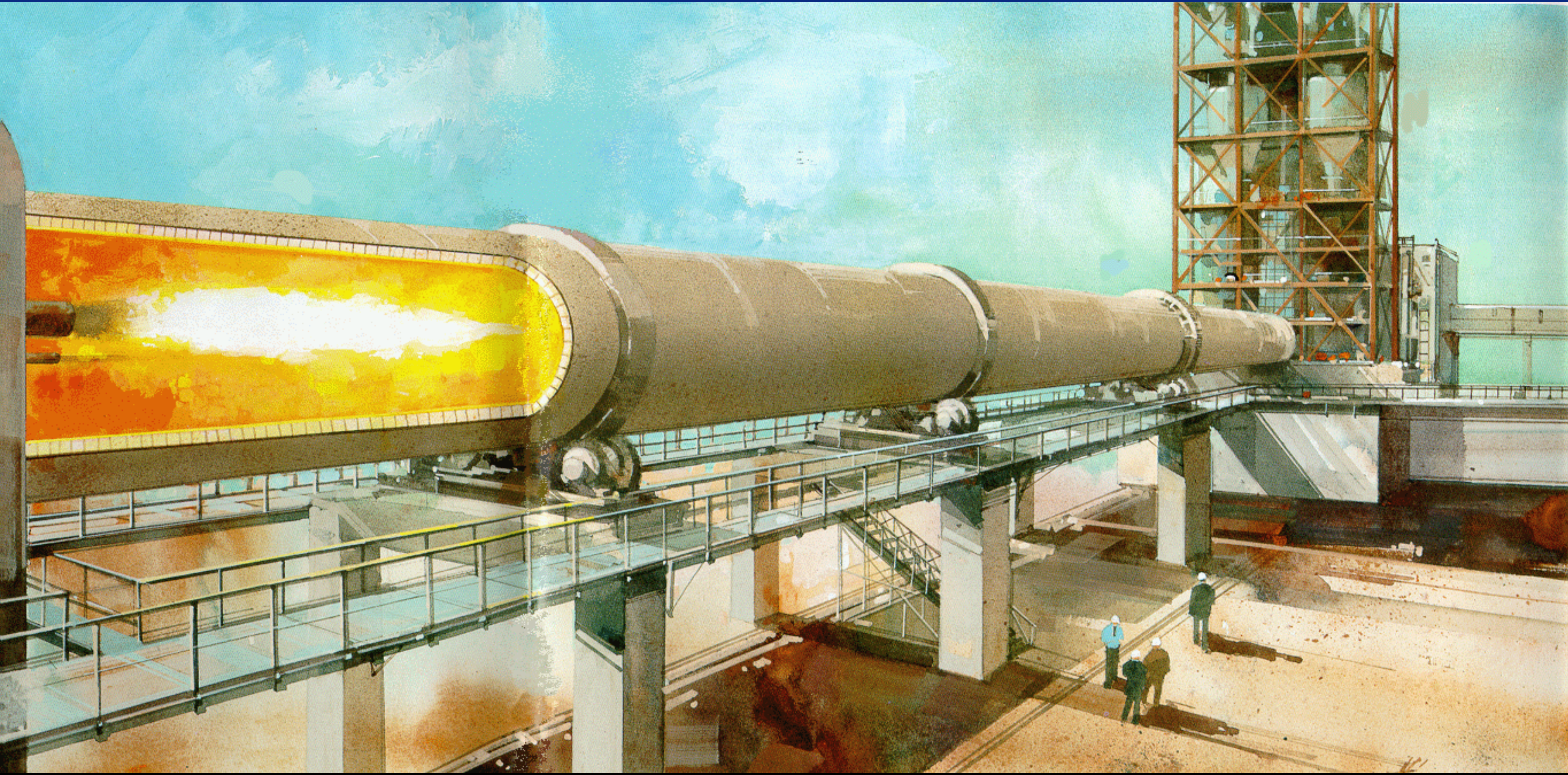
NACT 245
Cement Manufacturing



National Training Program

- Air Pollution Problem

History

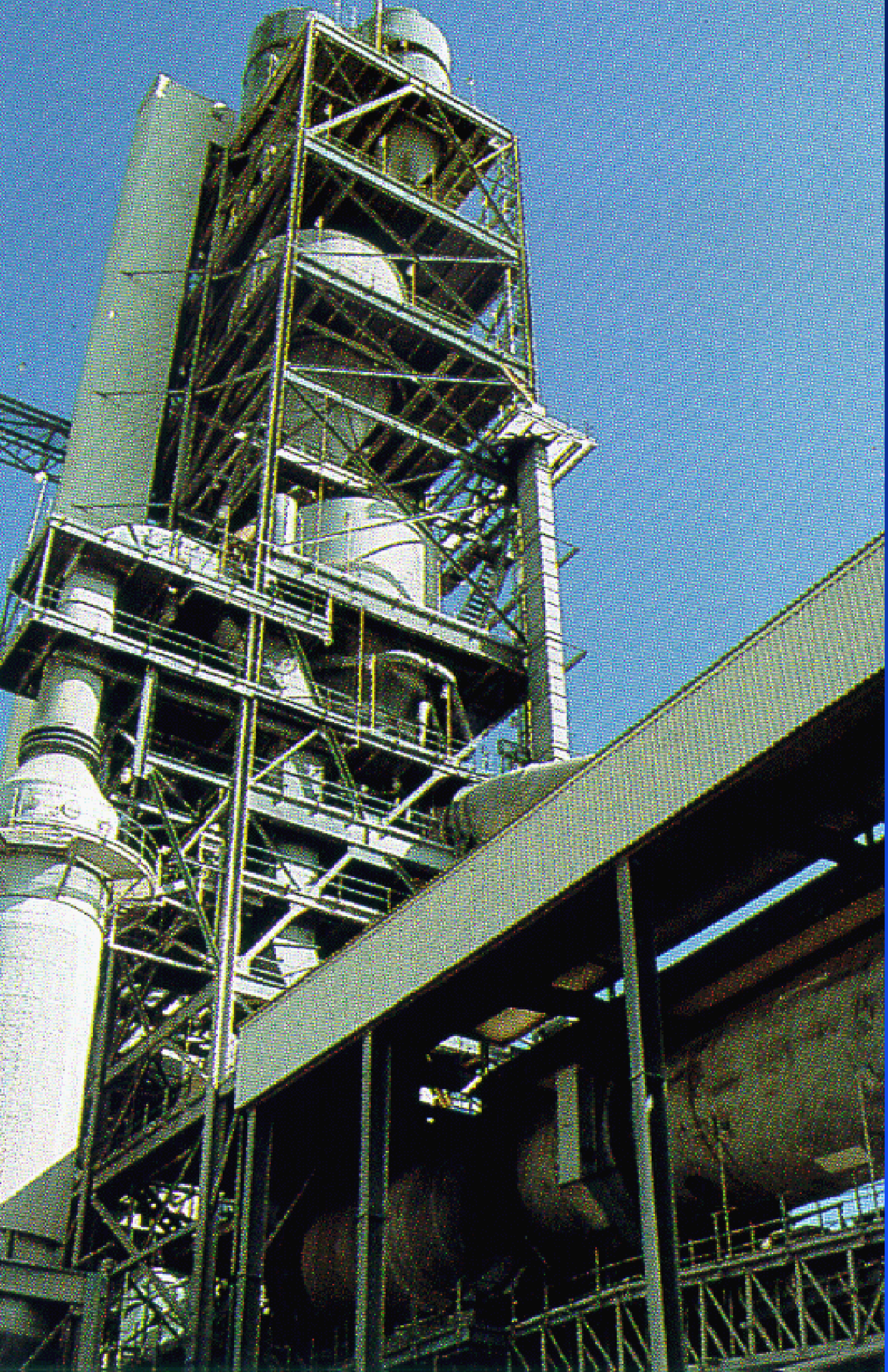
- Assyrians and Babylonians used clay
- Egyptians used lime and gypsum
- Greeks used natural cement
- Romans used slaked lime, pozzolana (volcanic ash)
- Joseph Aspdin, Leeds UK, developed Portland Cement

