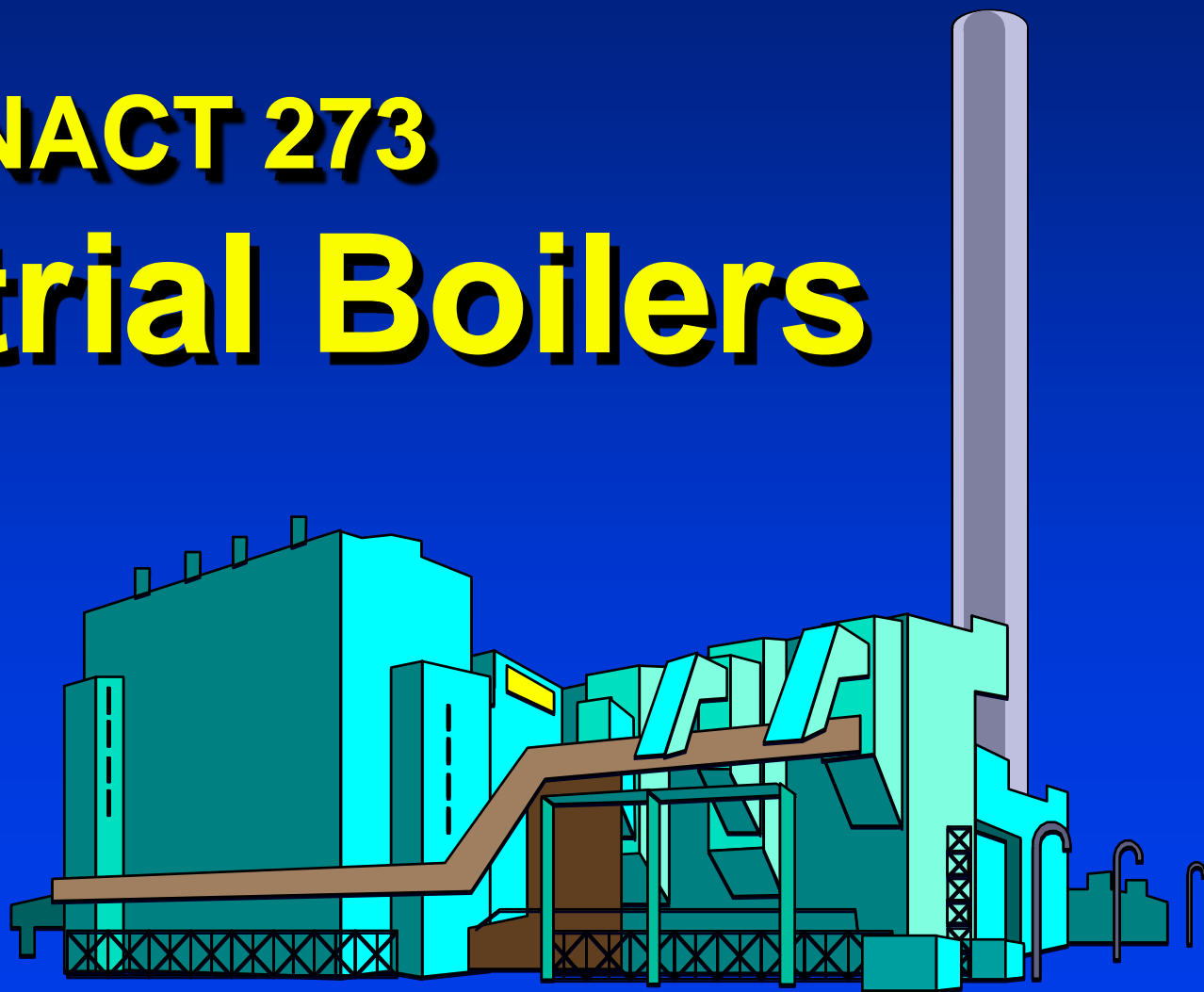


**NACT 273**  
**Industrial Boilers**



# Course Overview

◆ Air Pollution *Why*

◆ Boiler Uses *What*

◆ Boiler Theory and Operation

◆ Air Pollution Formation

◆ Air Pollution Control Devices

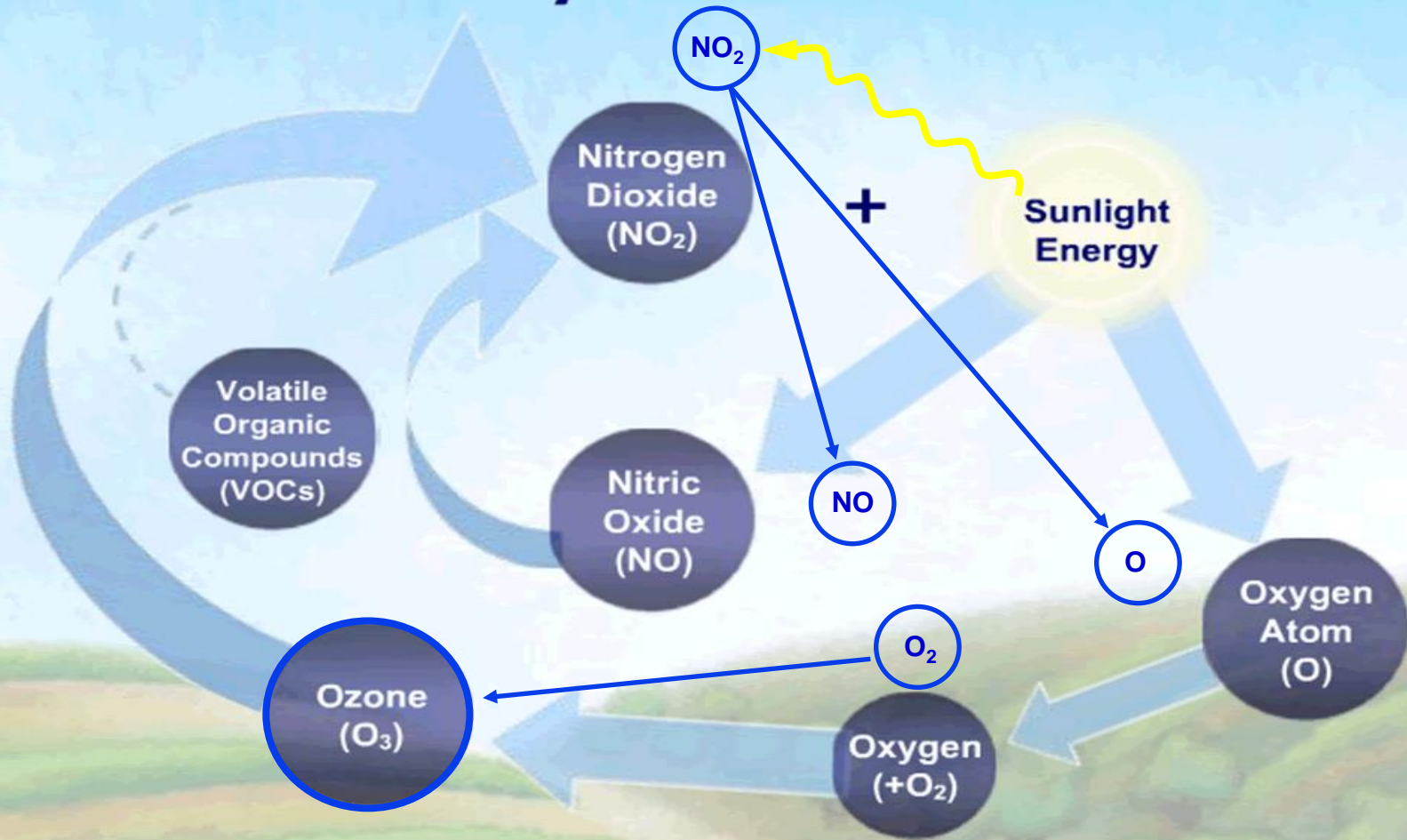
◆ Boiler Regulations *How*

◆ Typical Permit Conditions

◆ Inspection Procedures



# Ozone Photochemistry



# Uses of Boilers

◆ Electrical generation

High Pressure (2,000 -3,800 psi)

◆ Space heating

Low Pressure (150 – 1,600 psi)

◆ Food preparation

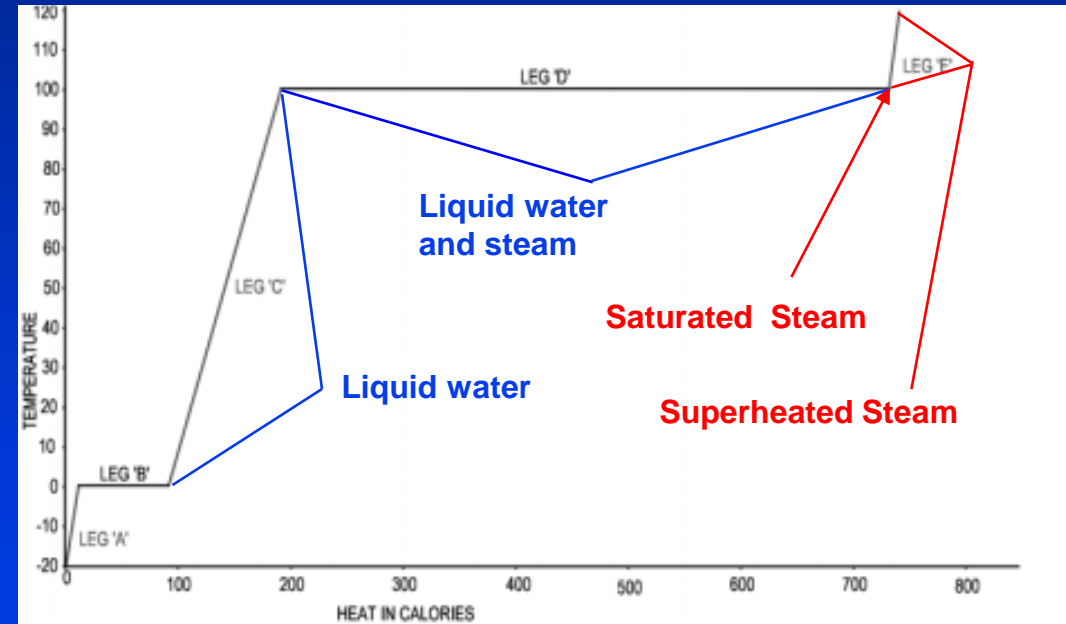
◆ Commercial laundries

◆ Pulp & paper industry

◆ Petroleum industry

◆ Chemical industry

◆ Municipalities : Water, Sewage & Garbage





**Small  
Firetube  
Boiler**

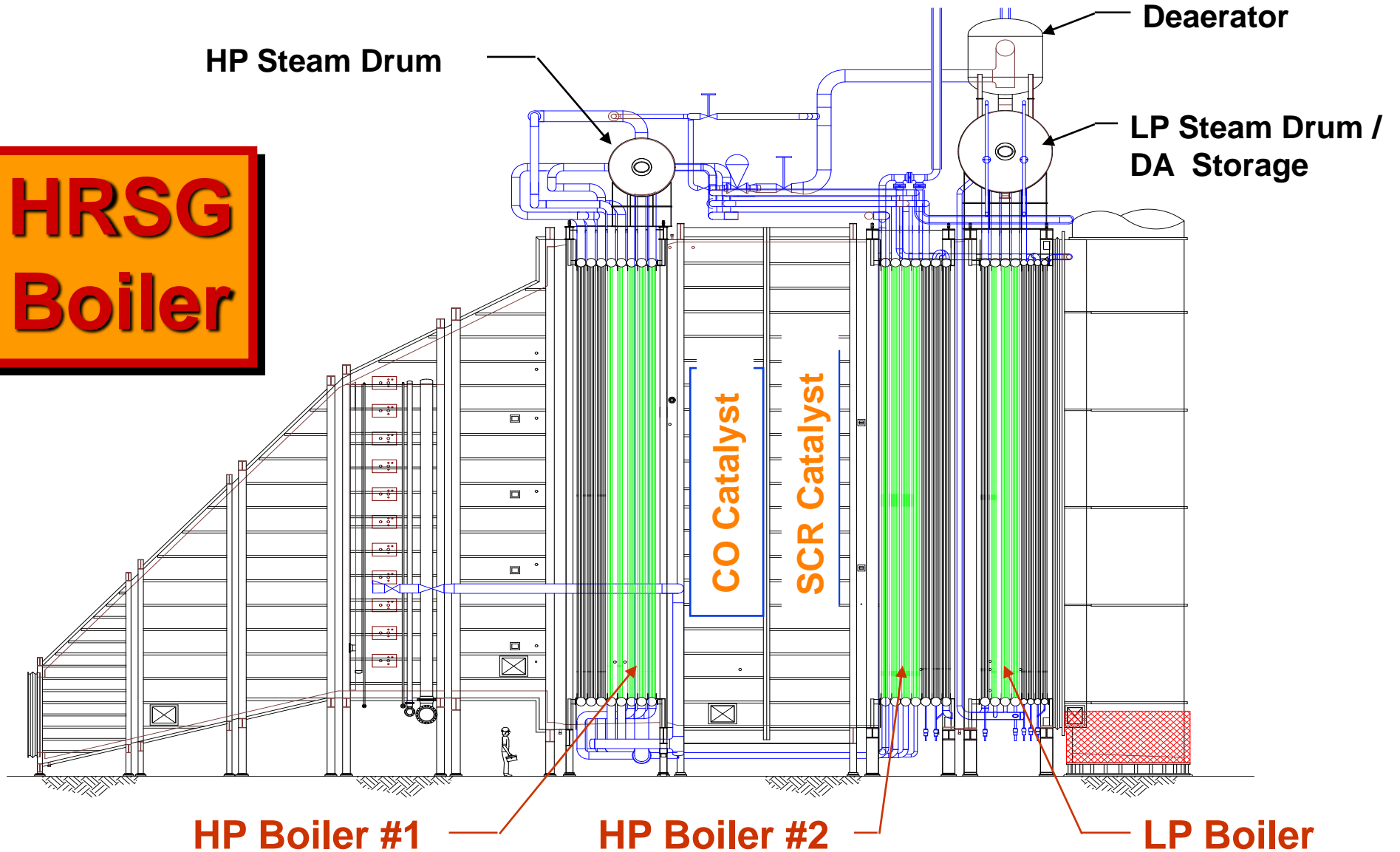


# Industrial Boiler

# Babcock & Wilcox Utility Boiler



# HRSG Boiler







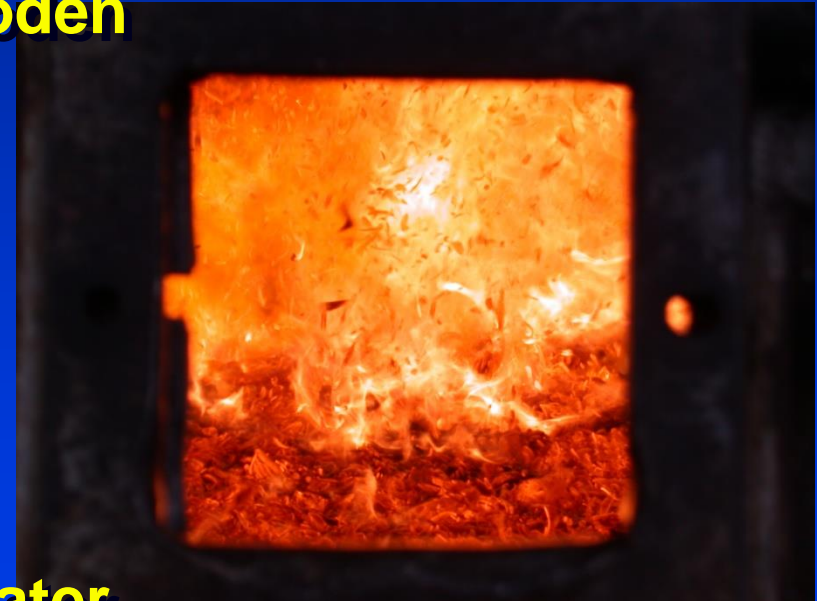
**Boilers &  
Opacity**



**History of Boilers : Ringelmann Chart**

# Hot Numbers

- ◆ **British Thermal Unit (BTU)**
  - ◆ 1 BTU the amount of energy needed to heat one pound of water one degree Fahrenheit or  $\approx$  energy given off by burning one wooden match
- ◆ **Lower Heating Value (LHV)**
  - ◆ Heating value of a fuel not counting heat needed to vaporize water
- ◆ **Higher Heating Value (HHV)**
  - ◆ Heating value of a fuel including heat needed to vaporize water





# **Boiler Ratings**

- Millions of BTU/hr**
- Boiler HP**
- Pounds of Steam/hr**
- Megawatts**
- Tons per day**


# COMBUSTION ENGINEERING, INC.

NEW



YORK

## C-E STEAM GENERATOR

RATED STEAMING CAPACITY	1,540,000 LB/HR	MAX PRESSURE	2300 PSI	SUPERHEATER	955°F		
REHEATER CAPACITY	1,452,500 LB/HR	MAX PRESSURE	650 PSI	TEMPERATURE	855°F		
HEATING SURFACES	SQ. FT. BOILER	WATER WALLS	32,980	ECONOMIZER	115,000		
BUILT TO A S M E			RULES				
CONTRACT NO.	6468	MFR'S NO.	20942	TYPE	RRP	YEAR BUILT	1970

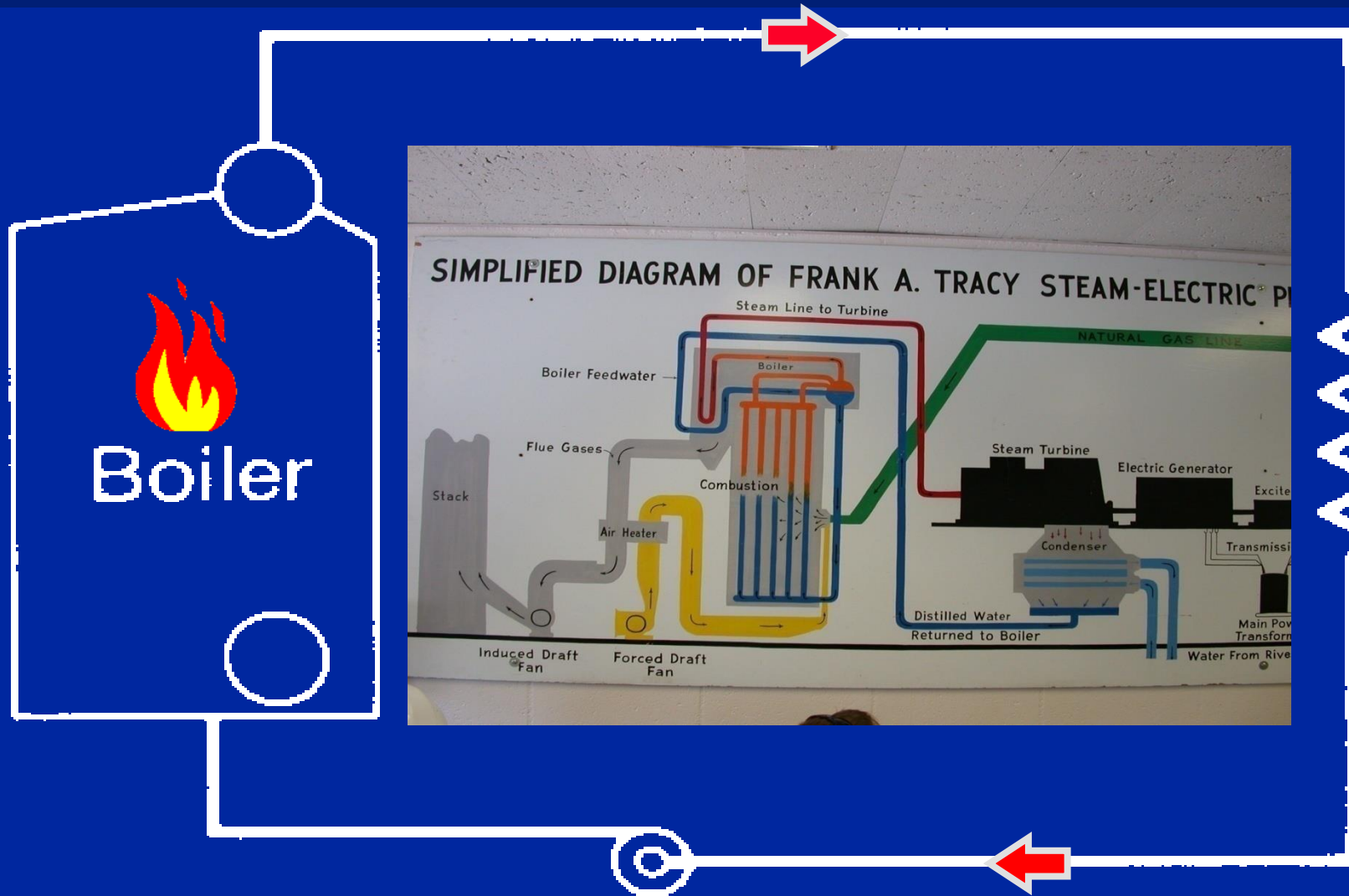
**Typical Boiler Rating**

# Boiler Fuels

- ◆ Natural gas
- ◆ Diesel fuel oils
- ◆ Tire Derived Fuel (TDF)
- ◆ Coal/Petroleum Coke
- ◆ Municipal waste
- ◆ Bio-Mass
- ◆ Waste gas
- ◆ Nuclear



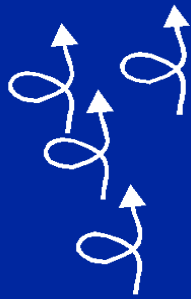
# Steam Plant Basic Elements



  
Boiler

  
Boiler Feedpump

Heating and Process Use



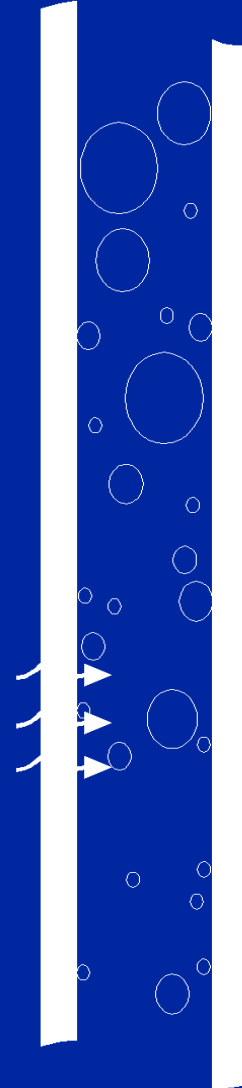
**CONVECTION**  
HOT GASES  
TRANSFER HEAT  
TO THE TUBE

**RADIATION**



HEAT TRANSFER  
THRU SPACE

**CONDUCTION**  
HEAT TRANSFER  
THRU THE  
METAL TUBE  
WALL



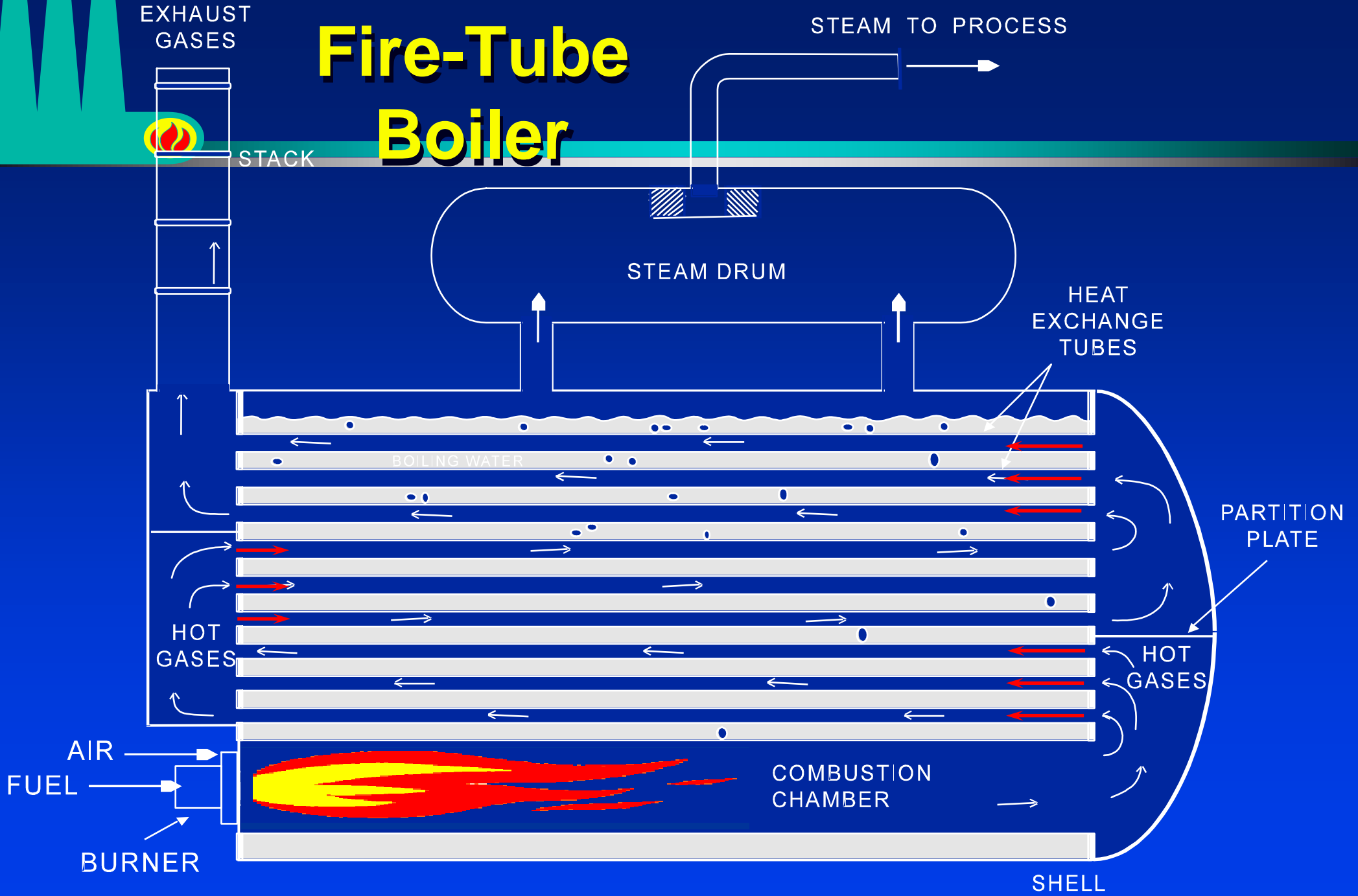
# Heat Transfer Methods





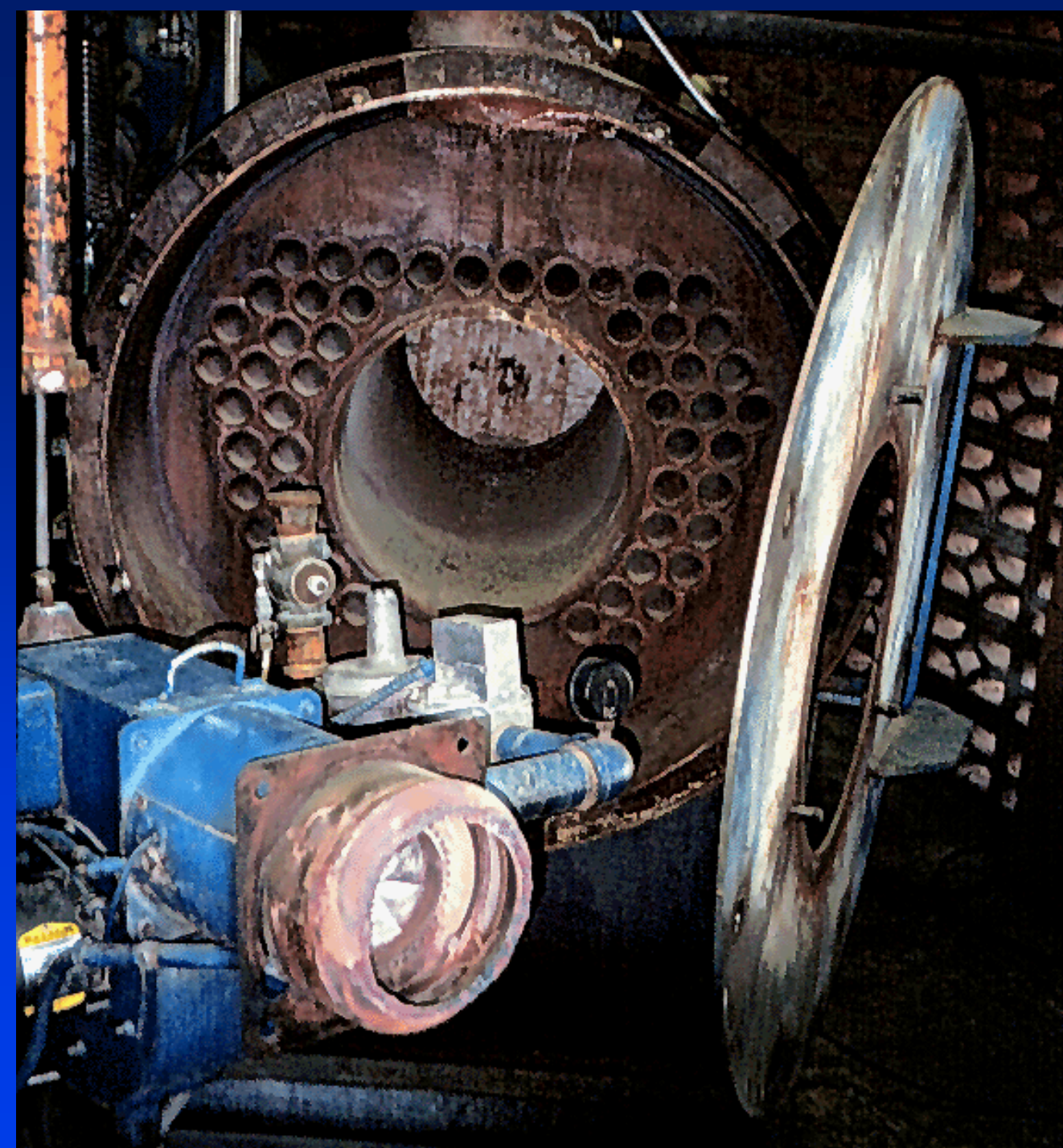
**Let's Discuss Firetube &  
Watertube Boilers**

