PLAINTIFF'S EXHIBIT

H&G-53

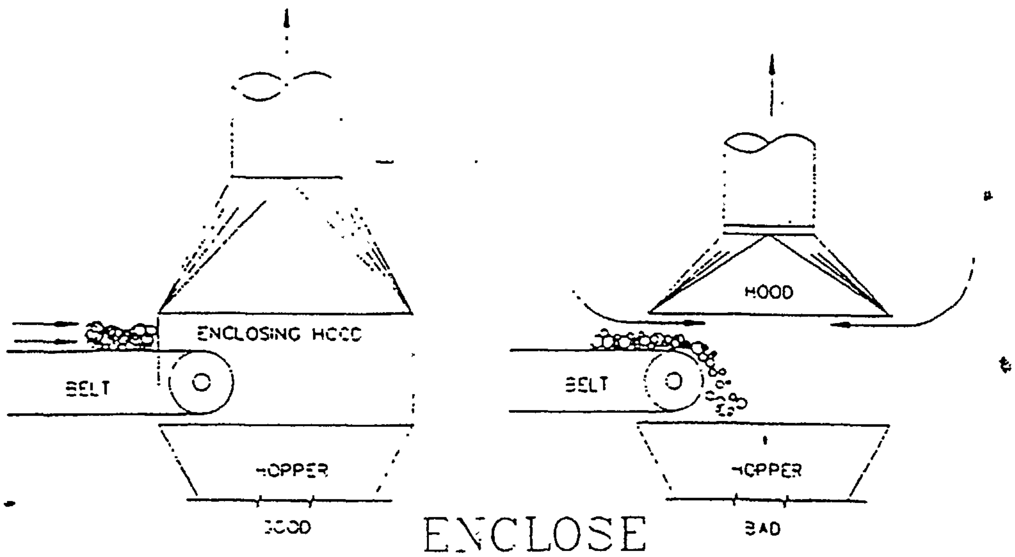
INDUSTRIAL VENTILATION

21st Edition

A Manual of Recommended Practice

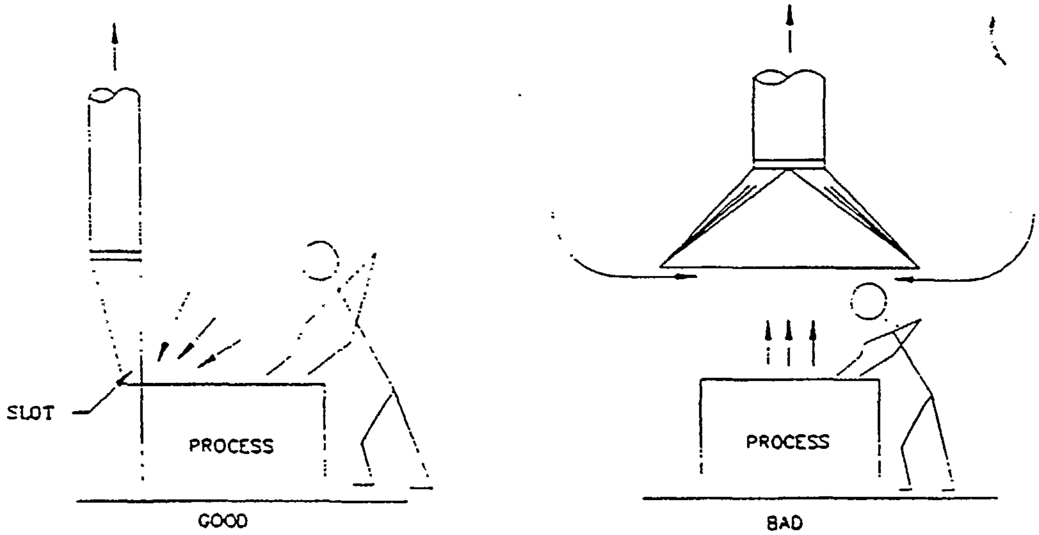
1992

Sales
American Conference of Governmental Industrial Hygienists
6500 Glenway Avenue, Bldg. D-7
Cincinnati, Ohio 45211 USA



ENCLOSE

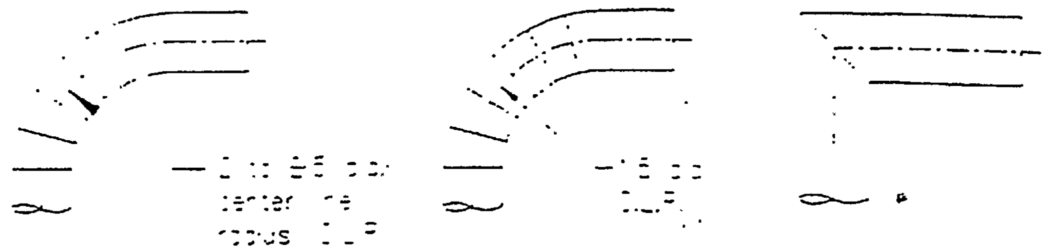
ENCLOSE THE OPERATION AS MUCH AS POSSIBLE. THE MORE COMPLETELY ENCLOSED THE SOURCE, THE LESS AIR REQUIRED FOR CONTROL



DIRECTION OF AIR FLOW

LOCATE THE HOOD SO THE CONTAMINANT IS REMOVED AWAY FROM THE BREATHING ZONE OF THE OPERATOR.

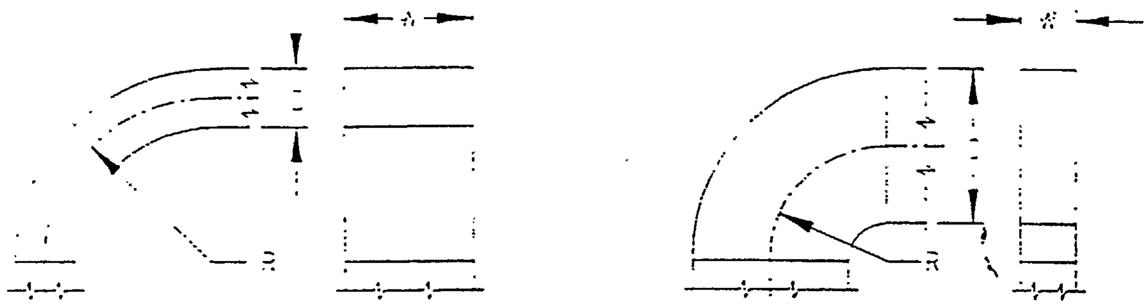
AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*ENCLOSURE AND OPERATOR/ EQUIPMENT INTERFACE*		
	DATE 1–88	FIGURE 3–3	



PREFERRED ACCEPTABLE AVOID

ELBOW RADIUS

Elbows should be 2 to 2.5 diameter centerline radius except where space does not permit. See Fig. 5-16 for loss factor.



