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.

- 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:** Total Reduced Sulphur

- General term for Kraft mill odourous bivalent sulphur compounds
  - Hydrogen sulphide $\text{H}_2\text{S}$
  - Methyl mercaptan $\text{CH}_3\text{SH}$
  - Dimethyl sulphide $(\text{CH}_3)_2\text{SH}$
  - Dimethyl disulphide $(\text{CH}_3)_2\text{S}_2$

**CNCG:** Concentrated Non-Condensable Gas

- 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**: Dilute Non-Condensable Gas

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

**SOG**: Stripper Off Gas

- 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, Na₂S, in the liquor reacts with a methyl group in the lignin in an oxygen deficient environment)

CNCG Composition

<table>
<thead>
<tr>
<th>Compound</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRS</td>
<td>47</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Water</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Oxygen</td>
<td>3</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>44</td>
<td>14</td>
<td>78</td>
</tr>
</tbody>
</table>
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 TOXIC
**NCG Toxicity**

- **Highly Toxic**
  - Responsible for a number of injuries and deaths

- **250 to 800 ppm of H<sub>2</sub>S exposure**
  - Severe sickness, permanent damage to respiratory system and mucous membranes

- **1000 ppm of H<sub>2</sub>S exposure**
  - 30 minutes is fatal

- **TRS concentration in CNCG systems**
  - 100,000 to 500,000 ppm

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**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**

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**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

<table>
<thead>
<tr>
<th>Compound</th>
<th>LEL (vol %)</th>
<th>UEL (vol %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂S</td>
<td>4.3</td>
<td>45</td>
</tr>
<tr>
<td>CH₃SH</td>
<td>3.9</td>
<td>21.8</td>
</tr>
<tr>
<td>Methanol</td>
<td>6.7</td>
<td>36.5</td>
</tr>
<tr>
<td>Alpha Pinene</td>
<td>0.8</td>
<td>6.0</td>
</tr>
<tr>
<td>TRS</td>
<td>2</td>
<td>50</td>
</tr>
</tbody>
</table>

## Explosive Range of CNCG

![Explosive Range of CNCG](image-url)
Requirements for Fires

Fuel

Oxygen

Ignition

Safe Design

Keep the Air Out
Eliminate Ignition Sources

- FANS
- WELDING
- TURPENTINE

4. System Design
## CNCG Volumes

<table>
<thead>
<tr>
<th>Source</th>
<th>ft³/ ton</th>
<th>m³/ tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch digester</td>
<td>100 - 200</td>
<td>2.6 - 5.2</td>
</tr>
<tr>
<td>Continuous digester</td>
<td>150 - 300</td>
<td>3.9 - 7.7</td>
</tr>
<tr>
<td>Turpentine System</td>
<td>40 - 80</td>
<td>1.0 - 2.0</td>
</tr>
<tr>
<td>Evaporator Hotwell</td>
<td>50 - 200</td>
<td>1.3 - 5.2</td>
</tr>
</tbody>
</table>

### Continuous NCG Collection

- Pressure Vacuum Device
- Sealed Source
- Vent
- Overflow Loop Seal
- Flame Arrester
- To Ejector
Blow Gas Collection

Batch Digesters

Blow Steam Condensers **Must** Work Properly
Continuous and Batch NCG Sources MUST be separated
Explosive Range of NCG

Effects of Steam Flow
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
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**

- 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**

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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 SO₂ 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
Lime Kiln

TRS Emissions

% Oxygen

TRS ppm

0 10 20 30 40 50

0 1 2 3 4
Power Boilers

Advantages
- Easiest

Disadvantages
- Increased SO$_2$
- Corrosion

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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

- $\text{H}_2\text{S}$ converted to $\text{SO}_2$ in combustion
- $\text{SO}_2$ is further converted to $\text{Na}_2\text{SO}_4$
- Captured as sodium dust fume
- Recovered as $\text{Na}_2\text{S}$ in smelt

Incinerator

Advantages
- Least Risk

Disadvantages
- Expensive
- $\text{SO}_2$ 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