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

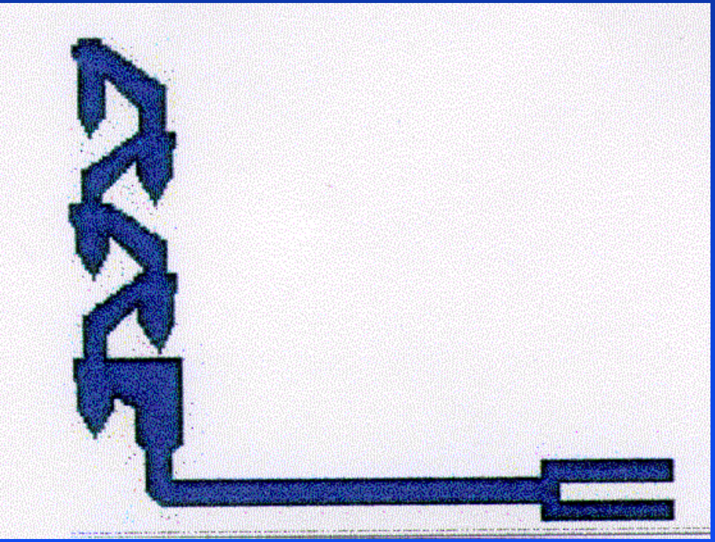
Types of Cement Kilns

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

Greenhouse Gas CO_2

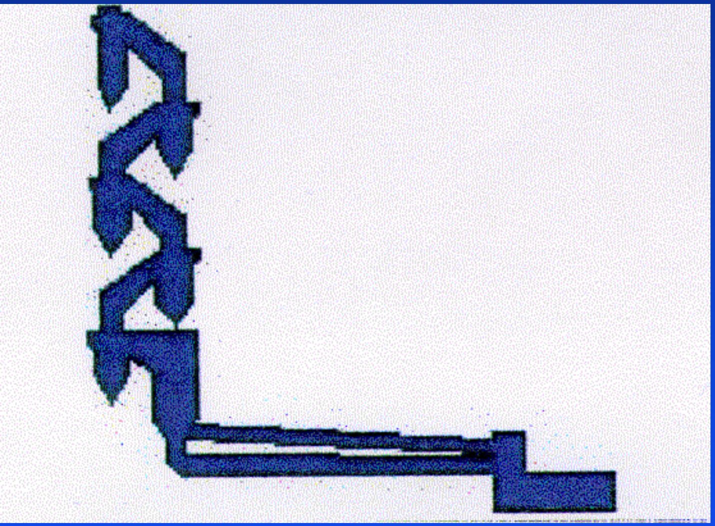
- 1997 Approximately 100 million tons of CO_2 emissions from cement kilns

Types of Calciner Towers



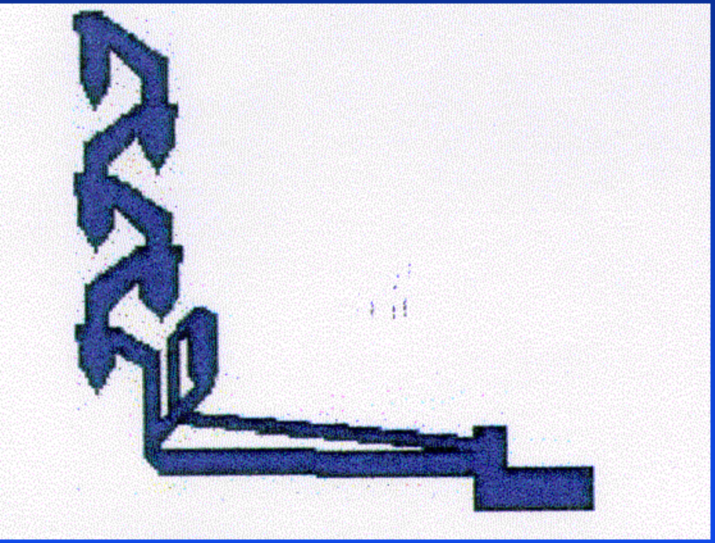
- ILC-E In-Line Calciner Using Excess Air
- Single string cyclone preheater kiln with a small precalciner built into the kiln riser duct.
- Combustion air for the precalciner is drawn through the kiln

Types of Calciner Towers



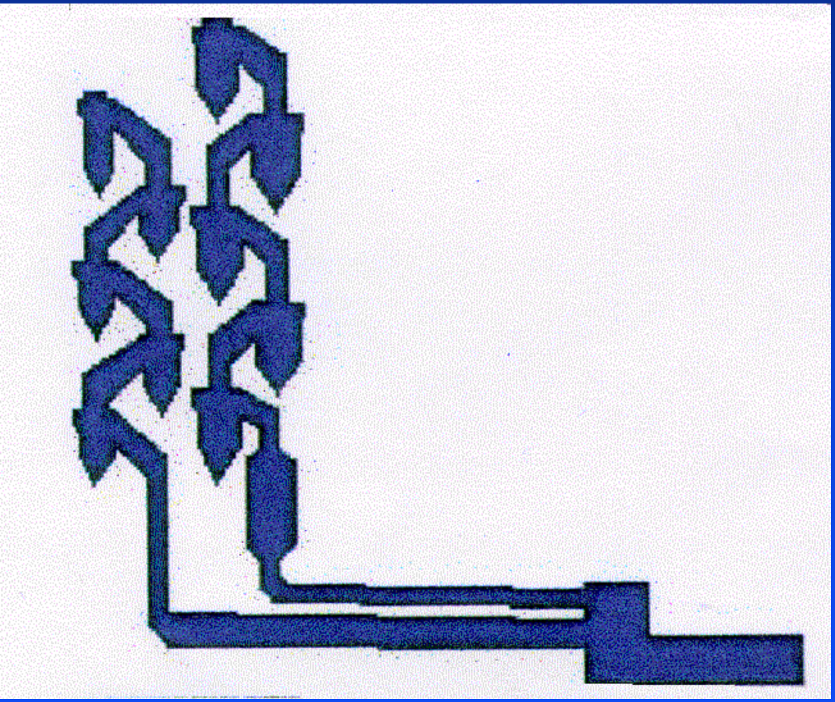
- ILC^{TM}: In-Line Calciner
- Single-string or double-string cyclone pre-heated kiln with precalciner built into the kiln riser duct. Combustion air for the prcalciner is drawn through a separate tertiary air duct between the cooler and the calciner.

Types of Calciner Towers



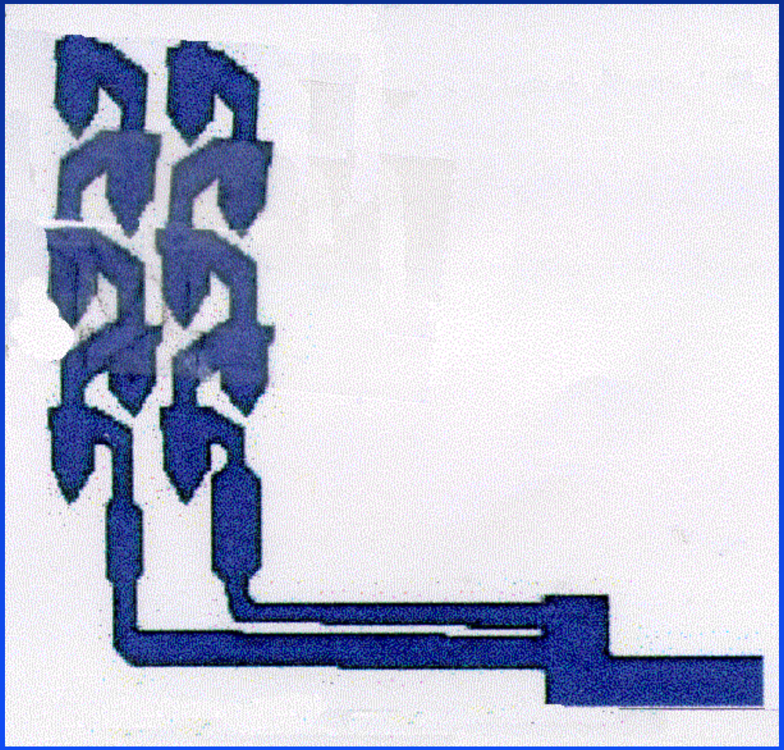
- SLC-D:Separate-Line Calciner-Downdraft
- Single-string or double-string cyclone preheater kiln with a combustion chamber/precalciner placed parallel to the riser duct.

