PLAINTIFF'S EXHIBIT

CAP-230

cc D. Weaver ... mark confid ... cc E.S. ... in ... indicated

RECEIVED

January 18, 1968

Mr. M. J. Messel
Lake Asbestos of Quebec

In a "1968 Notice of Intent" the American Conference of Industrial Hygienists Committee on Threshold Limits announces a change in the listing of the limit for asbestos dust in the air of work places.

The limit of 5 million particles per cubic foot of air will be the same as before but a note in the Appendix will read:

"A limit of 5 mppcf, based on impinger samples counted by light-field technics, is satisfactory to control exposures to most forms of asbestos. Crocidolite, however, has been shown to produce, in addition to the asbestotic inflammation, also mesothelioma. Since no safe limit can be established for this form of asbestos at this time, until more definitive data are obtained, it is recommended that workers exposed to crocidolite be equipped with air-supplied helmets."

It seems to me this note does us no harm and perhaps some good.

K. W. Nelson

KWN/mb

cc: D. K. Soutar
E. A. Farrell

CAPCO KIN 0000460

# INDUSTRIAL VENTILATION

*A Manual of Recommended Practice*

[illegible] Edition

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

CAPCO KIN 0000461

# INDUSTRIAL VENTILATION

*A Manual of Recommended Practice*

COMMITTEE ON INDUSTRIAL VENTILATION
P. O. BOX 453
LANSING, MICHIGAN, 48902, U.S.A.

American Conference of Governmental Industrial Hygienists

| *Manual* | | *Calculation Sheets* |
|---|---|---|
| U.S.A. | Outside U.S.A. | $2.00 — 25 copies |
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# FOREWORD

In this revision for the Twelfth Edition, the Committee on Industrial Ventilation, American Conference of Governmental Industrial Hygienists, has attempted to keep abreast of new developments and standards for industrial ventilation systems. A critical review has been made of the previous edition, modifying and rewriting certain portions for improved clarity and accuracy.

The committee continues its policy of presenting the material in a practical, concise, easy-to-understand manner. Theoretical discussions and complex equations are not given. The manual is sufficiently complete so that an industrial ventilation system can be designed without reference to other texts.

New material and revisions include:

SECTION 3 - Ventilation for Heat Control

The information relating to radiant heat as a factor in calculating effective temperature has been revised to clarify the procedure.

SECTION 4 - Hood Design Data

Additional information is given explaining the proper selection of exhaust Capture Velocity. Slot hood design factors and limitations are discussed.

SECTION 5 - Specific Operations

Specific design data with new drawings is presented for Low Volume-High Velocity exhaust systems. The [illegible] design data has been up-dated to correspond to the new Federal Occupational Safety and Health [illegible]. Nineteen other drawings of exhaust hood designs have been revised.

SECTION 6 - Duct Design Procedure

The method for evaluating duct velocity changes and the corresponding static pressure corrections has been rewritten for better comprehension. A detailed explanation of Fan Static Pressure and Fan Total Pressure is presented. Air density correction data has been extended. Design data for duct expansions and evasé discharges has been revised.

SECTION 7 - Oil and gas fuels data and calculations have been extended to include the gas composition by [illegible].

SECTION [illegible] - Fans

[illegible] illustrates fan performance in series and parallel operation. Revised discussion of fan [illegible] air.

[illegible] Current Threshold Limit Values for Airborne Contaminants are presented.

[illegible]

1. The new Ventilation System Testing Guide describes the standard test method for testing an industrial ventilation system and includes the necessary charts, tables, data sheets and formulae.

2. The Metric Supplement comprises a set of tables, graphs and charts in metric units which can be used to replace the English charts in the Standard ventilation manual to enhance its use worldwide.

3. [illegible] programs for designing industrial exhaust systems are available.

COMMITTEE ON INDUSTRIAL VENTILATION

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## DEFINITIONS

Aerosol: An assemblage of small particles, solid or liquid, suspended in air. The diameter of the particles may vary from 100 microns down to 0.01 micron or less, e.g., dust, fog, smoke.

Air Cleaner: A device designed for the purpose of removing atmospheric air-borne impurities such as dusts, gases, vapors, fumes and smokes. (Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters.)

Air Filter: An air cleaning device to remove light particulate loadings from normal atmospheric air before introduction into the building. Usual range: Loadings up to 3 grains per thousand cubic feet (0.003 grains per cubic foot). Note: Atmospheric air in heavy industrial areas and in-plant air in many industries have higher loadings than this and dust collectors are then indicated for proper air cleaning.

Air Horsepower: The theoretical horsepower required to drive a fan if there were no losses in the fan, that is, if its efficiency were 100%.

Air, Standard: Dry air at 70 F and 29.92 in (Hg) barometer. This is substantially equivalent to 0.075 lb/cu ft.

Aspect Ratio: The ratio of the width to the length. $AR = \frac{W}{L}$

Aspect Ratio of an Elbow: The width (W) along the axis of the bend divided by depth (D) in plane of bend. $AR = \frac{W}{D}$

Blast Gate: Sliding damper.

Blow (throw): In air distribution, the distance an air stream travels from an outlet to a position at which air motion along the axis reduces to a velocity of 50 fpm. For unit heaters, the distance an air stream travels from a heater without a perceptible rise due to temperature difference and loss of velocity.

Brake Horsepower: The horsepower actually required to drive a fan. This includes the energy losses in the fan and can be determined only by actual test of the fan. (This does not include the drive losses between [illegible].)

Capture Velocity: The air velocity at any point in front of the hood or at the hood opening necessary to [illegible] air currents and to capture the contaminated air at that point by causing it to flow into the hood.

[illegible] of Entry: The actual rate of flow caused by a given hood static pressure compared to the [illegible] flow which would result if the static pressure could be converted to velocity pressure with 100% [illegible]. It is the ratio of actual to theoretical flow.

[illegible] (Average): The range of effective temperatures over which the majority (50 per cent or [illegible]) feel comfortable.

[illegible]: The motion resulting in a fluid from the differences in density and the action of gravity. In [illegible] this meaning has been extended to include both forced and natural motion or circulation.

[illegible]: The ratio of the mass of a specimen of a substance to the volume of the specimen. The mass of [illegible] a substance. When weight can be used without confusion, as synonymous with mass, density [illegible] of a unit volume of a substance.

[illegible]: The ratio of actual air density to density of standard air. The product of the density [illegible] density of standard air (0.075 lb/cu ft) will give the actual air density in lbs per cu ft. [illegible] actual density of air, lbs per cu ft.

[illegible] solid particles created by the breaking up of larger particles by processes such as crushing, [illegible], explosions, [illegible] particles already in existence in a mixture of materials may escape [illegible] such operations as shoveling, conveying, screening, sweeping, etc.

[illegible]: An air cleaning device to remove heavy particulate loadings from exhaust systems before [illegible]. Usual range: Loadings 0.003 grains per cubic foot and higher.

Entry Loss: Loss in pressure caused by air flowing into a duct or hood. (Inches $H_2O$).

Fumes: Small solid particles formed by the condensation of vapors of solid materials.

Gases: Formless fluids which tend to occupy an entire space uniformly at ordinary temperatures and pressures.

Gravity, Specific: The ratio of the mass of a unit volume of a substance to the mass of the same volume of a standard substance at a standard temperature. Water at 39.2 F is the standard substance usually referred to. For gases, dry air, at the same temperature and pressure as the gas, is often taken as the standard substance.

Hood: A shaped inlet designed to capture contaminated air and conduct it into the exhaust duct system.

Humidity, Absolute: The weight of water vapor per unit volume, pounds per cubic foot or grams per cubic centimeter.

Humidity, Relative: The ratio of the actual partial pressure of the water vapor in a space to the saturation pressure of pure water at the same temperature.

Inch of Water: A unit of pressure equal to the pressure exerted by a column of liquid water one inch high at a standard temperature.

Lower Explosive Limit: The lower limit of flammibility or explosibility of a gas or vapor at ordinary ambient temperatures expressed in per cent of the gas or vapor in air by volume. This limit is assumed constant for temperatures up to 250 F. Above these temperatures, it should be decreased by a factor of 0.7 since explosibility increases with higher temperatures.

Manometer: An instrument for measuring pressure; essentially a U-tube partially filled with a liquid, usually water, mercury or a light oil, so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Micron: A unit of length, the thousandth part of 1 mm or the millionth of a meter, (approximately 1/25,0 of an inch).

Mists: Small droplets of materials that are ordinarily liquid at normal temperature and pressure.

Plenum: Pressure equalizing chamber.

Pressure, Atmospheric: The pressure due to the weight of the atmosphere. It is the pressure indicated by a barometer. Standard Atmospheric Pressure or Standard Atmosphere is the pressure of 29.92 inches of mercury.

Pressure, Static: The potential pressure exerted in all directions by a fluid at rest. For a fluid in motion it is measured in a direction normal to the direction of flow. Usually expressed in inches water gauge when dealing with air. (The tendency to either burst or collapse the pipe.)

Pressure, Total: The algebraic sum of the velocity pressure and the static pressure (with due regard to sign).

Pressure, Vapor: The pressure exerted by a vapor. If a vapor is kept in confinement over its liquid so that the vapor can accumulate above the liquid, the temperature being held constant, the vapor pressure approaches a fixed limit called the maximum or saturated, vapor pressure, dependent only on the temperatu and the liquid. The term vapor pressure is sometimes used as synonymous with saturated vapor pressure.

Pressure, Velocity: The kinetic pressure in the direction of flow necessary to cause a fluid at rest to flow at a given velocity. Usually expressed in inches water gauge.

Radiation, Thermal (Heat) Radiation: The transmission of energy by means of electromagnetic waves of very long wave length. Radiant energy of any wave length may, when absorbed, become thermal energy and result in an increase in the temperature of the absorbing body.

Slot Velocity: Linear flow rate of contaminated air through slot, fpm.

Smoke: An air suspension (aerosol) of particles, usually but not necessarily solid, often originating in a solid nucleus, formed from combustion or sublimation.

Temperature, Effective: An arbitrary index which combines into a single value the effect of temperature, humidity and air movement on the sensation of warmth or cold felt by the human body. The numerical value is that of the temperature of still, saturated air which would induce an identical sensation.

Temperature, Wet-Bulb: Thermodynamic wet-bulb temperature is the temperature at which liquid or solid water, by evaporating into air, can bring the air to saturation adiabatically at the same temperature. Wet-bulb temperature (without qualification) is the temperature indicated by a wet-bulb psychrometer constructed and used according to specifications.

Threshold Limit Values (TLV): The values for air borne toxic materials which are to be used as guides in the control of health hazards and represent time weighted concentrations to which nearly all workers may be exposed 8 hours per day over extended periods of time without adverse effects. (See Appendix)

Transport (Conveying) Velocity: Minimum air velocity required to move the particulates in the air stream, fpm.

