

Regulatory Docket 148
NUCLEAR METALS INC.

Applicant.....
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 Amount/Date 440.50.....
 Type of Payment Amendment.....
 Date Check Paid 12/4/79.....
 Received By: [Signature]

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November 5, 1979

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United States Nuclear Regulatory Commission
 Division of Materials Licensing
 Washington, D. C. 20555

Subject: License Amendment Application
 References: License SMB-179
 Docket 40-672

RECEIVED BY LFM:B
 Date NOV 16 1979
 Log. NOV P&B Amend.
 By: P&BWM
 Orig. To.....
 Action Cont. 12/4/79

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Gentlemen:

We have performed our annual review of our current license and stemming from this review we are requesting the incorporation of certain amendments to the license. These amendments are intended to incorporate two reports from our consultants extending our evaluations of effluent air as regards the degree of conservatism inherent in the method of sampling the air and the extent of dilution of the plume to demonstrate compliance with 10CFR 20.106:

Attachment 1 to this letter defines the degree of conservatism in the sampling of effluent air, and Attachment 2 defines the dilution of the effluent plume.

We have been encouraged by Region 1, Inspection and Enforcement, to make this submittal of information so that the license will be a more definitive document.

XA Copy Has Been Sent to PDR,

Sincerely,

[Signature]
 Aiden R. Gilman,
 Radiation Safety Officer

8001020309
 XA

ARG:dg
 Enclosures

A-30

A22

FREDERICK J. VILES, JR.
ENVIRONMENTAL HEALTH CONSULTANT
81 BRUCE ROAD
NORWOOD, MASS. 02062

ATTACHMENT 1

October 16, 1978

Mr. Herbert Sawyer
Nuclear Metals, Inc.
2229 Main Street
Concord, Massachusetts 01742

Dear Mr. Sawyer:

At your request, I am submitting the following discussion on duct sampling of particulates at non-isokinetic conditions. I have also included estimates of the errors that may be anticipated for various ranges of sampling and duct air flow velocities, particle diameters and particle densities.

The concept of isokinetic and non-isokinetic sampling is presented in the attached Figure 1. When the air (or gas) velocity entering the sampling probe is identical to that of the surrounding air stream (Fig. 1a), no deviations of the streamlines occur; and, assuming uniform mixing of contaminants, representative sampling is obtained. When the sampling velocity is lower than the surrounding velocity in the duct (Fig. 1b), some of the air will be deflected around the probe inlet; but some of the particulates associated with this deflected air, because of their inertia, will enter the probe resulting in a collection of particles greater than that associated with the air sampled (sampled concentration too high). Conversely, if the sampling velocity is greater than the duct velocity (Fig. 1c), some of the particles associated with the air sampled will miss the probe inlet because of their inertia causing a reduction in the collection of the particles associated with the sampled air (sampled concentration too low).

Davies⁽¹⁾ has suggested the following equation for estimating the sampling error for non-isokinetic sampling conditions when using a sharp-edged or very thin-walled tube for the probe inlet:

$$\frac{C_s}{C_a} = \frac{V_a}{V_s} - \frac{V_a/V_s - 1}{(4V + 1)}$$

(1) Davies, C.N., Dust is Dangerous, p. 21, Faber, London (1954).

Where C_s = concentration of particles in sampled air.

C_a = concentration of particles in duct air.

V_a = velocity of air in duct.

V_s = velocity of air in probe inlet.

ψ = inertial impaction parameter (dimensionless).

$\psi = d^2 C_p V_a / 18 \mu D$.

Where d = diameter of particle.

C = Cunningham (slip) correction factor.

p = density of particle minus density of gas*.

μ = viscosity of gas.

D = diameter of probe inlet.

Calculations were made, using this equation, to estimate the errors that may occur in the stack (and duct) sampling program at Nuclear Metals, Inc..

According to Mr. R. Francis of Nuclear Metals, Inc., the probe inlet diameter is 0.178 inches or 0.452 cm., and is the value used for D in these calculations.

