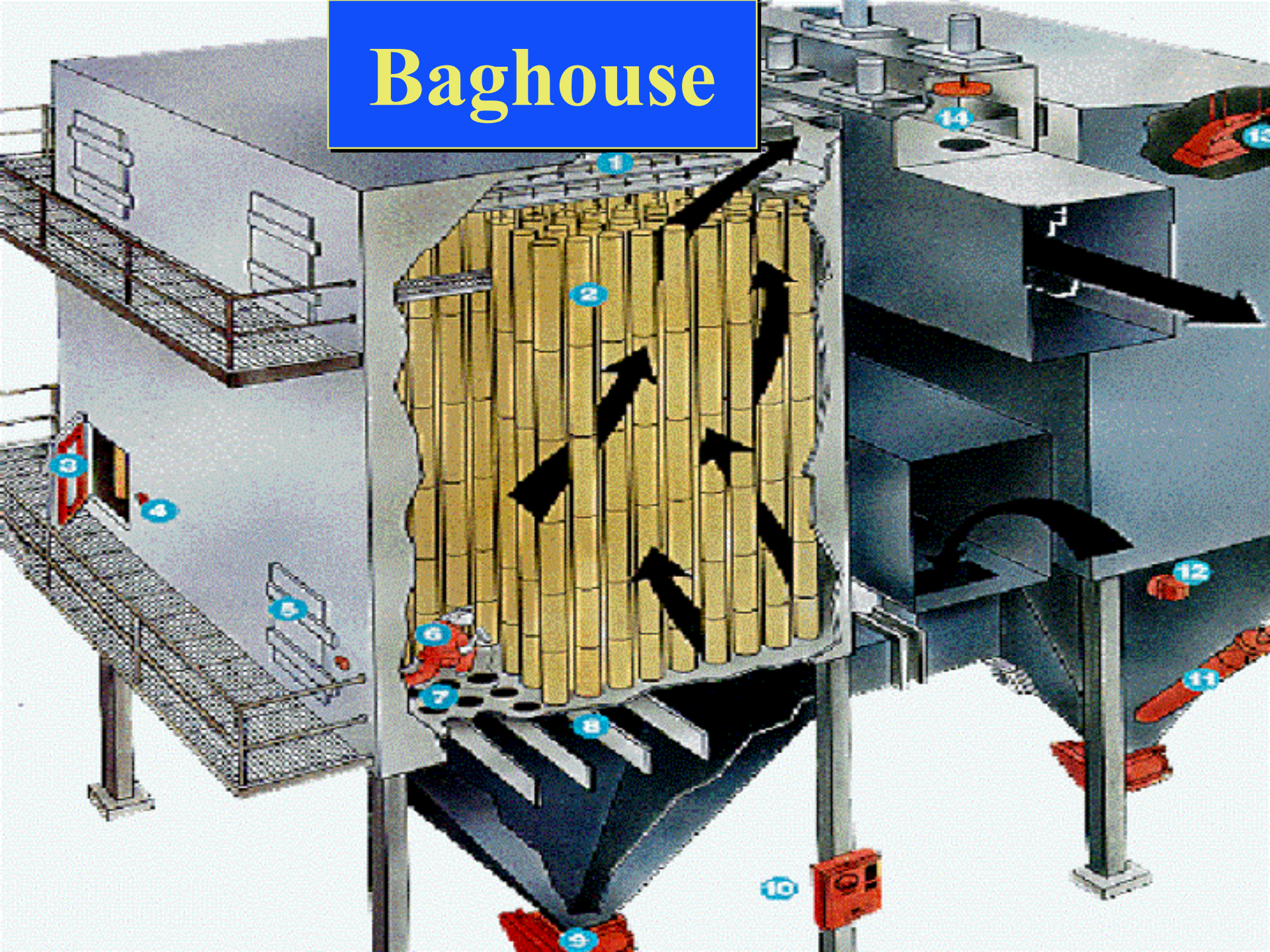
Electrostatic Precipitator



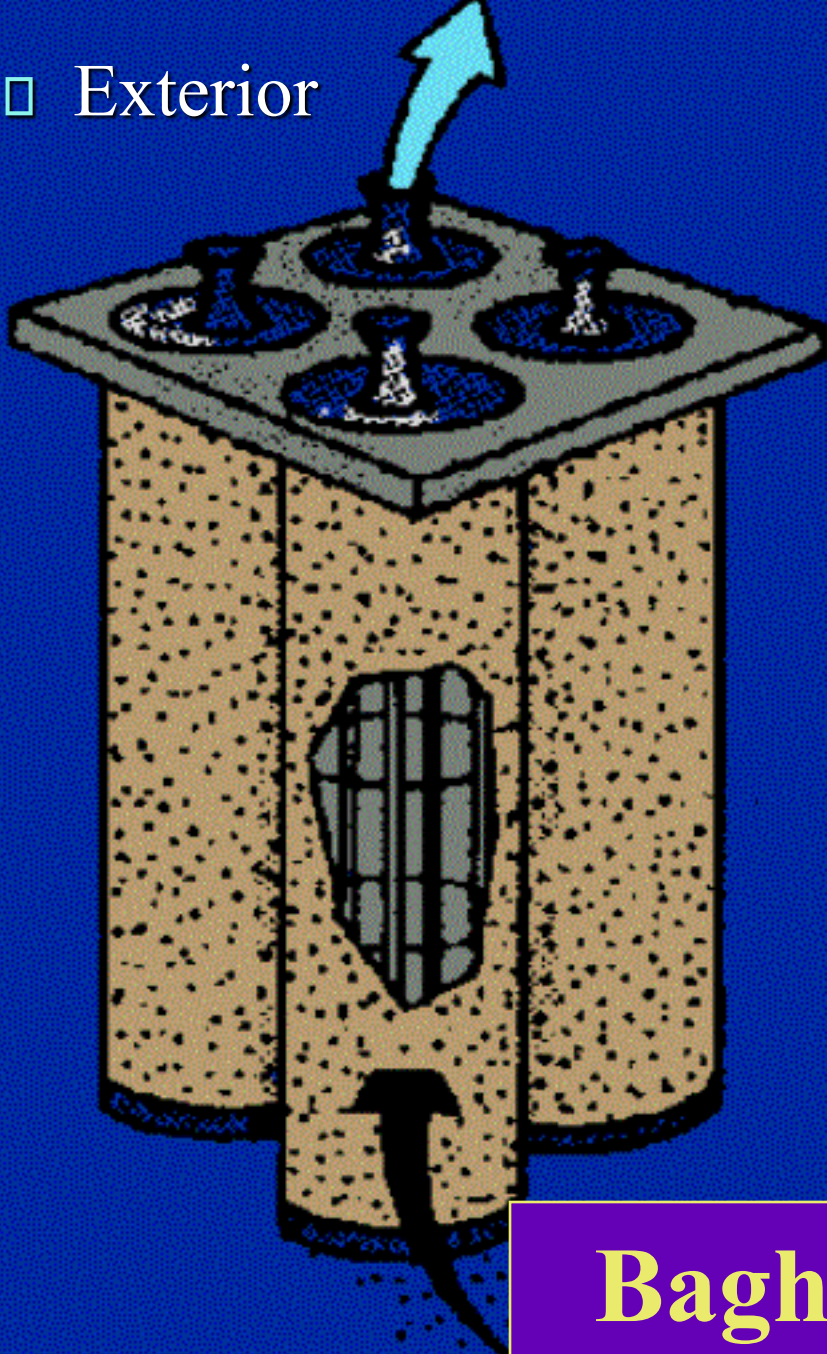
Cyclone Serving a Baghouse