Vapor: The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states either by increasing the pressure or decreasing the temperature. Vapors diffuse.

## ABBREVIATIONS

| | |
|---|---|
| A ....... | Area |
| AHP ..... | Air horsepower |
| acfm ..... | actual cfm |
| AR ...... | Aspect ratio |
| B ....... | barometric pressure |
| bhp ...... | Brake horsepower |
| btu ...... | British thermal unit |
| btuh ...... | btu/hr |
| $C_e$ ....... | Coefficient of entry |
| cfm ...... | Cubic feet per minute |
| cu ft ..... | Cubic foot |
| d ....... | Density factor |
| D ....... | Diameter |
| ET ...... | Effective temperature |
| F ....... | Degree, Fahrenheit |
| fpm ...... | Feet per minute |
| fps ...... | Feet per second |
| g ....... | Gravitational force, ft/sec/sec |
| gpm ..... | Gallons per minute |
| gr ....... | Grains |
| $h_e$ ....... | Hood entry loss |
| hp ....... | Horsepower |
| hr ....... | Hour |
| in ....... | Inch |
| LEL ..... | Lower explosive limit |
| ME ...... | Mechanical efficiency |
| mg ...... | milligram |
| MRT ..... | Mean radiant temperature |
| mm ...... | Millimeter |
| min ...... | Minute |
| MW ...... | Molecular Weight |
| ppm ..... | Parts per million |
| lb ....... | Pound |
| psi ...... | Pounds per square inch |
| Q ....... | Quantity of air, cfm |
| RH ...... | Relative humidity |
| $\rho$ ........ | Density of air in lb/cu ft |
| rpm ..... | Revolutions per minute |
| SFM ..... | Surface feet per minute |
| sq ft ..... | Square foot |
| sq in ..... | Square inch |
| SP....... | Static pressure |
| $SP_h$...... | Hood static pressure |
| scfm ..... | Cfm at standard air conditions |
| sp gr .... | Specific gravity |
| STP ..... | Standard temperature and pressure |
| TLV..... | Threshold Limit Values |
| TP ..... | Total pressure |
| V ....... | Velocity, fpm |
| VP ...... | Velocity pressure |
| wg ..... | Water gauge |

# GENERAL PRINCIPLES OF VENTILATION

## Principles of Air Flow

The flow of air between two points is due to the occurrence of a pressure difference between the two points. This pressure difference results in a force on the air, causing air flow from the high pressure zone to the low pressure zone. The quantity of air flow (Q) and the velocity of flow (V) are related according to the equation

$$Q = AV$$

where: Q = volume, cubic feet per minute
A = cross sectional area through which the air flows in square feet
V = velocity in lineal feet per minute

This basic relationship describes the flow of air under all conditions.

Air traveling at a specific velocity will create a definite pressure which is known as the Velocity Pressure. There is a definite relationship between the velocity of air and the Velocity Pressure. The basic statement of this relationship is

$$v = \sqrt{2gh}$$

where: v = velocity, feet per second
g = gravitational acceleration, feet per second per second
h = head of air, feet

When g = 32.2 ft/sec² and air density is 0.075 pounds per cubic foot, this formula converts to

$$V = 4005\sqrt{VP}$$

where: V = air velocity, feet per minute
VP = velocity pressure, inches of water

It should be emphasized that Velocity Pressure is always exerted in the direction of air flow.

Air confined within an enclosure, whether in motion or not, creates another type of pressure which exerts itself perpendicularly to the walls of the enclosure. This pressure is known as Static Pressure and it is completely independent of the velocity of the air.

When Static Pressure is below atmospheric pressure it is negative. When it is above atmospheric pressure it is positive. Velocity Pressure is always positive.

The algebraic sum of Static Pressure and Velocity Pressure is Total Pressure. This may also be written in the form of an equation—the symbols are those used throughout this book:

$$TP = SP + VP$$

The significance of these pressures can be demonstrated under actual conditions. For example, assume a [illegible] chamber (sealed) containing air pressure of 0.05 pounds per square inch. This 0.05 psi pressure is referred to as static pressure. If a small hole is drilled into this chamber and a U-tube is used, a reading of 1.39 inches of water will result. (1 psi = 27.7 inches of water.) Since there is no air flow, the velocity pressure will be zero and the total pressure will be 1.39 inches of water. This is shown in Figure 1-1.

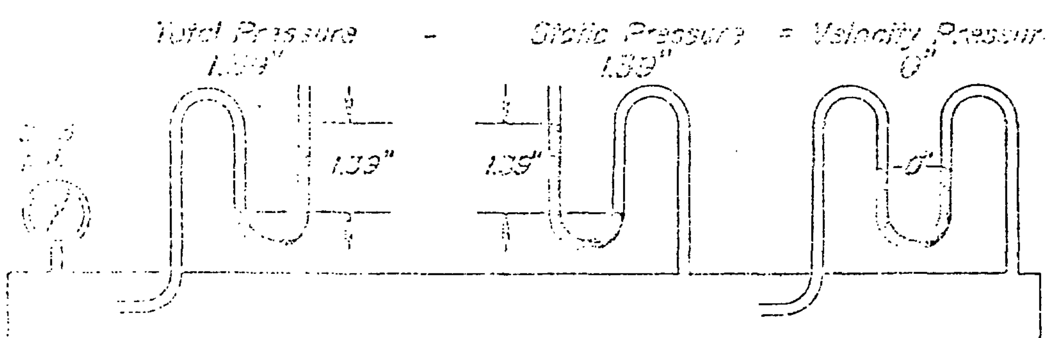


Fig. 1-1

If the ends of this chamber are opened, it becomes a duct through which air may flow. With air flowing through this duct there are now two distinct pressures, namely, static pressure and velocity pressure. The algebraic sum of these two pressures is called total pressure. If a fan is placed so that air is blown through the duct, the pressures shown in Figure 1-2 could result.

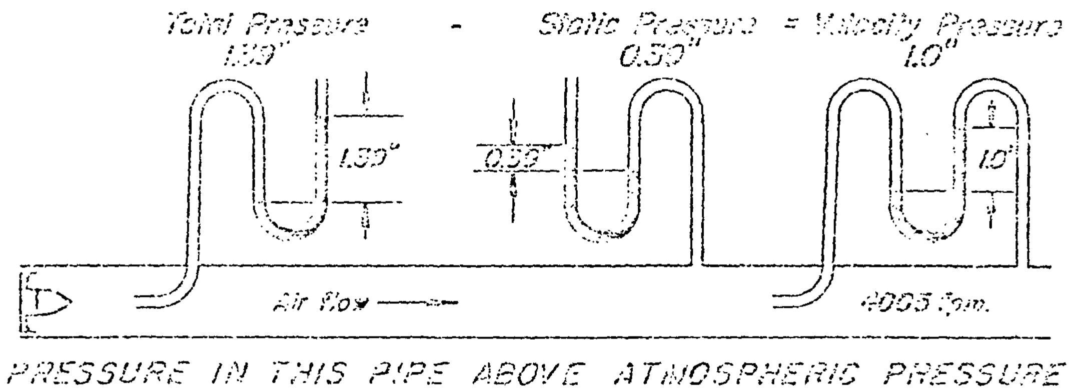


Fig. 1-2

If a fan is placed so that air is drawn through the duct, the pressures indicated in Figure 1-3 could result.

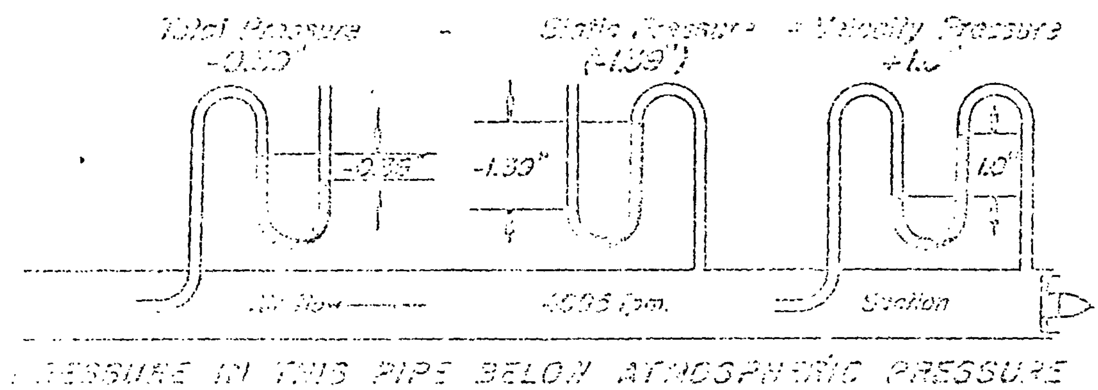


Fig. 1-3

In Figure 1-4 typical static and velocity pressures are shown in a long section of exhaust duct equipped with a flanged hood.

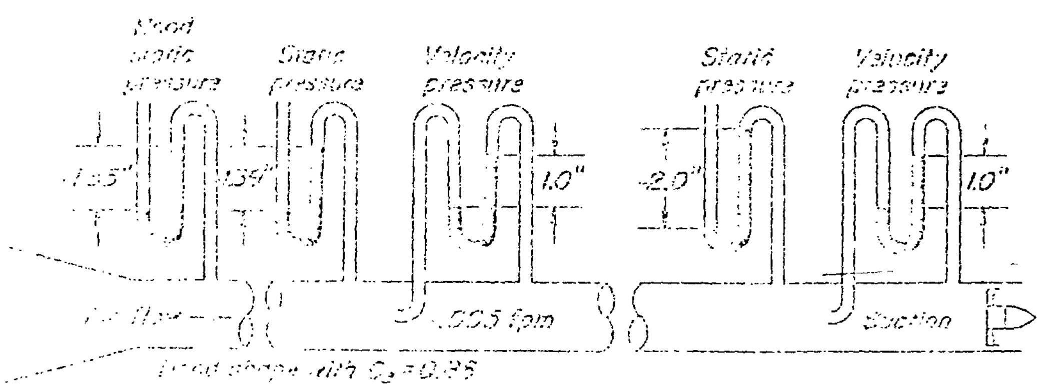


Fig. 1-4

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Acceleration of Air and Hood Entrance Losses

The pressure difference required to move air into an opening must be sufficient to both accelerate the air from rest to a velocity and to overcome the turbulence losses at the opening.

For acceleration, the energy required is equal to the Velocity Pressure corresponding to the velocity.

Turbulence losses are caused by the opening and vary with the shape of opening. The coefficient of entry ($C_e$) indicates the extent of turbulence losses. In a theoretically perfect hood with no turbulence loss, $C_e = 1.0$.

