Final Exam 2001 CHE 467S
Environmental Engineering
Instructor D.W.Kirk

Marks
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1(a). Dose Response Prediction

What percentage of your plant workers would be at risk from exposure to a spill of methyl isocyanate?
A probit model for permanent health damage by methyl isocyanate is available from the literature $P_r = -0.64 + \ln C^{0.7}t$, where t is time in minutes C is concentration in ppm and P_r is the probit value. The time to evacuate the plant having 50 personnel is 10 minutes and the concentration is 50 ppm.

TABLE: Transformation of probit to percent affected

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33

%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

1 (b) Pollutant dispersion.

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Your company has been cited for exceeding Ontario air emission standards for NO_x. After analyzing the emission data it is clear that there were no upset conditions on the days that the OntarioMinistry of the Environment recorded the excess emission data.However, the excess emission data are found only on days with "F" type stability and when the wind is from the NW. You begin to suspect another emission source up wind is the real emission culprit.One such plant is 50 km from your company and is directly NW of your location. What would the emission rate of the other company need to be if your plant contributes 25µg/m^3 NO_x to the local emission reading?

Wind conditions during excess emissions are 2 m/s from NW Ambient Air Temperature is 10°C Air Quality Standards are: NO_x 100µg/m^3 and emission value recorded 150 µg/m^3

The USEPA dispersion model may be used for the calculation.

$$C(x,y,z) = \frac{Q}{2\pi v \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \cdot \left(\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right)$$

where C= concentration in kg/m^3 at position x,y,z
Q = source strength (kg/s)
v = average wind speed (m/s)
σ_y and σ_z are the y and z dispersion coefficients
y is the horizontal direction perpendicular to the wind direction
x is the wind direction
H is the height of the plume ie stack + plume rise (m) **(assume 50 m)**

Note: dispersion coefficients are provided on last page.

2. Chemical exposure and lifetime cancer risk

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Workers in your plant are manufacturing a chemical Mephosfolan using a solvent acrylonitrile . As an environmental engineer, you have been asked to investigate the risk of workers exposed in the manufacturing plant. You determine that in the packing section of the plant, there is a dust concentration of Mephosfolan of 25 mg/m^3 but the workers are all required to wear dust masks which are very effective in filtering these solids. In the manufacturing section of the plant Mephosfolan is found only as a dissolved species in the solvent and you note that Mesphosfolan has no vapour pressure. The solvent is detected in the air at a concentration of 8.1 µg/m^3. The workers are required to wear dust masks and in addition protective gloves to avoid solvent contact.

You also note that in the packing section all of the workers are female but in the production side the workers are male.

a) Determine the quantitative risks to the 2 groups of workers.

b) Explain the meaning of the respective risks (ie explain how the risks have been determined and how they should be interpreted.

c) What will you recommend to your boss?

Clearly indicate any assumptions made.

Chemical	Slope factor (mg/kg/day)$^{-1}$ inhalation	Slope factor (mg/kg/day)$^{-1}$ oral	RfD (mg/kg/day) oral
Acrylonitrile chronic(human) lung	(B1) 2.4×10^{-1}	(B1) 5.4×10^{-1}	
Mephosfolan subchronic (rat) liver			9×10^{-4}

Data:
avg. body weight (BW)= 70 kg males, 60 kg females
breathing rate = 0.83 m^3/h
skin exposure 0.388 m^2 males, 0.338 m^2 female
dermal permeability = 8×10^{-4} m/h
retention of contaminant 100%
days at plant per year = 220
time at plant = 8h/day
working life time (ED) = 30y
averaging time for cancer (AT) = 70y (=25,500d)

EPA model. Chronic daily intake (CDI) = $\frac{C(mg/m^3) * CR\ (m^3/d) * EF(d/y) * ED(y)}{BW(kg) * AT\ (d)}$

where CR is contact rate, EF is frequency, ED is exposure duration.

3. Critical Analysis

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Carefully read the following article.

a) Identify 6 environmental issues introduced in this article.

b) Of the issues identified, which ones might be described as "red herrings" ie not directly linked to the Kyoto agreement?

c) Briefly describe the Kyoto agreement

d) List 5 benefits claimed to depend on the Kyoto Agreement

e) List 5 negative impacts associated with the Kyoto Agreement

f) What tools or techniques is the author using to promote his perspective on this issue?

Canada must say no to Bush on Kyoto (T.S. Apr. 5 2001)

"Bush has already said he opposes stringent environmental regulations during the current economic downturn and energy crisis. Breaking a campaign promise, he also recently announced he would not require power plants to reduce emissions of carbon dioxide, the same carbon dioxide often ending up in central and eastern Canada. Although this America First approach might appeal to U.S. business groups, many of whom generously backed Bush's electoral campaign, it has extremely serious implications for ordinary people, especially in this country where the fallout from U.S. environmental practices is felt on a day to day basis as witnessed by the growing frequency of degraded air quality, lakes and rivers adversely affected by U.S.-origin toxic substances. (Even the breast milk of Inuit mothers in Canada's remote northern regions is now contaminated by long-range pollutants)...
As Britain's environment Minister put it succinctly, "The U.S. must be brought to its senses." "

author: Harry Sterling, former diplomat is an Ottawa based commentator

4.Energy system analysis

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You have been assigned to analyze 2 options for the power supply for a plant expansion.
The electrical and thermal energy required for the plant expansion is to be provided on site by cogeneration. Option 1 will purchase diesel engines to turn electical generators. The exhaust gas will be taken through a waste heat recovery boiler fired by additional supplemental oil if necessary.
Option 2 will purchase 1 natural gas fired turbine generator. The offgas will be taken through a waste heat recovery boiler fired by additional supplemental natural gas or electrical resistance heating if necessary.
Note: the electrical needs must be provided.

a)Provide a sketch of the 2 systems with % efficiencies and energy input and output values.

b)What is the input energy usage for the 2 systems

c)What is the CO_2 output for both systems

d)What is the NO_x output for both systems.

