Science and Technology of one of the first Nanomaterials – Carbon Black

Presented by
Dr. Wesley Wampler
Tokai Carbon

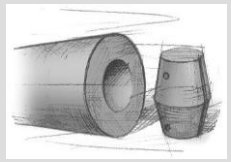
Tokai Carbon Group Basic Philosophy

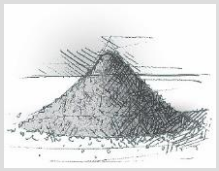
Tokai Carbon Group continues to pursue our basic philosophy of Ties of Reliability through our core business activities in the manufacturing industry, mainly carbon materials, in accordance with the five guidelines.

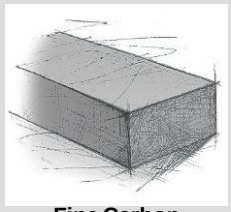
Corporate Philosophy
Ties of Reliability

Guidelines
Integrity, Innovation, Challenge, Co-creation, Agility

Core Strategies
Stable supply, Technical expertise, Long-term relationships


Graphite Electrodes


Carbon Black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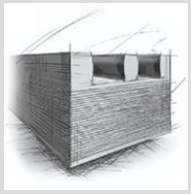
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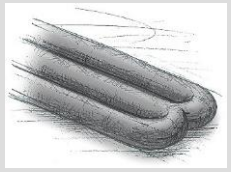
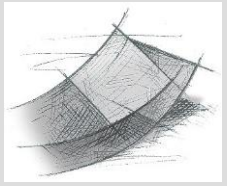
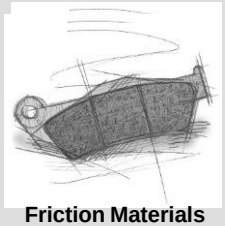
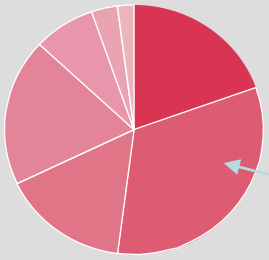

Industrial Furnaces and Related Products


Anode Materials


Friction Materials



Carbon Black 32%

Tokai Carbon

(Global Production Locations – Carbon Black)

- 8 production plants
- 937KT annual capacity
- 5th largest player in the global carbon black market

Carbon Black

- Produced by the incomplete combustion of hydrocarbons (insufficient oxygen for complete combustion)

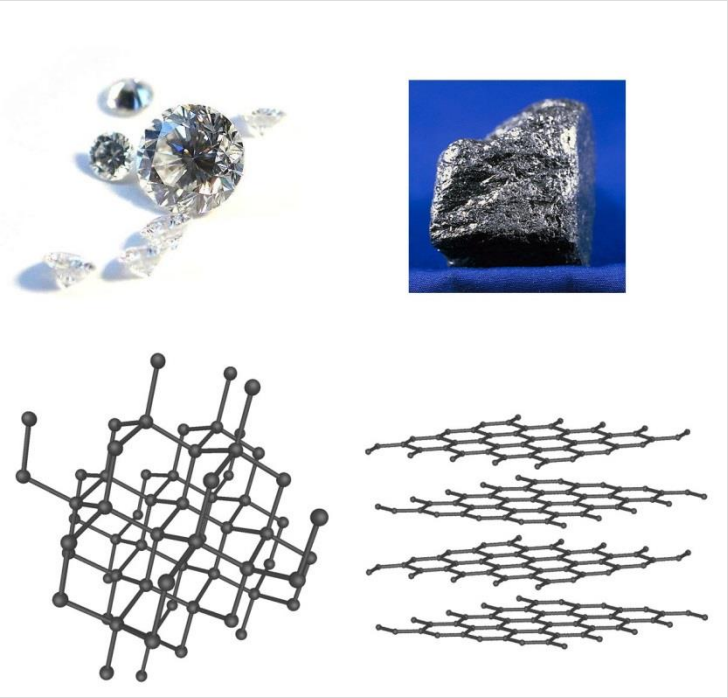
Acetylene Torch

Candle + Spoon

Carbon Black

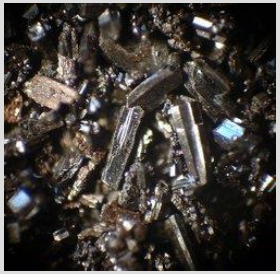
- Produced by the incomplete combustion of hydrocarbons
  - $C_mH_n + yO_2 \longrightarrow 2yCO + n/2H_2 + (m-2y)O_2$
  - Solid carbon formed when $m > 2y$
- Historical evidence that it was used as colorant by Chinese in 3rd century A.D.
- Large scale industrial production started in early 1900s after discovery of its reinforcing potential in rubber

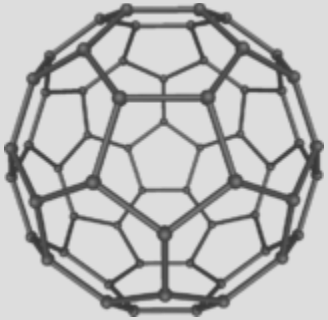
Allotropic Forms of Carbon



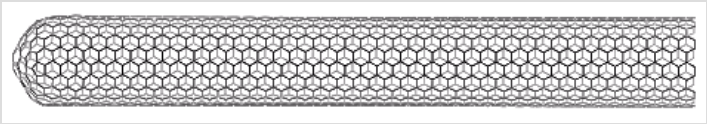
Structure of Diamond

Structure of Graphite

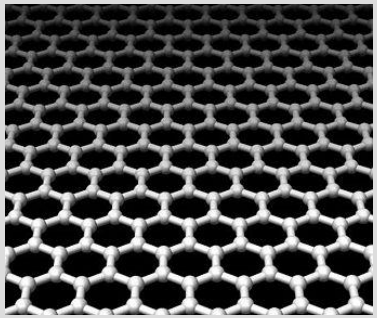




Structure of Fullerene



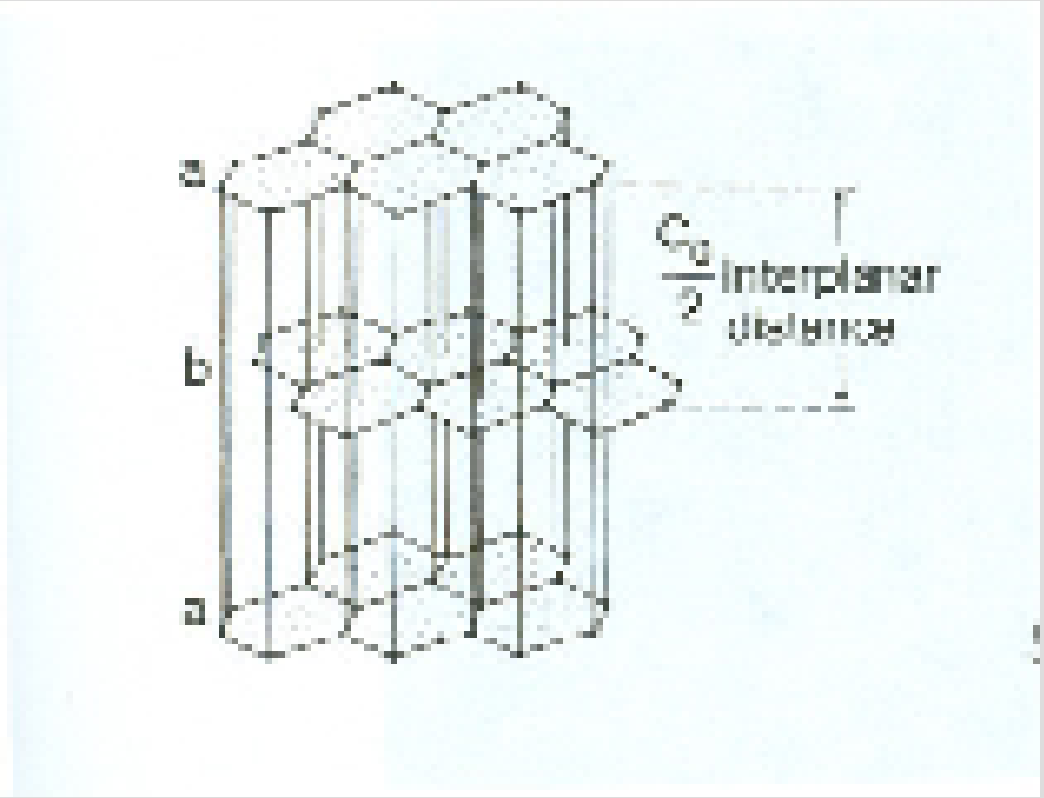
Structure of Nanotubes



Graphene

Structural element of graphite, nanotubes and fullerenes

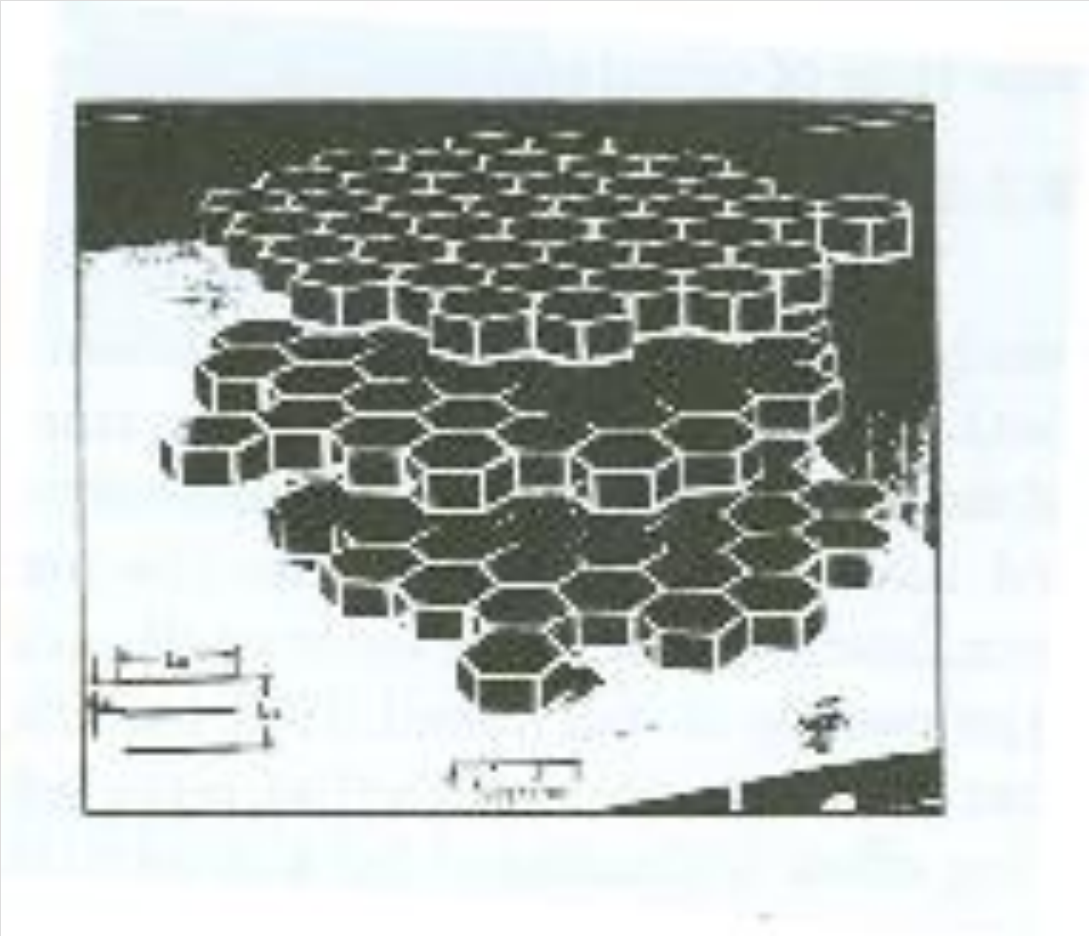
Graphite



Every other layer aligned. X-ray diffraction only shows three dimensionsal reflections (00*l*) reflections.