Hood Static Pressure ($SP_h$) is a direct measurement, in inches of water, of both the acceleration energy and turbulence losses. For a perfect hood with no turbulence loss, $C_e = 1.0$ and $SP_h = VP$ (See Section 4). In this case:

$$V = 4005\ C_e \sqrt{SP_h} = 4005 \sqrt{SP_h}$$

For the hood shown in Figure 1-4 where $C_e = 0.86$ this becomes:

$$V = 4005\ C_e \sqrt{SP_h} = 4005 \times 0.86 \sqrt{SP_h} = 3444 \sqrt{SP_h}$$

To obtain the desired velocity, 4005 fpm, the required $SP_h$ can be calculated from the above formula:

$$\sqrt{SP_h} = \frac{V}{3444} = \frac{4005}{3444}$$

$$SP_h = \left(\frac{4005}{3444}\right)^2 = 1.35 \text{ inches of water}$$

As previously stated, the hood static pressure indicates both the acceleration ($VP$) and turbulence losses ($h_e$). This may be expressed as

$$SP_h = VP + h_e$$

For design purposes the entry loss ($h_e$) is often designated as a decimal fraction ($F_h$) of the velocity pressure ($VP$). In this form it applies to all velocities.

$$h_e = F_h VP$$

(See Section 4, Figure 4-5; Section 5; Section 6, Figure 6-10.)

Pressure Drop Through Ductwork

Air flowing through ducts encounters resistance to flow due to (1) friction losses and (2) dynamic (turbulence) losses. Friction losses are caused by the actual rubbing of the air against the surfaces of the duct. Dynamic losses result due to air turbulence which takes place whenever air flow through a duct changes direction or velocity; i.e., whenever the duct changes direction or varies in cross-sectional area. The result of friction and dynamic losses is to cause a pressure drop to occur as the air flows through a duct.

The well known Bernoulli's Theorem frequently used in flow of fluids is merely a statement of the laws of conservation of energy. Bernoulli's Theorem as applied to air is: static pressure plus velocity pressure at a point upstream in direction of air flow is equal to the static pressure plus velocity pressure at a point downstream in direction of air flow plus the friction and dynamic losses:

$$SP_1 + VP_1 = SP_2 + VP_2 + \text{losses}$$

For practical purposes, the total amount of friction through any round duct varies directly as the length, inversely as the diameter of the duct and directly as the square of the velocity of air flowing through the duct. The pressure drop through a duct system due to dynamic losses depends upon (1) number and type of elbows and fittings and (2) the frequency with which the velocity of air changes as it flows through the duct system.

In order to overcome the resistances of a duct system, it is necessary to expend energy in maintaining a pressure differential between the two ends of the system. This is usually accomplished by the use of a fan. The fan delivers air at a static pressure great enough to overcome the resistance of the system. Figure 1-5 is a graphical description of actual pressure changes in a simple exhaust system.

Effect of Specific Gravity

Frequently, the location of exhaust hoods is mistakenly based on a supposition that the contaminant is "heavier than air" or "lighter than air." In most health hazard applications, this criterion is of little value. Fine dust, fumes, vapors and gases are truly air-borne, following air currents and are not subject to appreciable motion either upward or downward because of their own density. For example, consider the

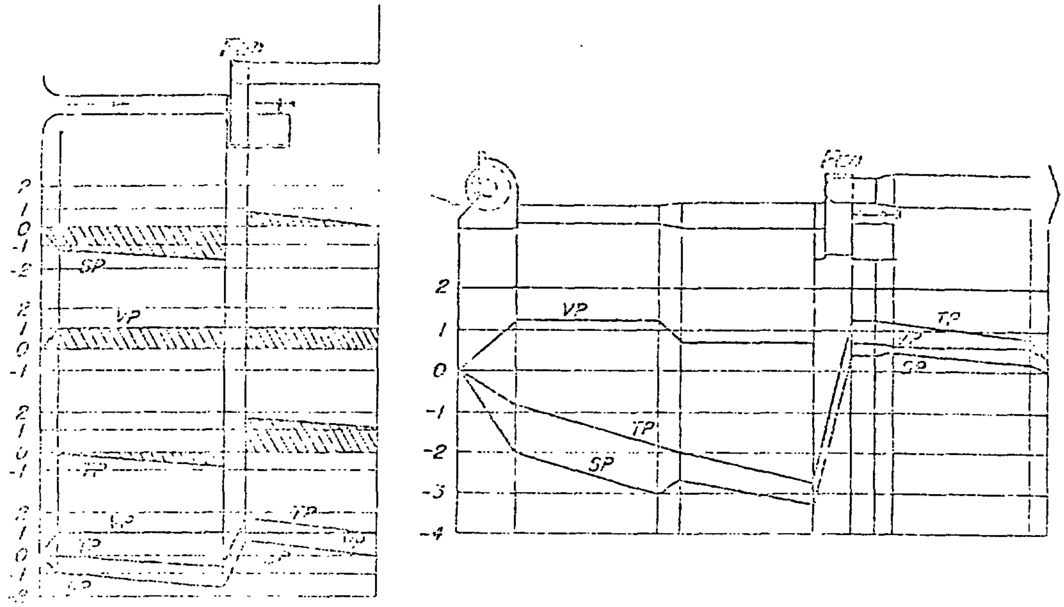


Fig. 1-5

degreasing solvent, perchloroethylene (tetrachloroethylene). Assuming the perchloroethylene vapor is well mixed with air, the following calculations indicate the effective specific gravity of a 10,000 ppm perchloroethylene-air mixture.

Specific gravity of air = 1
Specific gravity of $C_2Cl_4$ = 5.7
10,000 ppm = 1 part $C_2Cl_4$ : 99 parts of air
0.01 × 5.7 = 0.057
0.99 × 1.0 = 0.990
1.047 = effective specific gravity of mixture

Since 10,000 ppm is 100 times the TLV value of perchloroethylene, the mixture normally encountered ... much less than 10,000 ppm. By a similar calculation a 100 ppm perchloroethylene-air mixture ... effective specific gravity of 1.0005.

Therefore, the perchloroethylene-air mixtures compared to clean air would have a tendency to move downward ... by the ratio of 1047/1000 in the case of the 10,000 ppm mixture or 10005/10000 in the case of the ... ppm mixture and not by the ratio of 5.7/1 as is frequently implied. Thus the effects of window ventilation ... currents, traffic and heat can drive into insignificance the effect of specific gravity. A vapor of large specific gravity has been chosen for illustration; obviously the influence of specific gravity will be even less in the case of those gases and vapors whose specific gravity is closer to the specific gravity of air.

Characteristics of Blowing and Exhausting

... from a small opening retains its directional effect for a considerable distance beyond the plane of the opening. However, if the flow of air through the same opening were reversed so that it operated as an exhaust opening handling the same volume of air, the flow would become almost completely non-directional and its range of influence would be greatly reduced. For this reason, local exhaust hoods must not be contemplated for any process which cannot be conducted in the immediate vicinity of the hood. Figure 1-6 illustrates the fundamental difference between blowing and exhausting.

Make-up Air

... systems will require a mechanical system of supplied air to offset the air exhausted. For ... discussion of design, refer to Section 7, "Make-Up and Recirculated Air."

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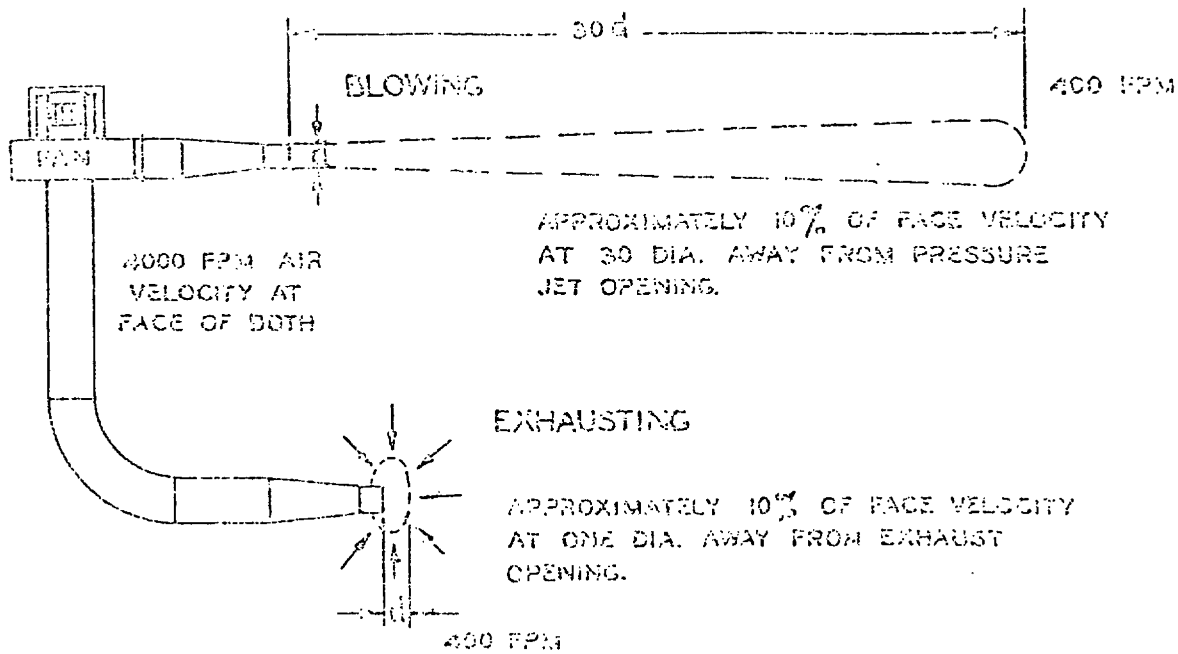