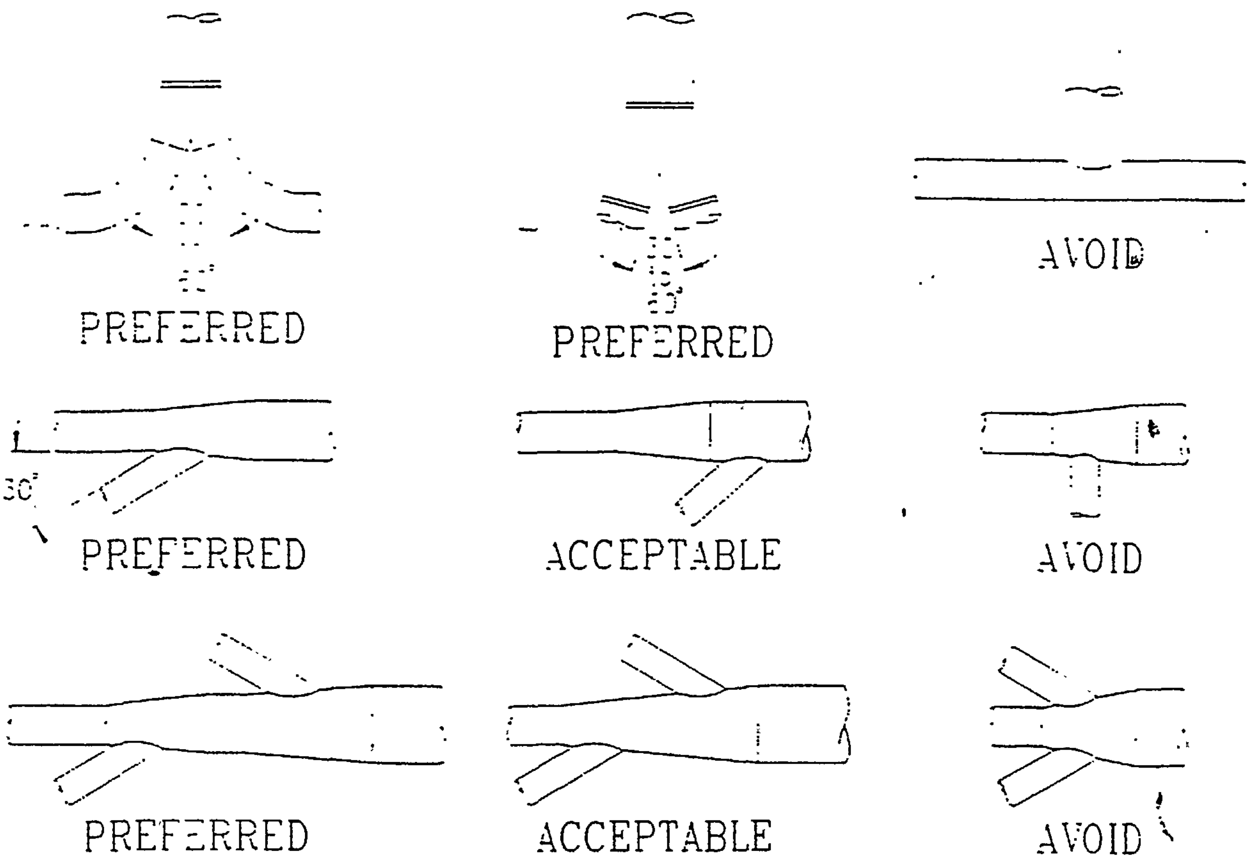
PREFERRED AVOID

ASPECT RATIO $(\frac{W}{D})$

Elbows should have $(\frac{W}{D})$ and $(\frac{R}{D})$ equal to or greater than 1. See Fig. 5-16 for loss factor.

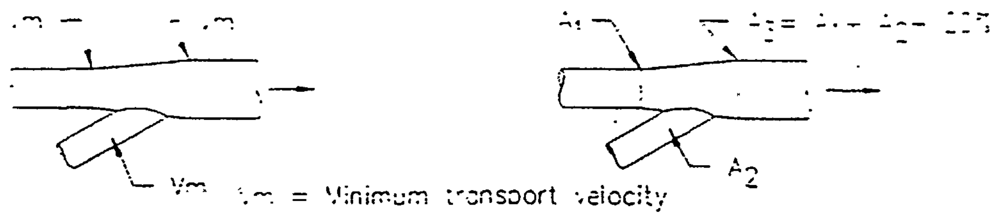
Note: Avoid mitre elbows. If necessary, use only with clean air and provide turning vanes. Consult mfg. for turning vane loss factor.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*PRINCIPLES OF DUCT DESIGN ELBOWS*
DATE 1-88	FIGURE 5-27



BRANCH ENTRY

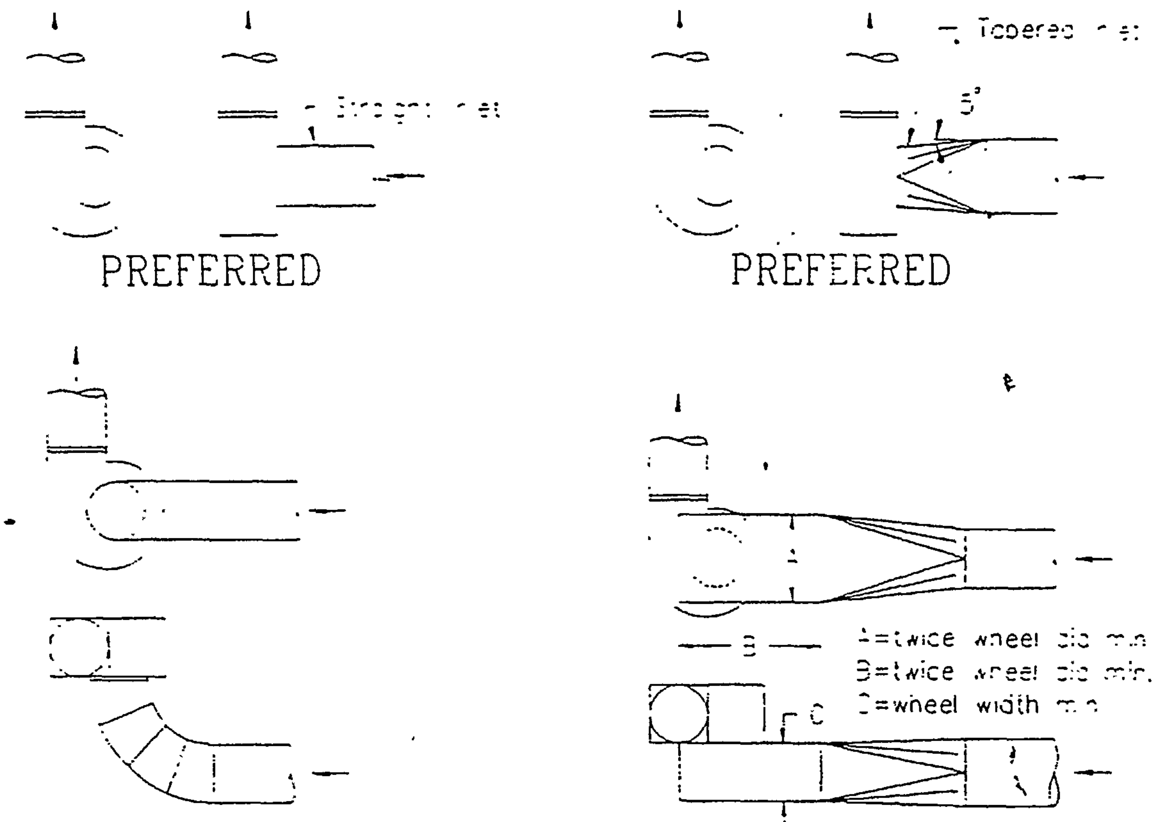
Branches should enter at gradual expansions and at an angle of 30° or less (preferred) to 45° if necessary. Expansion should be 15° maximum. See Fig. 5-17 for Loss Factor.



