The National Air Compliance Training Program

Course 288
Petroleum Refining

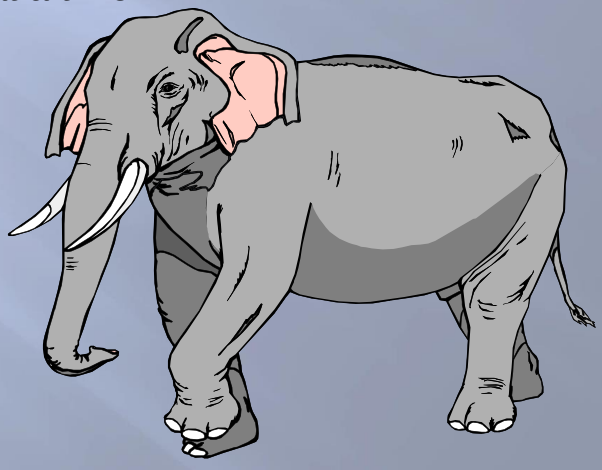
2017

Course Objectives

- Familiarize with refinery:
  - terminology
  - process
  - process equipment
- Identify:
  - air emissions sources
  - inspection points
  - regulations

How do you eat an Elephant?

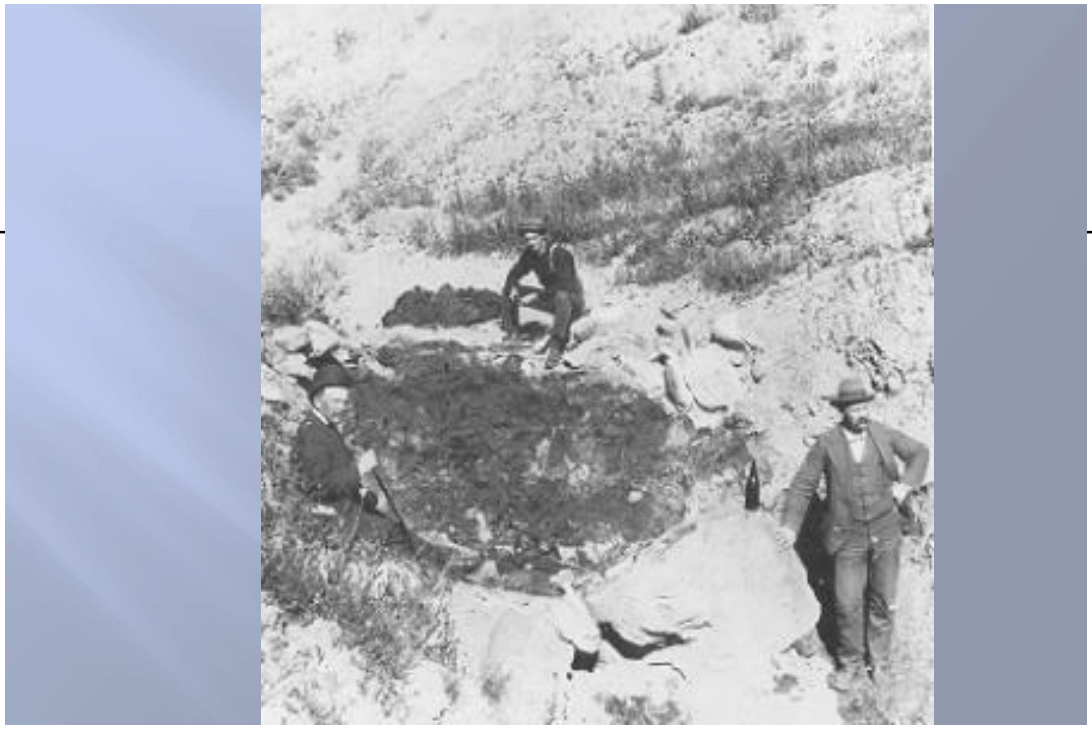
One bite at a time.



Early Uses of Petroluem

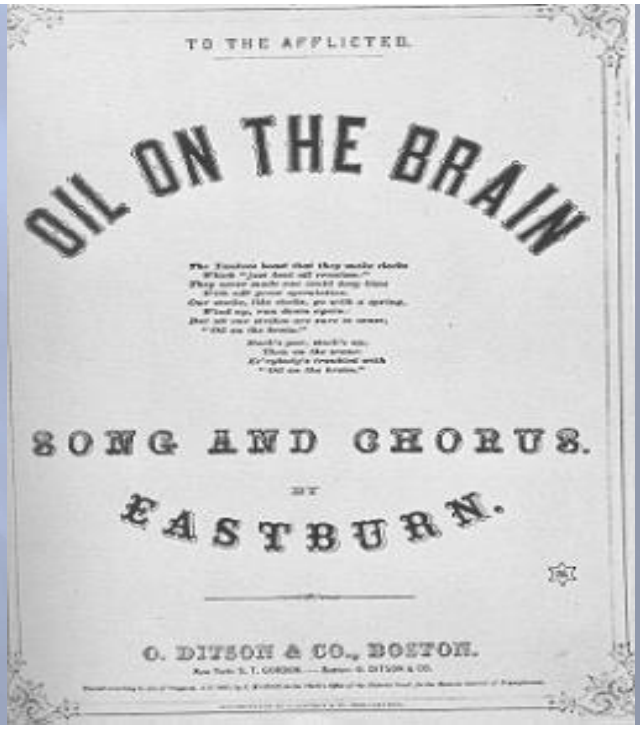
- **Water Repellent and Caulking**
- **Grease and Lubricants**
- **Lamp Oil**
- **Medicines**

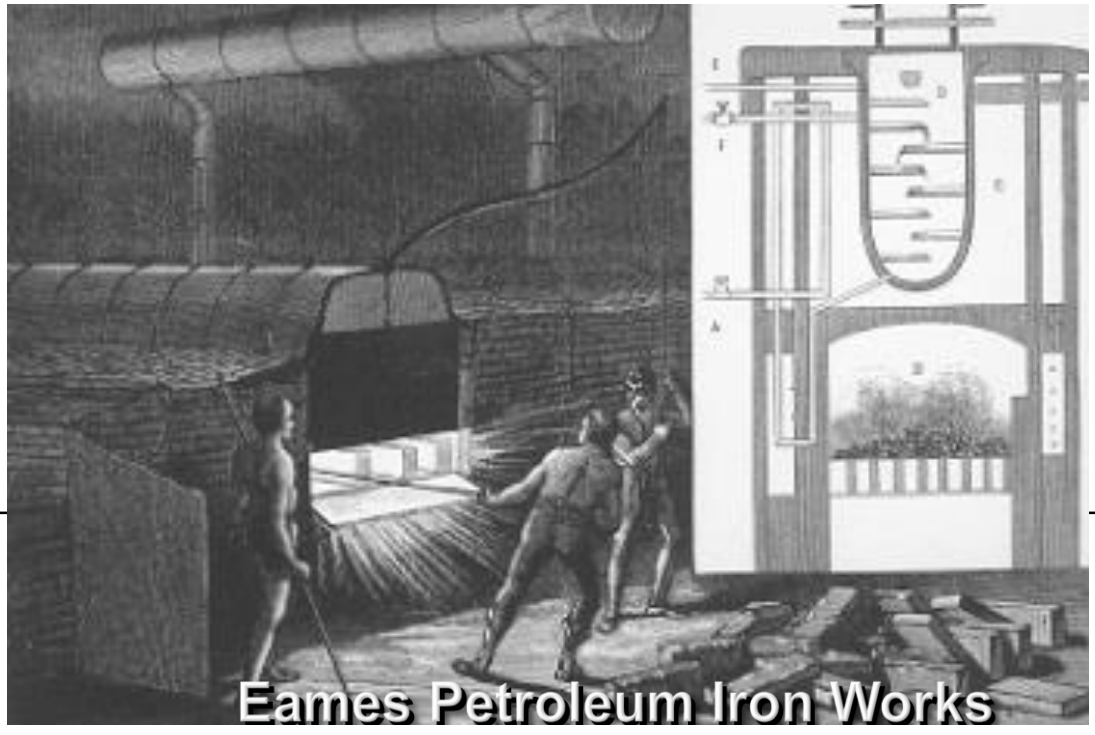

LAKE ERIE
ERIE
N. Y.
PA.
CORRY
UNION MILLS
WARREN
IRVINETON
GARLAND
TIDIOUTE
LINESVILLE
MEADVILLE
TITUSVILLE
OIL CITY
FRANKLIN
OIL REGION
1859 — 1870
SCALE



The Oil Boom

1859 was to oil as 1849 was to gold. But what to do with all of the oil?





PETROLEUM, OR ROCK OIL.

A NATURAL REMEDY!

PROCURED FROM A WELL IN ALLEGHENY COUNTY, PA.

Four hundred feet below the Earth's Surface!

PUT UP AND SOLD BY

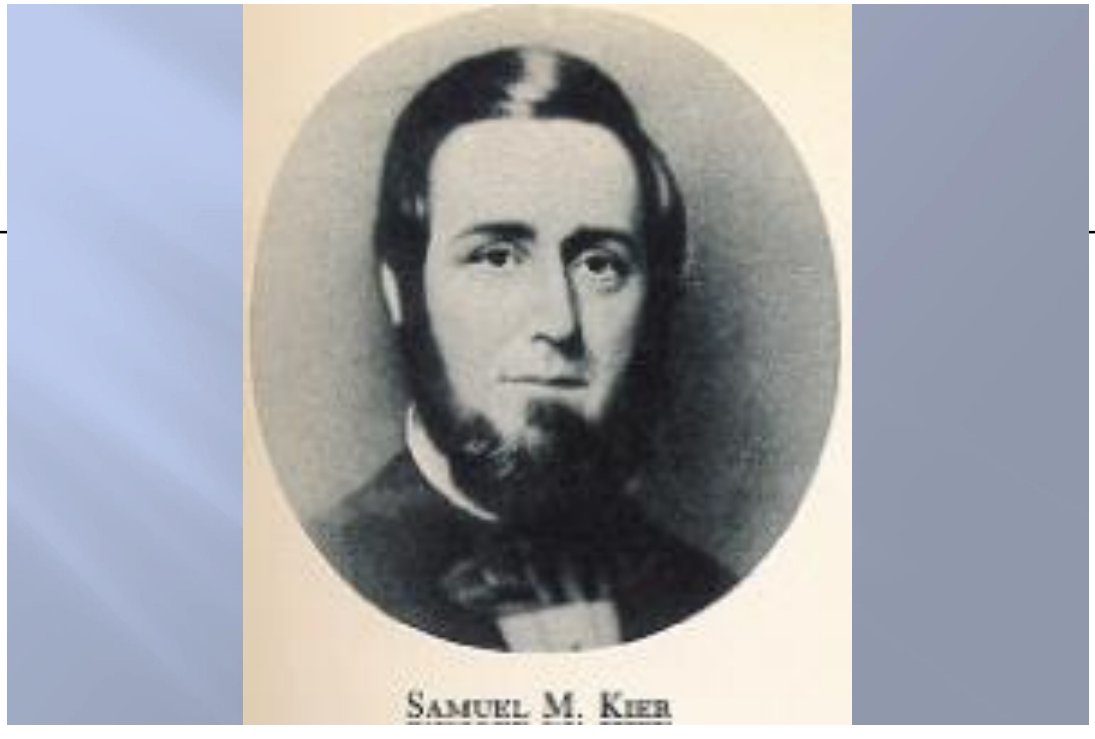
SAMUEL M. KIER,

CANAL BASIN, SEVENTH STREET, PITTSBURGH, PA.

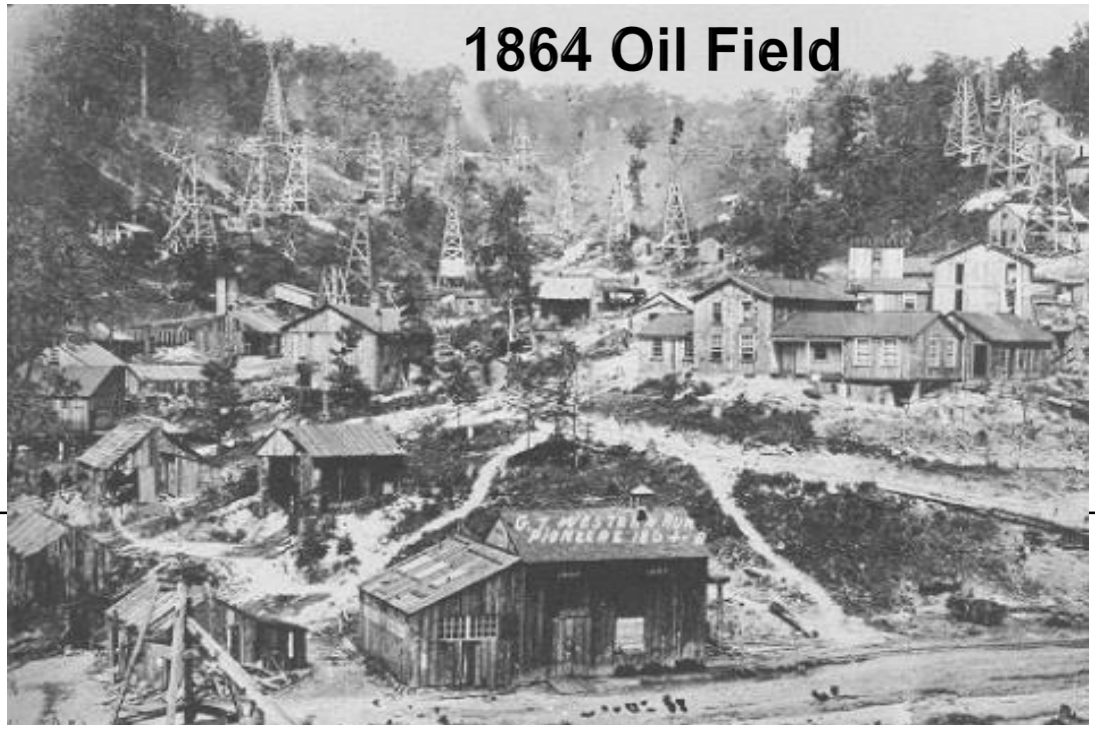
The healthful balm from Nature's secret spring.
The bloom of health, and life, to man will bring.
As from her depths the magic liquid flows,
To calm our sufferings, and assuage our woes.

CAUTION.—As many persons are now going about and vending an article of a spurious character, calling it Petroleum, or Rock Oil, we would caution the public against all preparations bearing that name not having the name of S. M. KIER written on the label of the bottle.

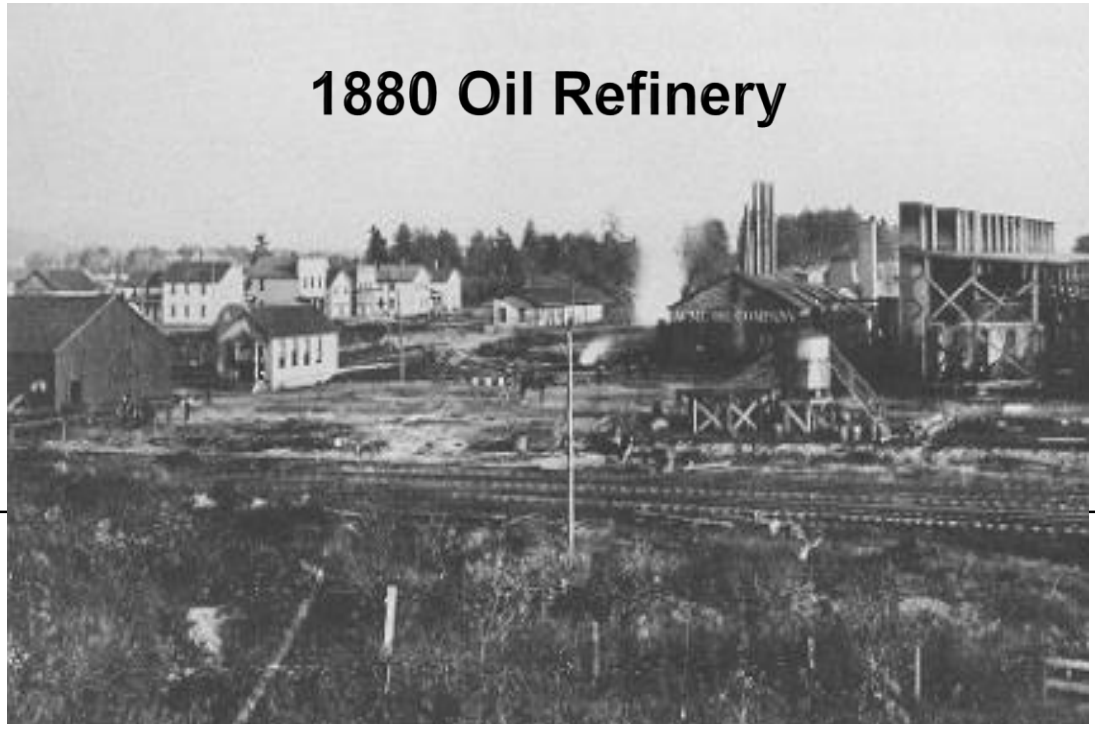
PETROLEUM.—It is necessary, upon the introduction of a new medicine to the notice of the public, that something should be said in relation to its powers in healing diseases, and the manner in which it acts. Man's organization is a complicated one; and to understand the functions of each organ, requires the study of years. But to understand that certain remedies produce certain impressions upon those organs, may be learned by experience in a short time. It is by observation in watching the effects of various medicines, that we are enabled to increase the number of curative agents; and when we have discovered a new medicine and attested its merits, it is our duty to bring it before the public, so that the benefits so be derived from it may be more generally diffused, but have no right to hold back a remedy whose powers are calculated to remove pain and to alleviate human suffering and disease. THE PETROLEUM HAS BEEN FULLY TESTED. About one year ago, it was placed before the public as A REMEDY OF WONDERFUL EFFICACY. Every one not acquainted with its virtues, doubted its healing properties. The cry of humbug was raised against it. It had some friends,—those that were cured through its wonderful agency. These spoke out in its favor. The lame, through its instrumentality, were made to walk—the blind, to see. Those who had suffered for years under the tormenting pains of RHEUMATISM, GOUT and NEURALGIA, were restored to health and usefulness. Several who were blind have been made to see, the evidence of which will be placed before you. If you still have doubts, go and ask those who have been cured! Some of them live in our midst, and can answer for themselves. In writing about a medicine, we are aware that we should write TRUTH—that we should make no statements that cannot be proved. We have the witnesses—crowds of them, who will testify in terms stronger than we can write them to the efficacy of this Remedy, who will testify that the PETROLEUM has done for them what no medicine ever could before—cases that were pronounced hopeless, and beyond the reach of remedial means—cases abandoned by Physicians of unquestioned celebrity, have been made to exclaim, "THIS IS THE MOST WONDERFUL REMEDY EVER DISCOVERED!" We will lay before you the certificates of some of the most remarkable cases, to give them all, would require more space than would be allowed by this circular. Since the introduction of the Petroleum, about one year ago, many Physicians have been convinced of its efficacy, and now recommend it in their practice; and we have no doubt that in another year it will stand at the head of the list of valuable Remedies. If the Physicians do not recommend it, the people will have it of themselves—for its transcendent power to heal, will and must become known and appreciated—when the voices of the cured speak out; when the cripple throws away his crutch and stands erect in bold relief, and when he who for years has suffered with the tortures and pangs of an immedicable lesion, that has been shortening his days, and hastening him "to the narrow house appointed for all the living," when he speaks out in its praise, who will doubt it? THE PETROLEUM IS A NATURAL REMEDY—it is put up as it flows from the bosom of the earth, without anything being added to or taken from it.