The particulates involved are uranium and its compounds such as oxides which could offer a wide range of densities particularly if these particles are present in oil or water particulates. Elemental uranium has a density of 19, and its oxides have a density range of 7.3 to 11. The oxides would be more representative of fume from burning uranium (burning chips from machining) which is often produced from some Nuclear Metals operations. For these calculations, a density of 10 gms/cc has been assumed; but some calculations have been made for densities of 2 and also 19 gms/cc to demonstrate the effect of particle density on non-isokinetic sampling errors.

Sampling rates at Nuclear Metals, Inc. have varied in the past from 0.5 to 4.6 L/min. (liters per minute). The sampling flows (L/min.) and corresponding probe inlet velocities (ft./min.) used in these calculations are noted in the following Table I:

* Density of air omitted -- error negligible.

Table I
Probe Inlet Flows and Velocities*

<u>Q (L/min.)</u>	<u>V_s (ft./min.)</u>	<u>Q (L/min.)</u>	<u>V_s (ft./min.)</u>
0.5	102	4.0	818
1.0	204	6.0	1227
2.0	409		

Since there are numerous exhaust ventilation systems operating at many different velocities at Nuclear Metals, Inc., calculations were made at the selected duct air velocities of 1000, 2000, 3000 and 4000 ft./min. with the data plotted to permit estimation of sampling errors at other duct air velocities.

Particle sizes selected for these calculations were 1.0, 5.0 and 0.1 μm (micrometers, microns) which have Cunningham Correction Factors (C) of 1.149, 1.015 and 2.64, respectively (0° C. slightly higher at 20° C.). For air viscosity, a value of $.0185 \times 10^{-2}$ poises (25° C.) was used.

An estimate of the ratios of sampled to duct air concentrations (C_s/C_a), according to Davies' equation, for 1 micrometer particles of 10 gms/cc density is presented in Figure 2. Also included are data for particle densities of 2 and 19 gms/cc. It is noted that low sampling velocities in high velocity air streams result in gross over-collection of particulates even for small (airborne) 1 μm particles. For example, a 102 ft./min. (0.5 L/min.) sampling velocity in a 2000 ft./min. air stream would produce an estimated particle ($p = 10$) concentration 5.2 times that in the duct air. Obviously, such low sampling velocities should not be used if more reasonable sampling errors are desired. Even the more acceptable 2 liters per minute sampling rate ($V = 409$ ft./min.) which was proposed initially for this duct sampling program produces a high excess concentration error. In this case, the ratio of sampled to actual duct concentration would be 1.9 for a 2000 ft./min. stream velocity and 4.4 for 4000 ft./min.. It should be observed, however, that for nominal dust ($p = 2$) this ratio is 2 for a 4000 ft./min. duct velocity and as high as 5.7 for uranium metal particulates ($p = 19$). Obviously, high density particulates have a marked effect on the magnitude of the error caused by non-isokinetic sampling.

For particles larger than 1 μm , this error due to below isokinetic sampling can be considerably greater than that for 1 μm particles. This is demonstrated in Figure 3 which presents data for particles of

*Based on probe inlet diameter of 0.178 in. (0.452 cm).

5 μ m diameter. For a sampling velocity of 102 ft./min. in a 2000 ft./min. air stream, the estimated C_s/C_a ratio would be 17.4 and in a 4000 ft./min. stream 36.5. It should be noted, however, that exhaust systems with air cleaners, particularly those with efficient filters, would not be expected to have any significant numbers of this size (or larger) particles; and for such systems, the problem of highly inaccurate sample results because of these larger particles would not be expected to add to the sampling error drastically. Exhaust systems without air cleaners (or with inefficient units) would involve very large sampling errors if the sampling and duct velocities are markedly different.

It is interesting to note that even for fume particulates extremely low sampling velocities in high velocity streams can produce concentration results noticeably higher than that of the air stream. This is demonstrated in Figure 4 which presents data for 0.1 μ m particles ($\rho = 10.0$ gms/cc). For a low sampling velocity of 102 ft./min. (0.5 L/min.), estimated C_s/C_a ratios of 1.03, 1.13, 1.30 and 1.55 would result for duct air velocities of 1000, 2000, 3000 and 4000 ft./min., respectively. However, when the ratio between stream and sample velocities is no greater than 5 (or no less than 1/5), sampling errors would be negligible for this size particle.

