NCG Collection and Incineration

2008 Kraft Recovery Short Course

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Agenda

1. Introduction
2. Glossary
3. Types of NCG Systems
4. System Design
5. NCG Equipment
6. NCG Incineration

1. Introduction

NCG is an all encompassing term for Kraft mill odourous gases that contain sulphur compounds, organics such as methanol and terpenes, water vapour and air

1. Introduction

Kraft mill odourous gases are caused by sulphur compounds originating from:

- digesters
- evaporators
- turpentine systems
- stripping systems
- brown stock washers
- filtrate tanks
- liquor storage tanks

1. Introduction

- NCG collection and treatment systems eliminate kraft mill odour by collecting and destroying the gaseous reduced sulphur compounds

1. Introduction

- NCG vented to atmosphere can cause injury, environmental damage, and nuisance odour around the mill and surrounding community
- Stringent environmental regulations require collection and incineration of these gases

2. Glossary

TRS: **T**otal **R**educed **S**ulphur

- General term for Kraft mill odourous bivalent sulphur compounds
  - Hydrogen sulphide H_2S
  - Methyl mercaptan CH_3SH
  - Dimethyl sulphide $(CH_3)_2SH$
  - Dimethyl disulphide $(CH_3)_2S_2$

2. Glossary

CNCG: **C**oncentrated **N**on-**C**ondensable **G**as

- Low Volume High Concentration (LVHC)
- Consists of Kraft mill odourous gases from digester and evaporator areas
- Composed of TRS, wood organics, air and water vapour

2. Glossary

DNCG: **D**ilute **N**on-**C**ondensable **G**as

- High Volume Low Concentration (HVLC)
- Collected from BSW, filtrate tanks, liquor tanks
- Consists primarily of air with trace TRS, wood organics and water vapour

2. Glossary

SOG: **S**tripper **O**ff **G**as

- Product vapours from trim condenser
- Consists of methanol, TRS, terpenes, wood organics and water vapour
- Target concentration:
  - 50 wt % combustibles
  - 50 wt % water vapour

3. Types of NCG Systems

- Concentrated (LVHC)
- Dilute (HVLC)
- Chip Bin Gas
- Stripper Off Gas

3.1 CNCG Systems

Low Volume High Concentration
(LVHC)

CNCG - General

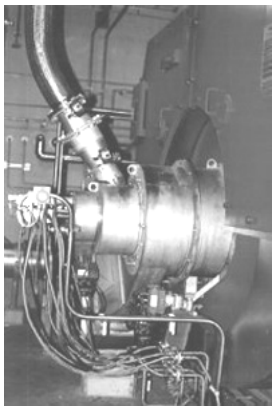
- NCG released during the Kraft pulping process are noxious and have a very low threshold of odour detectability
- TRS is generated in the pulp digesters when wood is cooked with Kraft liquor (sodium sulphide, Na_2S, in the liquor reacts with a methyl group in the lignin in an oxygen deficient environment)

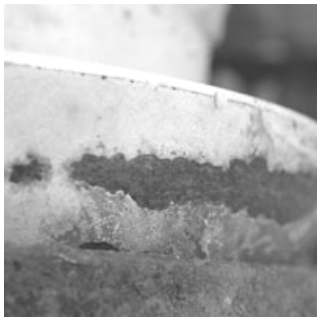
CNCG Composition

Compound	**Average**	Minimum	Maximum
TRS	**47**	30	70
Water	**6**	4	10
Oxygen	**3**	0	20
Nitrogen	**44**	14	78

CNCG System

- CNCG systems typically collect gases from the digesters, evaporators, turpentine recovery system and foul condensate tank
- CNCG is typically disposed of by incineration in the lime kiln, power boiler, recovery boiler or dedicated incinerator
- US Cluster Rules state that CNCG sources must be collected and destroyed with only 1% downtime





NCG is

CORROSIVE

Materials of Construction

- Mild steel corrodes quickly
- FRP experience is mixed
- 300 Series stainless steel works well

NCG is

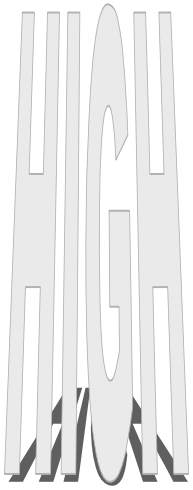
T O X I C

NCG Toxicity

- Highly Toxic
  - Responsible for a number of injuries and deaths
- 250 to 800 ppm of H_2S exposure
  - Severe sickness, permanent damage to respiratory system and mucous membranes
- 1000 ppm of H_2S exposure
  - 30 minutes is fatal
- TRS concentration in CNCG systems
  - 100,000 to 500,000 ppm

NCG Vents

Make them



NCG System Toxicity

- System vents directed to a high point clear of well-travelled areas
  - E.g. up the side of recovery boiler stack
- Design with ejector near incineration point
  - Ensure entire collection system is kept under vacuum
- Leaks must be fixed immediately
- Scott air packs must be used when entering areas with high TRS concentrations

NCG is

EXPLOSIVE

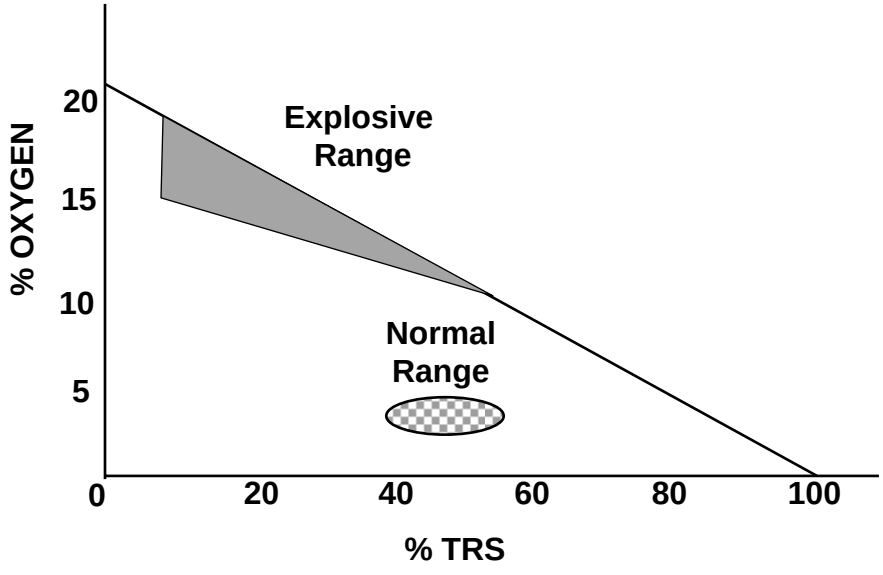
Combustion Properties

- Combustibles in CNCG are above UEL (Upper explosive limit)
  - Insufficient oxygen to sustain combustion
- Combustibles in DNCG are below LEL (Lower explosive limit)
  - Insufficient combustibles to sustain combustion
- CNCG and DNCG streams should never be combined
  - Result in explosive mixture