PROPER DUCT SIZE

Size the duct to maintain the selected or higher transport velocity.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*PRINCIPLES OF DUCT DESIGN BRANCH ENTRY*		
	DATE	*1-88*	FIGURE *5-28*

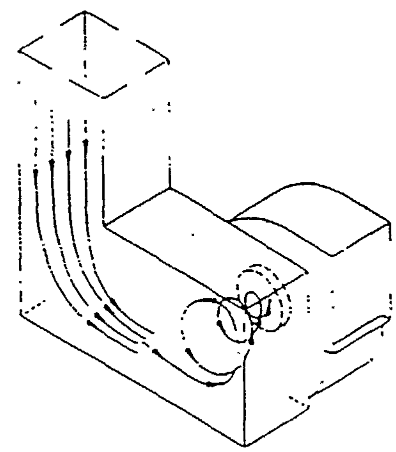


PREFERRED

PREFERRED

ACCEPTABLE
inlet elbow see note

ACCEPTABLE
inlet elbow see note



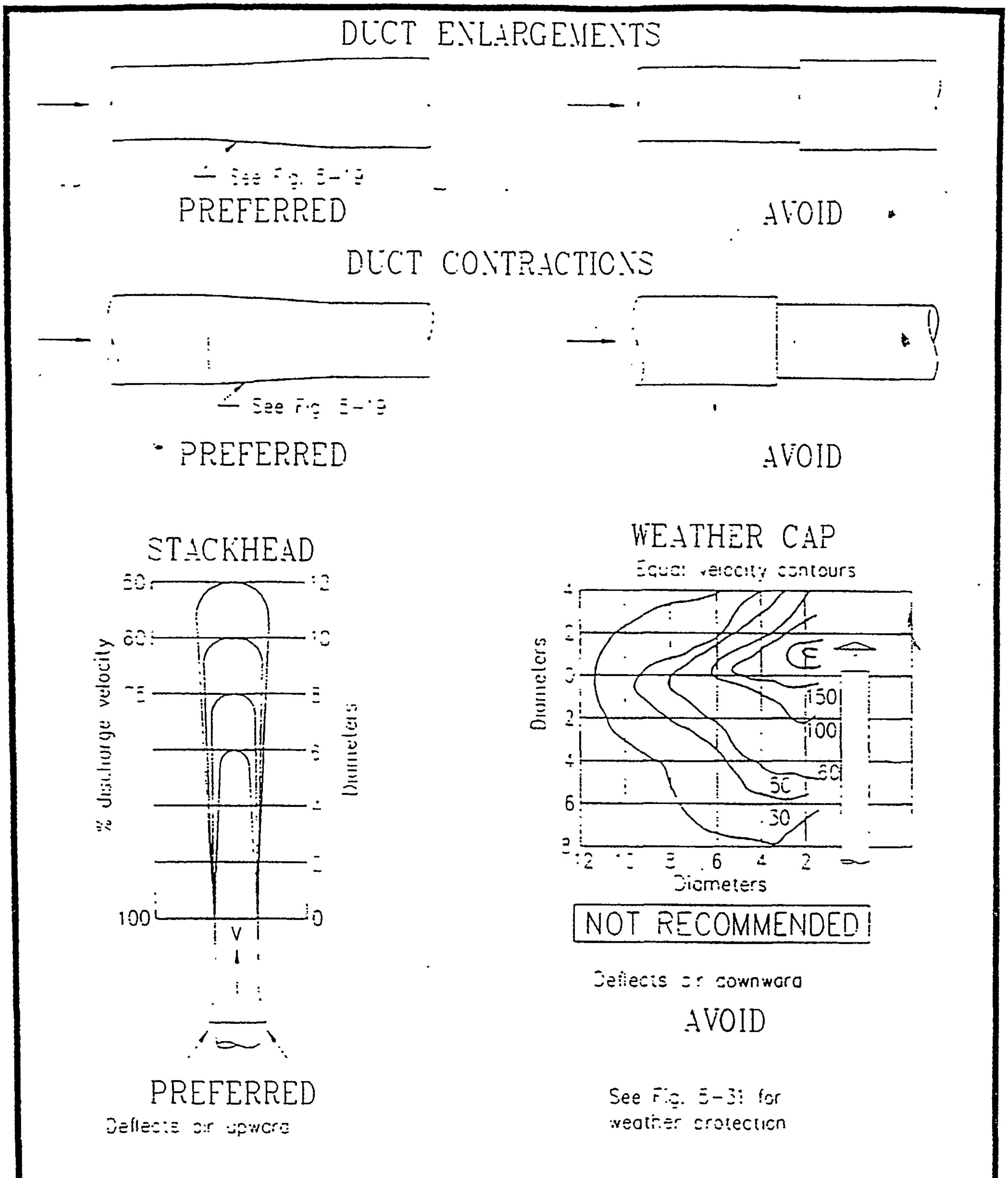
Note:
See Chapter 6 for system effect factors based on inlet and outlet duct arrangements.

Use duct turn vanes to eliminate air spin or uneven loading of fan wheel.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*PRINCIPLES OF DUCT DESIGN FAN INLETS*	
	DATE *1-88*	FIGURE *5-29*