Types of Calciner Towers



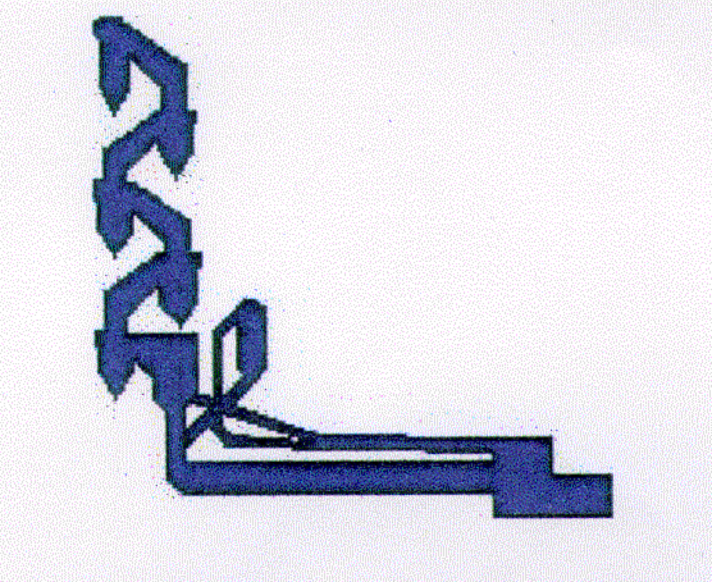
- SLC- Separate-Line Calciner
- Double-string or triple-string cyclone preheater kiln with a precalciner placed parallel to the kiln riser duct

Types of Calciner Towers



- SLC-I^{TM}: 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_X™: 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

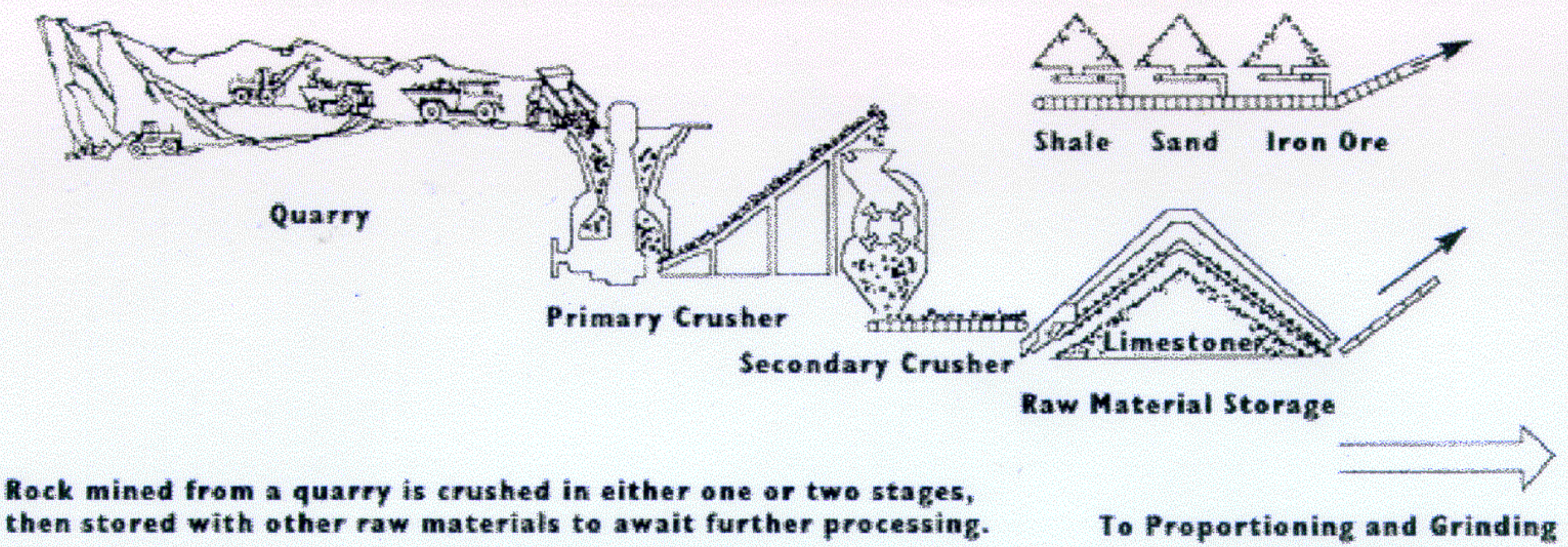
- Originally produced by the Romans
- Hydrated lime and finely ground volcanic materials containing aluminum, silicon, sodium, and potassium
- Named for a town in Italy, Pozzolana
- Requires two raw material components: Calcinate limestone and finely ground Pozzolana