The accuracy of Davies' equation may be questioned, since it is offered as an estimate for determining the ratio of the sampled and actual duct particle concentrations. It is obvious, however, that if the stream velocity is always greater than the probe inlet velocity, sampled results will be higher than those existing in the stream sampled. It is also evident that very low sample velocities relative to the stream velocity will provide sampled concentrations grossly greater than actual stream concentrations. It is strongly suggested, if not recommended, therefore, to increase probe inlet velocities to a value close to the minimum duct (or stack) air velocity of all the systems involved in this sampling program. This step will eliminate or at least minimize considerably gross over-estimates of actual duct or stack particulate concentrations.

Before undertaking this change, however, it must be remembered that excessive particulate loadings on the filter used to collect these samples may cause a significant reduction in sample flow rate during the period of sampling which will not result in a representative or true average of the concentration of particulates during the period of sampling. In order to avoid this problem, the volume of air sampled or the sampling rate for the period of sampling must be such that the flow rate is essentially the same (or reduced insignificantly) at the end of the sampling period. Experience has indicated that using the present filter collectors sampling rates less than 4 L/min. suffice for uniform sampling rates for the designated monthly sampling periods. To meet this limitation and yet provide more acceptable sampling probe velocities, it will be necessary to reduce the diameter of the sampling probe. It is suggested that the probe inlet be reduced

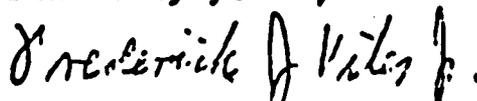
October 16, 1978

from the present 0.178 in. (0.452 cm.) to 1/8 in. (0.125 in. - 0.3175 cm.) and that a sampling rate of 3 l./min. be used. This will result in a sampling velocity of 1244 ft./min. which is, I believe, below any present duct or stack velocity. Calculations reveal that for this sampling velocity in a 4000 ft./min. stream the C_p/C_a ratios would be 3.10 and 1.97 for 5 and 1 μ m particles, respectively ($p = 10$).

It should be noted that the probe inlet diameter has a significant influence on the impaction parameter (Davies' equation); namely, the larger the diameter the smaller the impaction parameter. Smaller impaction parameters result in reduced sampling errors at non-isokinetic conditions. In order to use larger probe diameters, higher sampling rates will be necessary which will require larger sample collectors. If further reductions in non-isokinetic sampling errors are desirable, perhaps a change in sample collectors may be considered.

I shall be pleased to discuss this subject further at your convenience and assist in implimenting any revisions of your emissions sampling program that you may consider.

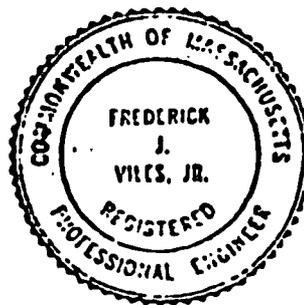
Sincerely yours,



Frederick J. Viles, Jr.

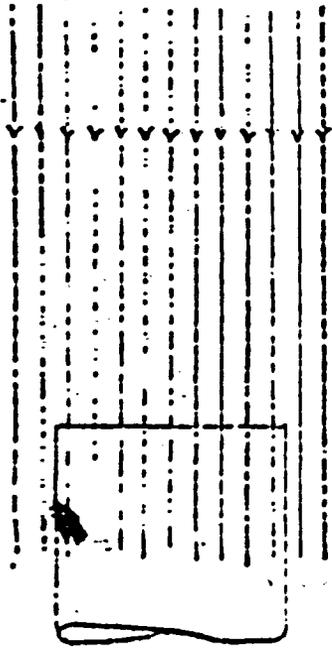
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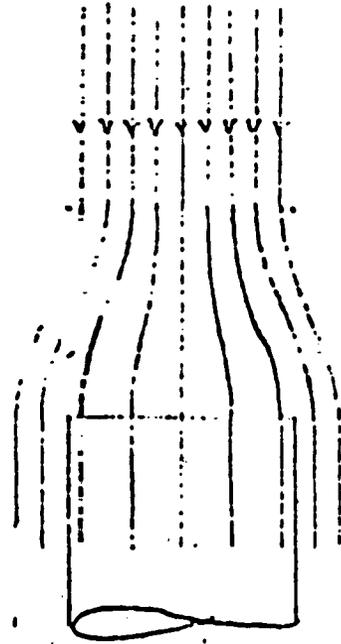