# Fire-Tube Boiler





# Fire-Tube Boiler

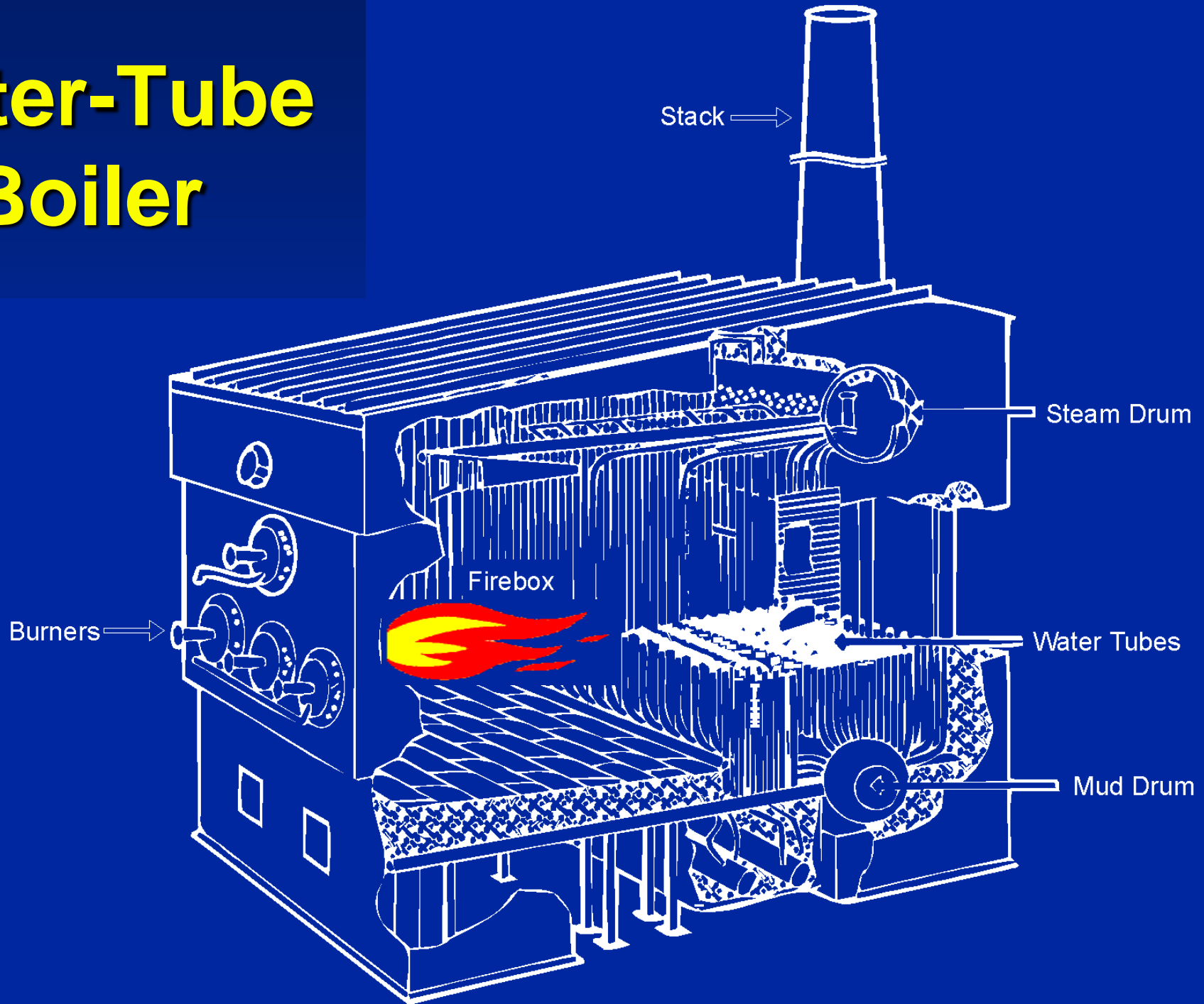


**Small  
Fire-  
Tube  
Boiler**



**Fire-Tube Boiler**

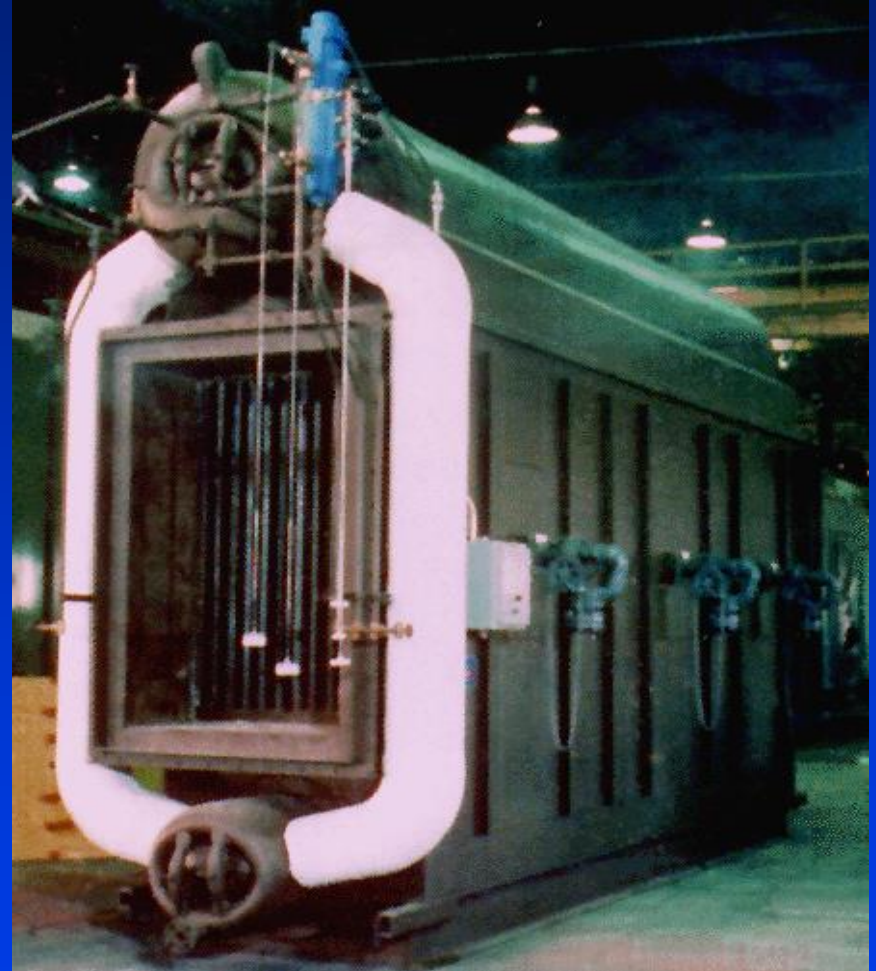
# Water-Tube Boiler





**Water-Tube Boiler**

# Boiler Construction

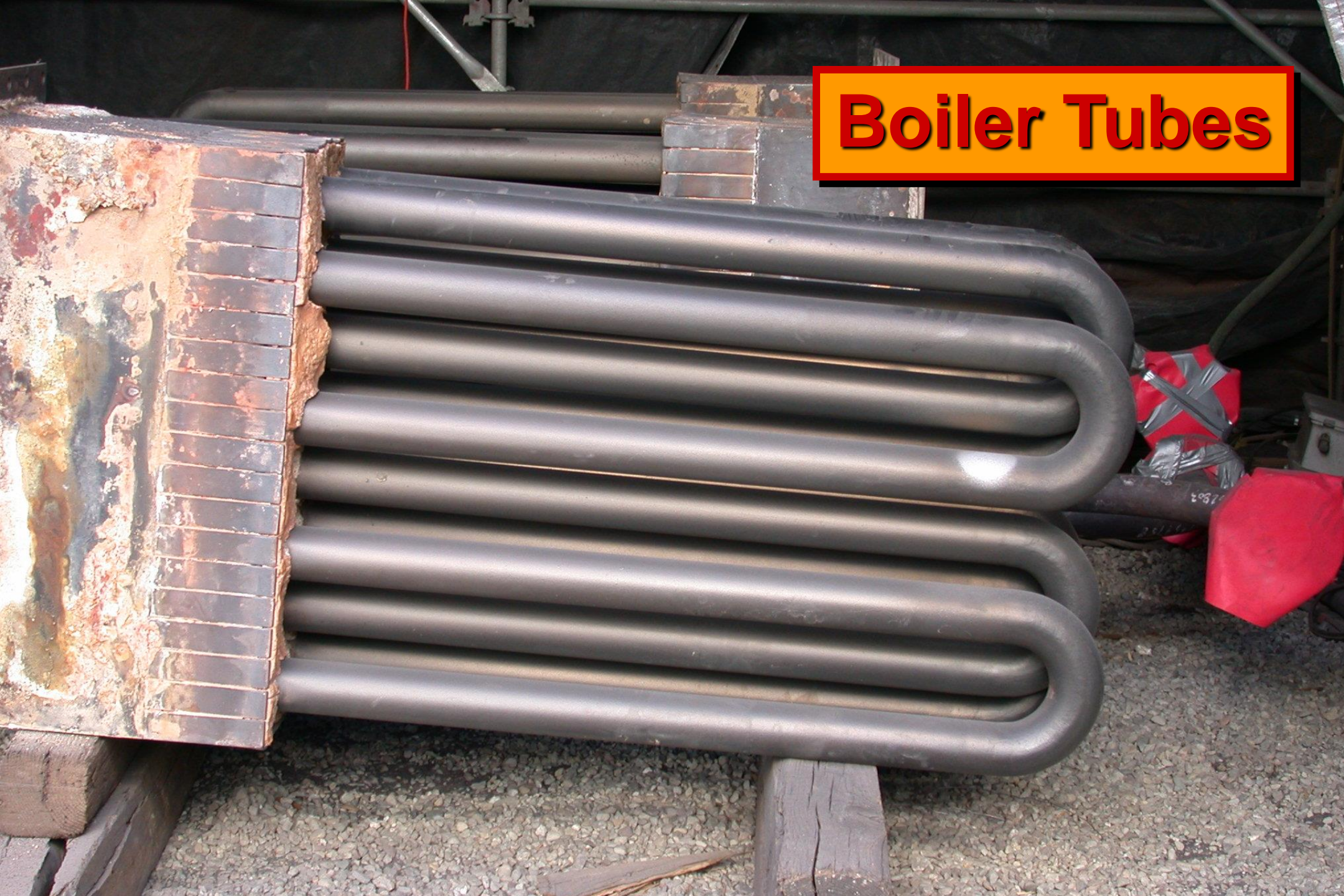


Graphics Courtesy of ERI





# Boiler Tubes

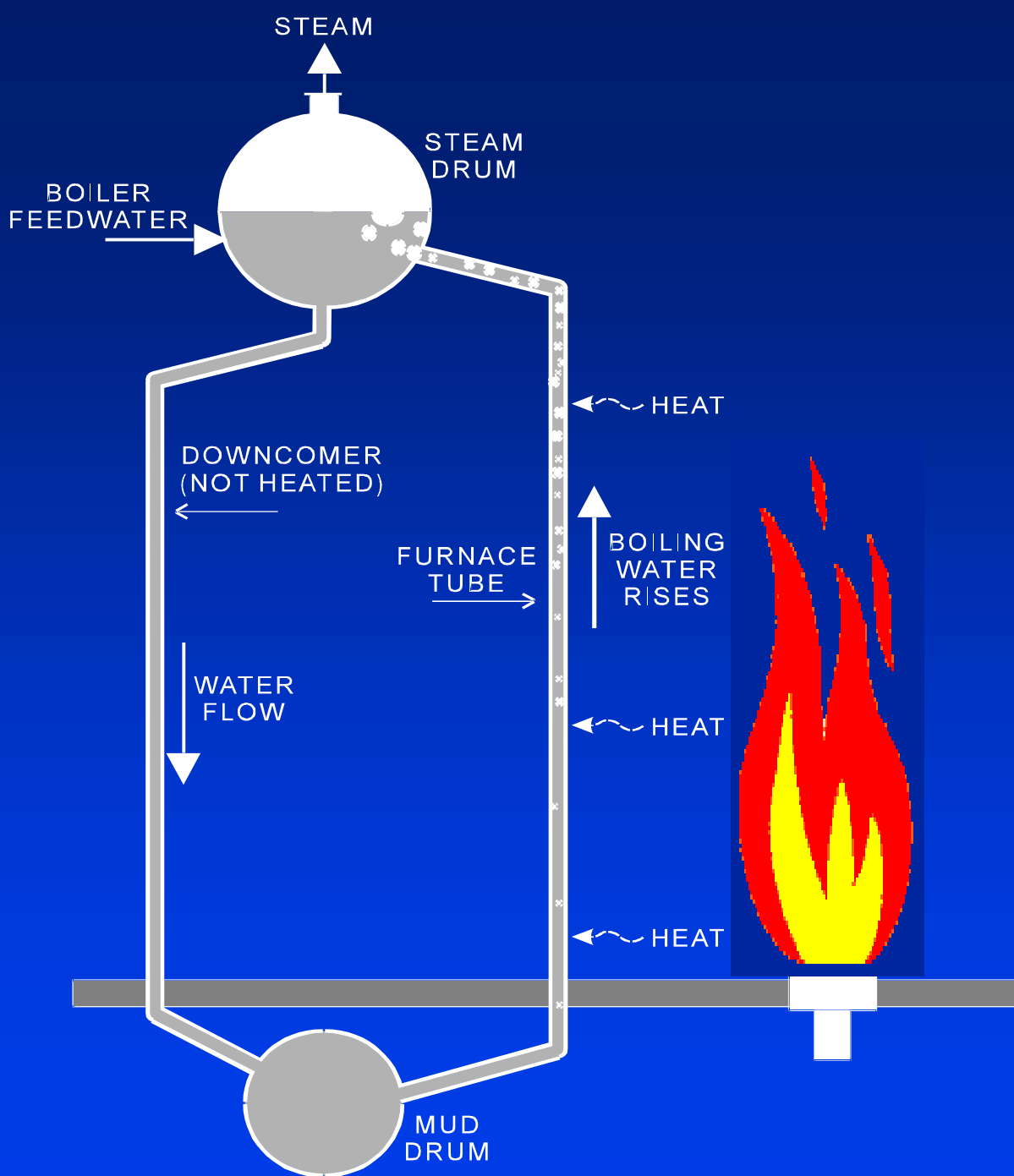


The image shows a close-up, horizontal view of a stack of approximately ten boiler tubes. Each tube is covered in a dense, fine-grained pattern of small, rectangular fins, which are designed to increase the surface area for heat transfer. The tubes are stacked closely together, and the lighting highlights the texture of the fins. At the bottom center, there is a yellow rectangular box with a red border containing the text "Boiler Tubes with Fins" in a bold, red, sans-serif font.

**Boiler Tubes with Fins**

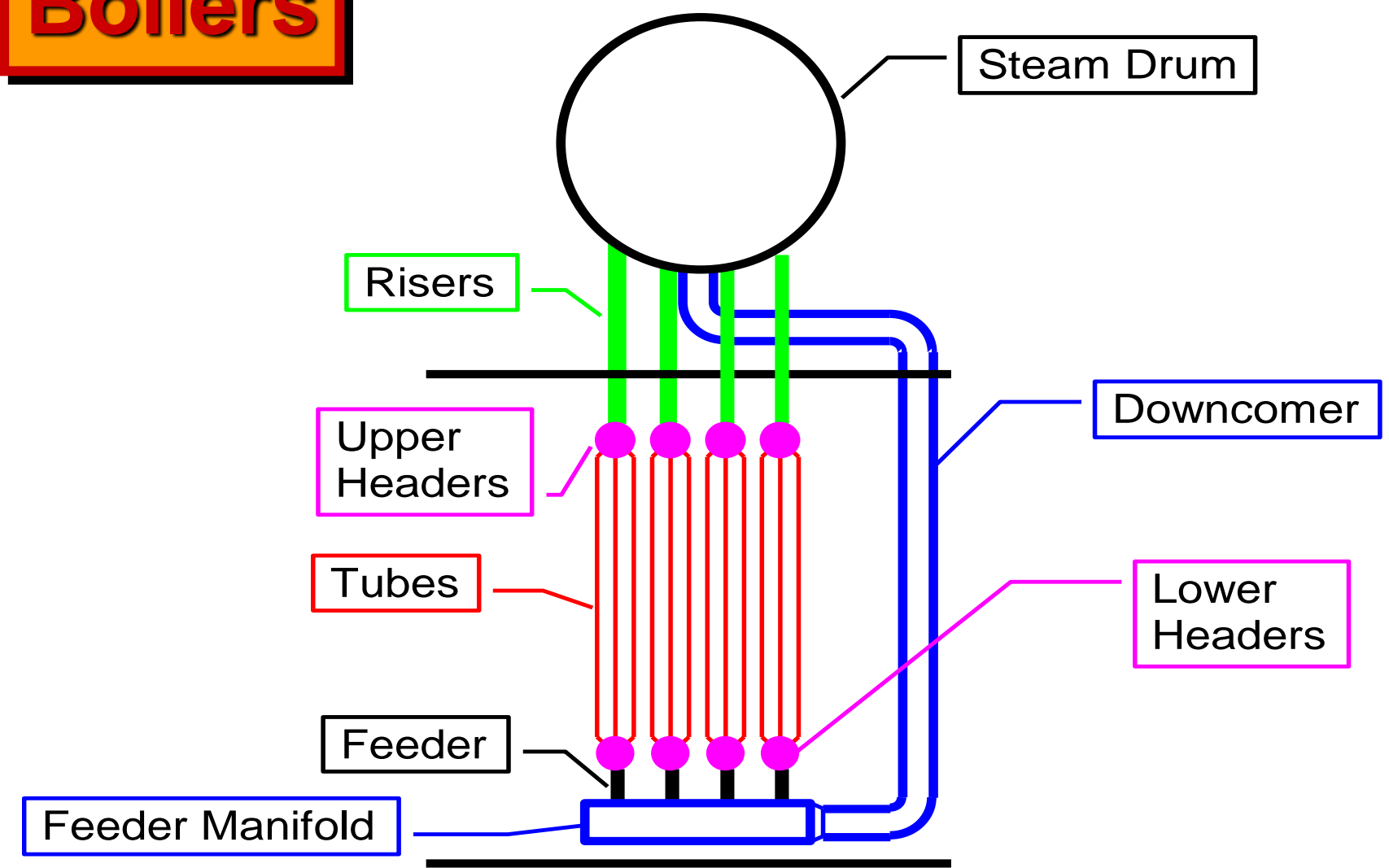
# **Boiler Circulation**





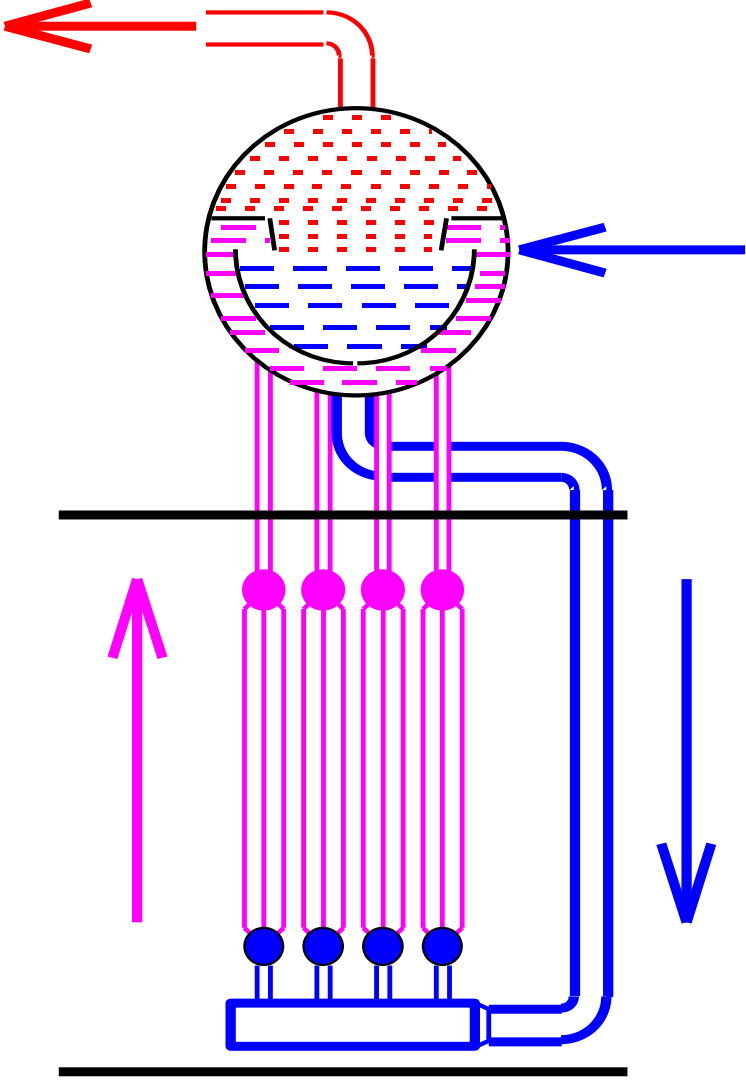
# Water to Steam Circulation Loop

# Boilers

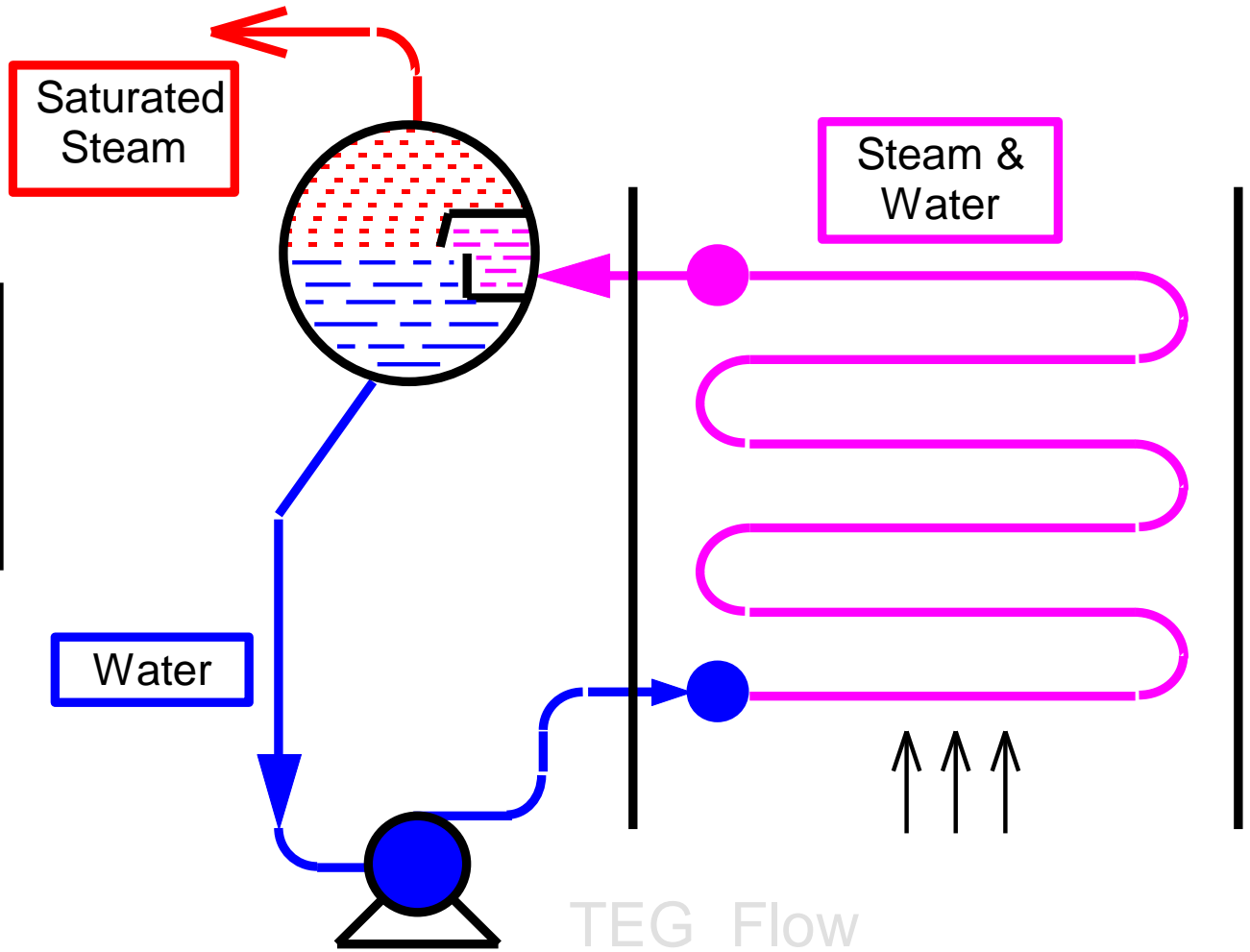


# Natural Circulation

- Water
- Steam & Water
- Saturated Steam



# Forced Circulation



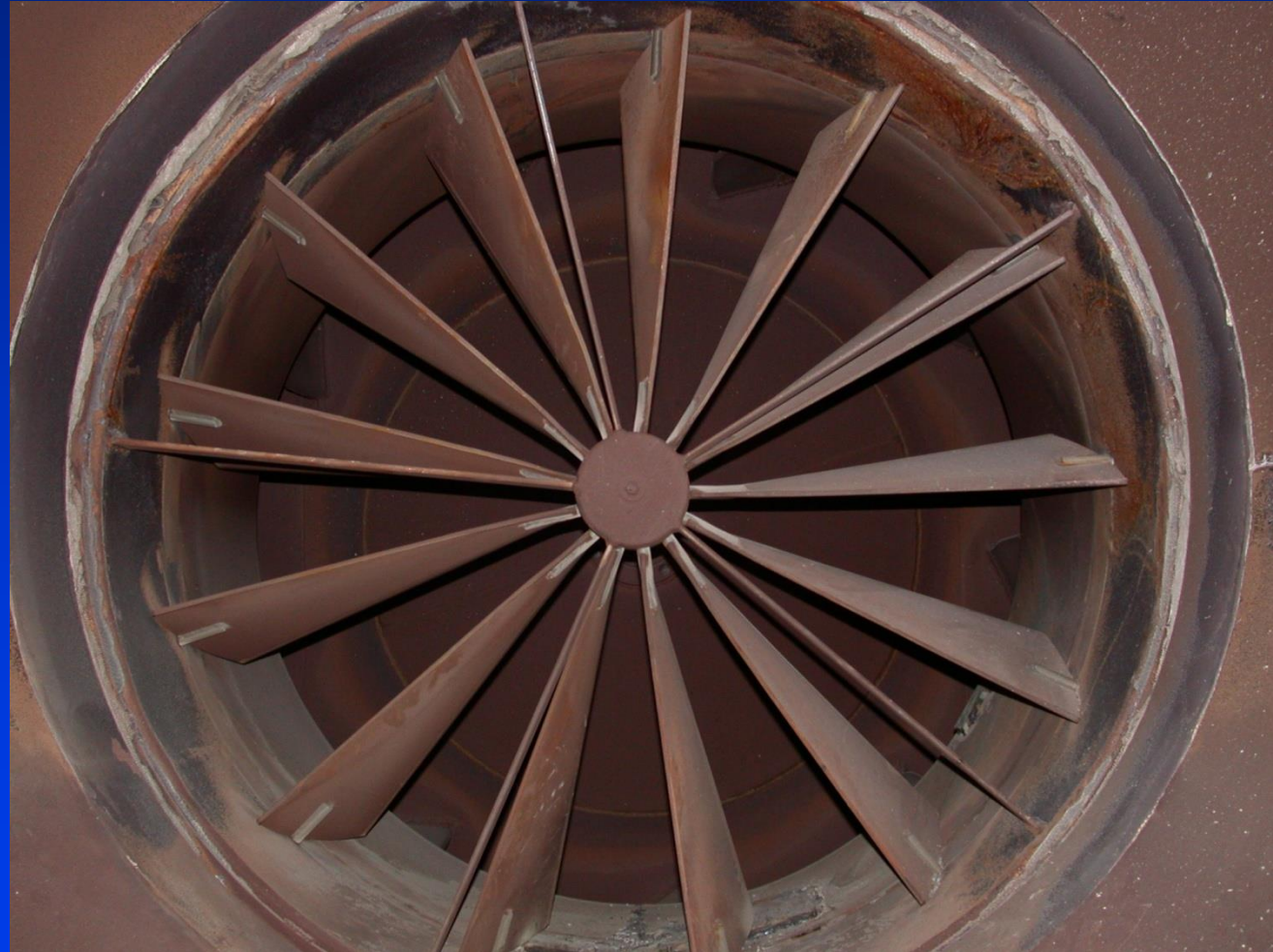




**Let's Discuss Boiler  
Air Requirements**

# Boiler Air Requirements

- ◆ **Draft**
  - ◆ **Natural**
  - ◆ **Forced**
  - ◆ **Induced**
- ◆ **Combustion air**
  - ◆ **Primary**
  - ◆ **Secondary**
  - ◆ **Excess**





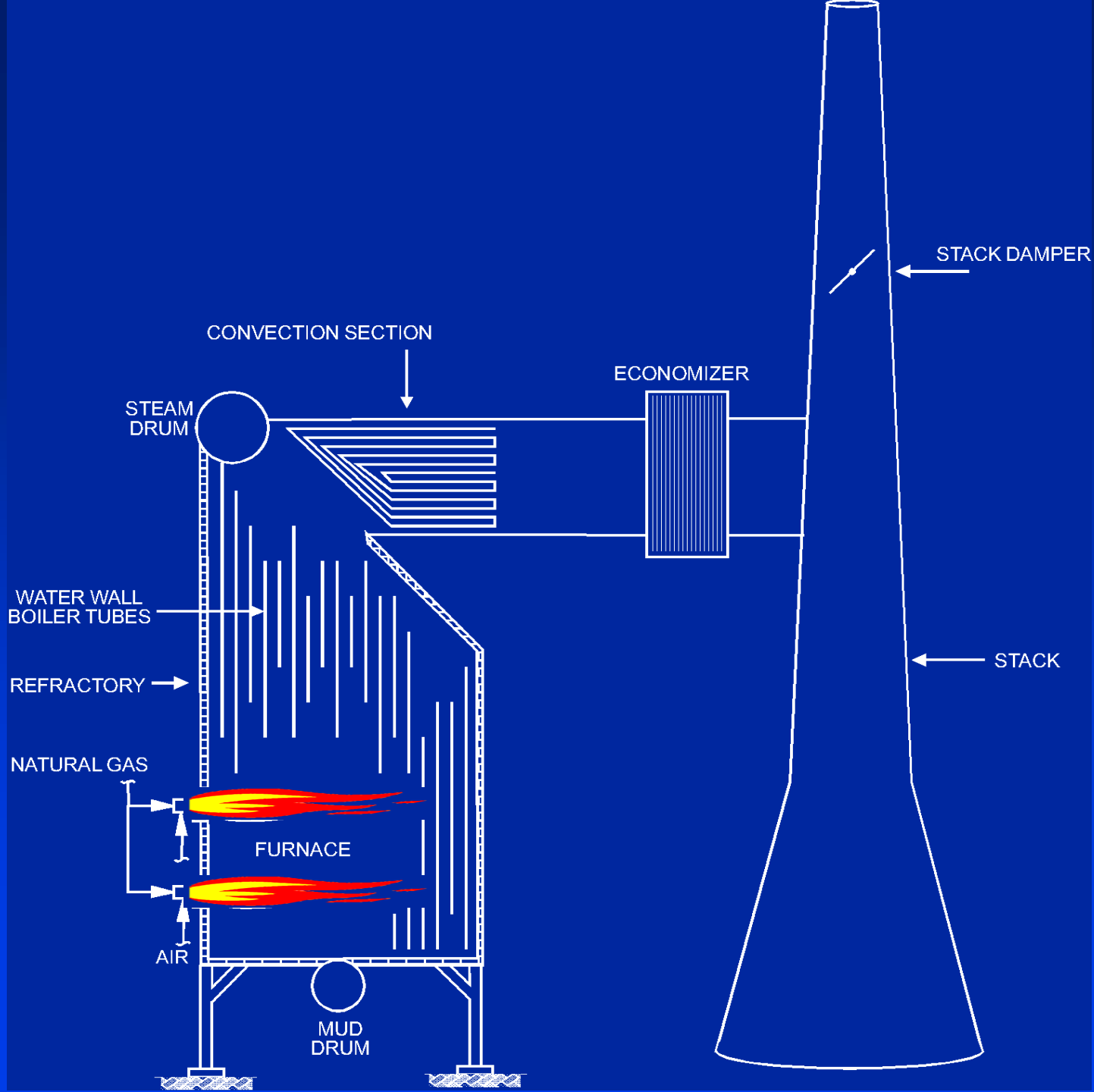
**Forced Draft Fans**



**Induced Draft Fan**

# Induced Draft Fans





# Gas Fired Water Tube Boiler



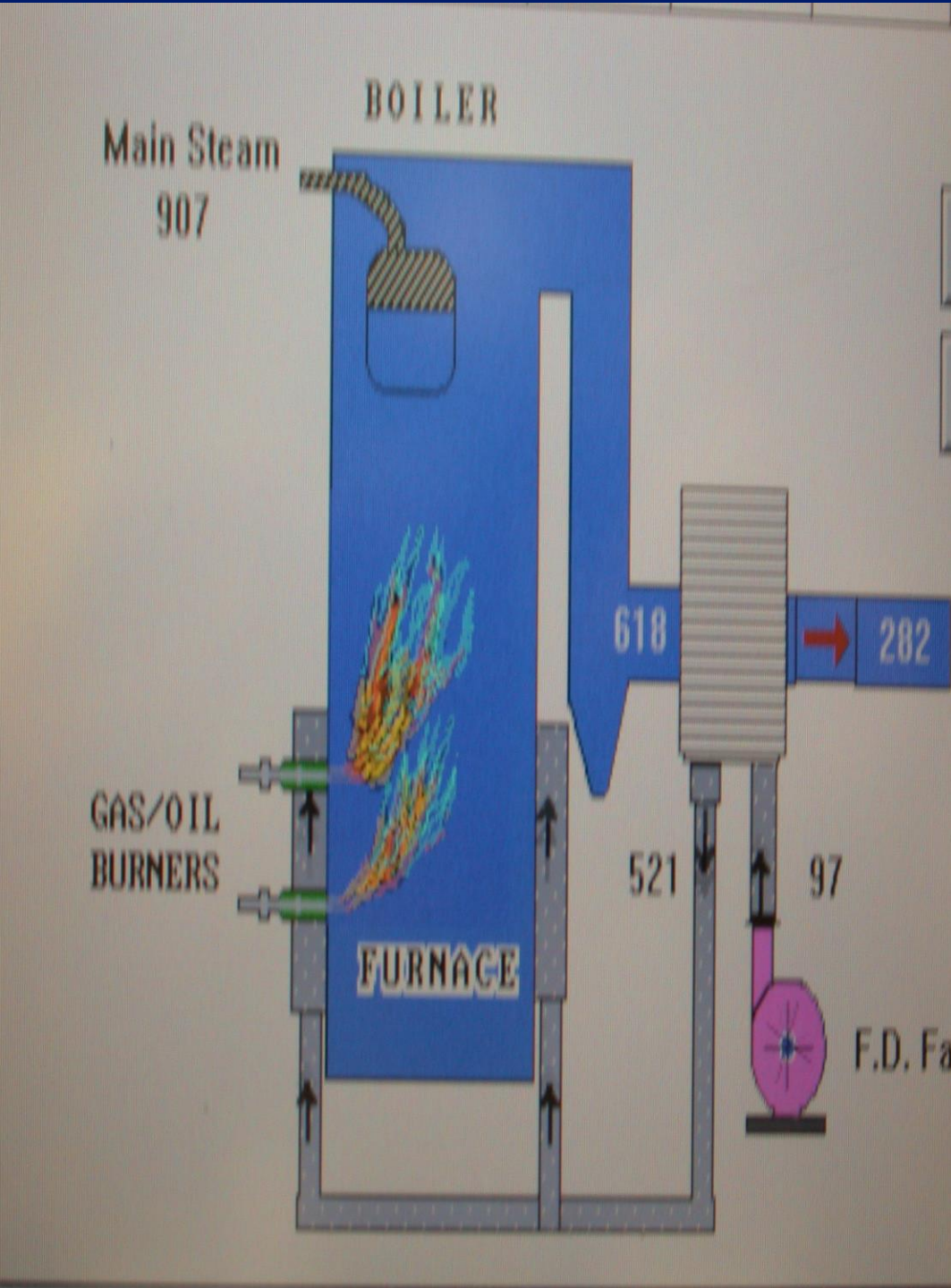
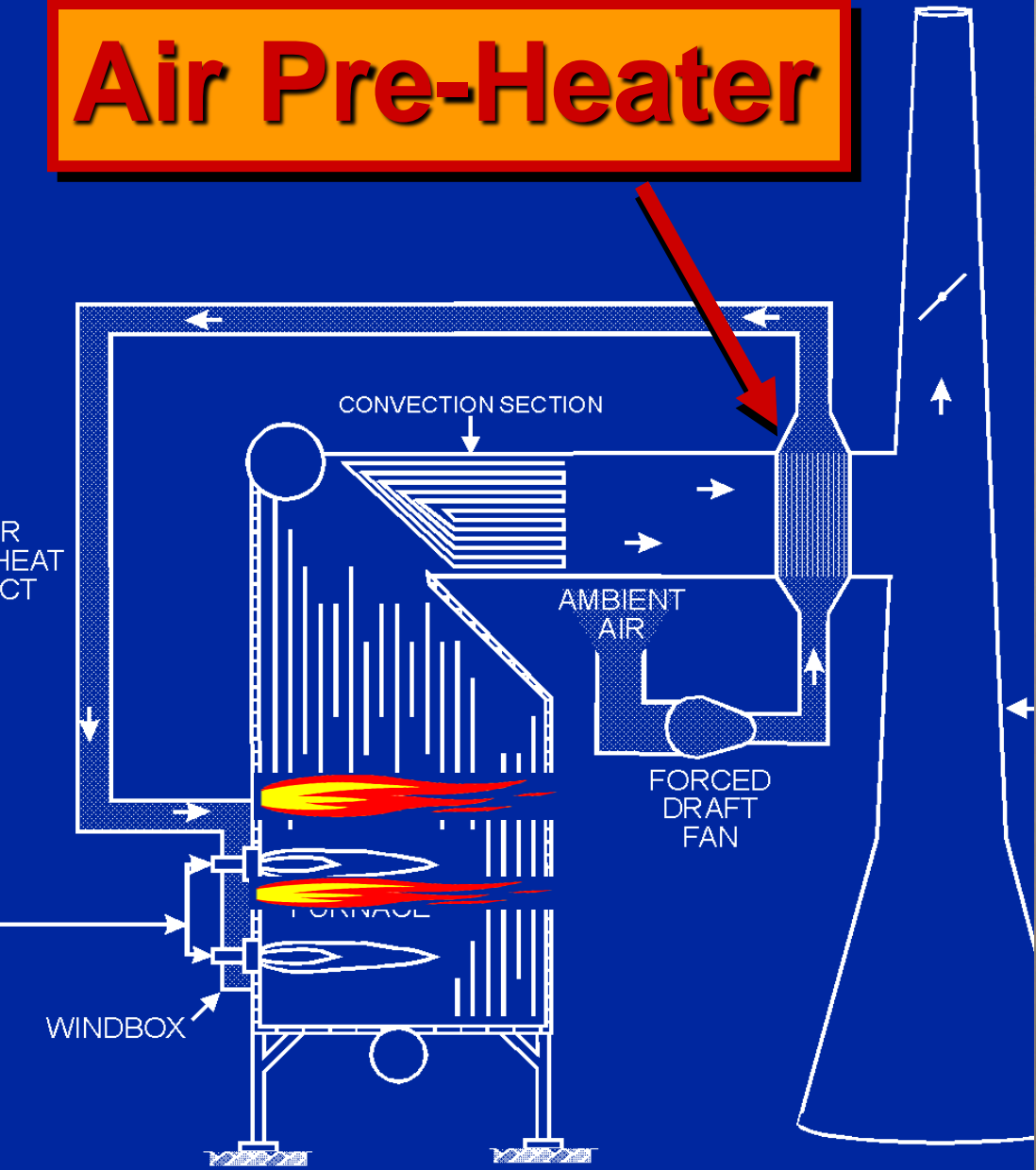
**Let's Discuss Economizers  
& Air-Preheaters**

