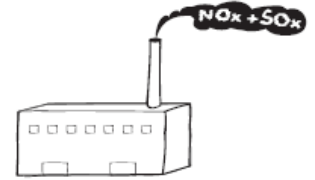


ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

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



TRADE-OFFS AND CO-BENEFITS ACCOMPANYING NO_x CONTROL

TRS Incineration NO_x

The incineration of pulping-related gas streams in mill combustion devices creates further opportunity for incremental emissions of NO_x. The potential for NO_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 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. NO_x emissions from use of these various devices are highly dependent upon the nitrogen content of the gas streams. Levels vary from negligible to as much as 38% of fuel nitrogen content, depending upon combustion conditions.

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

Another prominent reduced sulfur gas stream of consequence is stripper off-gas (SOG) that originates from the stripping of foul condensates. What is distinctive about this stream is the added presence of ammonia at levels that, if completely converted to NO_x, could rival emissions from the kraft recovery furnace. Conversion of NH₃ to emitted NO_x is reported to be as great as 38%, depending upon the choice of combustion device, its design features, and the combustion conditions under which it is operated. Observations also exist showing little or no conversion, and even reductions of NO_x emissions.

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 NO_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.

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 SOGs and NCGs include a) having another piece of costly equipment to install, maintain, and run; and b) loss of the heat content of the gases.

What factors affect the choice and the NOx 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 do 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 factors.

References

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