Fig. 1-6

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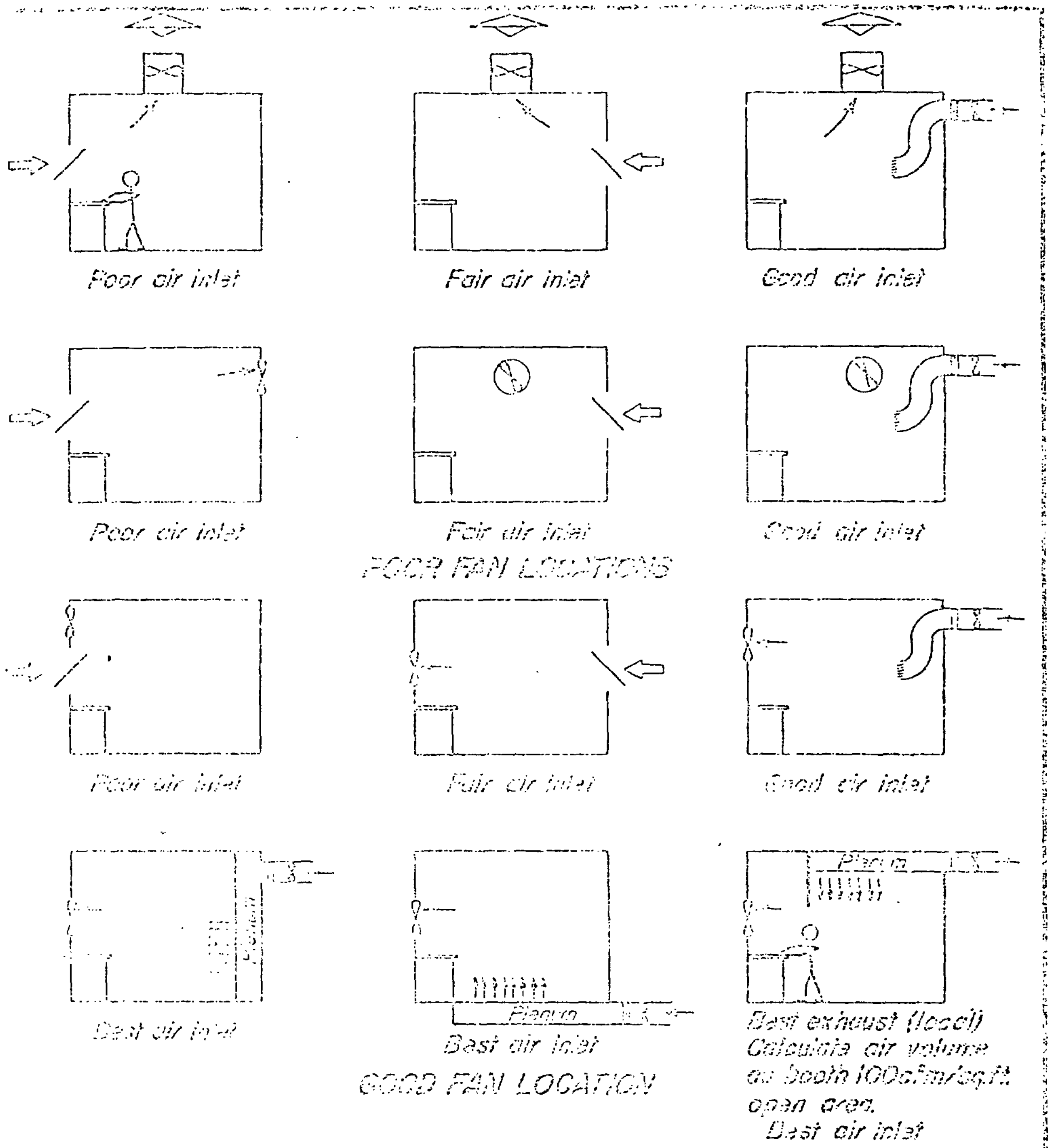


Note:
Inlet air requires tempering
during winter months.
See Section 7

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PRINCIPLES OF DILUTION VENTILATION

DATE 1-66 | Fig. 2-1

## Section 4

## HOOD DESIGN DATA

### Introduction

Proper design of exhaust hoods is necessary if a local exhaust system is to effectively control atmospheric contamination at its source with a minimum air flow and power consumption. The theory of capture velocity depends on the creation of air flow past the source of contaminant sufficient to remove the highly contaminated air around the source or issuing from that source and to draw the air into an exhaust hood.

It can be shown that dust particles in the small micron sizes, even if impelled at extremely high original velocities, travel a very short distance in air--a matter of a few inches at the most (References 7, 16). Thus the fine dust particles of health significance follow the air currents and are often referred to as "air-borne dust." The same considerations apply to mists and fumes. Vapors and gases, of course, mix intimately with air and follow the air currents.

Larger dust particles released at high velocities (example, the larger particles from grinding) do have an appreciable trajectory or "throw" in air. These larger particles cannot be captured unless directed into the hood. Scattering can also be prevented by properly placed barriers. It is desirable to collect this dust as well as the truly air-borne dust and thus utilize the exhaust ventilation to improve the housekeeping and maintenance situation in the plant.

### Principles of Hood Design

[illegible], hood design requires sufficient knowledge of a process or operation so the most effective hood or enclosure can be installed to provide minimum exhaust volumes for effective contaminant control. The more complete the enclosure, the more economical and effective the installation will be. Many designers [illegible] their hoods by mentally enclosing the operation completely, from there providing access and working openings as indicated. From this complete enclosure concept, familiar hood shapes like booths, side or [illegible] hoods with or without side shields are developed. All openings are kept to a minimum and located [illegible] the natural path of the contaminant travel whenever possible. Inspection and maintenance openings are provided with doors whenever practicable.

[illegible] hoods that do not enclose or confine the contaminant are recommended only as a last resort because [illegible] volumes are large and control can be so easily upset by cross drafts in the area.

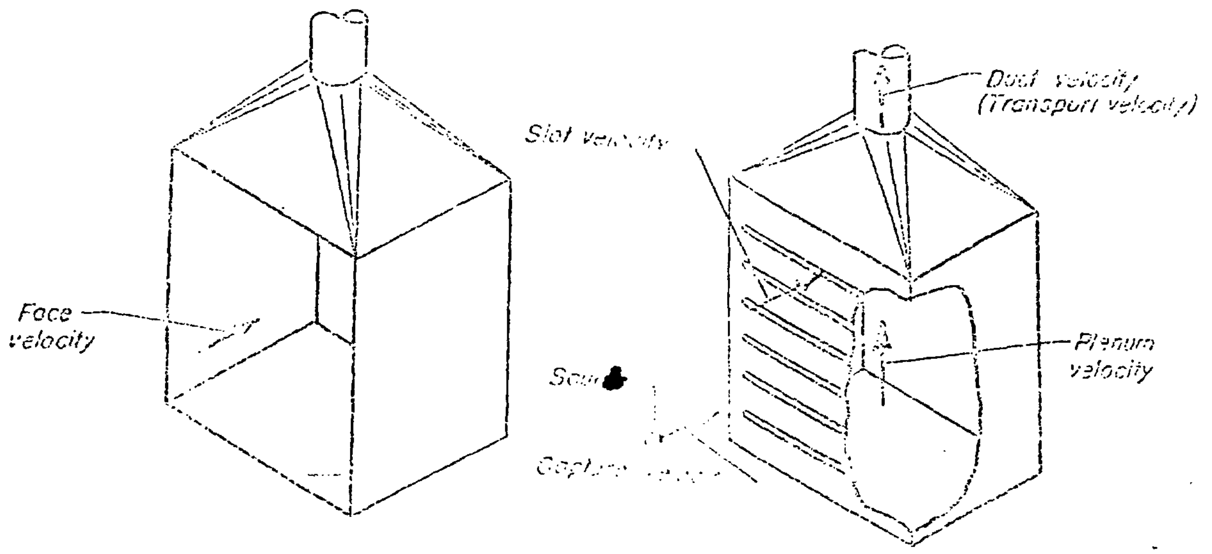
[illegible] hoods are effective for the control of hot processes and for those operations which release sudden [illegible] of hot gases and vapors. Canopies should not be used where men must work directly over the operation [illegible] the case of plating tanks and cementing tables since the flow of air passes the worker's breathing [illegible] increase his exposure to toxic materials.

[illegible] duct takeoffs will be located, when possible, to be in the line of normal contaminant travel and [illegible] so desired distribution of exhaust air flow is attained. In the case of large shallow hoods, [illegible] tends to concentrate in front of the duct opening. Satisfactory air distribution can be attained [illegible] multiple takeoffs or by installing interior baffles or filter banks.

[illegible]

[illegible] possible, flanges should be provided to eliminate air flow from ineffective zones where no [illegible]. Increasing the hood effectiveness in this manner will usually reduce air requirements by [illegible] (See Figures 4-2, 4-3 and 4-4.) For most applications the flange width can be equal to the hood diameter [illegible] not exceed 6 in.

[illegible] the hood design has been determined that exhaust volume requirements can be calculated. [illegible] volumes are calculated from the known open area of the hood and the selection of the capture [illegible] sufficient to prevent outward escapement. Where enclosure of the process is impractical [illegible] pattern in front of the hood must be such that selected capture velocities will be maintained [illegible], conveying the contaminant to the hood opening.




*Capture Velocity* — Air velocity at any point [illegible] the hood or at the hood opening necessary to overcome [illegible] opposing air currents and to capture the contaminated [illegible] point by causing it to flow into the hood.

*Face Velocity* — Air velocity at the hood [illegible]

*Slot Velocity* — Air velocity through the [illegible] slot-type hood, fpm. It is used primarily as a means [illegible] uniform air distribution across the face of the hood.

*Plenum Velocity* — Air velocity in the plenum [illegible] For good air distribution with slot-types of hoods [illegible] plenum velocity should be 1/2 of the [illegible] or less.

*Duct Velocity* — Air velocity through the [illegible] section, fpm. When solid material is present in the air [illegible] the duct velocity must be equal to the minimum Transport [illegible] velocity.

*Transport (Conveying) Velocity* — Minimum [illegible] required to move the particulates [illegible] stream, fpm.

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[illegible] INDUSTRIAL HYGIENISTS

[illegible] OF EXHAUST HOODS

DATE [illegible] | Fig. 4-1

Plain Openings

Air will move in all directions toward openings under suction. By definition, 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.) Figure 4-2 illustrates air flow in front of a circular opening.

The equation of flow before free hanging hoods (Reference 9) for round hoods, and rectangular hoods which are essentially square, is:

$$V = \frac{Q}{10X^2 + A}$$

Where:

- 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 1-1/2 D)
- Q = Air flow, cfm.
- A = Area of hood opening in square feet.
- D = Diameter of round hoods or side of essentially square hoods.

As can be seen from this equation and from Figure 4-2, there is a rapid velocity decrease with increasing distances from the hood, varying almost inversely with the square of the distance.

Where distances of X are greater than 1-1/2D, the velocity decreases less rapidly with distance than the above equation indicates (See References 38 and 54).