# Economizer – H<sub>2</sub>O Inside Tubes

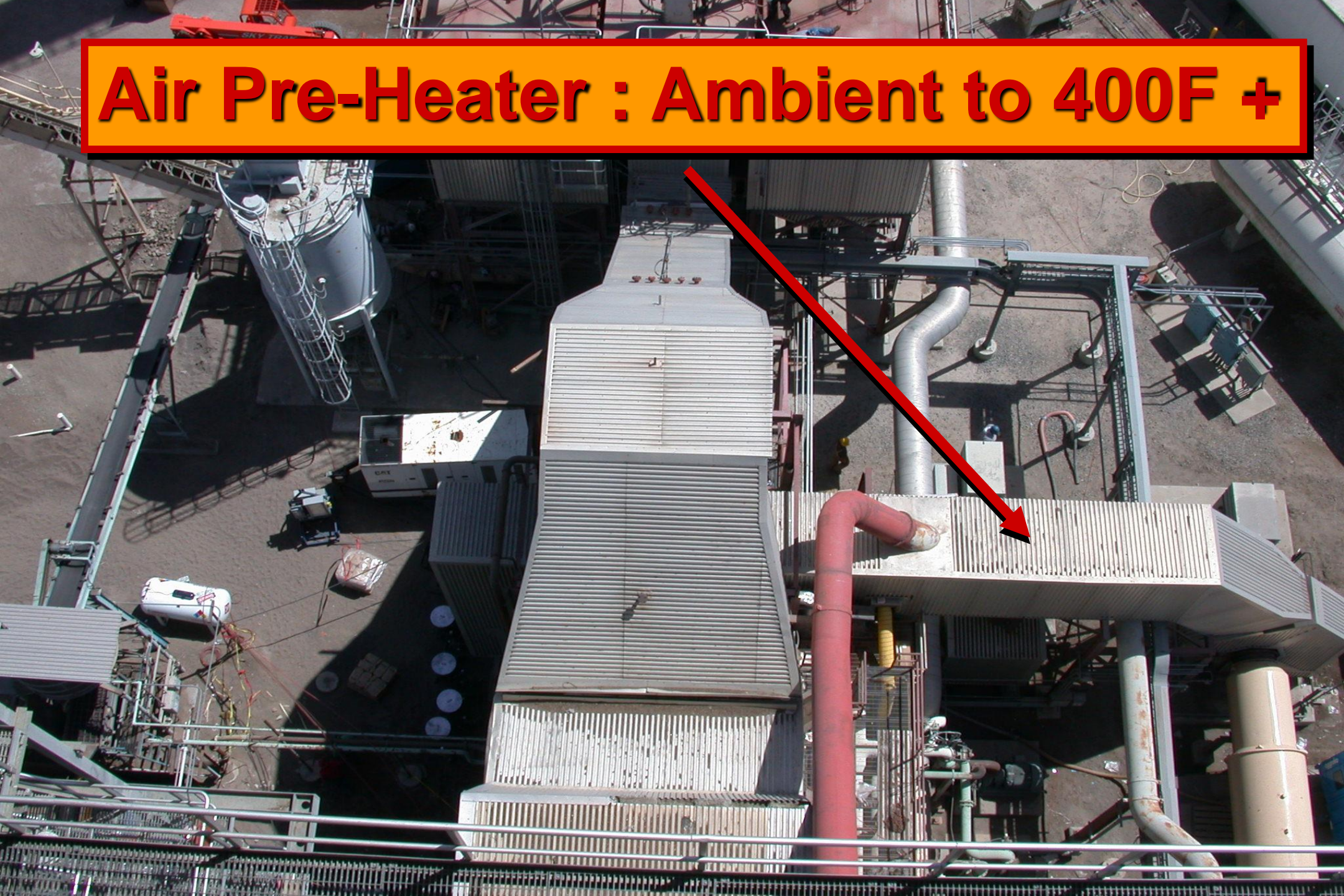




# Air Pre-Heater

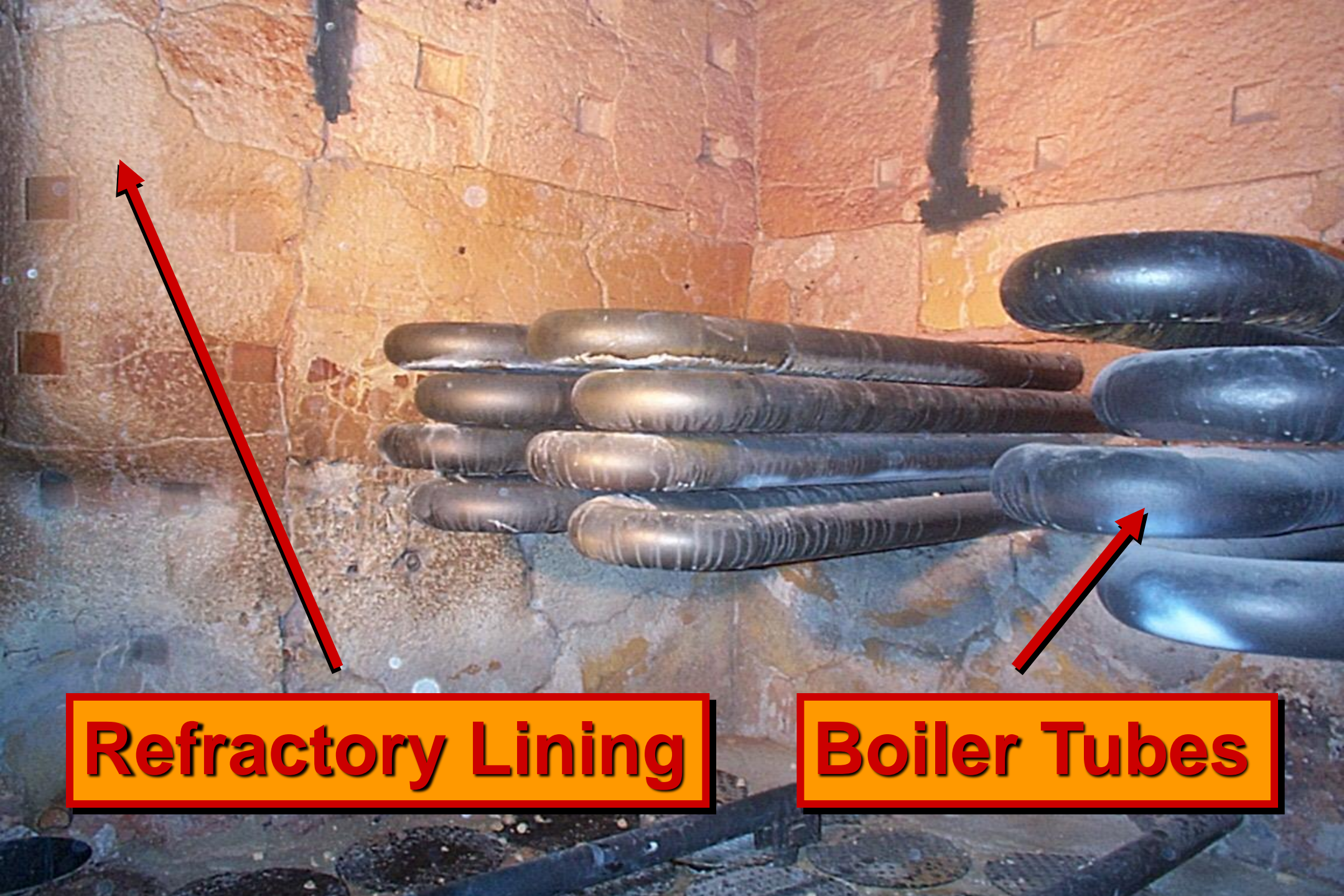


**Air Pre-Heater : Ambient to 400F +**





**Fire Wall**



**Refractory Lining**

**Boiler Tubes**

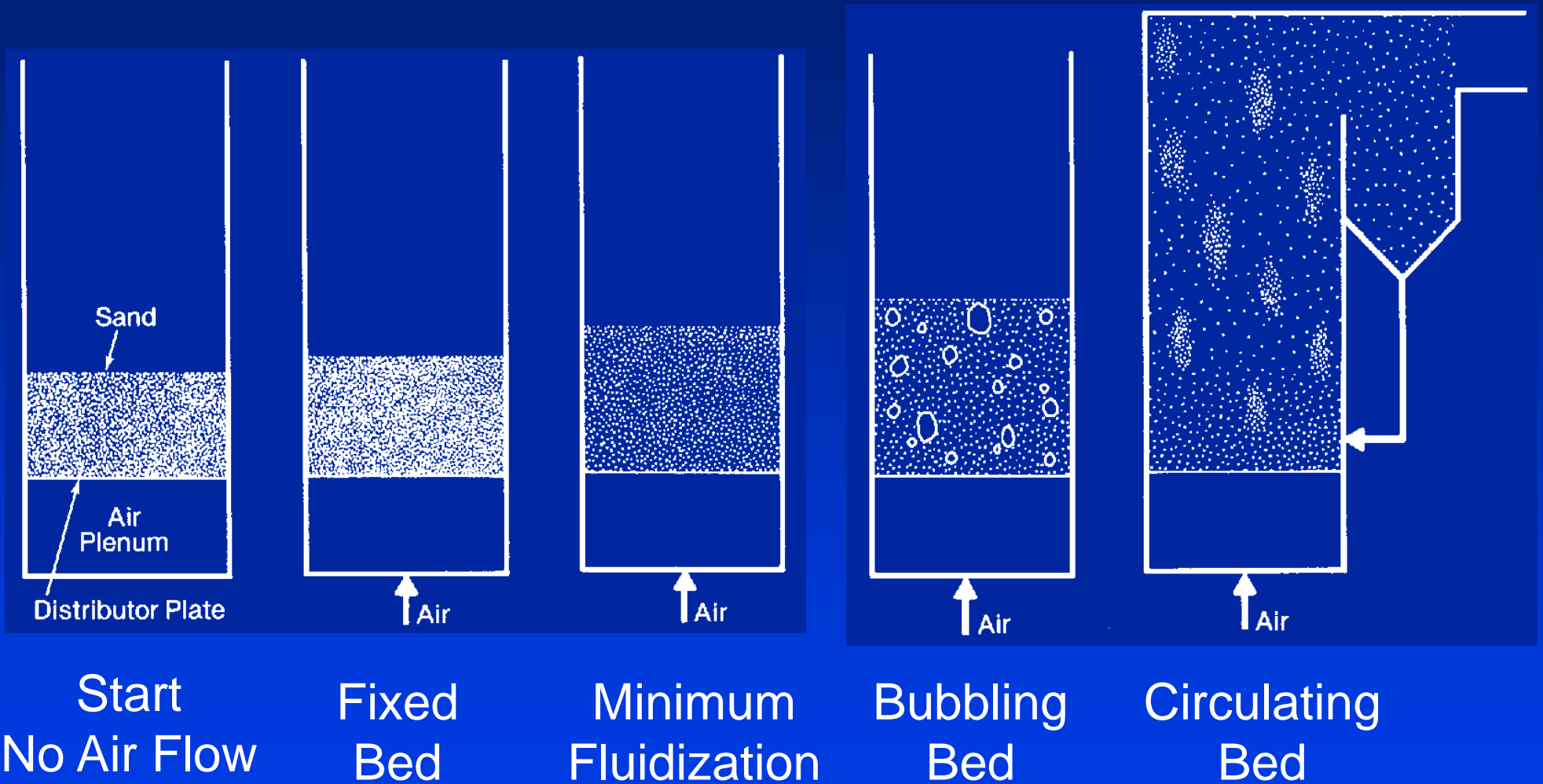


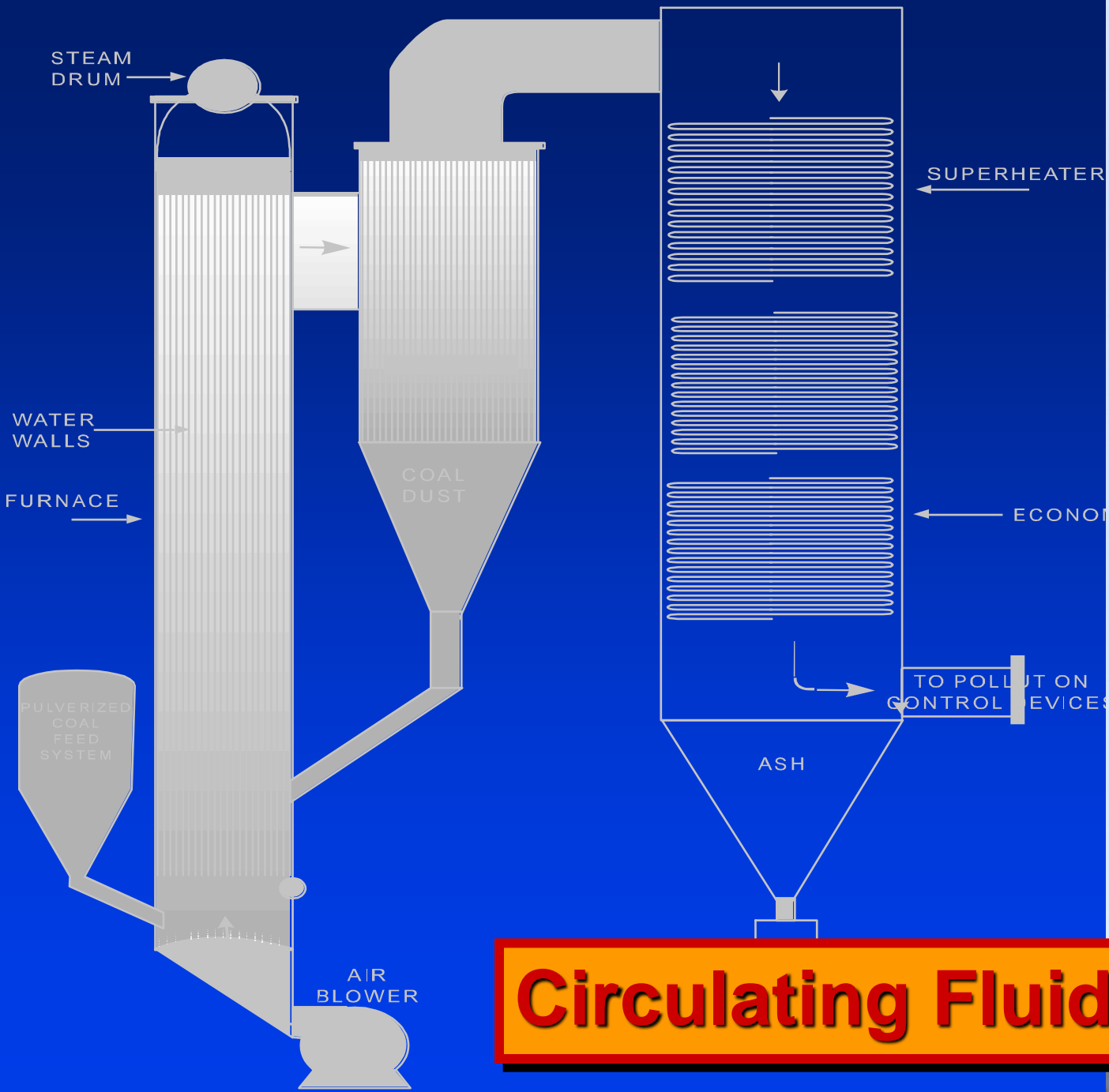
**Boiler Tubes**



**Let's Discuss Fluidized  
Bed Boilers**

# Fluidized Bed Modes



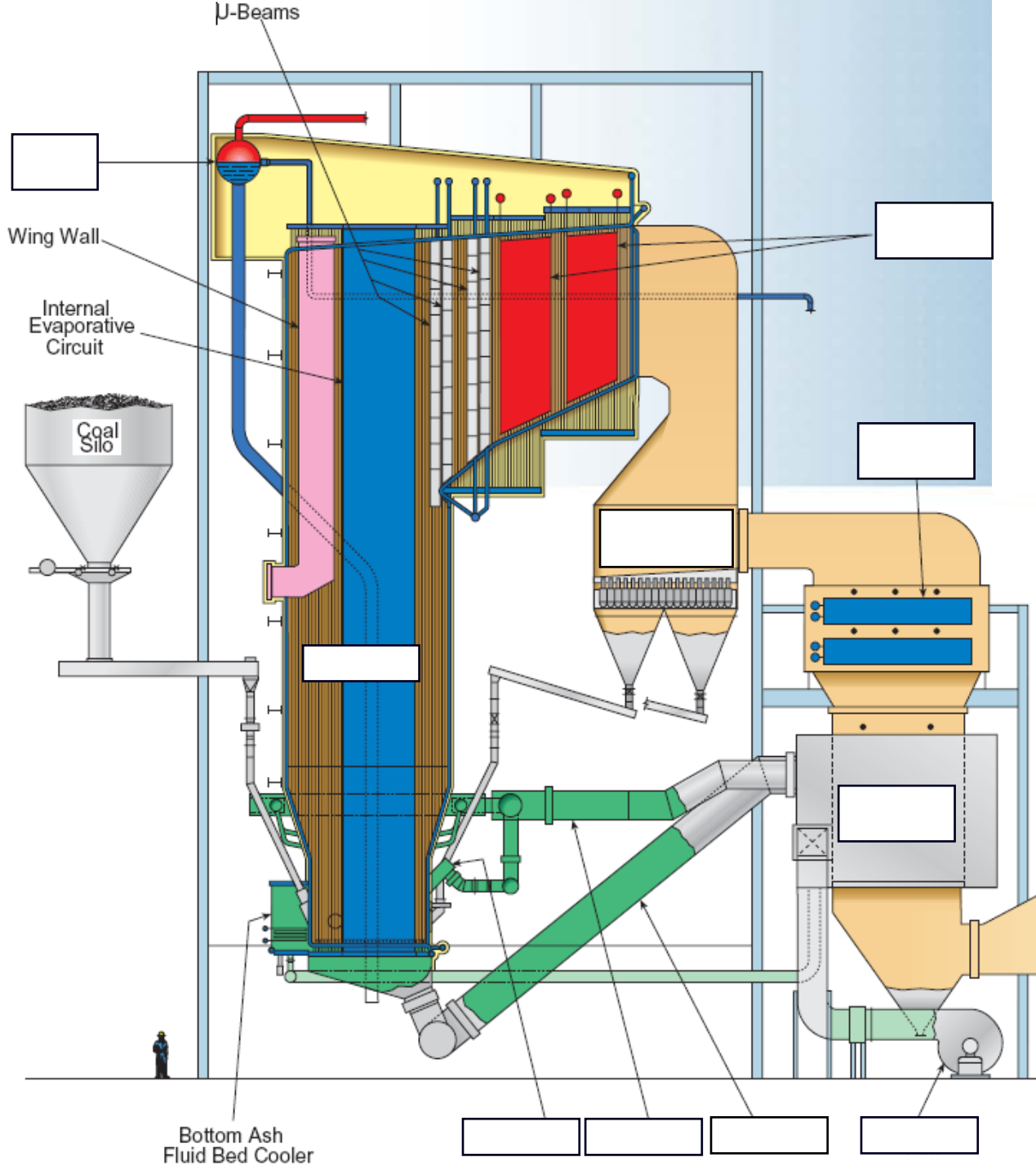


**Circulating Fluidized Bed (CFB)**



# Circulating Fluidized Bed Boiler

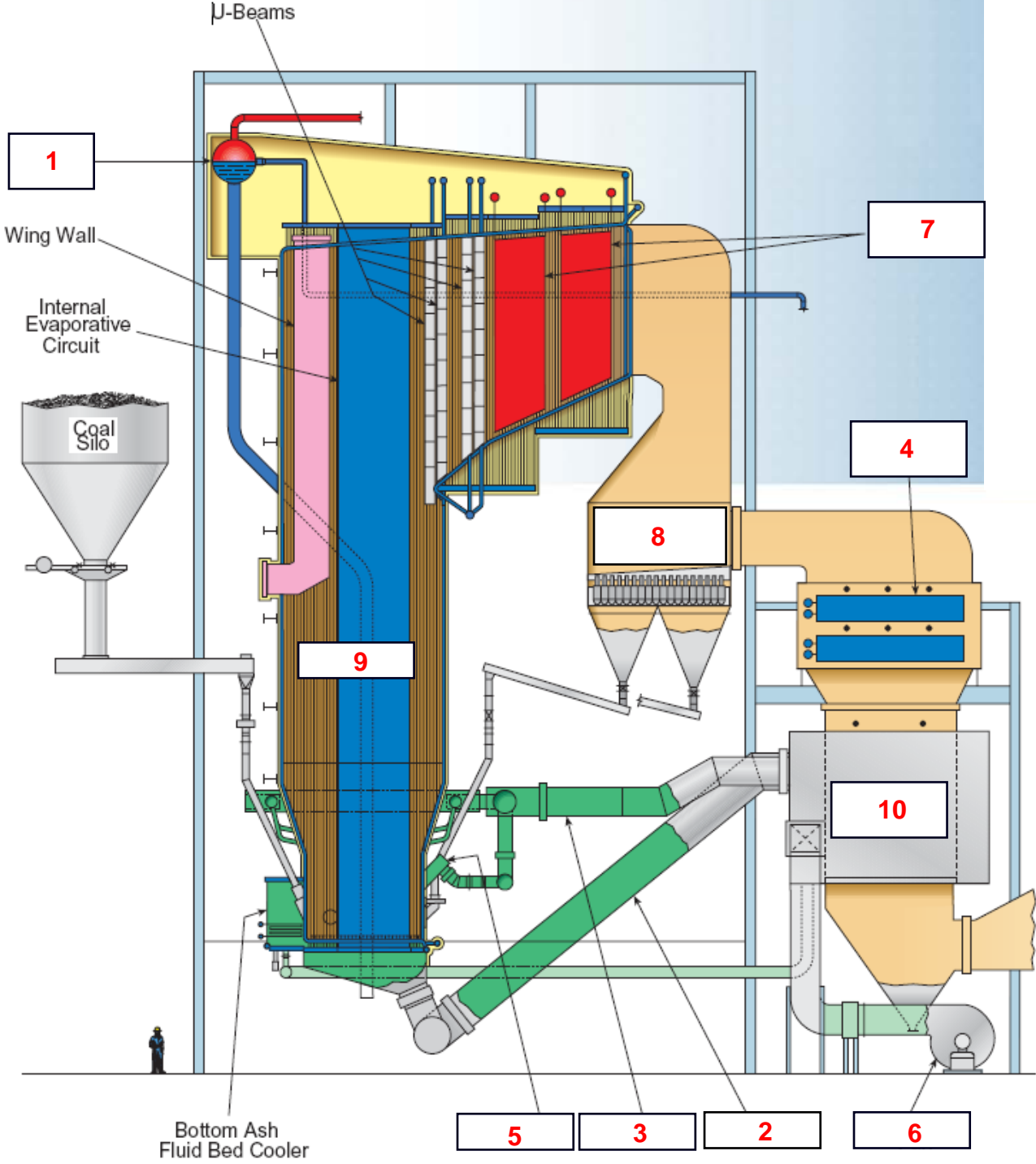
## Interactive Exercise



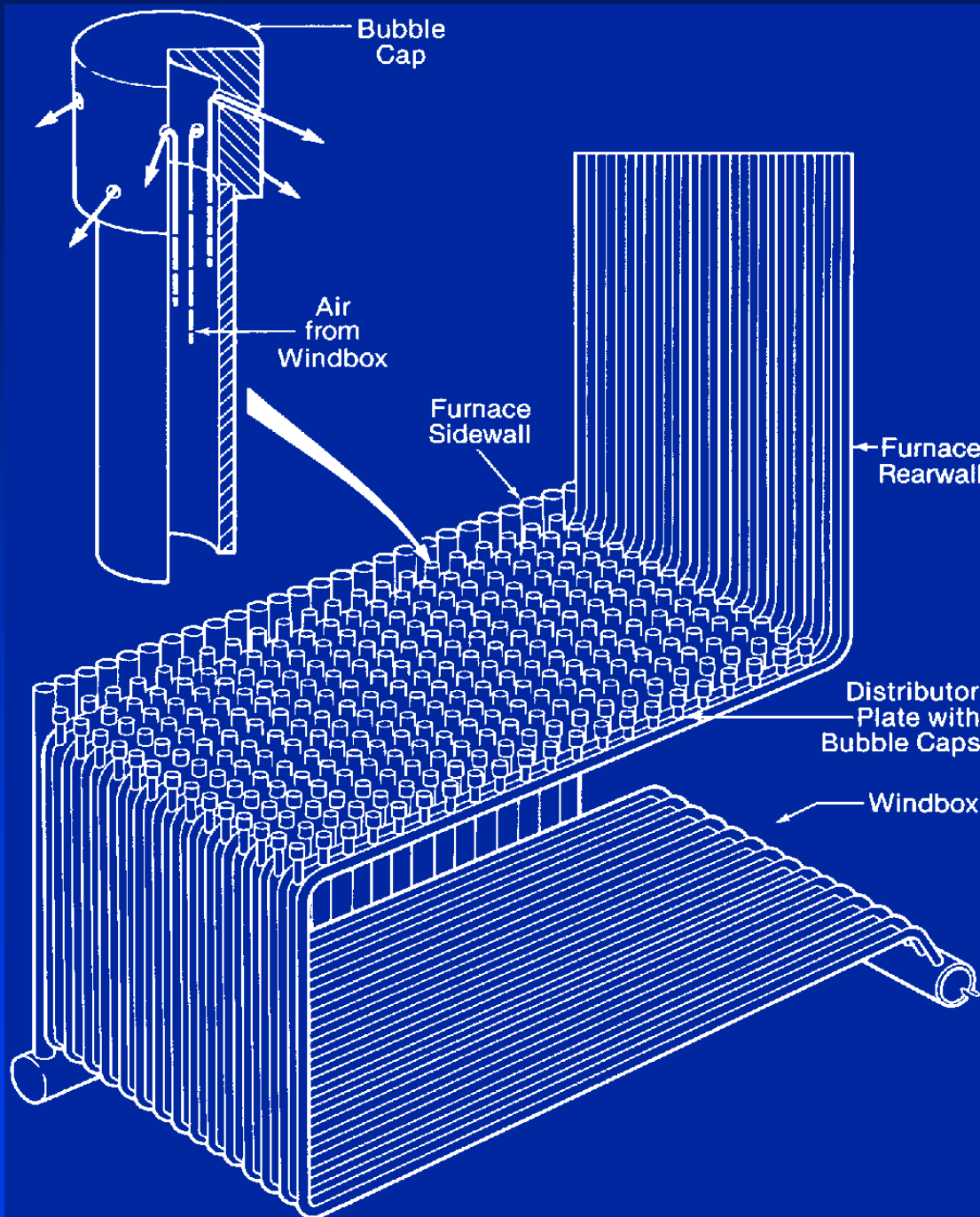
1. Steam Drum
2. Primary Air
3. Secondary Air
4. Economizer
5. Startup Burner
6. Forced Draft Fan
7. Superheater
8. Multi-cyclone
9. Furnace
10. Air Heater

# Circulating Fluidized Bed Boiler

## Interactive Exercise



1. Steam Drum
2. Primary Air
3. Secondary Air
4. Economizer
5. Startup Burner
6. Forced Draft Fan
7. Superheater
8. Multi-cyclone
9. Furnace
10. Air Heater