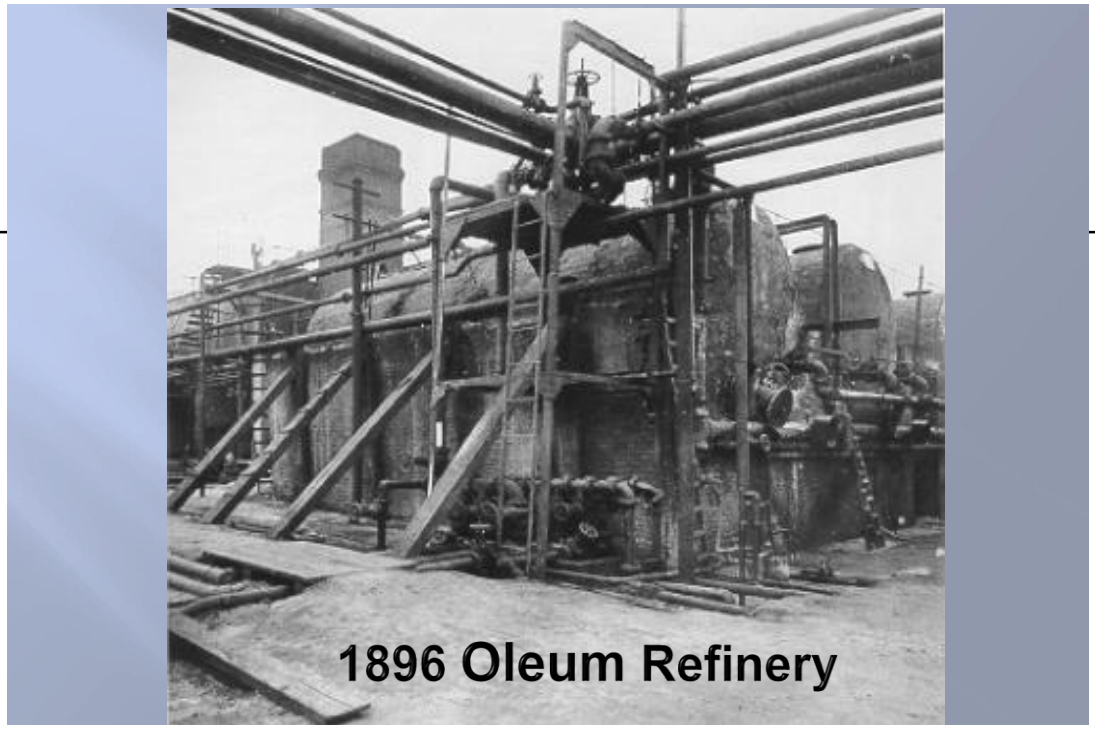


SAMUEL M. KIER

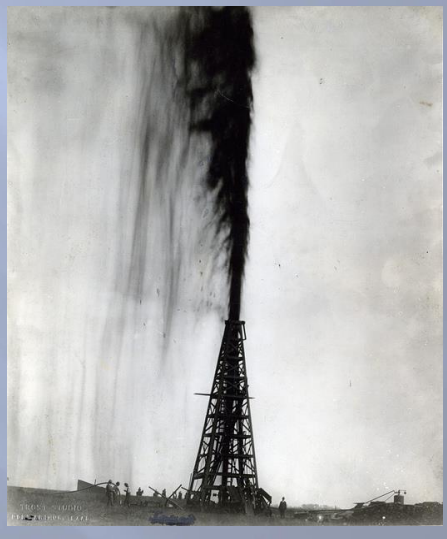

1864 Oil Field


1864 Refinery


1880 Oil Refinery


1896 Oleum Refinery

Gushers



Early Refining

Top US Refineries

1. Port Arthur Refinery (Montiva), Port Arthur, TX, 600,250 Bbl/day
2. Baytown Refinery (ExxonMobil), Baytown, Texas, 584,000 Bbl/day
3. Garyville Refinery (Marathon), Garyville, LA, 522,000 bbl/day
4. Baton Rouge Refinery (ExxonMobil), Baton Rouge, LA, 503,000 Bbl/day
5. Hovensa LLC (Hovensa LLC), Kingshill, Virgin Islands, 500,000 Bbl/day
6. BP (BP), Texas City, TX, 460,000 Bbl/day
7. Lake Charles Refinery (Citgo), Lake Charles, LA, 427,800 Bbl/day\
8. BP (BP), Whiting, IN, 399,000 Bbl/day
9. ExxonMobil (Exxon Mobil), Beaumont, TX, 344,500 Bbl/day
10. Philadelphia Energy (Carlyle Group), Philadelphia, PA, 335,000 Bbl/day
11. WRB Refining, (WRB Refining) Wood River, IL, 333,000 Bbl/day
12. Chevron (Chevron USA Inc.), Pascagoula, MS, 330,000, Bbl/day

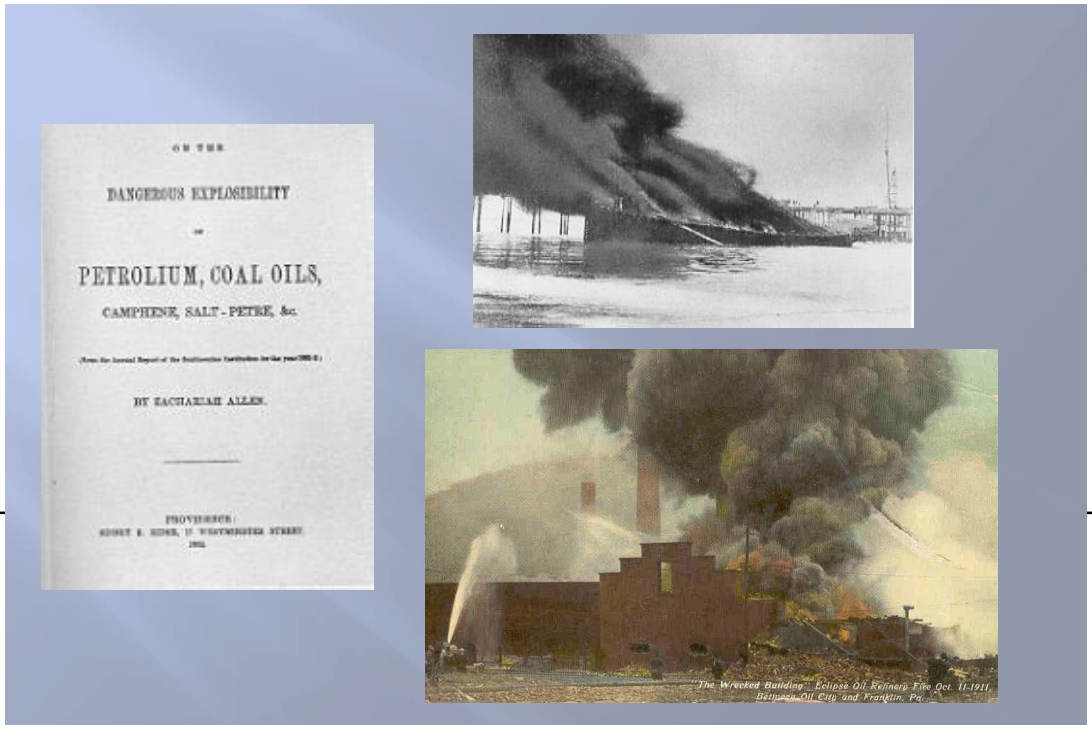
WORLD'S LARGEST REFINERIES

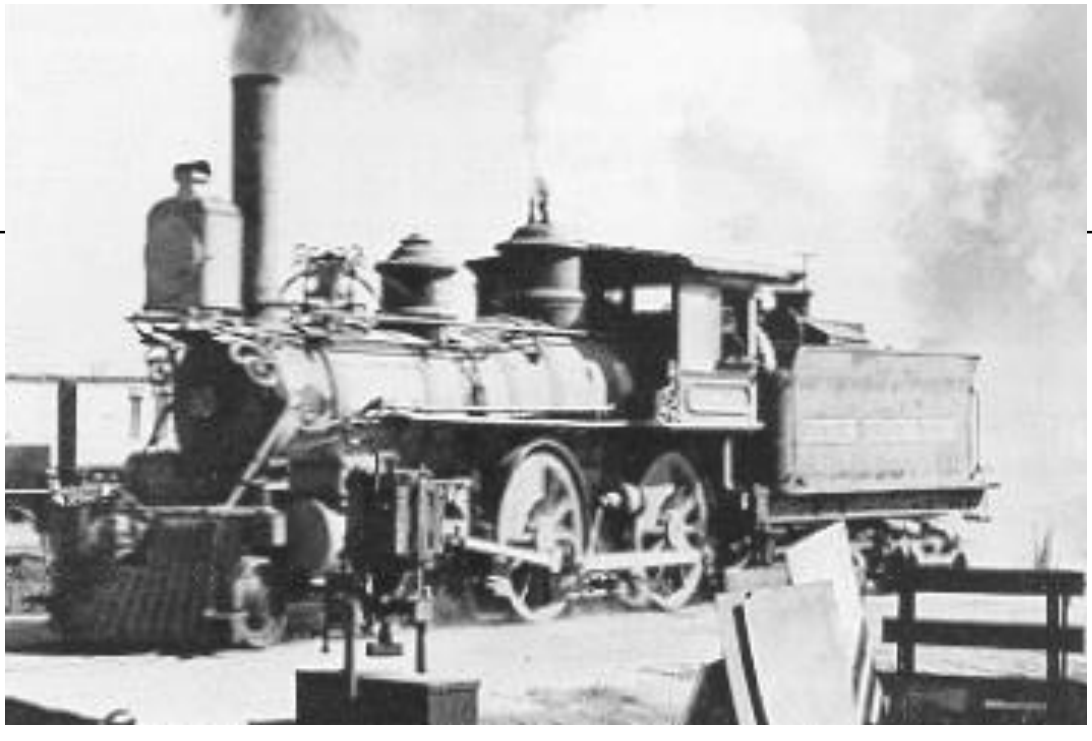
Table 3

	Company	Location	Crude capacity, b/cd
1	Paraguana Refining Center	Cardon/Judibana, Falcon, Venezuela	940,000
2	SK Innovation	Ulsan, South Korea	840,000
3	GS Caltex Corp.	Yeosu, South Korea	760,000
4	Reliance Petroleum Ltd.	Jamnagar, India	660,000
5	ExxonMobil Refining & Supply Co.	Jurong/Pulau Ayer Chawan, Singapore	605,000
6	Reliance Industries Ltd.	Jamnagar, India	580,000
7	S-Oil Corp.	Onsan, South Korea	565,000
8	ExxonMobil Refining & Supply Co.	Baytown, Tex.	560,500
9	Saudi Arabian Oil Co. (Saudi Aramco)	Ras Tanura, Saudi Arabia	550,000
10	Formosa Petrochemical Co.	Mailiao, Taiwan	540,000
11	ExxonMobil Refining & Supply Co.	Baton Rouge, La.	502,500
12	Hovensa LLC	St. Croix, Virgin Islands	500,000
13	Marathon Petroleum Co. LLC	Garyville, La.	490,000
14	Kuwait National Petroleum Co.	Mina Al-Ahmadi, Kuwait	466,000
15	Shell Eastern Petroleum (Pte.) Ltd.	Pulau Bukom, Singapore	462,000
16	BP PLC	Texas City, Tex.	451,250
17	Citgo Petroleum Corp.	Lake Charles, La.	440,000
18	Shell Nederland Raffinaderij BV	Pernis, Netherlands	404,000
19	Sinopec	Zhenhai, China	403,000
20	Saudi Arabian Oil Co. (Saudi Aramco)	Rabigh, Saudi Arabia	400,000
21	Saudi Aramco-Mobil	Yanbu, Saudi Arabia	400,000

- **ConocoPhillips Co., Ponca City:** 198,400 barrels per day
- **Holly Refining and Marketing Co., Tulsa (East):** 70,300 barrels per day
- **Holly Refining and Marketing Co., Tulsa (West):** 85,000 barrels per day
- **Valero Refining Co. Oklahoma, Ardmore:** 85,000 barrels per day
- **Wynnewood Refining Co., Wynnewood:** 70,000 barrels per day

Refinery Class





What Refineries Do

- They make useful products like:
  - gasoline
  - diesel fuel
  - jet fuel (JP-4, JP-5 and A-1)
  - heating oil
  - feed stock for petro-chemicals
- From Petroleum Crude

What Refineries Do

- They also make waste products:
  - air emissions
  - hazardous waste
  - waste water

Sources of Emissions

- **NOx - Combustion Sources**
  - **Fired Heaters (70%)**
  - **Fluid Catalytic Cracker (10-15%)**
- **SOx - Fuel Containing Sulfur**
- **CO - Incomplete Combustion**
- **VOC - Fugitive Emissions**
- **Miscellaneous Sources (50%)**

Summary of Regulations

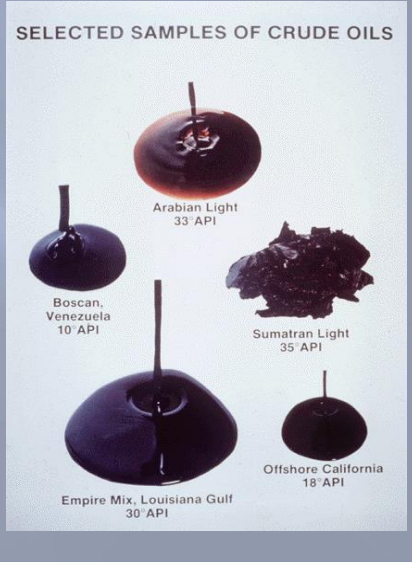
- MACT
- NSPS
- Title V
- Fugitives
- Visible Emissions
- Fence line Monitoring
- Review of Refinery NSPS/NESHAP/MACT Standards Handout

High Priority Sources

- Fired Heaters
- Flares
- Catalytic Cracking
- Sulfur Recovery
- Fugitive Emissions
- Storage Tanks
- Wastewater Treatment
- Cooling Towers
- Vacuum Systems

Crude Oil Terms

- Heavy-Light Crude
- Sweet-Sour Crude
- API Gravity



Petroleum Chemistry

- Nomenclature
- Physical Properties
- Structure

Nomenclature

- C1 = Methane (C_1H_4)
- C2 = Ethane (C_2H_6)
- C3 = Propane (C_3H_8)
- C4 = Butane (C_4H_{10})
- C5 = Pentane (C_5H_{12})
- C6 = Hexane (C_6H_{12})
- C8 = Octane (C_8H_{18})- Octane Rating
- C16 = Cetane ($C_{16}H_{34}$)- Cetane Rating

Physical Properties

- Boiling point
- Structure
- Reactivity
  - Exothermic
  - Endothermic

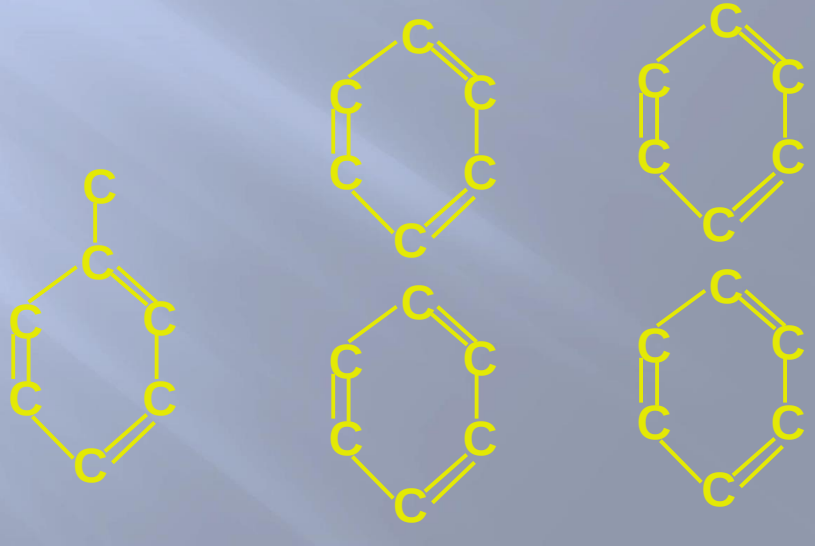
Physical Properties

NAME	FORMULA	BOILING POINT
Methane	CH_4	-162
Ethane	C_2H_6	-88.5
Propane	C_3H_8	-42
n-Butane	C_4H_{10}	0

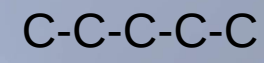
Structure

- Paraffin (straight chain - saturated)
  - Normal c-c-c-c
  - Branched (iso)
- Napthenes (ring or cyclo)
- Olefins (double bond)
  - unsaturated C= C-C-C
- Aromatics (cyclo-resonating bonds)