Raw Materials

- Calcium
- Silicon
- Aluminum
- Iron

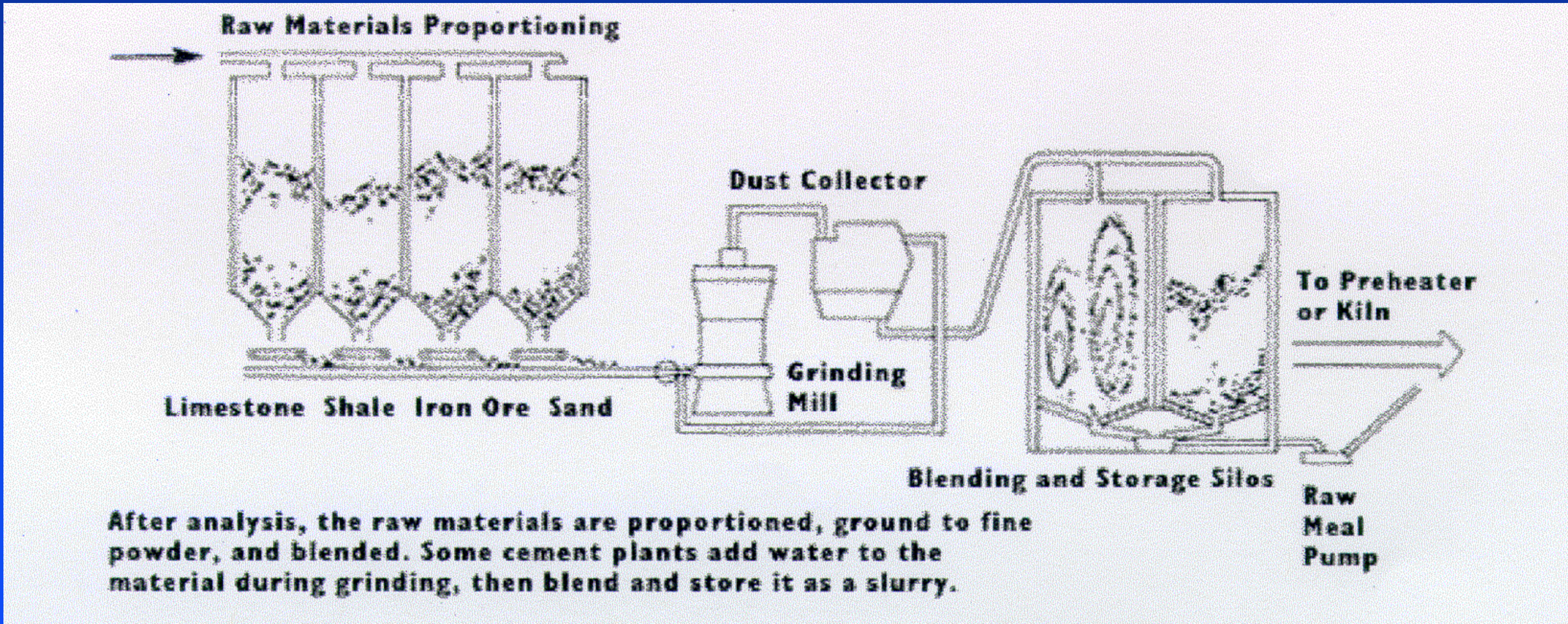
Raw Materials

Raw Material Process

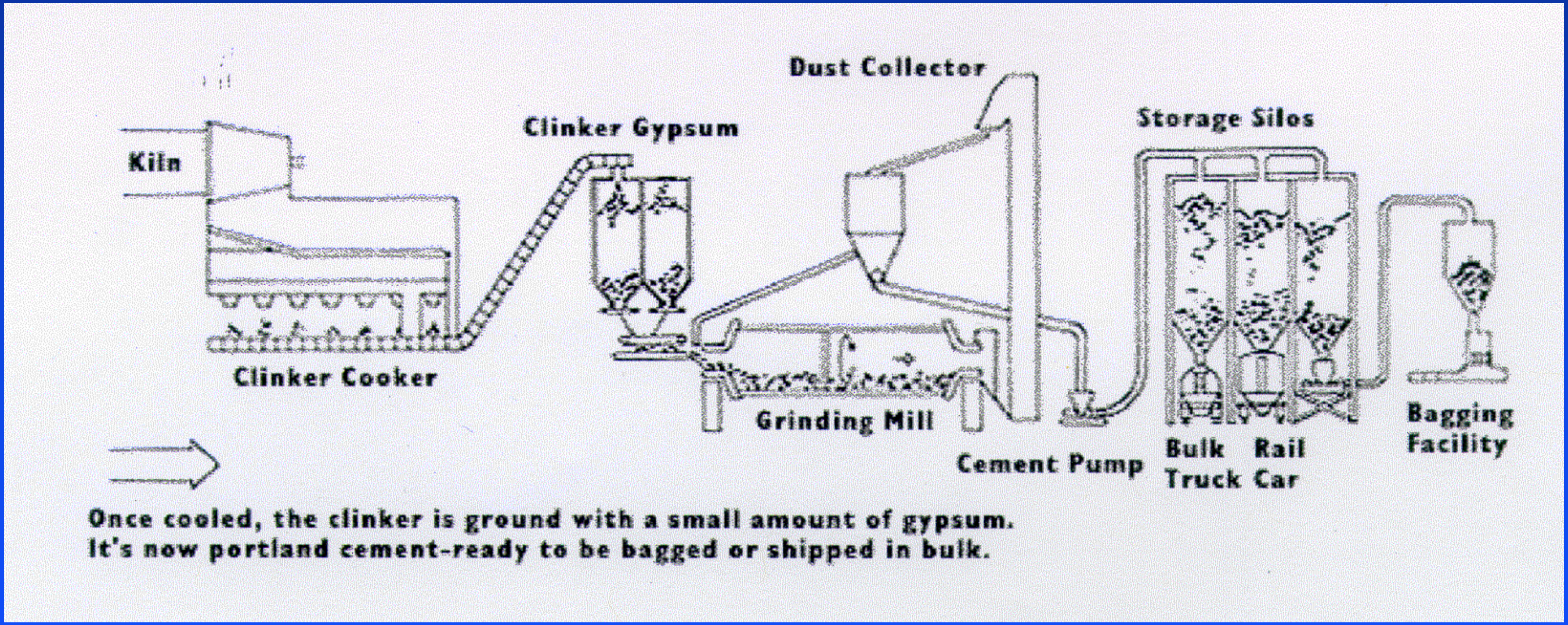


Rock mined from a quarry is crushed in either one or two stages, then stored with other raw materials to await further processing.