# Fluidized Bed Distributor Plate & Bubble Caps

*Graphic Courtesy of B&W*

**Feed Lot**

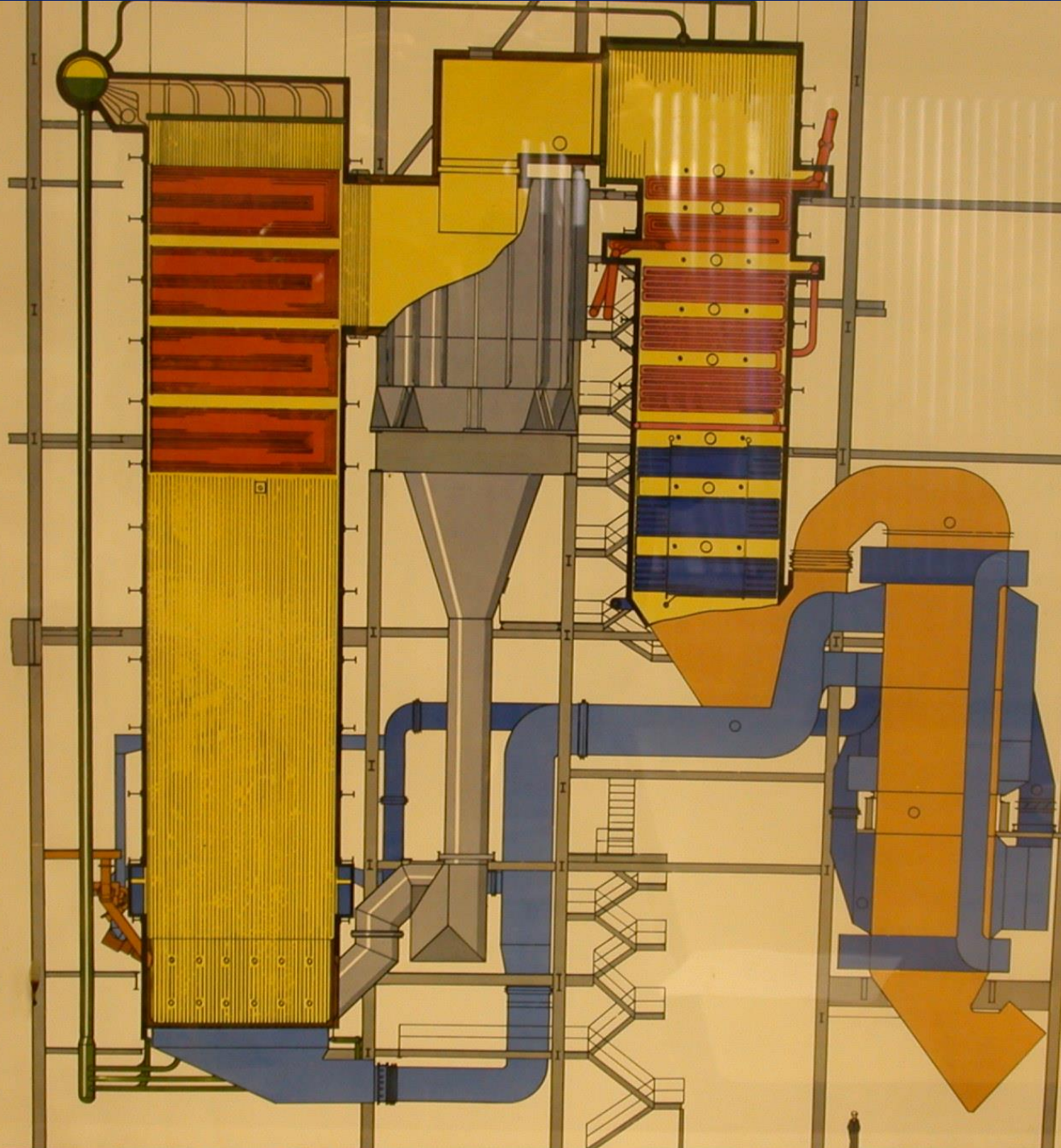
**Enclosed Conveyors**



**Fuel Storage Silo**

**Enclosed Conveyor**





**Water  
to  
Steam  
Loop**



**Superheater**

**Economizer**

**Air Preheater**

**Furnace**

**Pulverized  
Coal Lines:  
Gravity Fed**





# Inside the Boiler



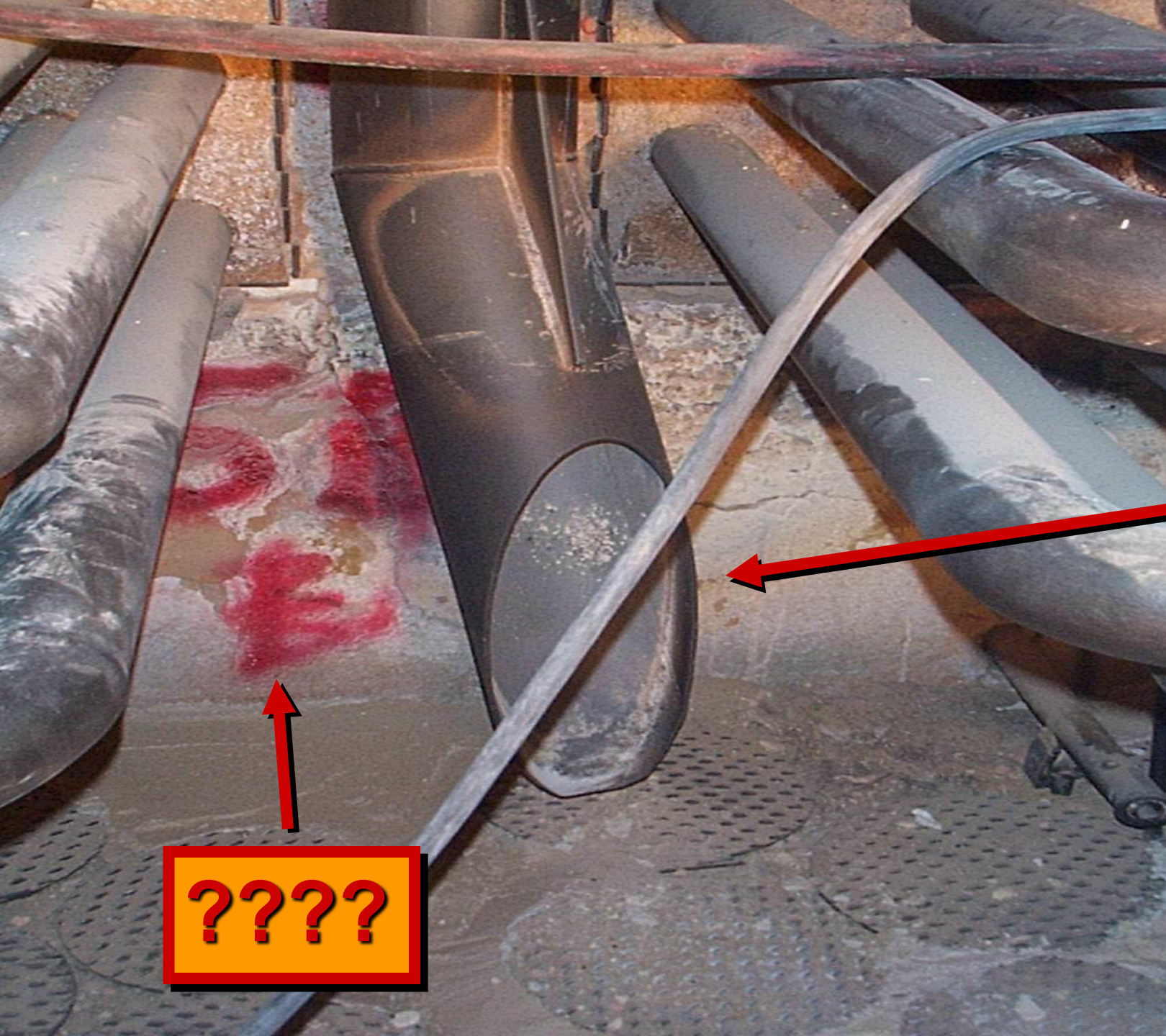


**Water Tubes**



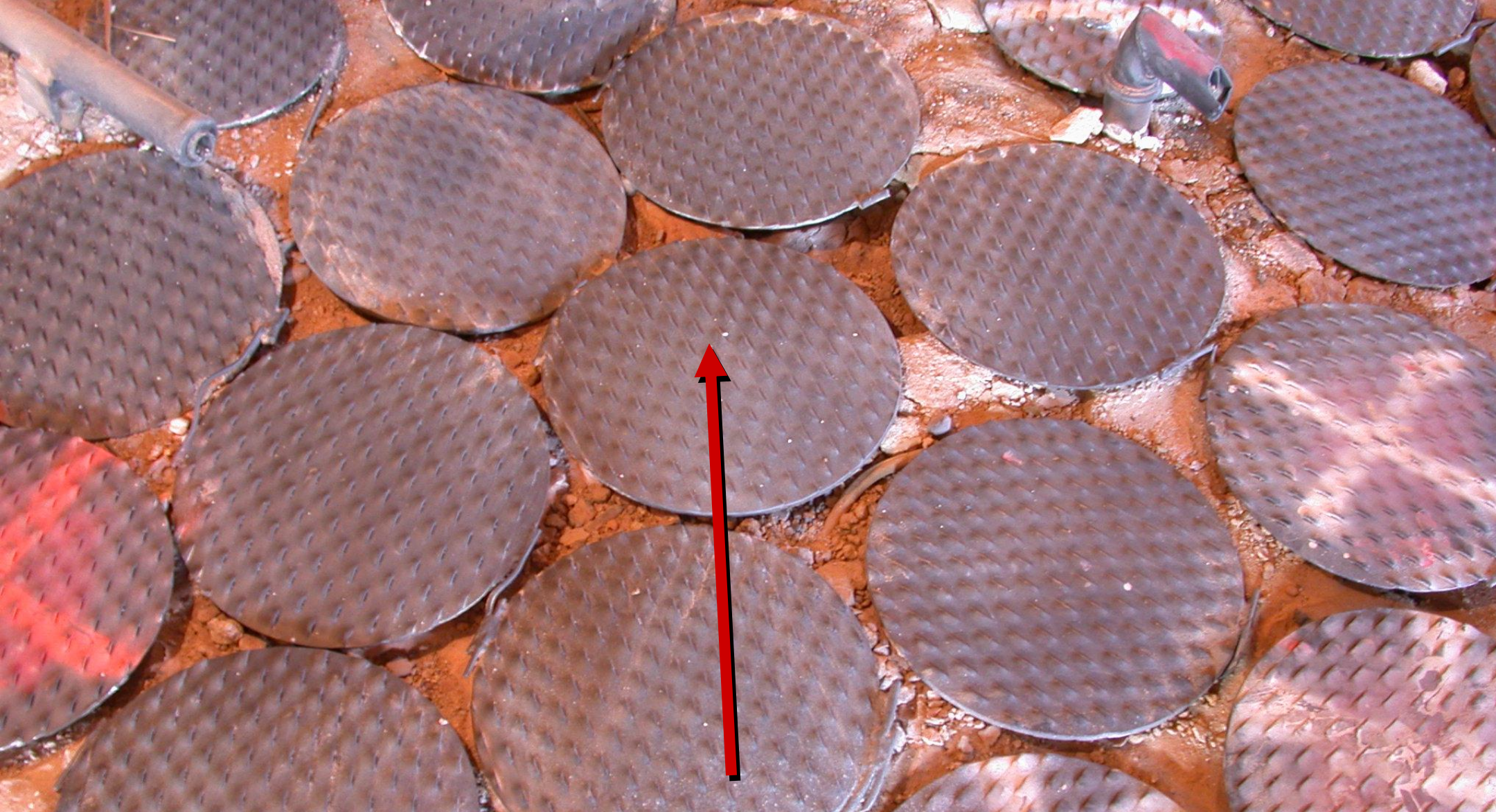
55

**Water  
Tubes**



**Re-cir.  
Fines  
Nozzle**

**?????**



**Distributor Plates & Bubble Caps**



**Bubble  
Caps**

# Bed Nozzles & Underfire Air





**Ash  
Loadout**



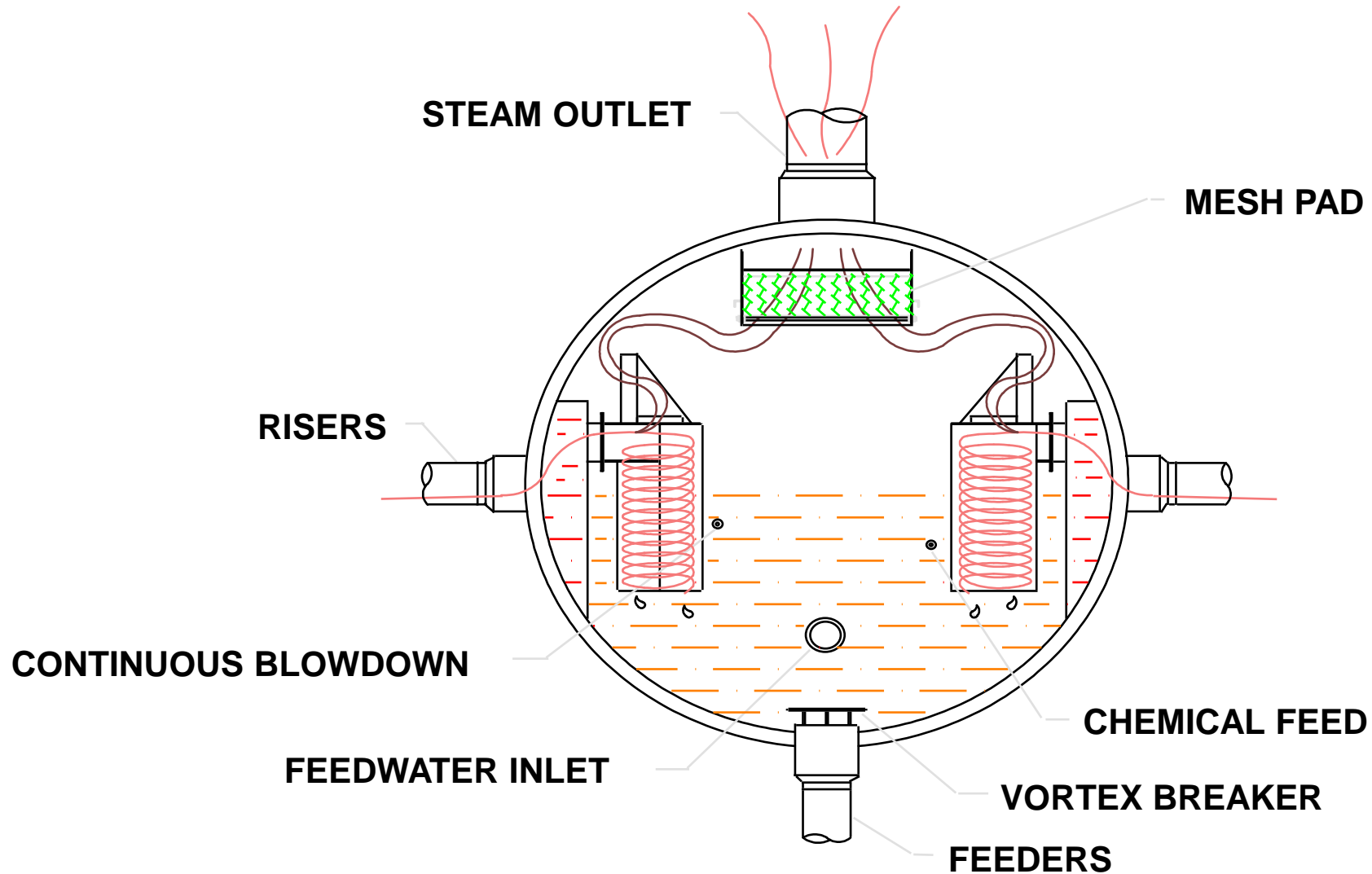


**High Pressure Steam Drums**

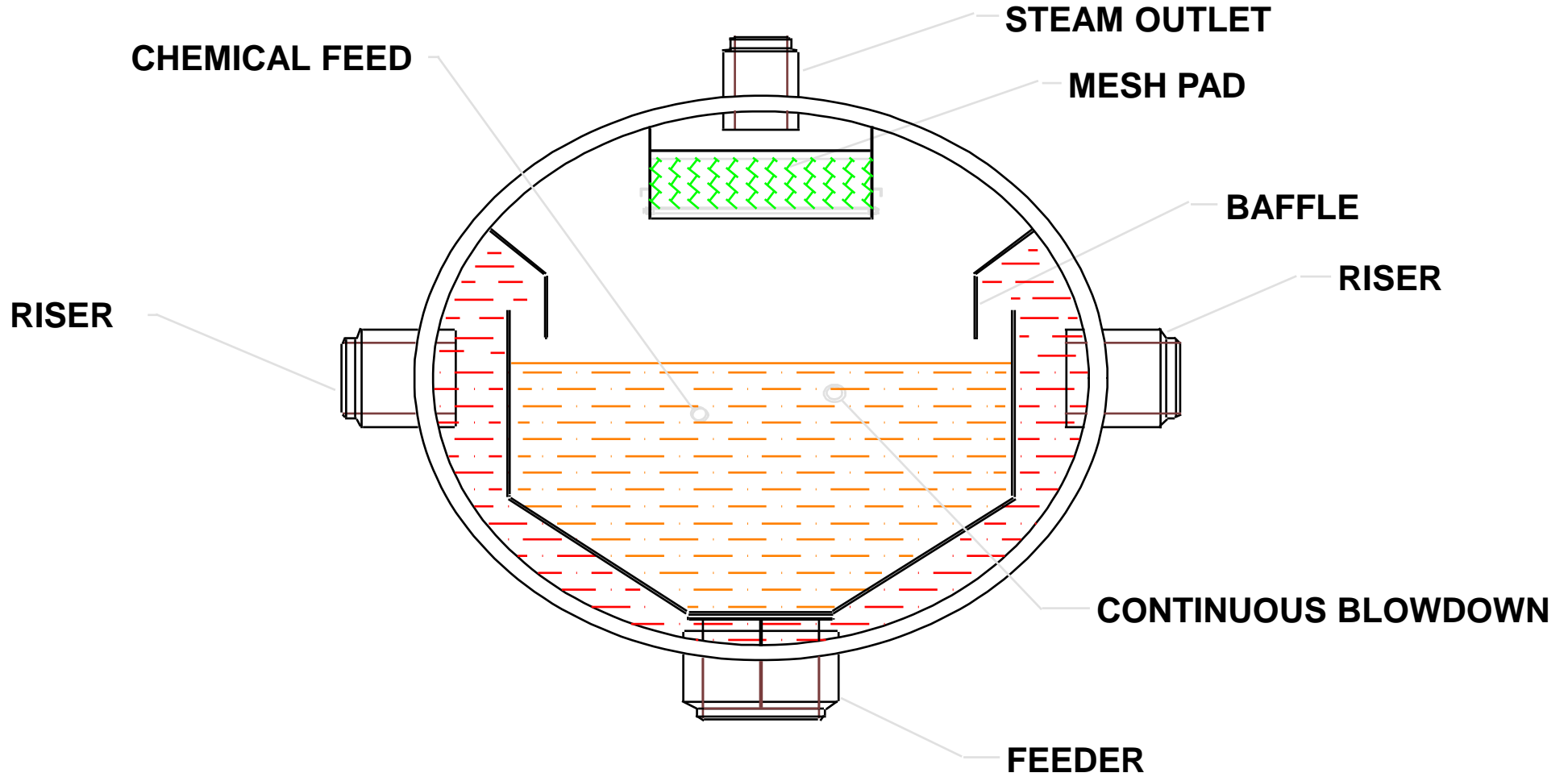


**Steam Drum w/Cyclone &  
Chevron Separators**

# STEAM DRUM INTERNALS CYCLONES WITH MESH PAD

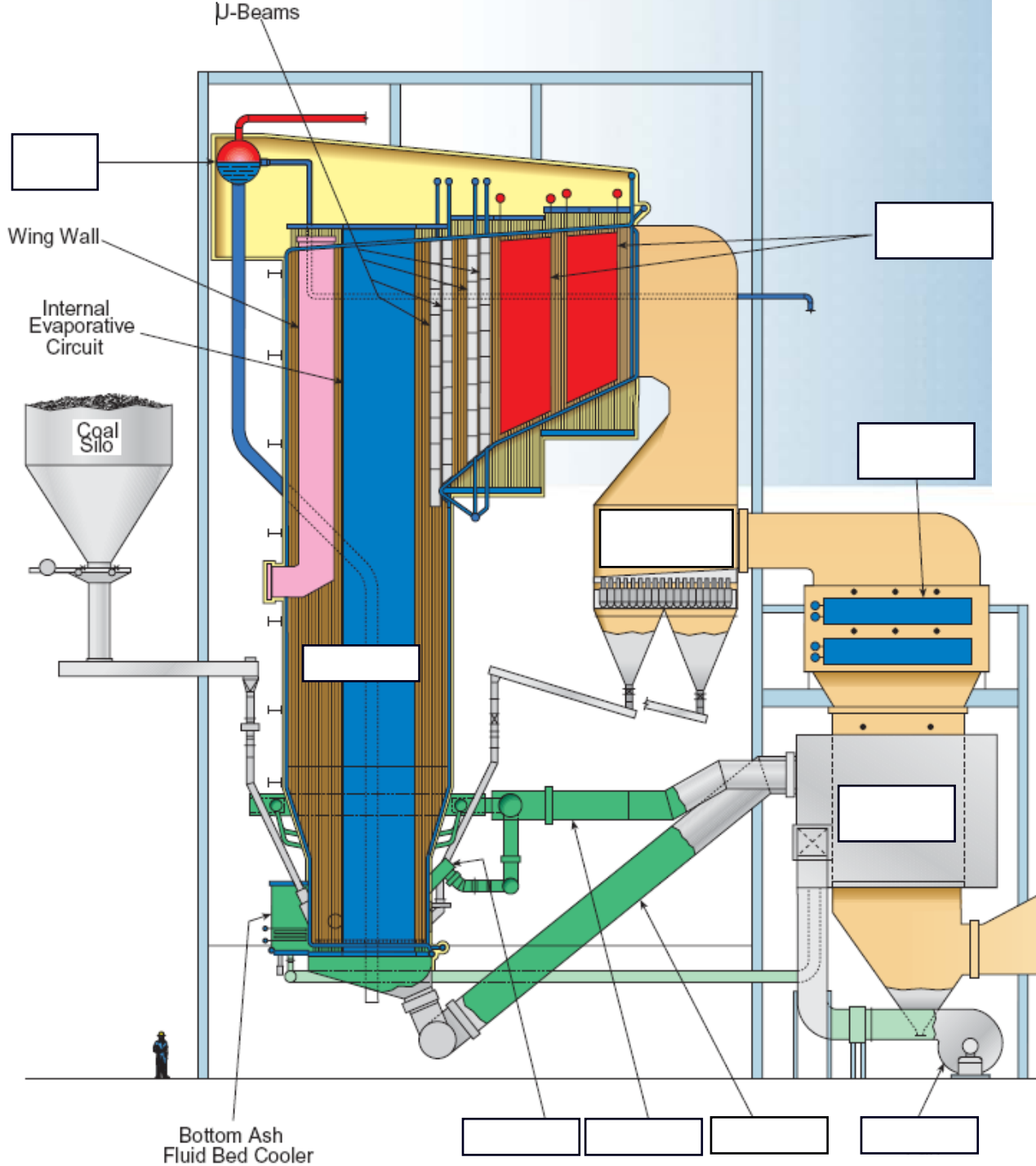


# STEAM DRUM INTERNALS BAFFLE PLATE WITH MESH PAD



# Circulating Fluidized Bed Boiler

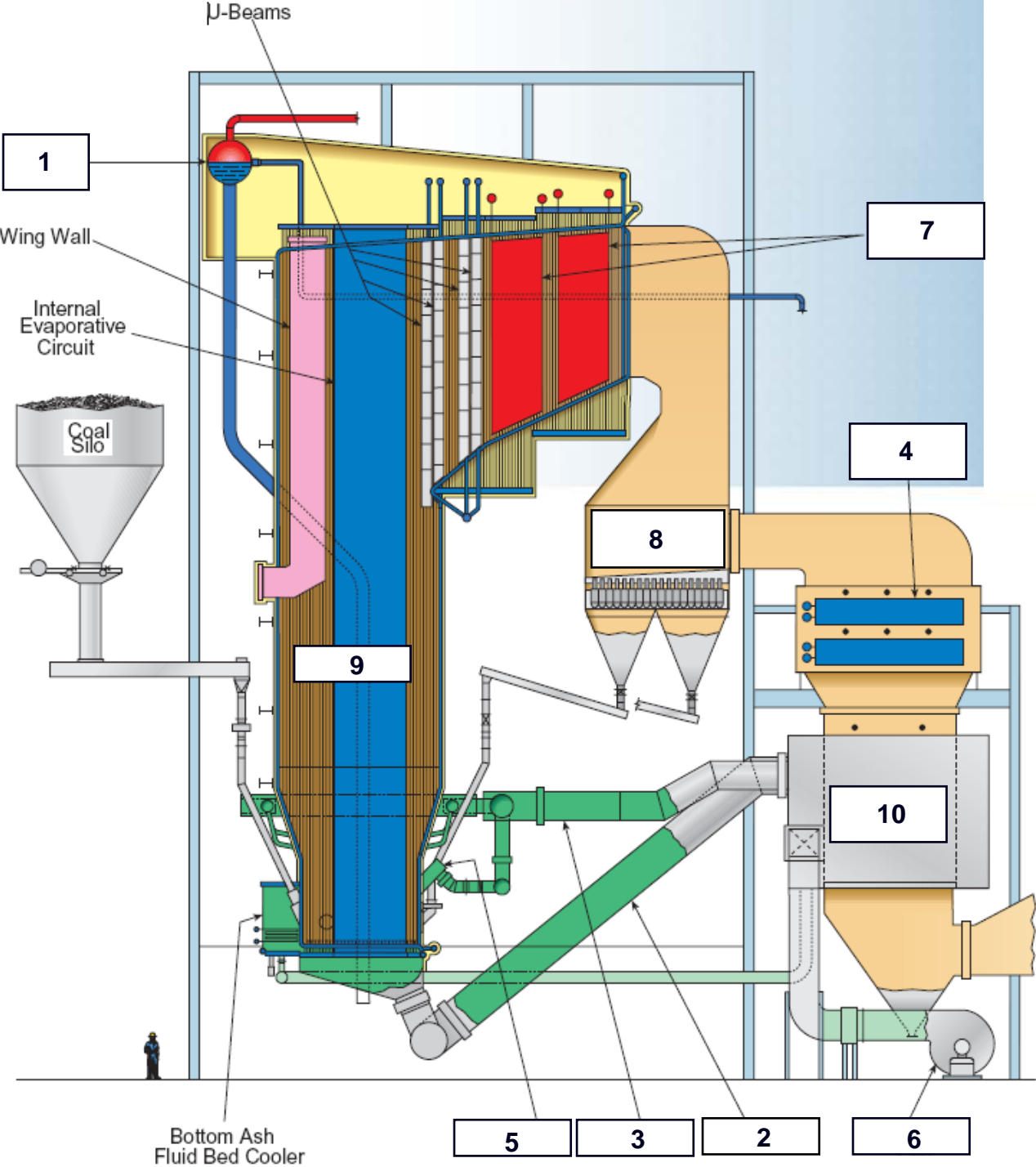
## Interactive Exercise



1. Steam Drum
2. Primary Air
3. Secondary Air
4. Economizer
5. Startup Burner
6. Forced Draft Fan
7. Superheater
8. Multi-cyclone
9. Furnace
10. Air Heater

# Circulating Fluidized Bed Boiler

## Interactive Exercise



1. Steam Drum
2. Primary Air
3. Secondary Air
4. Economizer
5. Startup Burner
6. Forced Draft Fan
7. Superheater
8. Multi-cyclone
9. Furnace
10. Air Heater

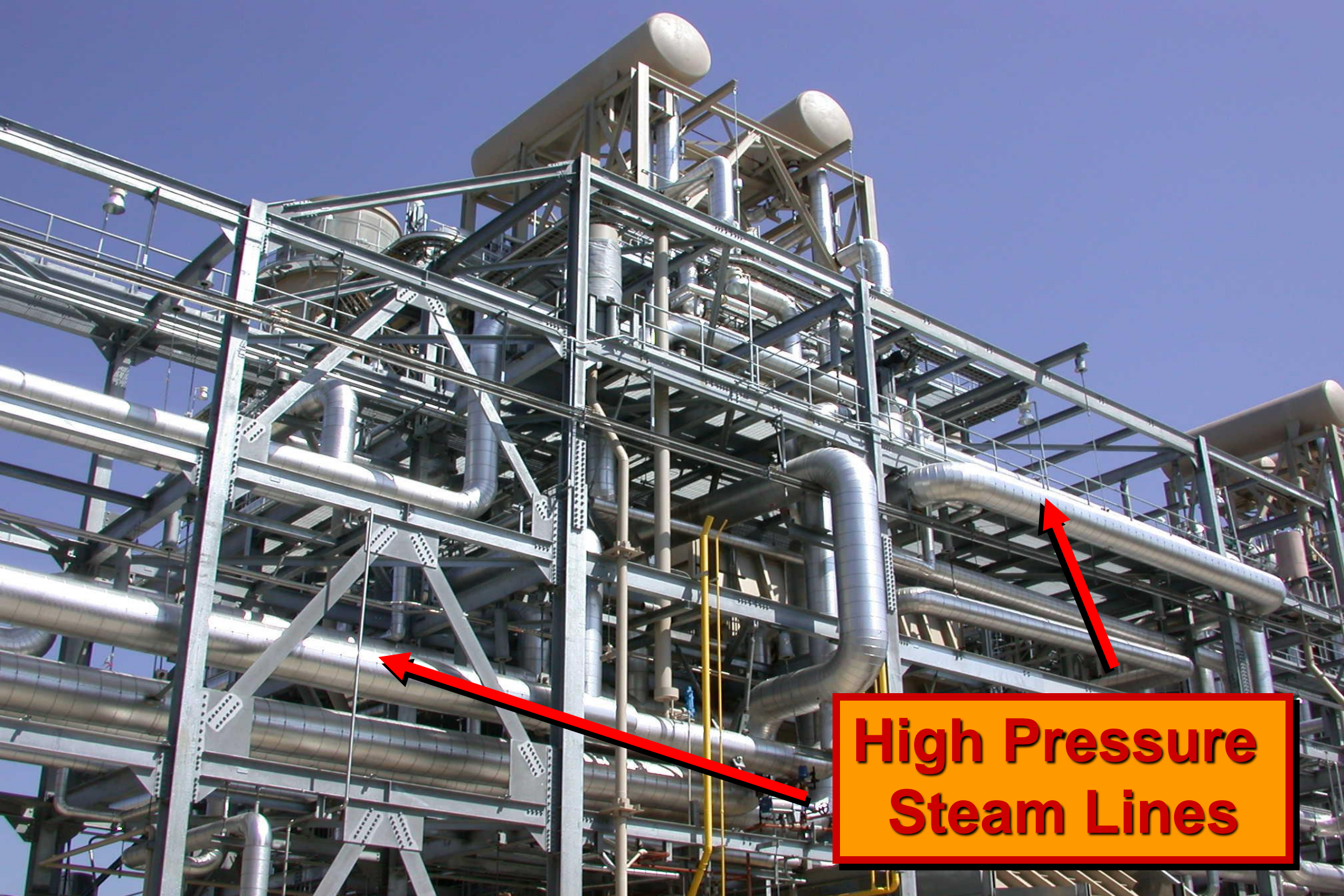


**Let's Discuss  
Power  
Generation**


# High Pressure Steam Lines







**High Pressure  
Steam Lines**

A large industrial steam turbine is the central focus of the image, situated within a complex power plant environment. The turbine is heavily insulated with thick, white, quilted thermal blankets. It is surrounded by a dense network of pipes, some of which are also insulated. The scene is illuminated by warm, yellowish lights, creating a high-contrast, industrial atmosphere. In the background, structural steel beams and other machinery are visible, suggesting a large-scale facility. A prominent yellow box with a red border in the upper right corner contains the text 'Steam Turbine' in a bold, red, sans-serif font.

# Steam Turbine

# Steam Turbine





**Generator**

**Steam Turbine**



# Cooling Towers

# Cooling Tower Shell



# Typical Control Room



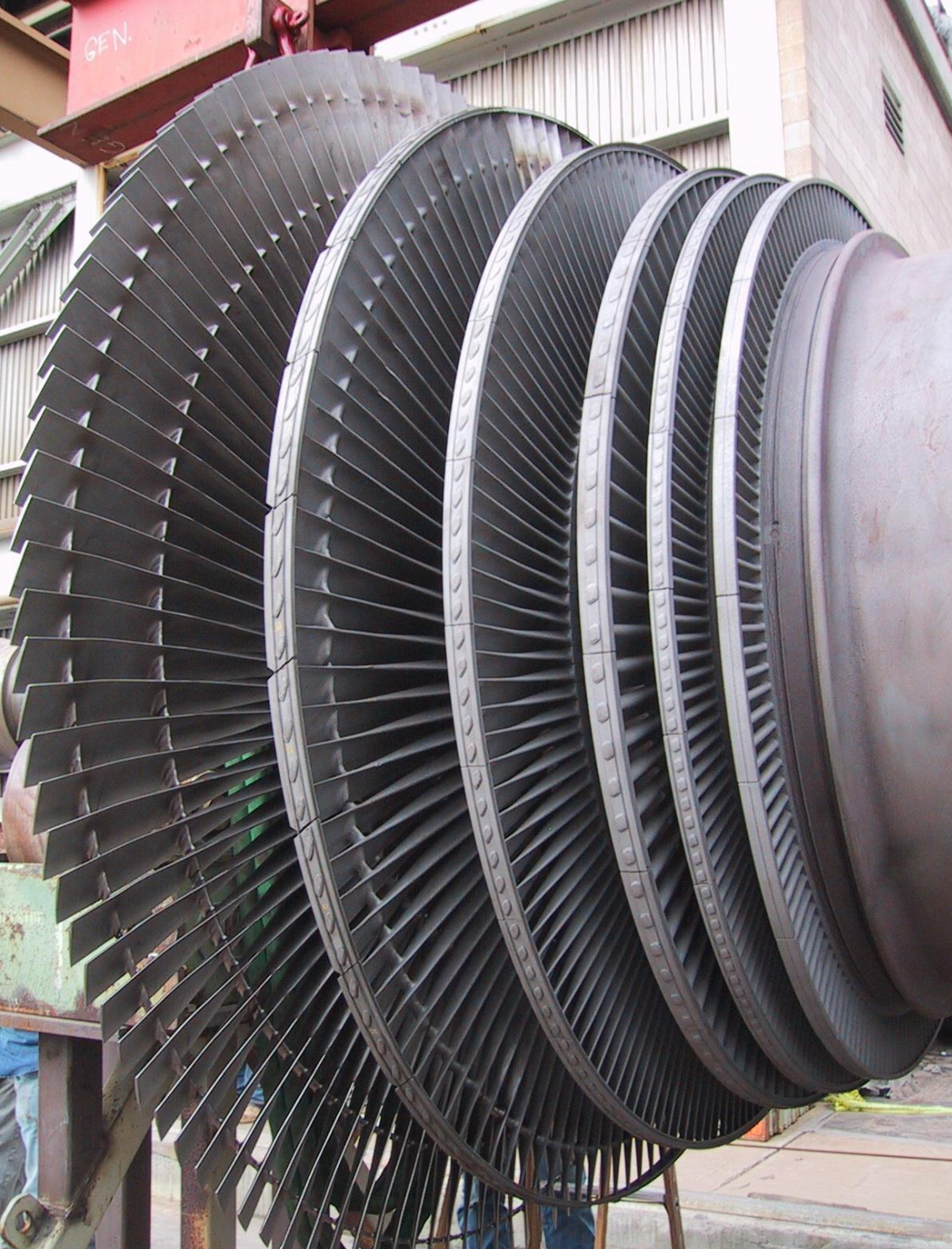


**Utility Boiler**

**Steam  
Turbine**

GENERAL ELECTRIC





# Steam Turbine Blades

# Steam Turbine



# HP Steam Turbine

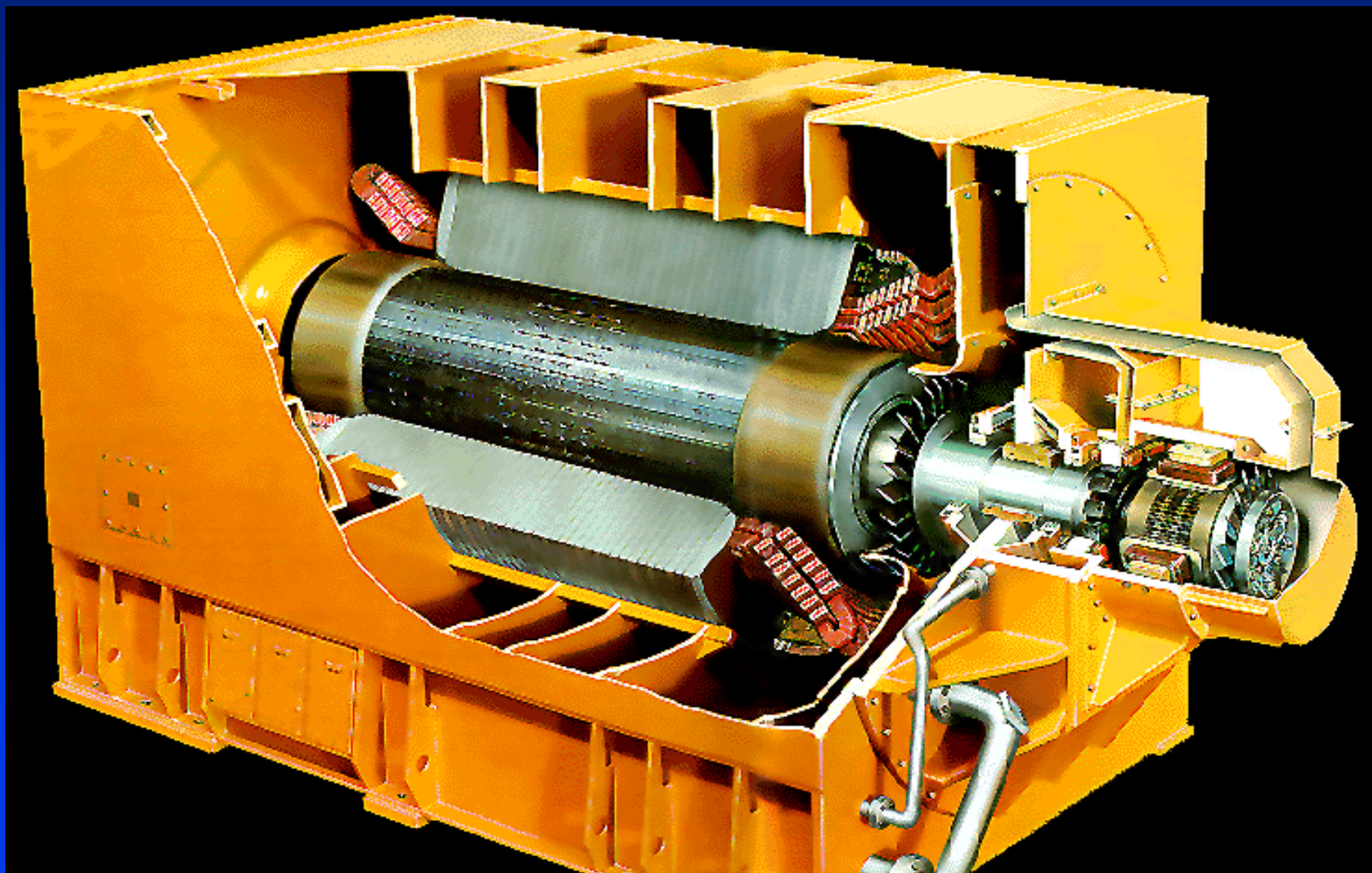


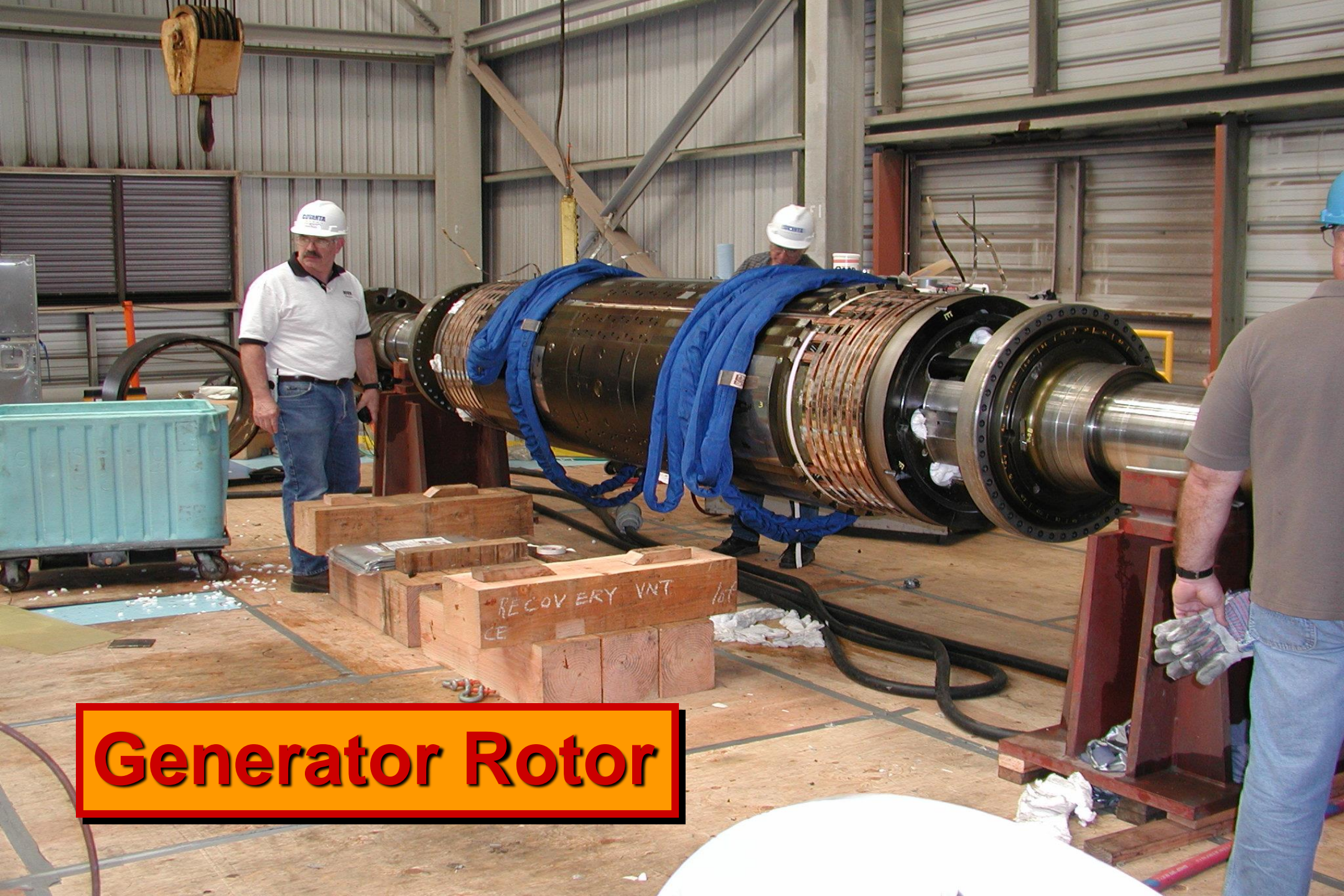
An aerial view of a large industrial generator and steam turbine assembly on a factory floor. The generator is a long, cylindrical, tan-colored structure with several access panels. The steam turbine is a smaller, more complex structure with a large, curved, metallic component. A red scissor lift is positioned near the turbine. The floor is made of dark, worn metal plates. In the background, there are other industrial structures and a person in a pink shirt.

