Comment On"The Change of Concentration Standard Deviations with Distance"

Delance O. Martin

portant in keeping with the need to reduce costs and energy requirements associated with particulate control equipment design and operation. Use of cascade impactors has become quite common as a sampling method for separating particles into various size fractions based on their physical size, shape, and density. The size of the particles which exist in a given fraction is stated in terms of a cut diameter which must either be obtained from calibration curves or calculated from basic equations. Existing calibration curves are of limited value since cut diameters must be obtained from curves which are valid for only a limited temperature range and for sampling pressures near atmospheric conditions. In addition, the calibration curves must all be corrected for particle density, if it is desired to calculate an actual physical diameter as opposed to an aerodynamic diameter. To calculate cut diameters by hand requires a knowledge of the working equations and at best is tedious, involving trial and error calculations. Centralized computer facilities elimi-

nate the tedious aspect but require keypunching of data and one to three days turnaround time to obtain results. By incorporating impaction equations into a programmable tape (Program 9, Table I) it is possible to determine particle cut diameters while in the field within minutes after an impactor sample has been obtained. While time may not necessarily be of the essence in obtaining particle size data, the cost savings associated with reduced man-hour requirements remains an important consideration.

Rapid Stack Sampling Test Results

The preprogrammed tapes described above along with three others (Programs 3, 4, and 10) summarized in Table I make it possible to reduce the data for a single stack test for particulate matter in about 15 to 20 min. Of equal significance is the fact that the data reduction can be done *on site* within minutes after the analytical data become available. This capability means stack sampling consultants can not only provide clients with faster

service at less cost per stack test but also, by providing for optimization of field operating conditions through quick access to stack test results, reduce the clients' costs for an overall source or control equipment evaluation program. In addition, the preprogrammed tapes make it possible for persons with limited knowledge of stack sampling calculations to reduce test data by following sample instructions for entering designated raw data into the calculator. This capability provides those responsible for reviewing source sampling reports a quick and accurate method for verifying results.

References

1. W. K. Weddendorf, "A computer program for processing stack sampling data," *J. Air Poll. Control Assoc.*, 25: (1975).
2. R. L. Byers, "Determination of Source Sampling Requirements By Means of a Programmable Field Calculator," APCA East Central Section Meeting, September, 1975.
3. *Federal Register*, 36, (237): 24890 (Dec 23, 1971).

Comment on

"The Change of Concentration Standard Deviations with Distance"

Delance O. Martin
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In the note "The Change of Concentration Standard Deviations with Distance,"[1] it appears that the author may not be aware of the algorithm employed in the AQDM and IPP models for obtaining σ_z. A similar procedure was devised by me for obtaining σ_y, but not published since it was not used in the models upon which the AQDM and IPP models were developed.[2]

The basic equations are:

$$\sigma_y = aX^b \qquad \sigma_z = cX^d + f$$

where a, c, d, and f are stability-de-

pendent constants, b is a constant of value 0.894, and c, d, and f assume different values for $X \leqslant$ and $X \geqslant 1$ km (X expressed in km).

Values for these constants were obtained by trial a number of years ago when small programmable calculators were not available (Table I). However

> Mr. Martin, presently retired, was formerly employed by ESSA and assigned to USDHEW, and by Kentucky Air Pollution Control Commission.

the two approaches (McMullen's and mine) give very similar (often identical) results (Table II), and both have the virtue of eliminating errors in reading values of σ_y and σ_z from the graphs (Figs. 3-2 and 3-3, pp. 8, 9, Turner[3]).

A comment on σ_y: My own reading of earlier literature (upon which Turner based his work) suggested that a log–log plot of σ_y should be a straight line, not the slight curve which appears in Turner's workbook. Thus my omission of a constant added term in the equation for σ_y, and a suggestion

Table I. Values of a, c, d, and f for σ_y and σ_z as a function of downwind distance, for six stability conditions.

Stability Condition	a	X ≤ 1 km c	d	f	X ≥ 1 km c	d	f
A[a]	213	440.8	1.941	9.27	459.7	2.094	−9.6
B	156	106.6	1.149	3.3	108.2	1.098	2.0
C	104	61.	.911	0	61.	.911	0
D	68	33.2	.725	−1.7	44.5	.516	−13.0
E	50.5	22.8	.678	−1.3	55.4	.305	−34.0
F	34	14.35	.740	−0.35	62.6	.180	−48.6

[a] As defined in Table 3-1, p. 6, Turner.[3]

that K in McMullen's Table I should be zero (with slight adjustments of I and J).

I suggest that a choice between the two approaches could well be based on the relative efficiency of the calculator or computer used as applied to the equations. However, where limited mixing must be dealt with my equation gives a unique value for X_1 (the distance at which limited mixing becomes a significant factor {where $\sigma_z = 0.47$ L }) and McMullen's requires a choice between two values (roots of a quadratic equation).

References

1. R. W. McMullen, "The change of concentration standard deviations with distance," *J. Air Poll. Control Assoc.* **25**: 1057 (1975).
2. D. O. Martin, "An urban diffusion model for estimating long term averages of air quality," *J. Air Poll. Control Assoc.* **21**: 16 (1971).
3. D. B. Turner, *Workbook of Atmospheric Dispersion Estimates*, U.S. Department of Health, Education and Welfare, Rev. 1969.