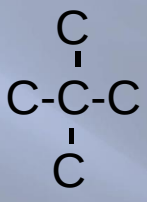
Aromatics



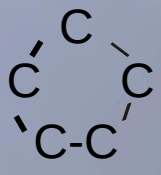
PENTANES (Paraffin)



62 Octane



120 Octane



80 Octane

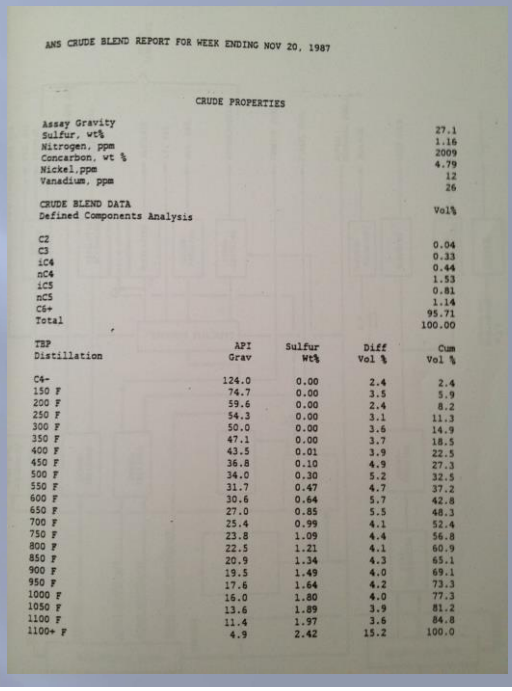
Cracking Expansion

$C_{16}H_{34}$ → C_2H_4, C_6H_{12}, C_8H_{18}

7.2 lbs → **7.2 lbs**

1 gallon → **1.3 gallons**

Crude Oil Assay



ANS CRUDE BLEND REPORT FOR WEEK ENDING NOV 20, 1987

CRUDE PROPERTIES

Assay Gravity	27.1
Sulfur, wt%	1.16
Nitrogen, ppm	2009
Concarbon, wt %	4.79
Nickel,ppm	12
Vanadium, ppm	26

CRUDE BLEND DATA
Defined Components Analysis — Vol%

C2	0.04
C3	0.33
iC4	0.44
nC4	1.53
iC5	0.81
nC5	1.14
C6+	95.71
Total	100.00

TBP Distillation	API Grav	Sulfur Wt%	Diff Vol %	Cum Vol %
C4-	124.0	0.00	2.4	2.4
150 F	74.7	0.00	3.5	5.9
200 F	59.6	0.00	2.4	8.2
250 F	54.3	0.00	3.1	11.3
300 F	50.0	0.00	3.6	14.9
350 F	47.1	0.00	3.7	18.5
400 F	43.5	0.01	3.9	22.5
450 F	36.8	0.10	4.9	27.3
500 F	34.0	0.30	5.2	32.5
550 F	31.7	0.47	4.7	37.2
600 F	30.6	0.64	5.7	42.8
650 F	27.0	0.85	5.5	48.3
700 F	25.4	0.99	4.1	52.4
750 F	23.8	1.09	4.4	56.8
800 F	22.5	1.21	4.1	60.9
850 F	20.9	1.34	4.3	65.1
900 F	19.5	1.49	4.0	69.1
950 F	17.6	1.64	4.2	73.3
1000 F	16.0	1.80	4.0	77.3
1050 F	13.6	1.89	3.9	81.2
1100 F	11.4	1.97	3.6	84.8
1100+ F	4.9	2.42	15.2	100.0

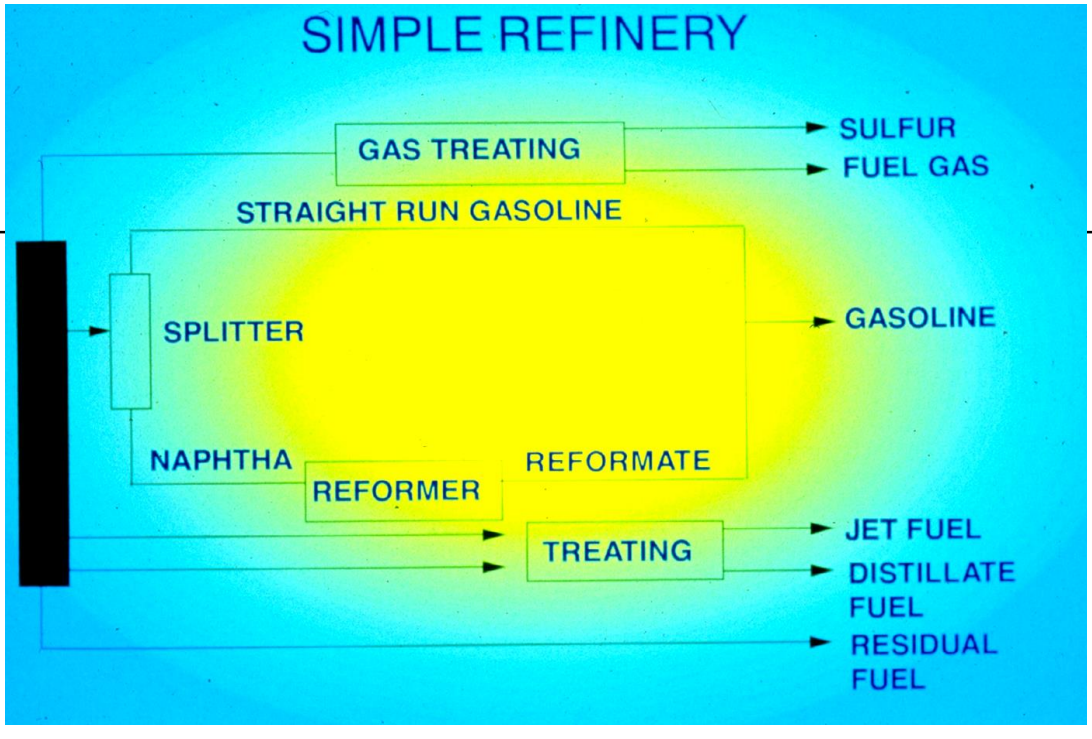
Quick Review 1

- Primary Sources of emissions
  - Combustion
  - Fugitive
  - Process particulates
- Regulations & Requirements
  - NSPS, Part 61 & 63 NESHAPS, MACT, general SIP
  - Plus NSR/PSD permits, Title V, NSR consent decree
- Crude Petroleum classifications
  - Sweet/sour
  - Light/heavy
- Chemistry
  - Nomenclature
  - Physical properties
  - Structure
    - Octane
    - Expansion

Process Units by Refinery Type

Simple	**-Crude Distillation** **-Hydrotreating of Middle Distillation** **-Catalytic Reforming of Naptha**
Complex- **Simple Plus**	**-Vacuum Distillation** **-Catalytic Cracking** **-Alkylation Plant** **-Gas Processing**
Very Complex **-Complex Plus**	**-Olefin Unit** **-Residue Reduction (Coker)**

Simple Refinery



Complex Refinery

Very Complex Refinery

Complexity and Yields

Fuel Type	% Yield		
	Simple	Complex	Very Complex
Gasoline	30	50	65
Jet Fuel	10	19	20
Distillate Fuel	20	17	25
Residual Fuel	35	20	0
Total	95	106	110
Gain	-5	6	10

EQUIPMENT COMBUSTION

Equipment Used in the Refining Process

- Fired Heaters
- Heat Exchangers
- Flares
- Cooling Towers
- Vacuum Jets
- Storage Tanks
- Pumps, Valves and Compressors

Fired Heaters

PURPOSE: To transfer heat from the combustion of fuels to water, oils, gases, or other fluids

Two Types of Fired Heaters

- Boilers - Designed for steam generation
- Process Heaters/Furnaces - Designed to heat liquid, oils and gases other than water

ProcessHeaters

Cabin Type

Upright Type

Multi-Pass Process Heater

Emissions From Boilers/Heaters

Fuel + Air (N_2, O_2)

- H_2O
- CO_2
- CO
- NO_X
- HC
- SO_X
- PM
- CHO

Types of Fired Heaters

- Natural Draft Heater
- Forced Draft Heater
- Induced Draft Heater
- Balanced Draft Heater

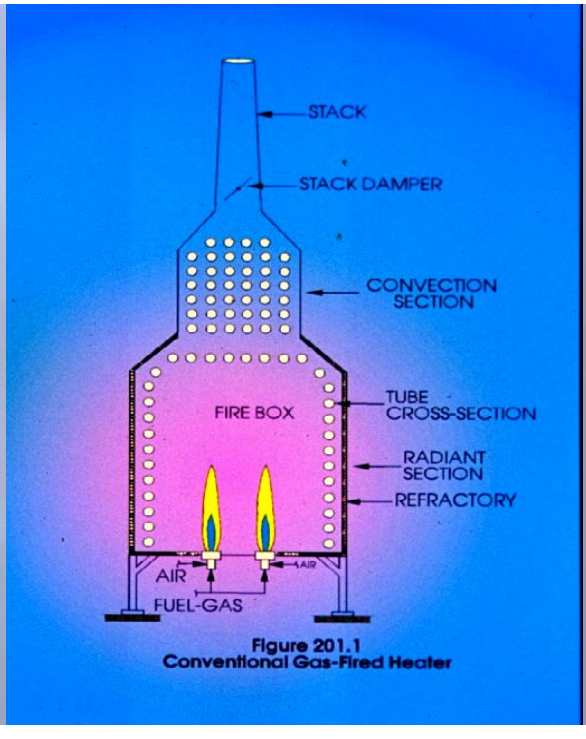
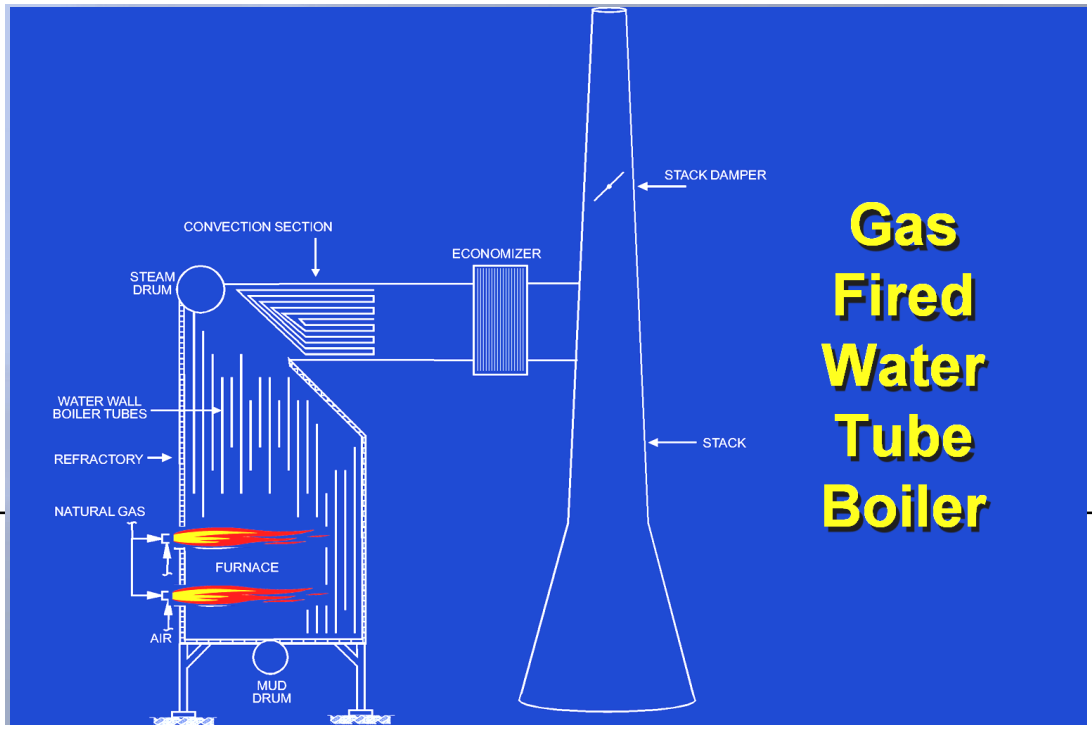
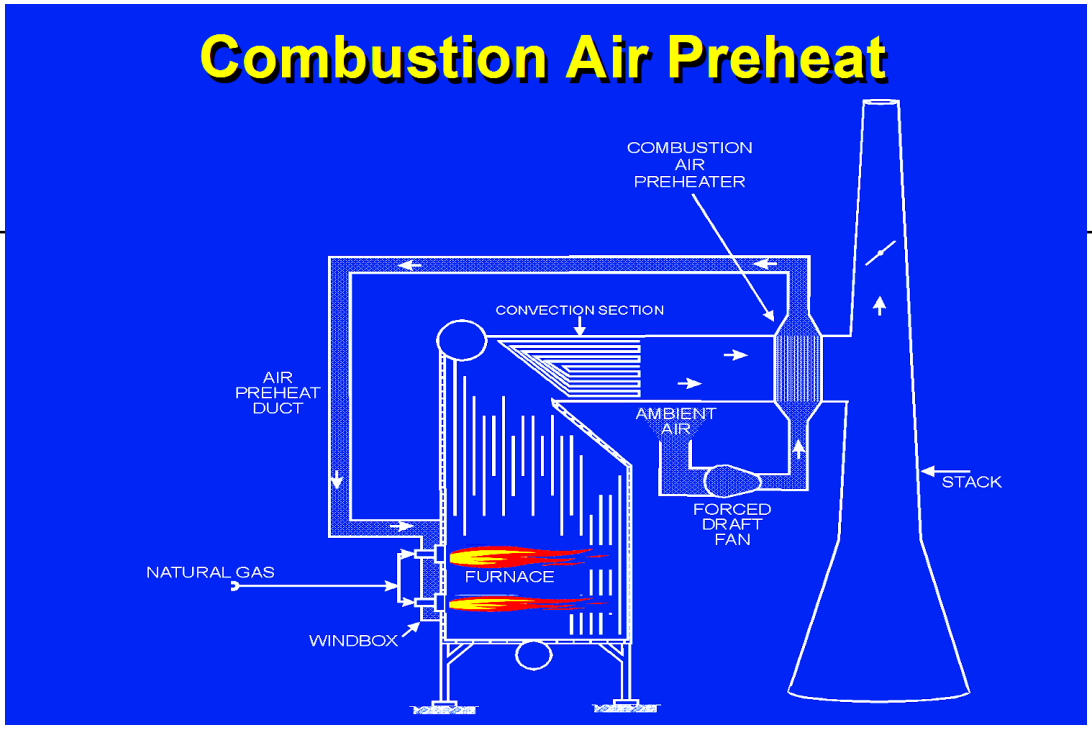


Figure 201.1
Conventional Gas-Fired Heater


Gas Fired Water Tube Boiler
STACK DAMPER
CONVECTION SECTION
ECONOMIZER
STEAM DRUM
WATER WALL BOILER TUBES
REFRACTORY
STACK
NATURAL GAS
FURNACE
AIR
MUD DRUM


Combustion Air Preheat
COMBUSTION AIR PREHEATER
CONVECTION SECTION
AIR PREHEAT DUCT
AMBIENT AIR
STACK
FORCED DRAFT FAN
NATURAL GAS
FURNACE
WINDBOX

Stack Damper on Natural Draft Heater

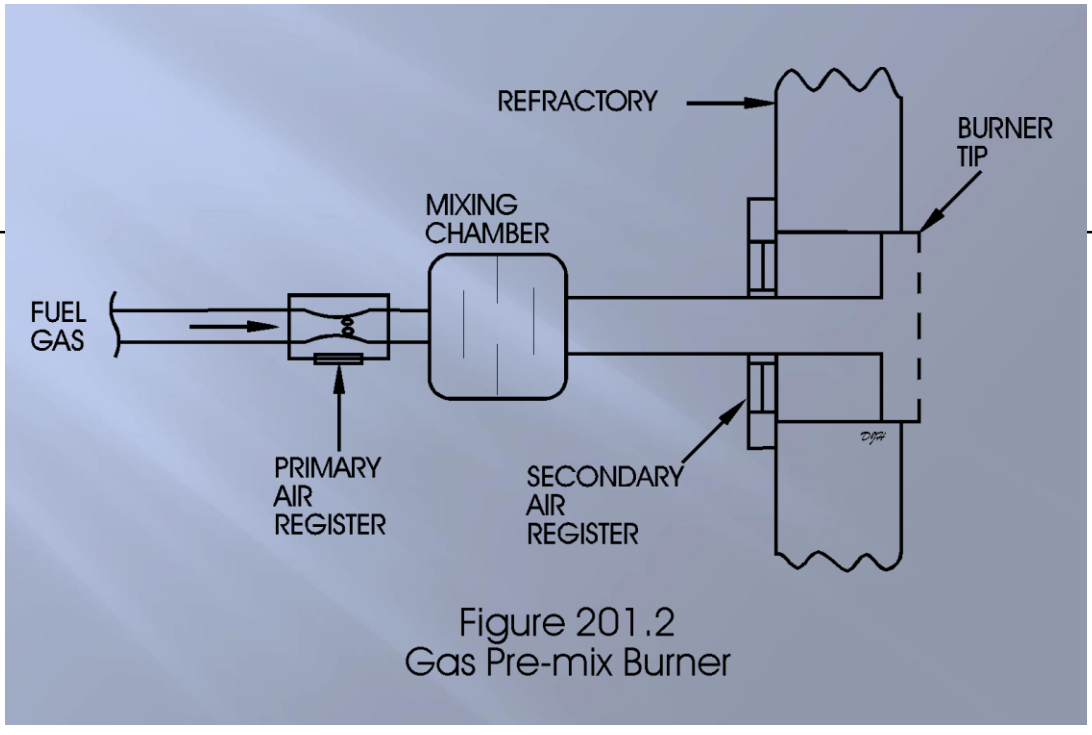
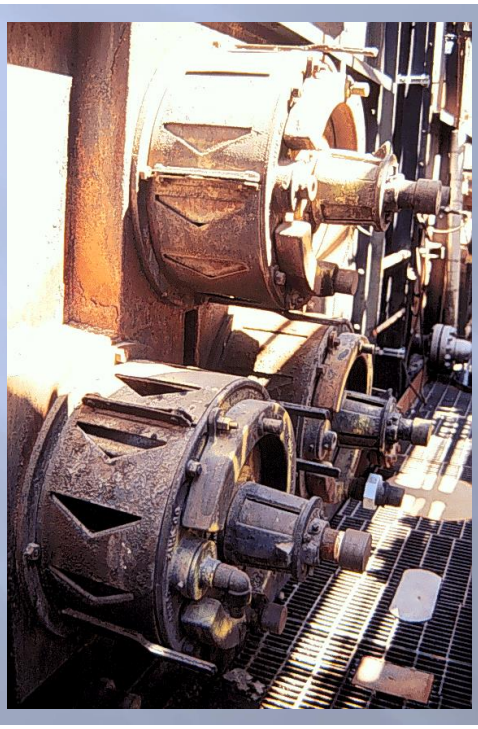
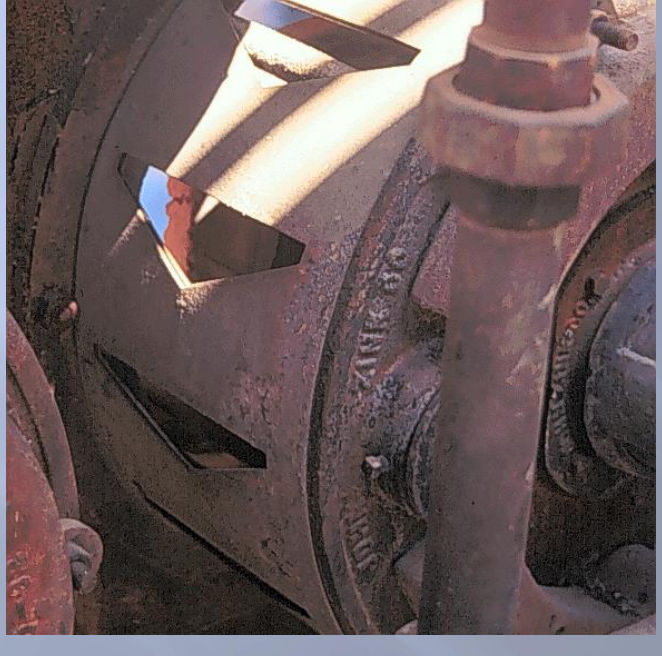