HG-000060

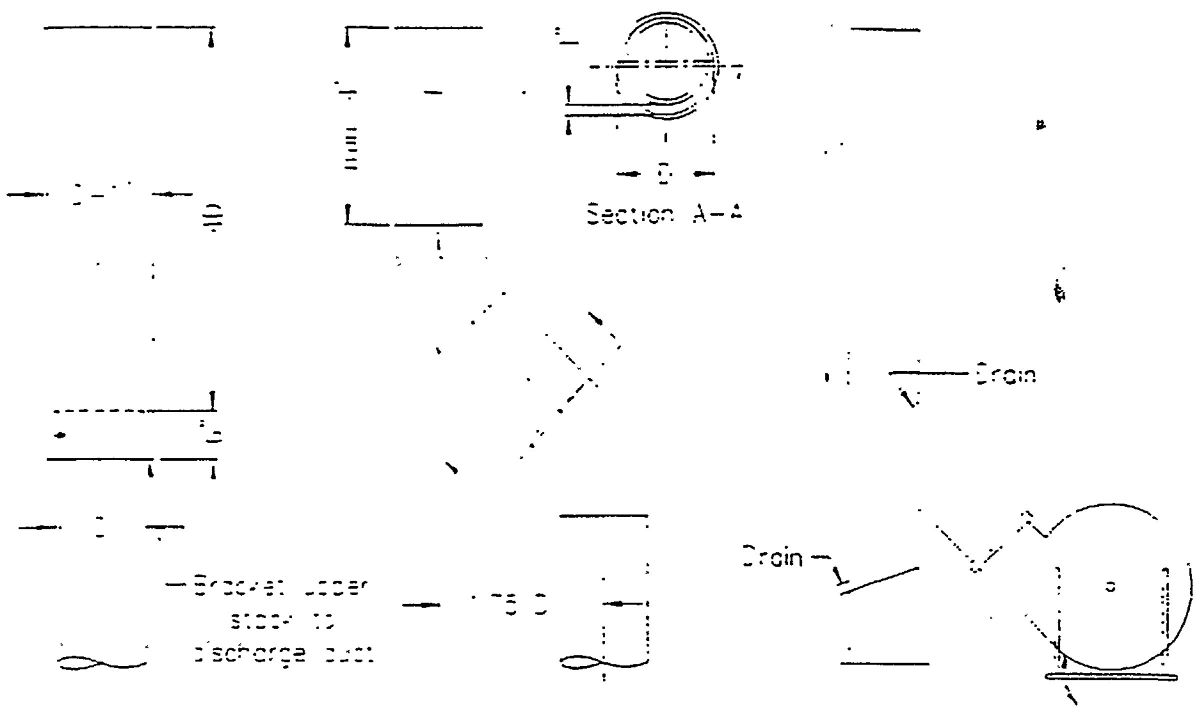
000059



AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

PRINCIPLES OF DUCT DESIGN

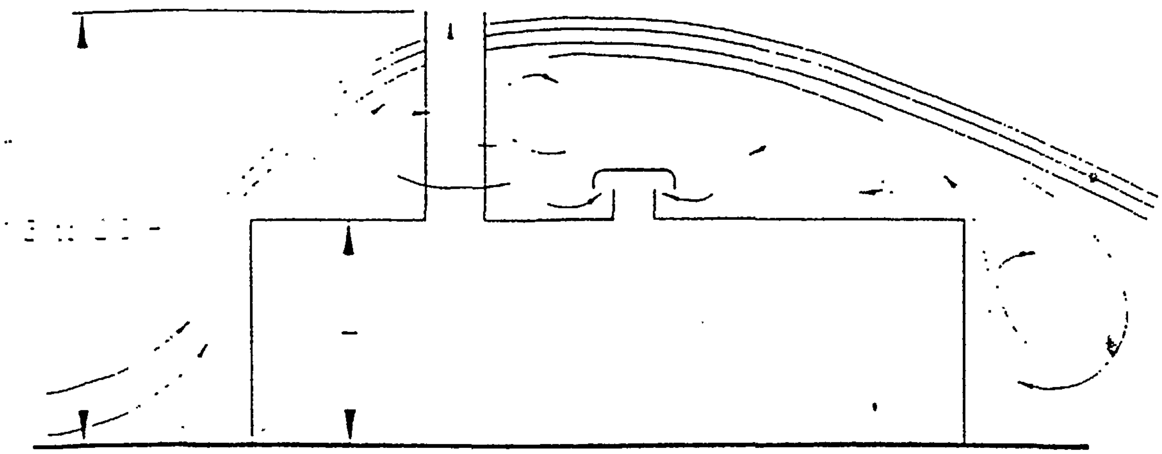
DATE 1-88 | FIGURE 5-30



1. Rain protection is superior to a deflection cap 0.75 D above top of stack.

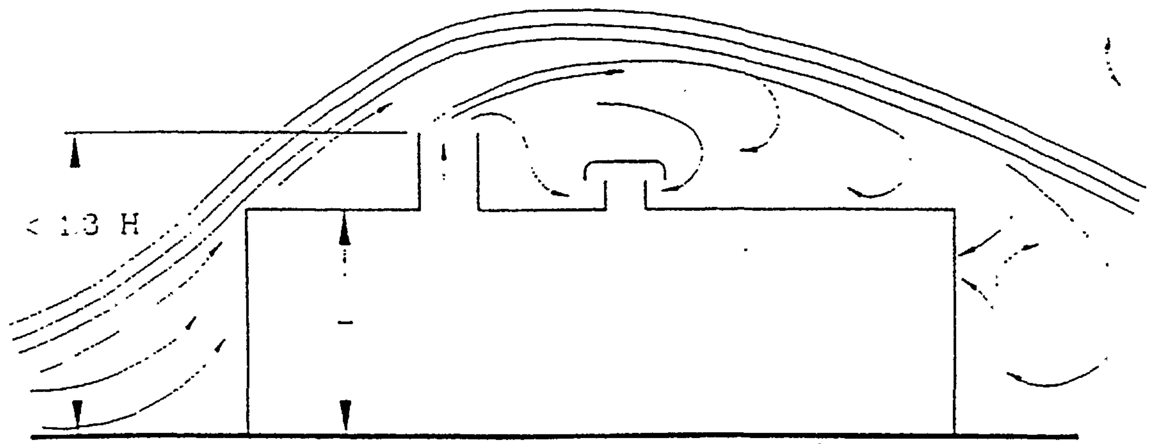
2. Since the height of upper stack is related to the amount of rain protection afforded, excessive height may cause stack gas to flow out the drain.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	STACKHEAD DESIGNS
DATE 1-88	FIGURE 5-31



PREFERRED

High discharge stack relative to building height.
air inlet on roof.



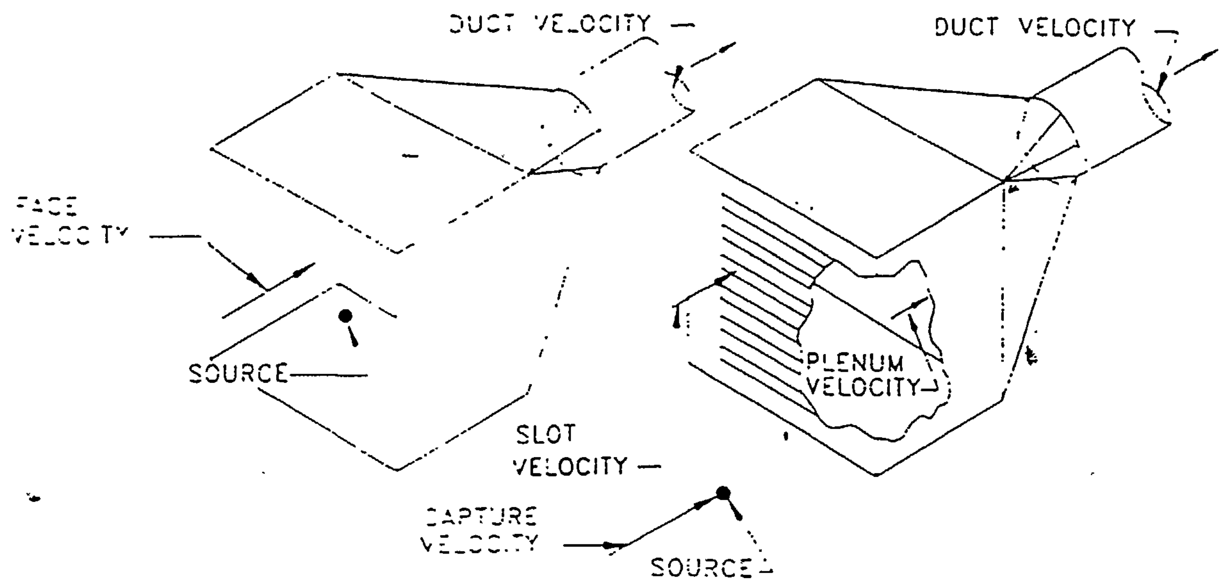
AVOID

Low discharge stack relative to building height and air inlets.

