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State of New Jersey
Department of Environmental Protection and Energy
Air Quality Regulation Program
CN 027
Trenton, NJ 08625-0027

Scott A. Weiner
Commissioner

William O'Sullivan, P.E.
Administrator

May 17, 1993

Annamaria Colecchia
United States Environmental Protection Agency
Region II
Jacob K. Javits Federal Building
New York, New York 10278-0012

RE: Calculating Plume Rise for Stacks with Horizontal Releases or Rain Caps

Dear Ms. Colecchia:

The Bureau of Air Quality Evaluation (BAQEv) of the New Jersey Department of Environmental Protection and Energy (NJDEPE) will soon be reviewing an air quality modeling analysis for a paint production facility known as Cookson Pigments, Inc. Located in Newark, New Jersey, it is an existing facility with significant lead emissions. NJDEPE is concerned that these lead emissions may be causing an exceedance of the state and federal ambient air quality standard for lead.

A number of the individual sources within the Cookson Pigments facility are stacks with plumes being released in a horizontal, not vertical, direction. In addition, there may also be a stack covered by a rain cap. To accurately model these sources, the momentum portion of the plume rise would have to be minimized. At the same time, the buoyant portion of the plume rise would have to be calculated in a normal fashion.

Plume rise in most USEPA models is calculated using the Briggs' plume rise equations. In a recent phone call I had with Gary Briggs of USEPA, he stated that if the volume flow of the stack was not changed, the buoyancy flux in his plume rise equation would be accurately calculated. In order to accomplish this, while keeping the momentum plume rise to a minimum, I was considering the following methodology:

1) Set the stack exit velocity to 0.1 m/s,
2) Input an adjusted stack diameter (ds') that will keep the volume flow unchanged using the equation:

$ds' = 3.16\ ds(Vs)^{1/2}$, where ds = original stack diameter
Vs = original exit stack velocity

Derivation of this equation is provided in the enclosure.

Using the revised stack diameter and exit velocity, the parameter which determines whether the momuntum or buoyancy plume rise equations are used (the crossover temperature) becomes much smaller. As a result, it will be much more likely that the difference between the stack gas exit temperature and the ambient temperature will exceed the crossover temperature. This results in the model using the buoyant plume rise equations instead of the momentum rise equations, a result that would seem appropriate.

Adjusting the stack diameter and exit velocity as proposed will cause the model to calculate an unrealistically large stack-tip downwash. As is common with these type stacks, all sources in question are all subject to building downwash. Based on statements made in Sections 1.1.4 and 1.1.4.10.1 of the *User's Guide for the Industrial Source Complex (ISC2) Dispersion Model - Volume II*, it would appear stack-tip downwash is not used when ISC2 is calculating plume rise in building downwash situations. I ran one quick test case with ISCST2 which confirmed this fact. In situations where there are no building downwash effects on the plume the stack-tip downwash option should not be used.

Please review the above procedure with the EPA Modeling Clearinghouse and let the BAQEv know if its use is appropriate for modeling of the Cookson Pigments facility with the ISC and SCREEN models.

If there are questions I can be contacted at (609)633-2675. Thank you for your assistance.

Sincerely,

Alan Dresser
Research Scientist I
Bureau of Air Quality Evaluation

Enclosure

c: Joann Held (BAQEv)
Rob Wilson (EPA Region 10)

Buoyancy Plume Rise for Stacks With Horizontal Releases or Weather Caps

Set stack exit velocity = 0.1 m/s

Calculate an adjusted stack diameter so that the volume flow (VF) from the stack is unchanged.

Adjusted stack diameter = ds',
Adjusted stack exit velocity = Vs' = 0.1 m/s

Note: $VF = Vs \times \text{area of stack} = Vs \times (\pi/4)(ds)^2$

$$VF = Vs' \times (\pi/4)(ds')^2 = 0.1 \text{ m/s} \times (\pi/4)(ds')^2$$

$$ds' = [(4/\pi) \times (VF/0.1)]^{1/2} = [12.73(VF)]^{1/2}$$

Replace VF with actual stack parameters (Vs, ds)

$$ds' = [12.73(Vs \times (\pi/4)(ds)^2]^{1/2}$$

$$ds' = 3.16\, ds(Vs)^{1/2}$$

Input to model:

stack diameter = ds'
stack exit velocity = 0.1 m/s

If use of an adjusted stack exit velocity (Vs') other than 0.1 m/s is more appropriate, the equation becomes:

$$ds' = ds\ (Vs/Vs')^{1/2}$$