Figure 201.2
Gas Pre-mix Burner



Burner Assemblies

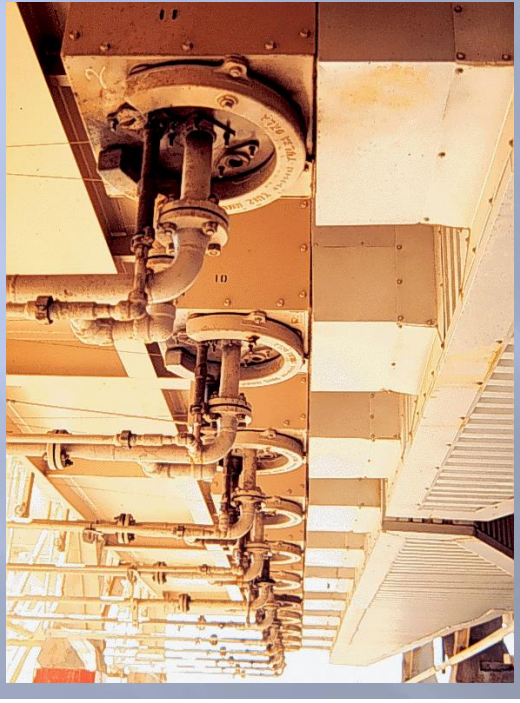


Close Up of Air Registers on Burner

Flames inside of a Firebox

Forced and Induced Draft Fans on a Heater

Up-Fired Burners with Pre-Heated Air

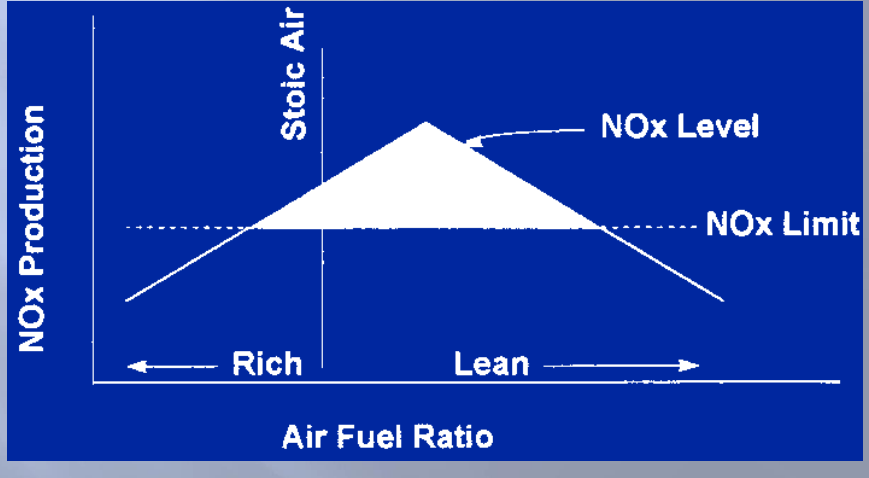


Up-Fired Burners with Pre-Heated Air

Pollutant Control Requirements

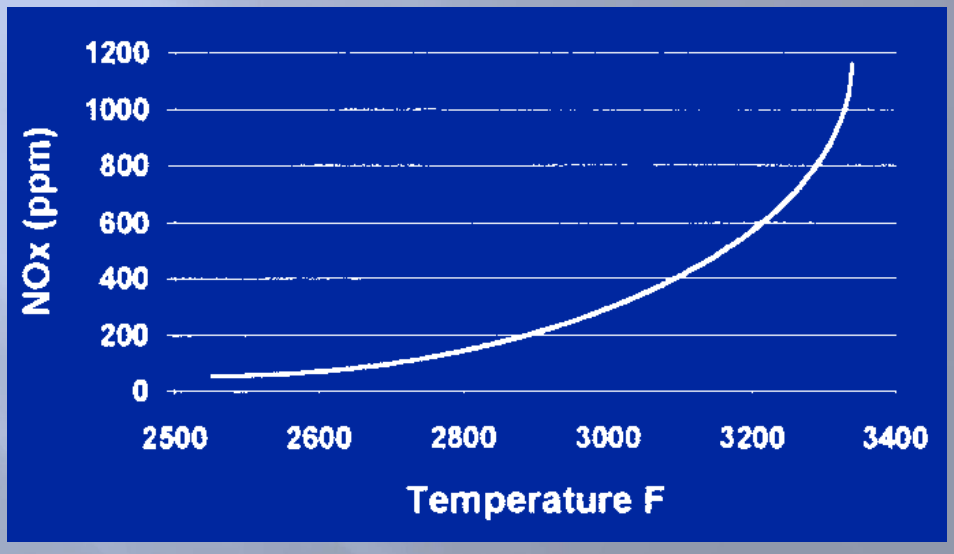
- NOx
  - Flue Gas Recirculation (FGR)
  - Low NOx Burners
  - Selective Catalytic Reduction (SCR)
  - Selective Non-Catalytic Reduction
- SOX
  - Limiting the amount of sulfur in the fuel gas
  - Post Combustion SO2 Scrubbers

NOx Production vs. Air/Fuel Ratio



Graphic Courtesy of Coen

Thermal NOx vs. Temperature



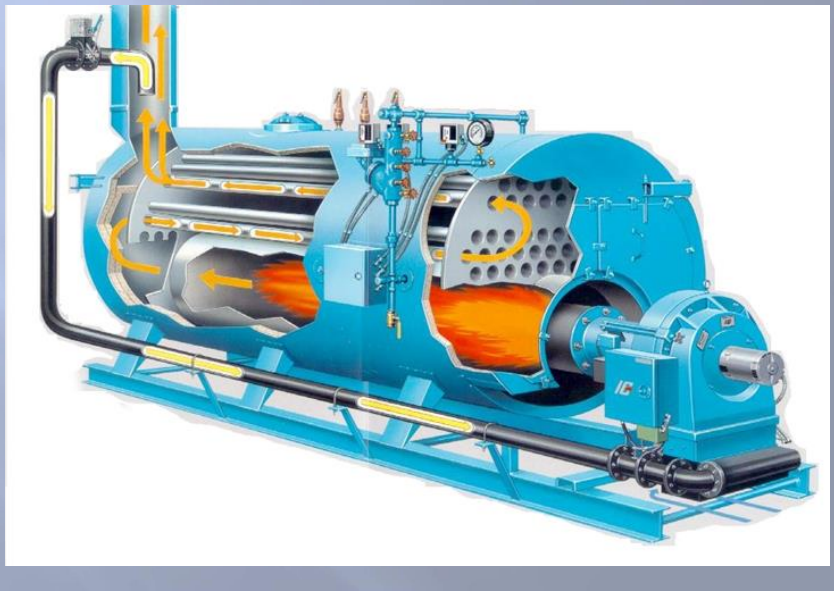
Graphic Courtesy of Coen

NOx Control Methods

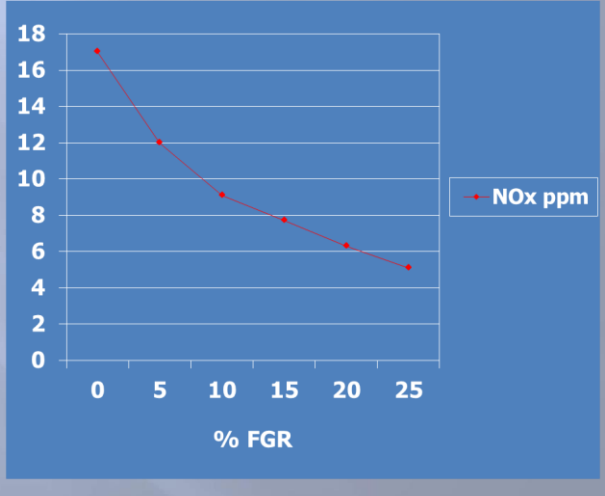
Pages 201-207

- Flue Gas Recirculation (FGR)
- Low NOx Burners
- Selective Catalytic Reduction (SCR)
- Selective Non-Catalytic Reduction

Flue Gas Recirculation (FGR)



FGR Impact



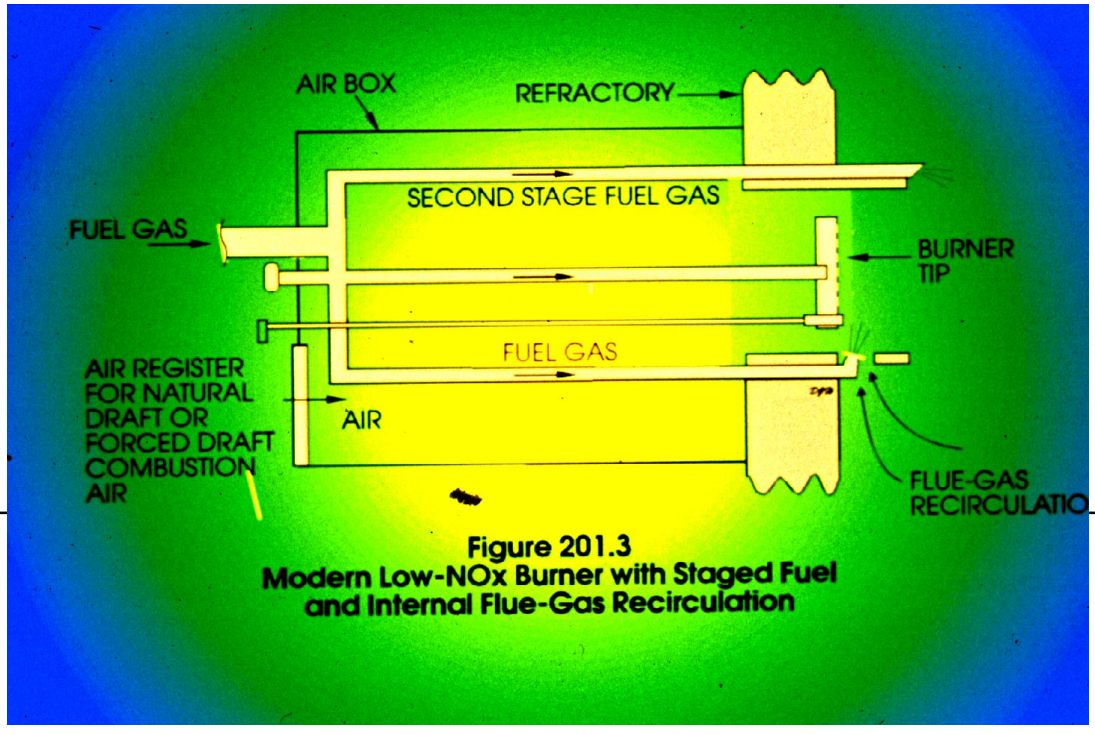


Figure 201.3
Modern Low-NOx Burner with Staged Fuel and Internal Flue-Gas Recirculation

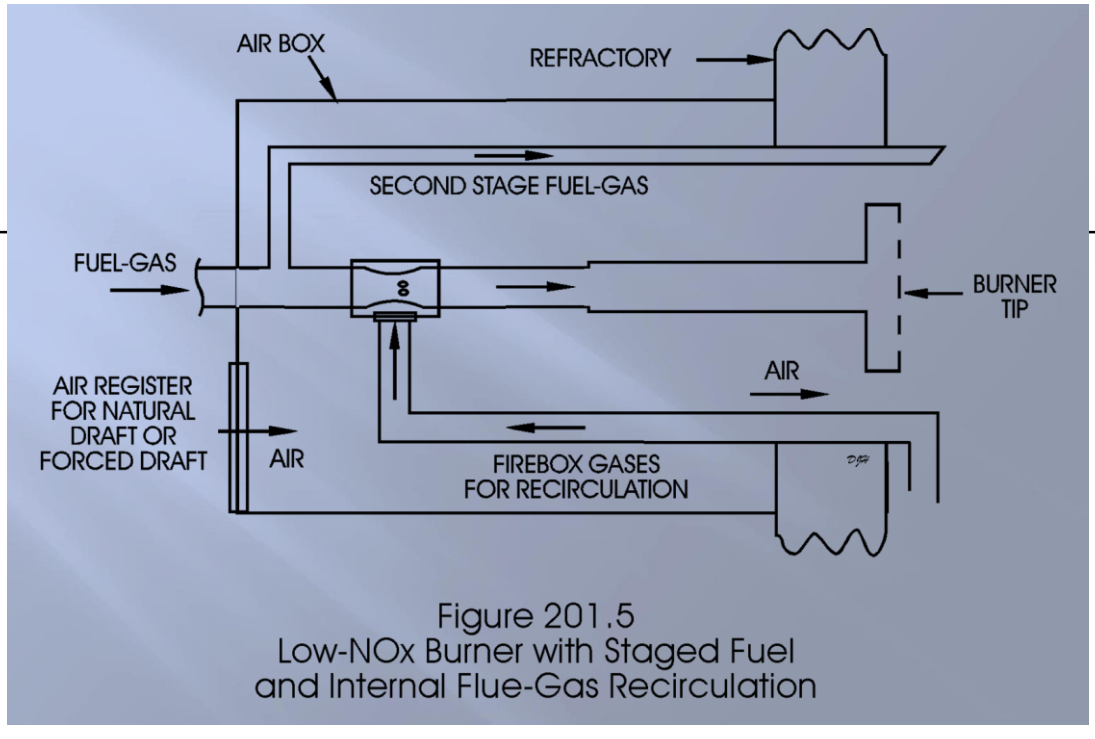


Figure 201.5
Low-NOx Burner with Staged Fuel and Internal Flue-Gas Recirculation

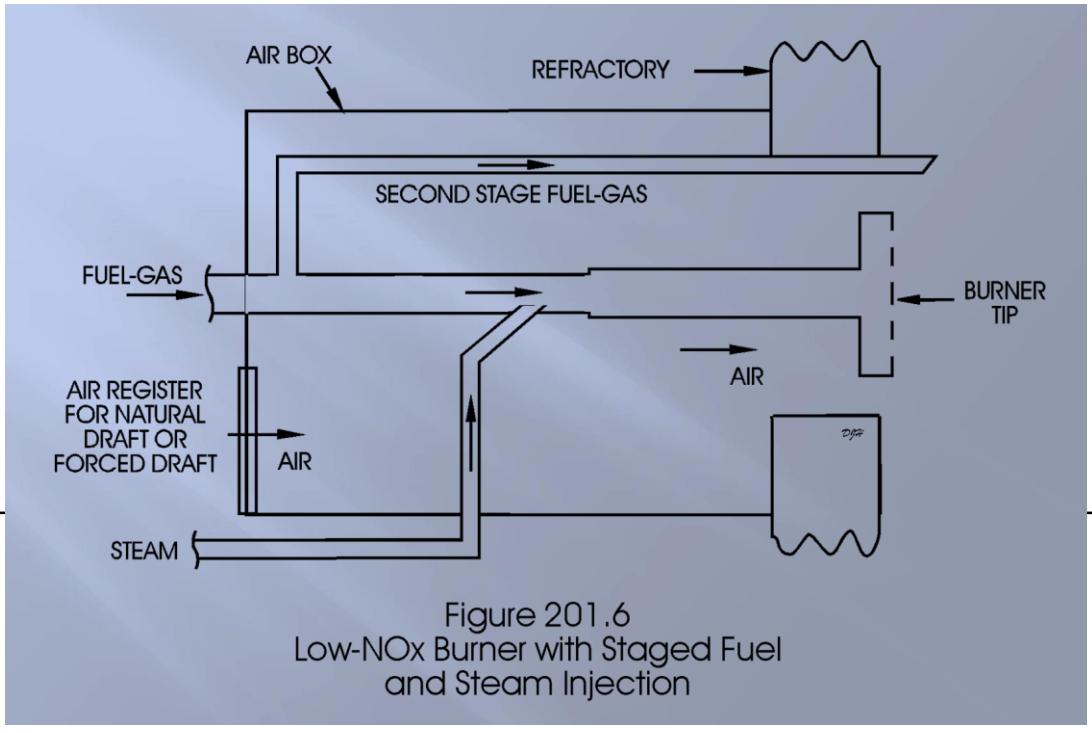
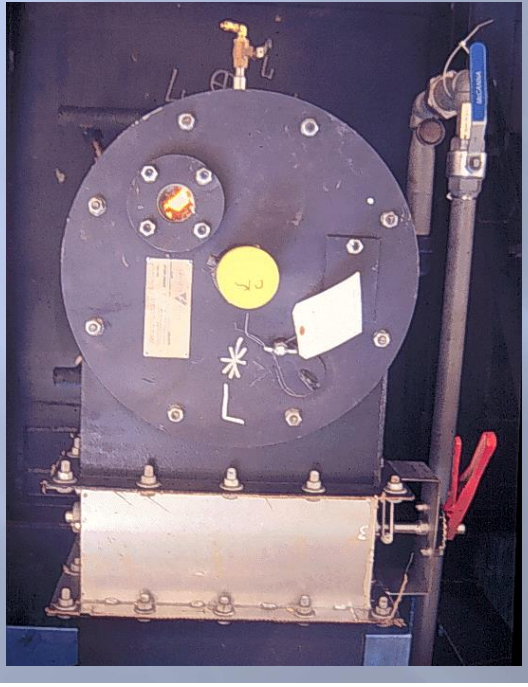
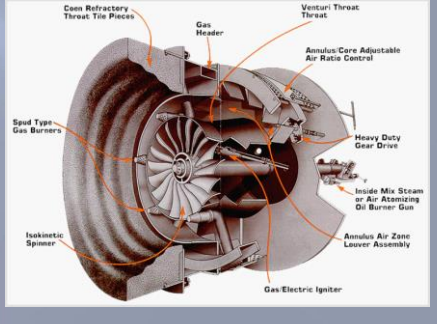