The d spacing, i.e. spacing between layers, is 0.335 nm

Carbon Black

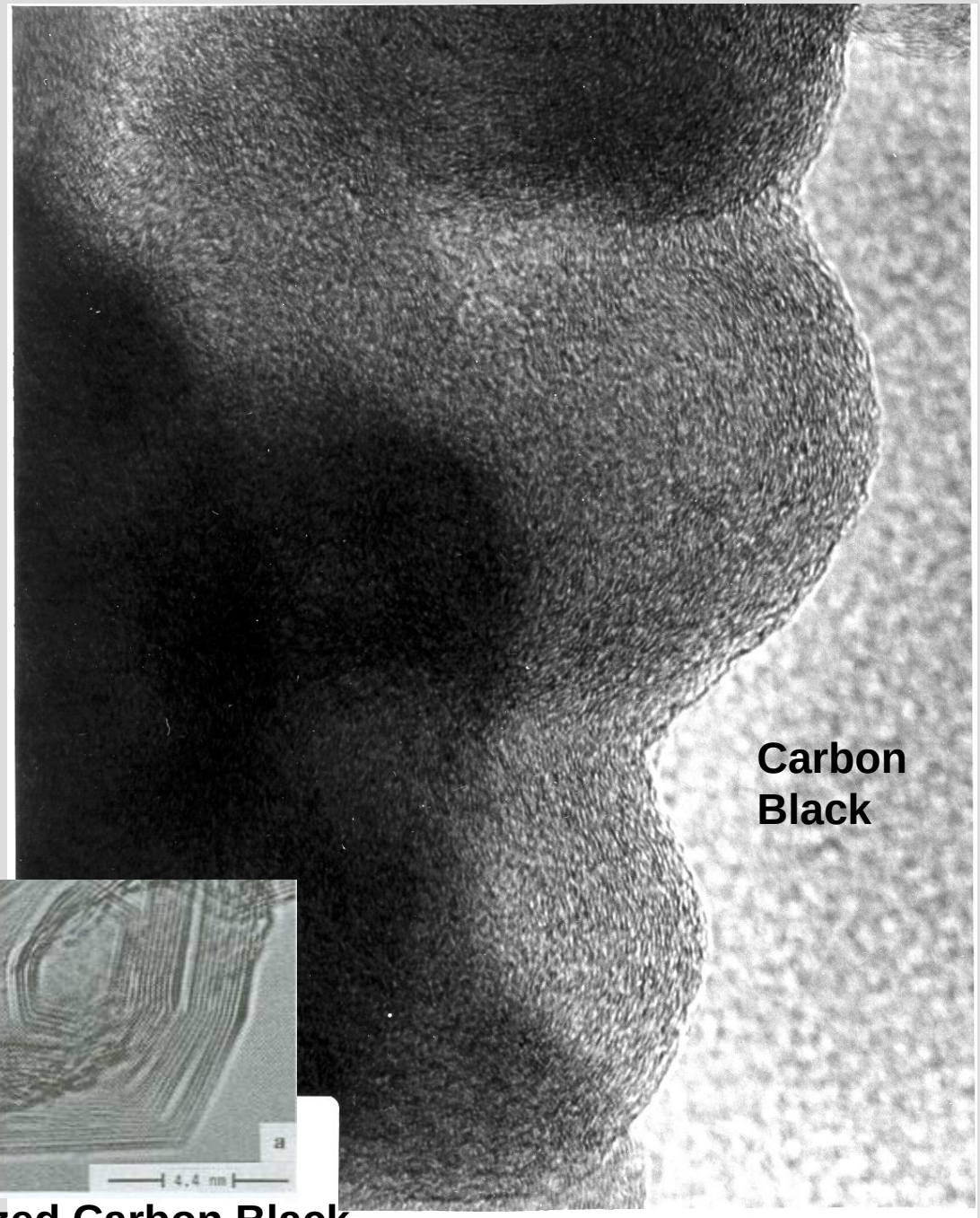


X-ray diffraction shows both three dimensional (00*l*) and two dimensional (*hk*) reflections – a type of structure known as turbostratic

Turbostratic – layers are parallel but rotated around c-axis

High Resolution Electron Micrograph of Carbon Black

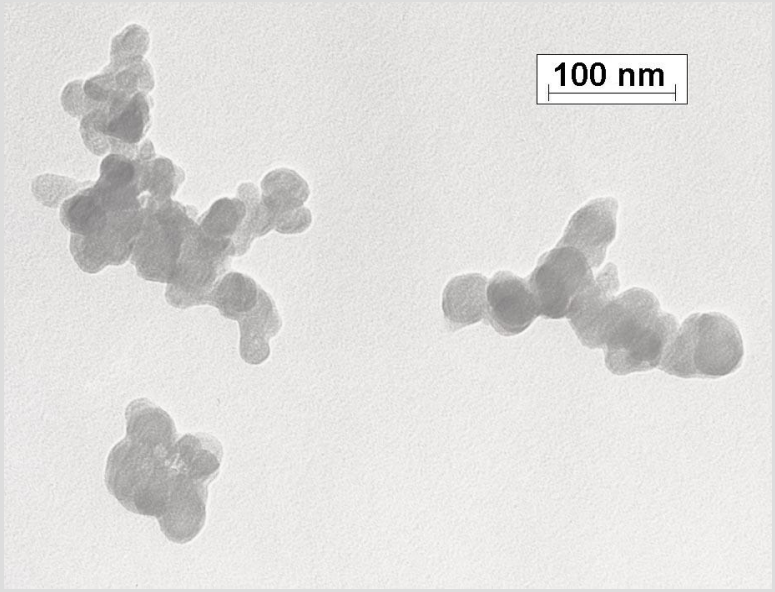
Turbostratic structure evident in carbon black

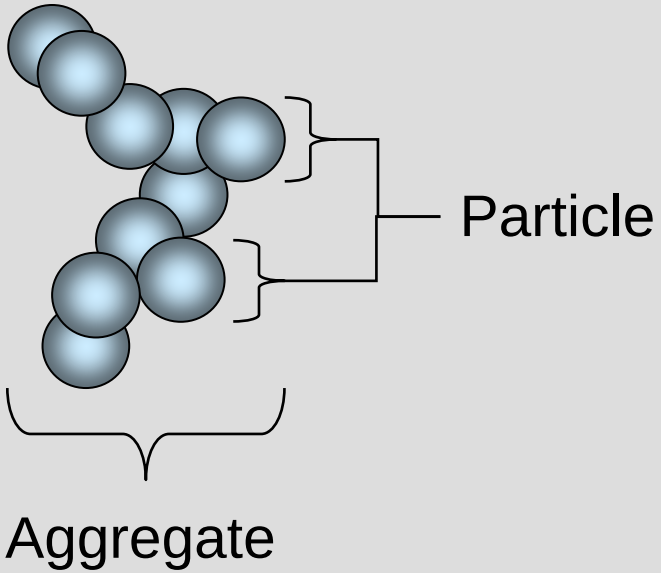


Graphitized Carbon Black

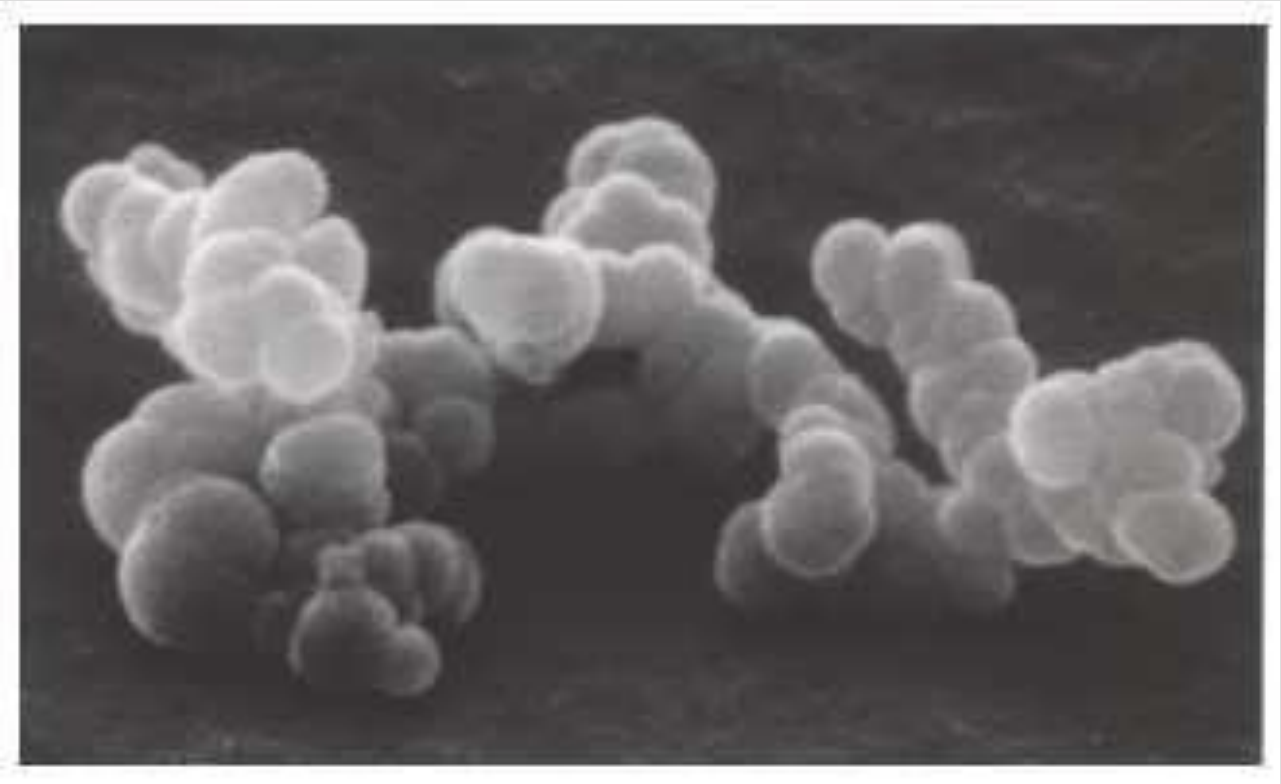
Model cutaway of single carbon black particle

Transmission Electron Micrograph of Carbon Black



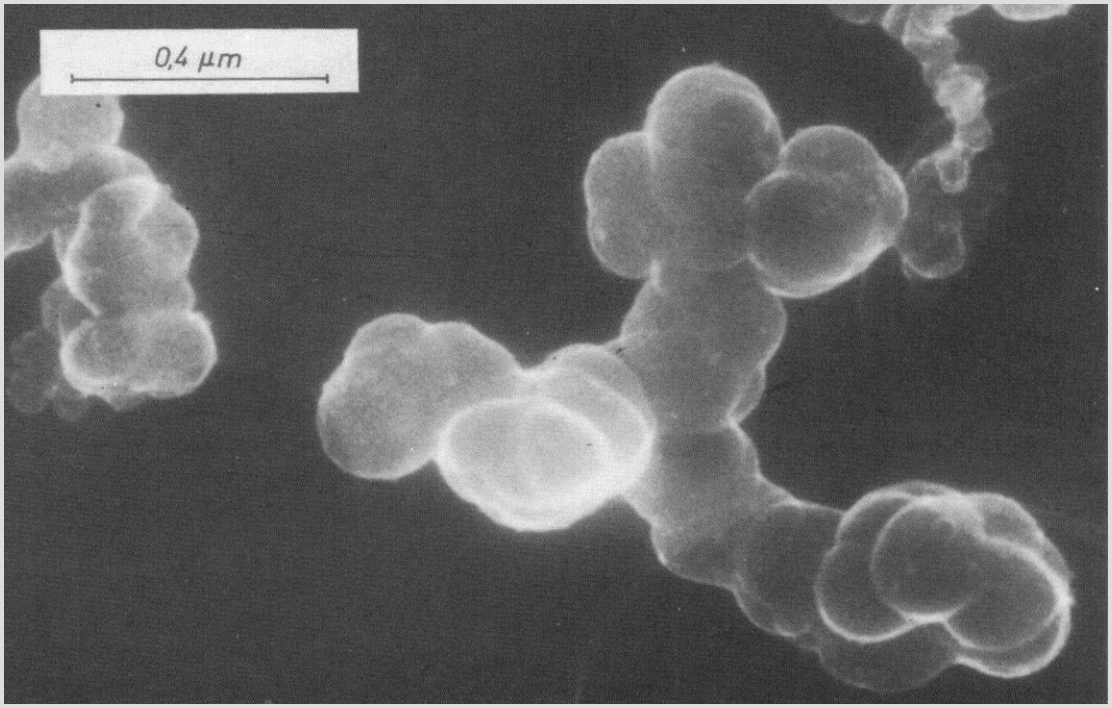


Scanning Electron Micrograph of Carbon Black Aggregate



Carbon Black – Tremendous Specific **Surface Area**

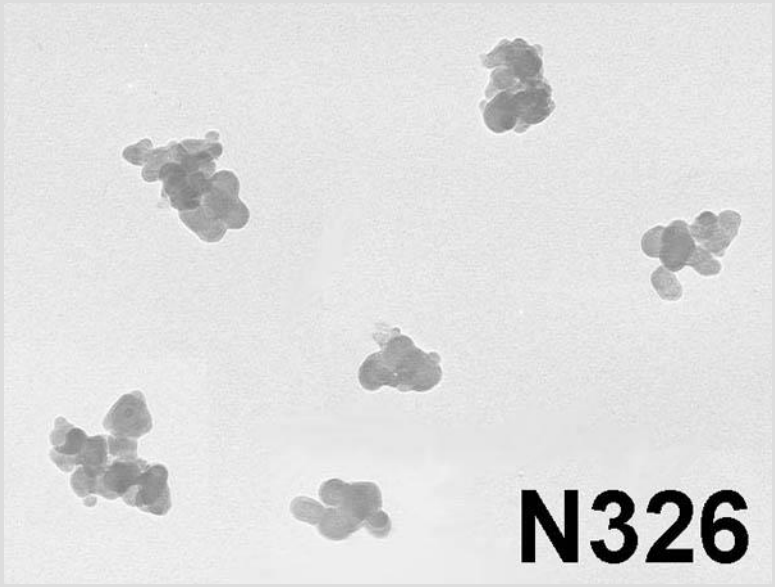
50 – 1000 m^2/g



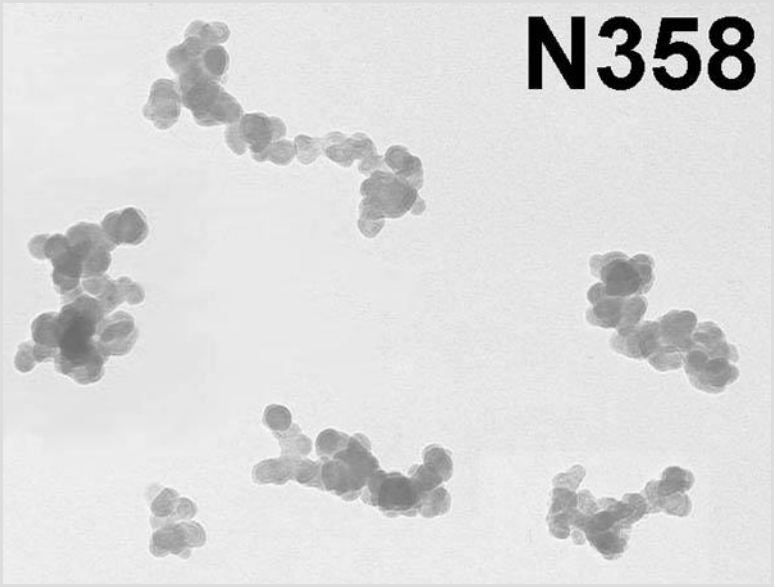
Specific Surface Area primary property influencing performance