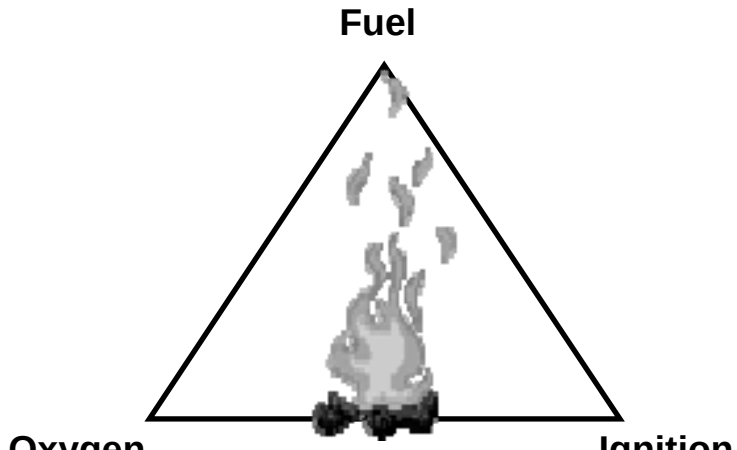
Combustion Properties

Compound	LEL (vol %)	UEL (vol %)
H_2S	4.3	45
CH_3SH	3.9	21.8
Methanol	6.7	36.5
Alpha Pinene	0.8	6.0
TRS	2	50

Explosive Range of CNCG

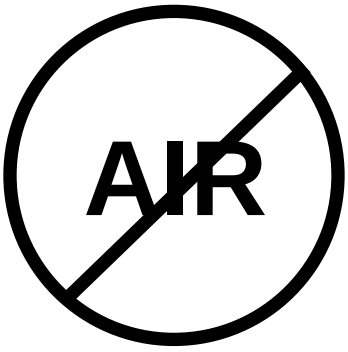


Requirements for Fires

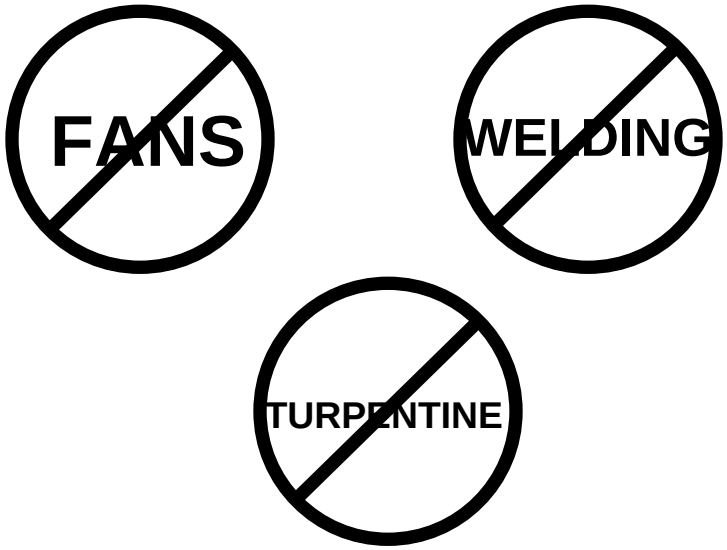


Safe Design

Keep the Air Out



Eliminate Ignition Sources

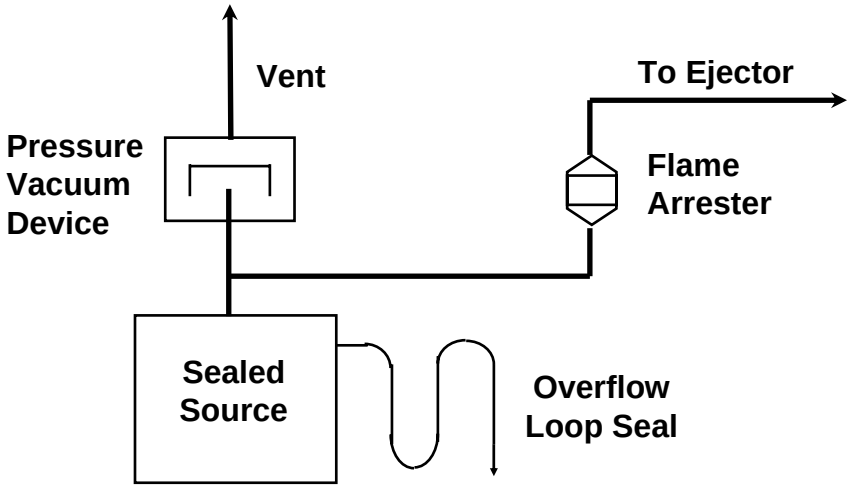


4. System Design

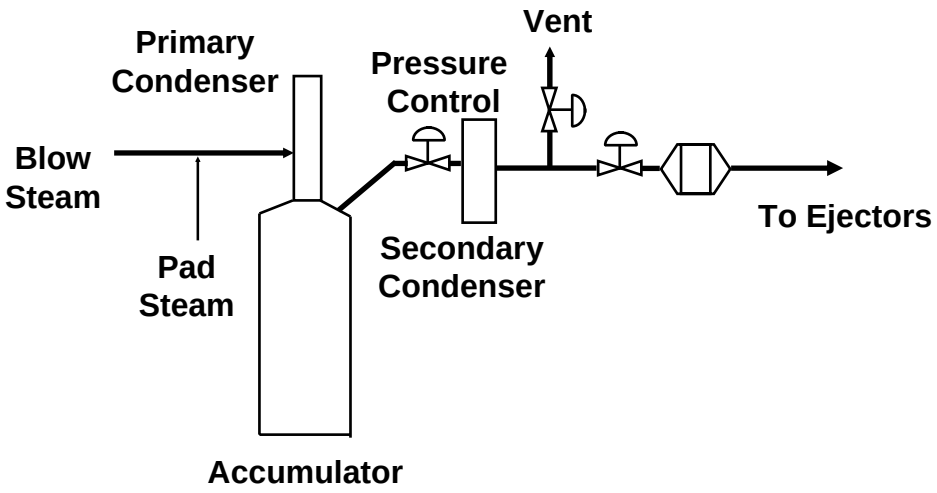
CNCG Volumes

Source	ft^3 / ton	m^3 / tonne
Batch digester	100 - 200	2.6 - 5.2
Continuous digester	150 - 300	3.9 - 7.7
Turpentine System	40 - 80	1.0 - 2.0
Evaporator Hotwell	50 - 200	1.3 - 5.2