Figure 201.6
Low-NOx Burner with Staged Fuel and Steam Injection



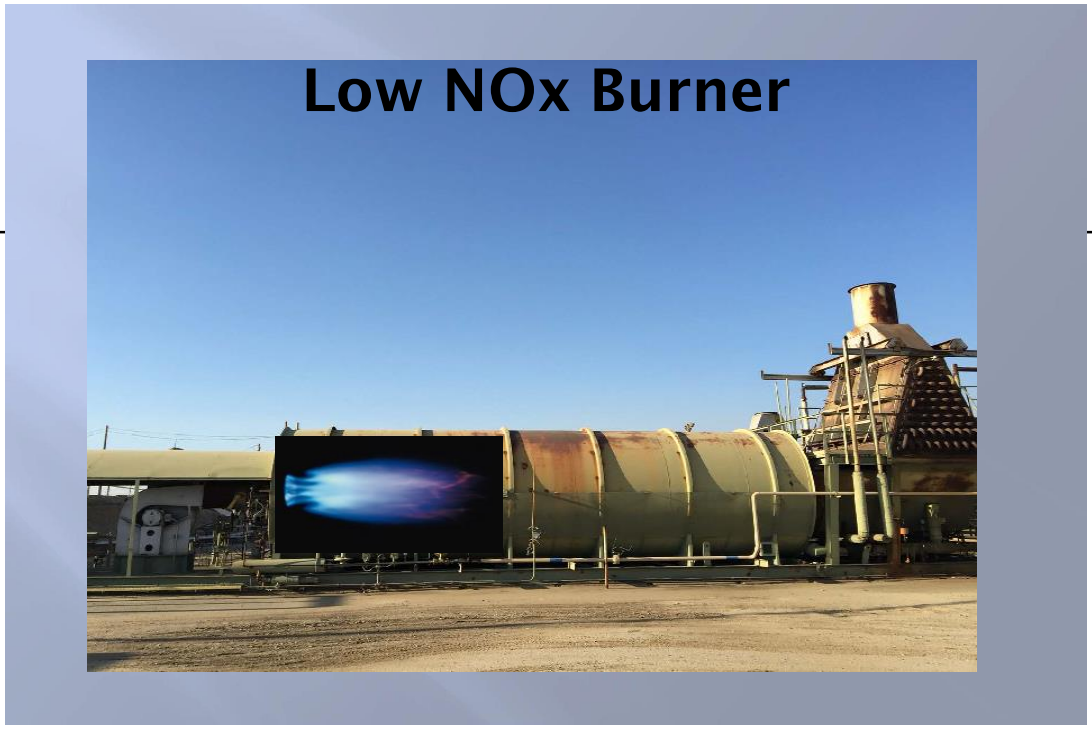
Low NO_x Burner



Low NO_x Burner Flames

Conventional Burner


Conventional Burner & FGR


Low NOx Burner

Low NOx Burner & FGR

Selective Catalytic Reduction (SCR)

NOx control thru ammonia (NH_3) injection

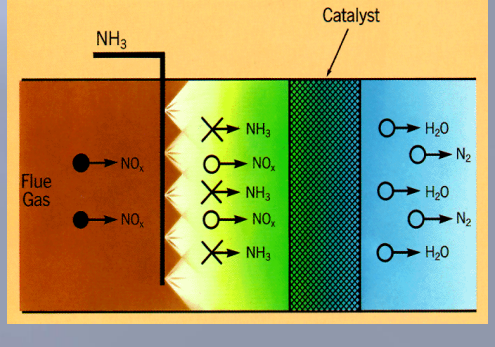
$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$

65-90% control

Problems

- **Expensive**
- **High maintenance**
- **Ammonia "slip"**
- **Catalyst replacement & disposal**



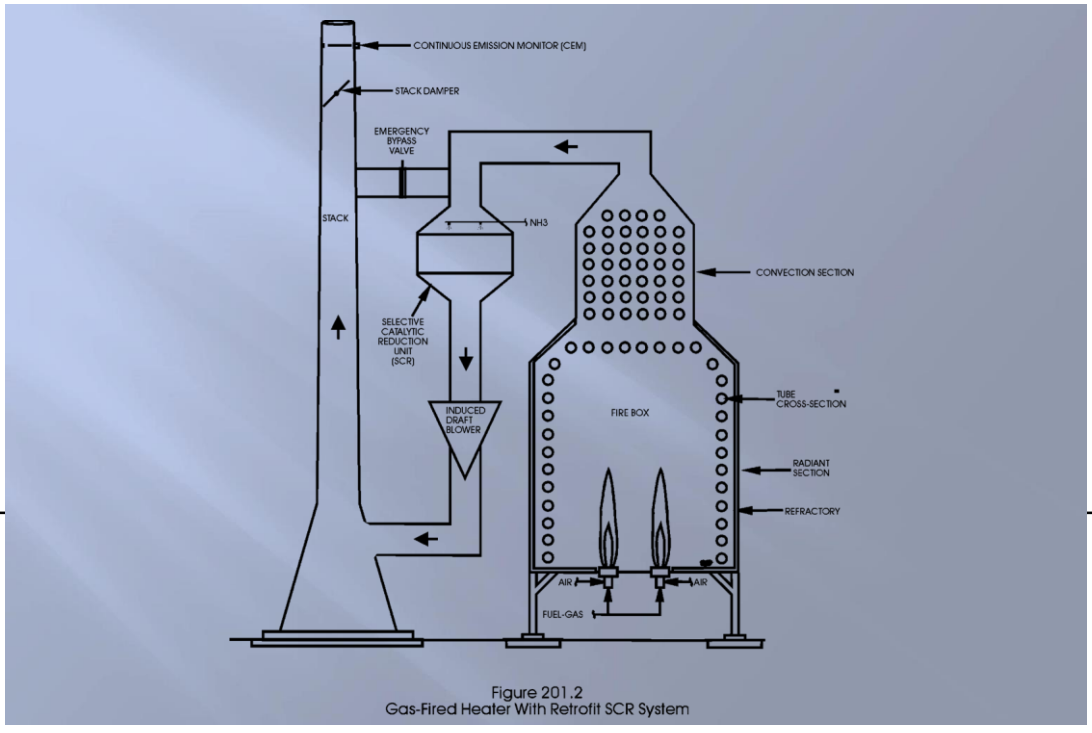


Figure 201.2
Gas-Fired Heater With Retrofit SCR System

Selective Catalytic NO_x Reduction (SCR)

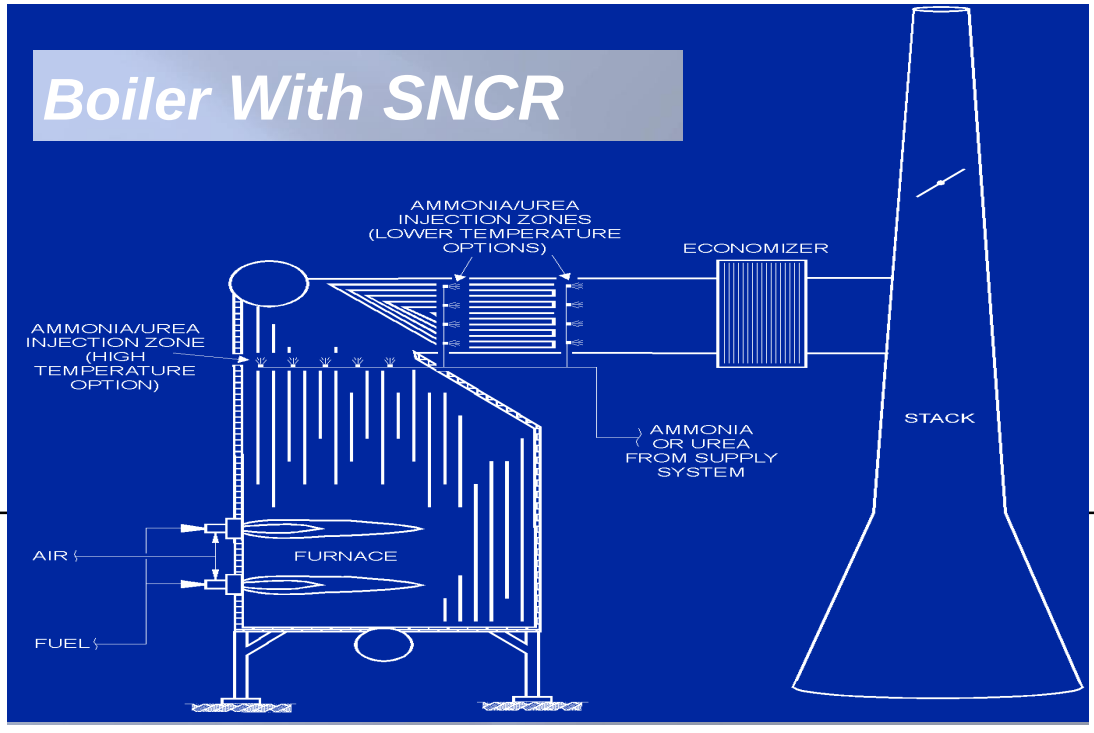
Ammonia Injection System for SCR

Selective Non-Catalytic Reduction

NOx control through ammonia or urea injection
No catalyst necessary
Temperature range 1400 ºF – 2000 ºF
Injected upstream of convection section
30% - 50% control under normal conditions

Problems:

- Changing flue temperatures with changing load
- Formation of ammonium salts
- Ammonia slip


Boiler With SNCR
AMMONIA/UREA
INJECTION ZONES
(LOWER TEMPERATURE
OPTIONS)
ECONOMIZER
AMMONIA/UREA
INJECTION ZONE
(HIGH
TEMPERATURE
OPTION)
AMMONIA
OR UREA
FROM SUPPLY
SYSTEM
STACK
AIR
FURNACE
FUEL

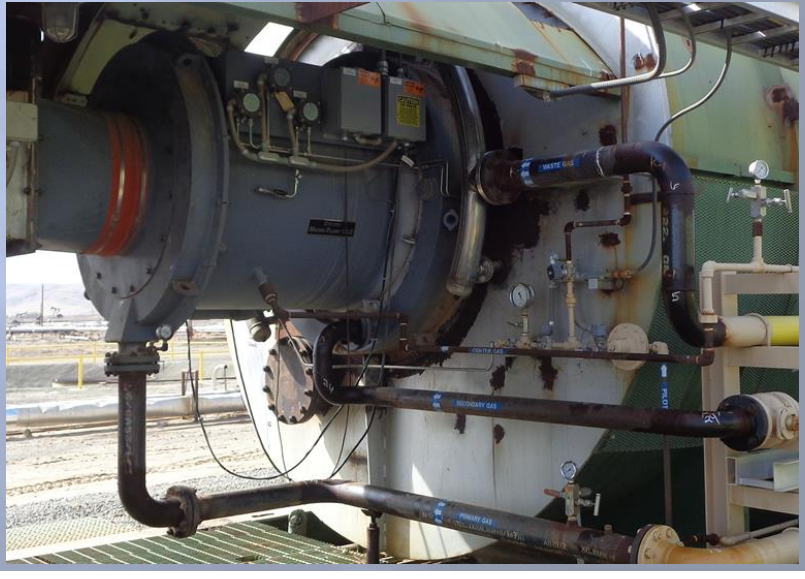

Ammonia Storage
ANHYDROUS
AMMONIA
AIR
PRODUCTS
STOCKTON COGEN FACILITY
3
0
DANGER
ANHYDROUS
AMMONIA

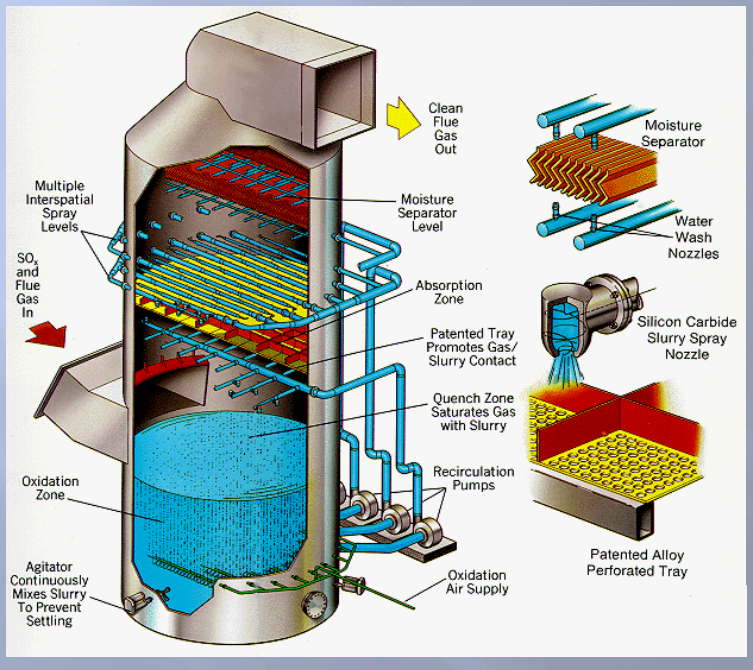
Inspection of SNCR

- Ammonia injection rate
- Operating temp 1400-1900 deg F
- May be required to test stack for ammonia slip.

- Contrasted to SCR that will often have CEMs for SCR temp should be 550-750 deg F

Waste Gas Burning

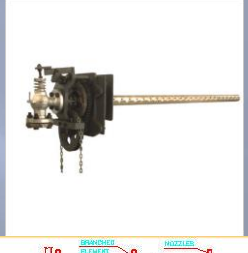


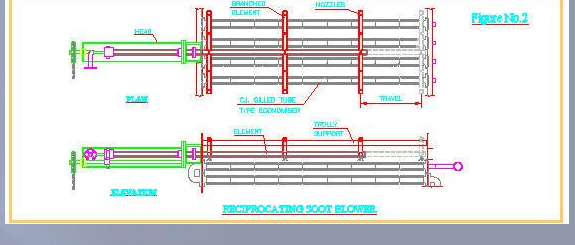


Wet FGD Scrubber

Soot Blowing

Blowing Dust From Boiler Tubes Using Steam Or Air





Fired Heaters

- **INSPECTION POINTS:**
  - **Fuel (BTUs, sulfur)**
  - **Control Equipment check**
  - **Permit conditions**
  - **Visible Emissions**
  - **Flame observation**

Regulations

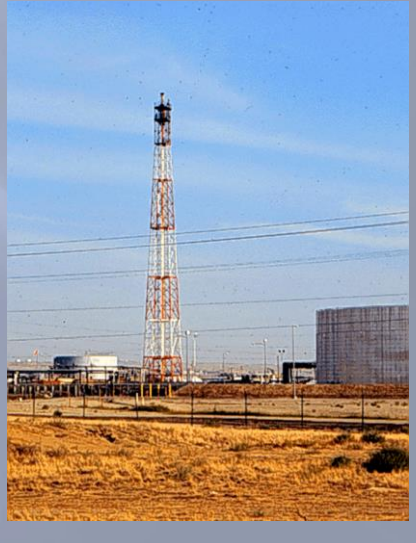
- **NSPS**
- **Boiler MACT**
- **Visible Emissions**
- **Local Regulations**
- **Permit Conditions**

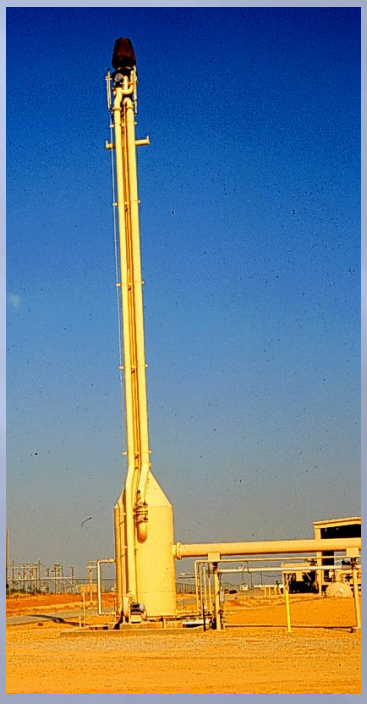
Heat Exchangers

Purpose: An energy conservation device used to transfer heat from a relatively hot fluid stream to a relatively cool fluid stream.

Flares

- PURPOSE: Emergency relief system for safe de-pressurizing of refinery process operations.
- Vented gases are burned at the tip of the flare.