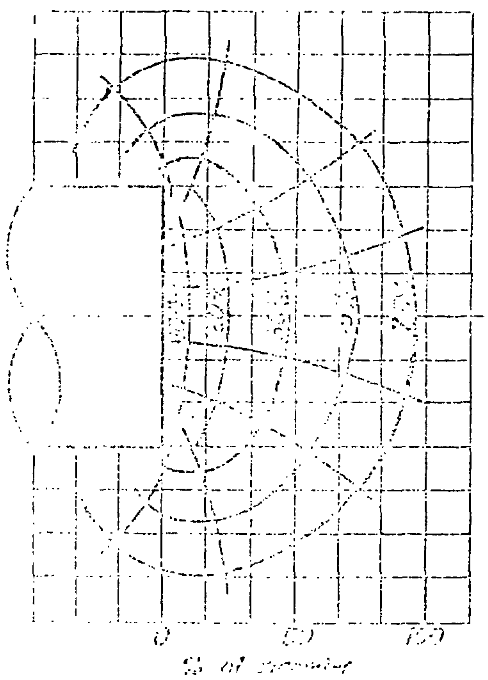



Fig. 4-2

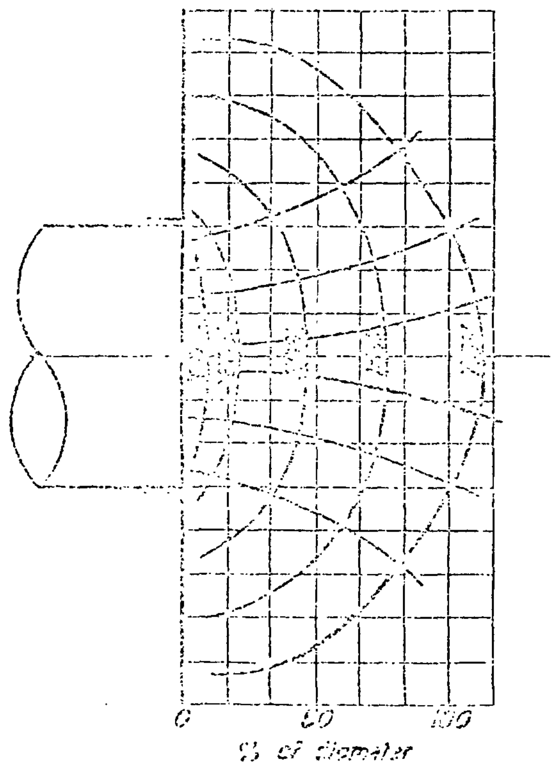



Fig. 4-3

Flow contours (expressed in percentage of opening velocity) and streamlines for circular openings.

The above formula applies to air flow conditions in front of freely suspended plain openings. Figure 4-3 illustrates other hood types and gives the air volume formulas which apply.

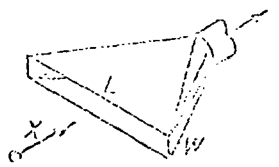
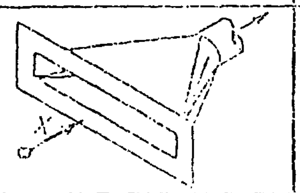
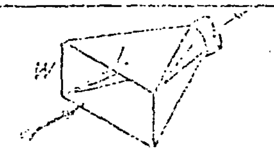
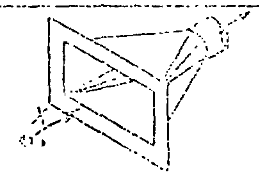
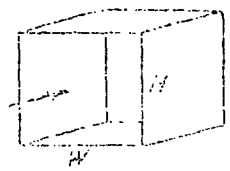
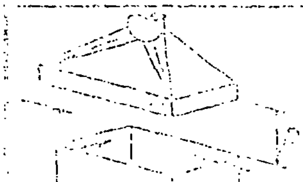
| HOOD TYPE | DESCRIPTION | ASPECT RATIO, $\frac{W}{L}$ | AIR VOLUME |
|---|---|---|---|
|  | SLOT | 0.2 or less | $Q = 3.7\,LVX$ (Reference 58) |
|  | FLANGED SLOT | 0.2 or less | $Q = 2.8\,LVX$ (Reference 58) |
|  A = WL (sq. ft) | PLAIN OPENING | 0.2 or greater and round | $Q = V(10X^2 + A)$ (Reference 9) |
|  | FLANGED OPENING | 0.2 or greater and round | $Q = 0.75V(10X^2 + A)$ (Reference 9) |
|  | BOOTH | To suit work | $Q = VA = VWH$ |
|  | CANOPY | To suit work | $Q = 1.4PDV$ See VS-903 P = perimeter of work D = height above work |

Fig. 4-1

Capture Velocities

Capture velocity is the velocity at any point in front of the hood necessary to overcome opposing air currents and to capture the contaminated air by causing it to flow into the exhaust hood.

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

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

Table 4-1 offers capture velocity data. Additional information is found in Section 5, Table 5-9-2.

TABLE 4-1

RANGE OF CAPTURE VELOCITIES (7,24)

| Condition of Dispersion of Contaminant | Examples | 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 of 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.

## Hood Design Procedure

Effective control of a contaminant producing process is brought about by first eliminating or minimizing all air motion about the process and then capturing the contaminated air by causing it to flow into the exhaust hood. Flow toward the suction opening must be sufficiently high to maintain the necessary capture velocity [illegible] opposing air currents.

[illegible] of sources of air motion as a first step in hood design is an important factor in cutting down [illegible] volume and the corresponding power consumption. Important sources of air motion are:

1. [illegible] air currents, especially from hot processes or heat-generating operations.
2. [illegible] machinery, as by a grinding wheel, belt conveyor, etc.
3. [illegible] motion, as in dumping or container filling.
4. [illegible] of the operator.
5. [illegible] air currents (which are usually taken at 50 fpm minimum and may be much higher).
6. [illegible] and heating equipment.

[illegible] the hood, its size, location and rate of air flow are important design considerations.

[illegible] should enclose the operation as much as possible. If enclosure is not practicable, the hood should [illegible] as possible to the source and shaped to control the area of contamination.

[illegible] should be used whenever possible to eliminate exhausting air from ineffective areas (see page 4-1) [illegible] decrease the hood entry loss.

[illegible] Coefficient and Static Pressure

[illegible] air enters an opening, a typical flow pattern results as shown in Figure 4-2. Maximum [illegible] of the air stream occurs at a short distance downstream at the plane of the vena contracta where [illegible] the jet is smaller than the diameter of the duct.

[illegible] of the vena contracta is accompanied by a conversion of static pressure to velocity pressure [illegible] pressure back to static pressure. A loss of about 2% in static pressure results from the [illegible] to velocity pressure and a much greater loss in static pressure results from the conver- [illegible] velocity pressure at the vena contracta to static pressure as the air fills the duct. The area of the [illegible] the vena contracta will vary with the shape of the hood or duct opening and for most hood shapes [illegible] 100% of the duct area.

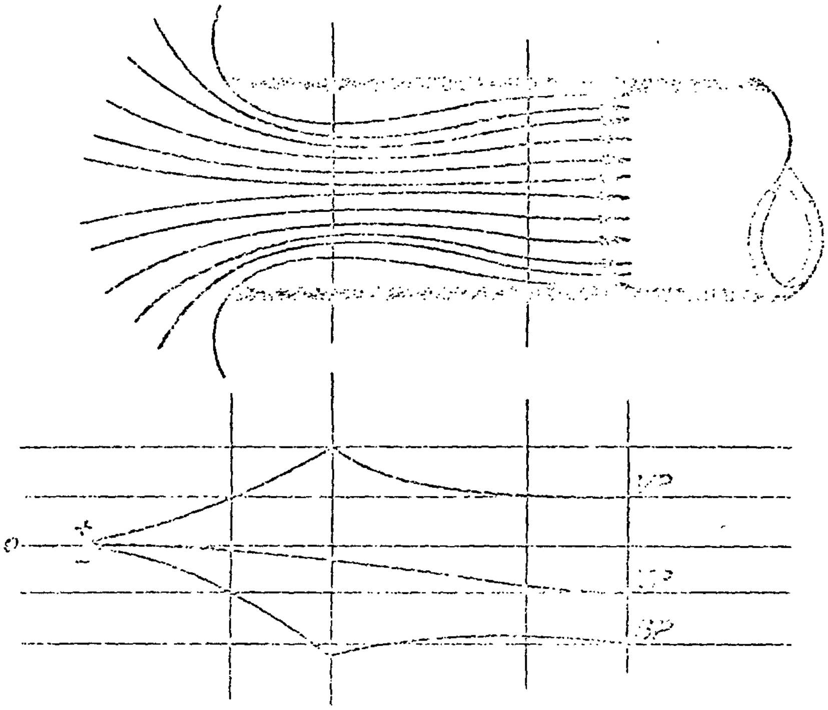



Fig. 4-5. Air flow at the vena contracta.

The losses due to pressure conversion result in a decreased rate of flow as indicated by the coefficient of entry, $C_e$. The coefficient of entry is defined as the actual rate of flow caused by a given static pressure compared to the theoretical flow which would result if the static pressure could be converted to velocity pressure with 100% efficiency. It is the ratio of actual to theoretical flow. Figure 4-6 provides $C_e$ values for many hood types.

Coefficient of entry $C_e$ represents the percentage of flow that will occur into a given hood based on the SP developed in the branch. CFM for any hood can be written either in the usual ($4005\ A\ \sqrt{VP}$) or as ($4005\ A\ C_e\ \sqrt{SP_h}$)

$$Q = 4005\ A\ \sqrt{VP} = 4005\ A\ C_e\ \sqrt{SP_h}$$

$$C_e = \sqrt{\frac{VP}{SP_h}}$$

Hood entry loss, $h_e$, is another convenient means of determining air flow through a hood and can be defined as representing the loss in pressure caused by air flowing into a duct.

$SP_h$ at hood = VP in the duct + $h_e$. Relationship between $C_e$ and $h_e$ can be derived as follows:

$$C_e = \sqrt{\frac{VP}{SP_h}}$$

Substitute: $SP_h = VP + h_e$

$$C_e = \sqrt{\frac{VP}{VP + h_e}}$$

$$C_e^2 = \frac{VP}{VP + h_e}$$

$$h_e = \frac{VP}{C_e^2} - VP$$

$$= \frac{(1 - C_e^2)}{(C_e^2)}\ VP$$

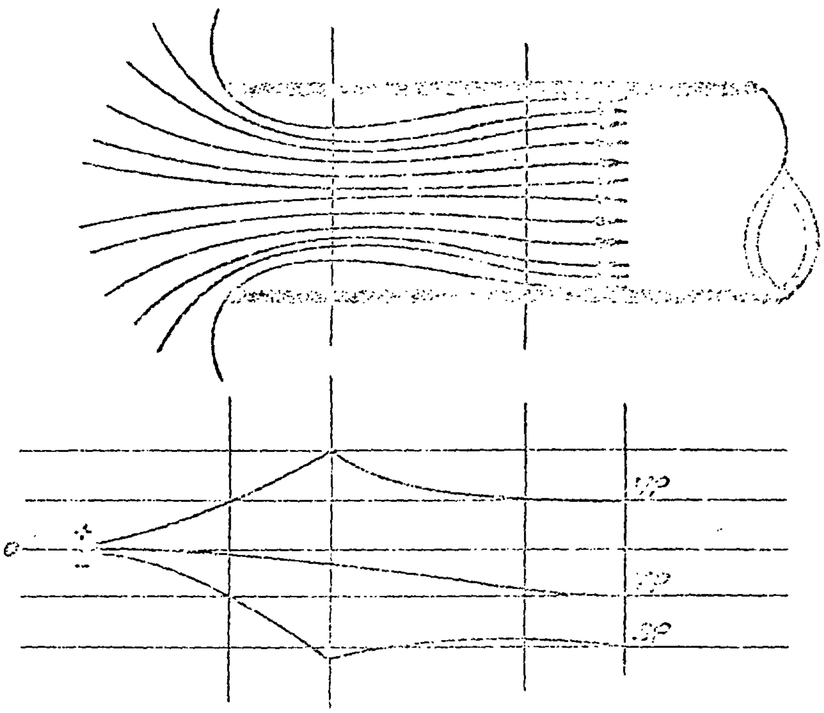



Fig. 4-5. Air flow at the vena contracta.