Raw Material Proportioning



Clinker Process



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

- $CaSO_4.2H_2O$
- 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

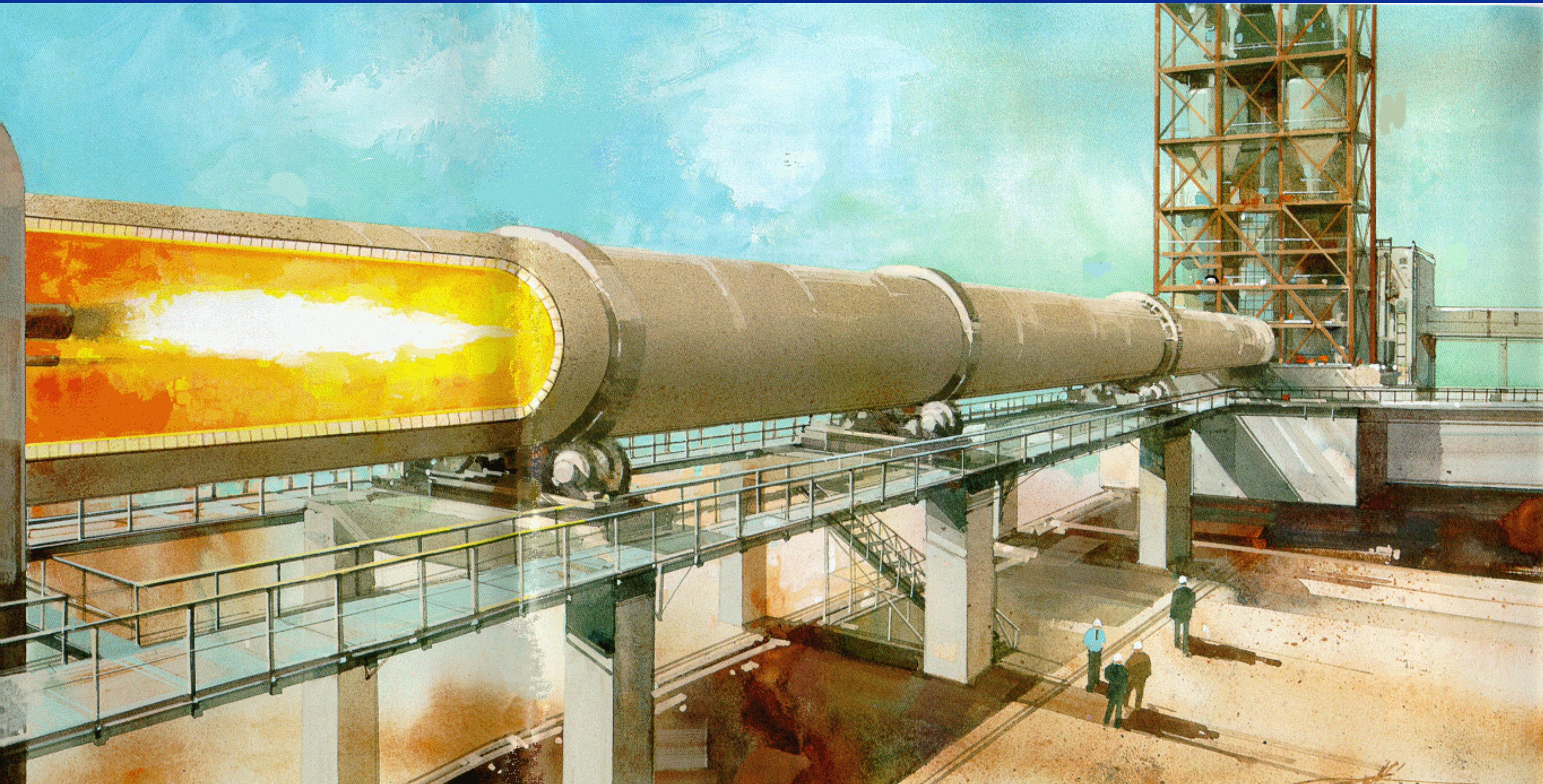
Radial Stacker

Pyro-processing

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

Calciner Towers

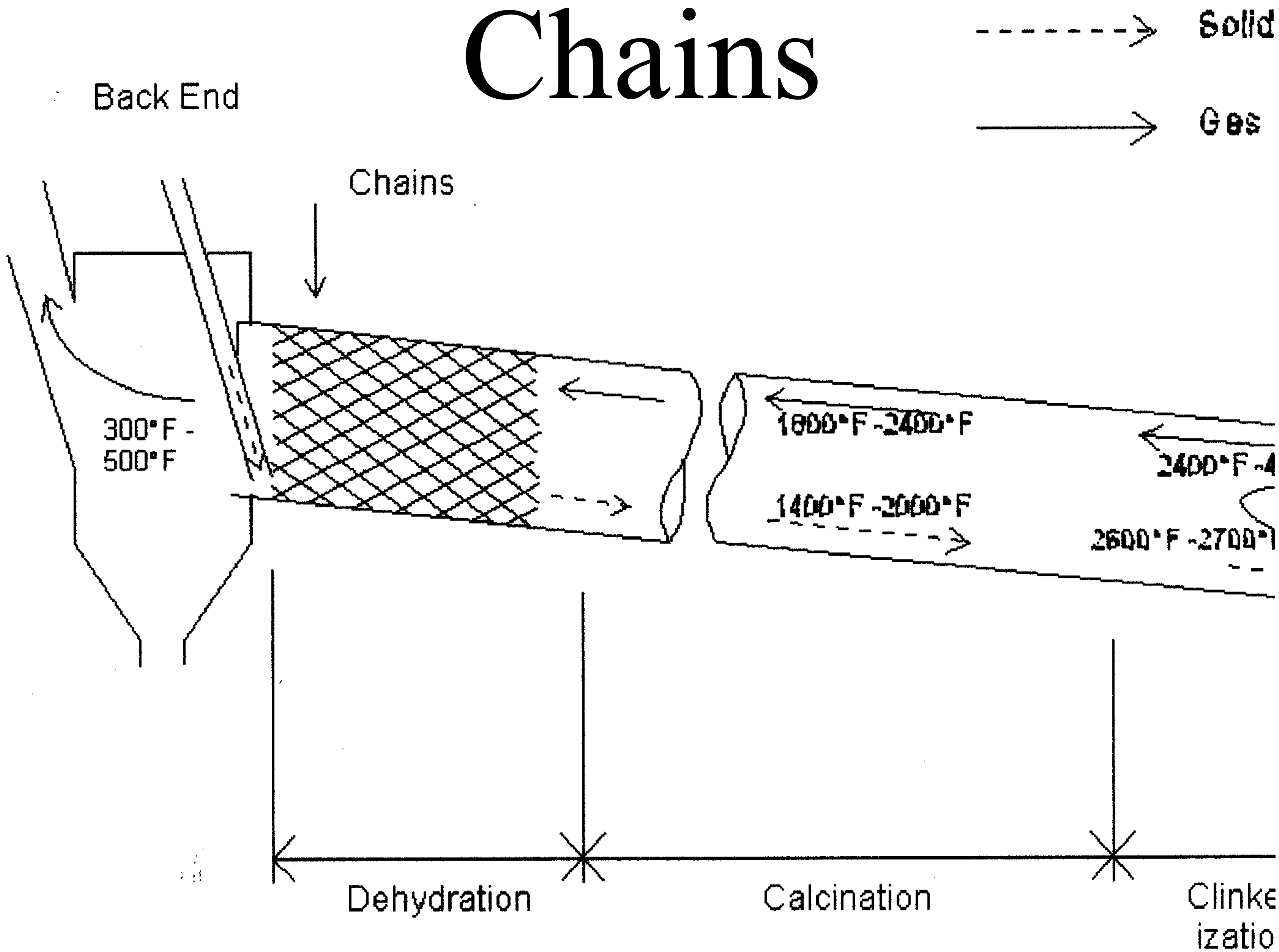
Conversion by Fire



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 ^oF
Calcining	1,480-2,192^oF
Upper-transition	2,192-2,552^oF
Sintering	2,552-2,750^oF
Cooling (lower transition)	2,750-2,350^oF

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

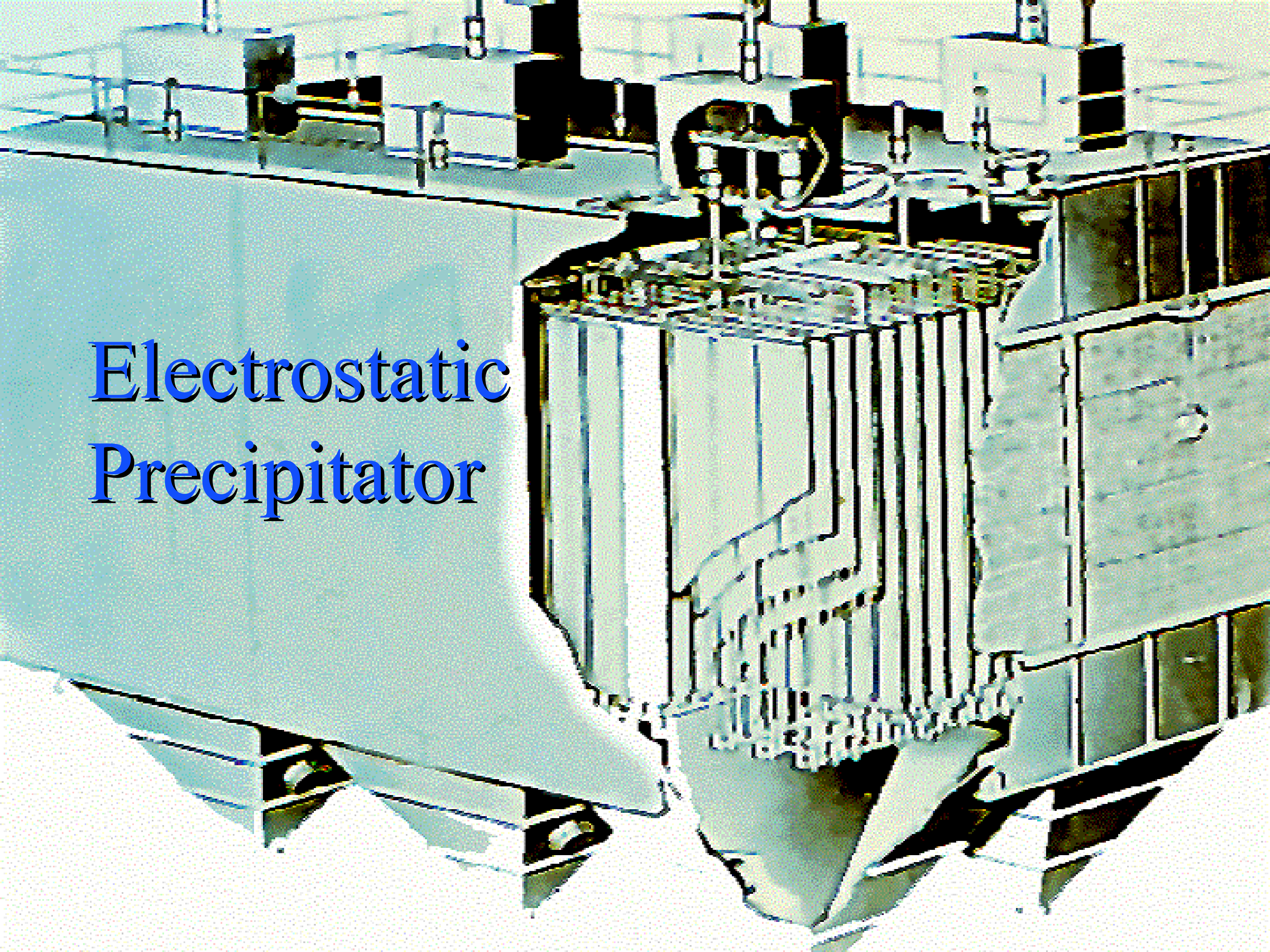
Mercury

- 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?