Flare

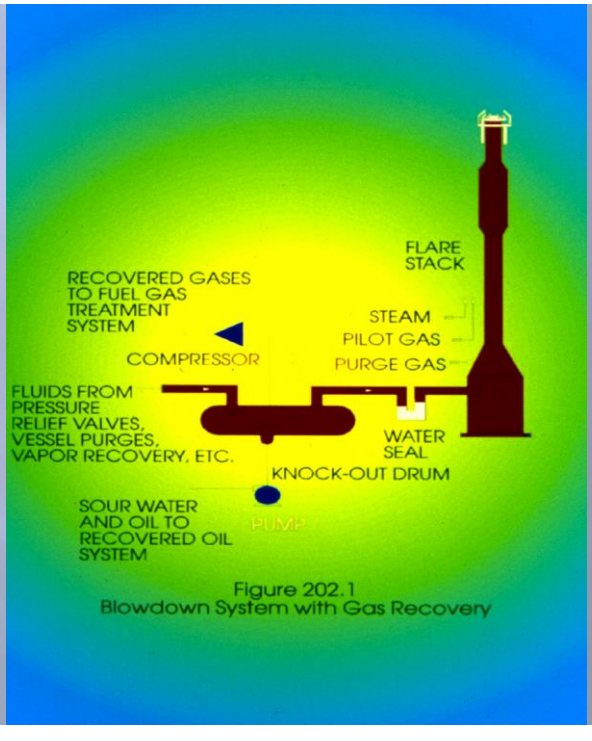


Figure 202.1
Blowdown System with Gas Recovery

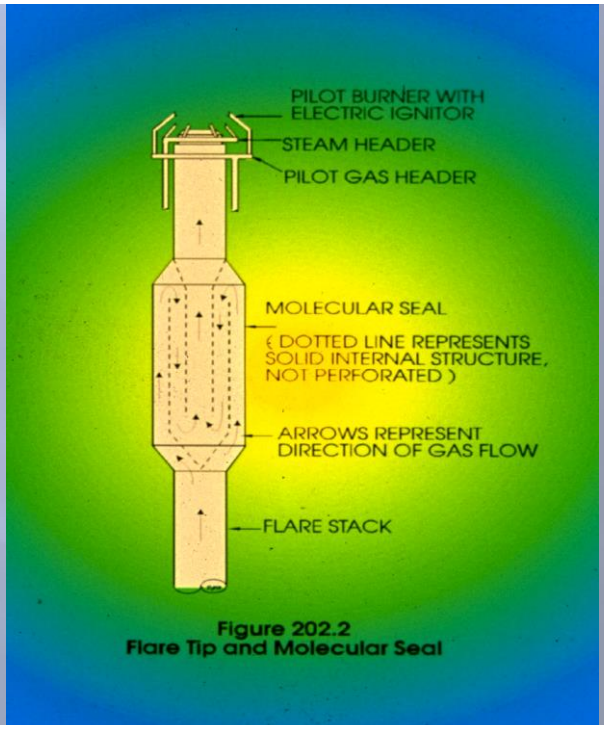
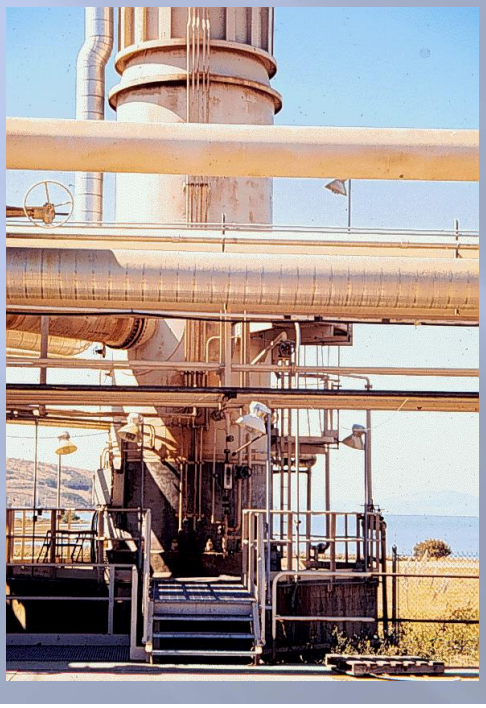


Figure 202.2
Flare Tip and Molecular Seal

Flare
With Smokeless Flame

Smokeless Flare Tip

Relief System - Knockout Drum

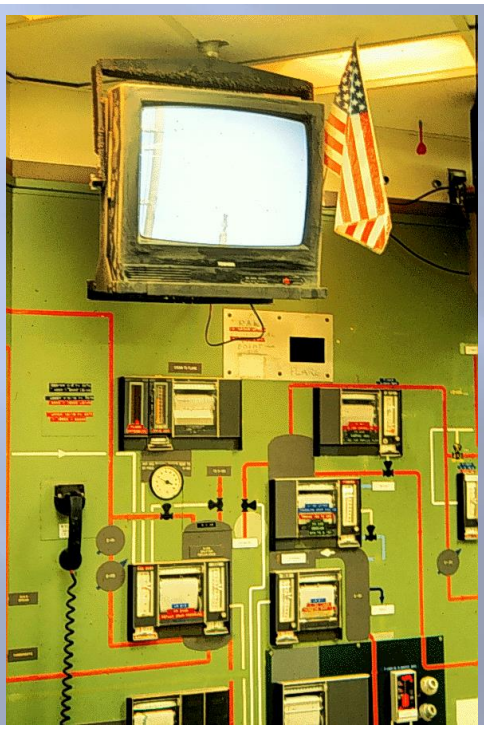


Base of Flare

Steam System for Flare Smokeless Operation

Water Seal Level for Flare

Continuous Overflow from the Water Seal



Video Monitor on Flare

Flares

- REGULATIONS:
  - NPSP
    - 40 CFR 60.18
    - Subpart QQQ Section 60.692-5 (c)
    - Subpart Kb, Section 60.113(b)
    - Subpart GGG, Section 60.592 (a)
  - Nuisance and odor issues
  - More tomorow

Flares Continued

- REGULATIONS:
- Visible Emission Evaluation (VEE)
- Odors
- SOx

Flares

- INSPECTION POINTS:
  - Visible Emission Evaluation (VEE)
  - Pilot Light
  - Odors
  - Gas Compressor if applicable
  - Water Seal
  - Flow Rates
  - Odors/Ground level SO2

EQUIPMENT (FUGITIVE VOC)

Coolers

Purpose: Use air to cool or condense process streams

Heat Exchangers Used in Conjunction with Air Coolers

Heat Exchangers

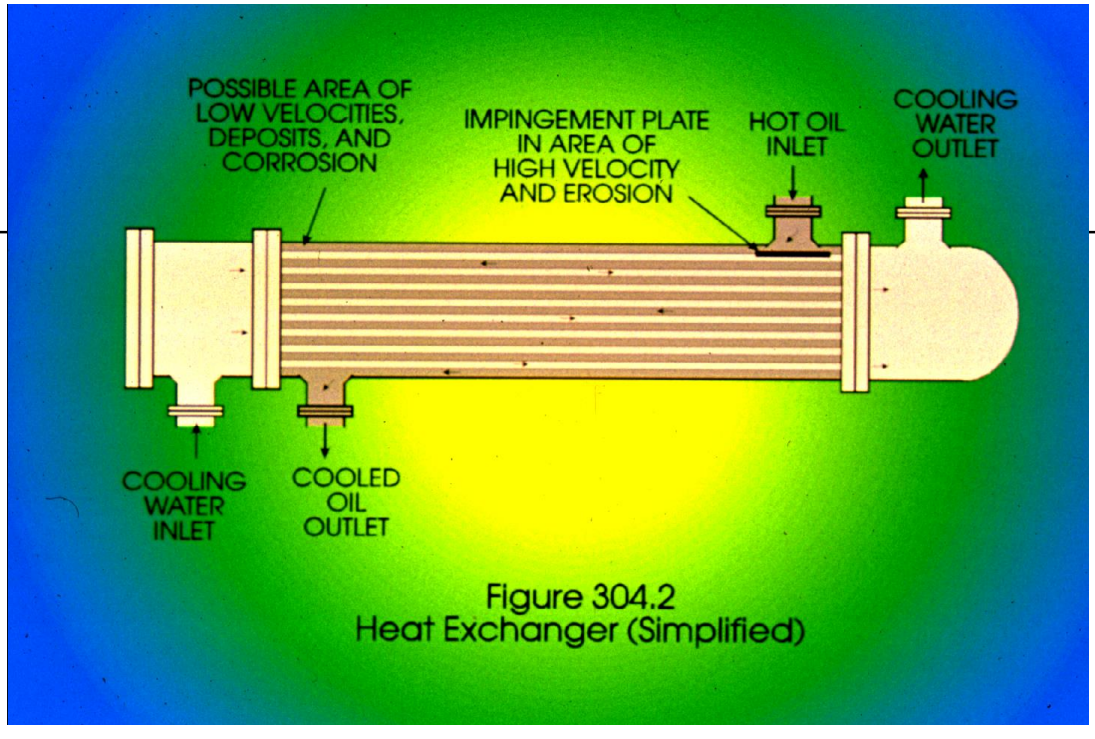
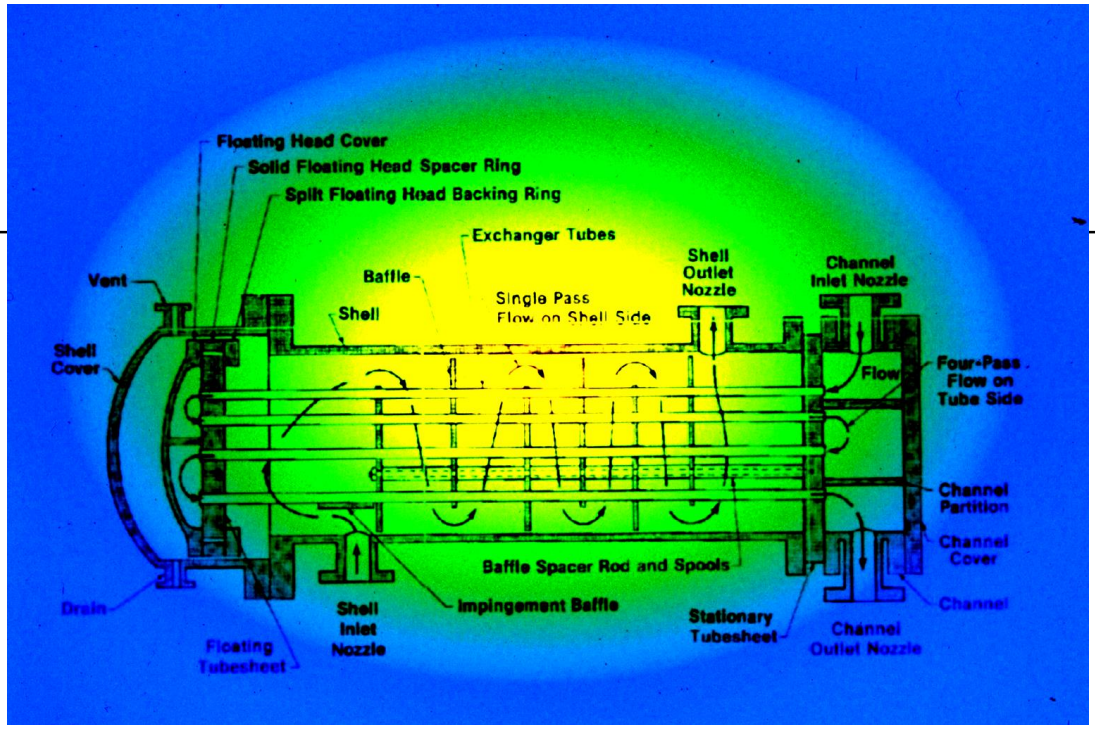
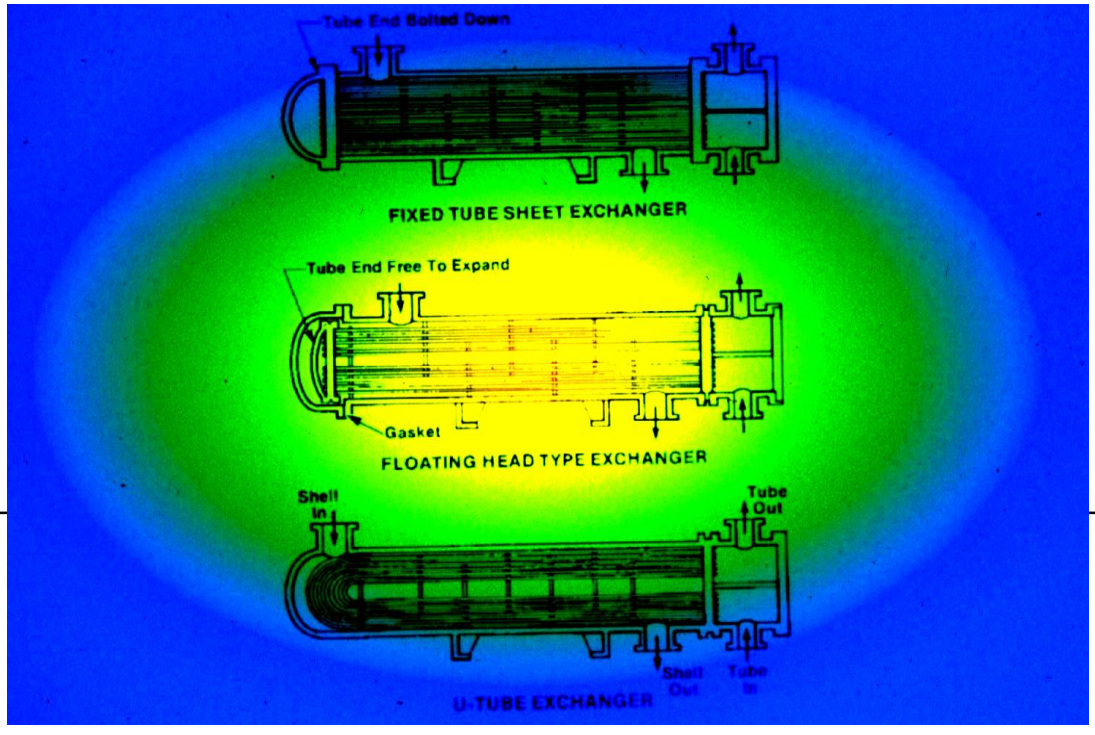


Figure 304.2
Heat Exchanger (Simplified)

Heat Exchanger Bundle

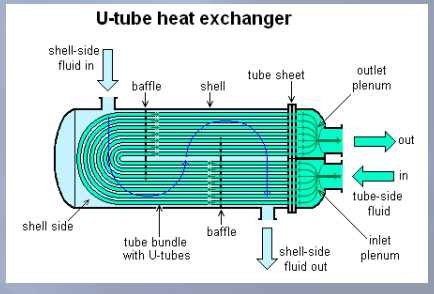




Air Cooling Fans

Why Do They Leak

- **Corrosion (pitting)**
- **Erosion (thinning of tubes)**



Cooling Towers

- PURPOSE: Used to cool water which had been warmed when circulated through process cooling equipment (exchangers)
- REACTION: Cools through evaporation of water into the air

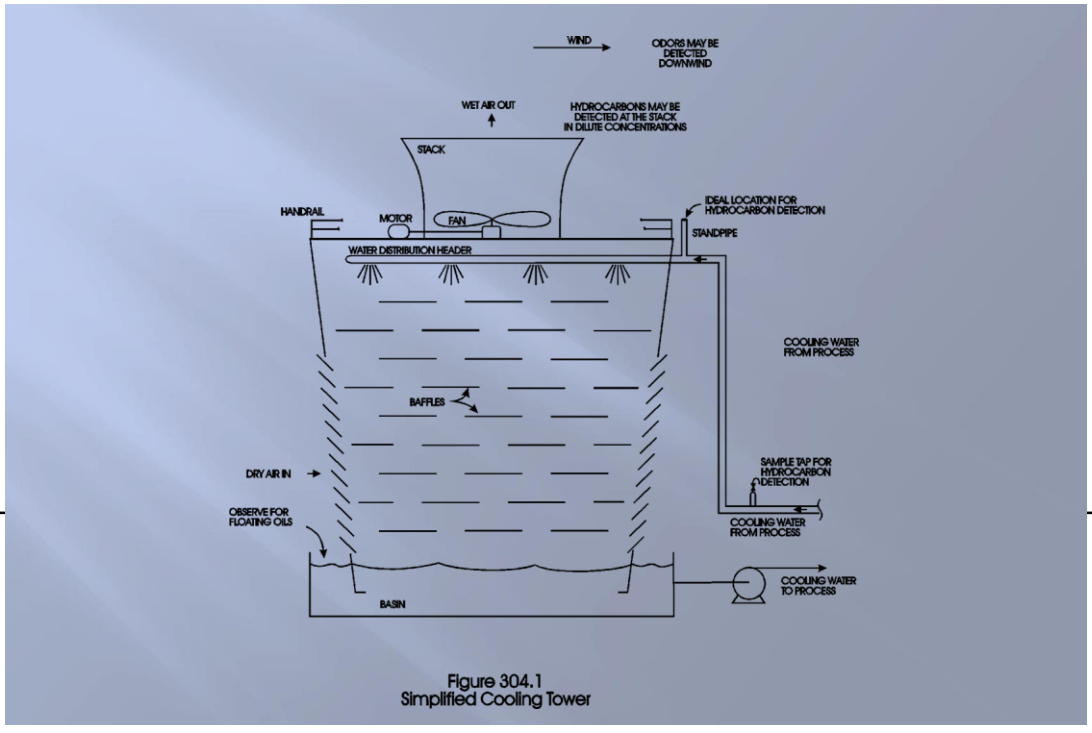
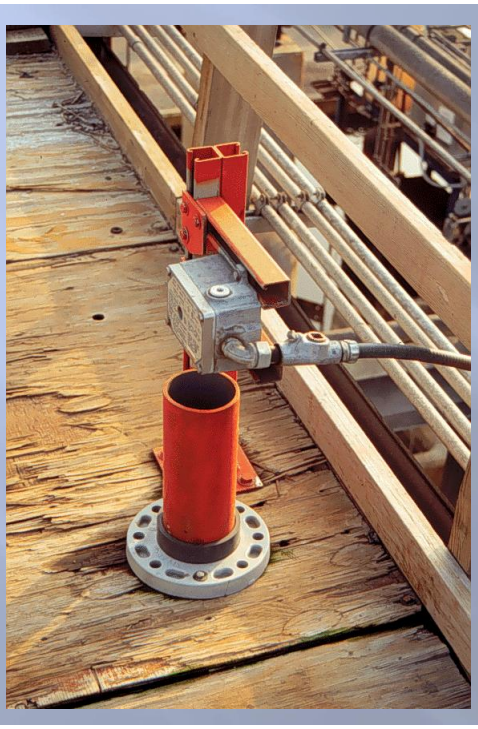