**Generator**

**Steam Turbine**

# Brush DAX Turbogenerator

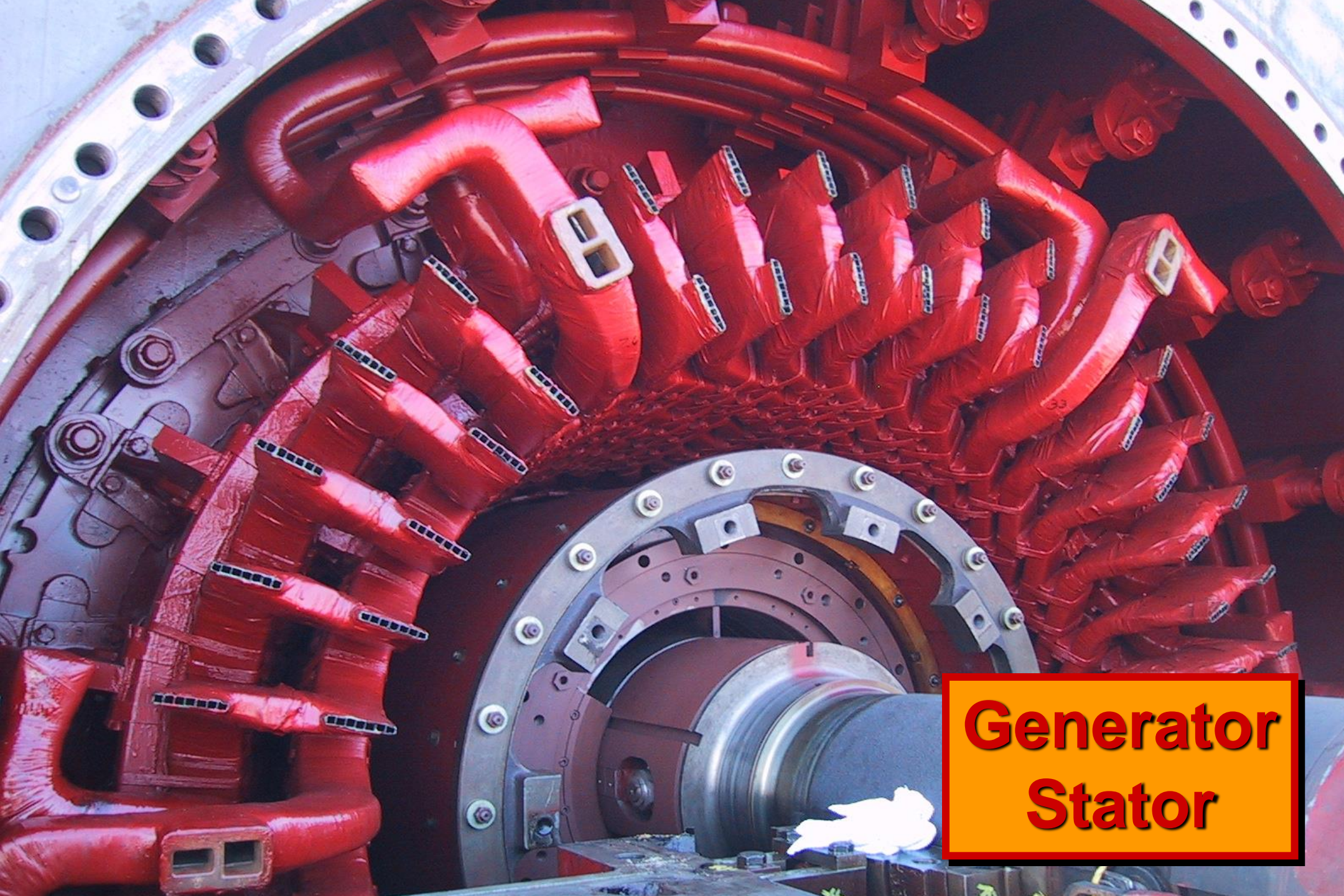




**Generator Rotor**

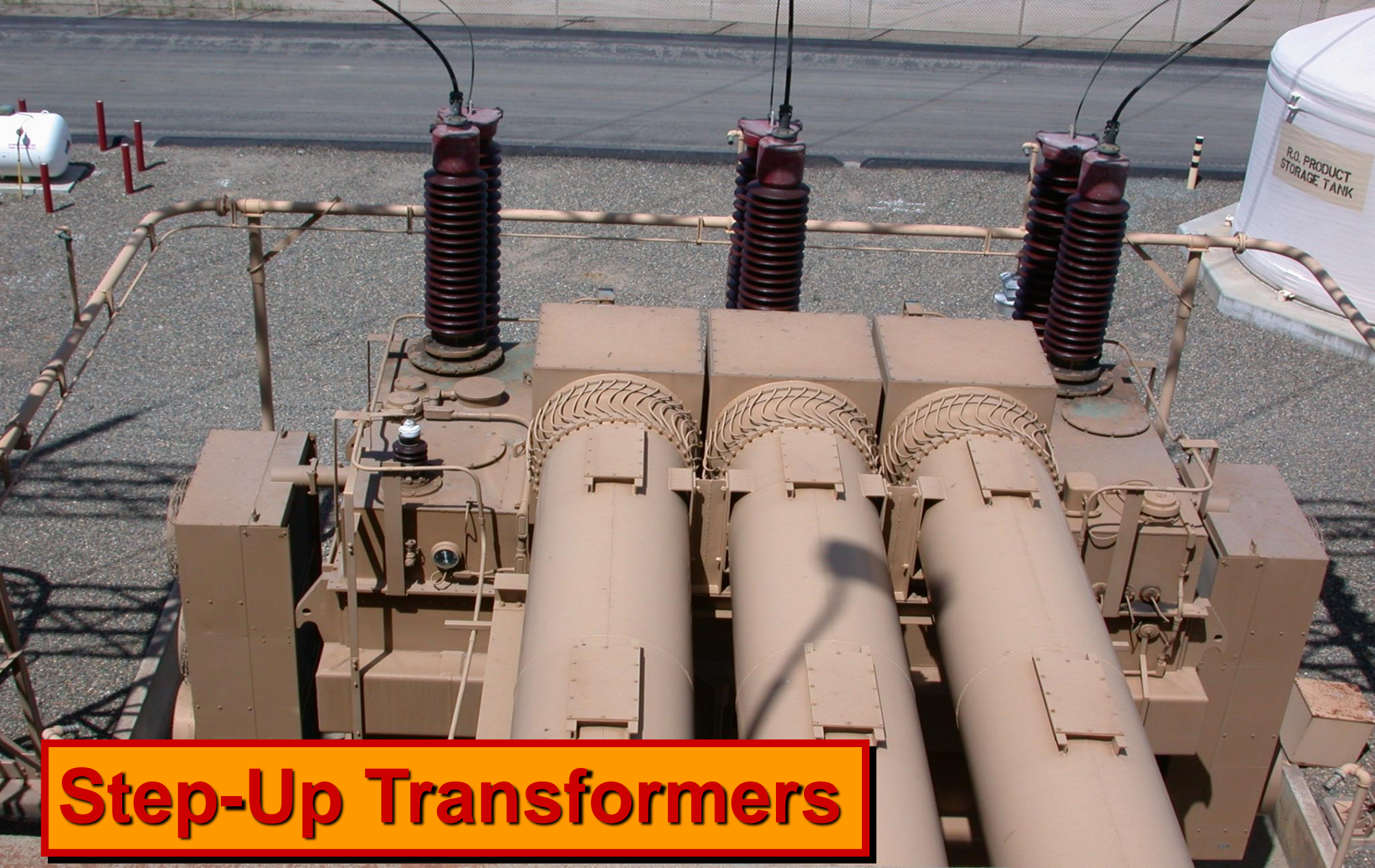


**Generator Rotor**



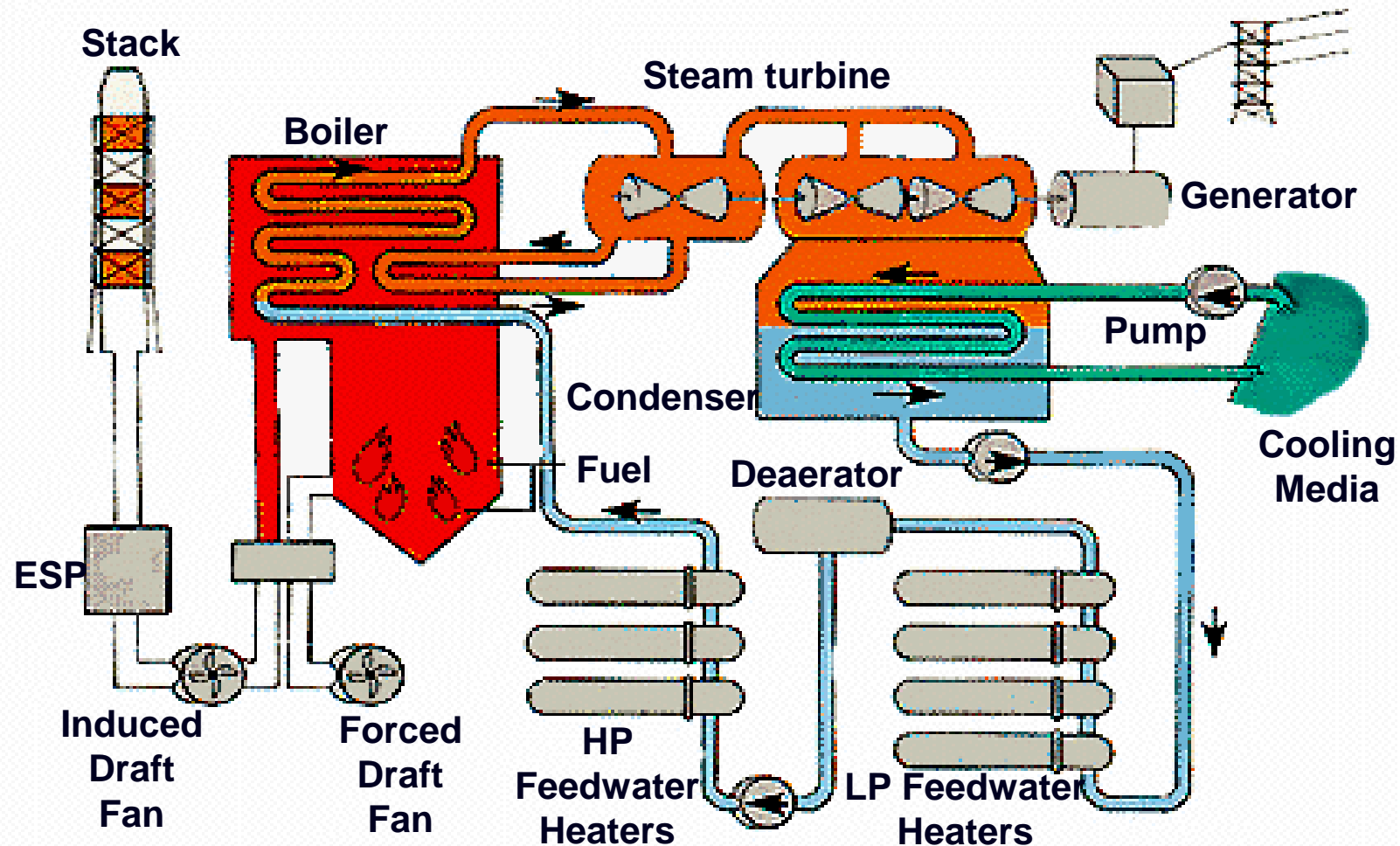
**Generator  
Stator**





# Step-Up Transformers

# Typical Electric Utility Plant

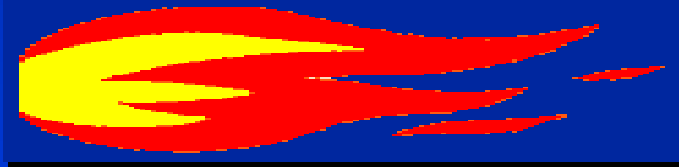




**Let's Discuss  
Emissions  
& Controls**

# Emissions From Boilers

**Fuel**  
**+**  
**Air**  
**(N<sub>2</sub>, O<sub>2</sub>)**



- ◆ H<sub>2</sub>O
- ◆ CO<sub>2</sub>
- ◆ CO
- ◆ NO<sub>x</sub>
- ◆ HC
- ◆ SO<sub>x</sub>
- ◆ PM
- ◆ CHO

# Emissions Control Methods

- ◆ **Boiler design**
- ◆ **Proper maintenance**
- ◆ **Operating conditions**
- ◆ **Fuel types**
- ◆ **Combustion modifications**
- ◆ **Exhaust treatment**



# Control of Gaseous Emissions

- ◆ Low-NO<sub>x</sub> burners
- ◆ OFA
- ◆ Ammonia injection (SNCR)
- ◆ Catalysts (SCR)
- ◆ FGR
- ◆ FGD



# Combustion Considerations

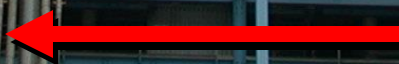
- ◆ Time
- ◆ Temperature
- ◆ Turbulence
- ◆ Oxygen
- ◆ Nitrogen





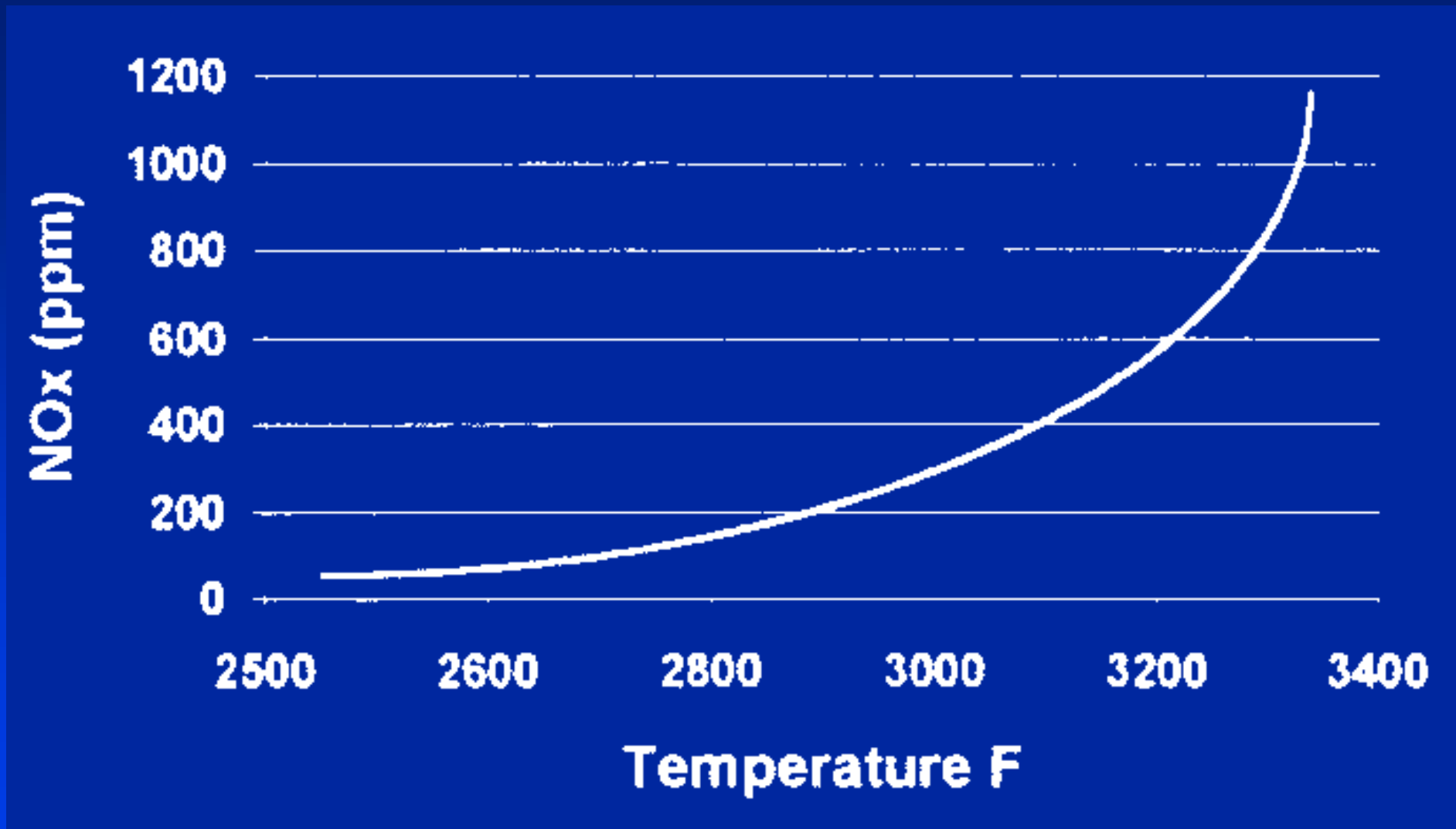
- ◆ Thermal NO<sub>x</sub>
- ◆ Fuel-bound NO<sub>x</sub>
- ◆ Prompt NO<sub>x</sub>

**NO<sub>x</sub> Creation**





# Thermal NOx vs. Temperature



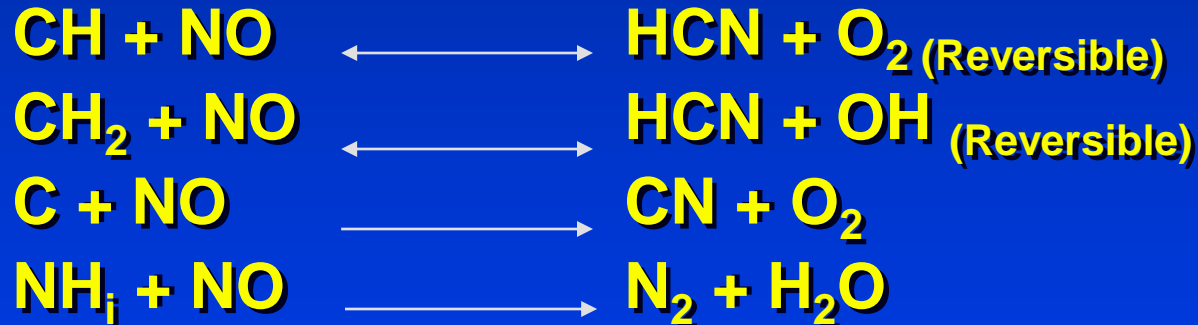
Graphic Courtesy of Coen

# COMBUSTION MODIFICATION

## ◆ NO<sub>x</sub> FORMATION



## ◆ NO<sub>x</sub> REDUCTION



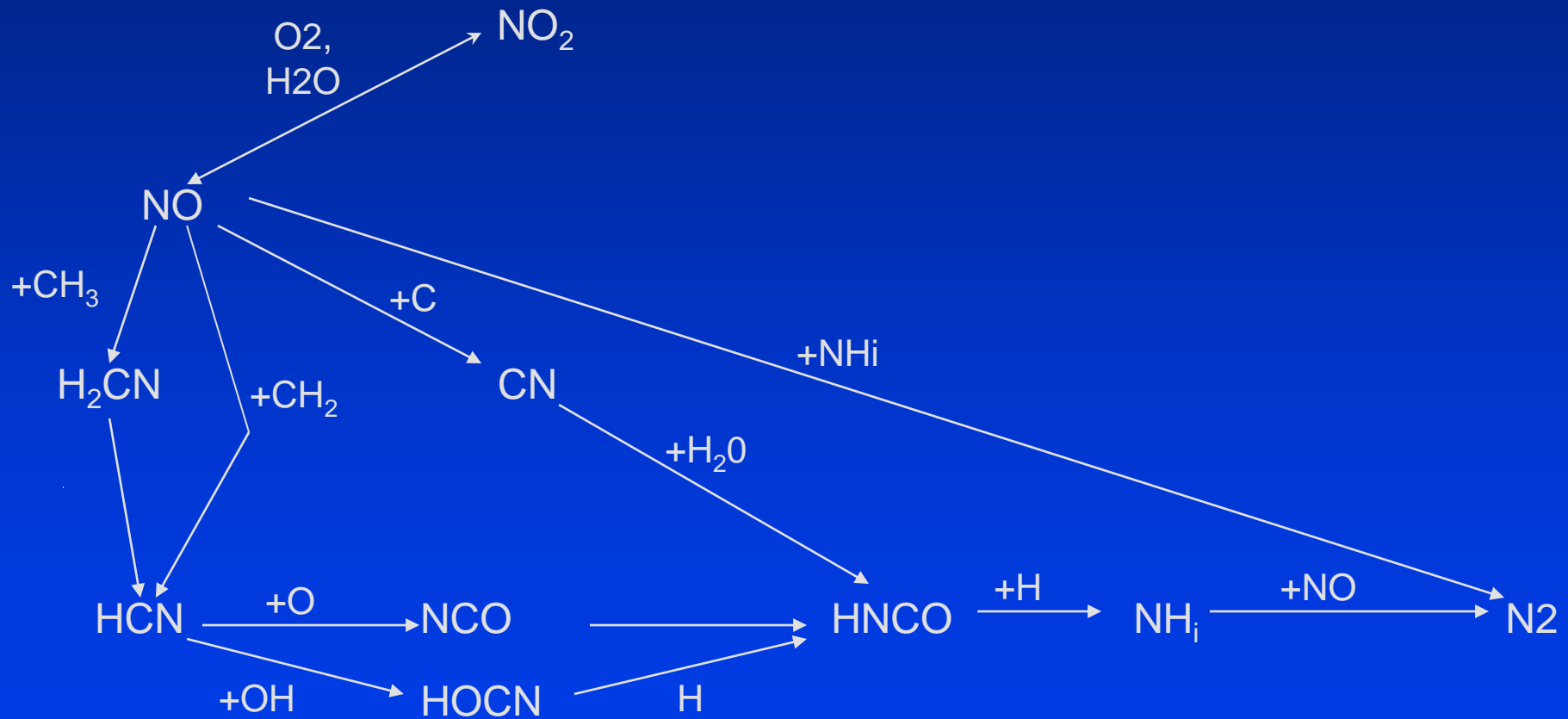
THESE NO<sub>x</sub> REDUCTANTS ARE FORMED BY PARTIAL COMBUSTION IN A REDUCING ATMOSPHERE

THE INTERMEDIATE SPECIES, HCN & CN, ARE CONVERTED TO N<sub>2</sub>, CO<sub>2</sub> & H<sub>2</sub>O IN THE FINAL BURNOUT ZONE

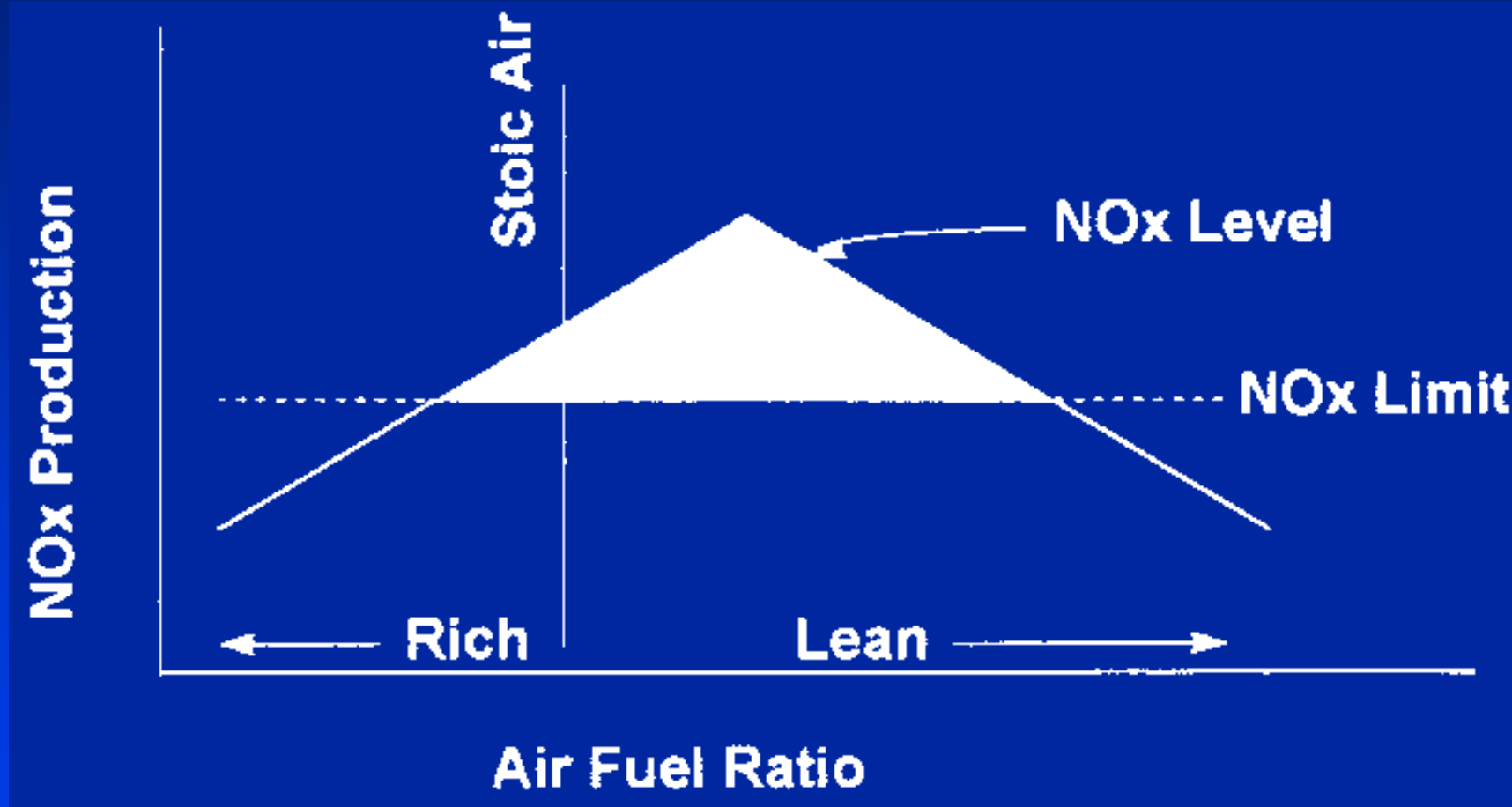
# **PROMPT NO<sub>x</sub>**

- ◆ **Rapid Formation <1ms.**
- ◆ **Little affect from temperature.**
- ◆ **Presence of CH<sub>i</sub> & HCN during initial combustion can contribute to prompt NO<sub>x</sub> formation in an oxidizing environment, but will inhibit NO<sub>x</sub> formation in a reducing environment.**
- ◆ **Presence of C & NH<sub>i</sub> in initial combustion process reduces the formation of prompt NO<sub>x</sub>.**
- ◆ **Reactor combustion is controlled to a stoichiometry <.6 and a temperature <2400F.**

# PROMPT NOx



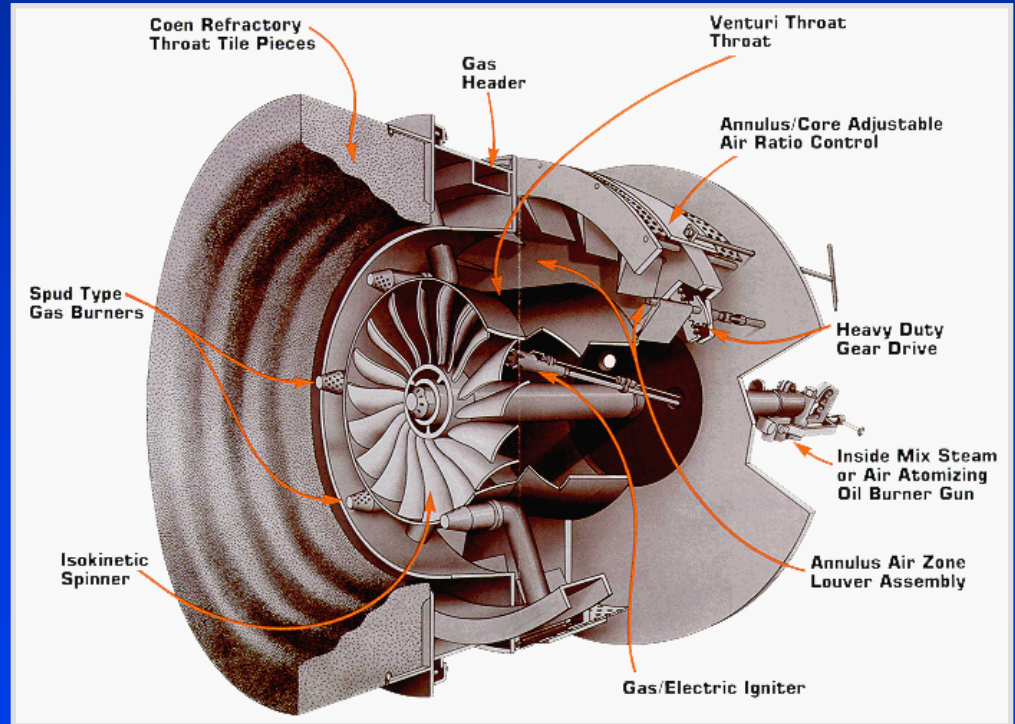
# NOx Production vs. Air/Fuel Ratio



Graphic Courtesy of Coen

# Industry Burner Definitions

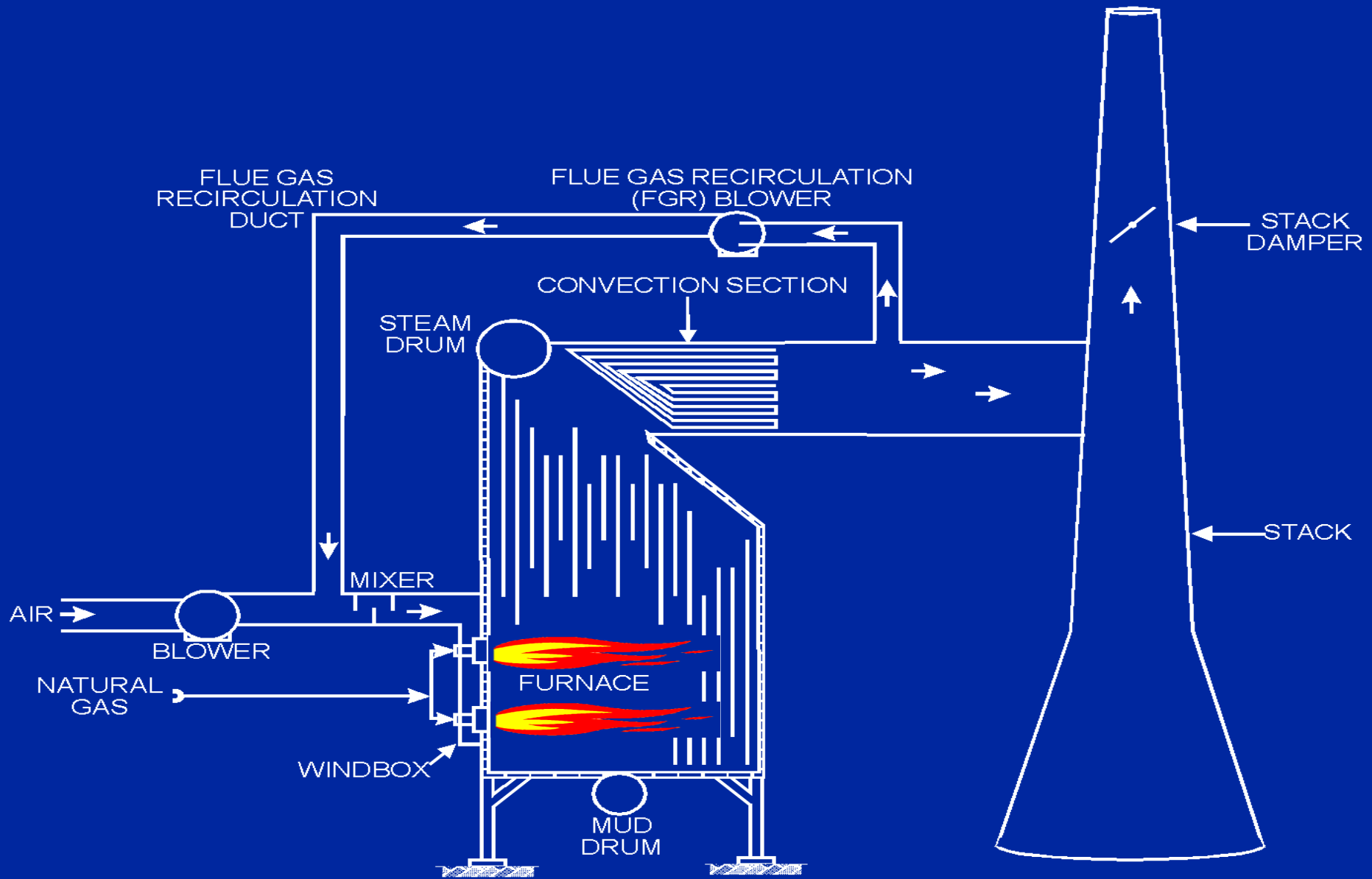
- ◆ **Modern conventional burners**
  - ◆ **NO<sub>x</sub> less than 80 ppm (<0.1 lb/MMBtu)**
- ◆ **Low-NO<sub>x</sub> burners**
  - ◆ **NO<sub>x</sub> less than 30 ppm (<0.04 lb/MMBtu)**
- ◆ **Ultra Low-NO<sub>x</sub> burners**
  - ◆ **9 ppm NO<sub>x</sub> (<0.01 lb/MMBtu)**





**Let's Discuss FGR**

# Flue Gas Recirculation (FGR)

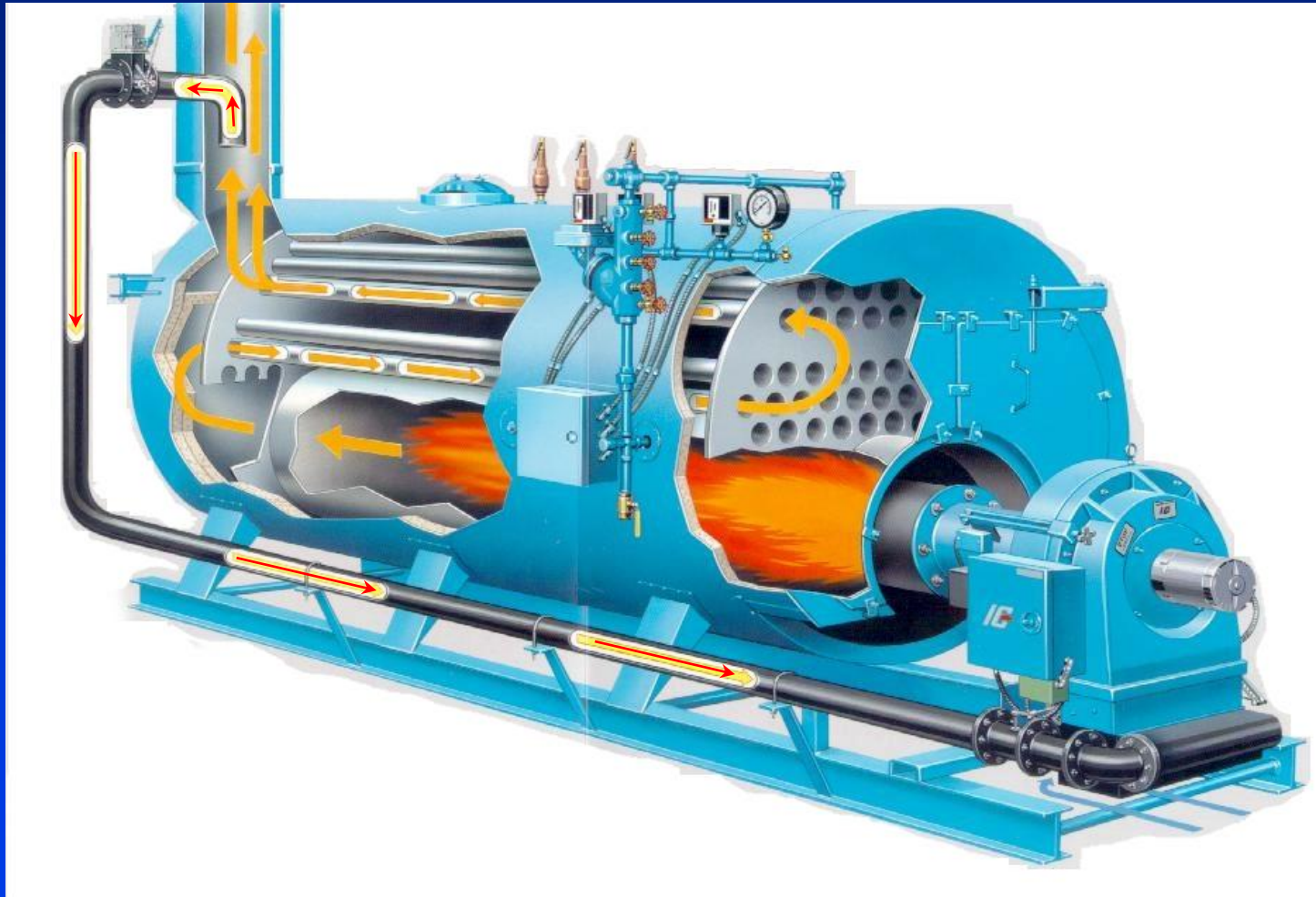







**Flue Gas Recirculation (FGR)**

# Flue Gas Recirculation (FGR)



The image shows a complex industrial environment, likely a power plant, featuring large-scale ductwork and machinery. A prominent feature is a large, horizontal, insulated duct that curves downwards and then turns vertically. This duct is surrounded by various structural elements, including metal beams, ladders, and other piping. The scene is lit with industrial lighting, highlighting the metallic surfaces and the intricate layout of the equipment. In the bottom right corner, a person's head is partially visible, providing a sense of scale to the massive machinery.