The losses due to pressure conversion result in a decreased rate of flow as indicated by the coefficient of entry, $C_e$. The coefficient of entry is defined as the actual rate of flow caused by a given static pressure compared to the theoretical flow which would result if the static pressure could be converted to velocity pressure with 100% efficiency. It is the ratio of actual to theoretical flow. Figure 4-8 provides $C_e$ values for many hood types.

Coefficient of entry $C_e$ represents the percentage of flow that will occur into a given hood based on the SP developed in the branch. CFM for any hood can be written either in the usual ($4005\ A\ \sqrt{VP}$) or as ($4005\ A\ C_e\ \sqrt{SP_h}$)

$$Q = 4005\ A\ \sqrt{VP} = 4005\ A\ C_e\ \sqrt{SP_h}$$

$$C_e = \sqrt{\frac{VP}{SP_h}}$$

Hood entry loss $h_e$ is another commonly used means of determining air flow through a hood and can be defined as representing the loss in pressure caused by air flowing into a duct.

$SP_h$ at hood = VP in the duct + $h_e$. Relationship between $C_e$ and $h_e$ can be derived as follows:

$$C_e = \sqrt{\frac{VP}{SP_h}}$$

Substitute: $SP_h = VP + h_e$

$$C_e = \sqrt{\frac{VP}{VP + h_e}}$$

$$C_e^2 = \frac{VP}{VP + h_e}$$

$$h_e = \frac{VP}{C_e^2} - VP$$

$$= \frac{(1 - C_e^2)}{(C_e^2)}\ VP$$

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It is, therefore, desirable to minimize the air stream contraction which occurs at the vena contracta zone by suitable hood design. Figure 4-8 illustrates the effect of hood design on the entry coefficient and on the entry loss in terms of velocity head in the connecting duct, the latter being another way of expressing hood entry loss.

Considering the grinding wheel hood shown in Figure 4-8, some typical calculations are as follows:

Example Problem I

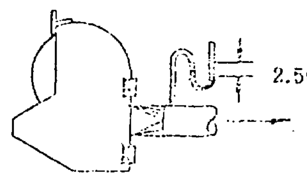
**GIVEN**

$C_e = 0.78$

$SP_h = 2.50$ inches water

Duct Diameter = 5 inches

Duct Area = 0.136 square feet




where $SP_h$ = static pressure, inches water

$VP$ = velocity pressure, inches water

$h_e$ = hood entry loss, inches water

$F_h$ = hood entry loss factor

**TO FIND**

a. Air Volume

b. Duct Velocity

c. Per Cent Loss in Velocity Head

a. $Q = 4005\ C_e\ A \sqrt{SP_h} = 4005 \times 0.78 \times 0.136 \sqrt{2.50} = 672$ cfm

b. $V = \frac{Q}{A} = \frac{672}{0.136} = 4950$ fpm

c. $VP = \left(\frac{V}{4005}\right)^2 = \left(\frac{4950}{4005}\right)^2 = 1.52$

$SP_h = VP + h_e$

$h_e = SP_h - VP = 2.50 - 1.52 = 0.98$

$F_h = \frac{0.98}{1.52} = 0.645$

% Loss = F × 100 = 0.645 × 100 = 64.5%

As a ventilation standard, static pressure alone without reference to the duct diameter is meaningless. Decreasing the branch duct size results in higher velocity, greater resistance and a lowered rate of flow although the static pressure value is increased. The ventilation performance of hoods should be based primarily on air volumes handled.

Slots for Air Distribution

[illegible] hoods are most commonly used to provide uniform exhaust air flow at adequate capture velocity over a [illegible] length of contaminant generation—such as an open tank—or over the face of a large hood such as a side [illegible] design. The function of the slot is solely to obtain proper air distribution. Slot velocity does not [illegible] to capture velocity; a high slot velocity simply generates high pressure losses. Note that the capture velocity equation (Figure 4-4) shows that the capture velocity is related to the exhaust volume and the [illegible] length, not the slot velocity.

[illegible] hoods usually consist of a narrow exhaust opening and a plenum chamber. Uniform exhaust air [illegible] across the slot is obtained by careful design. Splitter vanes may be used in the plenum; however, in [illegible] industrial exhaust systems vanes are subject to corrosion and/or erosion and provide locations for [illegible] build-up. Adjustable slots can be provided but these are subject to tampering and maladjustment. The most practicable hood is the fixed slot and unobstructed plenum type. The design of the slot and plenum [illegible] that the pressure loss through the slot is high compared with the pressure loss through the plenum. [illegible] all portions of the slot are subjected to essentially equal suction and the slot velocity will be essentially [illegible]

[illegible] no straightforward method for calculating the pressure drop from one end to the other of a slot-[illegible] combination. A very useful approximation, applicable to most hoods, is to design for a maximum [illegible] velocity equal to 1/2 of the slot velocity. For most slot hoods a 2,000 fpm slot velocity and 1,000 fpm [illegible] velocity is a reasonable choice for uniformity of flow and moderate pressure drop. Following are [illegible] design guidelines:

[illegible] design results in the smallest practical plenum size since the air approaches [illegible] directions. Where large, deep plenums are possible, as with [illegible] hoods, the slot [illegible] as low as 1,000 fpm with a 500 fpm plenum velocity.

[illegible] configurations require large plenum sizes because all of the air must pass in one direction.

Note that where slot-plenum hoods are used for dust control, plenum velocities must be 3,000 fpm or higher to transport particulate matter through the hood. Otherwise, settling and plugging will occur.

## Calculation of Static Pressure Losses in Exhaust Hoods

Simple Hoods: Plain duct openings, flanged duct openings, canopies and similar hoods have only one significant energy loss, at the point where the air enters the duct. At this location a pronounced vena contracta is formed and an energy loss occurs first in the conversion of static pressure to velocity pressure. As the air passes through the vena contracta, the flow area enlarges to fill the duct and velocity pressure converts to static pressure, again with some energy loss. The more pronounced the vena contracta, the greater will be the energy loss and hood static pressure. The hood entry loss ($h_e$) can be expressed therefore in terms of a single factor (F) which, when multiplied by the duct velocity pressure (VP), will give the entry loss ($h_e$) in inches of water.

### Example Problem II

In a simple hood (Figure 4-6) the hood static pressure is equal to the velocity pressure in the duct plus the hood entry loss. (See page 1-3, "Acceleration of Air and Hood Entrance Losses".) The velocity pressure represents the pressure necessary to accelerate the air from rest to the duct velocity; the hood entry loss represents the energy necessary to overcome the loss as the air enters the duct. This may be expressed as:

$$SP_h = h_{ed} + VP_d$$

when face velocity is less than 1000 fpm (when face velocity is higher than 1000 fpm, the hood should be treated as a compound hood. See following.).

Where: $h_{ed}$ = entry loss of transition (See Figure 6-10)

$VP_d$ = Duct Velocity Pressure

A typical calculation is as follows:

$$\text{Given: Face Velocity} = \frac{Q}{A_{face}} = 250\ fpm$$

$$\text{Duct Velocity} = \frac{Q}{A_{duct}} = 2000\ fpm$$

$$VP_d = 0.25''$$

$$F = 0.25\ VP_d$$

$$SP_h = h_{ed} + VP_d$$

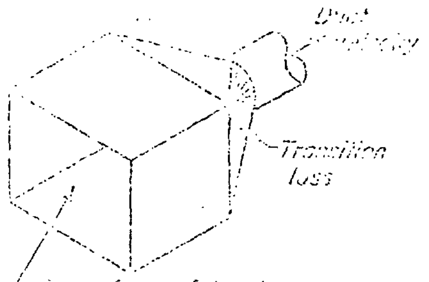



Fig. 4-6

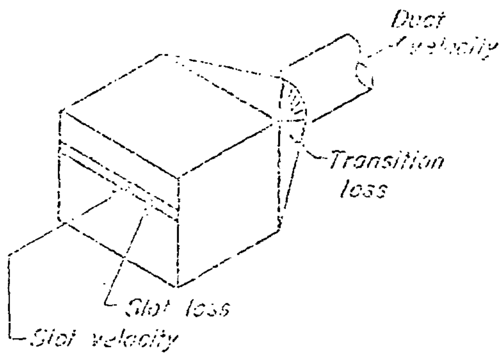



Fig. 4-7

[illegible] Hoods: Other types of hoods have two or more points of significant energy loss and must be [illegible] Common examples are hoods having double entry losses: slot type hoods and [illegible] hoods commonly used on plating, [illegible] dipping and degreasing tanks and [illegible] ventilation.

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Figure 4-7 illustrates a double entry loss hood; this is a single slot hood with a plenum and a transition from the plenum to the duct. The purpose of the plenum is to give uniform velocity across the slot opening. Air enters the slot, in this case a sharp-edged orifice, and loses energy due to the vena contracta at this point. The air then continues through the plenum where the greater portion of the slot velocity is retained because the air stream projects itself across the plenum in a manner similar to the "blowing" supply stream shown in Figure 1-6. (The retention of velocity in the plenum is characteristic of most local exhaust hoods because of the short plenum length. In the case of very large hoods or exhausted sealed rooms, however, the velocity loss must be taken into account.) The air then converges into the duct through the transition where the second significant energy loss occurs.

Example Problem III

In Figure 4-7 the air enters the slot, a slot entry loss occurs and the air is accelerated to the slot velocity. It then crosses the plenum and enters the duct through the hood transition where another entry loss occurs and the air is accelerated further from its initial velocity in the slot to the higher duct velocity. In most cases, the slot velocity is equal to or lower than the duct velocity; in all cases, however, the air must be accelerated to the higher velocity.