Continuous NCG Collection



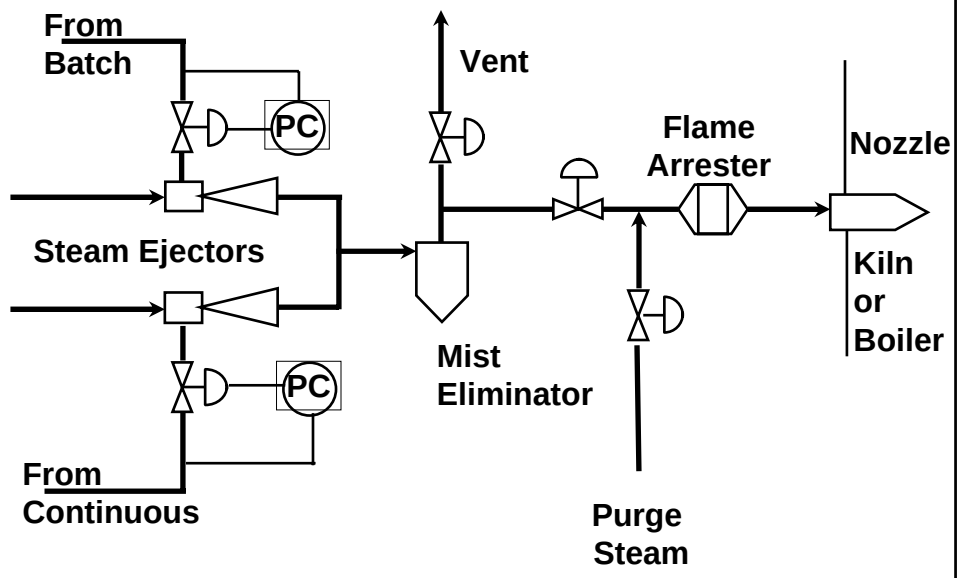
Blow Gas Collection



Batch Digesters

Blow Steam Condensers
<u>Must</u> Work Properly

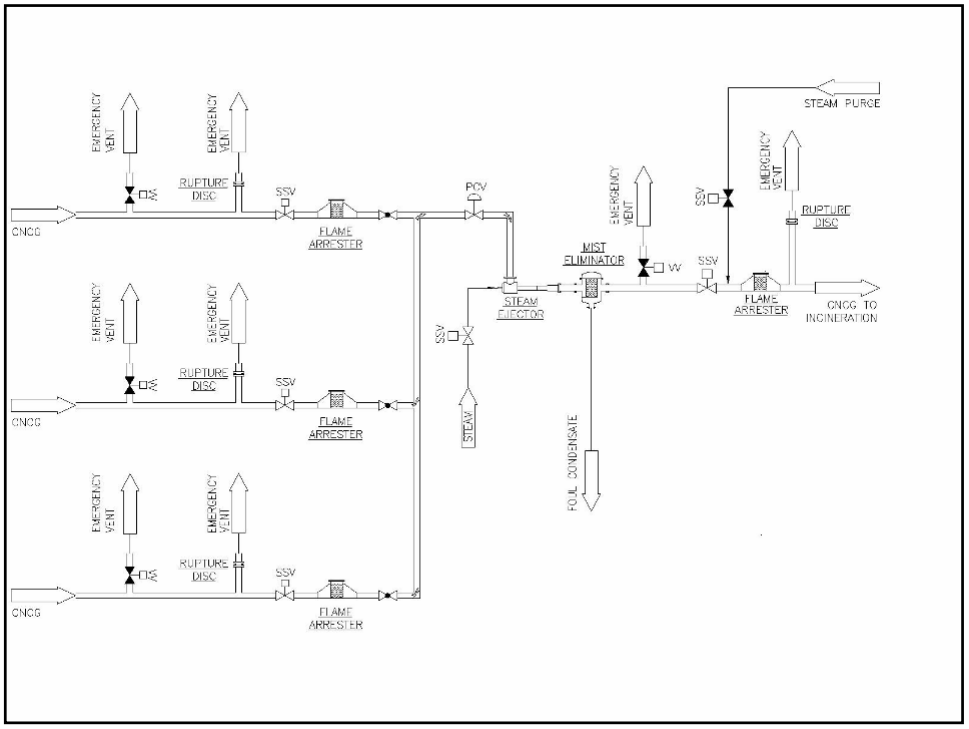
NCG Collection



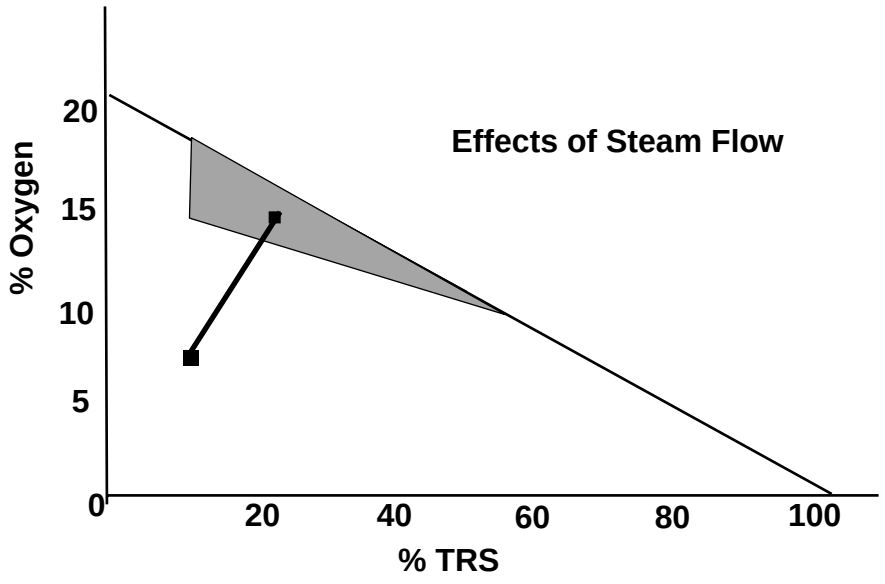
Continuous and

Batch NCG Sources

<u>MUST</u> be separated



Explosive Range of NCG



MURPHY'S LAW

If anything CAN possibly go wrong,

sooner or later,

it WILL go wrong

Levels of Protection

1. Keep Air Out