Structure of Carbon Black other key performance property

Structure is the relative degree or complexity of branching of the aggregates



Low Structure



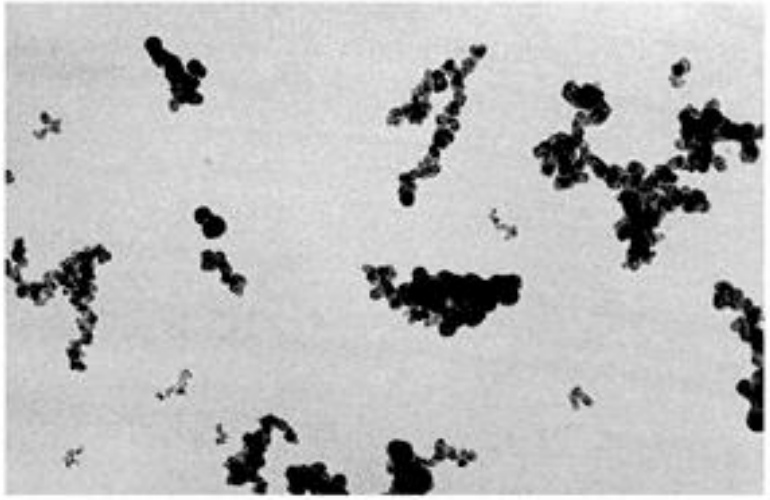
High Structure

TEM MICROGRAPHS SHOWING PARTICLE SIZE RANGE FOR TYPICAL FURNACE GRADES FOR RUBBER APPLICATIONS

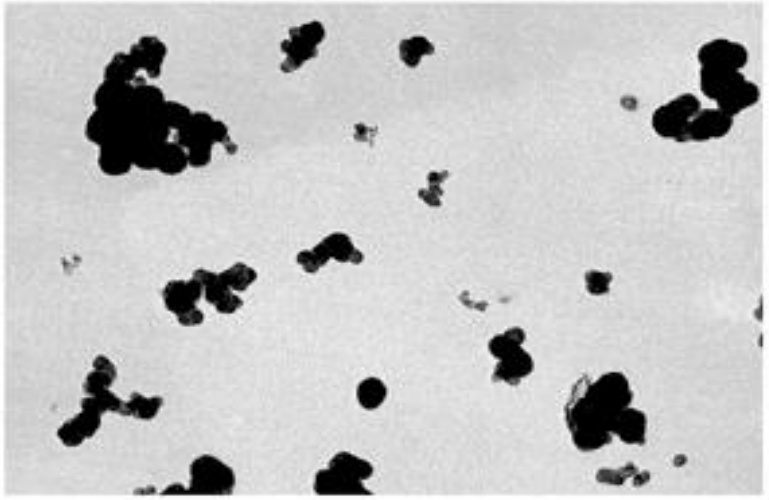
N110

N351

X50,000



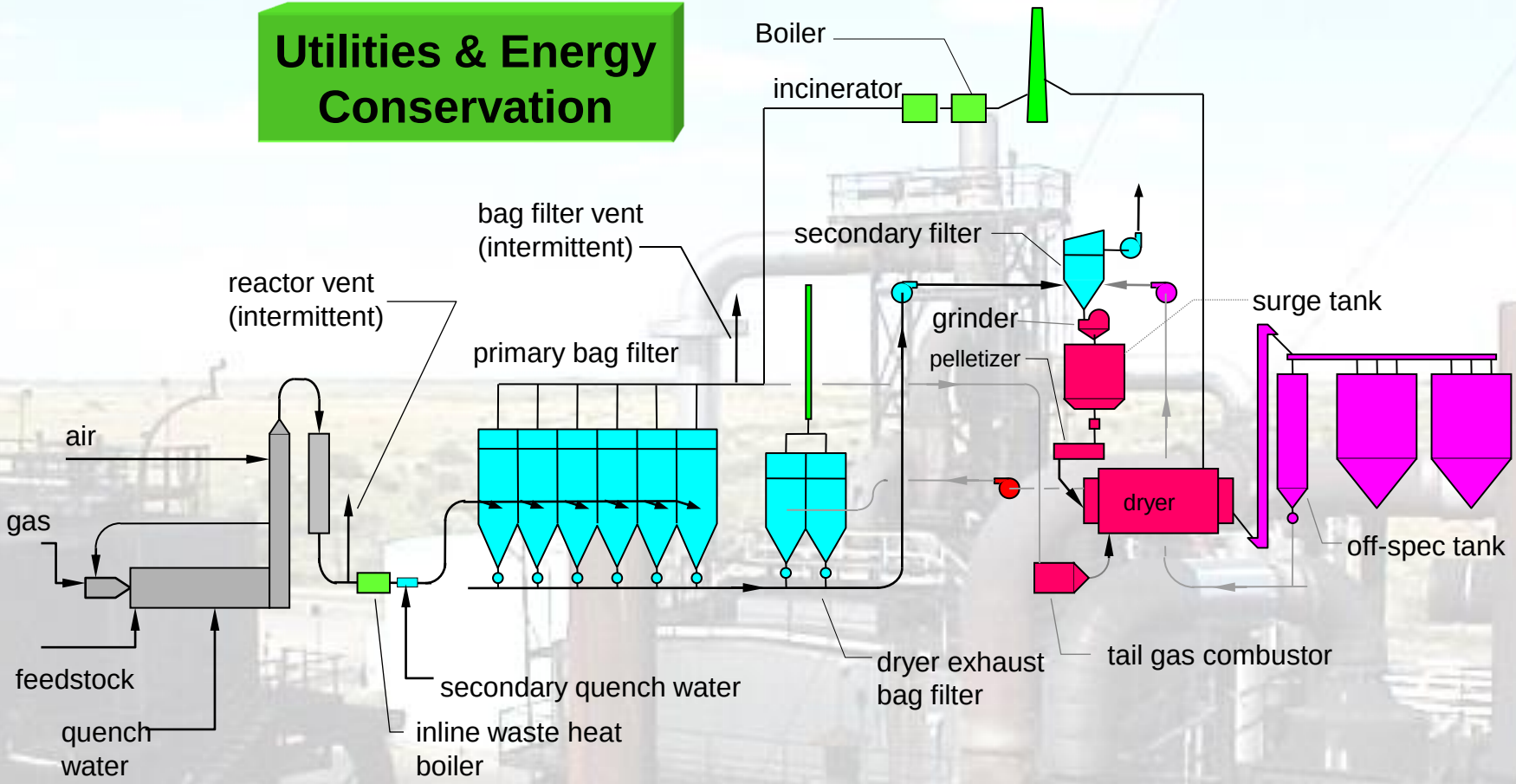
N650



N762

Carbon Black Process

Utilities & Energy Conservation



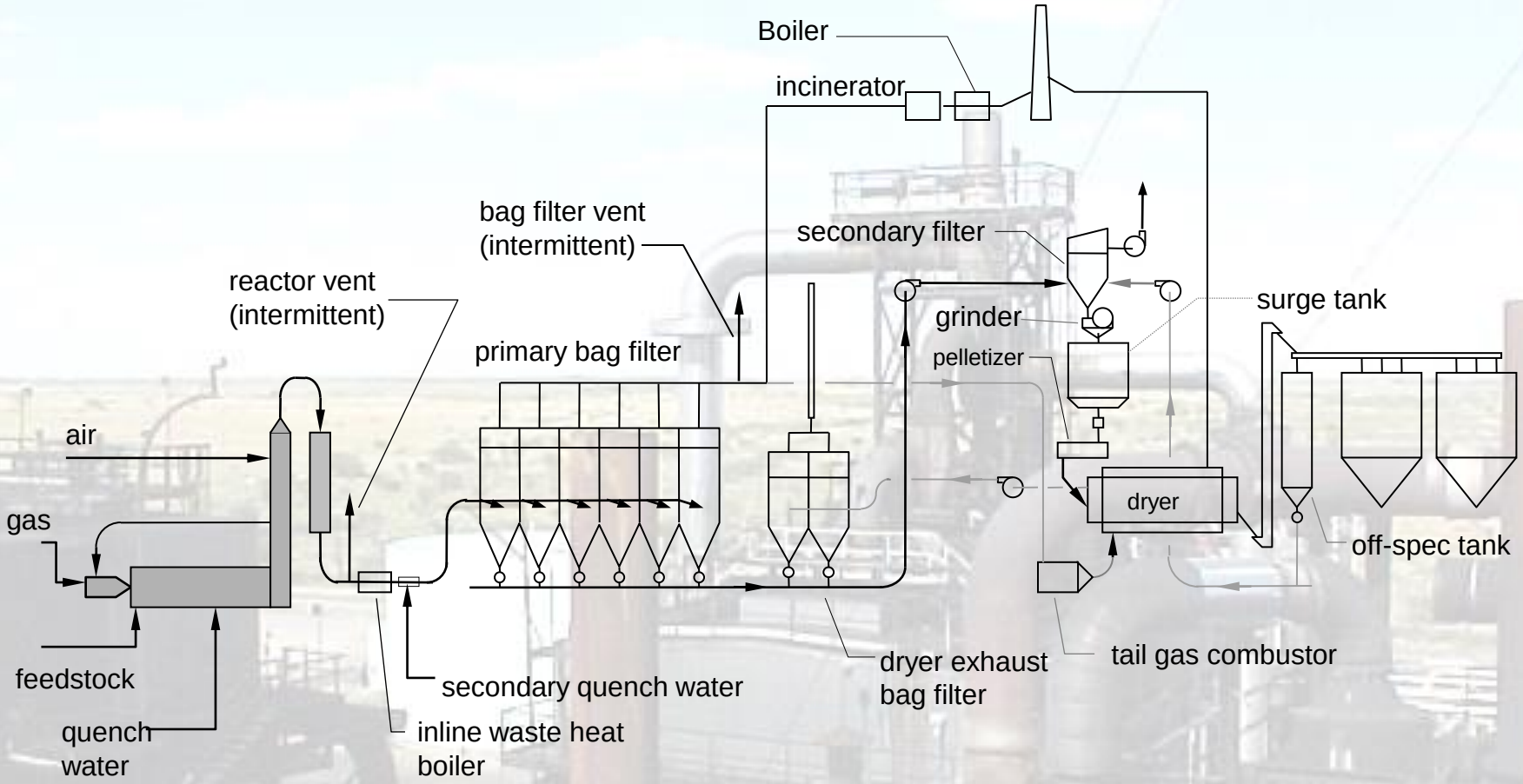
Reactor Section/Carbon Black Formation

Collection & Conveying

Pelletizing & Drying

Storage & Handling

Carbon Black Process



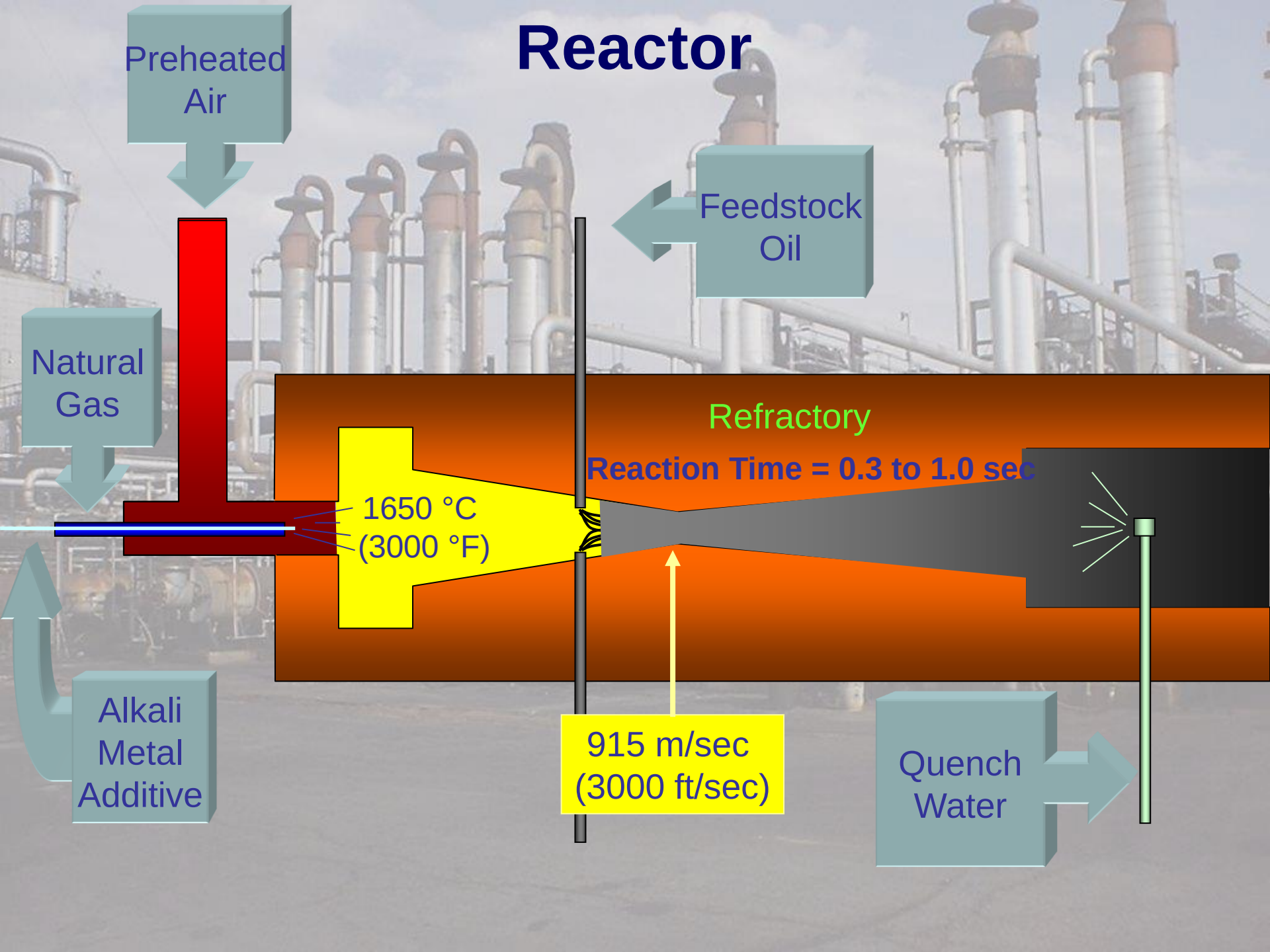
Reactor Section/Carbon Black Formation – where the carbon black is formed