Air Streamlines at Sampling Probe Inlet

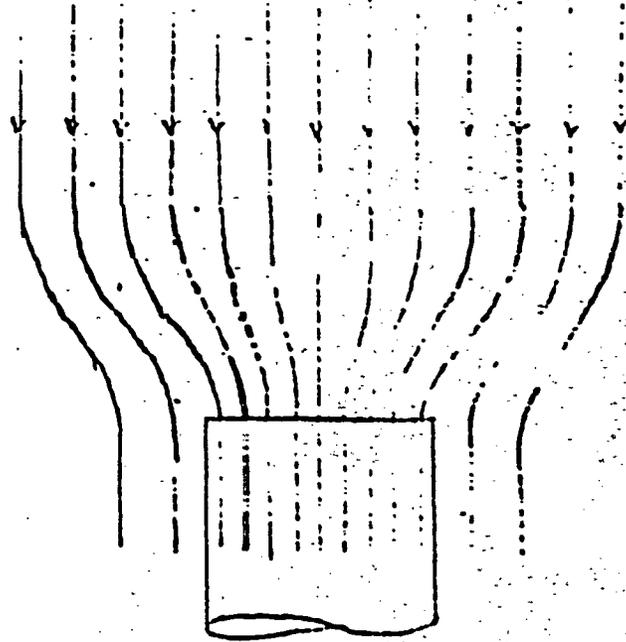
Fig. 1



a) Isokinetic Sampling



b) Sampling Velocity Too Low



c) Sampling Velocity Too High

Ratio of Sample Concentrations

to Duct Concentrations (C_s/C_d)

Sample Velocities 102, 104, 409, 818, 1227 Ft/min

Pipe Diameter 0.178 in (0.452 cm)

Particle d = 10 μm

Particle ρ = 1010 gms/cc

10

s/c_d

102 (P=19)

103

200

409 (P=2)

102 (P=2)

102

818

409 (P=2)

1227

Ratio of Sampled Concentrations
to Best Concentrations (Cs/Cr)

Sample Velocities 102, 204, 409, 818, 1227 FT/MIN.

Probe Diameter 0.178 IN. (0.452 cm)

Particle $d = 5.0 \mu m$
Particle $\rho = 10.5 g/cm^3$

102

102 (0.52)

204

409

409 (0.52)

818

1227

10

9

to Duct Concentrations (C_s/C_a)

Sample Velocities 102, 509, 218, 1327 Ft/min

Pipe Diameter 0.172 in. (4.52 mm)

Particle $\rho = 0.14$

Particle $\rho = 10.3$ ms/cc

10

S/C_a

02

409

ATTACHMENT 2

SEC, Inc.

J. D. Spengler, Ph.D., CCM

March 12, 1979

Nuclear Metals, Inc.
Concord, Mass.

Problem: To calculate the concentrations of radioactivity of depleted uranium discharges.

Purpose: To demonstrate that the monthly averaged concentrations in $\mu\text{C}/\text{ml}$ do not exceed NRC standards.

Approach: Calculate the concentration of depleted uranium in the wake cavity of the building for 4 wind directions.

Since the exit vents are on the roof of building C and the stack heights are small compared with the building height, emissions are assumed to be influenced by the aerodynamic flow over and around the building. It is a conservative approach to assume that all emissions are retained in the cavity. Wind flow over the sharp edges of the building cause flow separation. This occurs at the leading edge of a roof and corner and again at the lee edge of a building. These separated layers curve inward toward the wake axis, serving to enclose what is called a "cavity" or recirculated "bubble" immediately downwind of the building. The cavity zone is characterized by a low mean wind speed, high turbulence intensity, recirculation and relatively longer residence times of fluid particles "trapped" within the bubble (Fig. 1).

First, the physical dimensions of the cavity zone will be calculated. There is an empirical equation fitted to wind flow studies, for obstacles. For Nuclear Metals the building length for C & D is $\sim 500'$ where the height is $\sim 26'$. Width of A-B-C is $310'$. Width and length of Bldg. A are $80'$ by $225'$. The highest roof is $42'$ above grade (Bldg. A). Presently all emissions are from the roof of building C.