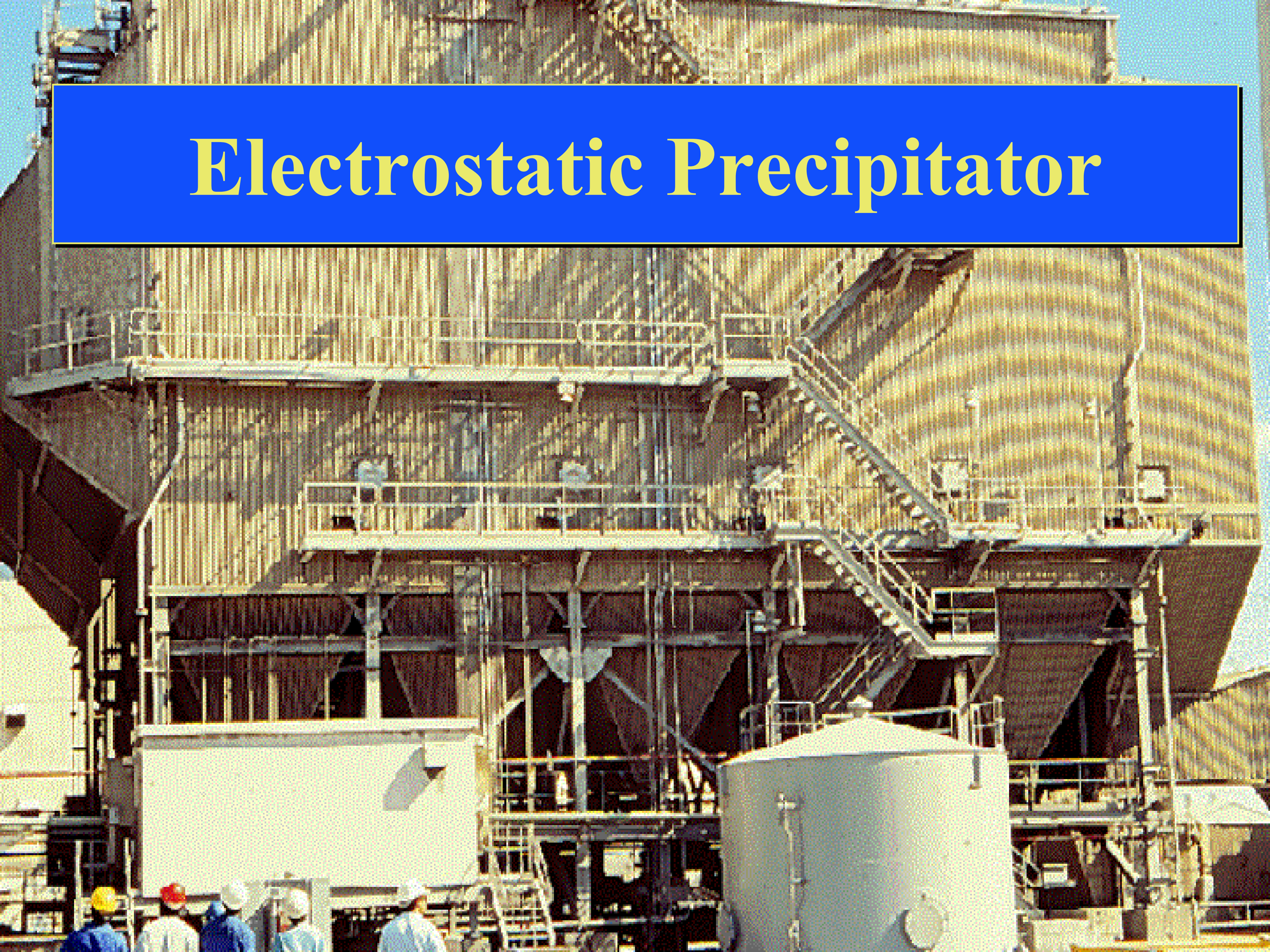
- Electrostatic Precipitators
- Baghouses