**FGR : Flue Gas  
Recirculation**

# FGR BURNERS

## FEATURES

- ◆ **CAN USE FGR FLOWS AS HIGH AS 40% OF THE TOTAL STACK EFFLUENT**
- ◆ **SOME SYSTEMS OPERATE VERY CLOSE TO THE LIMITS OF FLAMABILITY**
- ◆ **SOME SYSTEMS OPERATE WITH VERY RAPID MIXING, VERY CLOSE TO STOICHIOMETRY.**

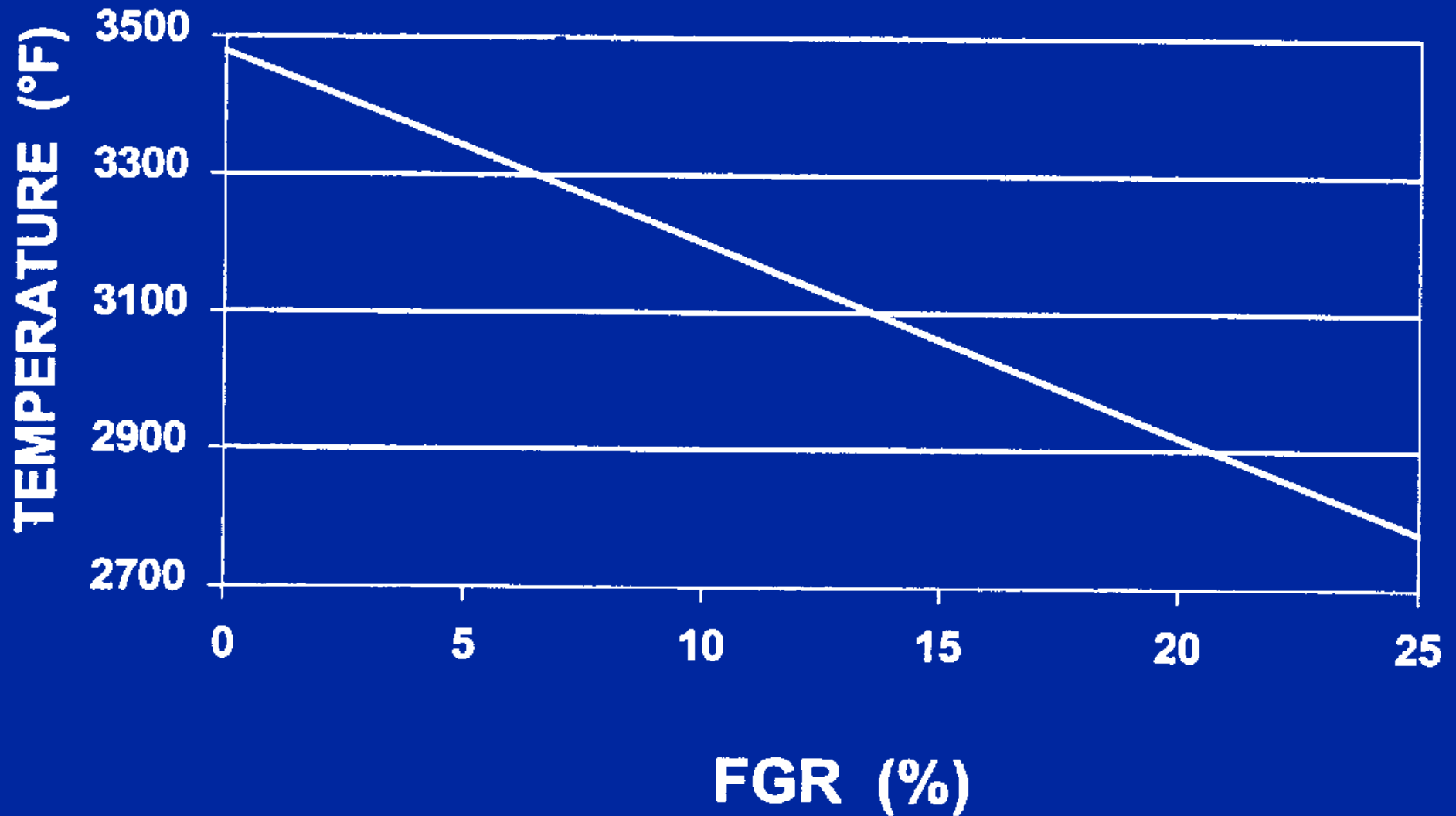
## CON'S

- ◆ **HIGH ELECTRICAL USAGE (*FGR fan HP doubled compared to RX system*)**
- ◆ **LOW TEMPERATURE, TRANSLUCENT, FLAME REDUCES HEAT TRANSFER & EFFICIENCY.**
- ◆ **COMBUSTION INSTABILITY**
- ◆ **CAN'T CHANGE FIRING RATE FAST ENOUGH TO FOLLOW CHANGING LOAD DEMANDS**

# Lower Cost to Industry

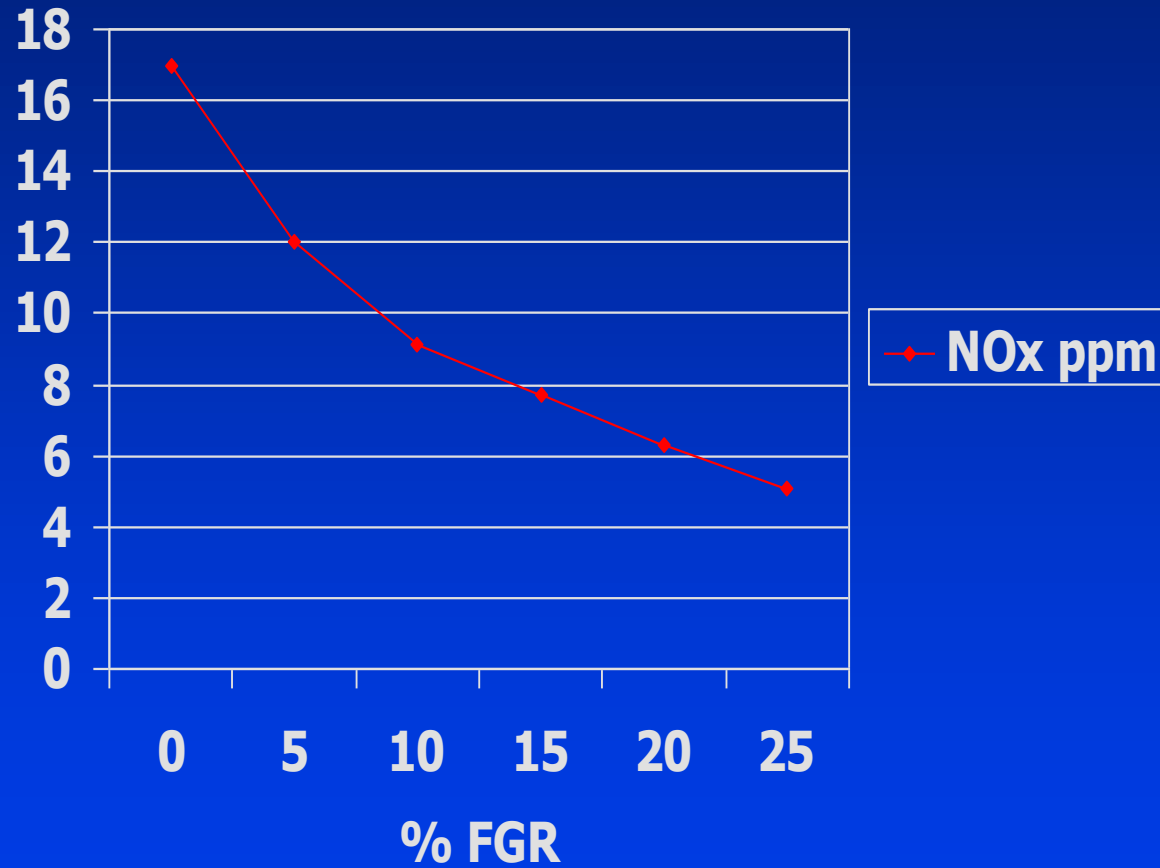
- ◆ **Simple durable refractory and steel construction results in:**
  - ◆ **Lower initial cost**
  - ◆ **Lower maintenance costs**
- ◆ **Lower operating cost**
  - ◆ **Less stack losses due to low excess air and low FGR requirements**
  - ◆ **Lower fan costs**
  - ◆ **Eliminates the need for chemicals & catalysts**

# Flame Temperature vs. FGR



Graphic Courtesy of Coen

# FGR Impact

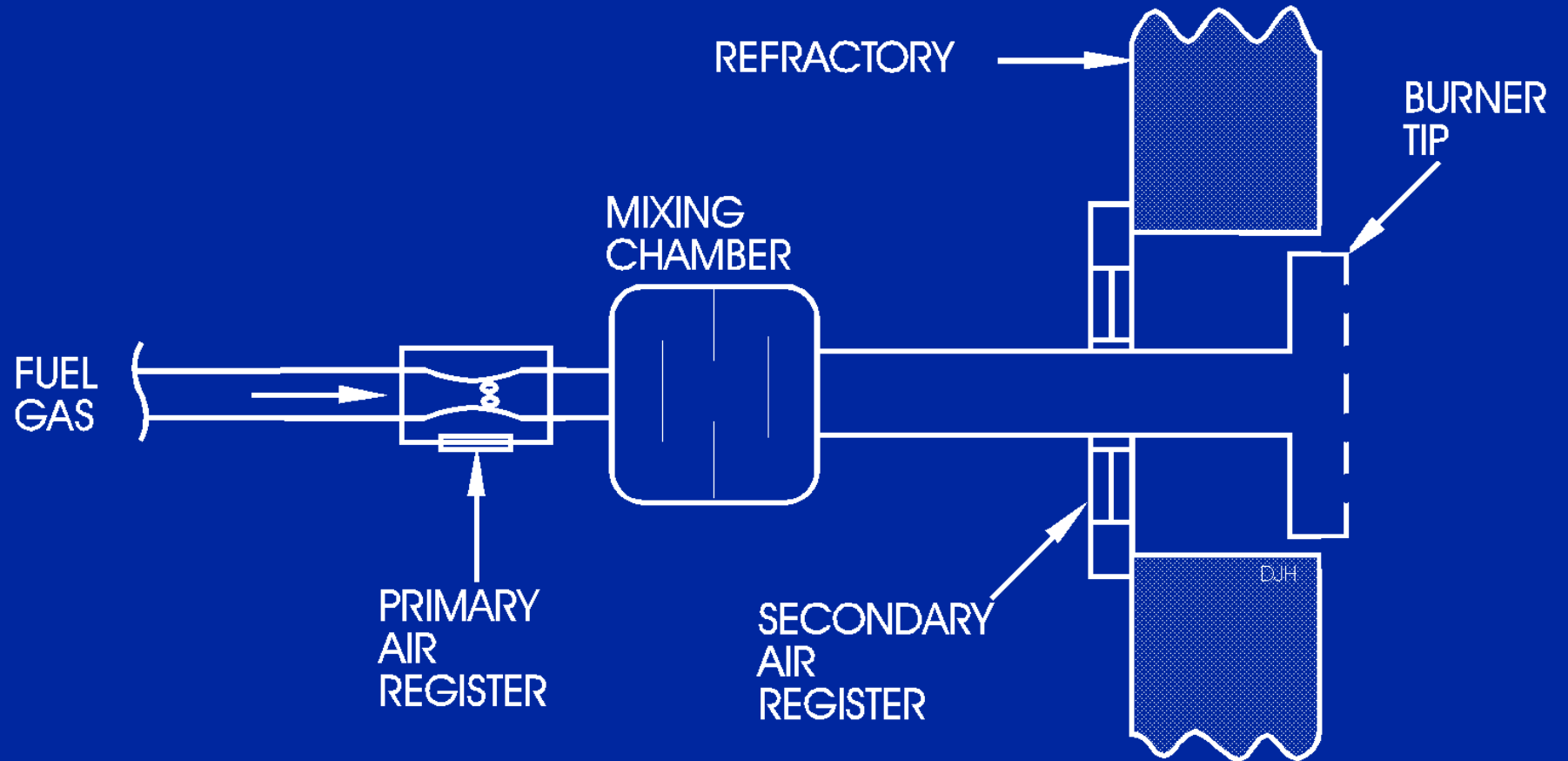


# Let's Discuss Staged Combustion

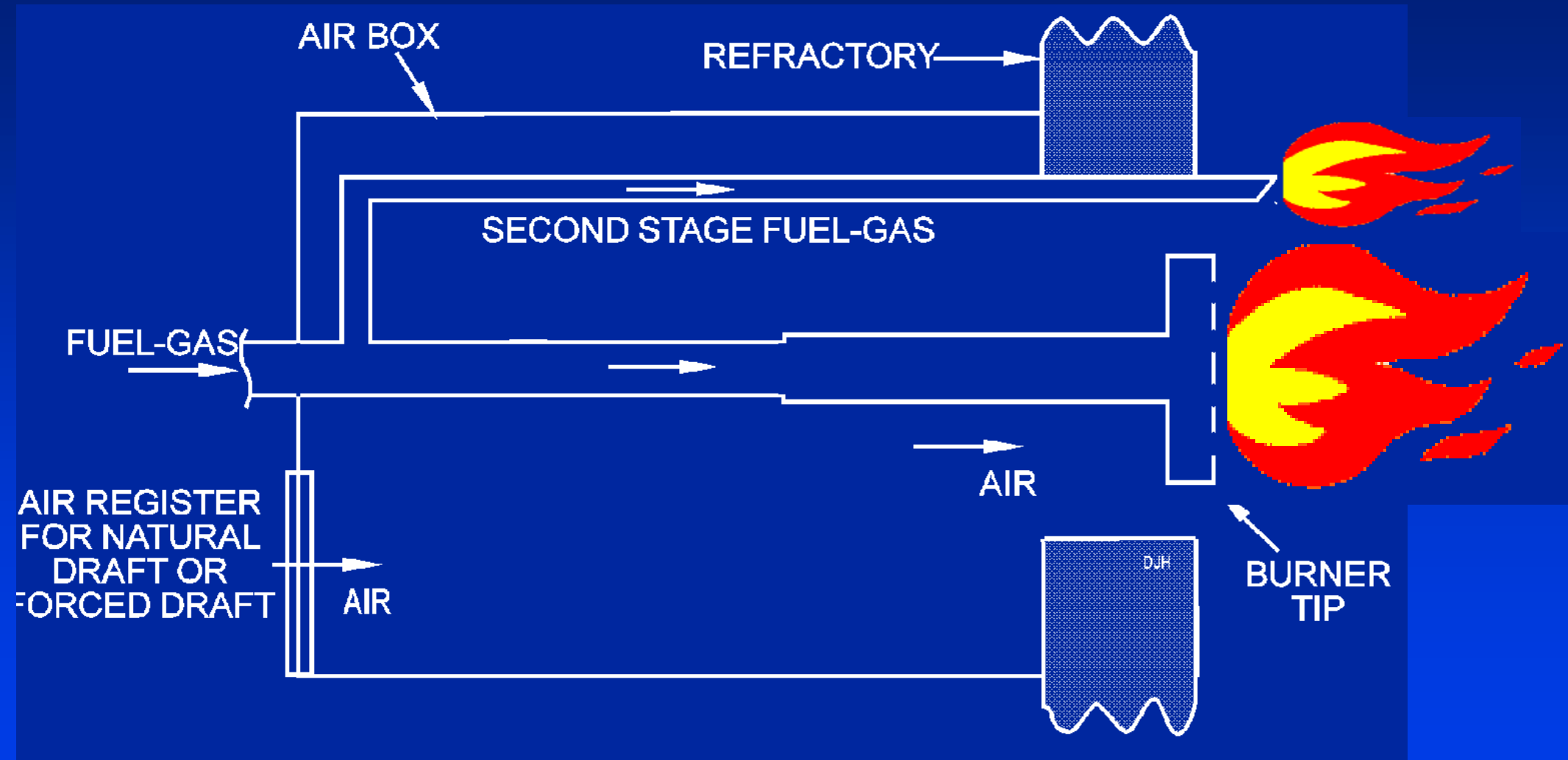




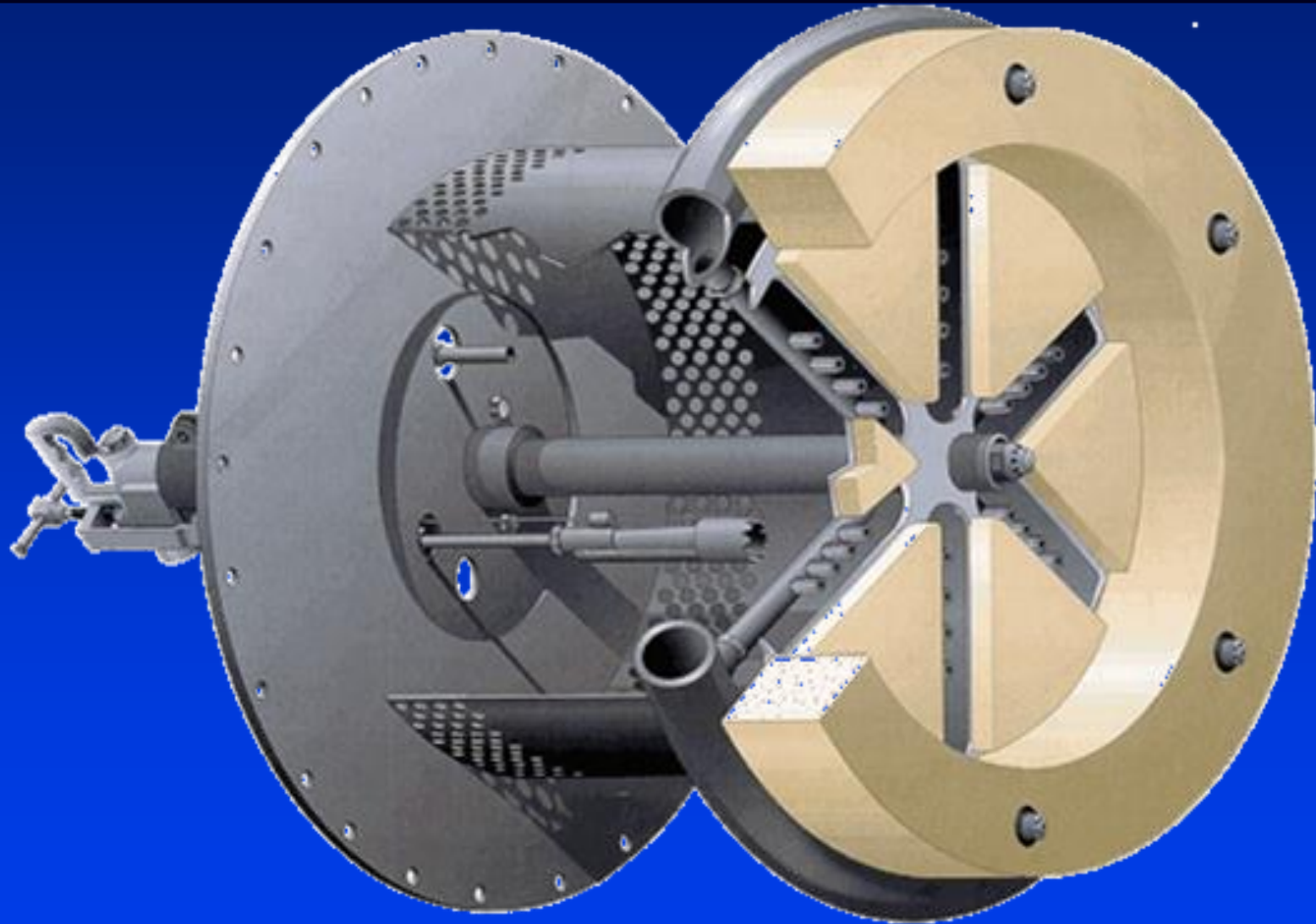
# Gas Pre-mix Burner



# Low-NOx Burner with Staged Fuel



# Low-NOx Burner with Staged Fuel

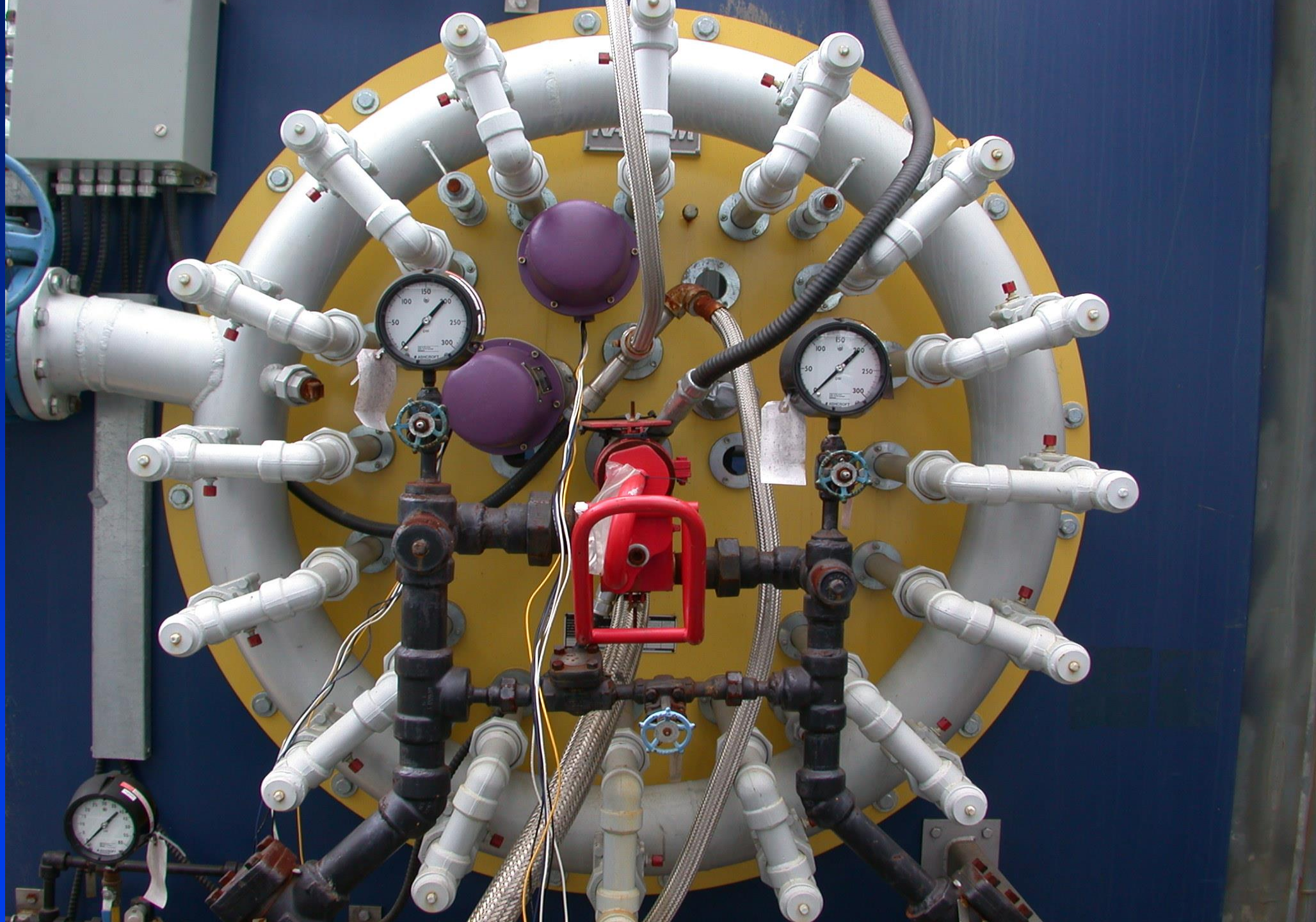


A photograph of a large industrial burner unit. The unit is primarily dark blue with a large, circular, stainless steel burner head on the left side. The burner head has several horizontal tubes and a central opening. A bright blue flame is visible at the bottom of the burner head. The blue panel on the right features the 'NATCOM' logo in white, with a stylized flame icon above the 'O'. Below the logo is a rectangular panel with a grid of screws and two handles. The unit is situated outdoors on a concrete surface, with a red chain-link fence and other industrial equipment in the background.