The hood static pressure for a double entry hood can be expressed as the equation:

$$SP_h = h_{es} + VP_s + h_{ed} + VP_d - VP_s$$

then: (1) $SP_h = h_{es} + h_{ed} + VP_d$ when duct velocity is greater than slot velocity

(2) $SP_h = h_{es} + h_{ed} + VP_s$ when slot velocity is greater than duct velocity

where: $h_{es}$ = entry loss through slot (See Figure 6-10)

$VP_s$ = slot velocity pressure

$h_{ed}$ = entry loss of transition (See Figure 6-10)

$VP_d$ = duct velocity pressure

Some typical calculations, using "Equation 1", are as follows:

| Plating Hood | Foundry Shakeout Hood |
| --- | --- |
| Slot velocity = $\frac{Q}{A_{slot}}$ = 20[illegible] fpm | Slot velocity = 1000 fpm |
| $VP_s$ = [illegible]" | $VP_s$ = 0.07" |
| $h_{es}$ slot = 1.78 $VP_s$ | $h_{es}$ slot = 1.78 $VP_s$ |
| Duct velocity = $\frac{Q}{A_{duct}}$ = [illegible] fpm | Duct velocity = 3500 fpm |
| $VP_d$ = [illegible] | $VP_d$ = 0.76" |
| $h_{ed}$ transition = 0.25 $VP_d$ | $h_{ed}$ transition = 0.25 $VP_d$ |

$$SP_h = h_{es} + h_{ed} + VP_d$$

[illegible]

$$SP_h = 1.78\ VP_s + 0.25\ VP_d + VP_d$$

| Plating Hood | Foundry Shakeout Hood |
| --- | --- |
| $SP_h$ = (1.78 × 0.[illegible]) + (0.25 × 0.25) + 0.25 | $SP_h$ = (1.78 × 0.07) + (0.25 × 0.76) + 0.73 |
| $SP_h$ = 0.77[illegible]" ≈ 0.7[illegible]" | $SP_h$ = 1.0746" ≈ 1.07" |

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The use of "Equation 2" is illustrated in the case of a hood where:

Slot velocity = 4000 fpm
Duct velocity = 2000 fpm
$VP_s$ = 1.00"
$VP_d$ = 0.25"

$$SP_h = h_{es} + h_{ed} + VP_s^{*}$$
$$= (1.78 \times 1.00") + (0.25 \times 0.25") + 1.00"$$
$$SP_h = 2.8425" = 2.84"$$

* In an actual installation there may be some regain of the higher VP as the air passes through the hood. It is not possible to predict this, however, and it is better to assume that the *energy requirement* is as shown.

Certain hoods may be constructed with internal baffles and/or slots and can have more than two significant energy losses. In such cases, a simple step-by-step calculation of all losses will result in an accurate determination of $SP_h$.

Ventilation of Radioactive and High Toxicity Operations

Ventilation of radioactive and high toxicity processes requires a knowledge of the hazards, the use of proven control methods and adequate maintenance, including monitoring. While the degree of air or gas cleanliness required will vary with the operation, in most cases the order of cleaning before discharge to atmosphere will be considerably beyond the more usual industrial clean air standards.

The chemical laboratory exhaust hood (VS-203) illustrates typical design criterion. The influence of eddy currents from air supply systems, the care in sizing and locating exhaust connections, the study of air flow patterns within the hood and the cleaning of exhaust gases are much more involved than the rule of thumb design efforts for usual laboratory hoods where dilution ventilation greatly contributes to satisfactory control. The same care is mandatory for air supply and exhaust systems and the selection of air cleaning equipment. Air cleaning of supply air is normally of a high order of efficiency and the exhaust air cleaning is often a combination of high-efficiency collectors or filters backed up by absolute or ultra high-efficiency designs.

Exposure of service personnel and contamination hazards from servicing or replacing collector or filter elements justify the expensive equipment so often encountered. Wet dust collector designs in place of inexpensive air filters may store material more safely and may make contamination of an area less likely. Reverse jet fabric arresters will often be used in place of less expensive conventional fabric because there are fewer feet of air seals to leak and fewer elements to be replaced. Scalping or prefilters installed in series with absolute filters will reduce replacement cycle, reduce handling, waste disposal and possible contamination problems.

The following general rules should be followed in the design of hoods for radioactive and high toxicity materials:

1. Operations in which radioactive materials are handled should be enclosed as much as possible to prevent contaminating large air volumes. (The use of glove boxes minimizes air volumes and simplifies [illegible].)
2. [illegible] velocities and cross-drafts should be avoided because they may increase contamination and dust loading [illegible].
3. The volume of air withdrawn from the hood must be greater than the volume of contaminated gases, [illegible] gases created in the hood.
4. If possible, the operations requiring large amounts of wet digestion and volatilized acid or solvent treatment should be confined to one group of hoods and the handling of dry material in others.
5. Wherever possible, radioactive aerosols should be removed by filtration as close to the hood as practical to prevent unnecessary contamination of equipment and ductwork.
6. The value or recoverability of the material may require a design so that even the smallest chips and [illegible] can be reclaimed.
7. An adequate supply of coolant inside the hood may be necessary, depending on the *pyrofori*c nature of the contaminant.
8. Accessibility for decontamination of the hood and duct system must be made as easy as possible and [illegible] stainless steel is used for the metal parts of the hood for this reason.
9. [illegible] be located so ductwork within the building is under a negative pressure.

[illegible] laboratory type hoods, an average face velocity of 125-200 fpm and a minimum face velocity [illegible] would be necessary to insure that no contaminant would escape into the room. In addition, face velocities of laboratory hoods with adjustable fronts should be controlled within reasonable limits in order to reduce the disturbances of air-borne materials within the hood. This velocity control can be accomplished by either proportional bypass (constant volume) or controlled face velocity (variable volume). Hoods with high heat loads should have a major portion of the air exhausted through the slot at the top.

In the laboratory handling of high alpha or beta emitters, enclosed glove boxes should be used. With the necessary tight construction, an exhaust volume of from 35 to 50 cfm is usually sufficient for these enclosures. The air locks needed with these hoods should be exhausted if they open directly to the room.

Adequate quantities of makeup air must be furnished by mechanical supply systems and intelligently distributed with relation to exhaust points. Supply air distribution must be arranged to provide general air flow from clean areas toward more contaminated areas. Filtration of supply air is necessary to reduce air-borne dust concentrations, thus prolonging the life of ultrahigh efficiency exhaust filters.

The use of prefilters in laboratory type hoods for radioactive materials prevents contamination of the exhaust piping. A gauge should be installed indicating pressure drop across the filter, so that the filter will be replaced when pressure drop exceeds design value. Filtration of room supply air will prolong the life of ultra high efficiency hood exhaust filters.

Where there is a possibility of spontaneous or continuous release of toxic materials, or where several hoods are connected to a single exhaust system the exhaust fan should be operated continuously. Standby fan capacity should be available for breakdowns.

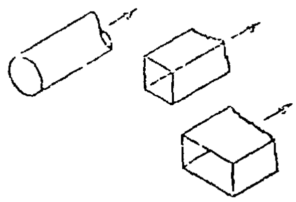
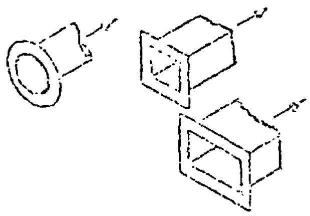
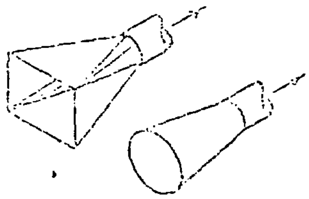
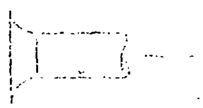
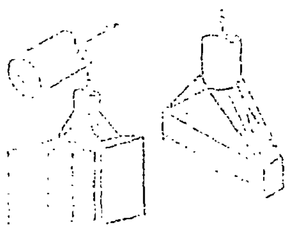
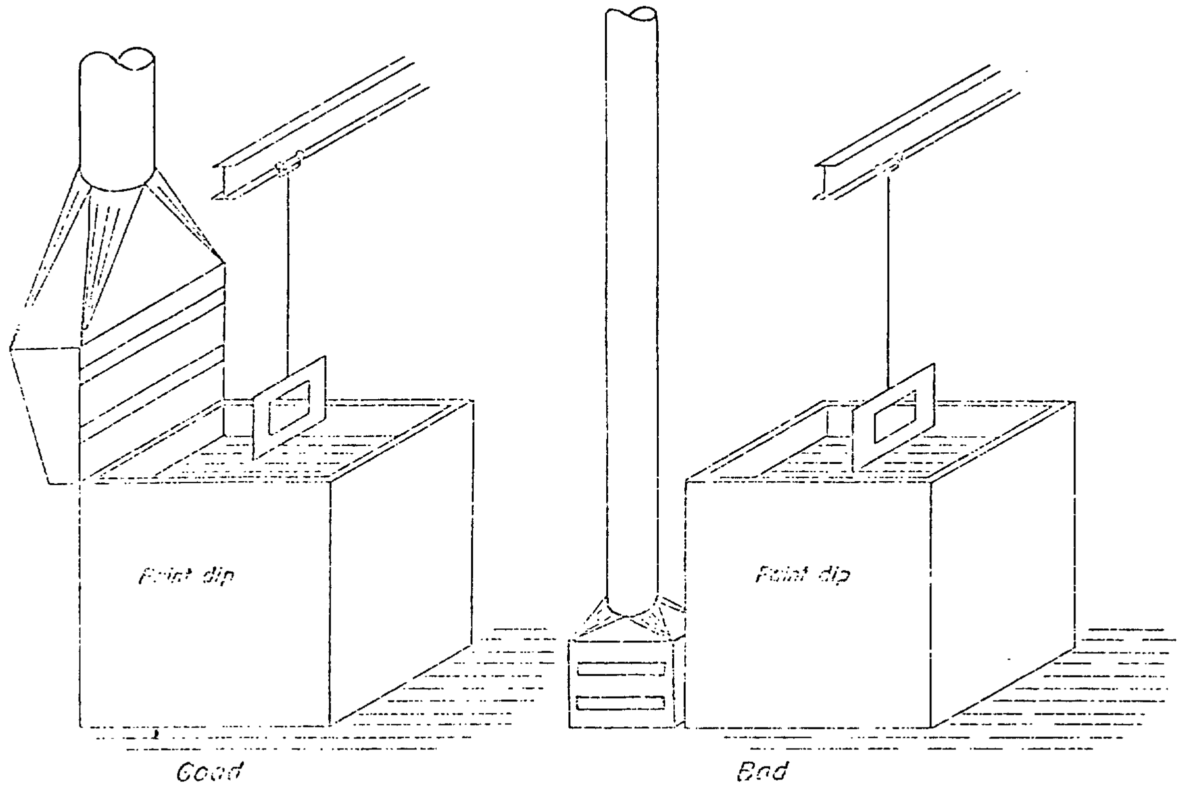
| HOOD TYPE | DESCRIPTION | COEFFICIENT OF ENTRY, Ce | ENTRY LOSS |
|---|---|---|---|
|  | PLAIN OPENING | 0.72 | 0.93 VP |
|  | FLANGED OPENING | 0.82 | 0.49 VP |
|  | TAPER or CONE HOOD | Varies with angle of taper or cone. See Fig. 6-10 | |
|  | BELL MOUTH INLET | 0.98 | 0.04 VP |
|  | ORIFICE | See Fig. 6-10 | |
|  | TYPICAL GRINDING HOOD | STRAIGHT TAKE-OFF 0.78 | 0.65 VP |
| | | TAPERED TAKE-OFF 0.85 | 0.40 VP |