Data:
The plant requires 4,000 kW electrical energy and 120 GJ/h steam.

Diesel Engine efficiency = 37% (Fuel value to electricity)
each unit rated at 500 HP (output)
Emissions: 70,690 kg_{CO_2}/TJ
161 kg_{NO_x}/TJ

Gas turbine efficiency = 28% (Fuel value to electricity)
Smallest turbine available produces 6MW with 42 ppm NO_x after water injection.
Emissions: 49,680 kg_{CO_2}/TJ
59 kg_{NO_x}/TJ

Waste heat boilers operate at 85% efficiency (heat to useful steam)
Emissions: 70,690 kg_{CO_2}/TJ Diesel; 49680 kg_{CO_2}/TJ Natural Gas
161 kg_{NO_x}/TJ Diesel; 59 kg_{NO_x}/TJ Natural Gas

Conversions:
1 H.P. = 745.7 W
1W = 1J/s

1kWh will produce 3.6MJ via electrical resistive heating

$M = 10^6$
$G = 10^9$
$T = 10^{12}$

5. Legislation

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a) Briefly describe 2 different voluntary programs for industry relating to environmental protection.

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b) Briefly describe 2 different pieces of governmental environmental legislation, one at the federal level and one at the provincial level.

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c) List 5 factors that make the voluntary programs effective

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d) List 5 factors that are detrimental features of governmental legislation.

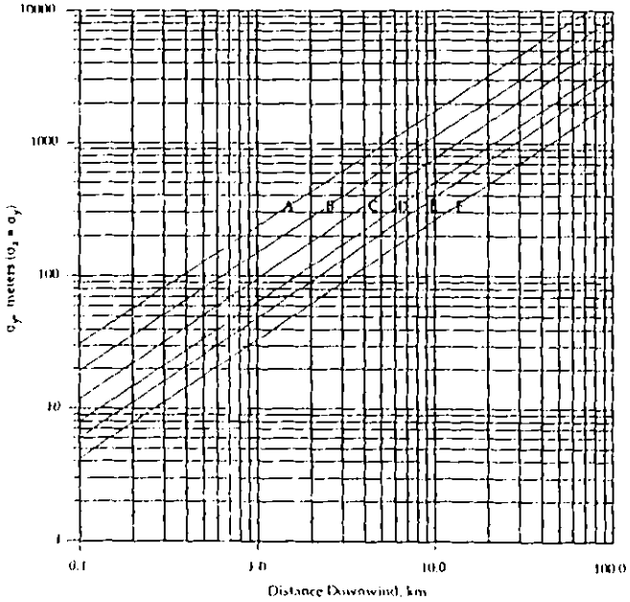

FIGURE 6.4 Horizontal dispersion coefficients for Pasquill-Gifford plume model.
Source: Turner, D.B., Workbook of Atmospheric Dispersion Estimates (Cincinnati, OH: U.S. Department of Health, Education, and Welfare, 1970).

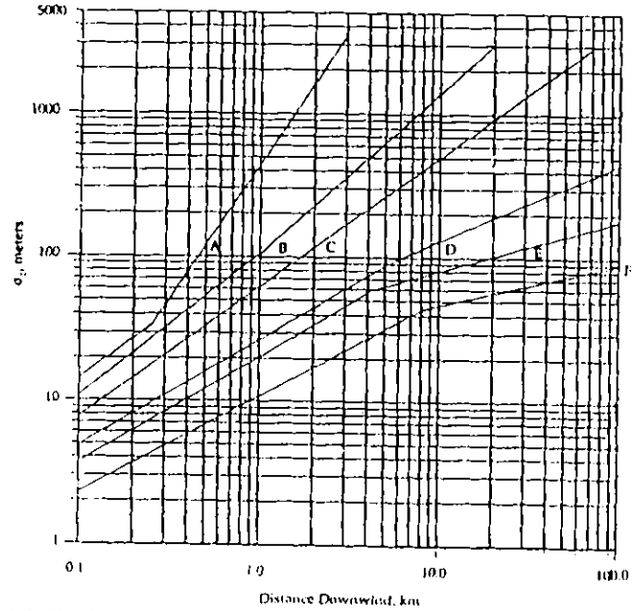

FIGURE 6.5 Vertical dispersion coefficients for Pasquill-Gifford plume model.
Source: Turner, D.B., Workbook of Atmospheric Dispersion Estimates (Cincinnati, OH: U.S. Department of Health, Education, and Welfare, 1970).