2. Eliminate Ignition Sources
3. Line Protection
   - Flame Arresters
   - Rupture Discs

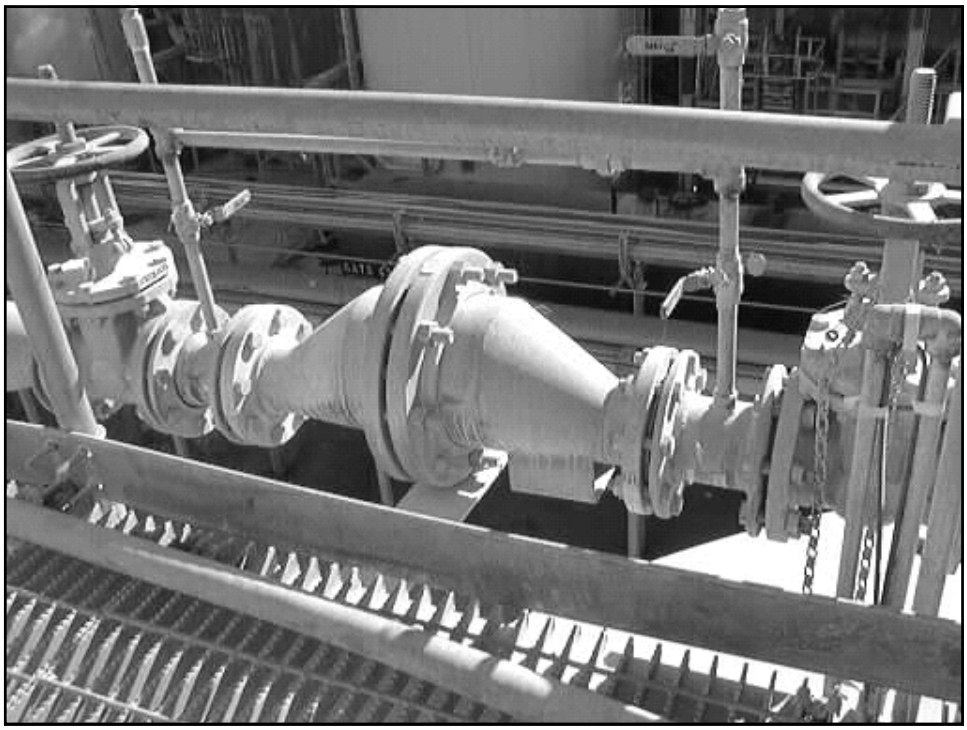
5. NCG Equipment

NCG Equipment

- Flame Arresters
- Pressure vacuum relief
- Rupture discs
- Mist eliminator
- Steam ejector
- Injection nozzles
- Control / divert valves

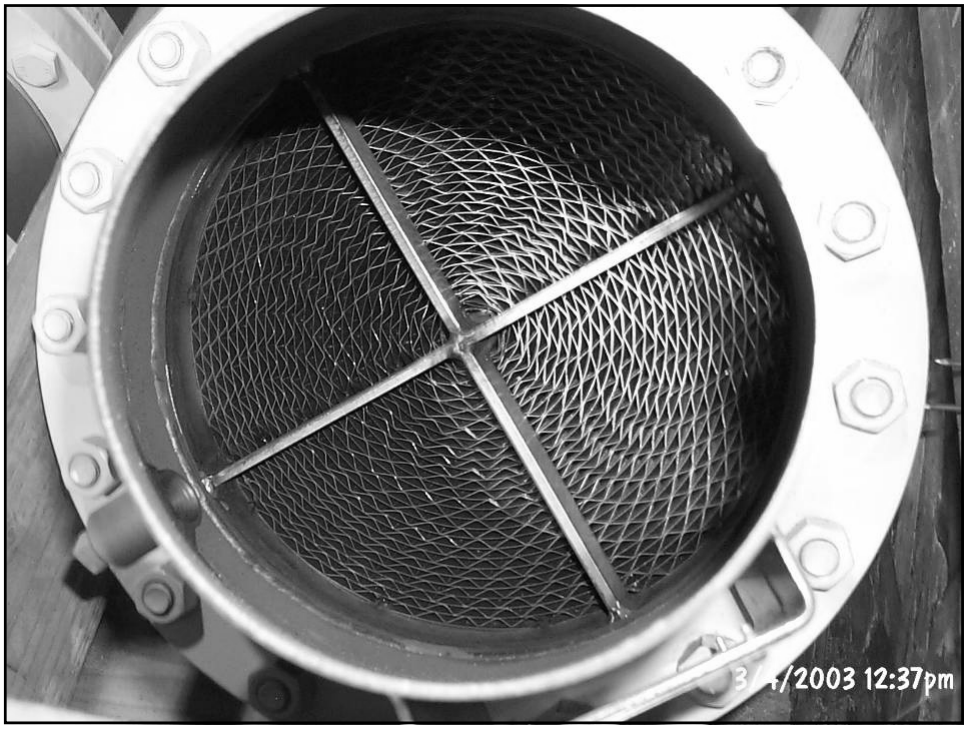
Flame Arresters

- In-line devices designed to protect against flame propagation or burn-back
- Located at each source and at each incineration point



