METALLURGY PROGRESS REPORT 2

Regional Copper-Nickel Study
Minnesota Environmental Quality Board

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Tall stacks or chimneys are used as an ultimate disposal method for wastes which would be difficult to treat. The primary effluent which is emitted from tall stacks or chimneys is sulfur dioxide. Sulfur dioxide originates as a gas from two principal sources:

- smelting operations
- electric power generation plants using a fossil fuel

The objective of the stack is to disperse SO_2 at elevated heights so as to prohibit contammination at ground level. Stacks may be as low as 46 meters, however, many and most are between 152 and 183 meters. For the first order approximations, it will be assumed that a Minnesota based, copper-nickel smelter, will have exit stacks 152-183 meters high, and will specifically vary with the height of typical inversion levels present in Minnesota.

When considering the stack as a form of disposal one must consider the following:

- acceptable ground level concentration of toxic materials and/or particulate matter
- topography of the area
- meteorological conditions
- constituents of the waste gas

Ross (1972) points out several rules which may be used by the average engineer in designing stack systems. These rules will be applied here in our first order approximation of the copper-nickel smelter. They are as follows.

- the stack (which in our case is 152-183 meters high) should be 2½ times the highest surrounding buildings or surrounding topography in order to avoid significant turbulence created by such objects. (This, of course, defines our highest possible building as being 11-30.5 meters).

- gas injection velocities from the stack to the atmosphere should be greater than 18.3 meters/sec. so that gases will be able to escape the turbulent wake of the stack. (If possible, gas velocities as high as 30.48 meters/sec. are desirable.)
- gases from stack with diameters less than 1.52 meters and heights less than 60.96 meters hit the ground part of the time causing high ground concentrations.
- maximum ground concentration of stack gases subjected to atmospheric diffusion occurs approximately 5 to 10 stack heights from the stack in a horizontal direction under windless conditions.
- stack gases subjected to atmospheric diffusion where building turbulence is not a factor, can have ground level concentrations on the order of 0.001-1.0 percent of the stack concentration.
- ground concentrations can be reduced through the use of higher stacks. The ground concentration varies inversely as the square of the effective stack height.

First order approximations to exit gas emissions are based on the material balances found in the second metallurgical preliminary report dated February 15, 1977. The following information is assumed (first order approximations for a hypothetical smelter model):

Basis or premise:	100,000 metric tons of metal type product	
Particulate emissions: (based on a 90% efficiency factor)	Cu	522 metric tons/year
	Ni	122 metric tons/year
	Fe	1008 metric tons/year
	S	392 metric tons/year
	Co	17.6 metric tons/year
	As	1.43 metric tons/year
	Pb	.365 metric tons/year
	Zn	28.5 metric tons/year
	Cd	1.82 metric tons/year
Gaseous emissions: (with no gas treatment)	Total Gas Flow	49,581 m^3/hr
	SO_2	7,437 m^3/hr
	N_2	34,210 m^3/hr
	H_2O	?
	CO_2	?
	O_2	?
	Others	?
Stack heights:	152 m - 183 m	
Stack diamters:	11 m - 30.5 m	
Building heights: (maximum)	61 m - 73 m	