Table II. Comparison at various distances of σ_y and σ_z as obtained from (a) Turner, (b) McMullen's equations, (c) Martin's equations.

Dist.	A a	A b	A c	B a	B b	B c	C a	C b	C c	D a	D b	D c	E a	E b	E c	F a	F b	F c
								σ_y										
.1	27	27	27	19	19	20	13	12	13	8	8	9	6	6	6	4	4	4
.3	72	72	73	52	52	53	34	34	35	22	22	23	16	16	17	11	11	12
.5	115	115	115	83	84	84	56	55	56	36	36	37	26	27	27	18	18	18
1.0	215	212	213	155	157	156	105	105	104	68	69	68	51	51	51	34	34	34
2.0	390	390	396	295	293	290	200	197	193	130	130	126	96	95	94	64	64	63
4.0	a			550	539	539	370	368	359	245	243	235	180	179	174	120	121	117
10.0				1190	1194	1222	840	833	815	550	549	533	420	408	396	275	273	266
20.0				2150	2154	2271	1540	1530	1514	1000	1007	990	760	755	735	500	503	495
40.0							2800	2792	2814	1830	1833	1840	1380	1390	1366	940	920	920
100.0										4100	3993	4174	3000	3081	3099	2000	2023	2087
								σ_z										
.1	14	14	14	11	10	11	7	7	8	5	5	5	4	4	4	2	2	2
.3	49	49	52	31	31	30	20	20	20	12	12	12	9	9	9	6	6	6
.5	105	111	124	51	53	51	32	32	32	18	18	18	13	13	13	9	9	8
1.0	455	418	450	110	109	110	61	61	61	32	30	32	21	21	22	14	14	14
2.0	1950	2060	1953	230	230	234	115	115	115	50	50	51	34	33	34	22	21	22
4.0	a			500	490	498	220	217	216	77	79	78	49	50	51	31	31	32
10.0				1350	1358	1358	510	502	497	135	140	133	79	80	78	46	47	46
20.0				2900	2982	2904	950	942	934	205	208	198	110	109	104	60	61	59
40.0							1800	1767	1757	290	300	286	145	141	137	74	74	73
100.0										455	463	466	185	187	192	93	90	95

[a] Values not calculated since they run off the top of Turner's graphs.

Author's Reply

Robert McMullen

I was aware in a general way that algorithms were routinely used for the standard deviation values for the Gaussian plume model in computer applications, but I was not aware of the specific algorithms cited by Mr. Martin.

He is correct in suggesting that the choice should be based on the relative efficiency of the calculator or computer to be used. In my case, I was faced with the problem of developing a calculator program which would calculate plume rise according to Briggs[1] and ground level concentrations in accordance with Turner.[2] I was constrained to 1024 program steps (each digit of a constant uses one step) and 64 data registers. Economical use of this capacity required that I use a single function for both σ_y and σ_z, without a breakdown for different distances from the source. Accordingly, I used the function shown in my note

which required 36 data registers for the constants. This was a barely manageable number; Mr. Martin's 43 constants would not have been.

References

1. G. A. Briggs, *Plume Rise*, U. S. Atomic Energy Commission, 1969.

2. D. B. Turner, *Workbook of Atmospheric Dispersion Estimates*, U. S. Department of Health, Education and Welfare, Rev. 1969.

Carbon Monoxide Exposures of Boston Bicyclists

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Bicycle path planning and construction has been proposed as a strategy to reduce vehicle miles traveled for several transportation control plans. Prior to development of urban bicycle paths, the carbon monoxide (CO) exposure of individuals using them should be assessed. In Boston, as in many urban areas, the automobile is responsible for well over 90% of all CO emissions.[1]

The extent of CO impairment to oxygen transport is dependent upon the CO concentration in inhaled air, the length of exposure, and the ventilation rate. Equilibrium between CO uptake and elimination at a fixed exposure will be reached more rapidly during physical exercise.[2] Thus, personal exposures to urban CO are of significant importance to bicyclists exercising and commuting in our cities. Further, CO provides an index of exposure to other motor vehicle related pollutants, such as asbestos[3] and lead.[4]

Much attention has been focused on design, locational, and recreational aspects of bicycle paths. Quantitative CO exposure of bicyclists has often been neglected as a planning criterion. In order to gain experience with cyclists' exposure to CO and to determine the important parameters gov-

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erning these exposures, a bicycle instrumented with a portable CO monitor and recorder was ridden over 200 mi of metropolitan Boston streets during the summer of 1974.

The instrument, a series 2000, dual range (0–50 ppm, 0–100 ppm) Ecolyzer, was zeroed and calibrated twice daily with a CO standard of 36 ppm. Instrument drift was always less than 1 ppm between semi-daily calibrations.

Routes commonly used by bicyclists were selected for the study. The time and distance of various trips ranged from 10 min to 45 min. Parallel alternative backroutes were monitored for a CO exposure comparison. Sixty-two different routes were monitored during a total of 176 test runs. The overall average CO concentration for all routes and all times was 12.6 ppm (s.d. 4.8). Further the CO concentrations were t-tested significantly (0.005) higher during rush hours (7–9:30 A.M., 3–5:30 P.M.) than non-rush hours. Al-