This applies only to the simple case of a low building without surrounding obstructions on reasonably level terain.

Note: Low pressure on the lee of a building may cause return of contaminants into the building through openings.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	STACK HEIGHT	
	DATE 1-88	FIGURE 5-32



CAPTURE VELOCITY– AIR VELOCITY AT ANY POINT IN FRONT OF THE HOOD OR AT THE HOOD OPENING NECESSARY TO OVERCOME OPPOSING AIR CURRENTS AND TO CAPTURE THE CONTAMINATED AIR AT THAT POINT BY CAUSING IT TO FLOW INTO THE HOOD.

FACE VELOCITY– AIR VELOCITY AT THE HOOD OPENING.

SLOT VELOCITY– AIR VELOCITY THROUGH THE OPENINGS IN A SLOT-TYPE HOOD. IT IS USED PRIMARILY AS A MEANS OF OBTAINING UNIFORM AIR DISTRIBUTION ACROSS THE FACE OF THE HOOD.

PLENUM VELOCITY– AIR VELOCITY IN THE PLENUM. FOR GOOD AIR DISTRIBUTION WITH SLOT-TYPES OF HOODS, THE MAXIMUM PLENUM VELOCITY SHOULD BE 1/2 OF THE SLOT VELOCITY OR LESS.

DUCT VELOCITY– AIR VELOCITY THROUGH THE DUCT CROSS SECTION. WHEN SOLID MATERIAL IS PRESENT IN THE AIR STREAM, THE DUCT VELOCITY MUST BE EQUAL TO OR GREATER THAN THE MINIMUM AIR VELOCITY REQUIRED TO MOVE THE PARTICLES IN THE AIR STREAM.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*HOOD NOMENCLATURE LOCAL EXHAUST*
	DATE *4–91* FIGURE *3–1*

- Movements of the operator.
- Room air currents (which are usually taken at 50 fpm minimum and may be much higher).
- Rapid air movement caused by spot cooling and heating equipment.

The shape of the hood, its size, location, and rate of air flow are important design considerations.

3.4.1 Capture Velocity: The minimum hood-induced air velocity necessary to capture and convey the contaminant into the hood is referred to as capture velocity. This velocity will be a result of the hood air flow rate and hood configuration.

Exceptionally high air flow hoods (example, large foundry side-draft shakeout hoods) may require less air flow than would be indicated by the capture velocity values recommended for small hoods. This phenomenon may be ascribed to:

- The presence of a large air mass moving into the hood.
- The fact that the contaminant is under the influence of the hood for a much longer time than is the case with small hoods.
- The fact that the large air flow rate affords considerable dilution as described above.

Table 3-1 offers capture velocity data. Additional information is found in Chapter 10.

3.4.2 Hood Flow Rate Determination: Within the bounds of flanges, baffles, adjacent walls, etc., air will move into an opening under suction from all directions. For an enclosure, the capture velocity at the enclosed opening(s) will be the exhaust flow rate divided by the opening area. The capture velocity at a given point in front of the exterior hood will be established by the hood air flow through the geometric surface which contains the point.

As an example, for a theoretical unbounded point suction

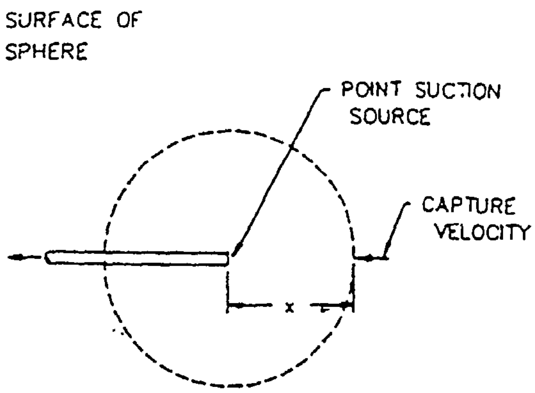


FIGURE 3-4 POINT SUCTION SOURCE

source, the point in question would be on the surface of a sphere whose center is the suction point (Figure 3-4).

The surface area of a sphere is $4\pi X^2$. Using $V = Q/A$ (Equation 1.3), the velocity at point X on the sphere's surface can be given by

$$Q = V(4\pi X^2) = 12.57VX^2 \quad [3.1]$$

where:

Q = air flow into suction point, cfm

V = velocity at distance X, fpm

A = $4\pi X^2$ = area of sphere, ft²

X = radius of sphere, ft

Similarly, if an unbounded line source were considered, the surface would be that of a cylinder and the flow rate (neglecting end effects) would be

$$Q = V(2\pi XL) = 6.28VXL \quad [3.2]$$

where:

L = length of line source, ft

Equations 3.1 and 3.2 illustrate, on a theoretical basis, the

TABLE 3-1. Range of Capture Velocities[3.1,3.2]

Condition of Dispersion of Contaminant	Example	Capture Velocity, fpm
Released with practically no velocity into quiet air.	Evaporation from tanks; degreasing, etc.	50–100
Released at low velocity into moderately still air.	Spray booths; intermittent container filling; low speed conveyor transfers; welding; plating; pickling.	100–200
Active generation into zone of rapid air motion.	Spray painting in shallow booths; barrel filling; conveyor loading; crushers.	200–500
Released at high initial velocity into zone at very rapid air motion.	Grinding; abrasive blasting; tumbling	500–2000

In each category above, a range of capture velocity is shown. The proper choice of values depends on several factors:

Lower End of Range

1. Room air currents minimal or favorable to capture.
2. Contaminants of low toxicity or of nuisance value only.
3. Intermittent, low production.
4. Large hood-large air mass in motion.

Upper End of Range

1. Disturbing room air currents.
2. Contaminants of high toxicity.
3. High production, heavy use.
4. Small hood-local control only.

relationship between distance, flow and capture velocity and can be used for gross estimation purposes. In actual practice, however, suction sources are not points or lines, but rather have physical dimensions which cause the flow surface to deviate from the standard geometric shape. Velocity contours have been determined experimentally. Flow[3.3] for round hoods, and rectangular hoods which are essentially square, can be approximated by

$$Q = V(10X^2 + A) \quad [3.3]$$

where:

- Q = air flow, cfm
- V = centerline velocity at X distance from hood, fpm
- X = distance outward along axis in ft. (NOTE: equation is accurate only for limited distance of X, where X is within 1.5 D)
- A = area of hood opening, ft^2
- D = diameter of round hoods or side of essentially square hoods, ft

Where distances of X are greater than 1.5 D, the flow rate increases less rapidly with distance than Equation 3.3 indicates.[3.4-3.5]

It can be seen from Equation 3.3 that velocity decreases inversely with the square of the distance from the hood (see