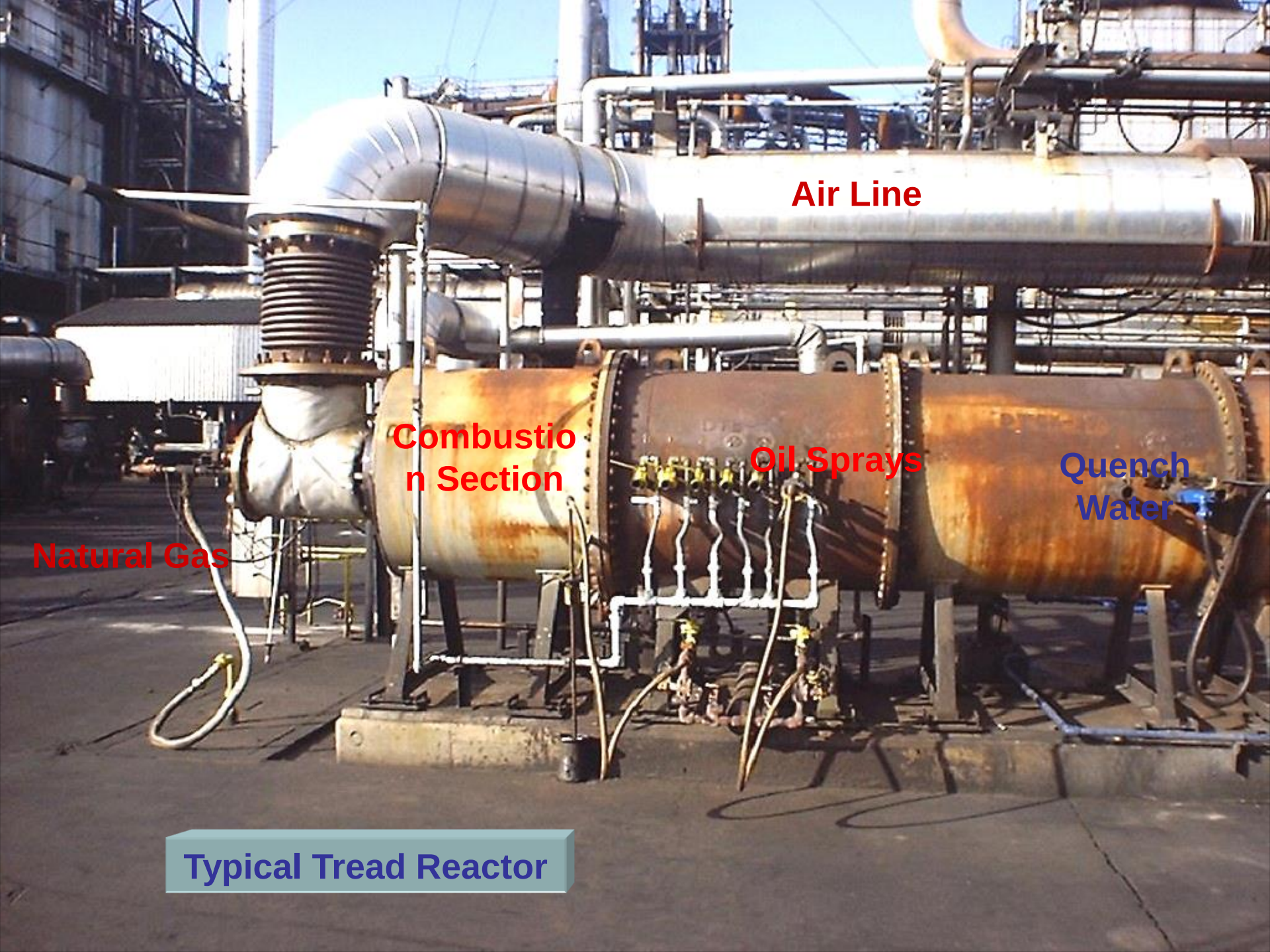
Raw Materials

Making carbon black requires five (5) materials:

- Fuel (natural gas or oil)
- Oxidizer (air)
- Feedstock Oil (no. 6 type oil)
- Water
- Structure control additive (potassium salt)

Reactor


Preheated Air
Feedstock Oil
Natural Gas
Refractory
Reaction Time = 0.3 to 1.0 sec
1650 °C
(3000 °F)
Alkali Metal Additive
915 m/sec
(3000 ft/sec)
Quench Water