Electrostatic Precipitator



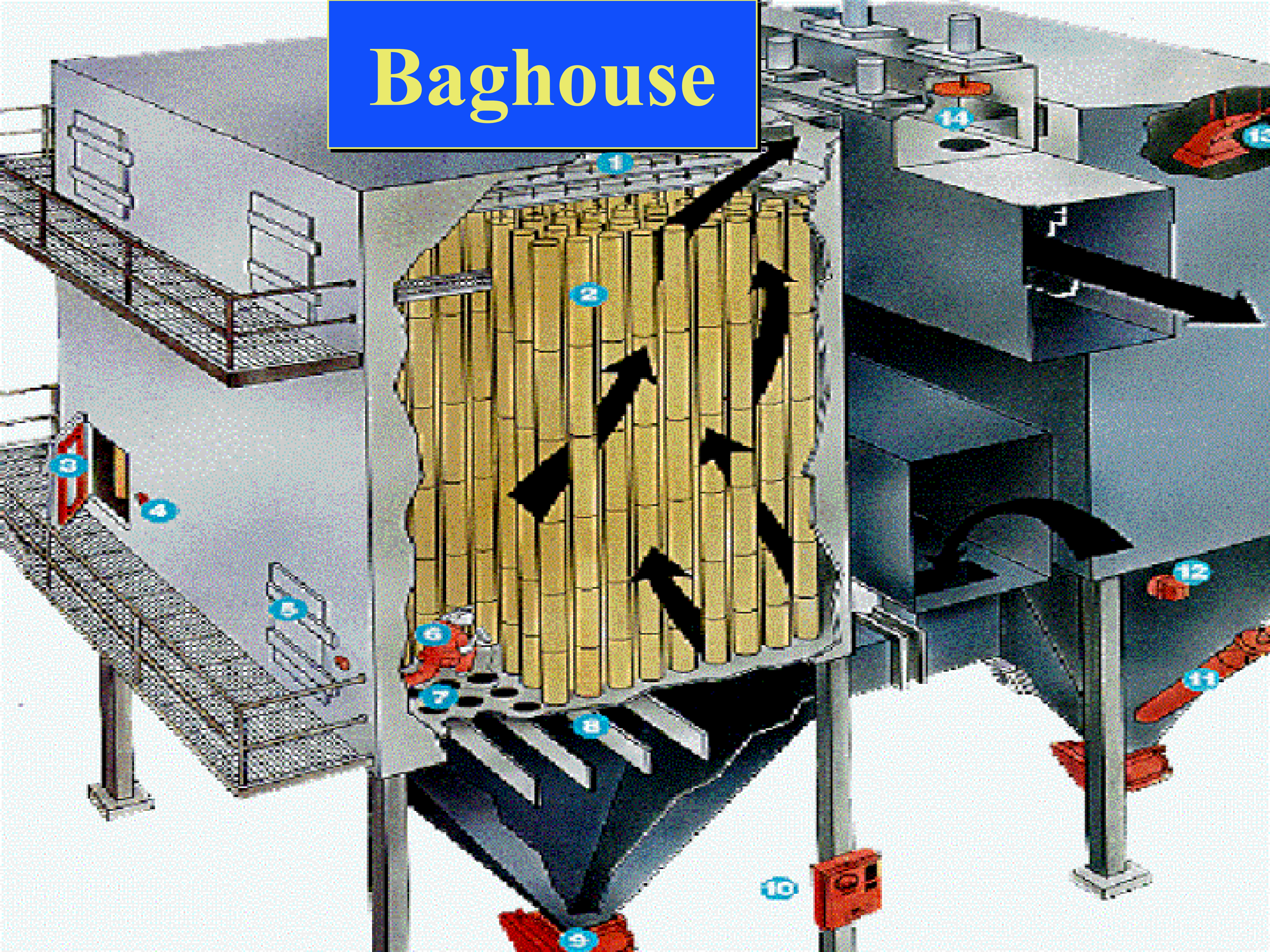
Electrostatic Precipitator Hopper

Electrostatic Precipitator

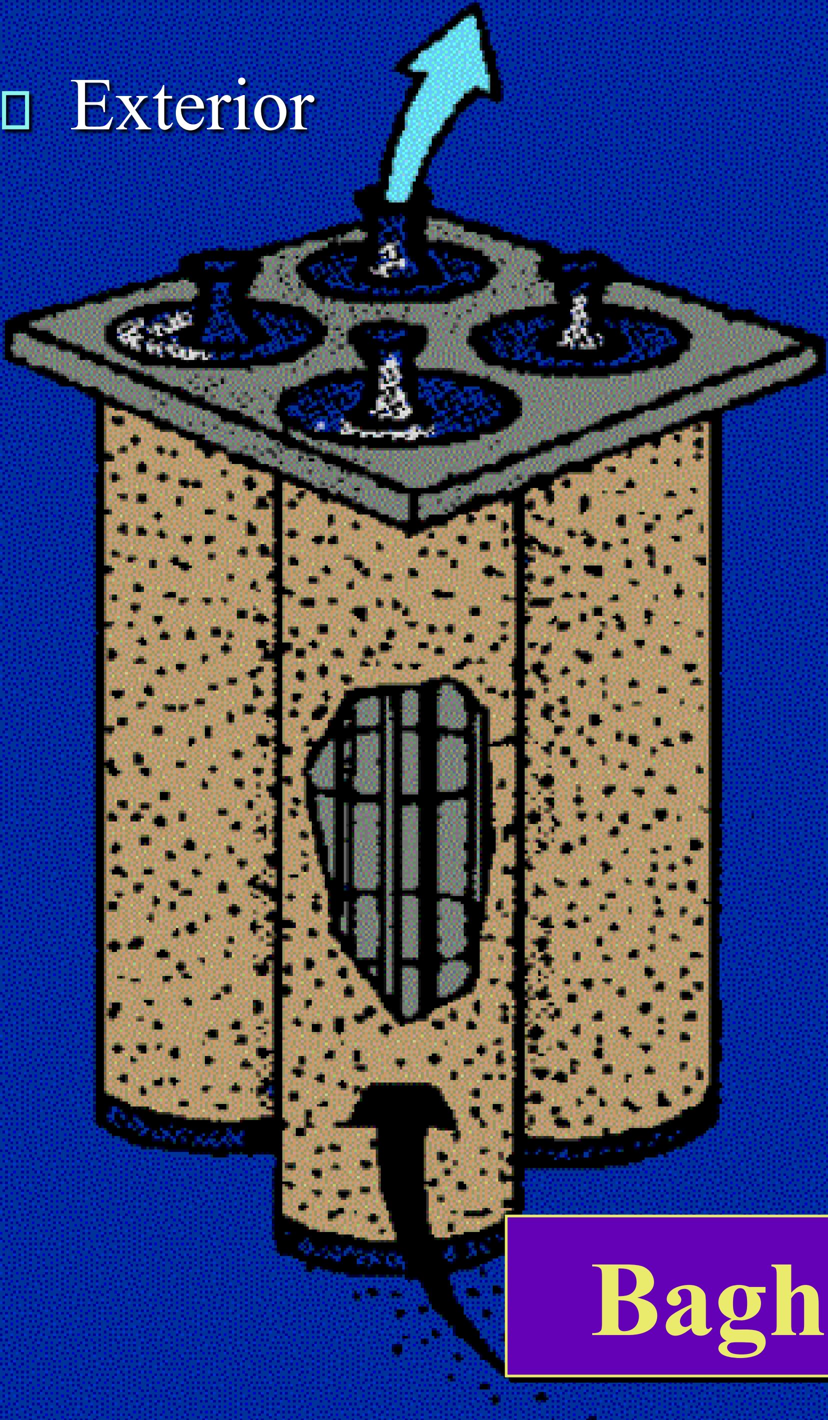


Cyclone Serving a Baghouse

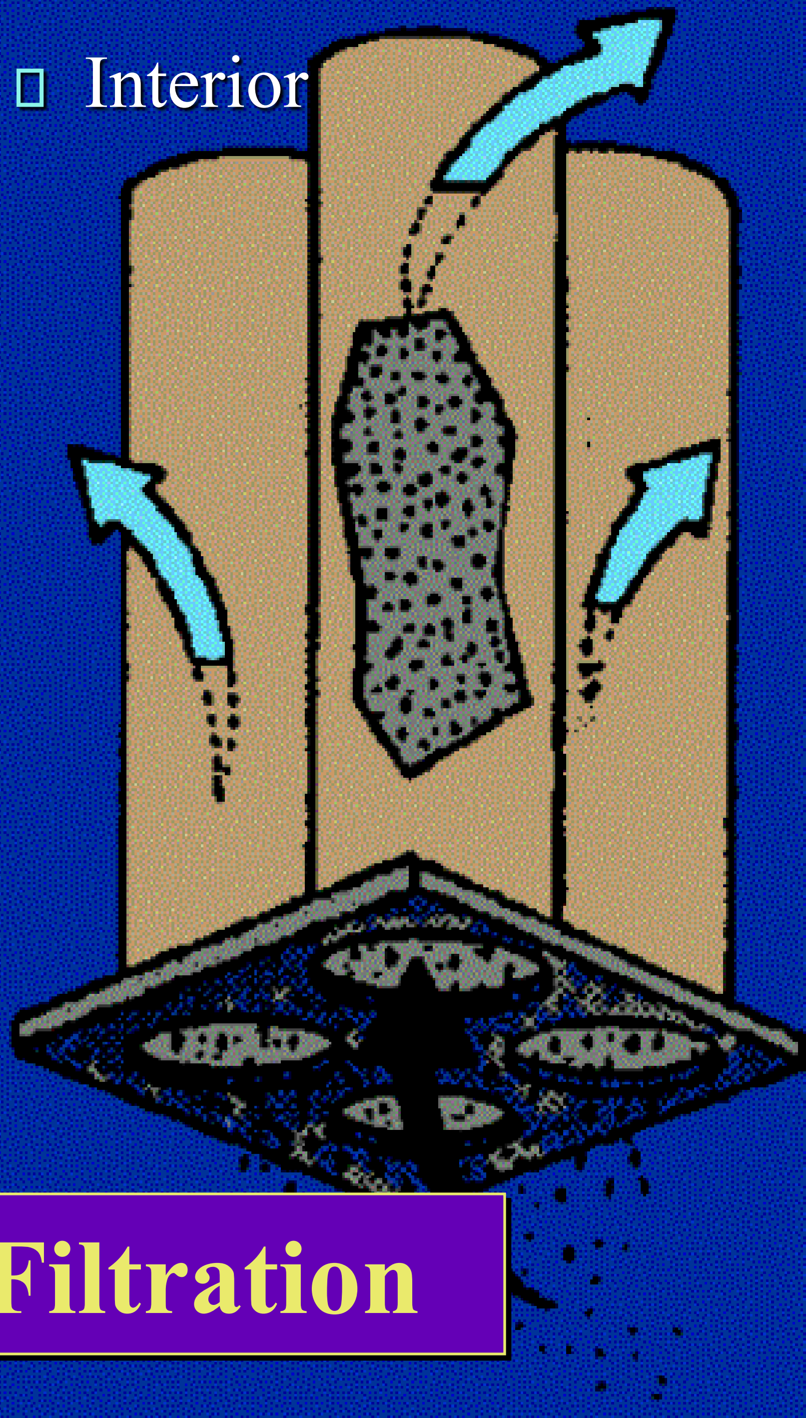
Baghouse