Figure 304.1
Simplified Cooling Tower

Cooling Tower

Risers Entering the Cooling Tower

Fan on Cooling Tower



Hydrocarbon Detector on a Riser Vent

Cooling Towers

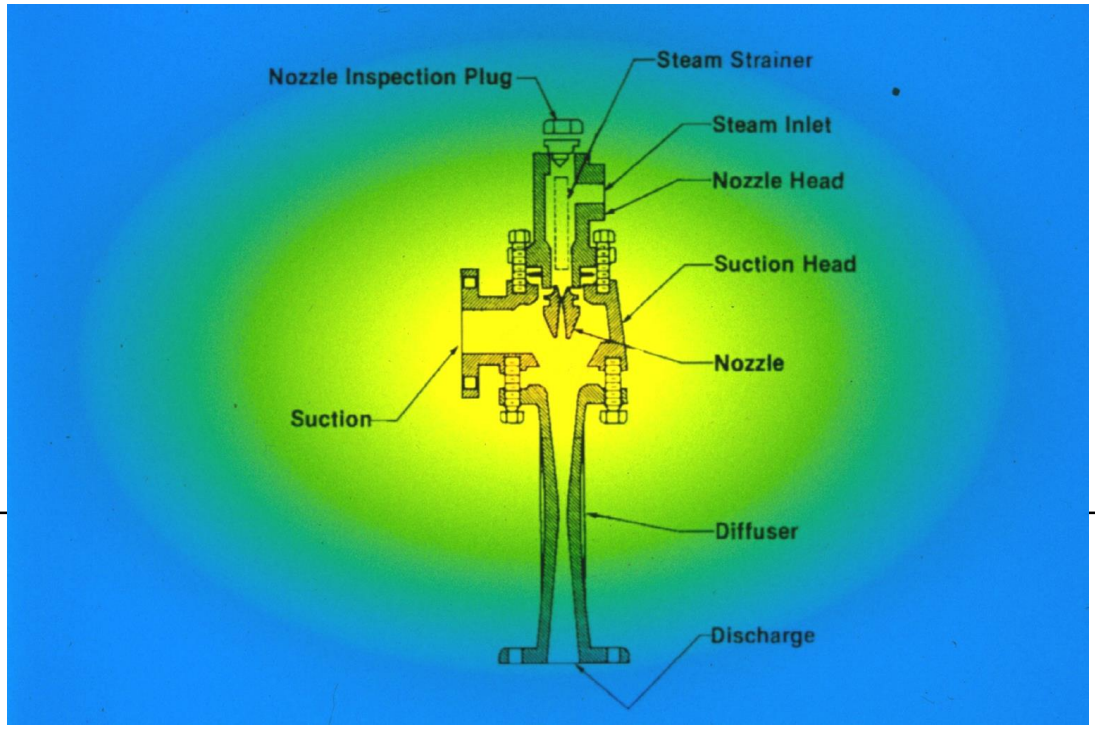
- REGULATIONS:
  - Fugitive Emissions
  - No hexavalent chrome additives (corrosion inhibitor)
  - Odors

Cooling Towers

- Inspection Points:
  - Fugitive VOC's
  - Hexavalent chrome
  - Permit conditions
  - Odors

Steam Jet Ejectors

- PURPOSE: To remove gases from the vacuum flasher to create the vacuum
- MECHANISM: Uses a nozzle to increase the velocity and momentum of the steam. The high velocity and momentum draw a vacuum in the area beside the nozzle.



Steam Ejectors on a Vacuum Distillation Unit - First Stage

Steam Ejectors on a Vacuum Distillation Unit - Second Stage

Steam Ejector System on a Vacuum Distillation Unit

Steam Jet Ejectors

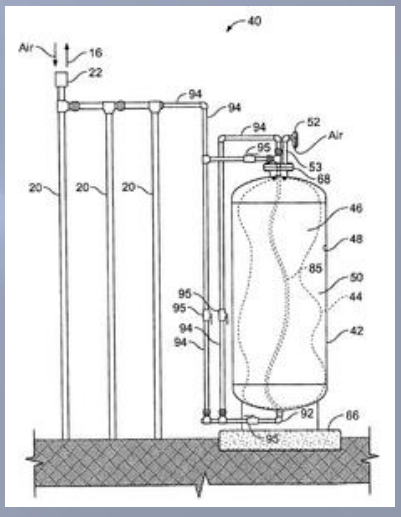
- Inspection Points:
  - Where do the noncondensables go?
  - Permit conditions
  - Covered condensate accumulator vessel (hot well)

Storage Tanks - Types

- Conservation tanks
- Pressure tanks
- Fixed roof tanks
- Internal floating roof tanks
- External floating roof tanks

Conservation Tanks

- Tanks designed to hold vapors
- Have internal flexible diaphragms, lifter roofs, or blankets
- Often found in vapor recovery systems



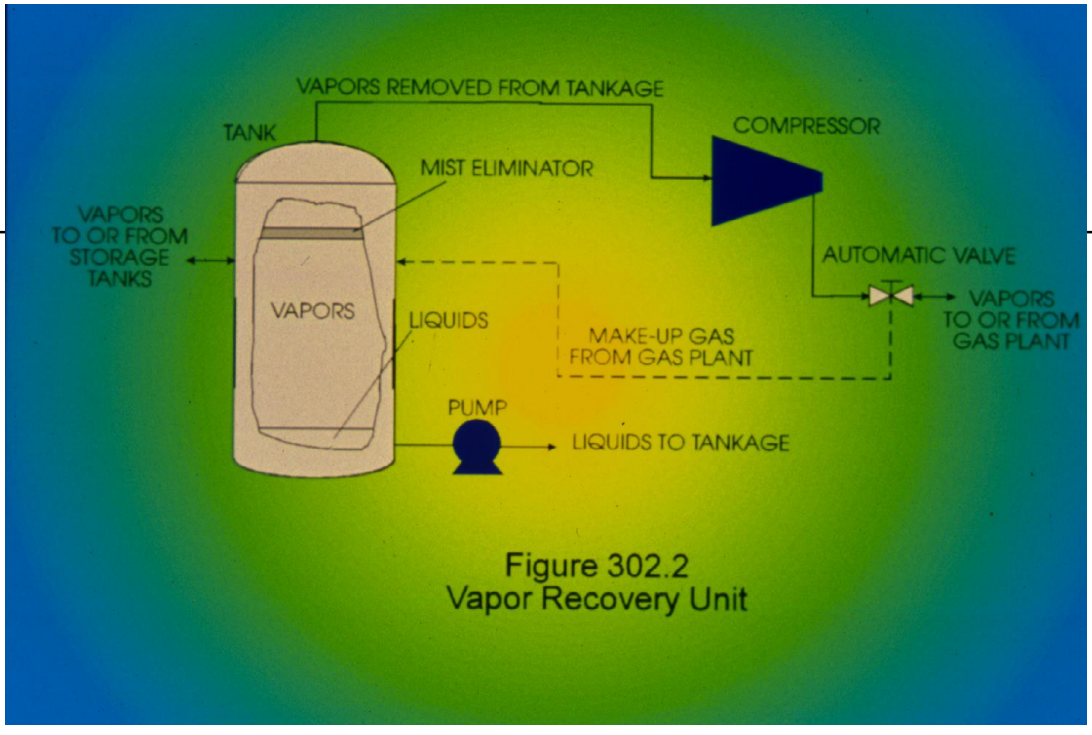


Figure 302.2
Vapor Recovery Unit

Pressure Tanks

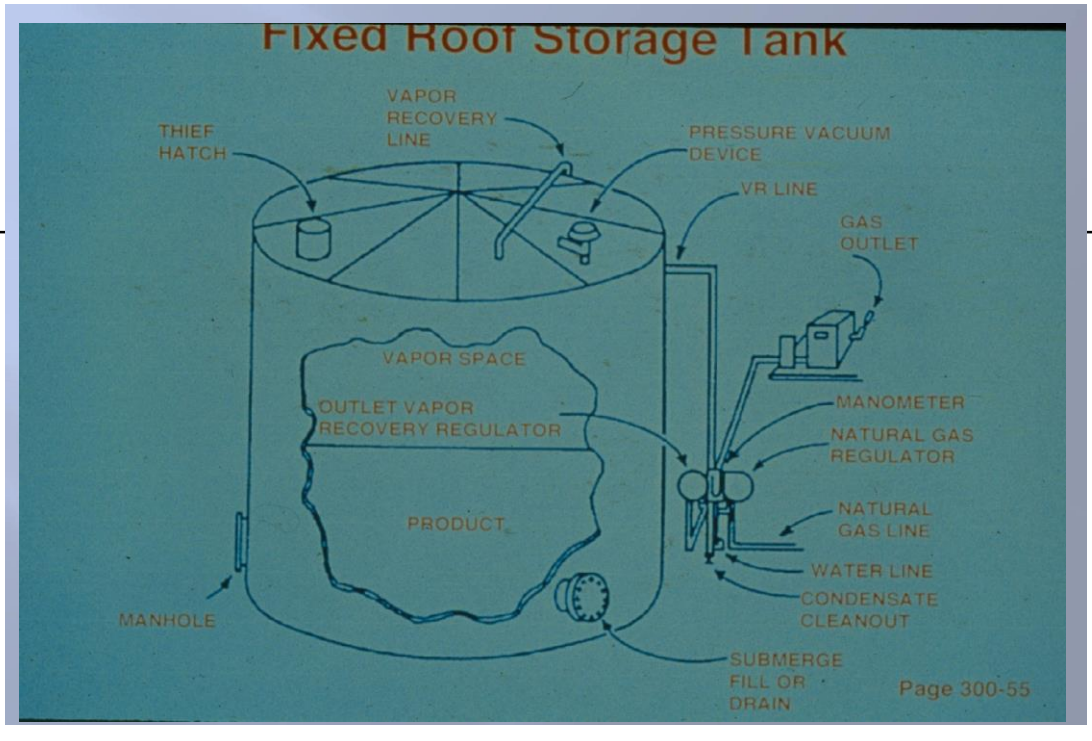
- A special type of fixed roof tank that are designed to operate above atmospheric pressure
- Commonly used to store liquefied petroleum gases (LPG)

Fixed Roof Tanks

- Cylindrically shaped vessels made of steel that are welded or riveted together and covered by a stationary roof
- The roof is generally conical in shape thus these tanks are also known as cone roof tanks

Fixed Roof Tanks

- VOC emissions (breathing losses and diurnal losses) are controlled by:
  - Vapor Recovery
  - Gas Blanketing (Test Warning)



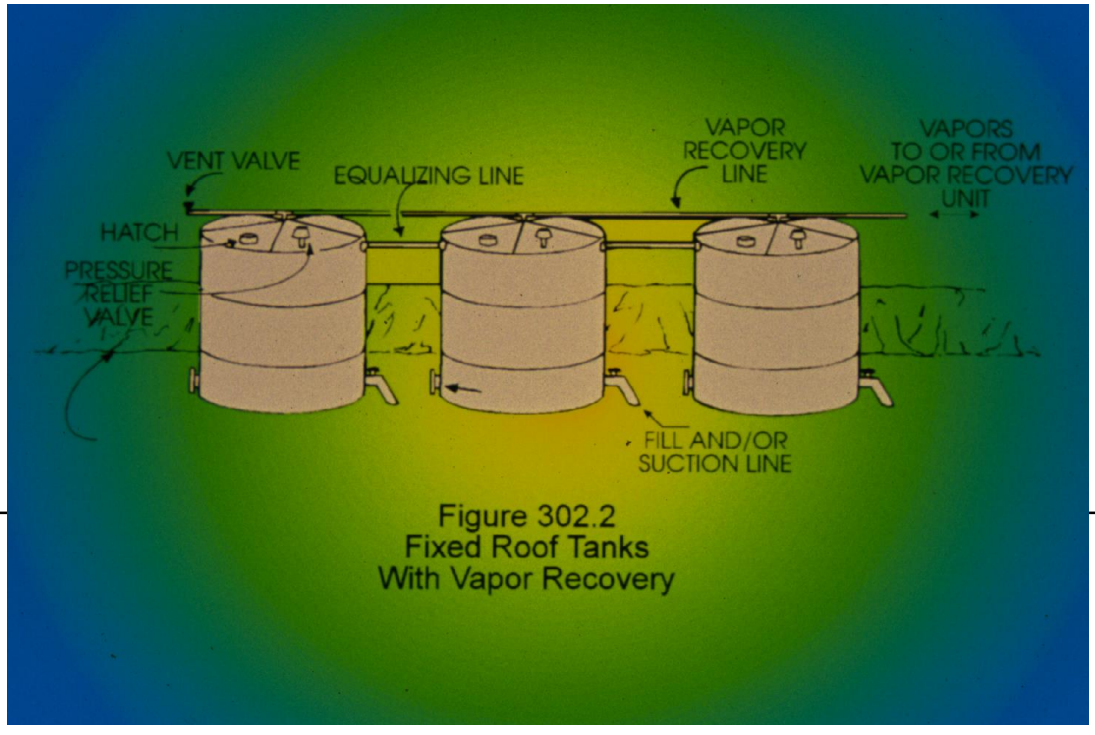
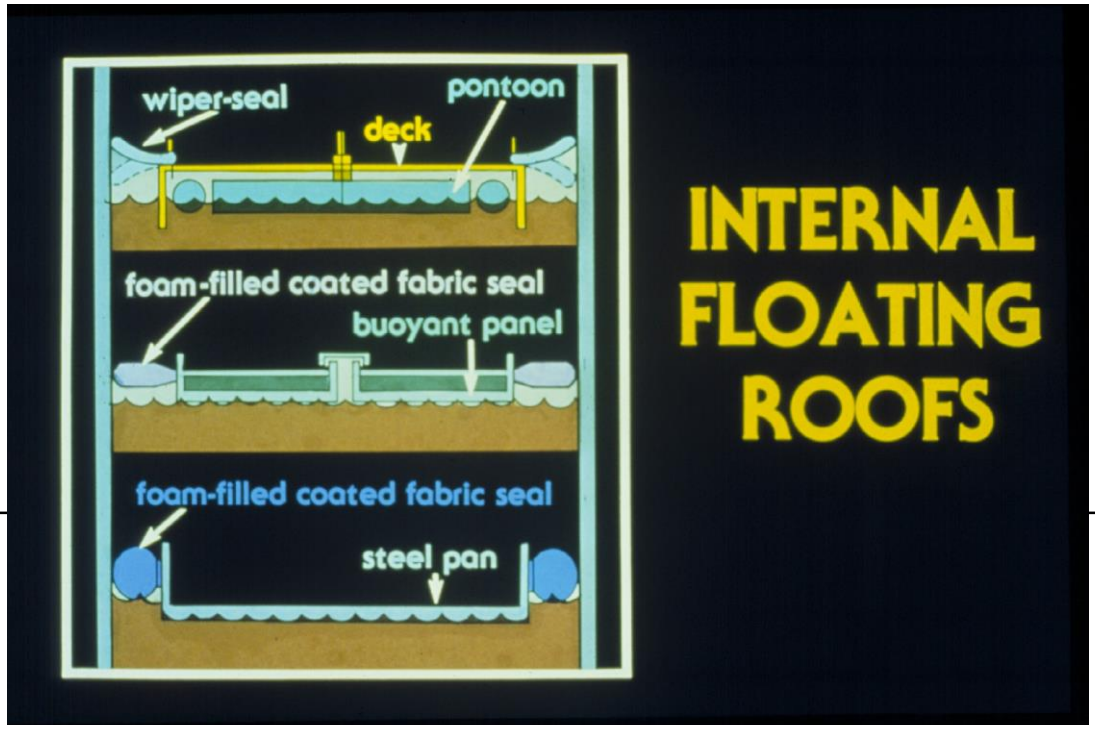
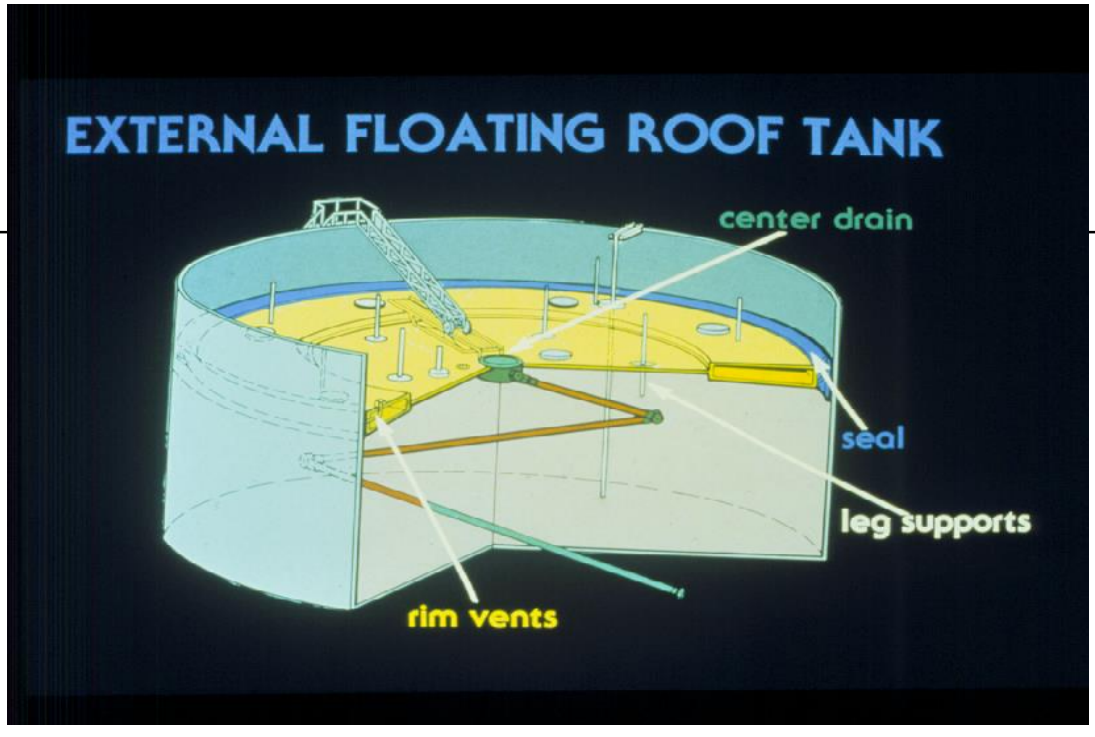