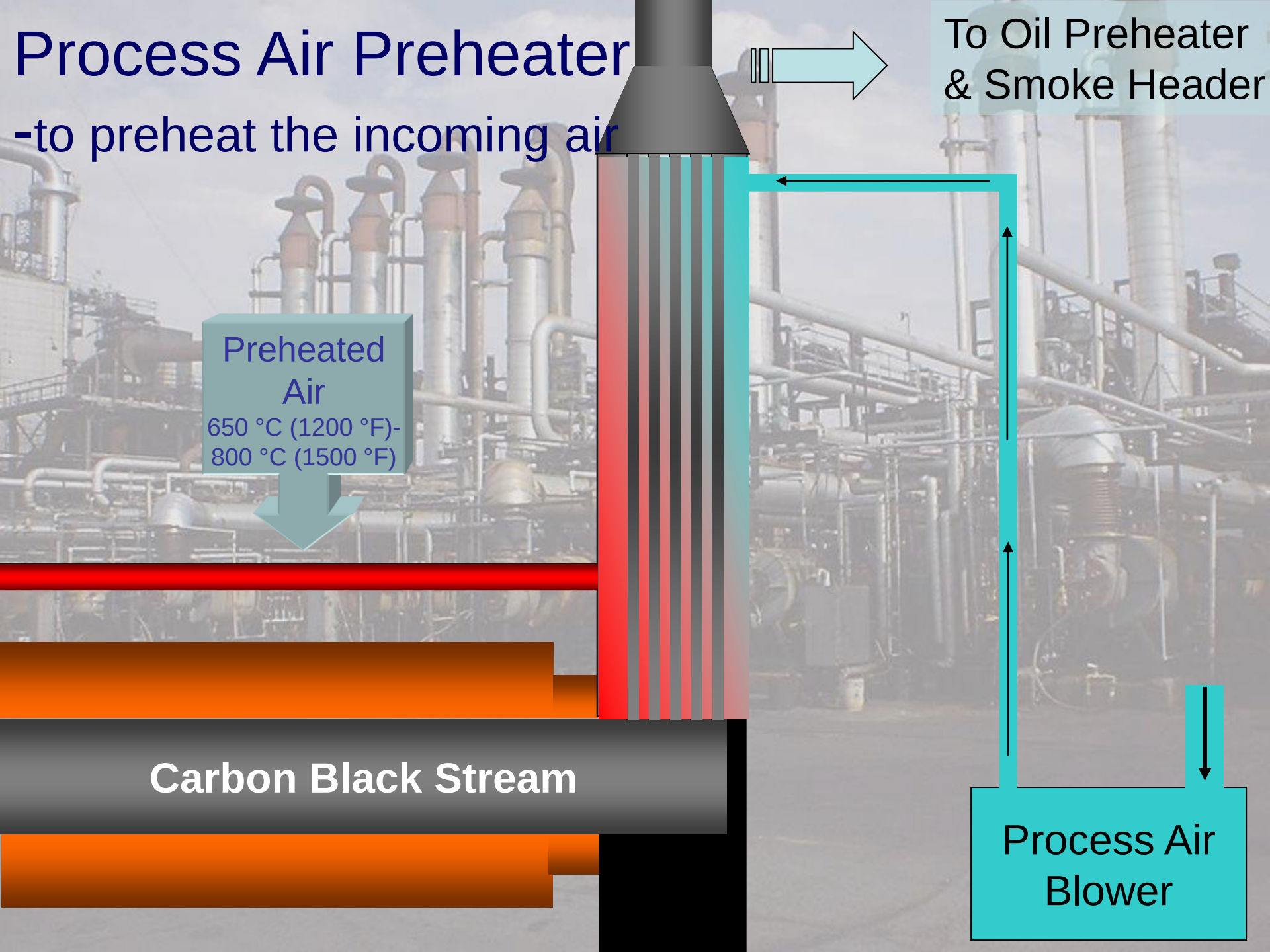


Typical Tread Reactor

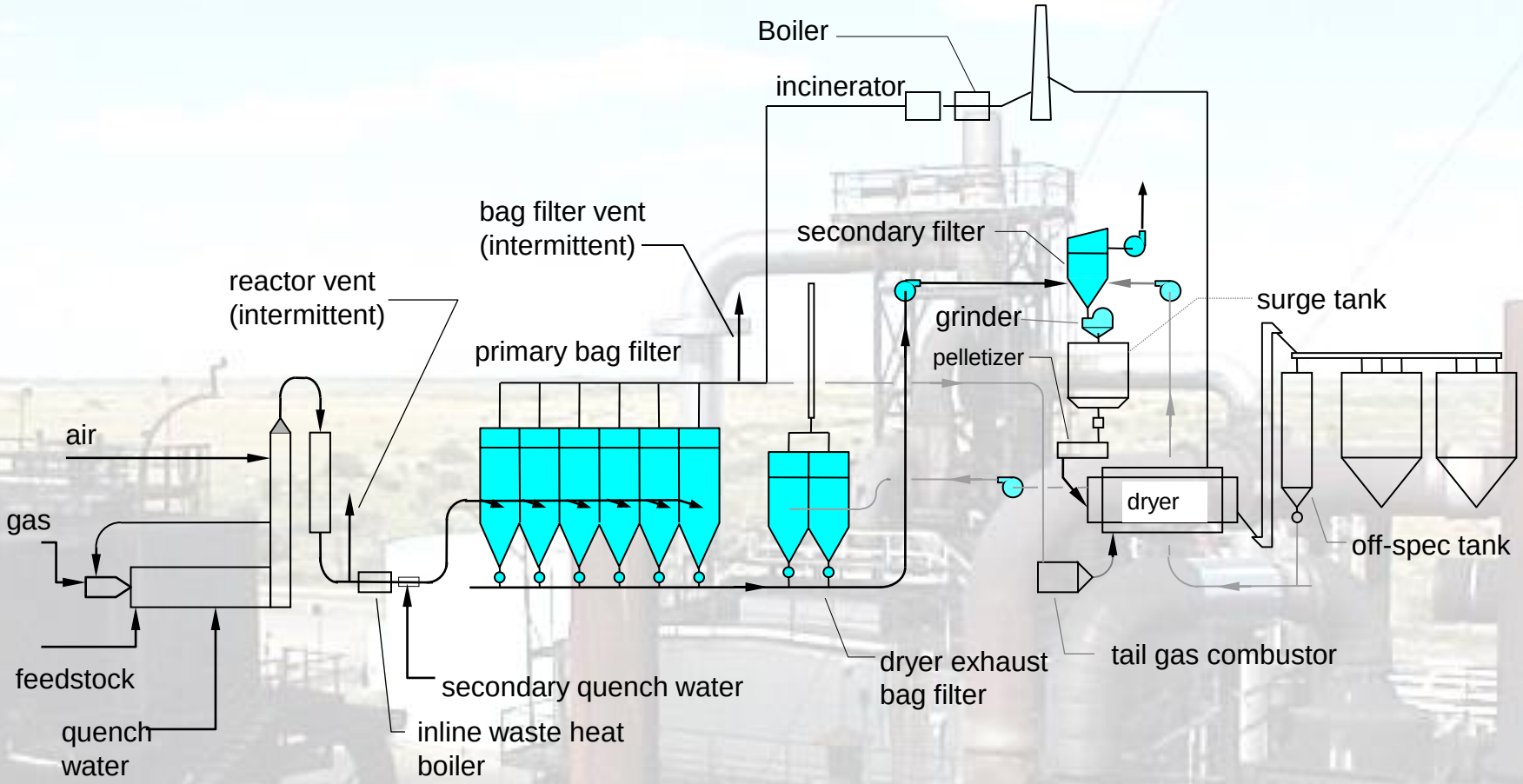
Typical Tread Reactor

Process Air Preheater

-to preheat the incoming air

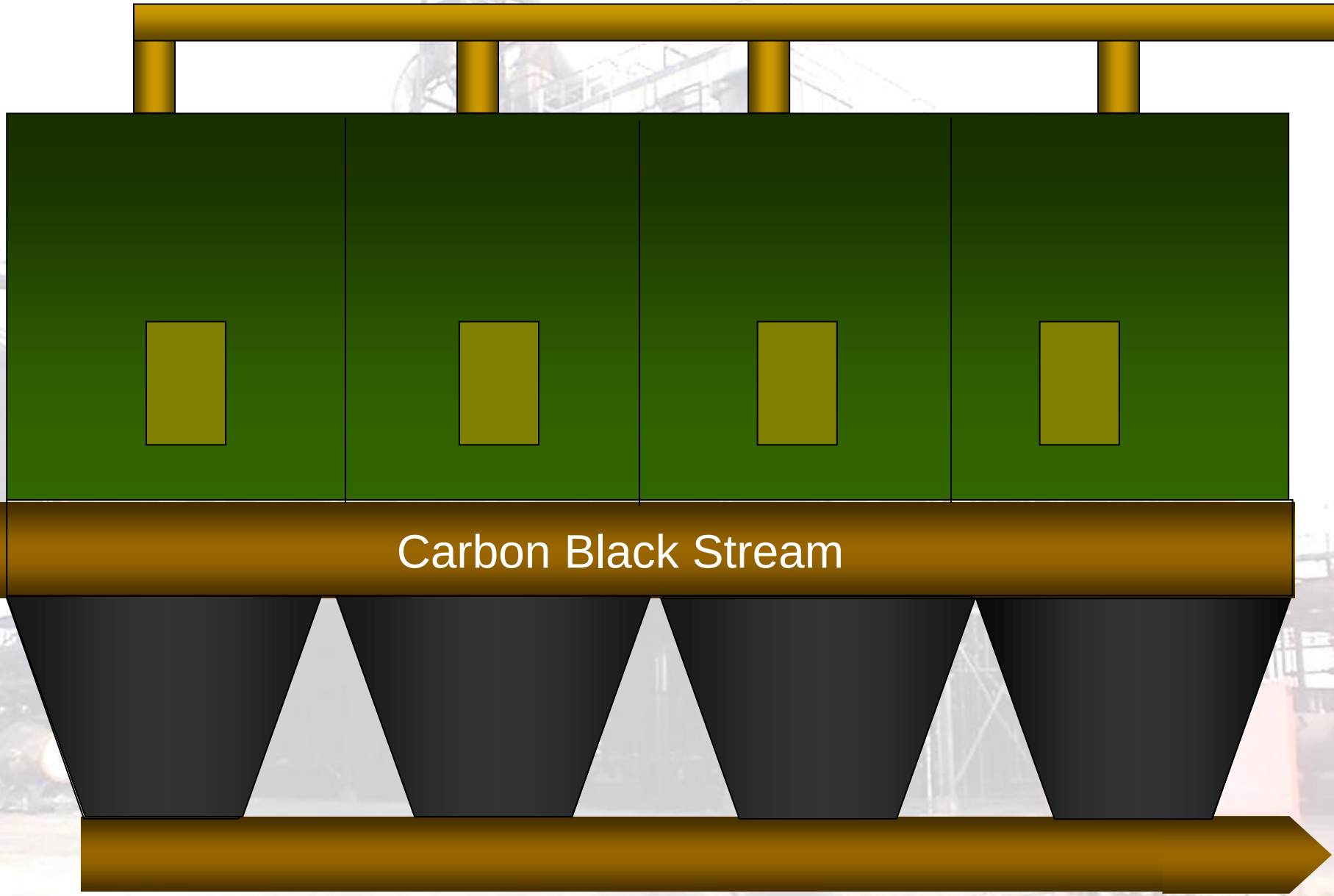


Carbon Black Process

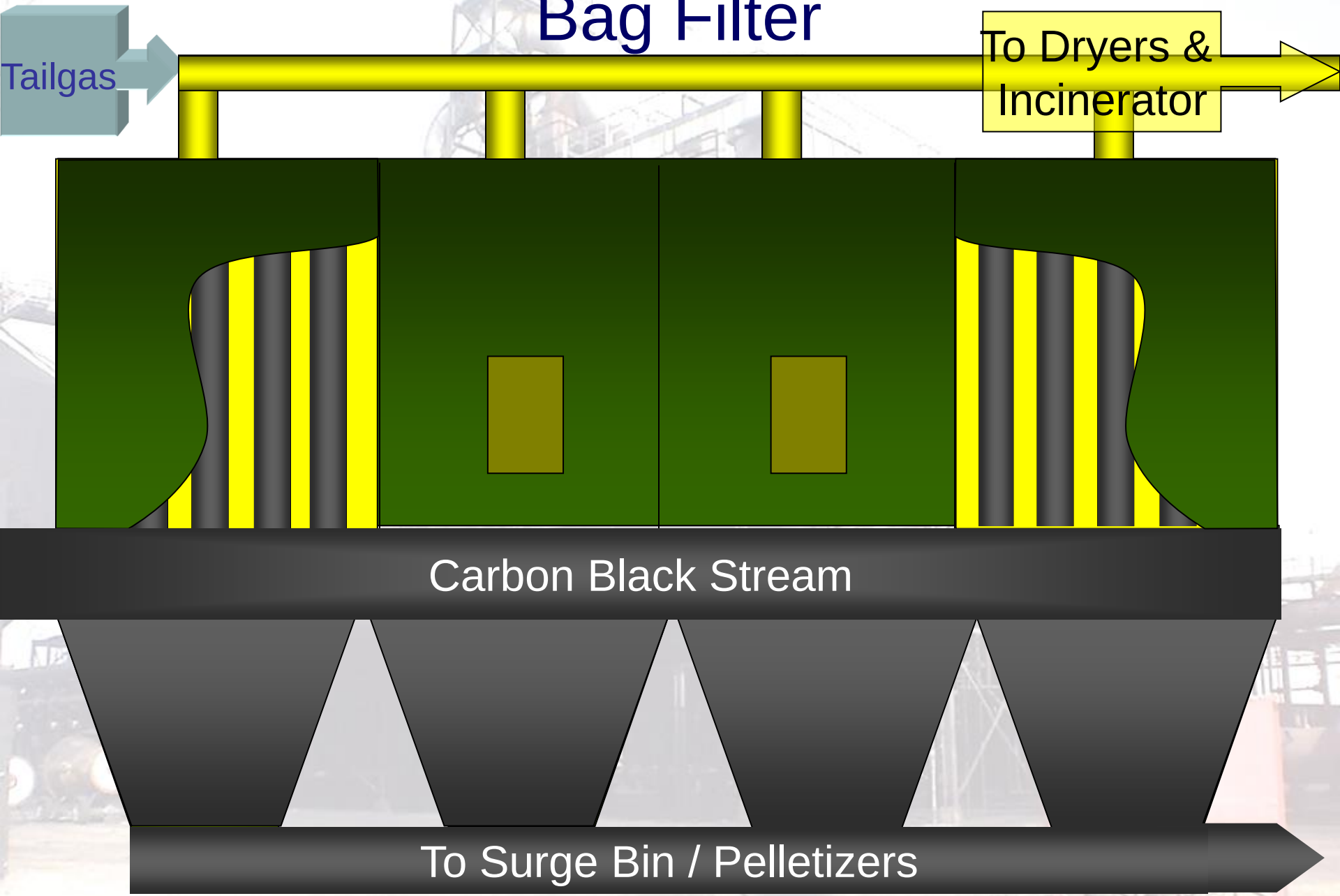


Collection & Conveying – separate carbon black from process gas stream & transport to pelletizing area