Flame Arresters

- Dense corrugated pack acts as heat sink to decrease flame temperature below ignition point
- All stainless steel construction
- Center pack bolted between flanges for removal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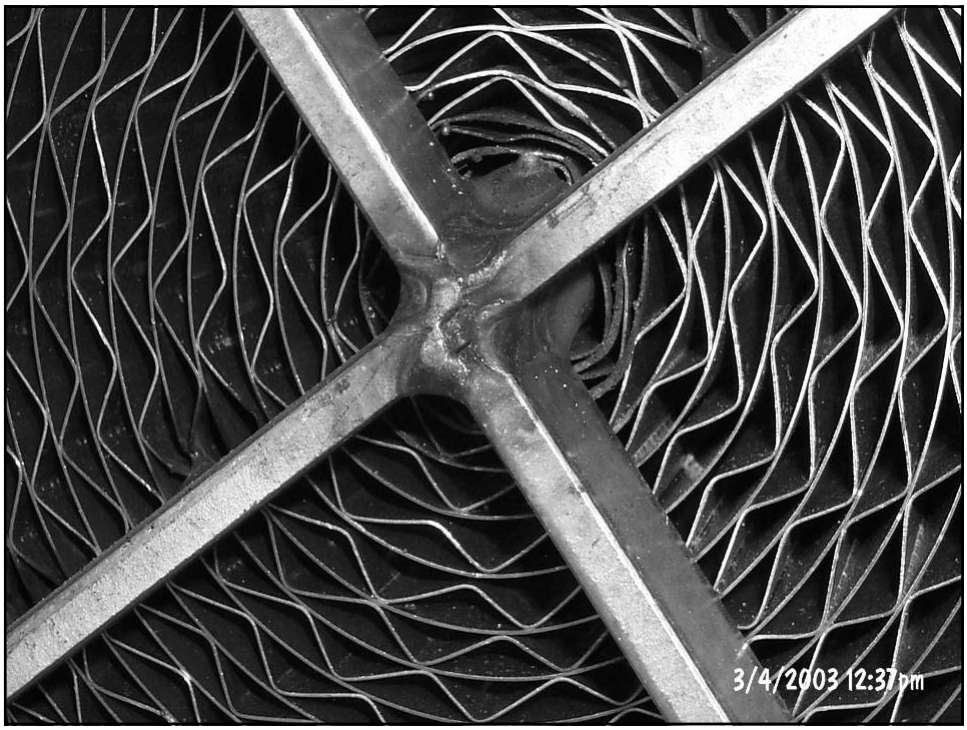
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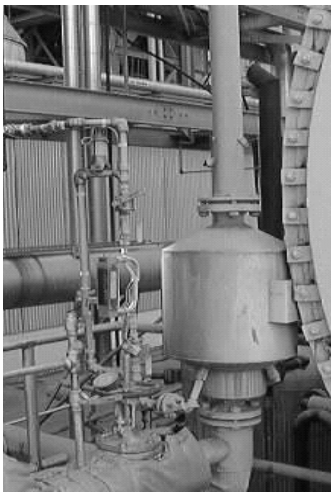
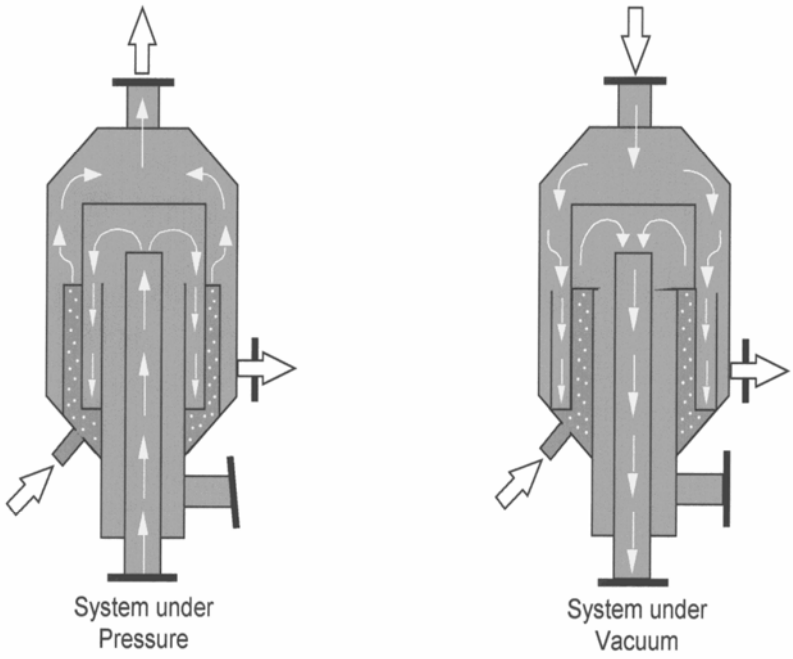
Pressure / Vacuum Relief

- Protect source vessel from excessive pressure and/or vacuum
- Prevent air ingress in CNCG system
- Mechanical or water-seal PVB

Pressure / vacuum breaker





Rupture Discs

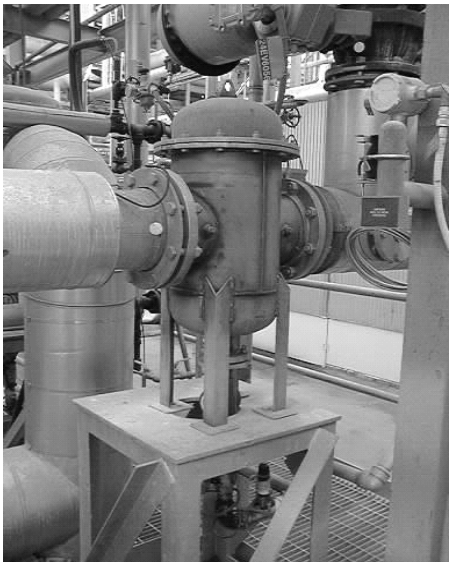
- Protect NCG line against overpressure
- Carbon (graphite) or stainless steel
- Full line size
- Located at 100 to 400 foot intervals
- Vent lines directed outdoors
- May be monitored

Rupture Disc

Mist Eliminator

- Removes water droplets before incineration
- Normally chevron demisters with vanes
- Horizontal flow units more efficient removes 99.5% of all droplets 10 microns or greater
- Must drain properly