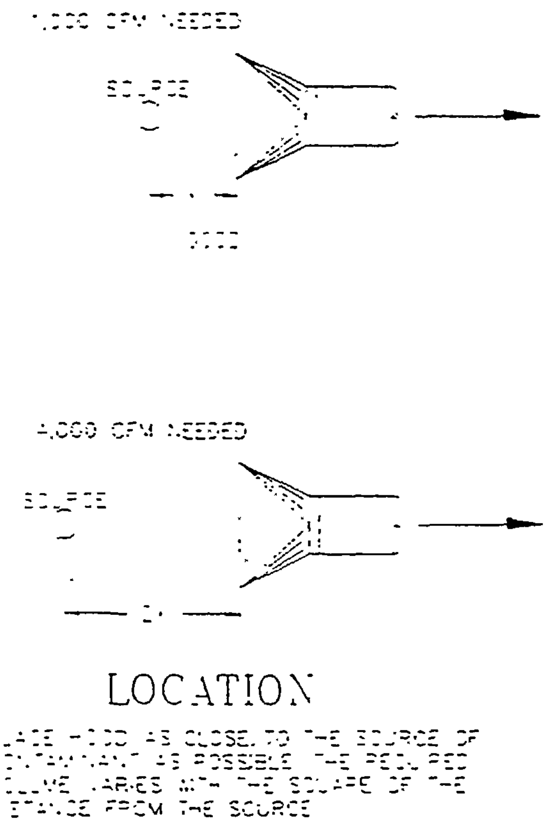


FIGURE 3-5 FLOW RATE AS DISTANCE FROM HOOD

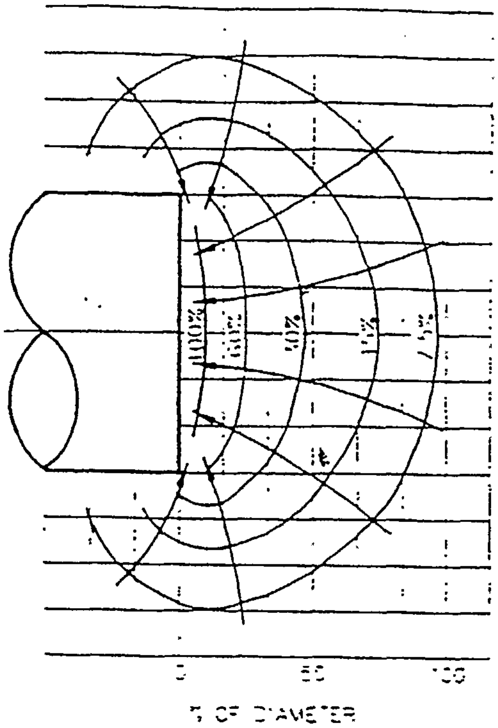


FIGURE 3-6 VELOCITY CONTOURS – PLAIN CIRCULAR OPENING – % OF OPENING VELOCITY

Figure 3-5.)

Figures 3-6 and 3-7 show flow contours and streamlines for plane and flanged circular hood openings. Flow contours are lines of equal velocity in front of a hood. Similarly, streamlines are lines perpendicular to velocity contours. (The tangent to a streamline at any point indicates the direction of air flow at that point.)

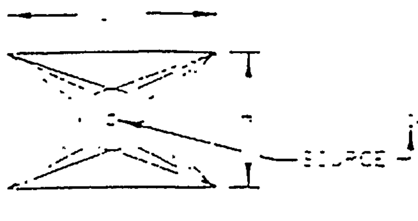
Flow capture velocity equations for various hood configurations are provided in Figures 3-8, 3-9 and 3-10.

3.4.3 Effects of Flanges and Baffles: A flange is a surface at and parallel to the hood face which provides a barrier to unwanted air flow from behind the hood. A baffle is a surface but which provides a barrier to unwanted air flow from the front or sides of the hood.

If the suction source were located on a plane, the flow area would be reduced (½ in both cases), thereby decreasing the flow rate required to achieve the same velocity. A flange around a hood opening has the same effect of decreasing the required flow rate to achieve a given capture velocity. In practice, flanging can decrease flow rate (or increase velocity) by approximately 25% (see Figures 3-6, 3-7, and 3-11). For most applications the flange width should be equal to the square root of the hood area ($\sqrt{A}$).

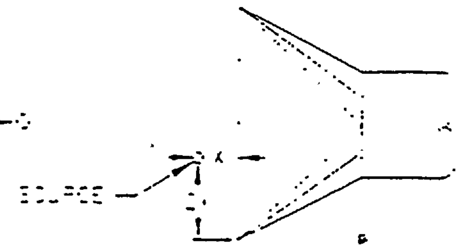
Baffles can provide a similar effect. The magnitude of the effort will depend on the baffle location and size.

Figure 3-11 illustrates several hood types and gives the velocity/flow formulas which apply.



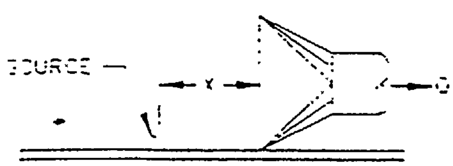
FREELY SUSPENDED HOOD

$Q = V(10X^2 + A)$



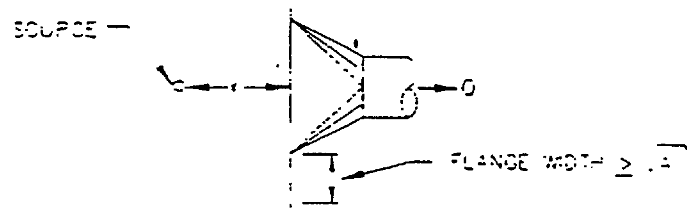
LARGE HOOD

LARGE HOOD, X SMALL--MEASURE X PERPENDICULAR TO HOOD FACE, NOT LESS THAN 2X FROM HOOD EDGE.



HOOD ON BENCH OR FLOOR

$Q = V(5X^2 + A)$



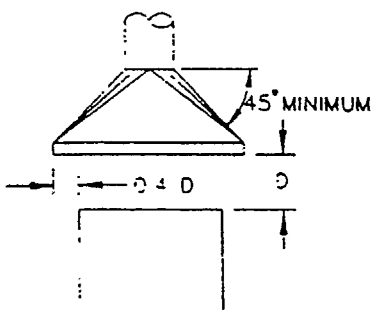
HOOD WITH WIDE FLANGE

$Q = V\ 0.75(10X^2 + A)$

SUSPENDED HOODS
(SMALL SIDE-DRAFT HOODS)

Q = REQUIRED EXHAUST AIR FLOW, CFM.
X = DISTANCE FROM HOOD FACE TO FARTHEST POINT OF CONTAMINANT RELEASE, FEET.
A = HOOD FACE AREA, FT^2
V = CAPTURE VELOCITY, FPM, AT DISTANCE X