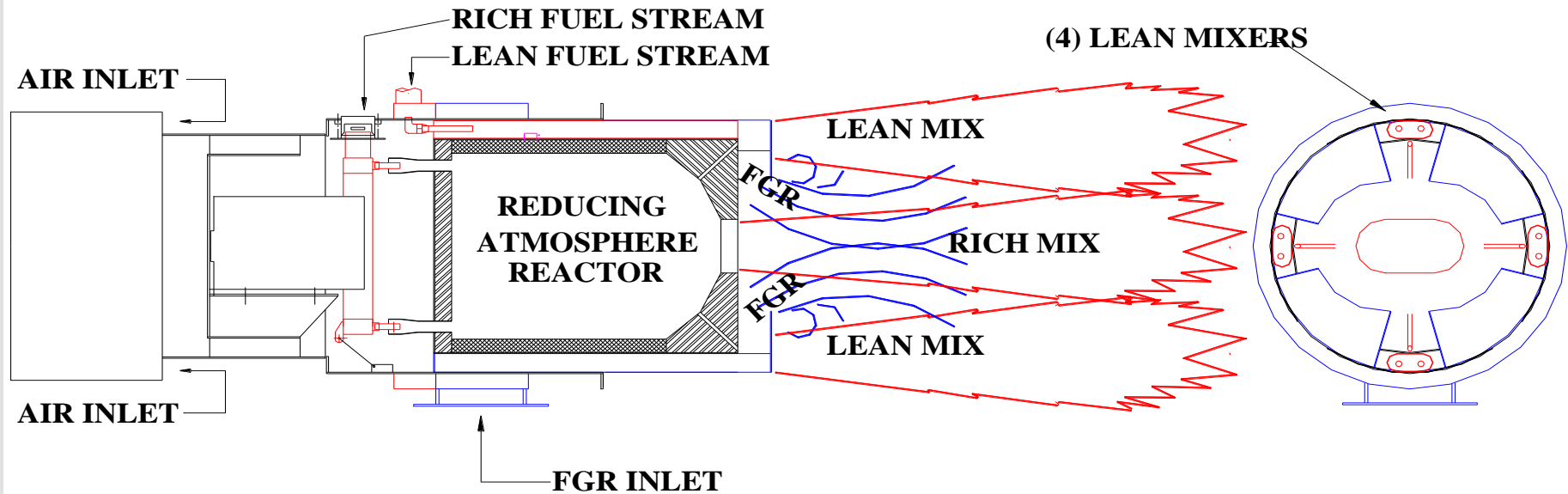
**NATCOM**

**Ultra Low-NOx Burner (9 ppm)**

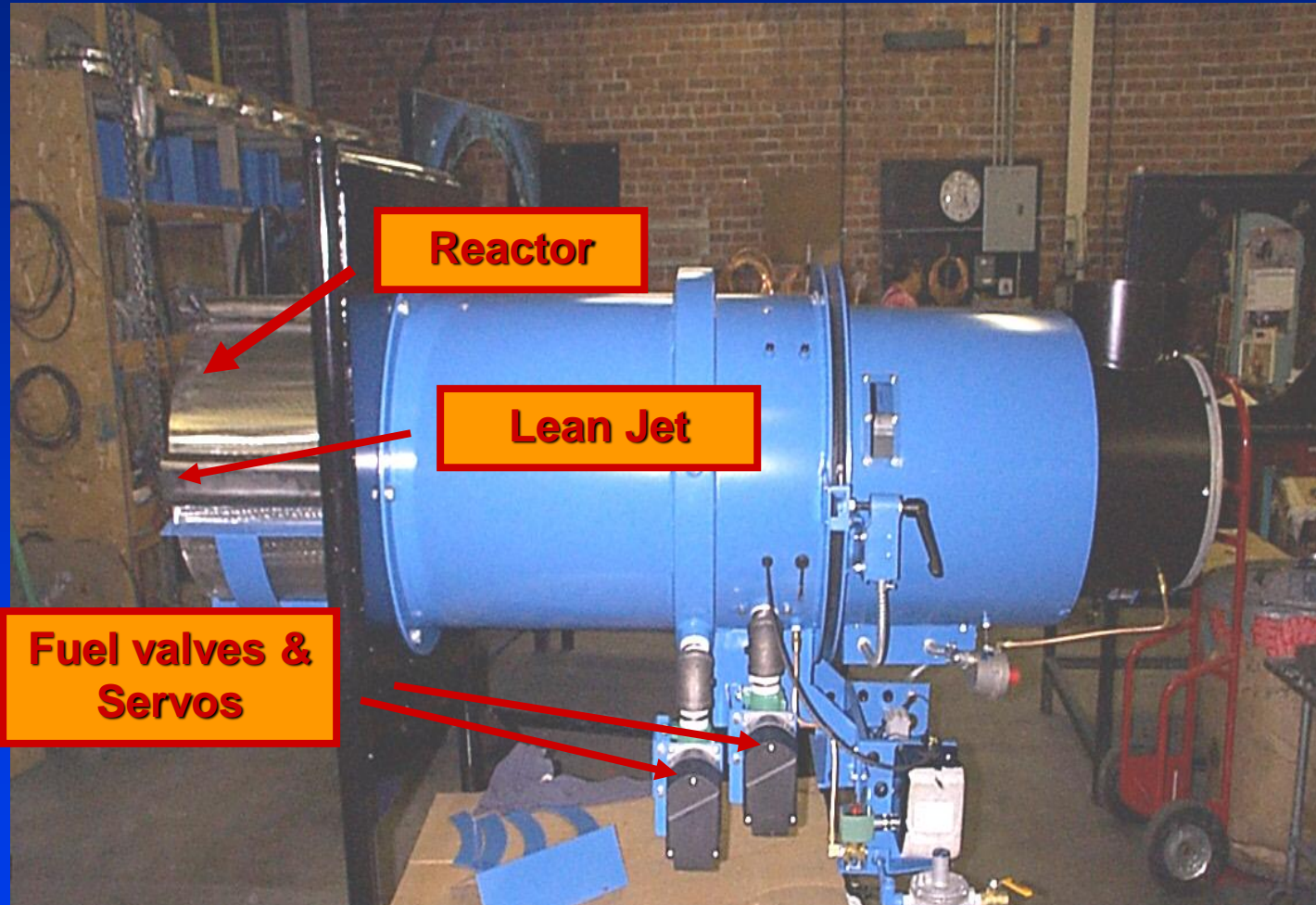




# Burner Cross-sectional View

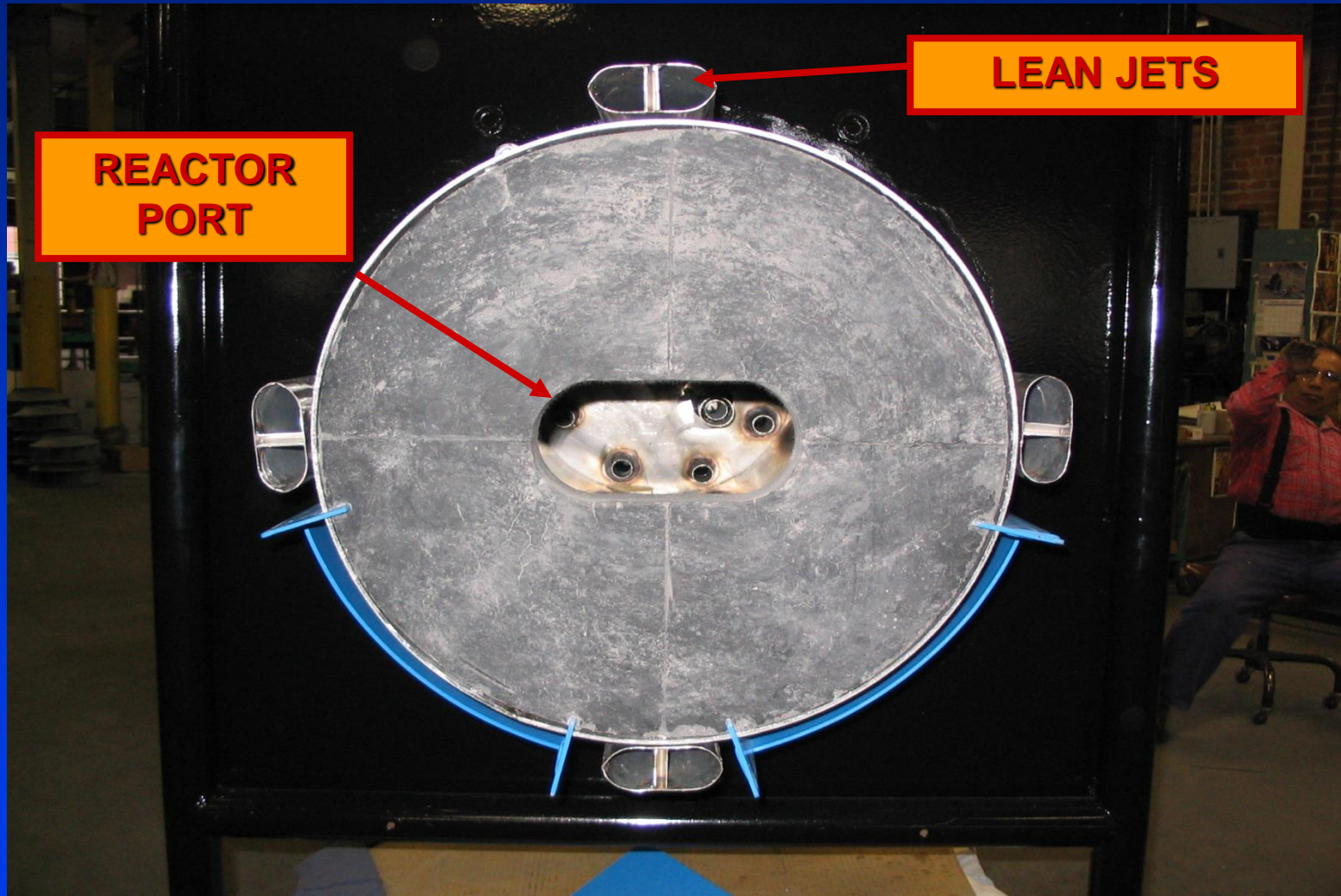


# TYPICAL COMPONENTS

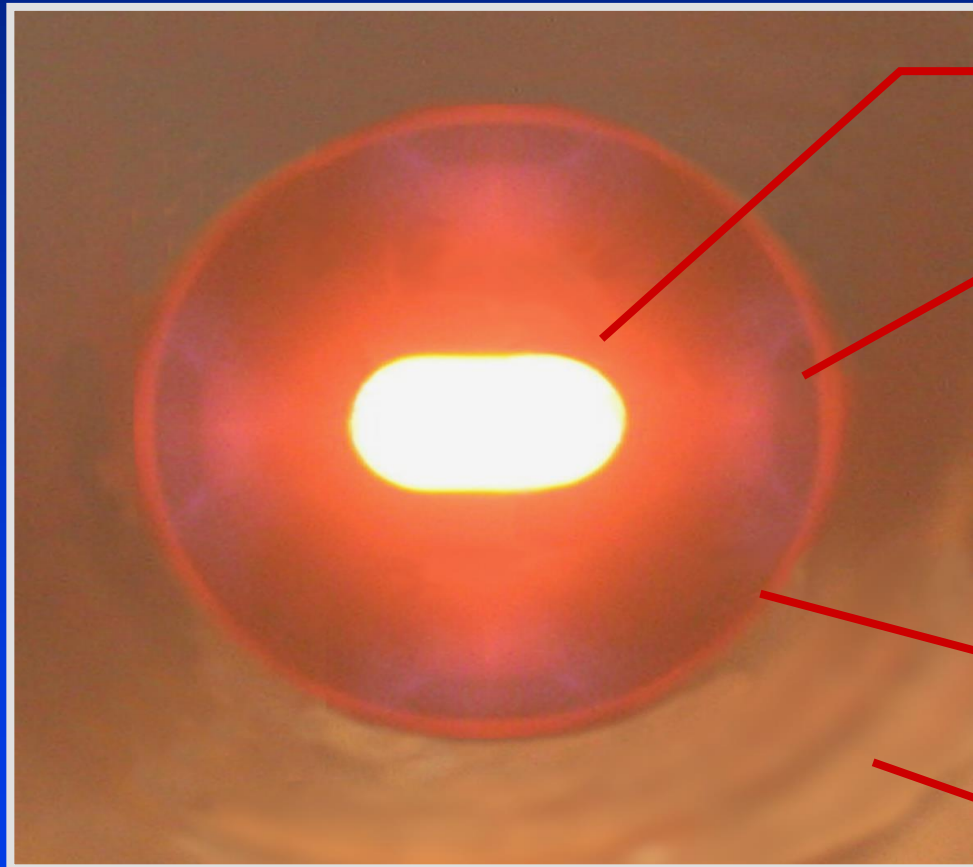




# TYPICAL COMPONENTS



# A Look Down the Furnace



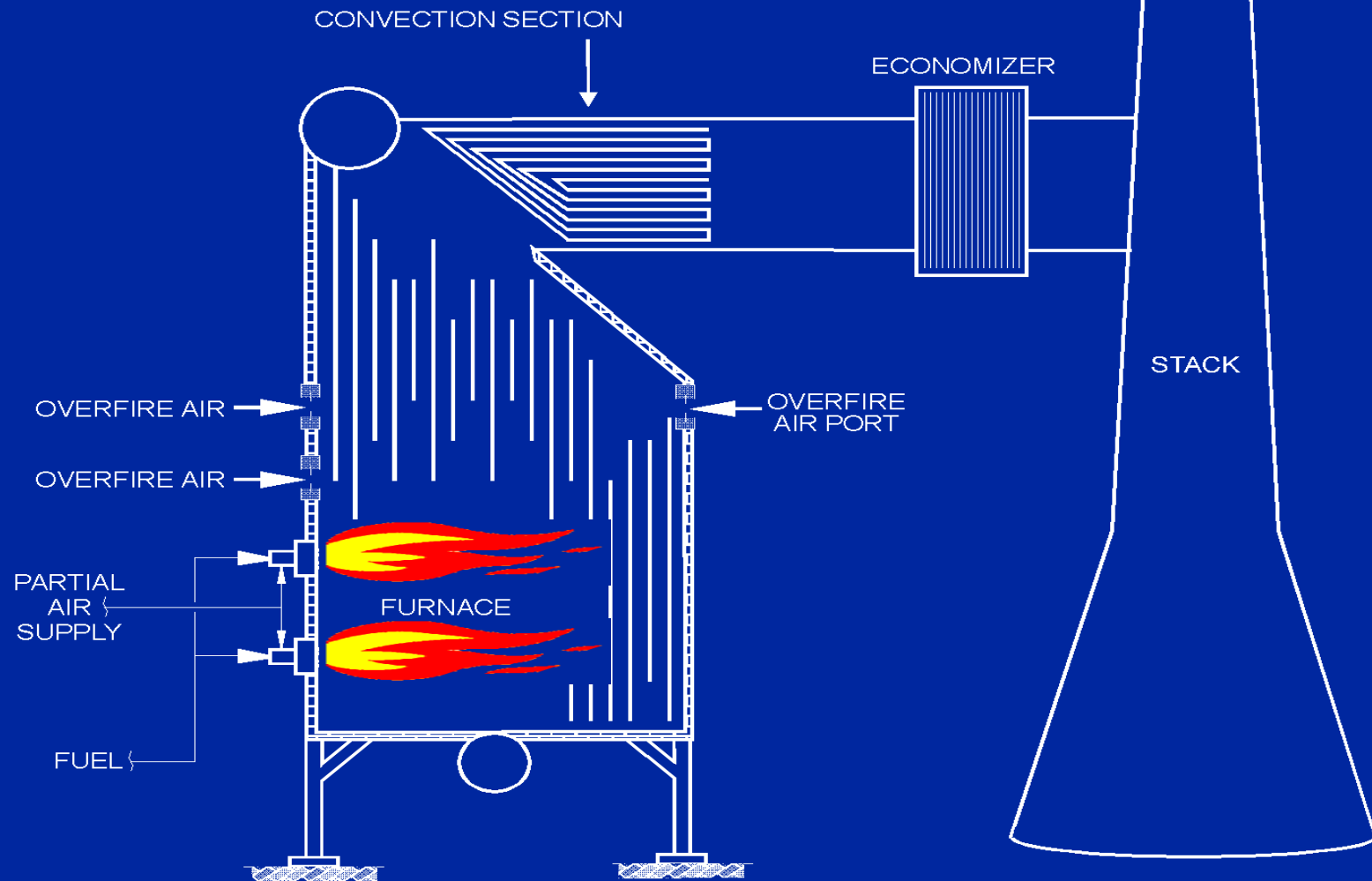
**Rich Flame**

**Lean Flames (x4)**

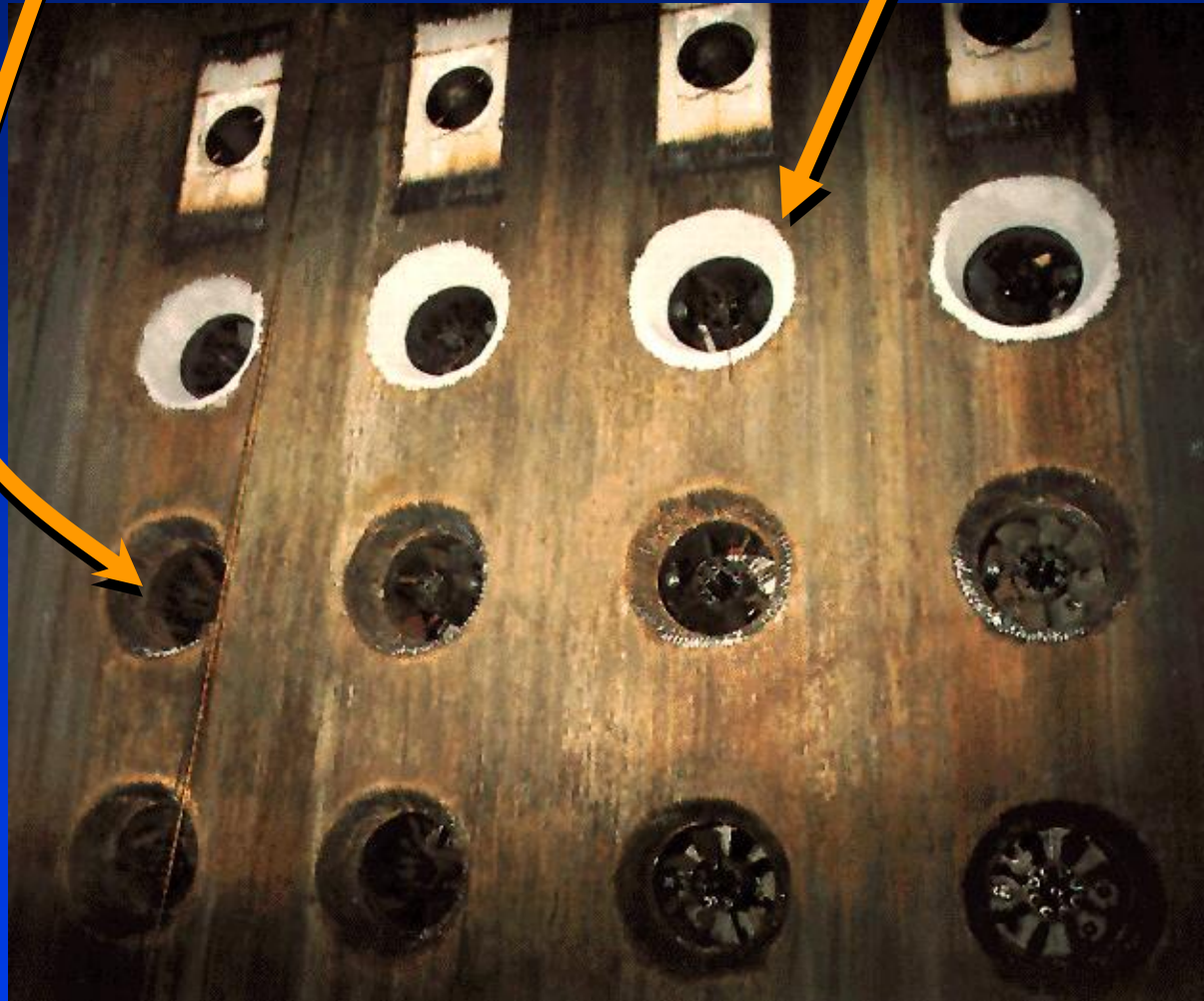
**FGR**

**Burnout Zone**

# Staged Combustion with Overfire Air

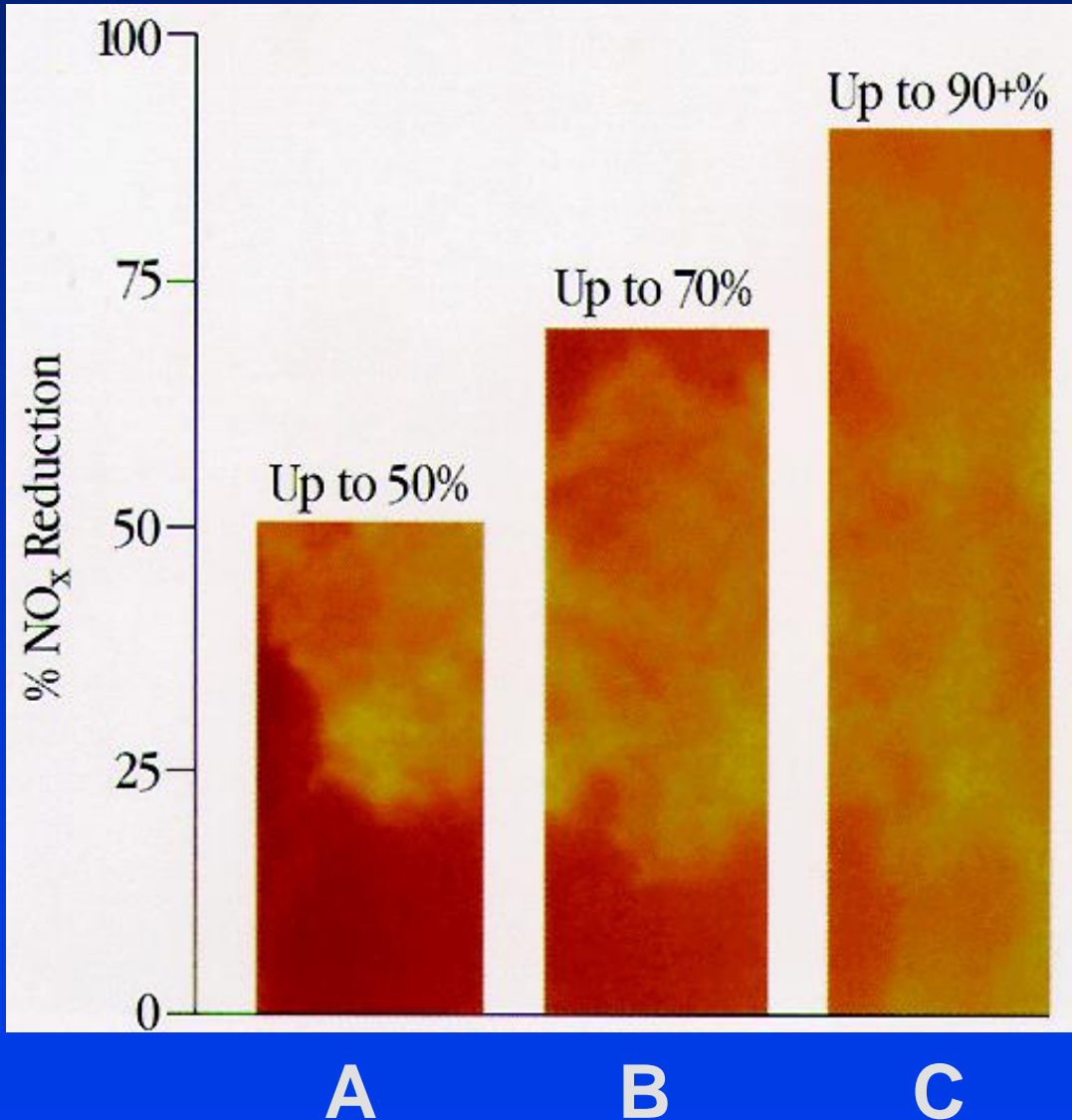


# Burners with Overfire Air



Graphic Courtesy of B&W

# NOx Reduction by Boiler Configuration



**A: Low-NOx burner only, no overfire air (OFA)**

**B: Low-NOx burner with OFA**

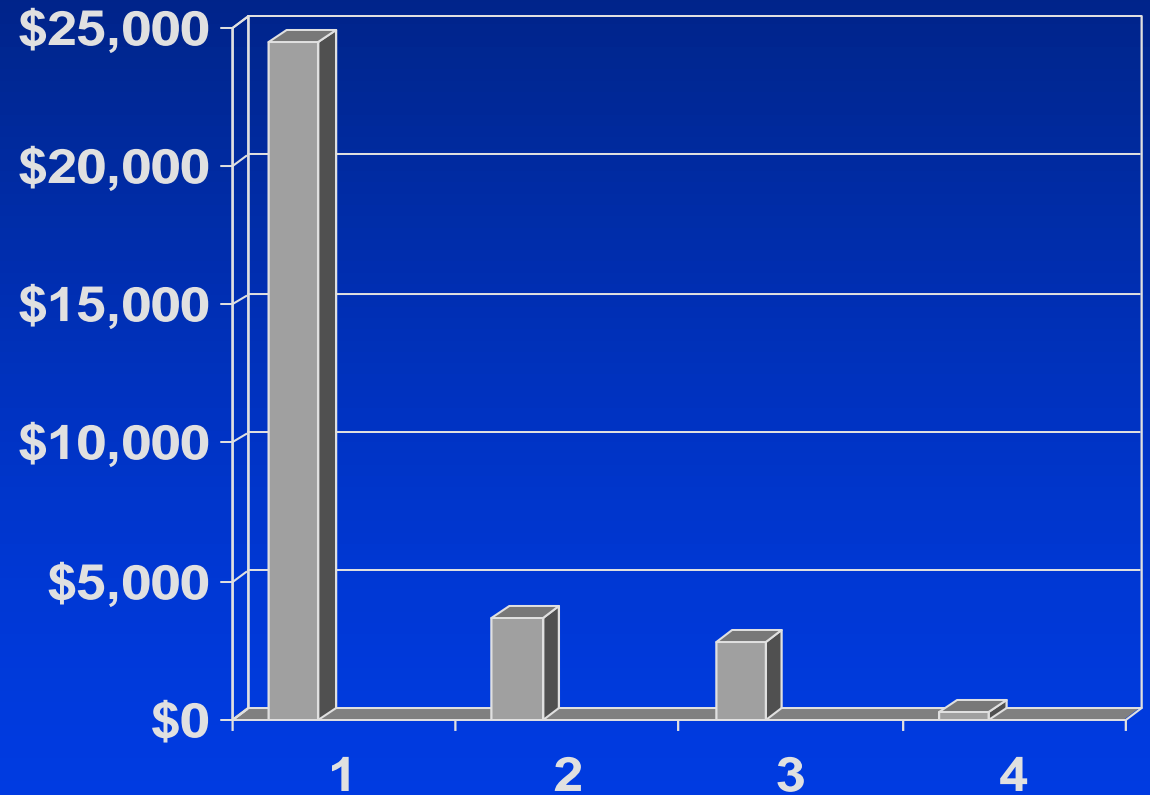
**C: Low-NOx burner with OFA and FGR**

Graphic Courtesy  
of B&W

# COST \$/ TON NOx REMOVED

## NEW BOILER SYSTEMS

- 1 **POST COMBUSTION**  
**\$ 24500 (SCR)**
- 2 **MASSIVE FGR**  
**\$ 3676**
- 3 **POROUS MATRIX**  
**\$ 2787**
- 4 **ULTRA LOW NOx**  
**TECHNOLOGY**  
**\$258**



# Existing Emissions & Goals

Emission	Existing	Proposed
NOx ppm @3% O2	25.3	5 - 6
CO ppm @ 3% O2	70.2	<50
Stack O2, %	6.2	2.5 – 3.2

Reduce NOx by 75%

Reduce O2 by 48 - 60%

Reducing O2 from 6% to 3% saves this customer 273 CFH of nat gas

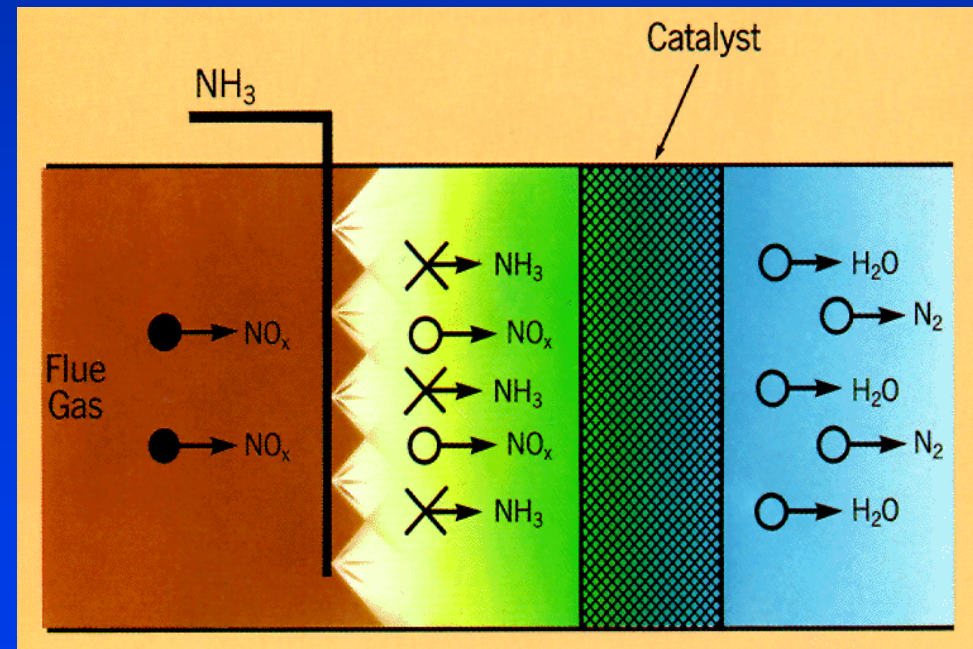
A scenic landscape featuring a large body of water in the foreground, reflecting the sky and surrounding terrain. The middle ground shows a rocky, grassy plain with scattered trees. In the background, several prominent, rugged mountains rise against a blue sky with scattered white clouds. A text box is overlaid on the left side of the image.

**Let's Discuss  
SCR  
Catalyst**



# Selective Catalytic Reduction (SCR)

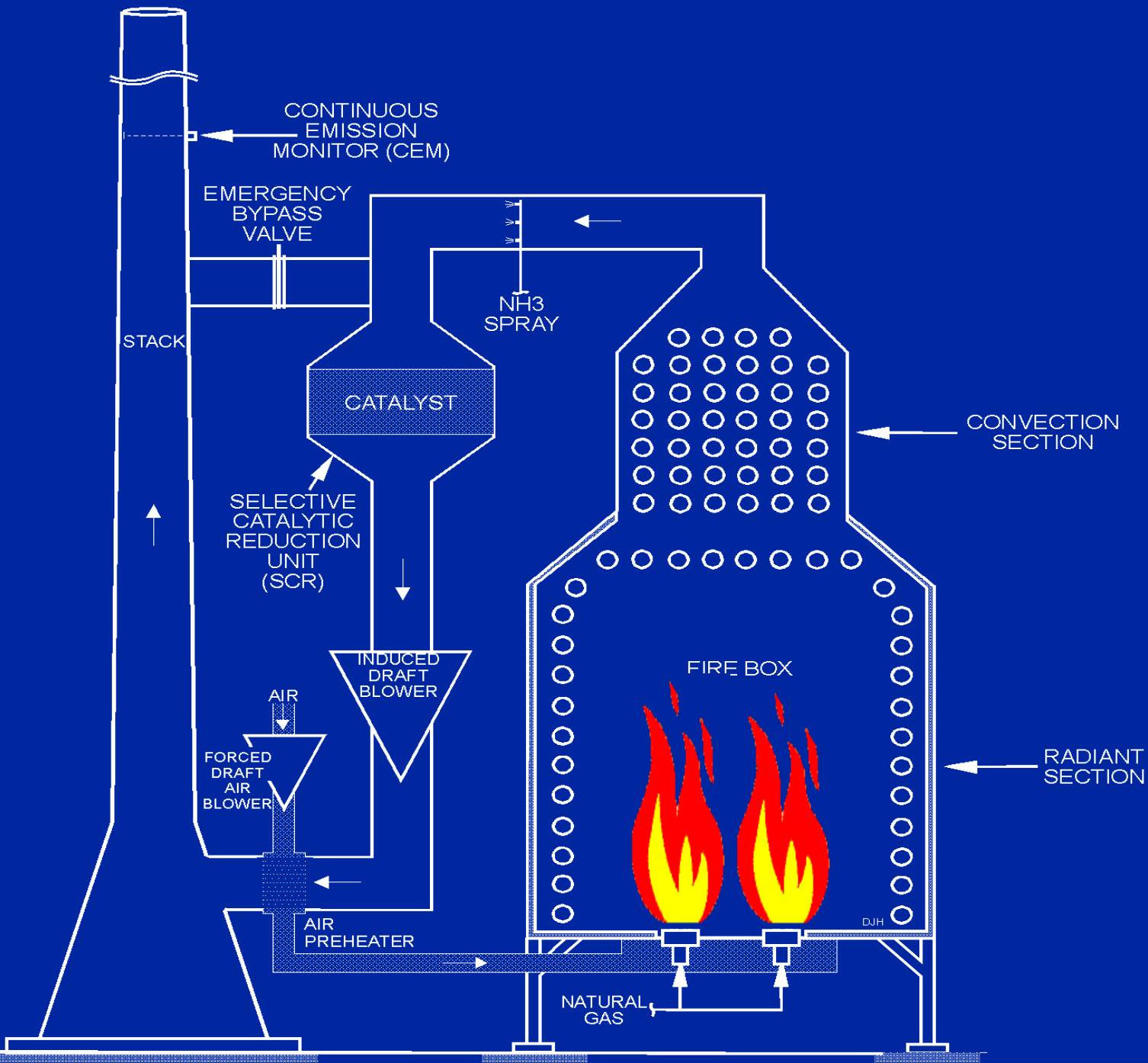
- ◆ NO<sub>x</sub> control thru ammonia (NH<sub>3</sub>) injection
- ◆  $4\text{NO} + 4\text{NH}_3 + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}$
- ◆  $2\text{NO}_2 + 4\text{NH}_3 + \text{O}_2 \rightarrow 3\text{N}_2 + 6\text{H}_2\text{O}$
- ◆ 90-95% control
- ◆ Problems
  - ◆ Expensive
  - ◆ High maintenance
  - ◆ Ammonia “slip”
  - ◆ Catalyst replacement & disposal



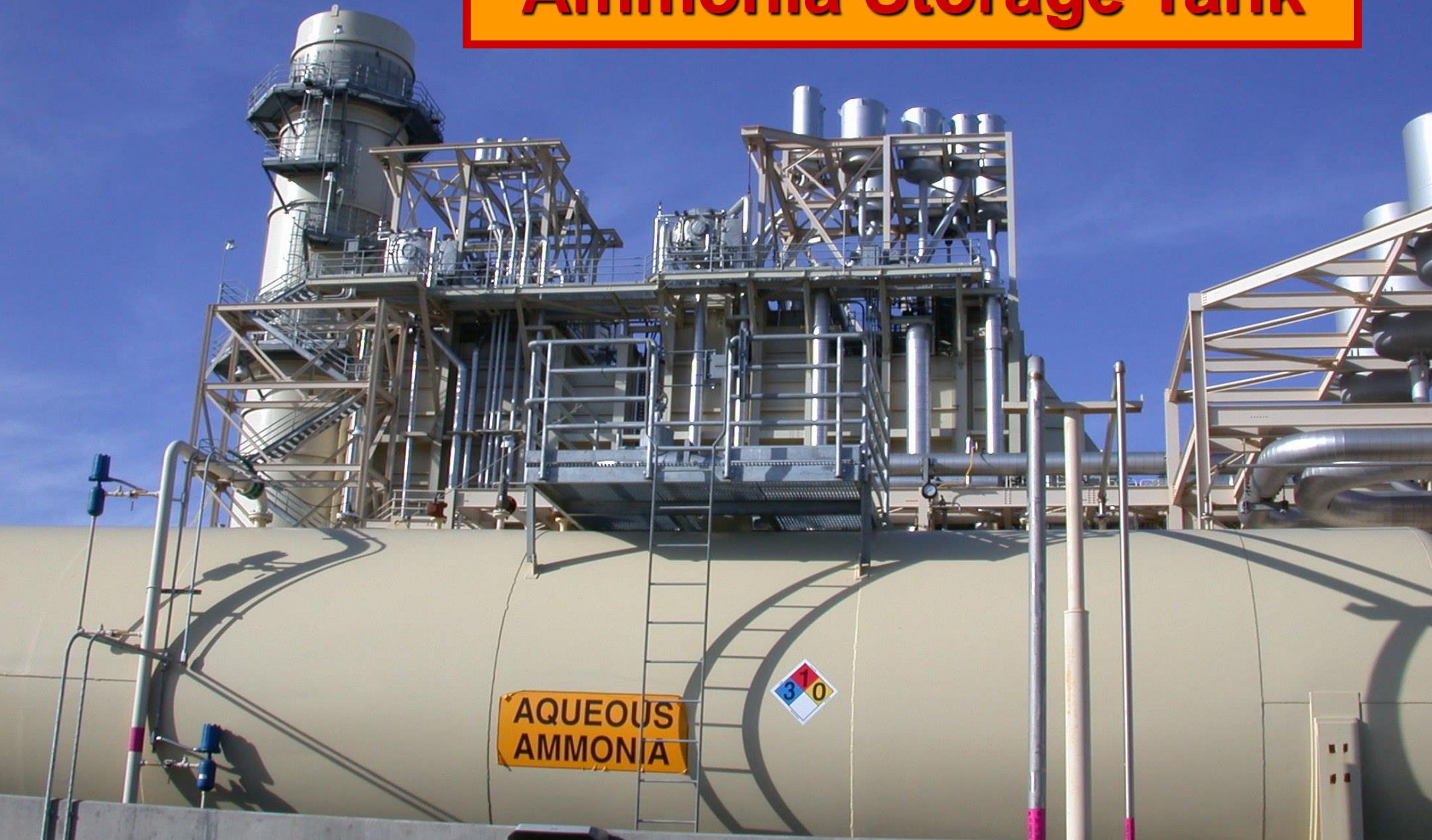


**Small Boiler  
with SCR**

# Boiler with Retrofit SCR



# Ammonia Storage Tank



# Anhydrous Ammonia Storage Tank



# Utility Boiler NH<sub>3</sub> Manifold

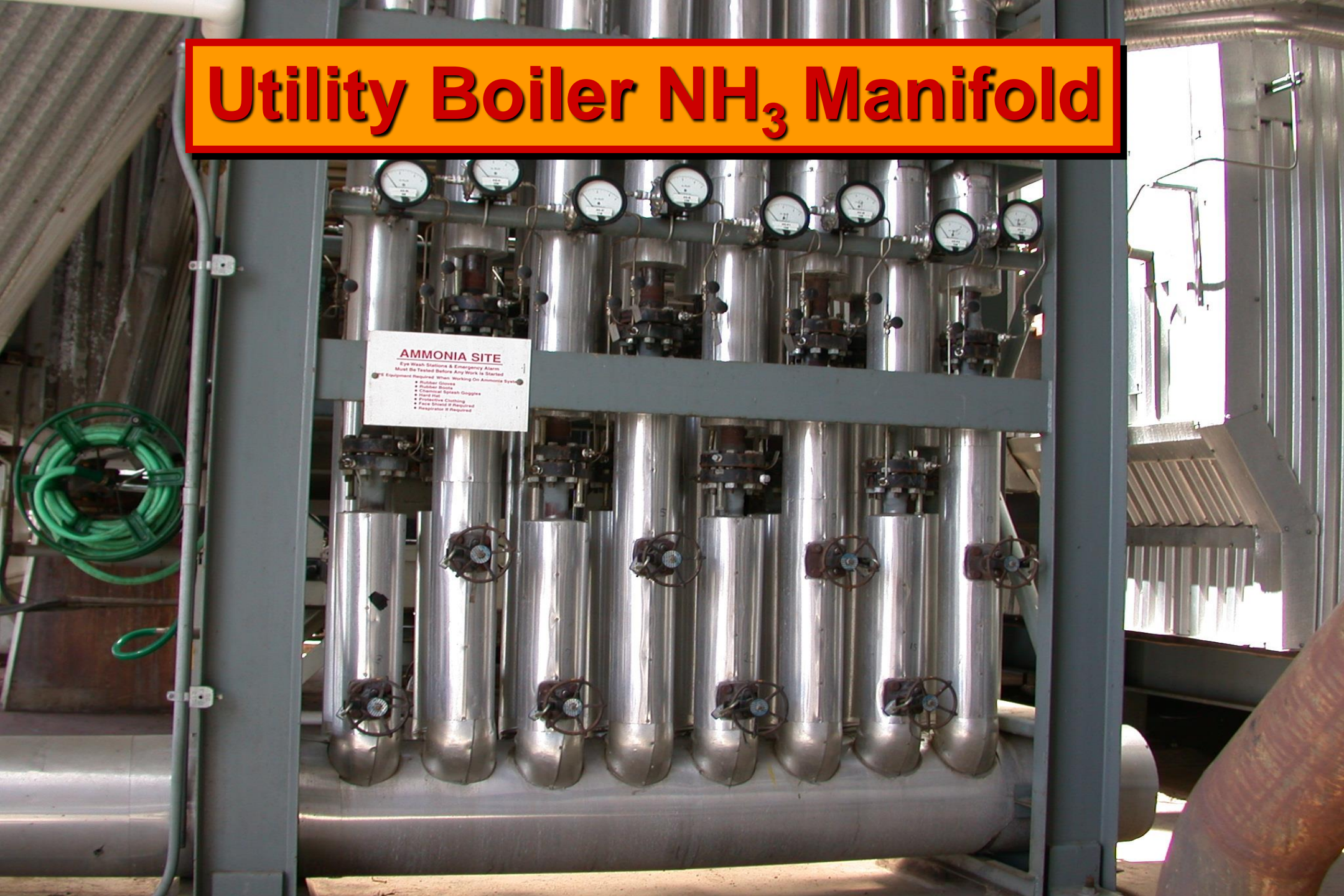
## AMMONIA SITE

Eye Wash Stations & Emergency Alarm

Must Be Tested Before Any Work Is Started

• PPE Equipment Required When Working On Ammonia System

- Rubber Gloves
- Rubber Boots
- Chemical Splash Goggles
- Hard Hat
- Protective Clothing
- Face Shield if Required
- Respirator if Required



**NH<sub>3</sub> Injection Tube**

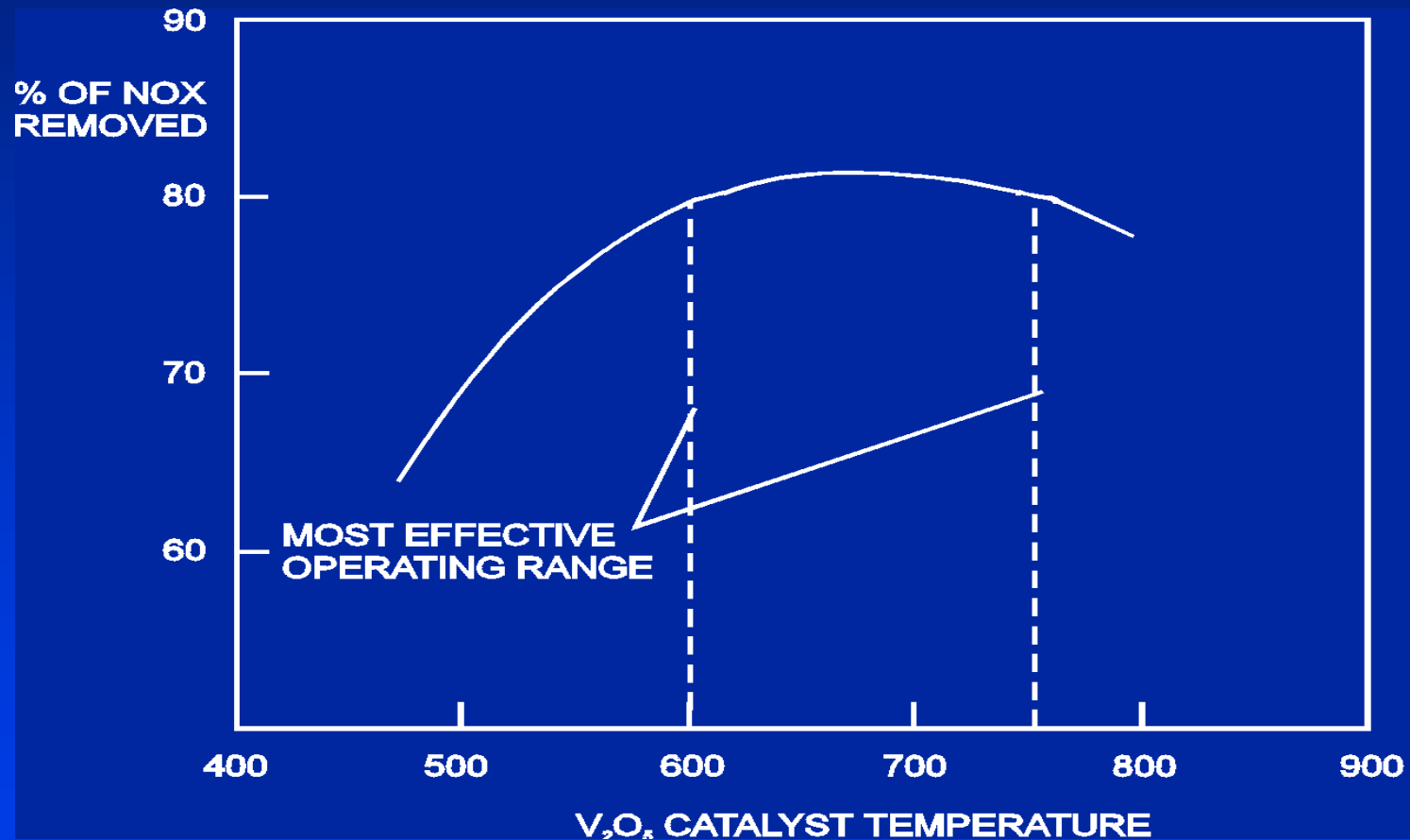


# SCR Catalyst





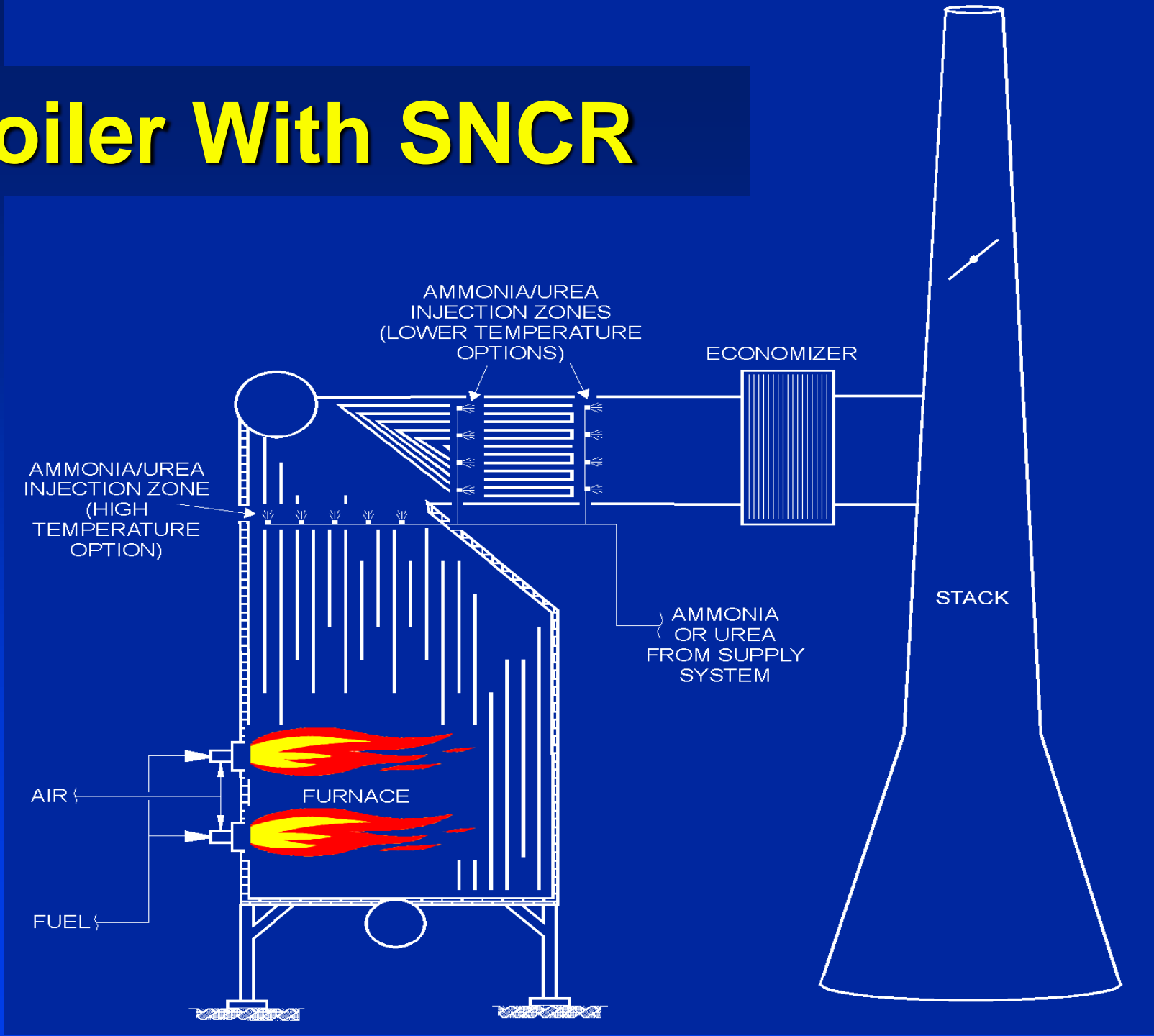
# % NO<sub>x</sub> Removed vs. Vanadium Pentoxide Catalyst Temperature