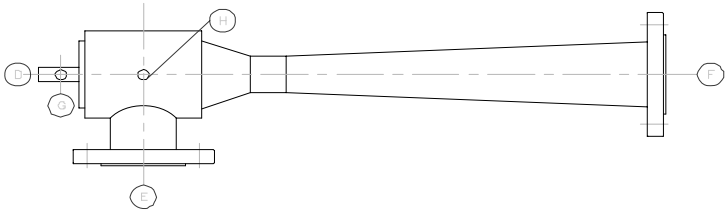
Mist Eliminator



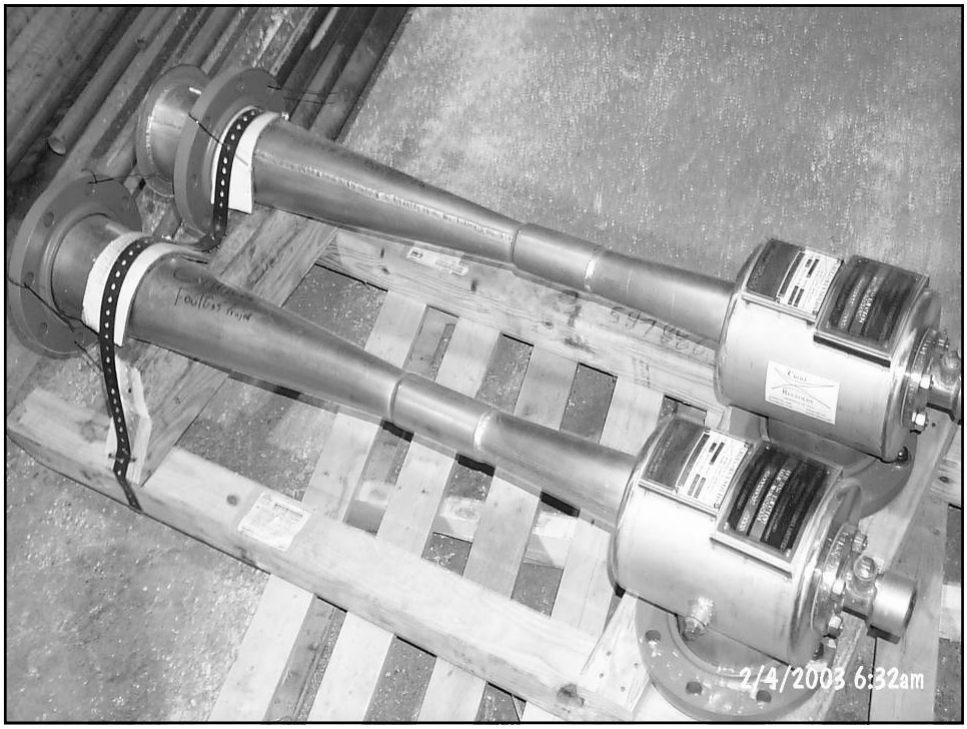
Steam Ejector

- Type of compressor using kinetic energy created by expanding a motive fluid (steam) to entrain and compress a second gas stream (NCG)
- No moving parts
- As steam passes through nozzle, a vacuum is created at the vapour inlet, pulling the NCG through the ejector

Steam Ejector

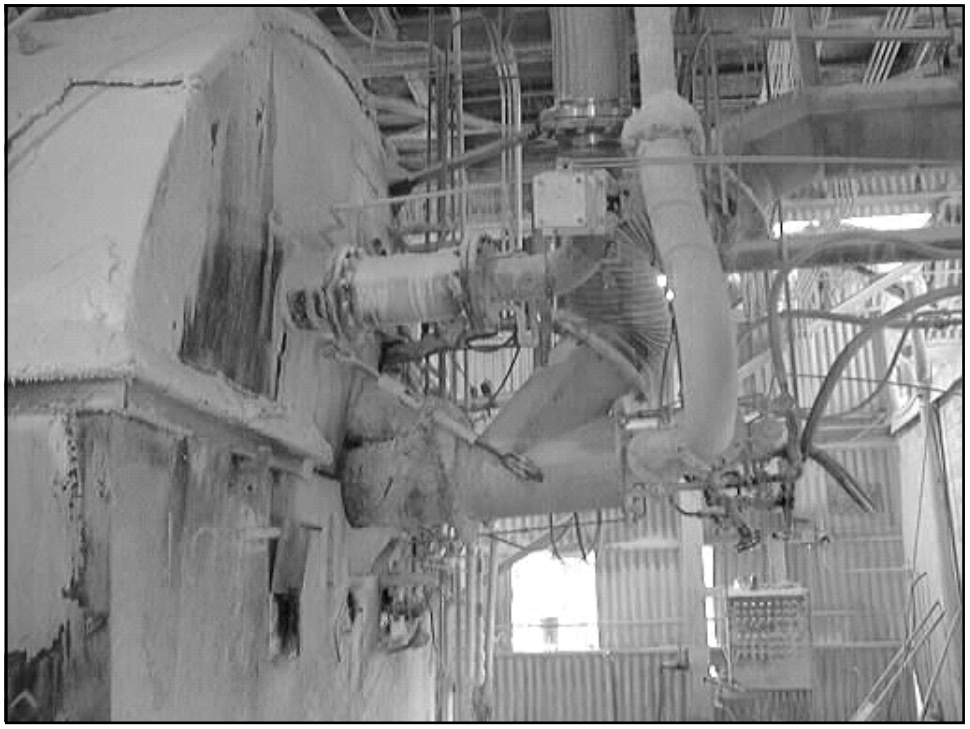


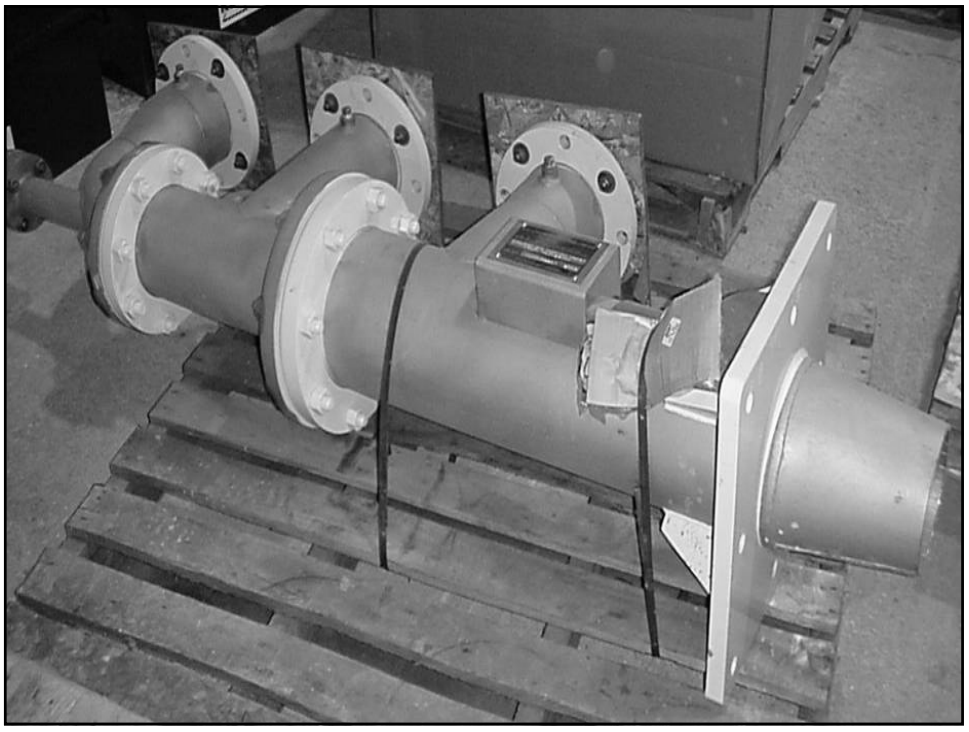
- Steam expands through a nozzle, converting pressure to velocity energy
- Steam contacts NCG in the suction chamber
- Mixture enters diffuser, where velocity is reconverted to pressure at ejector discharge