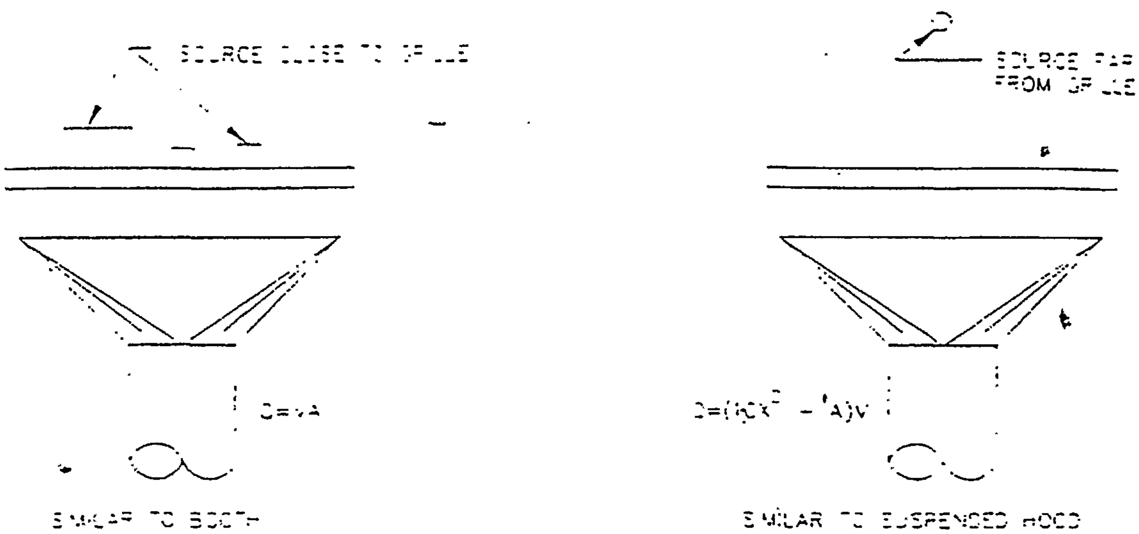
NOTE: AIR FLOW RATE MUST INCREASE AS THE SQUARE OF DISTANCE OF THE SOURCE FROM THE HOOD. BAFFLING BY FLANGING OR BY PLACING ON BENCH, FLOOR, ETC. HAS A BENEFICIAL EFFECT.



CANOPY HOOD

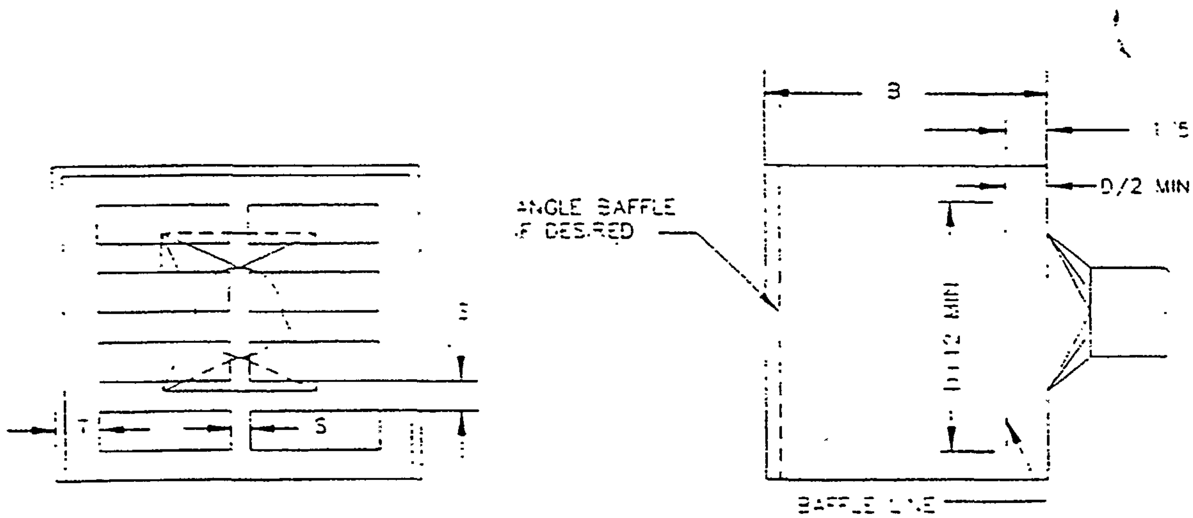
Q = 1.4 PDV(P=PERIMETER OF TANK, FEET).
NOT RECOMMENDED IF WORKERS MUST BEND OVER SOURCE. V RANGES FROM 50 TO 500 FPM DEPENDING ON CROSSDRAFTS. SIDE CURTAINS ON TWO OR THREE SIDES TO CREATE A SEMI-BOOTH OR BOOTH ARE DESIRABLE.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*FLOW/CAPTURE VELOCITY*
DATE 1-88	FIGURE 3-8



DOWNDRAFT HOODS

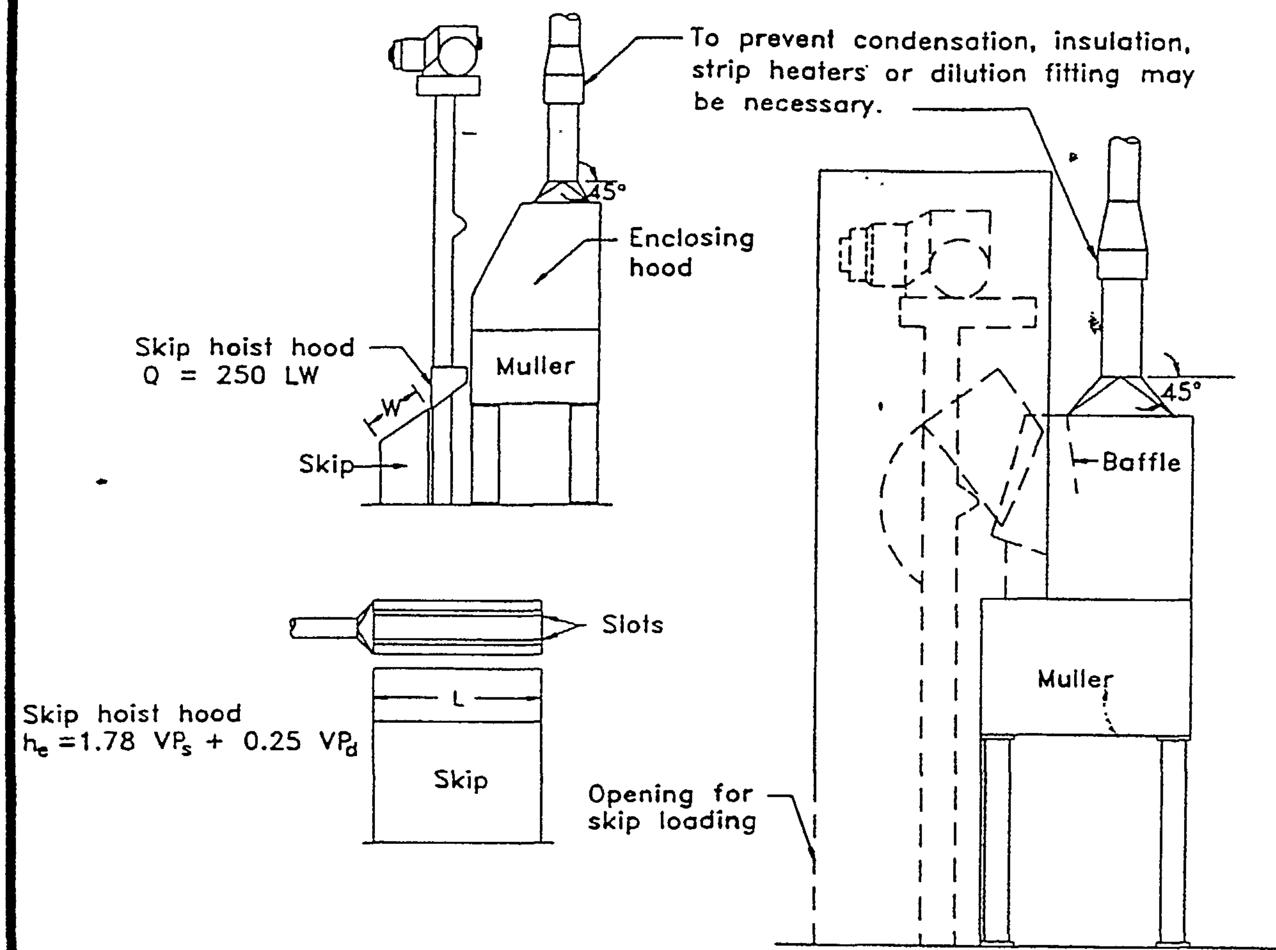
NOT RECOMMENDED FOR HOT OR HEAT-PRODUCING OPERATIONS IF DOWNDRAFT AREA IS LARGE. SEE "CAPTURE VELOCITY" IN THIS SECTION.