Where $L/H > 2$ the flow is considered to reattach along the roof and sides and then separate again at the trailing edge. Then:

$$\frac{x_r}{H} = \frac{1.75 (W/H)}{1.0 + 0.25 (W/H)}$$

where x_r is the horizontal extent of the wake cavity measured from the trailing edge of the building.

H is the height of the building

$$H_A = 42'; H_B = 26'; H_C = H_D = 26'.$$

W is the width of the building normal to the wind.

This formula is reported to fit field data to within 15% (1).

<u>Wind Normal to Building</u>	<u>W/H</u>	<u>X_r/H</u>	<u>X_r</u>	<u>Comment</u>
A	225/42	4	168 (51m)	Wake region influenced by A and retained behind Bldg. C
A-B-C	130/26	3.8	99 (30m)	Wake region behind D
D	150/26	2.9	75 (23m)	Wake region behind C primarily
45° } A-B-C	400/42	3.2	135 (41m)	Behind C-D

Next: The expected concentrations in the wake regions must be calculated. Briggs(2) gives a formula for approximating the concentration in the cavity region:

$$X = 4Q/(US^2)$$

where Q = source strength (gm/sec)
 U = wind speed (m/sec)
 S = distance from source along axis m.

From Vilos' letter of December 19, 1978, the highest monthly total emission rate was measured as 42 g/hr or 5.6×10^{-4} g/sec. Setting the monthly mean wind speed at 5mph (2.2 m/sec) is conservative.

Then the maximum concentration experienced in the wake regions along the axis over a hypothetical month persistent wind direction would be.

MAXIMUM MONTHLY MEAN CONCENTRATION IN WAKE REGION

Assume: 2g/hr avg monthly discharge
 5mph avg monthly windspeed
 Direction constant for month

<u>Distance (m)</u>	<u>X (g/m³)</u>	<u>X* (µc/ml)</u>
5	4×10^{-8}	1.4×10^{-11}
10	1×10^{-8}	3.6×10^{-12}
20	2.5×10^{-8}	9.0×10^{-13}
30	1.1×10^{-8}	4.1×10^{-13}
40	6.3×10^{-9}	2.3×10^{-13}
50	4.1×10^{-9}	1.5×10^{-13}

Beyond the wake region the concentrations decrease as the emissions are dispersed by the natural turbulence of the mean atmosphere.

For this hypothetical maximum month the concentrations are below the NRC standard of 9.4×10^{-12} $\mu\text{g}/\text{ml}$ everywhere beyond 20' from the building. There will be no violations of standards at property boundary.

Now consider the conservative assumptions of these calculations:

1. The average monthly emissions are 58% lower (.85g/hr not 2g/hr)
2. The wind speed and direction are highly variable. A persistent wind direction for an open area would not be expected more than 10% of the time. For Logan Airport a NW wind in January has a 10.1% frequency of occurrence. This is the maximum wind frequency for Logan. Frequencies of 5% are more typical for any wind direction.

If we now consider these more realistic conditions the monthly concentrations experienced close to the lee side of the buildings are more like 6×10^{-11} $\mu\text{c}/\text{ml}$. Even with a doubling of the emissions the concentrations will not violate the NRC standard of 9.4×10^{-12} $\mu\text{c}/\text{ml}$.

Conclusion

There will be no violations of the NRC monthly standard of 9.4×10^{-12} $\mu\text{g}/\text{ml}$ at ground level in the vicinity of Nuclear Metals' facilities in Concord, Mass. This conclusion is based on the emissions reported in F. G. Viles, Jr.'s letter of December 19, 1978 to Mr. Alden Gilman, Nuclear Metals, Inc., and the assumption that all emissions are trapped in the wake cavity behind the buildings. Allowing for some effluent to escape wake capture by virtue of stack discharge would lower the wake concentrations further.

It should be noted that without detailed physical descriptions of all vents and stacks as well as meteorological conditions, more accurate estimates of local concentrations cannot be done. The results of the conservative approach presented in this report indicates that more complex and expensive modeling is not warranted at this time.

References

1. Hosker, R. P., Jr. "Empirical Estimation of Wake Cavity Size Behind Block-Type Structure." 7th Symposium on Turbulence and Diffusion and Air Pollution, American Meteorological Society, Reno, Nevada, 1979.
2. Briggs, G. A. "Estimation of Down Wash Effects." In: Power Generation: Air Pollution Monitoring and Control (Ch. 6). Ann Arbor Sc., 1976.