Bag Filter

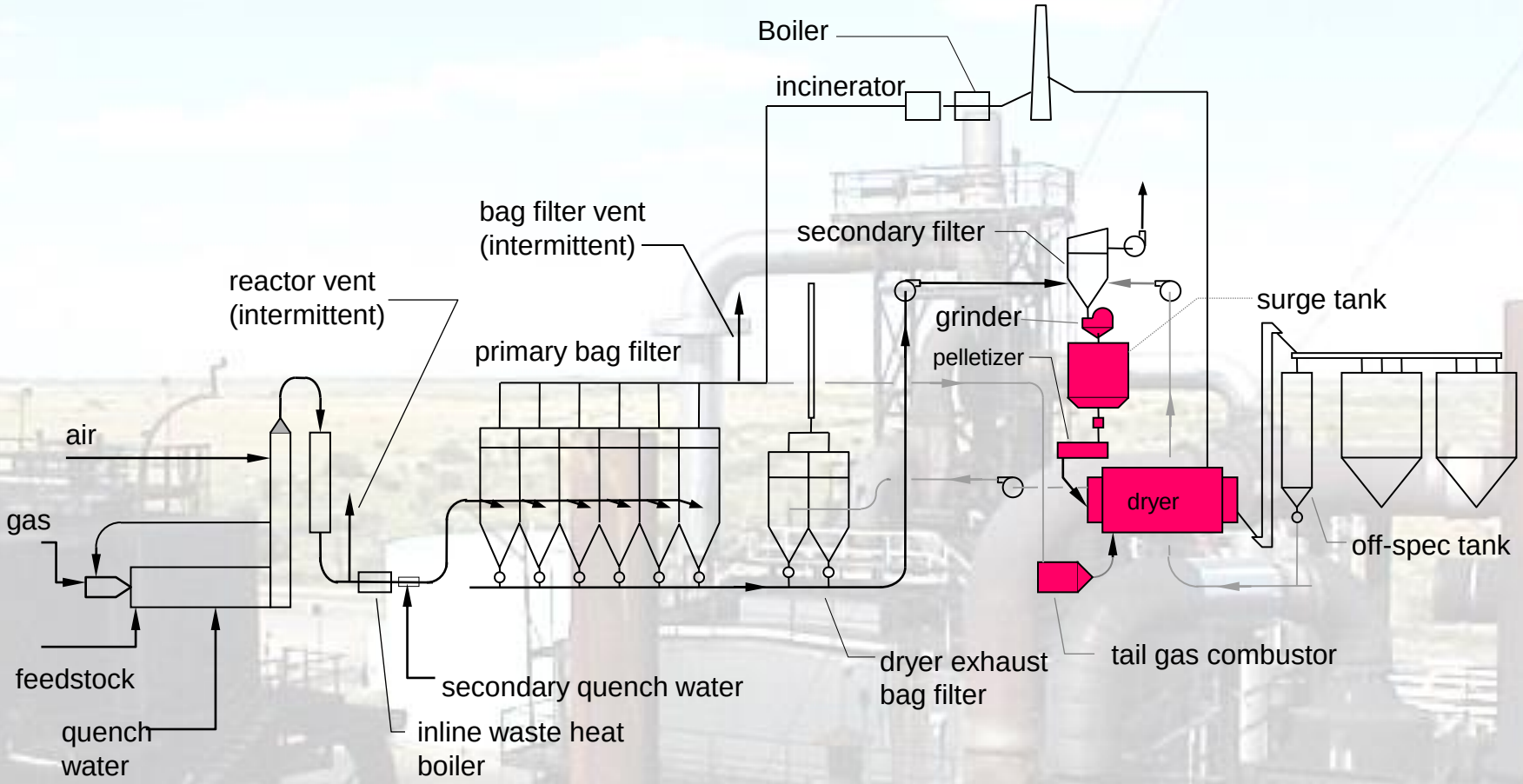


Bag Filter


Tailgas
To Dryers & Incinerator
Carbon Black Stream
To Surge Bin / Pelletizers

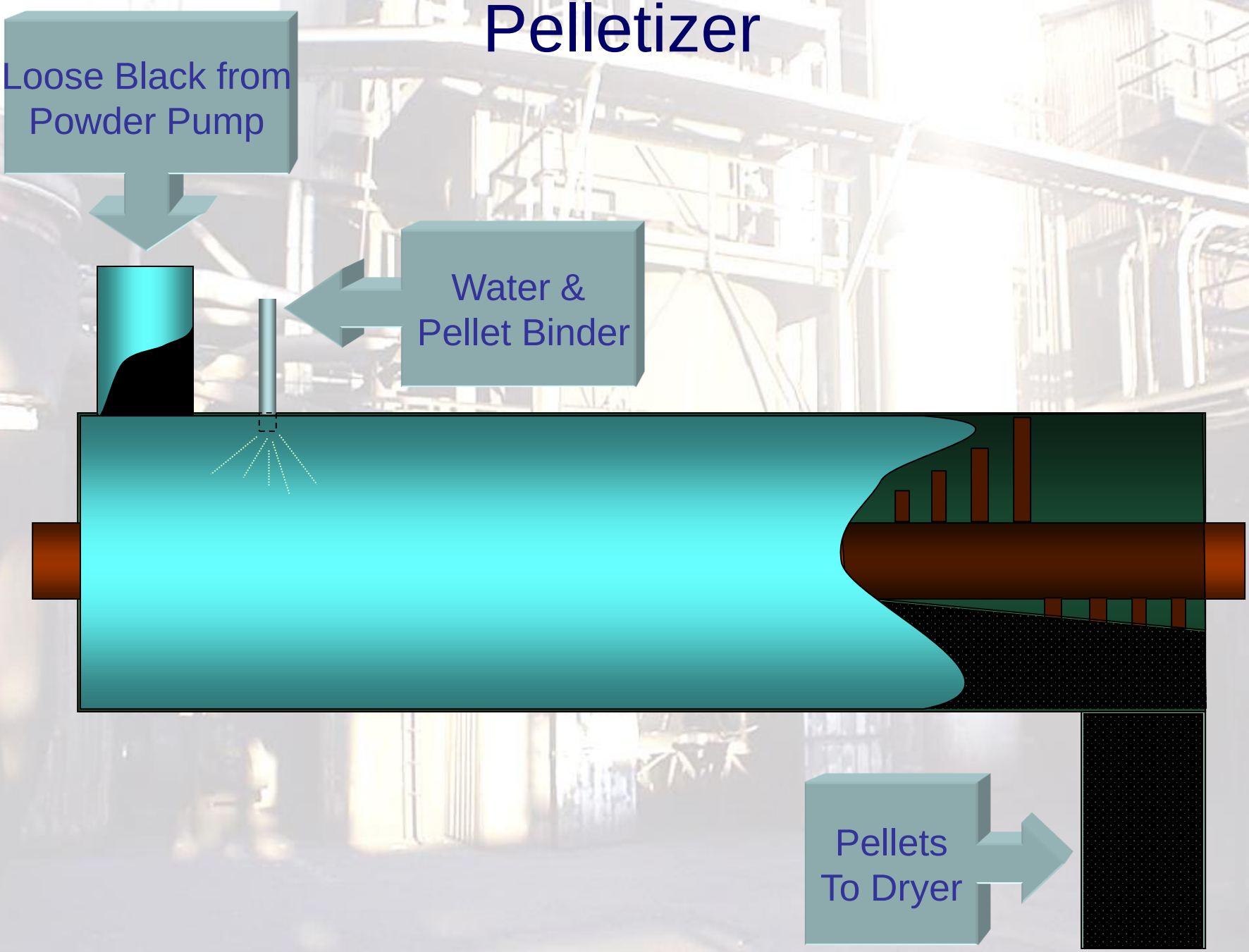
Typical Reverse Flow Bag Filter

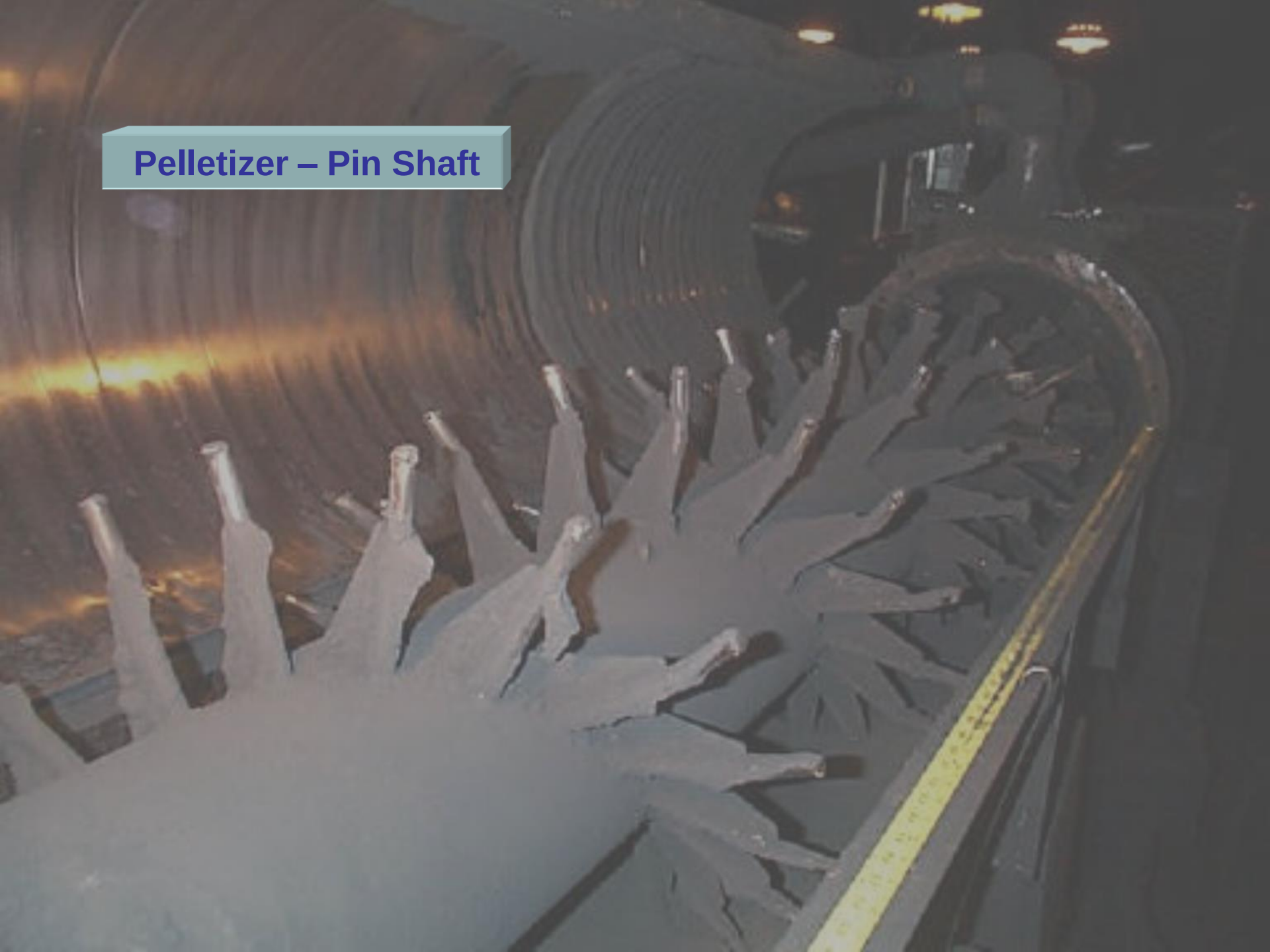
Carbon Black Process



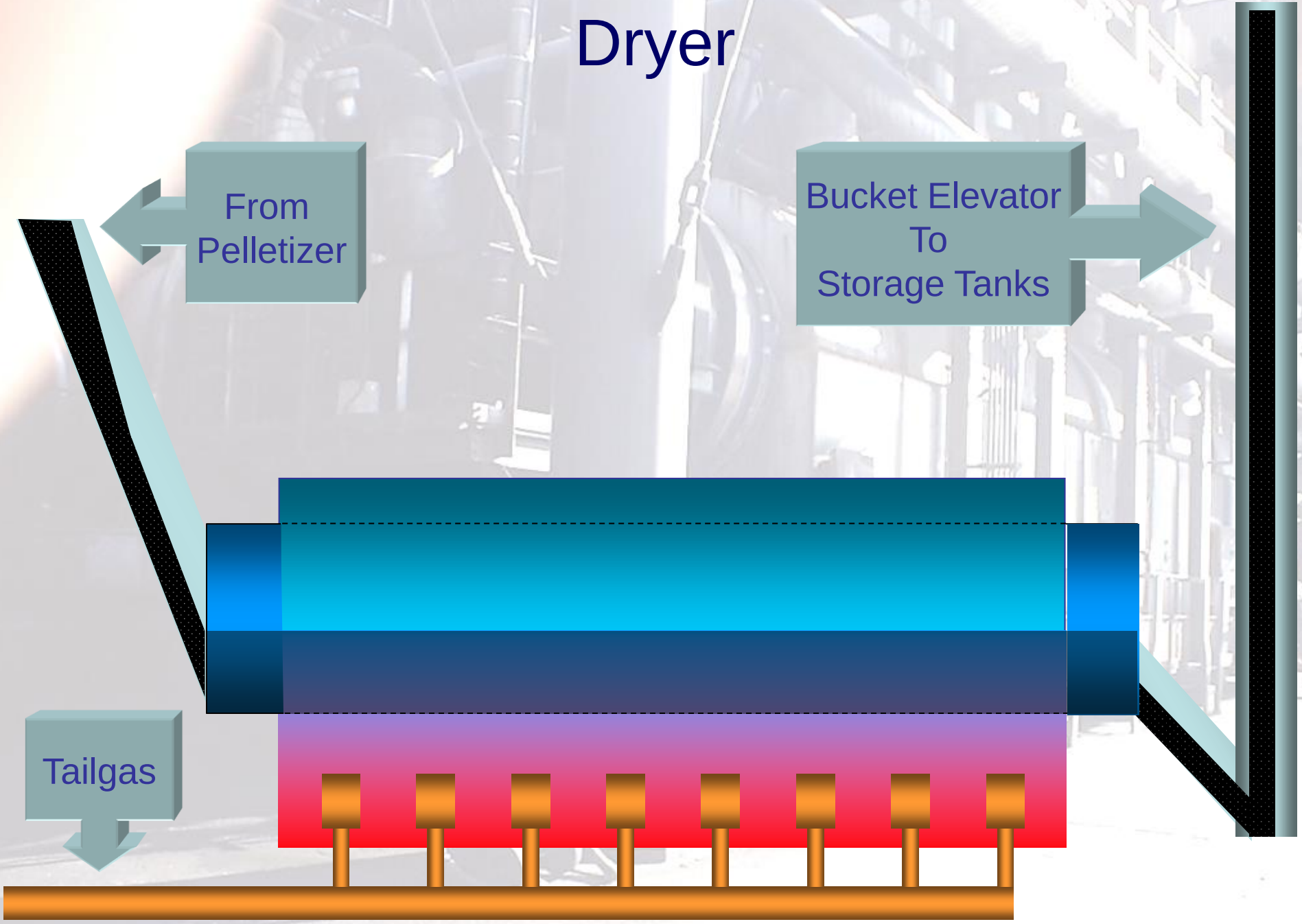
Palletizing & Drying – densify the carbon black to meet transportation & customer requirements