# Boilers & SNCR



# Boiler With SNCR



# Selective Non-Catalytic Reduction

- ◆ NO<sub>x</sub> control through ammonia or urea injection
- ◆ No catalyst necessary
- ◆ Temperature range 1400 °F – 1700 °F
- ◆ Injected upstream of convection section
- ◆ 80% control under normal conditions
- ◆ Problems:
  - ◆ Changing flue temperatures with changing load
  - ◆ Formation of ammonium salts
  - ◆ Ammonia slip



# Comparison of NOx Reduction Technologies

Technology	Approx. Reduction	Approx. lbs/MMBTU	Approx. ppmv @ 3% O2
Standard burners	Base case	0.14	120
Low NOx burners	60%	0.06	45
Ultra Low NOx burners – 1 <sup>st</sup> gen.	80%	0.03	25 - 30
Ultra Low NOx burners – 2 <sup>nd</sup> gen.	95%	0.007	6 - 9
FGR	55%	0.025	20
Compu- NOx w/ FGR	90%	0.015	15 - 20
SNCR	80%	0.033 - 0.085	27 - 70
Catalytic Scrubbing	70%	0.017 - 0.044	14 - 36
SCR	90 – 95%	0.006 - 0.015	5 - 12

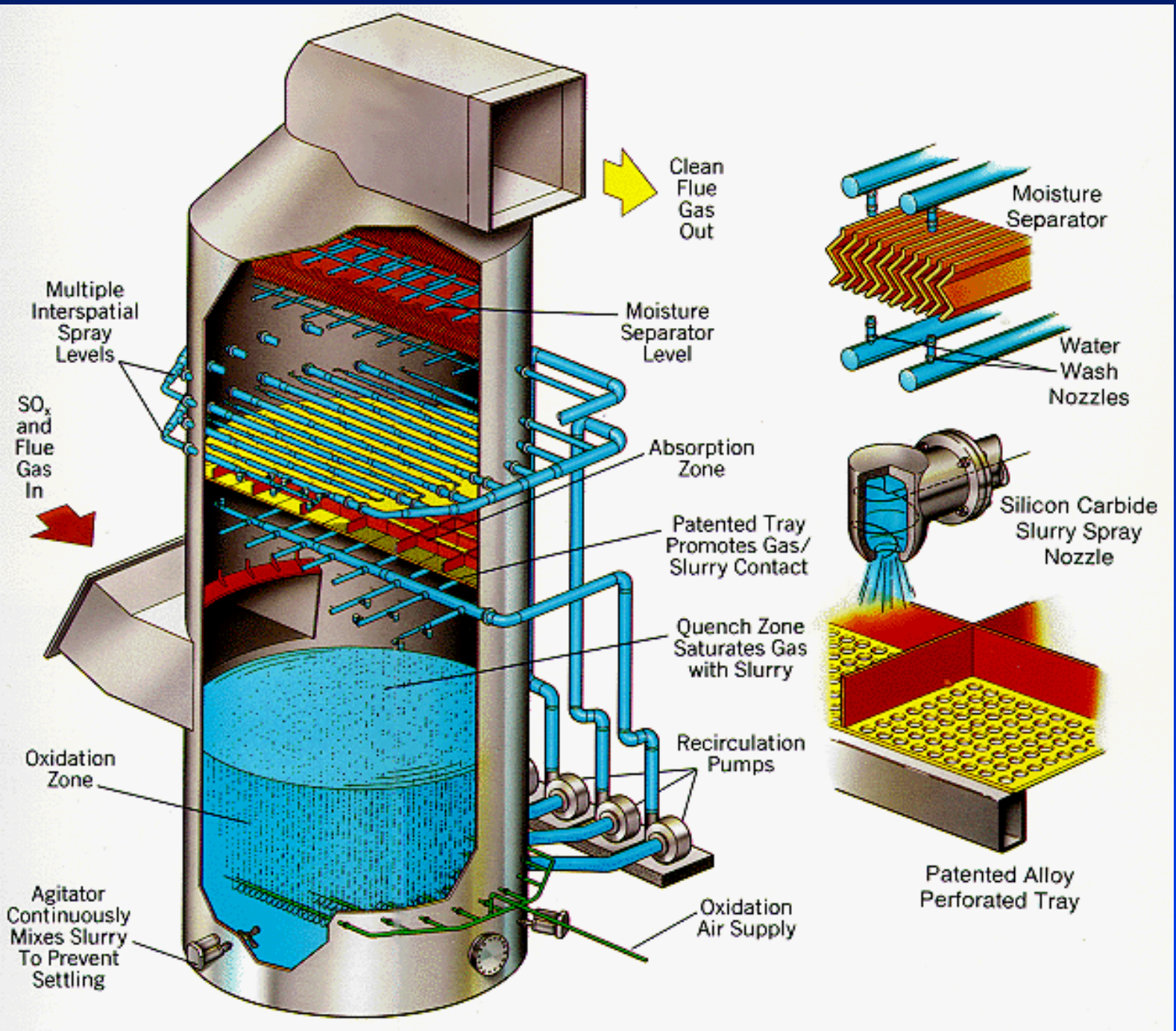


**Let's Discuss  
SOx Control**

## Sulfur Content of Various Fuels

Fuel	Sulfur Percent by Weight
Natural gas	0.0005
LPG	0.001
Fuel Oil No. 1	0.01 to 0.3
Fuel Oil No. 2	0.05 to 0.5
Diesel Motor Fuel	0.0015
Fuel Oil No. 4	0.2 to 1.75
Fuel Oil No. 5	0.5 to 1.75
Fuel Oil No. 6	0.5 to 1.75
Low Sulfur Fuel Oil No. 6	0.5
Subbituminous coal from Rocky Mt. states	0.3 to 1
Petroleum coke	2 to 10

**Fuel  
Sulfur  
Content**



# Spray Tower Wet FGD Scrubber

Graphic Courtesy of B&W



# Five FGD Scrubber Modules on Utility Boiler



Graphic Courtesy of B&W

# Let's Discuss PM Control



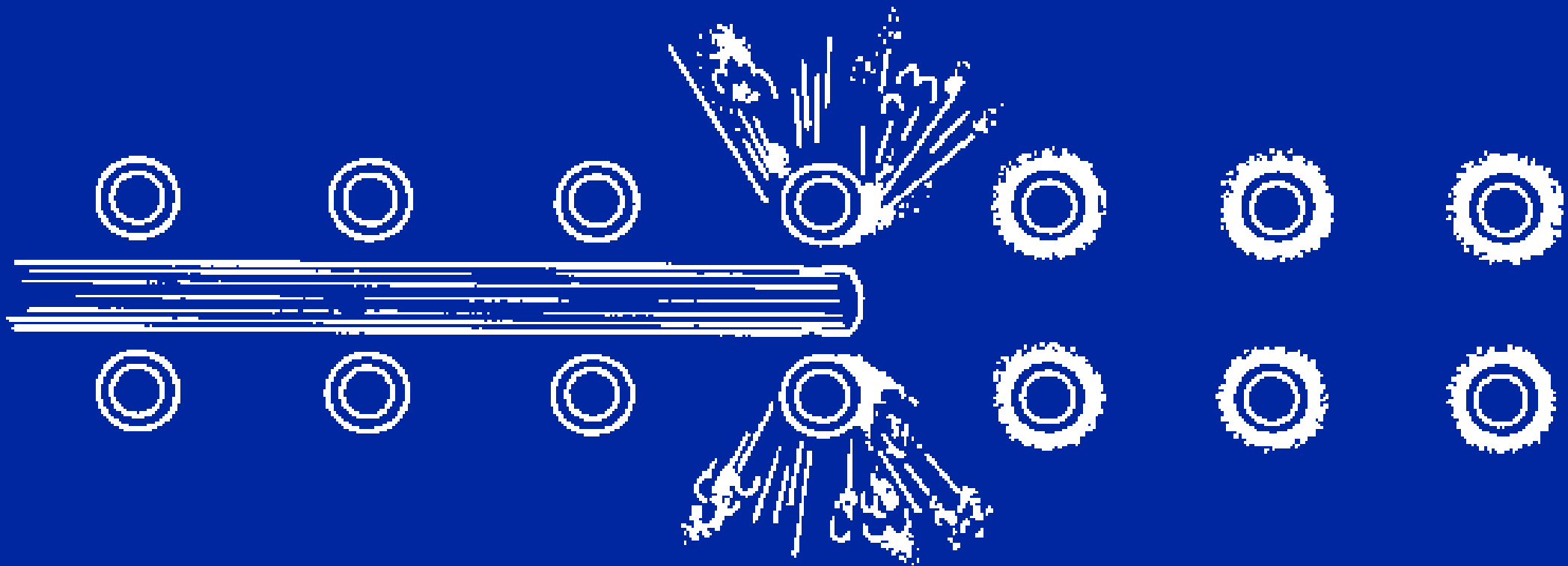
# Control of Particulate Emissions

- ◆ Settling chambers
- ◆ Cyclones
- ◆ Baghouses
- ◆ ESPs
- ◆ Scrubbers

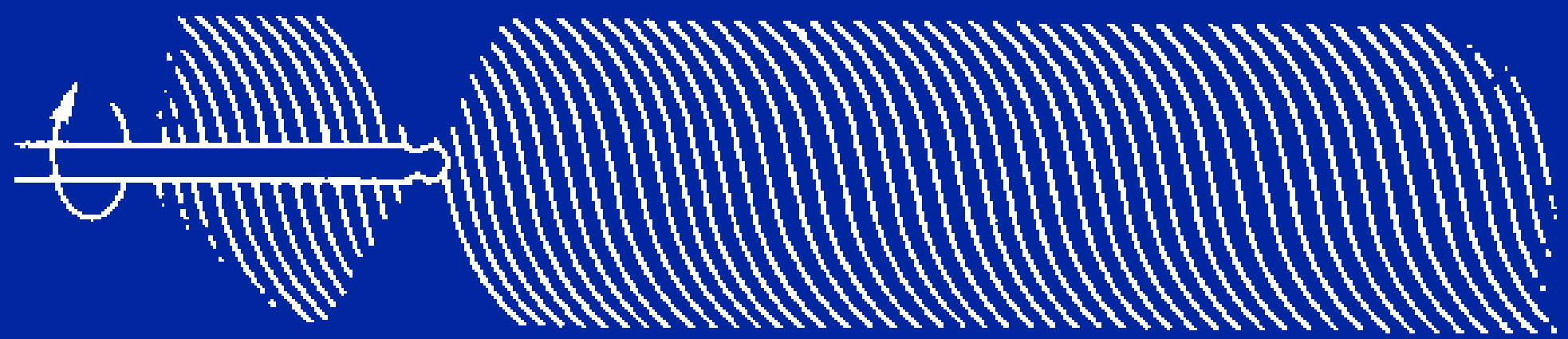


# Water Spray

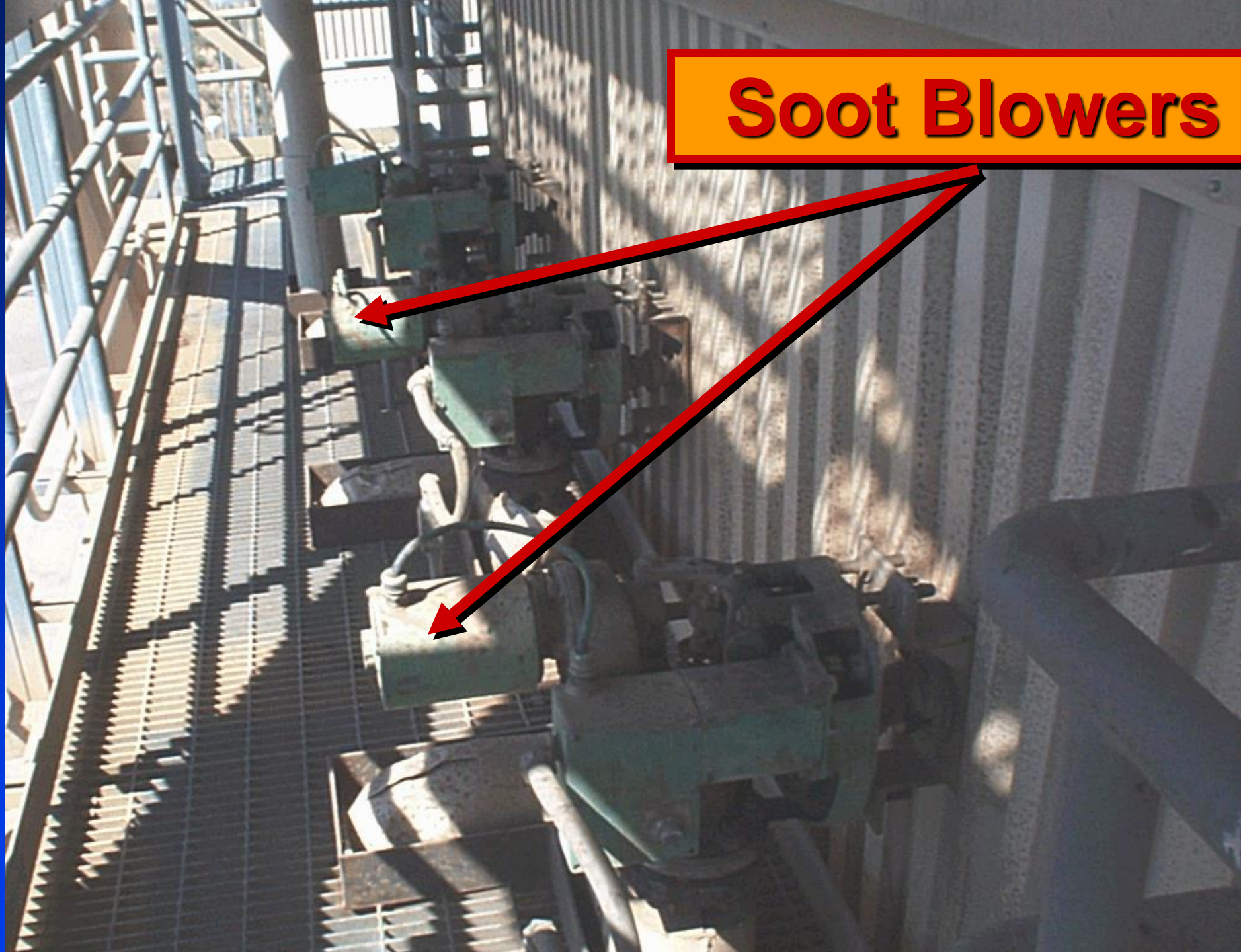




**Soot Blowing**



# Soot Blowers





**Soot  
Blowing/  
Rapping**



**Cyclone**





# Multi- Cyclone

Graphic Courtesy  
of B&W



**Baghouse**

**Baghouse**

**Dirty**

**Clean**



**ESP**





# Regulatory Requirements

# Regulatory Requirements

- ◆ **Federal, state, and local requirements**
- ◆ **Boiler specific limits**
- ◆ **Permit requirements**
- ◆ **Monitoring requirements**
- ◆ **Visible emission limits**
- ◆ **Nuisance regulations**
- ◆ **Breakdowns & variances**



# Boiler Regulations

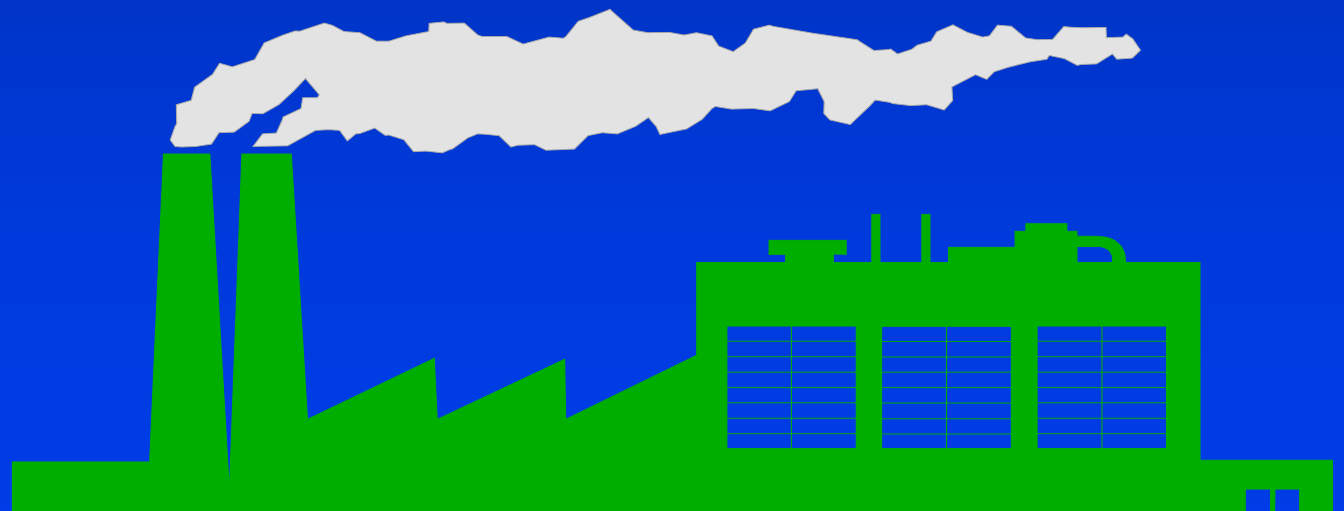


- ◆ NSPS 40 CFR Part 60 Subpart D, Da, Db, Dc, Ea
- ◆ Acid Rain Provisions (Parts 72,73,74,75, 76, 77, 78)
- ◆ RCRA 40 CFR Parts 264 & 266
- ◆ State Regulations including VE
- ◆ SIP Requirements
- ◆ Local Regulations
- ◆ MACTs – JJJJJJ & DDDDD



# Boiler Emission Limits

- ◆ **NO<sub>x</sub>, SO<sub>2</sub>, particulate, and opacity values for boilers are based on applicable subpart, heat input, date built or modified, and fuel used**
- ◆ **States and districts may have more stringent limits**





# BACT in CA

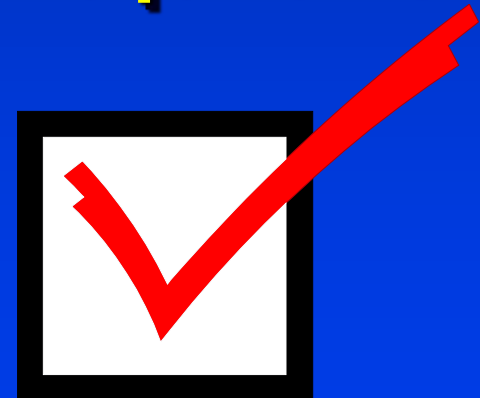
Type of Control	NOx Limits
Natural Gas Fired with SCR or equal	6 - 9 ppmvd @3% O <sub>2</sub> (0.011 lb/MMBTU)
Natural Gas Fired with Ultra Low NOx Burner	15 ppmvd @3% O <sub>2</sub> (0.018 lb/MMBTU)
Natural Gas Fired with Low NOx Burner	20 ppmvd @3% O <sub>2</sub> (0.024 lb/MMBTU)

# BARCT & RACT

Type of Control	NOx Limits
Natural Gas Fired with Low NOx Burner	9 - 30 ppmvd @3% O <sub>2</sub> 0.036 lb/MMBTU
Natural Gas Fired Units (< 40 MMBTU/hr)	74 ppmvd @3% O <sub>2</sub> 0.085 lb/MMBTU
Solid Fuel Fired Boilers	0.20 lb/MMBTU
Municipal Solid Waste	200 ppmv @12% CO <sub>2</sub> 0.24 lb/MMBTU

# Permit Categories

1. Emissions Limitations
2. Equipment Requirements
3. Operating Conditions
4. Monitoring and Recording Requirements
5. Compliance Testing
6. General Requirements



# Testing and Monitoring

- ◆ **Continuous Monitoring System**
- ◆ **Stack Testing**
- ◆ **Process Monitors**
- ◆ **Recordkeeping**

# Continuous Monitoring Types

- ◆ Opacity Transmissometers
- ◆  $\text{NO}_x$
- ◆  $\text{SO}_2$
- ◆ CO
- ◆  $\text{O}_2$  and/or  $\text{CO}_2$
- ◆ Ammonia
- ◆ Mercury Semi-Continuous

# Source Testing

- ◆ **Particulate Matter (PM, PM10, PM2.5)**
- ◆ **NOx, SO2, CO, Ammonia**
- ◆ **Mercury and Other Metals**
- ◆ **Hydrogen Chloride**
- ◆ **Formaldehyde**
- ◆ **Visible Emissions (Method 9)**

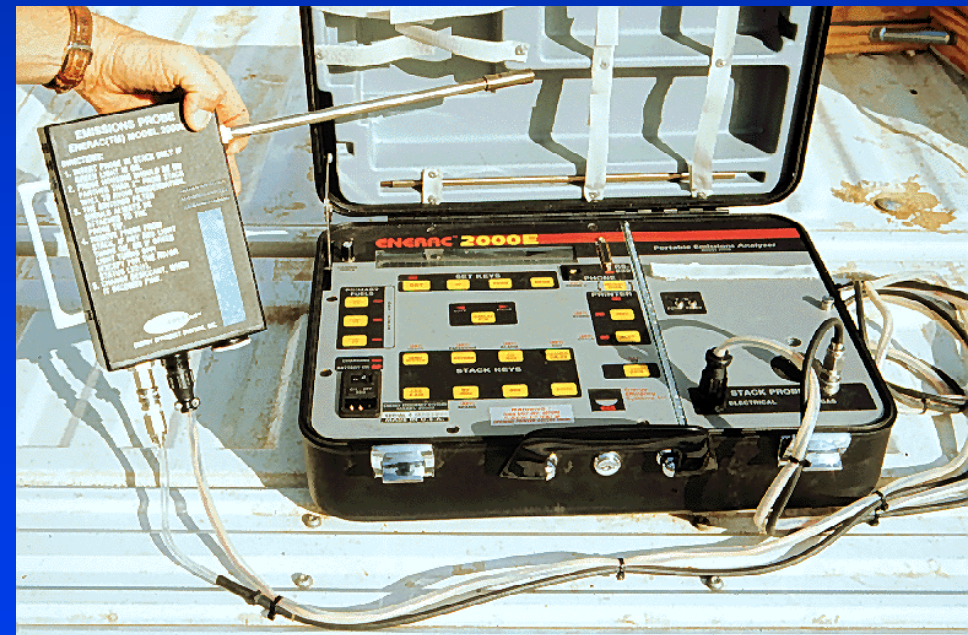
# Control Device Parameters

- ◆ **ESP Spark Rate and Fields in service**
- ◆ **Baghouse Pressure Drop**
- ◆ **Scrubber Pressure Drop and Liquor Flow Rate**
- ◆ **Fuel Usage**

# Alternative Monitoring

- ◆ Portable analyzer monitoring of NO<sub>x</sub>, CO, O<sub>2</sub>
- ◆ Determination of FGR rate
- ◆ Burner mechanical adjustments
- ◆ O<sub>2</sub> Trim concentration
- ◆ FGR valve(s) setting

**Portable Combustion  
Analyzer**







# Boiler Inspections

# Points of Inspection

- ◆ Capture
- ◆ Transport
- ◆ Air mover
- ◆ Control device
- ◆ Instrumentation
- ◆ Subsystem
- ◆ Records



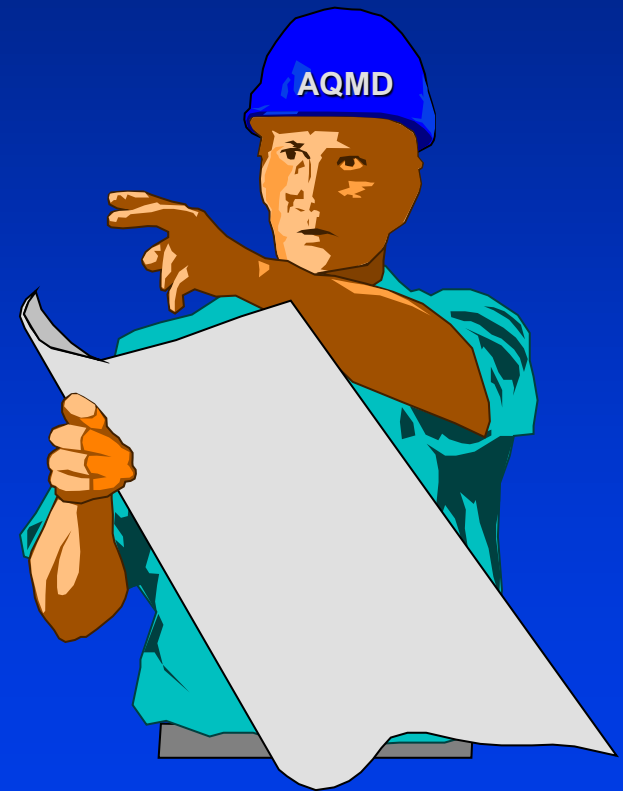
# Pre-Inspection



- ◆ Prepare inspection form
- ◆ File review
- ◆ Regulation review
- ◆ Equipment check
- ◆ Pre-entry & entry
- ◆ Pre-inspection meeting
- ◆ Permit check

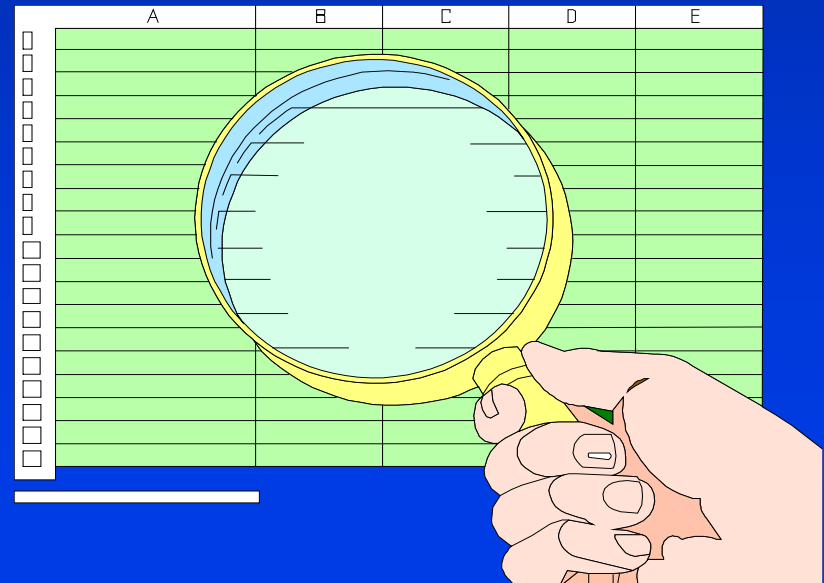
# Reasons for Inspections

- ◆ **Compliance determination**
- ◆ **Complaint investigation**
- ◆ **Source plan approval**
- ◆ **Review or renewal of permits**
- ◆ **Special studies**



# Inspection

- ◆ **Visible emission evaluation**
- ◆ **General upkeep & maintenance**
- ◆ **Monitoring instruments & records**
- ◆ **Fuel type and quality**
- ◆ **Maintenance records**
- ◆ **Operational records**
- ◆ **Source tests**

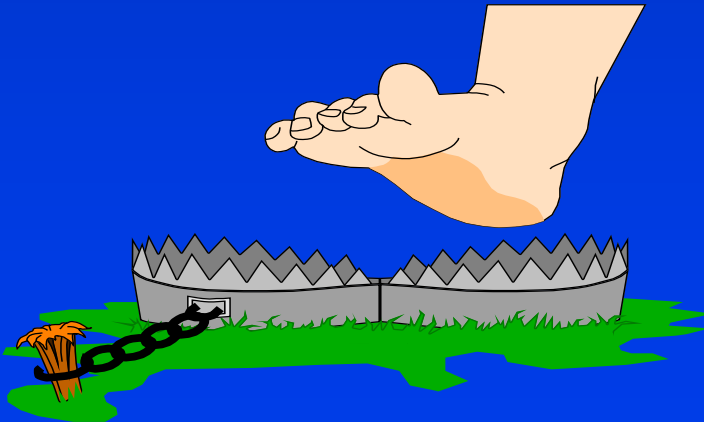


# Plant Safety



# Inspector Safety

- ◆ Proper equipment
- ◆ Plant warnings
- ◆ Heat
- ◆ High pressure steam
- ◆ Electrical hazards
- ◆ Noise
- ◆ Moving parts
- ◆ Inhalation hazards
- ◆ Hazardous materials
- ◆ Machine disintegration
- ◆ Fires
- ◆ Other hazards & traps





**Plant Safety**





**Plant Hazards**

**Confined  
Space**



**DANGER**  
**CONFINED SPACE**  
ENTER BY PERMIT ONLY

**Confined Space**

**DANGER**  
**CONFINED SPACE**  
POSSIBLE NITROGEN  
ATMOSPHERE  
ADEQUATE MECHANICAL  
VENTILATION REQUIRED

**DANGER**

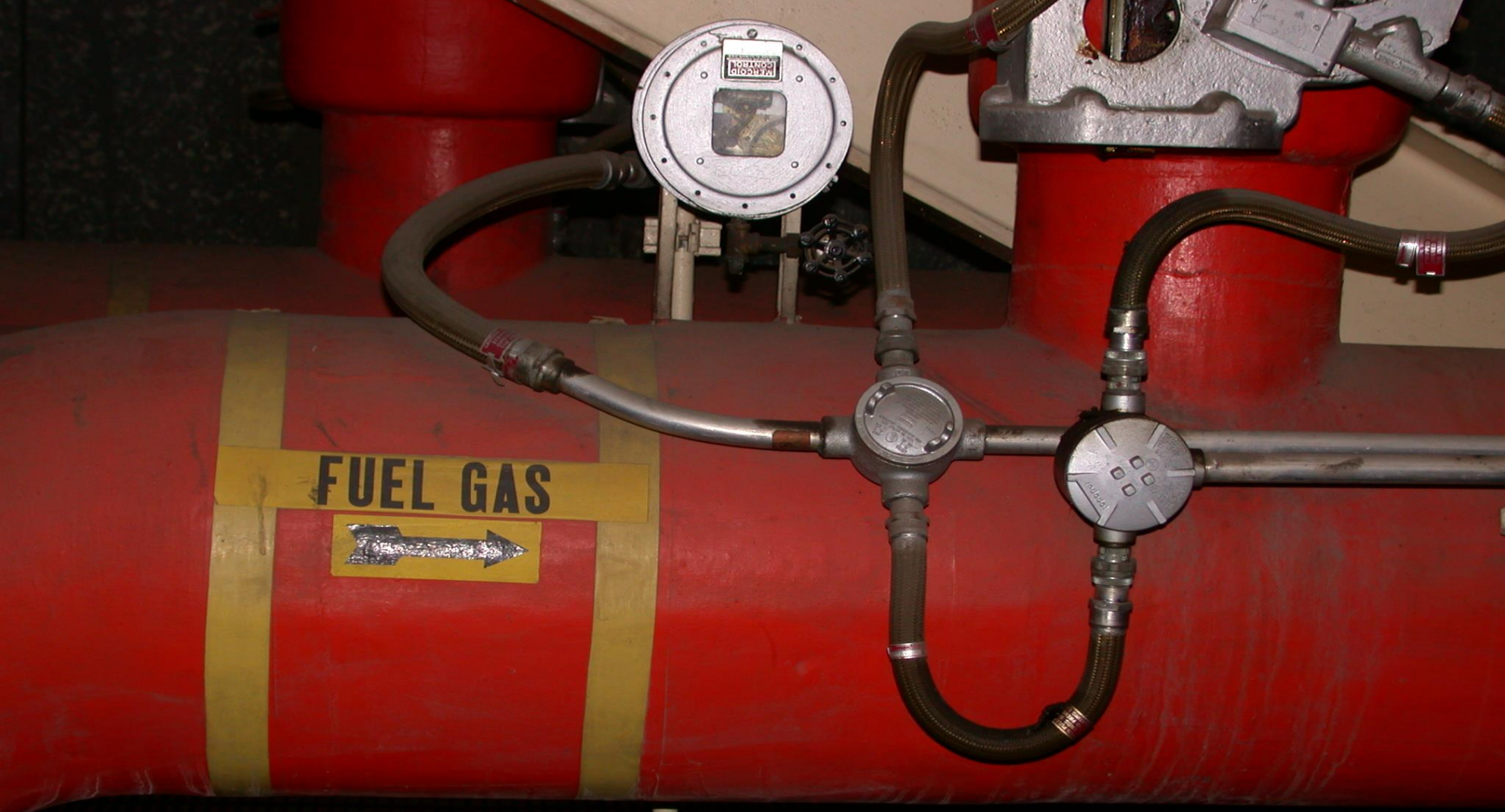
**CONTAINS ASBESTOS FIBERS**

**AVOID CREATING DUST**

**CANCER AND LUNG DISEASE HAZARD**

**AVOID BREATHING AIRBORNE ASBESTOS**


62-1397 (5/88)



**HP Gas Lines**

A photograph showing a significant structural failure in a wall. A large, jagged hole has been made in the drywall, exposing a network of pipes and conduits. The scene is illuminated by a bright, warm light source, likely a flashlight, which creates a strong glare and casts shadows. The exposed pipes appear to be made of metal and are surrounded by insulation and other building materials. The overall appearance is one of a major industrial or utility accident.

**Ruptured  
Steam Line**

A photograph of an industrial setting, likely a power plant or factory, showing a large piece of machinery with a prominent steam exhaust. The machinery is surrounded by various pipes, valves, and electrical components. The steam is thick and white, rising from the machinery. The scene is dimly lit, with a warm, yellowish glow from the machinery's lights. The steam exhaust is the central focus of the image.

**Steam  
Exhaust**

**Access**





**Access**



**Thank You!**