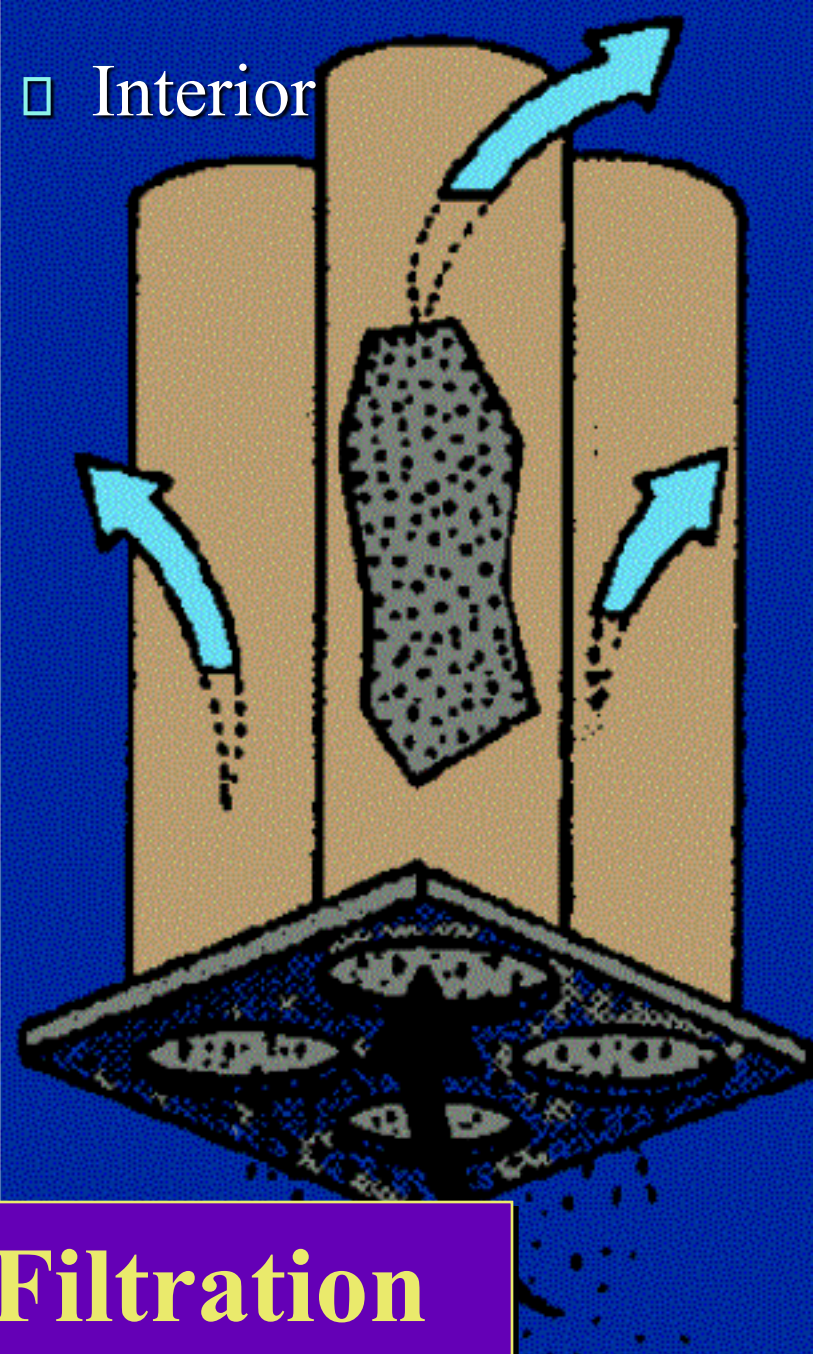
Baghouse



□ Exterior



□ Interior



Baghouse Filtration

Cement Kiln Dust (CKD)

- ❑ **No cement plant in California utilizes hazardous waste fuels under federal Boiler Industrial Furnace regulations**

