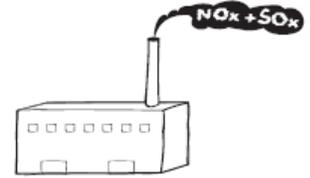


ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry



TRADE-OFFS AND CO-BENEFITS ACCOMPANYING SO_x CONTROL

TRS Incineration SO_x

The incineration of pulping-related gas streams in mill combustion devices creates further opportunity for incremental emissions of SO_x. The potential for SO_x emissions from this practice is relatively small compared with overall mill emissions and varies with the combustion devices chosen.

Power boilers are the most versatile, and approximately one-third of kraft mill power boilers are used to manage total reduced sulfur (TRS) gas streams. Lime kilns offer inherent advantages for SO_x reduction, but may have design limitations in their capacity to manage the various gas streams. Recovery furnaces are versatile, but require extreme safety precautions and higher liquor concentration. Free-standing thermal oxidizers offer the greatest flexibility for concentrated gases, but lose their energy value and require alkaline scrubbing for SO_x control.

Unless otherwise noted, the information provided in this segment of the website was derived from NCASI study results that have been compiled in a reference work intended for the use of NCASI member companies (NCASI 2004b).

Source of Emissions: Total reduced sulfur (TRS) compounds are the signature pollutants of kraft pulping. Their malodorous nature at extremely low concentrations has led to the need for the destruction of TRS compounds contained in non-condensable gas streams (NCGs) collected from across the pulp mill. These gas streams are characterized as falling in one of two categories:

- High Volume Low Concentration Gases (HVLCs) – low TRS and VOC content
- Low Volume High Concentration Gases (LVHCs) – low oxygen and up to 60% TRS content

Potential emissions of SO₂ that could accompany incineration are shown in Table S9.

Table S9. Average Potential SO₂ Emissions Pounds per Air Dry Ton of Unbleached Pulp

Incineration Type	SO ₂ Emissions
HVLC	0.14
LVHC	2.2
LVHCs & SOGs Combined	8.4

The European Union estimates total pulp mill emissions of SO₂ to be approximately 0.8 to 1.6 pounds per ton of pulp when the best available control techniques (BATNEEC) are applied. This illustrates the high degree of SO₂ reduction that accompanies the expected measures for management of total reduced sulfur gas streams.

Incineration Devices: Kraft mill recovery furnaces, lime kilns, and power boilers all find application in the incineration of one or another of the TRS gas streams. The combustion environment in recovery furnaces and the chemical environment within lime kilns, along with optimization of combustion conditions, enable high degrees of SO_x control. Wood-fired boilers provide a measure of control because of the presence of alkaline wood ash. These devices are also able to capture the heat value of the TRS gas, an energy dividend. The optimization of combustion conditions must take into account the process imperatives of recovery furnace and kiln operation, as well as accommodating the competing conditions necessary for concurrently limiting emissions of SO_x, NO_x, TRS, CO, and VOCs.

Trade-offs and Co-benefits Accompanying SOx Control
TRS Incineration SOx

A thermal oxidizer may be a preferred alternative for destruction of the more highly concentrated gas streams. It offers the advantage of avoiding problems with the process or process equipment that can result from putting TRS gases in devices often not specifically designed or engineered for their combustion. The disadvantages associated with using a thermal oxidizer to destroy stripper off-gases (SOGs) and non-condensable gases (NCGs) include a) having another piece of costly equipment to install, maintain, and run; and b) loss of the heat content of the gases. An external scrubber would be necessary to control SOx emissions.

What factors affect the choice and the SOx performance of combustion devices used for control of NCGs and SOGs?

Some factors in the choice and performance of combustion devices to control non-condensable gases and stripper off-gases are compiled in Table S10.

Table S10. SOx/NOx Performance of Combustion Devices for Control of Non-Condensable Gases and Stripper Off-Gases

Combustion Device	HVLCs	LVHCs	SOGs	Comments
Recovery Furnace	HVLC gases introduced with secondary or tertiary air ports, with some plugging of nozzles observed	Requires proper gas conditioning, rigorous safety precautions and black liquor solids > 70%		Historically limited application due to concerns over explosion potential
Lime Kiln	Kiln air flow limitations may limit applicability due to high HVLC flow rate	Additional combustion air requirements cannot always be met	Observed SOG NH ₃ conversion to NOx from -1% to 23% dependent upon kiln energy input flux and the manner of SOG introduction (NCASI 2002)	Ring formation observed with LVHC. Sulfur capture creates cumulative dead load on the kiln. Need for backup during kiln outage.
	Gas/Lime dust interaction absorbs SO ₂ (NCASI 2004a). High temperatures and residence times ensure TRS and organic destruction.			
Power Boilers	Relatively large size accommodates HVLC and LVHC. Potential increase of boiler SO ₂ emissions. SO ₂ can be absorbed by alkaline dust in wood and combination fuel boilers (NCASI 1992). NOx impact not studied but expected to be minimal.		Conversion of SOG ammonia (NH ₃) to NOx observed to range from (-11%) to 34%, dependent upon temperature and O ₂ availability at point of SOG introduction (NCASI 2002)	Boilers have much higher up-time than kilns
Thermal Oxidizers	Not typically utilized due to high flow rates of HVLCs (NCASI 2004b)	High level of SO ₂ emissions requires scrubber addition	Jet engine type oxidizers, now little used, have high NOx emissions. Others show NH ₃ conversion rates from 5% to 38% dependent upon air staging and NH ₃ concentration (NCASI 2004c).	Flexibility in location allows reduced ducting (NCASI 2004c). Requires addition of a waste heat boiler to enable capture of energy from NCG combustion (NCASI 2004b).
		Higher conversion of NH ₃ to NOx when SOG introduced with natural gas or LVHC in single stage oxidizer		

NOTE: Shaded areas=limiting factor

What are the trade-offs and co-benefits from thermal oxidizer SO_x control?

SO_x emissions from thermal oxidizers are themselves a trade-off resulting from the destruction of malodorous total reduced sulfur (TRS) gases. Boilers, kilns, and recovery furnaces are commonly used for TRS gas incineration, but site-specific circumstances, operational flexibility, and the need for backup control systems frequently compel use of thermal oxidizers.

Unless augmented with a waste heat boiler, thermal oxidizers forfeit the energy value of the TRS gases, unlike with incineration in the process combustion devices mentioned in the paragraph above. In addition, thermal oxidizers can exert their own energy demands, though auxiliary fuel is not needed where stripper off-gases (SOGs) are burned.

Conventional alkaline scrubbers are used to control SO_x emissions from thermal oxidizers. Spent scrubber liquid requires management in wastewater systems unless it can be recovered for process uses. Staging of combustion air is used for reduction of potential NO_x emissions, with the potential risk of greater CO emissions.

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