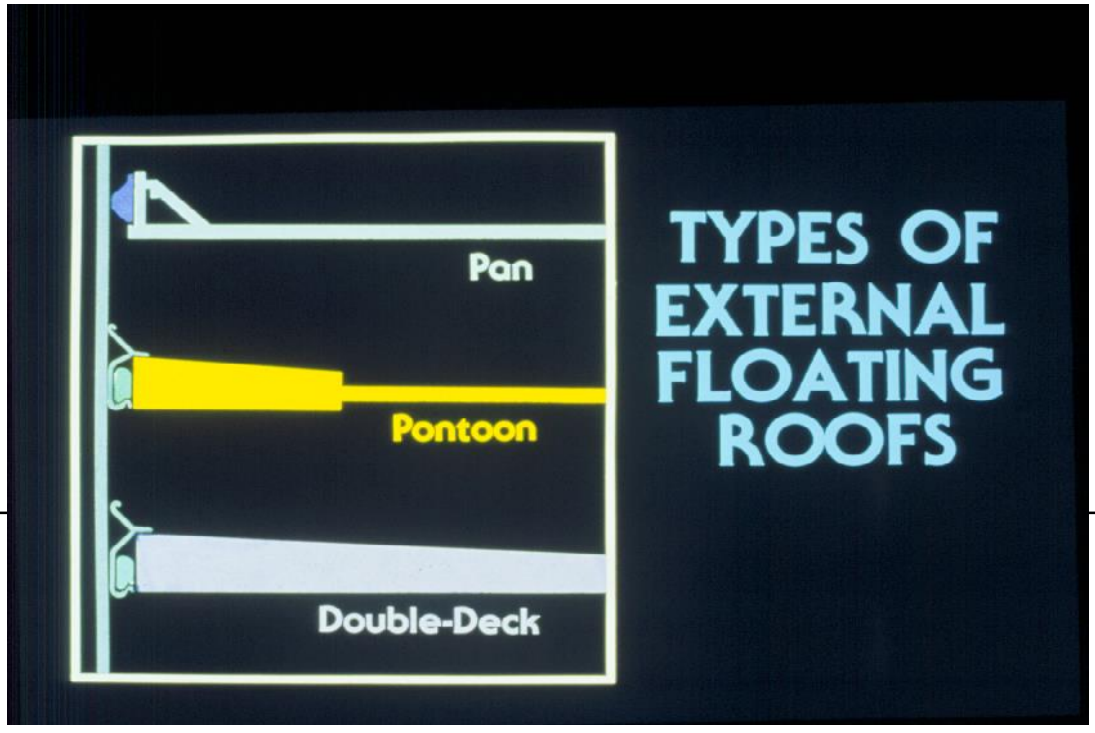
Figure 302.2
Fixed Roof Tanks
With Vapor Recovery

Floating Roof Tanks

- Tanks designed to have roofs that float on the liquid surface to eliminate the formation of a vapor space
- Types of floating roof tanks
  - Internal
  - External


wiper-seal
pontoon
deck
foam-filled coated fabric seal
buoyant panel
foam-filled coated fabric seal
steel pan
INTERNAL
FLOATING
ROOFS


EXTERNAL FLOATING ROOF TANK
center drain
seal
leg supports
rim vents

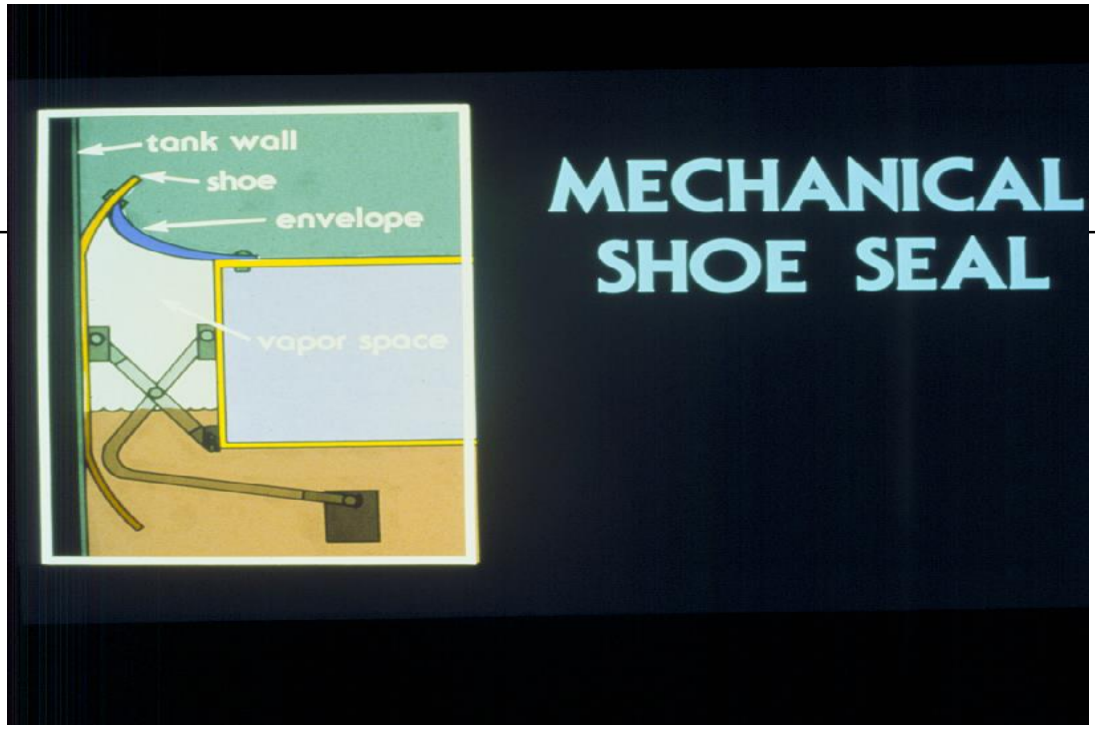


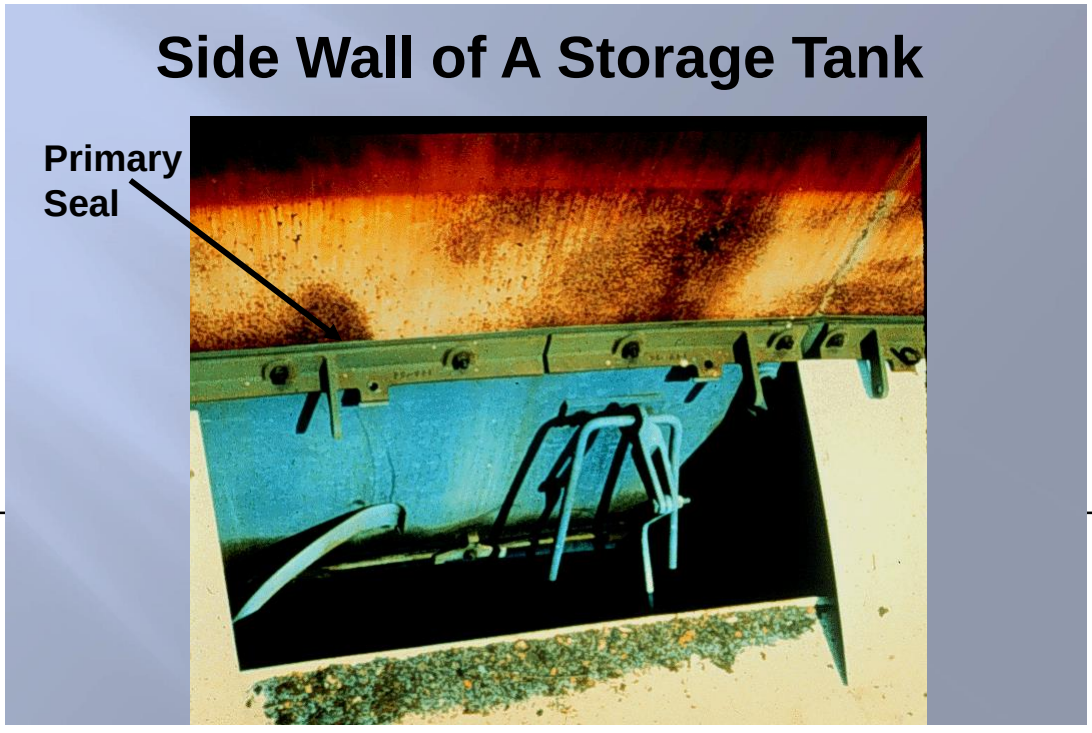
Primary/Secondary Seals

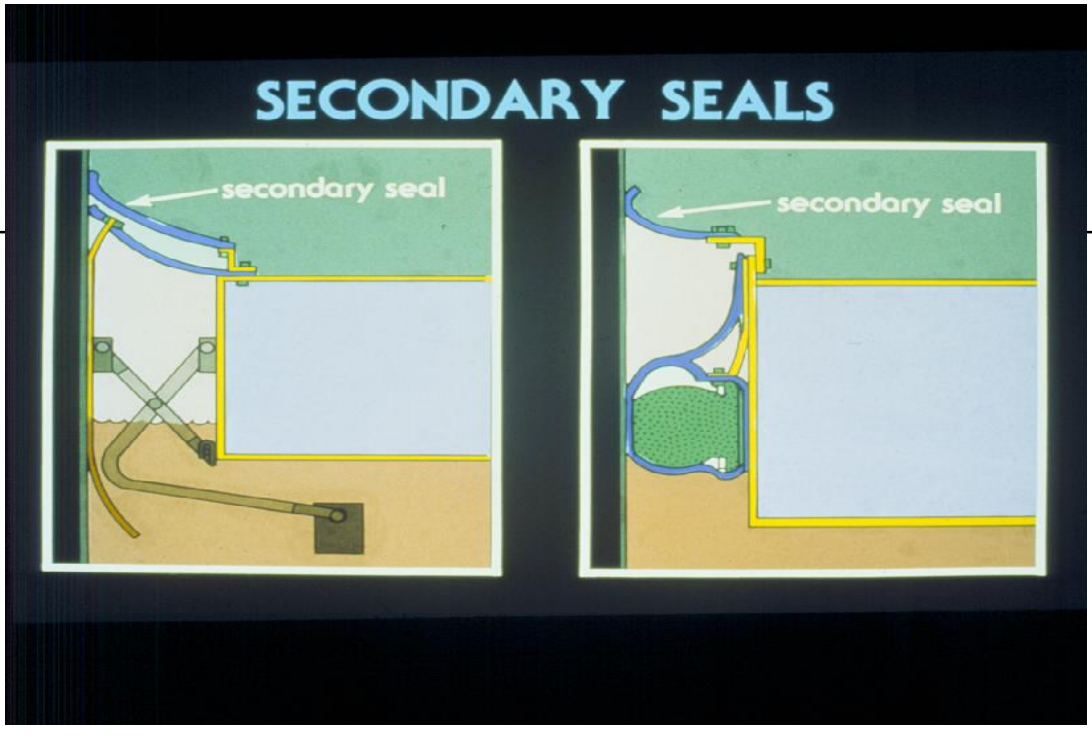
Primary Seals

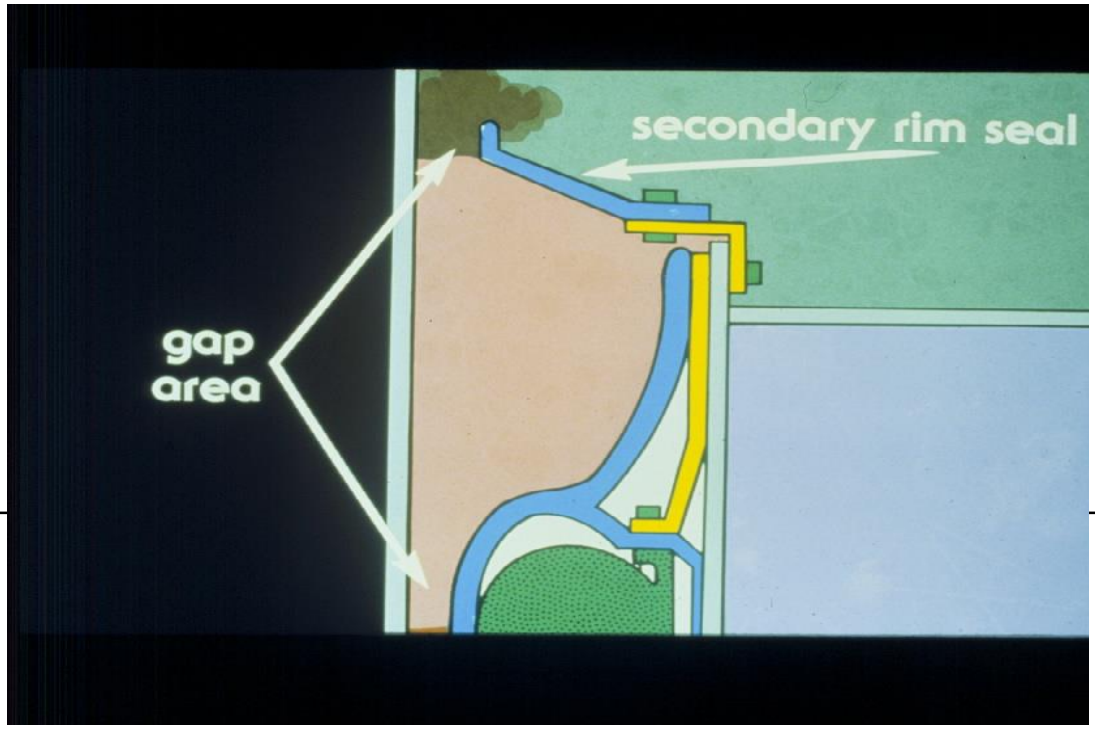
Metallic Shoe Page 302-16

Resilient toriod Page 302-17




Side Wall of A Storage Tank
Primary
Seal


SECONDARY SEALS
secondary seal
secondary seal

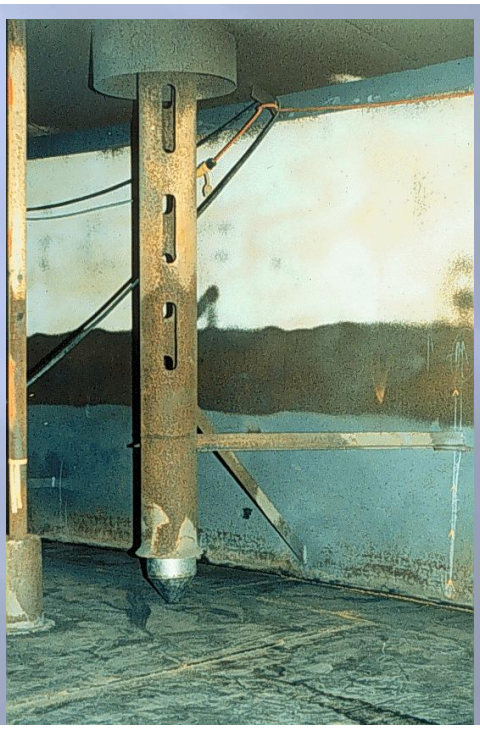


Inspection Points

- Primary and Secondary Seals
- Sample Hatch
- P/V Valce
- Level Gauge
- Water Draw
- Roof Drain/Emergency Roof Drain
- Temperature Gauges

Checking the Secondary Seal on a Storage Tank

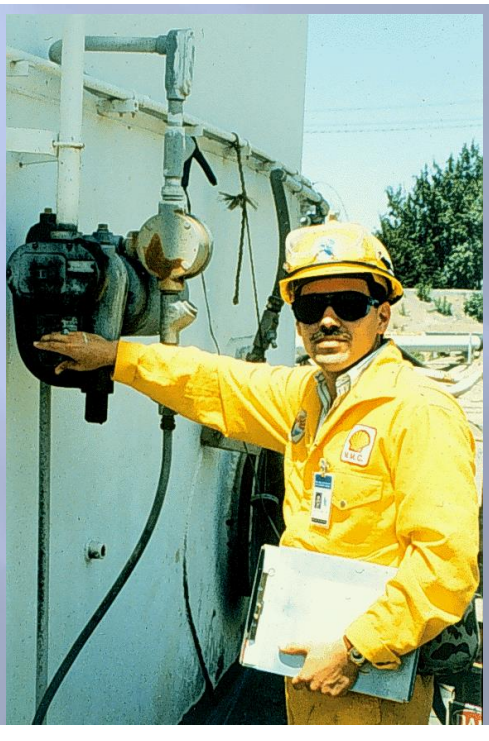
Sampling Hatch on Storage Tank



Sampling Well Inside of a Floating Roof Storage Tank

Leg of a Floating Roof Storage Tank - position of leg when the tank is in service

Inside of a Floating Roof Storage Tank



Level Gauge for Storage Tank

VOC Emission Control on Floating Roof Tank

Other Equipment

- Pumps, valves, compressors - Leaks
- Reciprocating internal combustion engines
- Gas turbines
- A big emitter we'll cover later – Fluid Catalytic Cracking Unit (FCCU)

Quick Review 2

- Equipment & associated emissions
  - Fired heaters - combustion
  - Heat exchangers – fugitives due to leaks
  - Flares - combustion, fugitives, odors
  - Cooling towers - fugitives, odors
  - Vacuum jets - fugitives
  - Storage tanks - fugitives
  - Pumps, valves, compressors - fugitives
  - Internal combustion engines - combustion
  - Gas turbines – combustion
  - Don't forget about the FCCU