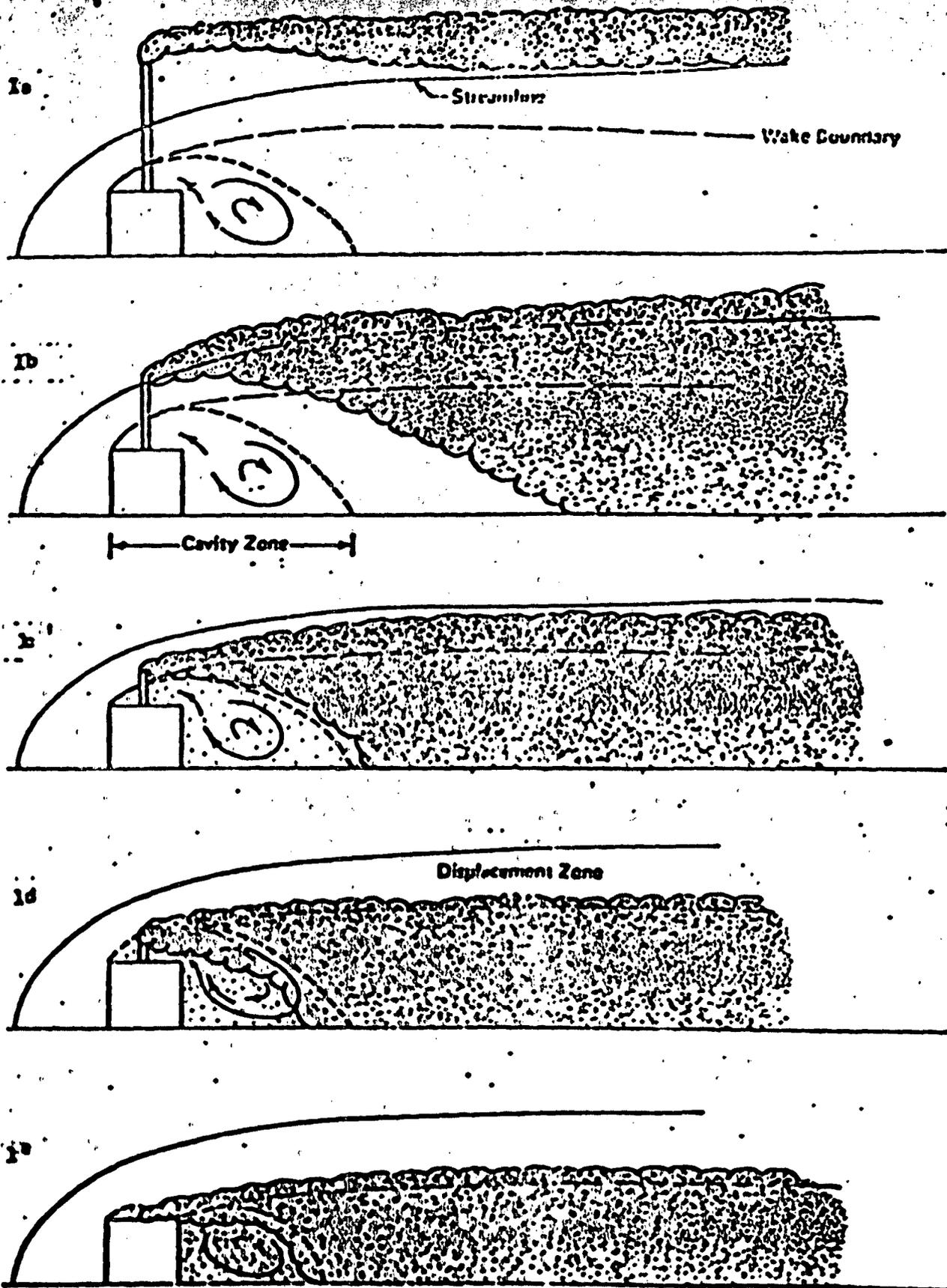


Figure 1. Observed Effects of Stack Height upon Plume Dispersion Patterns in Cuts of Buildings.