Pelletizer


Loose Black from Powder Pump
Water & Pellet Binder
Pellets To Dryer

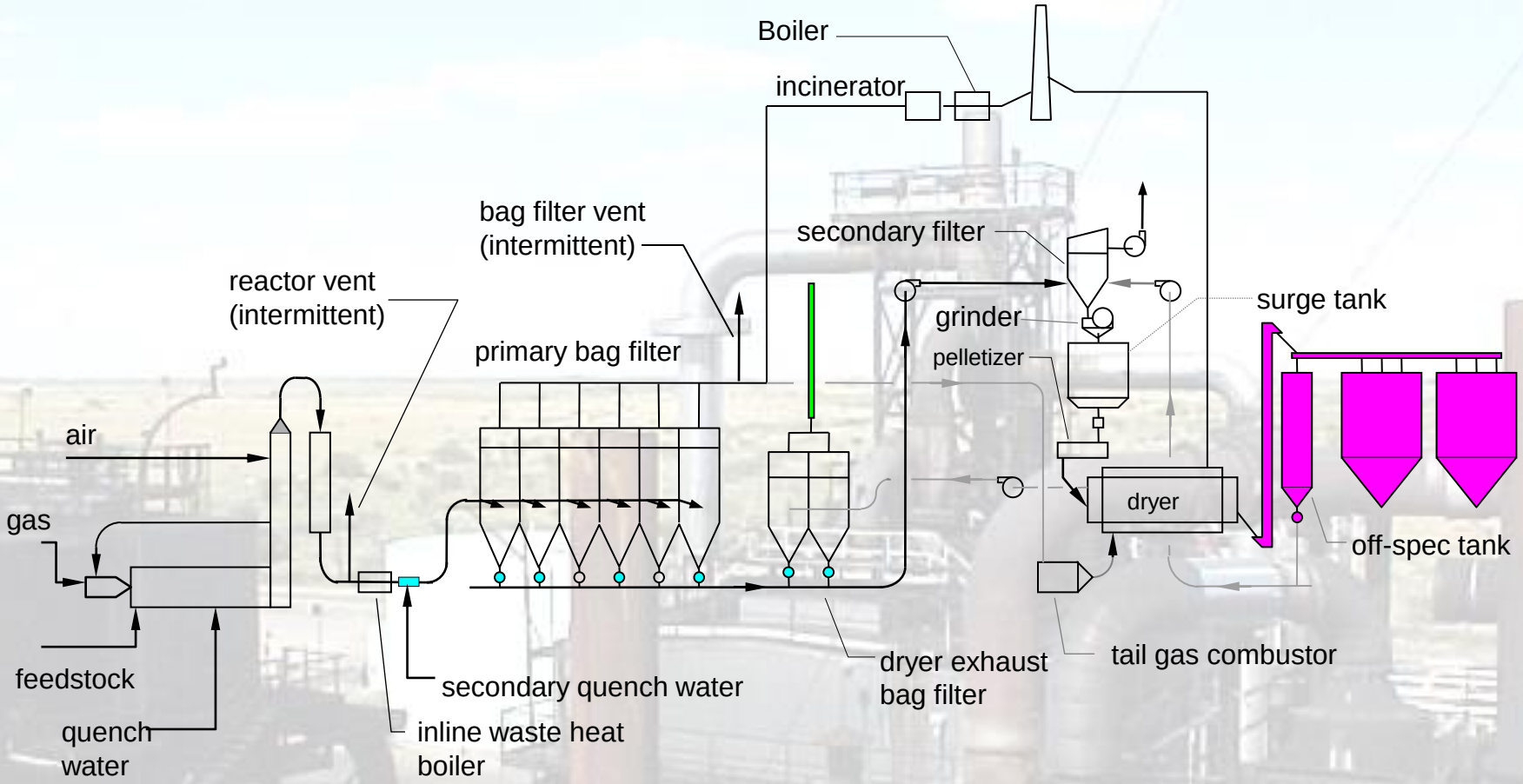

Pelletizer – Pin Shaft

Dryer



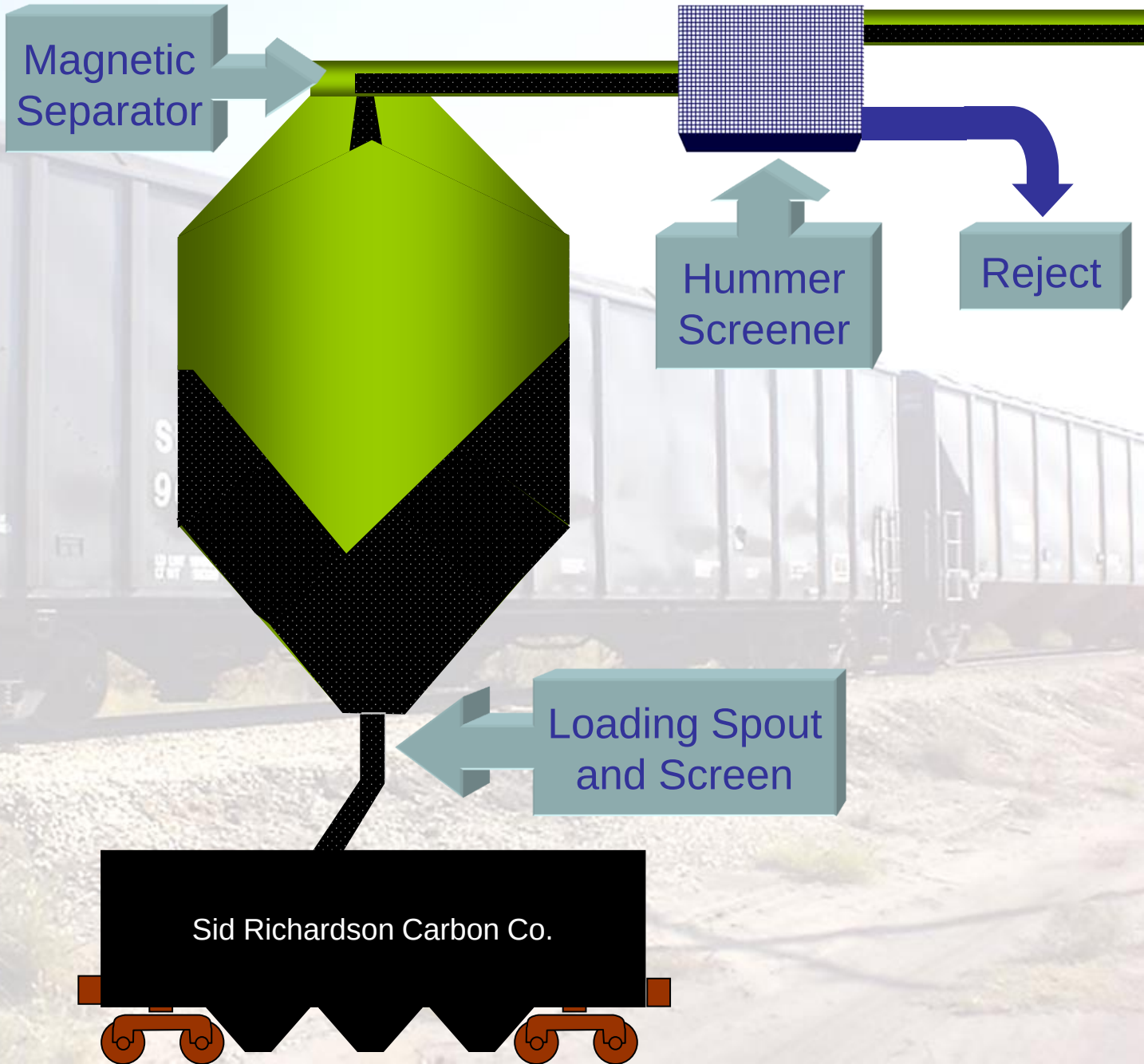
Dryer

Carbon Black Process



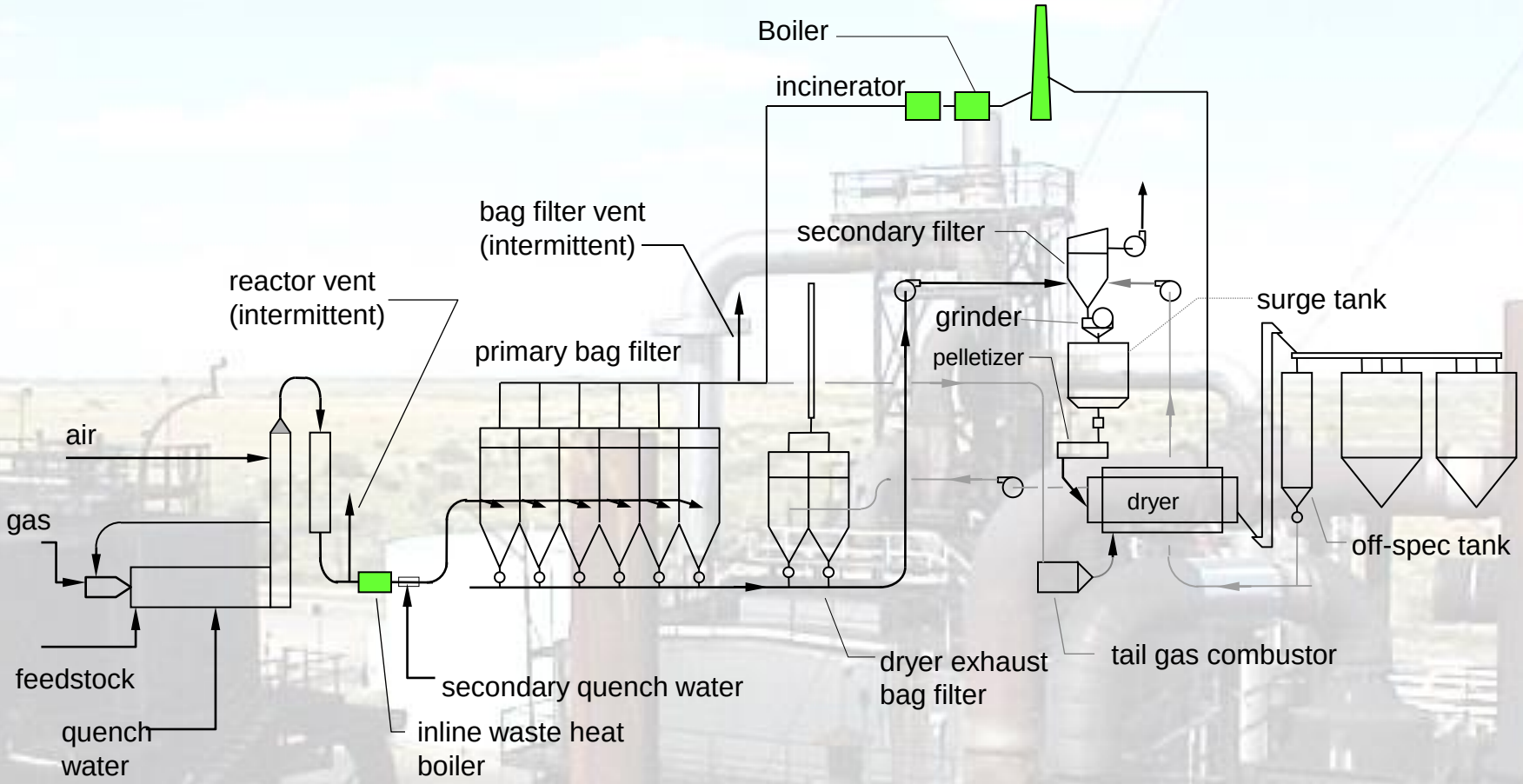
Storage & Handling – Convey carbon black pellets to storage area for transportation to customer

Storage & Loading



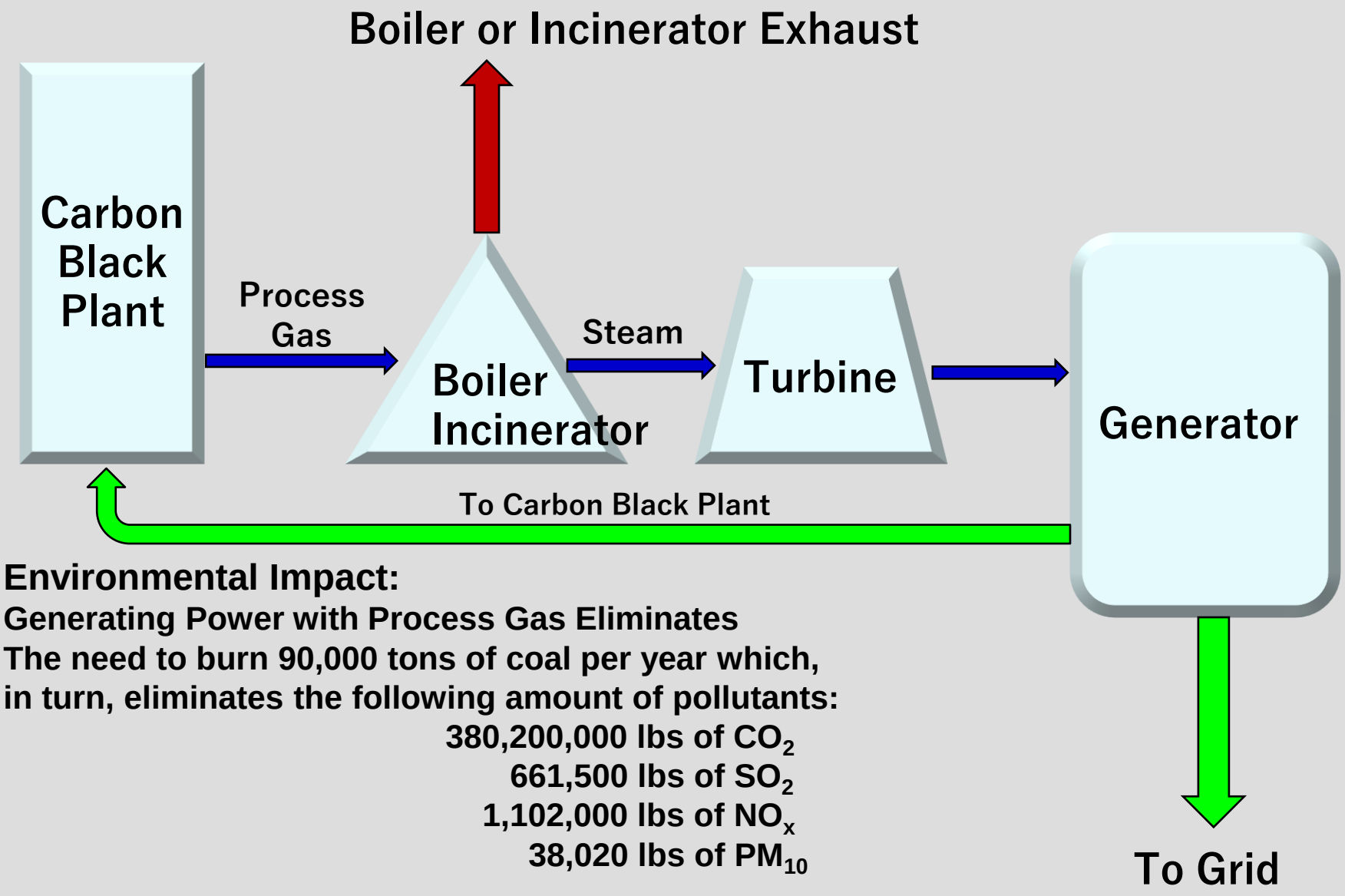
Storage Tanks

Carbon Black Process



Utilities/Energy Conservation – utilize the waste gases from the process for energy conservation and to produce steam and/or electricity

Carbon Black Co-Gen Plant



Environmental Impact:

Generating Power with Process Gas Eliminates The need to burn 90,000 tons of coal per year which, in turn, eliminates the following amount of pollutants:

380,200,000 lbs of CO_2
661,500 lbs of SO_2
1,102,000 lbs of NO_x
38,020 lbs of PM_{10}

Big Spring Electricity Co-Generation Unit – Major Contributor to CO_2 Emission Reduction

Tokai Carbon CB – Current Efforts

- TCCB is also reducing other emissions
  - NO_x (Nitrogen Oxides)
    - All 3 TCCB plants will have SCR (Selective Catalytic Reactor) units ready by 2023. This technology is similar to a catalytic converter in an automobile's exhaust pipe.
  - SO2 (Sulfur Dioxide)
    - Two plants will utilize WSA (wet sulfuric acid) units by 2023 to reduce SO_2. This converts SO_2 to SO_3 ultimately creating sulfuric acid, which will be repurposed.