- 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

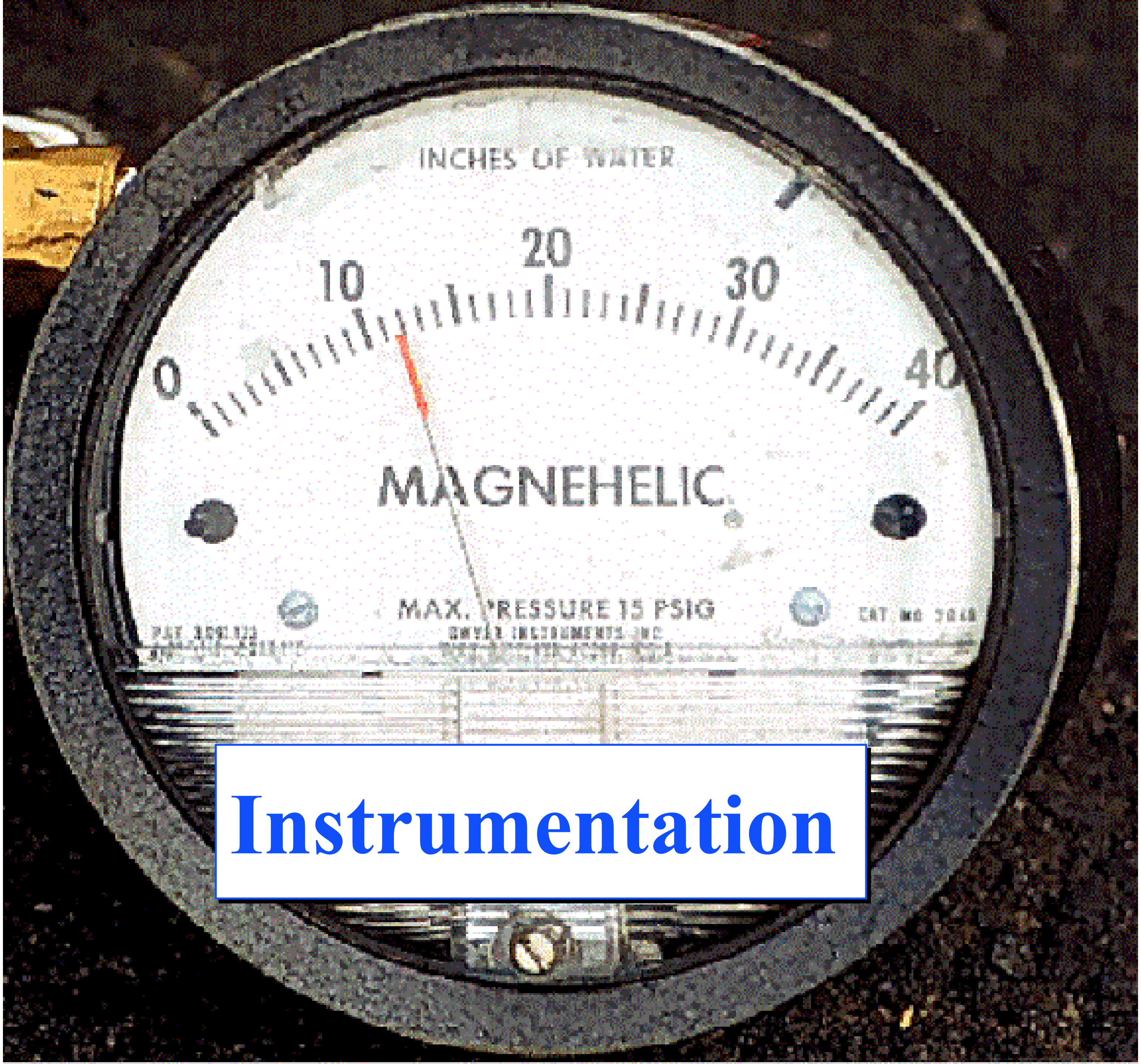
Transfer Points

Delivery Points

Storage

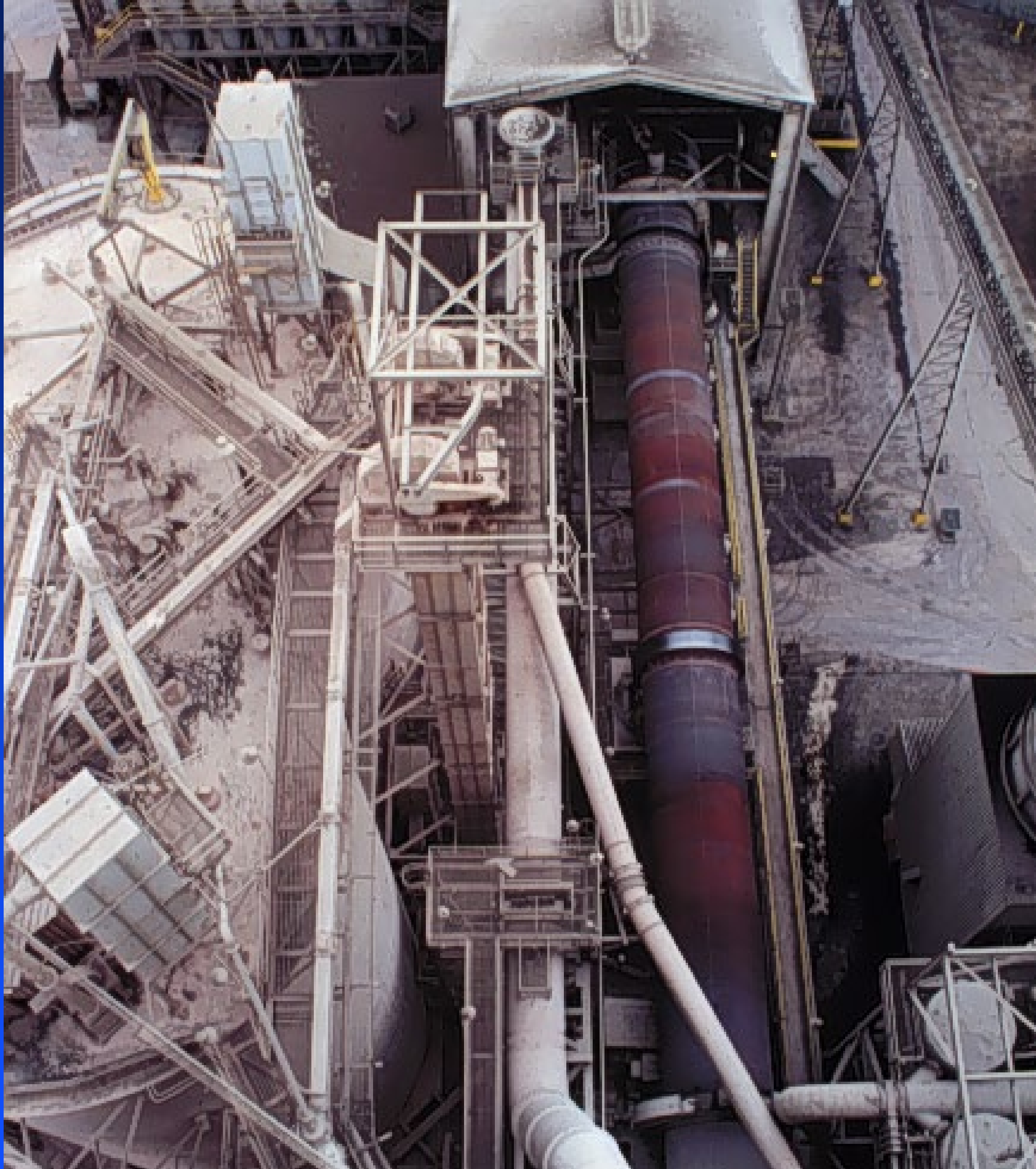
Housekeeping

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


The End