BOOTH-TYPE HOODS

Q=AV (A=FACE AREA, FT²; V=FACE VELOCITY, FPM).
BAFFLES ARE OPTIONAL FOR AIR DISTRIBUTION. NOT REQUIRED IF A WATER WALL BOOTH OR IF OTHER MEANS FOR DISTRIBUTION IS PROVIDED.
S VARIES FROM 4 INCHES TO 8 INCHES, DEPENDING ON SIZE OF BOOTH.
T VARIES FROM 6 INCHES TO 12 INCHES, DEPENDING ON SIZE OF BOOTH.
INCREASE THE NUMBER OF PANELS WITH SIZE OF BOOTH.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*FLOW/CAPTURE VELOCITY*			
	DATE	1-88	FIGURE	3-10



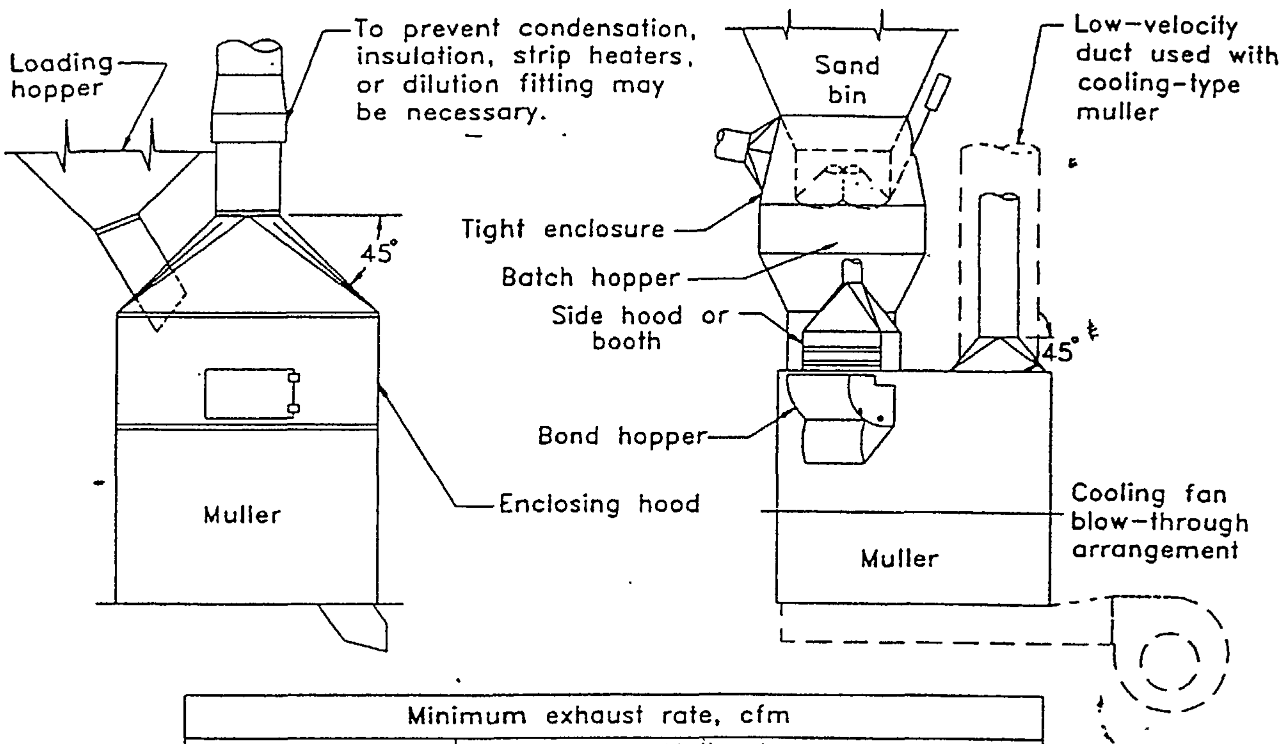
$Q = 150\ cfm/ft^2$ through all openings but not less than:

Muller diam. feet	Exhaust, cfm
4	750
6	900
7	1050
8	1200
10	1575

Minimum duct velocity = 4000 fpm
$h_e = 0.25\ VP_d$

Notes: 1. Other types of mixers: enclose as much as possible and provide 150 cfm/ft^2 of remaining openings.
2. When flammable solvents are used in mixer, calculate minimum exhaust rate for dilution to 25% of the LEL. See Chapter 2.
3. For air-cooled mullers, see VS-60-02.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	MIXER AND MULLER HOOD
	DATE 11-90 / FIGURE VS-60-01



Location	Minimum exhaust rate, cfm		
	Muller type		
	No cooling	Blow-though cooling	Draw-though cooling
Batch hopper	Note 1	600	Note 1
Bond hopper	600	600	600
Muller:	Note 2	Note 3	Note 3
4' diameter	750	"	"
6' diameter	900	"	"
7' diameter	1050	"	"
8' diameter	1200	"	"
10' diameter	1575	"	"

Minimum duct velocity = 4500 fpm

h_e = 0.25 VP

Notes:

1. Batch hopper requires separate exhaust with blow-through cooling. With other fan arrangement (muller under suction), separate exhaust may not be required. (If skip hoist is used, see VS-60-01.)
2. Maintain 150 fpm velocity through all openings in muller hood. Exhaust flow rates shown are the minimum for control.
3. Cooling mullers do not require additional exhaust if maintained in dust-tight condition. Blow-through fan must be off during loading. If muller is not dust-tight, exhaust as in note 2 plus cooling air flow rate.
4. When flammable solvents are used in mixer, calculate minimum exhaust flow rate for dilution to 25% of the LEL. See Chapter 2.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	AIR-COOLED MIXER AND MULLER
	DATE 11-90 FIGURE VS-60-02