Legal Requirements

- **Air Pollution Control District**
 - **Authority to construct**
 - **Permit to Operate**
- **Health and Safety Code**
- **U.S. Environmental Protection Agency**
 - **Resources Conservation and Recovery Act**
 - **Maximum Achievable Control Technology**

District – Level

- Authority to construct
- Permit to Operate
- Permit Conditions
- New Source Performance Standards
- Title III
- Title V

NO_x

- 1993 US EPA stated that cement kilns are a stationary source that emit more than 25 tons of NO_x per year
- US EPA recommended low NO_x burners to facilitate stage combustion
- US EPA estimated this would reduce NO_x by 25%

Maximum Achievable Control Technology

- ❑ MACT
- ❑ Three year compliance schedule on controls of dioxins and particulates
- ❑ Dioxin testing required every 2.5 years
- ❑ Particulate testing every 5 years
- ❑ Retesting for dioxins within 90 days of a significant change in raw materials or fuels
- ❑ Written operations and maintenance plan for kiln and all APCD systems
- ❑ Encouraging of particulate matter CEMs

Exemptions

- “Recycled”
- Chemical wastes

Regulations

- Will the cement kilns already burning hazardous wastes have to comply with the adopted regulations?

64CFR 31898 Subpart LLL

- ❑ **Final rule 6/14/99**
- ❑ **Will reduce emissions of air toxics such as arsenic, cadmium, lead, benzene, toluene, dioxin and furans, hexane, and formaldehyde.**
- ❑ **Reduced emissions form toxics approx 31% (90 TPY)**
- ❑ **Reduce emissions of PM 5200 TPY**
- ❑ **Reduce hydrocarbons by 220 TPY**

64CFR 31898 (continued)

- ❑ New test methods for measuring emissions
- ❑ CEMs required for PM
- ❑ Monitoring, record keeping, and reporting requirements.

Monitoring and Control Systems

- Maximum amount of hazardous waste fuel
- Maximum amount of metals from both raw materials and fuels
- Maximum feed rate of raw materials
- Maximum amount of chlorine from raw materials and fuels

How Often Do You Need to Monitor?

- Metals
- Chlorine
- Carbon Monoxide
- Total Hydrocarbons

Upsets

- Partial Blockage of the Kiln
- Fuel Interruptions and/or Power Failures
- Baghouse or ESP Breakdowns

US EPA Levels of Inspection

- Level 1 - Unannounced, drive-by.
- Level 2 - Serve to gather compliance data, identify violations.
- Level 3 - Focuses on a specific problem.
- Level 4 - Baseline data gathering.

40CFR part 60

- Continuous Emission Monitors
- Opacity
- NO_x
- SO_x

Six Points of Inspection

- Capture
- Transport
- Air Mover
- Instrumentation
- Subsystem
- Control Device

Capture



ESP Breakdown



Malfunction



Transport



Where would the emission points be?

- Baghouse stack
- Transfer points
- Material buildup
- Dust piles
- Housekeeping