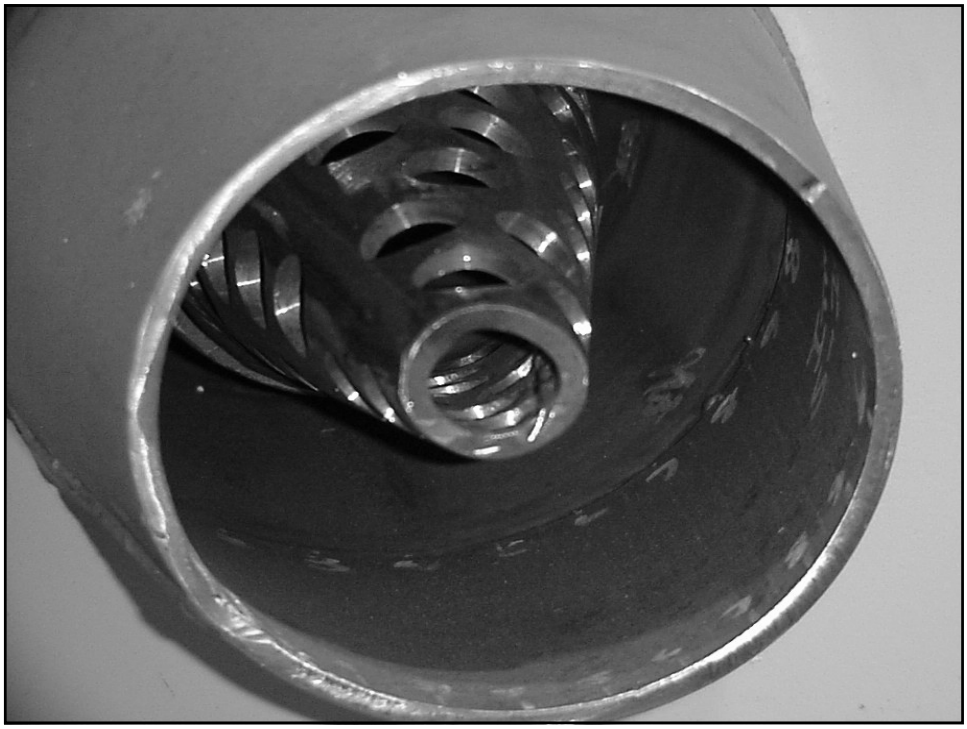


Injection Nozzle

- Delivers NCG into incineration point
- Not a burner
- Combination nozzle with separate annuli for CNCG, SOG, cooling media
- Cooling with water or air





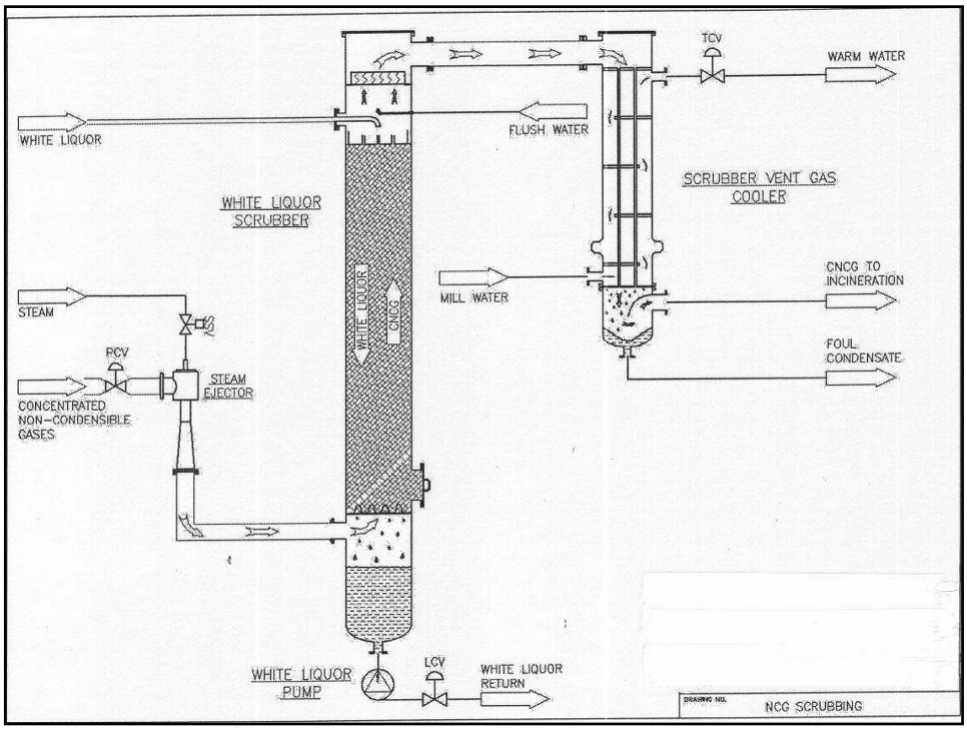


Scrubbing NCG

- Alkaline scrubbing ahead of incineration can reduce impact on the kiln:
  - Reduced ring formation, increased capacity
- Impact on power boiler:
  - Reduced SO_2 emissions, reduce corrosion concerns
- Reduces TRS During Venting

Scrubbing NCG

- Alkaline Solution
- White Liquor
- Specialty Chemical



6. NCG Incineration

Minimum Conditions for Burning NCG

- Temperature 1600 °F (870 °C)
- Residence time 0.75 seconds
- Excess oxygen 3 - 4 %