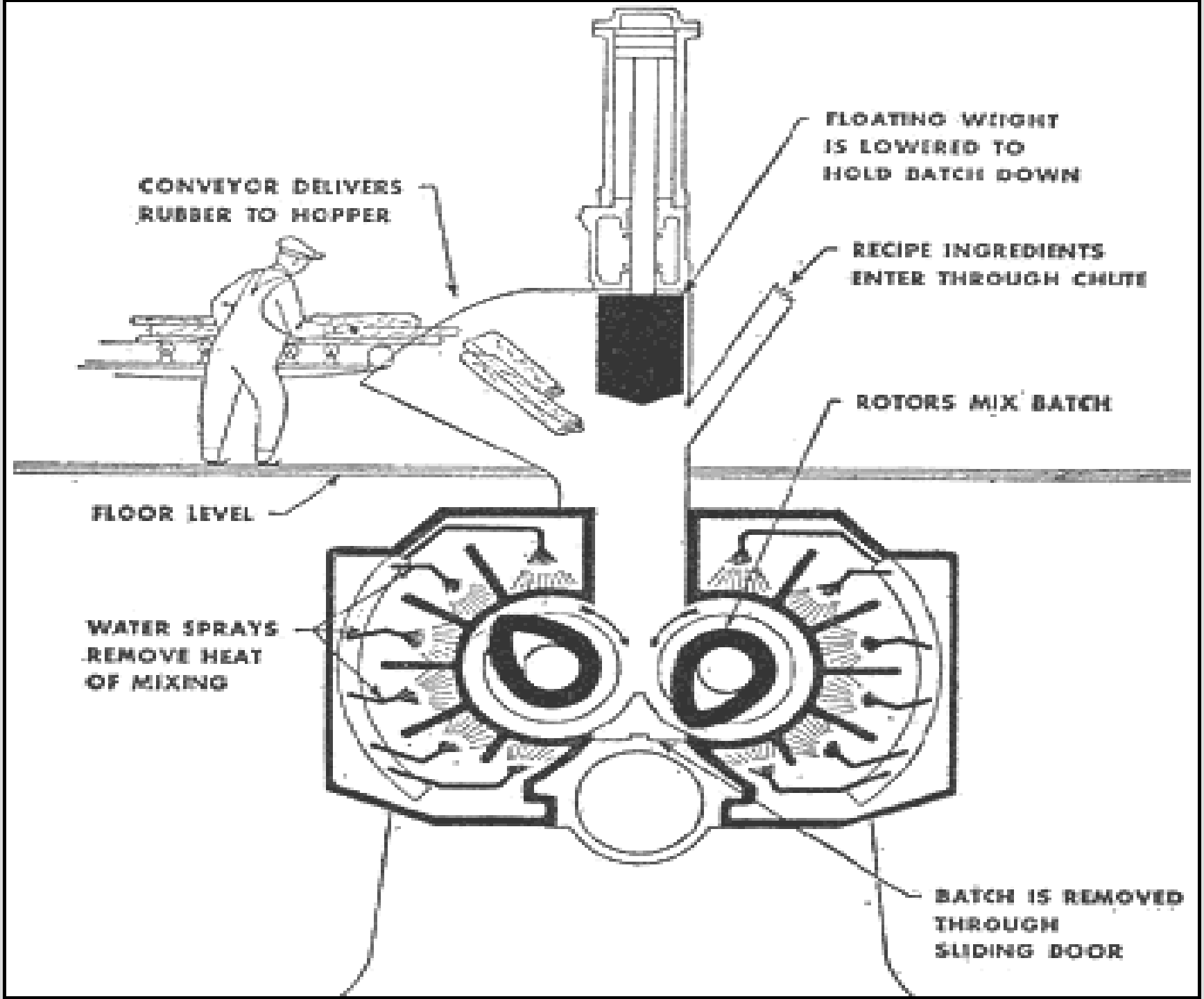
Projected NO_x Reduction (2023)

- Addis 809 tons - 95%
- Big Spring 401 tons – 76%
- Borger 586 tons– 62%
- Total 1,796 tons - 75%

Projected SO_2 Reduction (2023)

- Addis 8,332 tons – 95%
- Borger 4,927 tons– 62%
- Total 13,259 tons - 53%

Tire Customers


FLOATING WEIGHT
IS LOWERED TO
HOLD BATCH DOWN
CONVEYOR DELIVERS
RUBBER TO HOPPER
RECIPE INGREDIENTS
ENTER THROUGH CHUTE
ROTORS MIX BATCH
FLOOR LEVEL
WATER SPRAYS
REMOVE HEAT
OF MIXING
BATCH IS REMOVED
THROUGH
SLIDING DOOR

TIRES

Carbon Black provides strength to polymers

Different components of tire use various grades of CB

Tires normally are about 30% carbon black

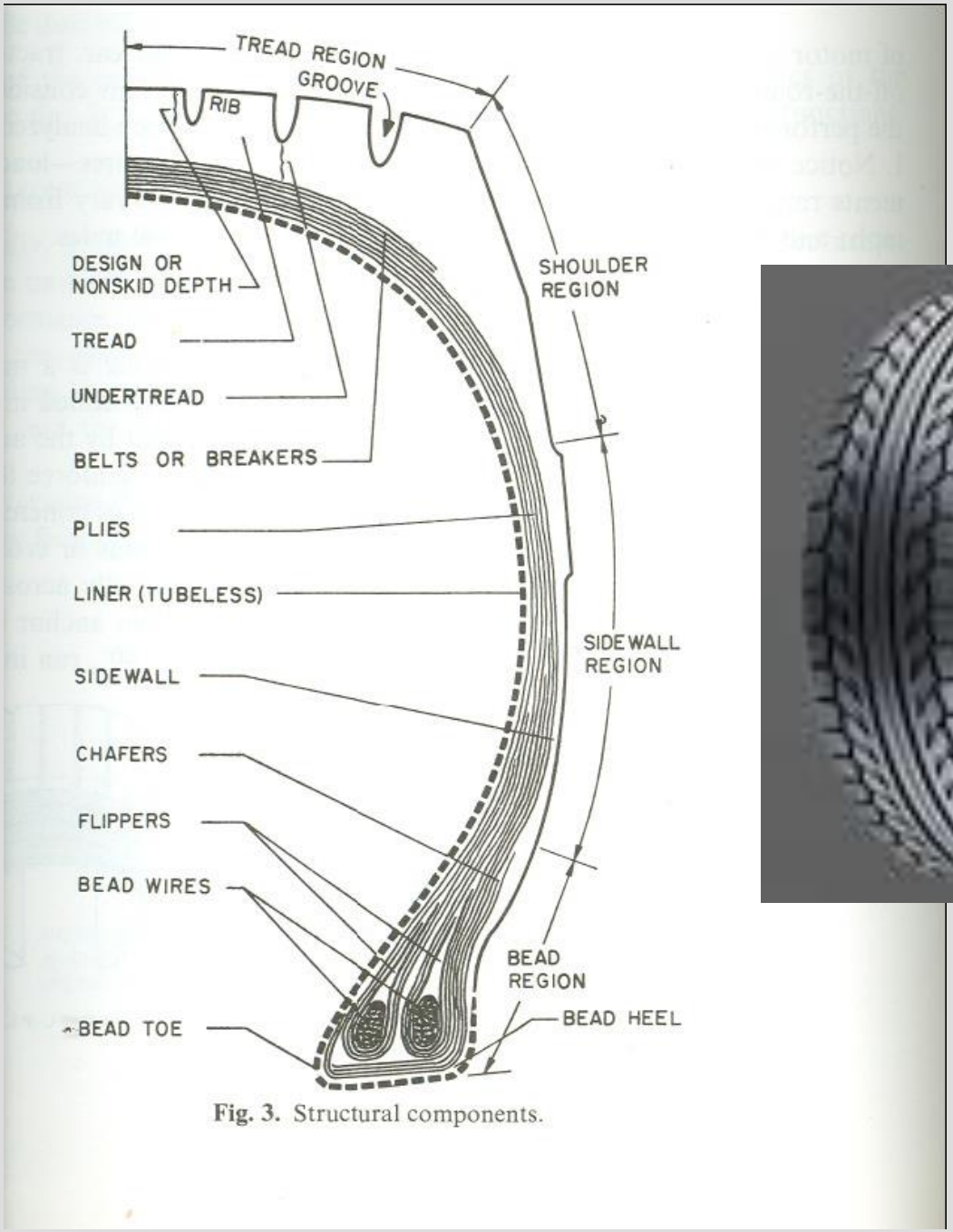


Fig. 3. Structural components.

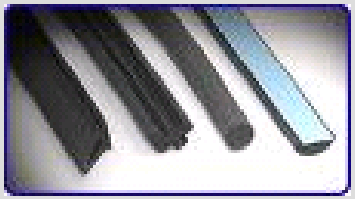
Mechanical Rubber Goods

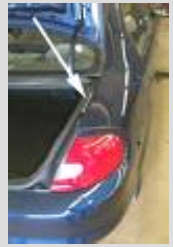
Rubber

Roofing

Belts, Hoses

Seals





Gates

Preferred Rubber Compounding Corp.

Parker

WATERVILLE TG inc.

HEXPOL

CARLISLE

Carlisle SynTec

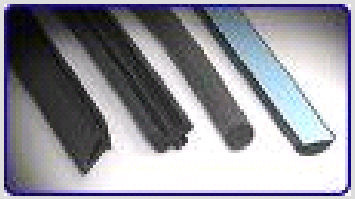
Firestone

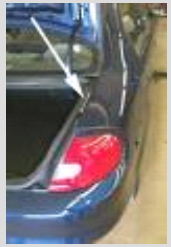
BUILDING PRODUCTS

Mechanical Rubber Goods
- reinforcing filler
Plastics
- UV protection, colorant

Belts, Hoses

Seals





Plastic Masterbatch

The Plastics Industry

PlasticsColor CORPORATION

MDI MODERN DISPERSIONS, INC.

DOW

Ampacet
Managing the Elements of Success™

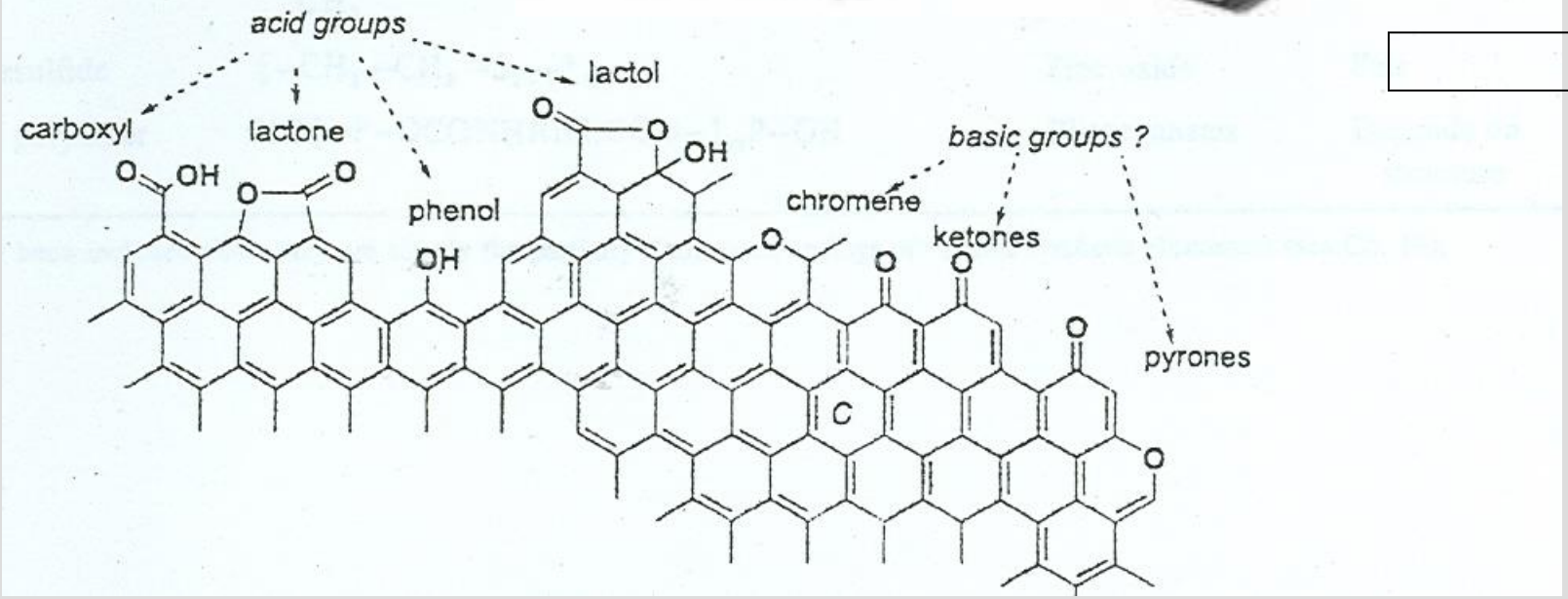
Carbon Black is Main Black Pigment Widely used in Inks, Paints, Coatings

Conductive Carbon Blacks

Primary Market – Industrial Cables

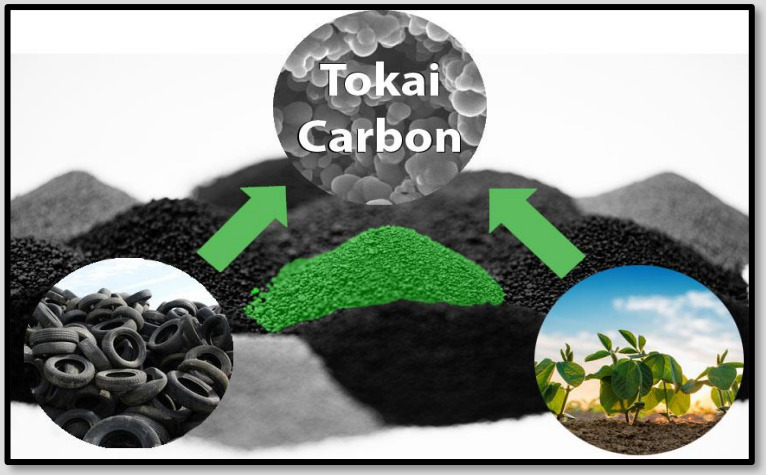
Purposes – Static Dissipation, UV Protection, EM Shielding

Surface Modified Carbon Blacks



Sustainability Efforts

ISCC
International Sustainability & Carbon Certification



Ecovadis

TOKAI CARBON CB LTD
United States of America | Manufacture of other chemical products n.e.c.

GOLD 2021 ecovadis Sustainability Rating

68/100

94th percentile

UNGC

UN GLOBAL COMPACT
United Nations Global Compact

ISO 14001

ISO

2018	• Bronze Ranking •38
2020	• Silver Ranking •58
2021	• Gold Ranking •68

Thanks for your attention!