Transfer Points





Delivery Points

Storage

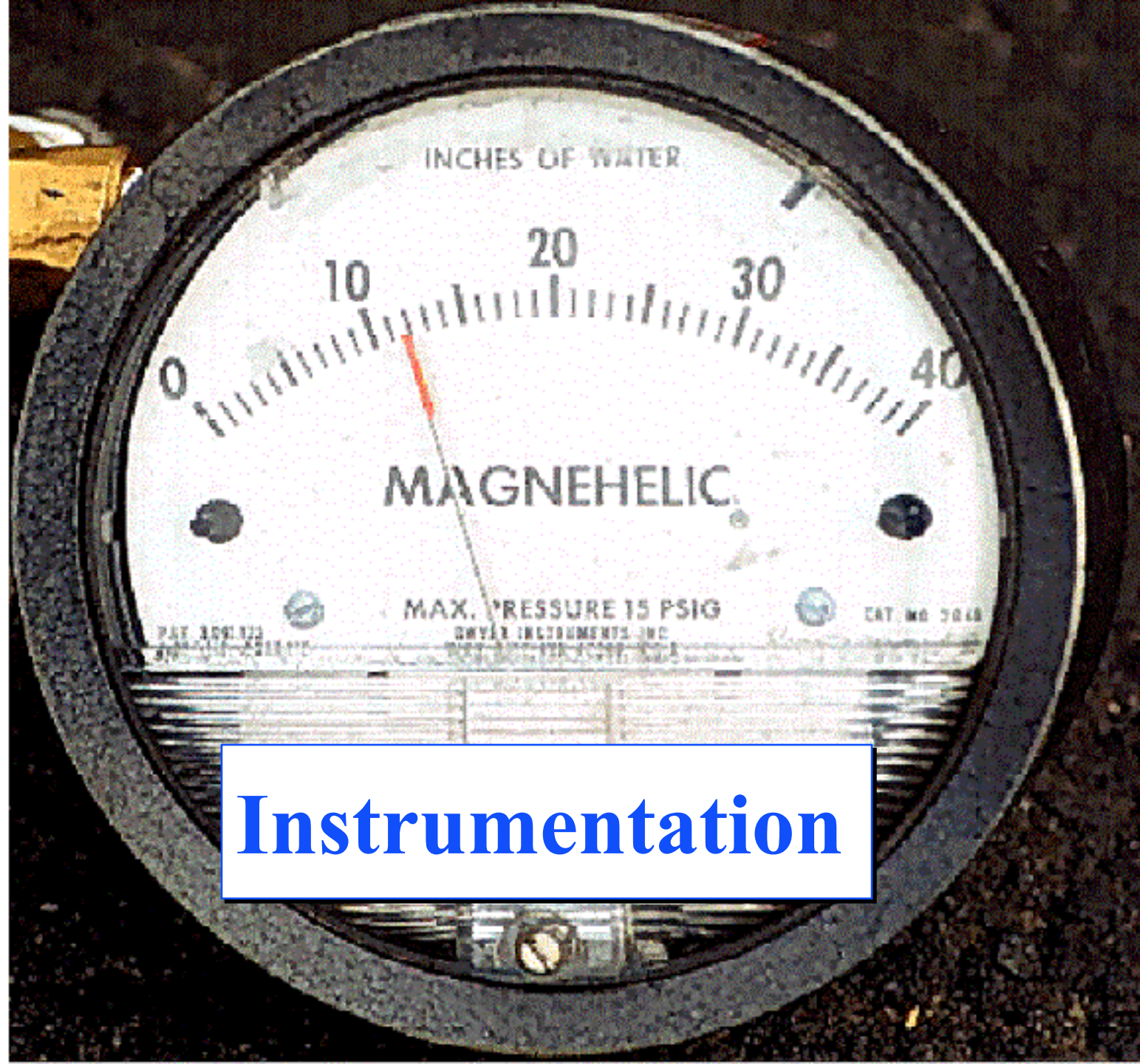


Housekeeping





Air Mover



Instrumentation

Subsystem





Control Device

Inspector Safety

- ❑ Proper Equipment
- ❑ First Aid Kit
- ❑ Safety Procedures of the Plant
- ❑ Hot surfaces
- ❑ Flow Chart
- ❑ Cell Phone (Emergency numbers)
- ❑ Noise

Hazards

- **Cement Kiln Dust**

- **Heat**

- **Caustic**

- **Inhalation**

Heights



Heavy Duty Equipment



A photograph of a speckled horse, likely an Appaloosa, standing in a dirt corral. The horse is white with dark spots and a reddish-brown tail. The corral is enclosed by a metal fence. In the background, there are trees and a cloudy sky. The text "The End" is overlaid in a stylized, light blue font with a black outline.

The End