Equipment for Burning NCG

- Lime Kiln
- Power (Bark) Boiler
- Recovery Boiler
- Incinerator

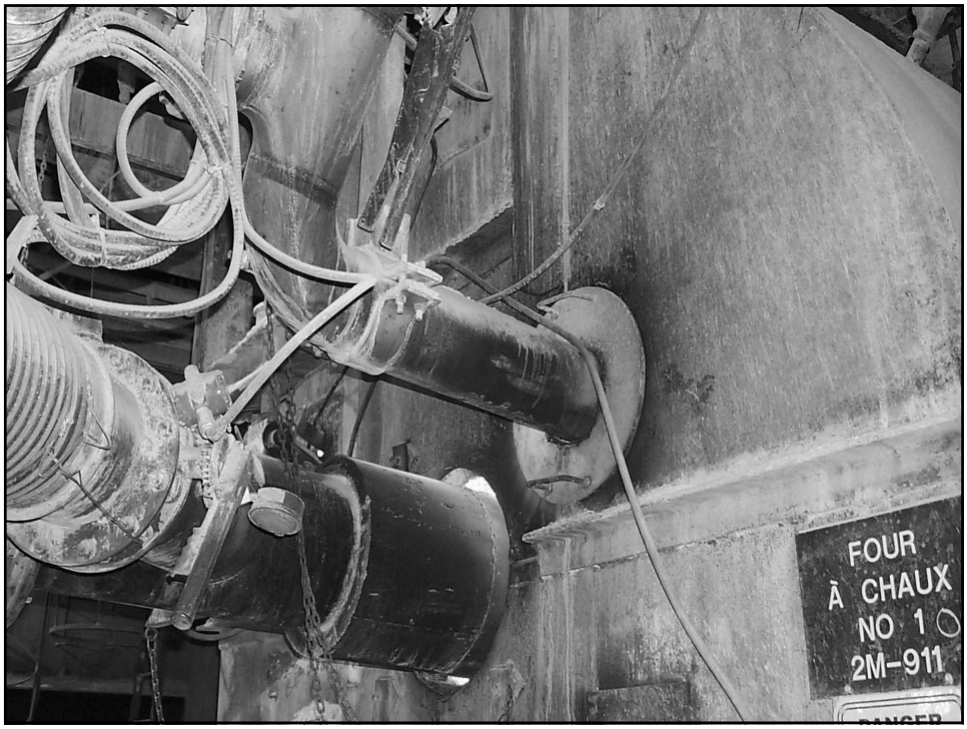
Lime Kiln

Advantages

- **Traditional**
- **Recovers SO_2**

Disadvantages

- **Inefficient**
- **Ring Formation**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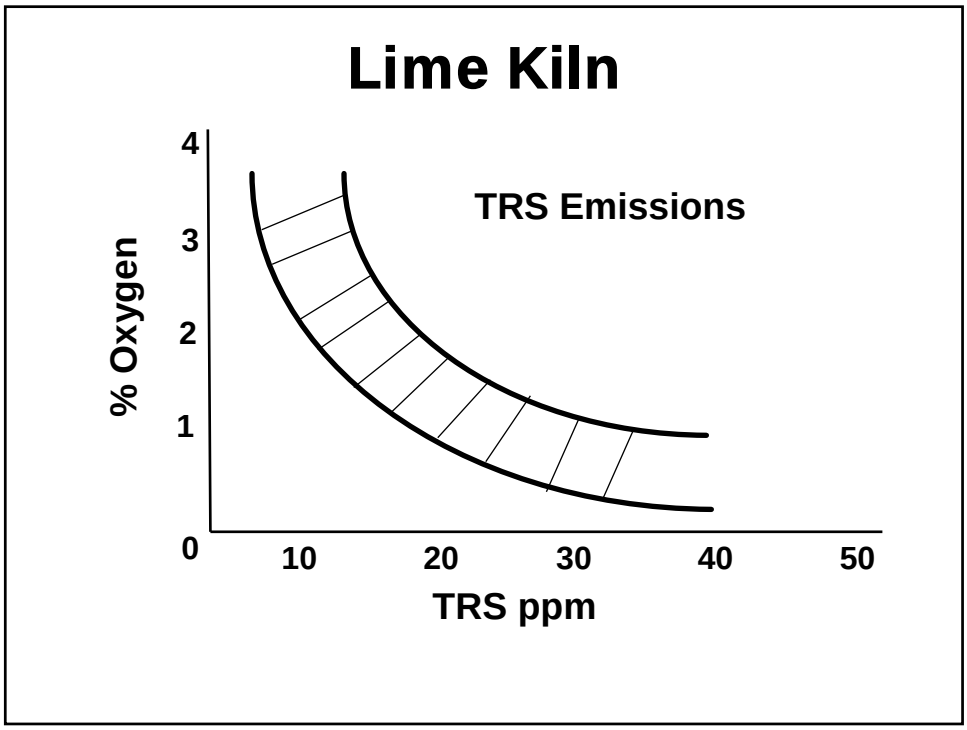

Lime Kiln
TRS Emissions
% Oxygen
4
3
2
1
0
10
20
30
40
50
TRS ppm

Power Boilers

Advantages

- **Easiest**

Disadvantages

- **Increased SO_2**
- **Corrosion**

Power Boilers

Ash from Coal and Bark Absorbs SO_2

Recovery Boiler

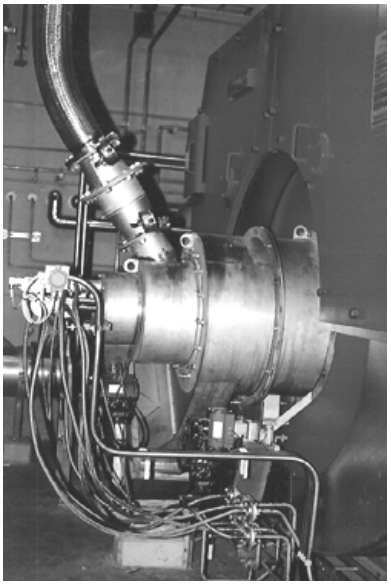
Advantages

- **Theoretically Best**
- **Recovers Sulfur**

Disadvantages

- **Adds complexity to boiler operation**

Recovery Boiler



Recovery Boiler

- H_2S converted to SO_2 in combustion
- SO_2 is further converted to Na_2SO_4
- Captured as sodium dust fume
- Recovered as Na_2S in smelt

Incinerator

Advantages

• Least Risk

Disadvantages

• Expen$ive
• SO_2 Emission
• Another Stack

Other Considerations

- Bigger is better
- Uptime
- Distance
- Politics

Cluster Rule

- Requires 99% uptime
- Downtime also allowed for “Startup, Shutdown and Malfunction”
- All vents must be monitored

Conclusion

Safe, Reliable, and Explosion Free NCG Systems are Possible