Fig. 4-8

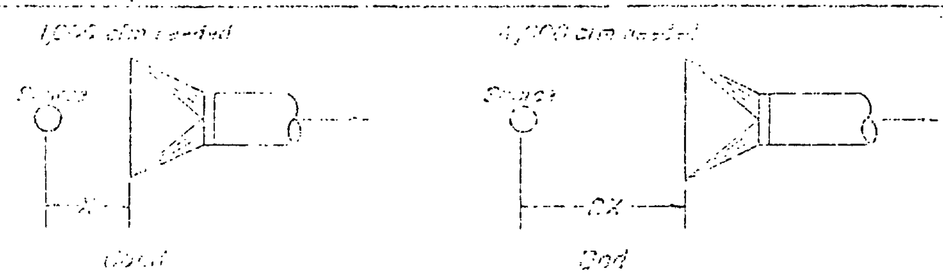
CAPCO KIN 0000487




LOCATION

Solvent vapors in health hazard concentrations are not appreciably heavier than air. Exhaust from the floor usually gives fire protection only.

| | | |
|---|---|---|
| Example: | Density of air | 1.0 |
| | Density of 100% amyl acetate vapor | [illegible] |
| | Density lowest explosive mixture | 1.0[illegible] |
| | Density T.L.V. mixture | 1.00[illegible] |




LOCATION

Place hood as close to the source of contaminant as possible. The required [illegible] varies as the square of the [illegible] from the source.

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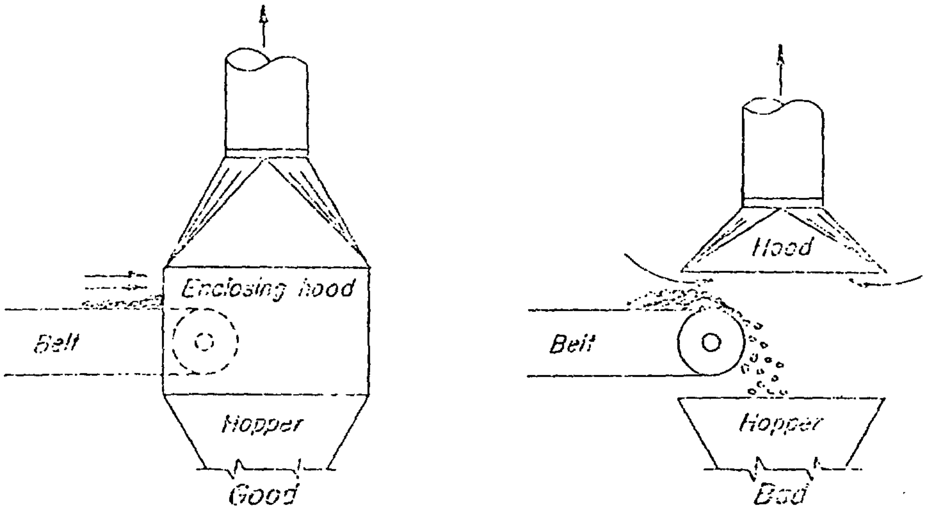
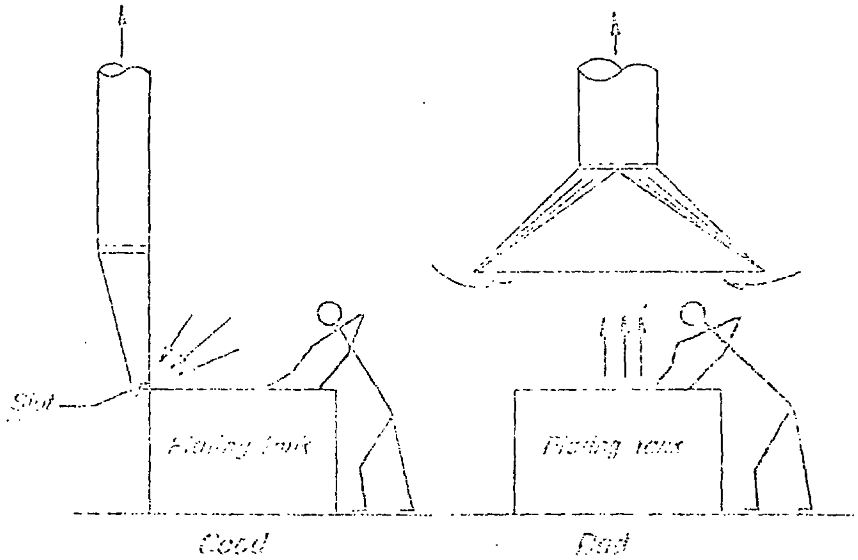
PRINCIPLES OF EXHAUST HOODS

DATE 1-64 | Fig. 4-[illegible]




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 worker.*

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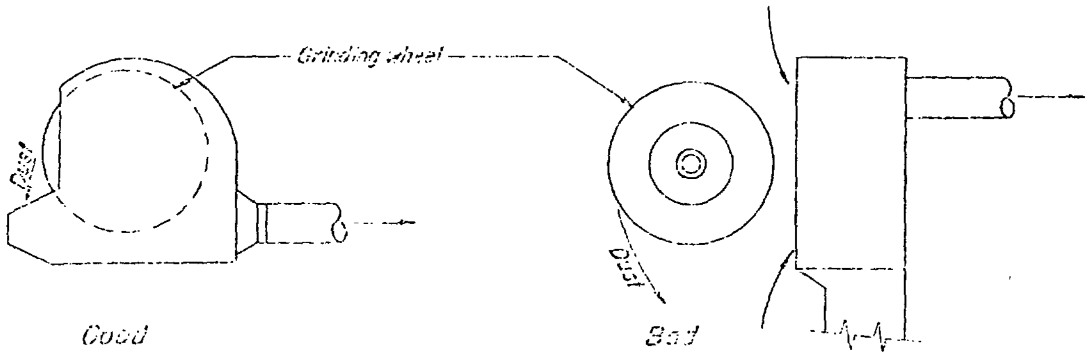
PRINCIPLES OF EXHAUST HOODS

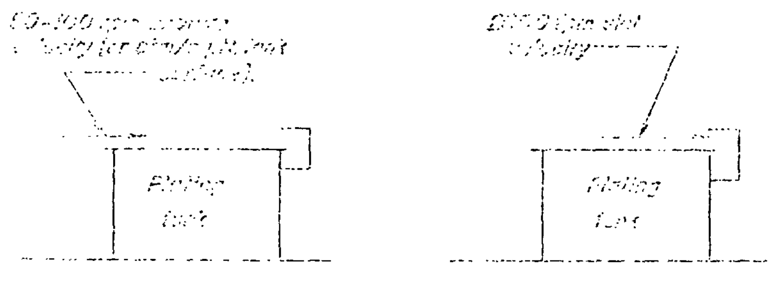
DATE 1-64 | Fig. 4-10

CAPCO KIN 0000489




LOCATION

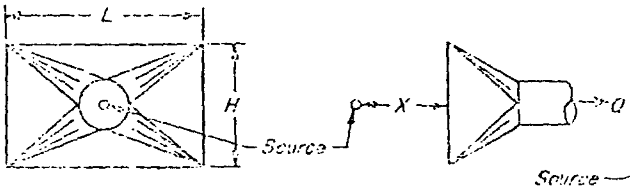
*Locate and shape the hood so the original velocity of the contaminant will throw it into the hood opening.*

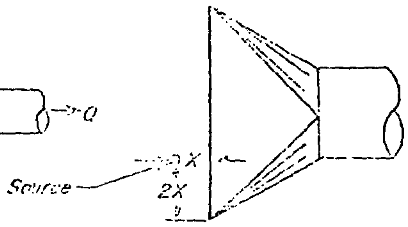



CAPTURE VELOCITY OR PROPER VOLUME

[illegible] the source sufficient to [illegible]
[illegible] (see [illegible]). Many
[illegible]
[illegible]
[illegible] of source.
[illegible] basis.

| | |
|---|---|
| AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS | |
| PRINCIPLES OF EXHAUST HOODS | |
| DATE 1-64 | Fig. 4-11 |



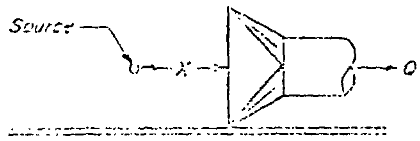

FREELY SUSPENDED HOOD

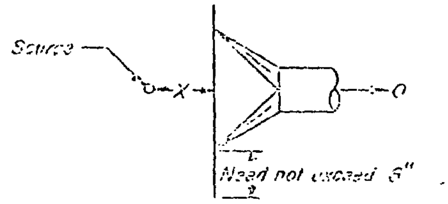
$Q = (10X^2 + A)V$

Refer to Section 4

LARGE HOOD

Large hood, X small -- measure X perpendicular to hood face, not less than 2X from hood edge.




HOOD ON BENCH OR FLOOR

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

HOOD WITH WIDE FLANGE

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

SUSPENDED HOODS

(Small side-draft hoods)

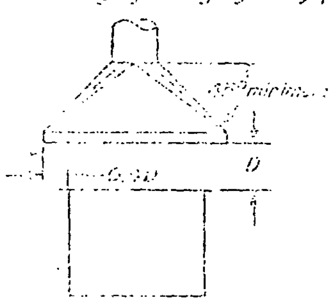
Q = Required exhaust volume, cfm

X = Distance from hood face to farthest point of contaminant release, feet.

A = Hood face area, sq ft

V = Capture velocity, fpm, at distance X.

Note: Air volume must increase as the square of distance of the source from the hood. Cutting 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 material is toxic and workers must bend over source. V ranges from 50 to 500 fpm depending on crossdrafts. Side curtains on two or three sides to make a booth or hoods are desirable. Suitable for steam vapor or other innocuous material.

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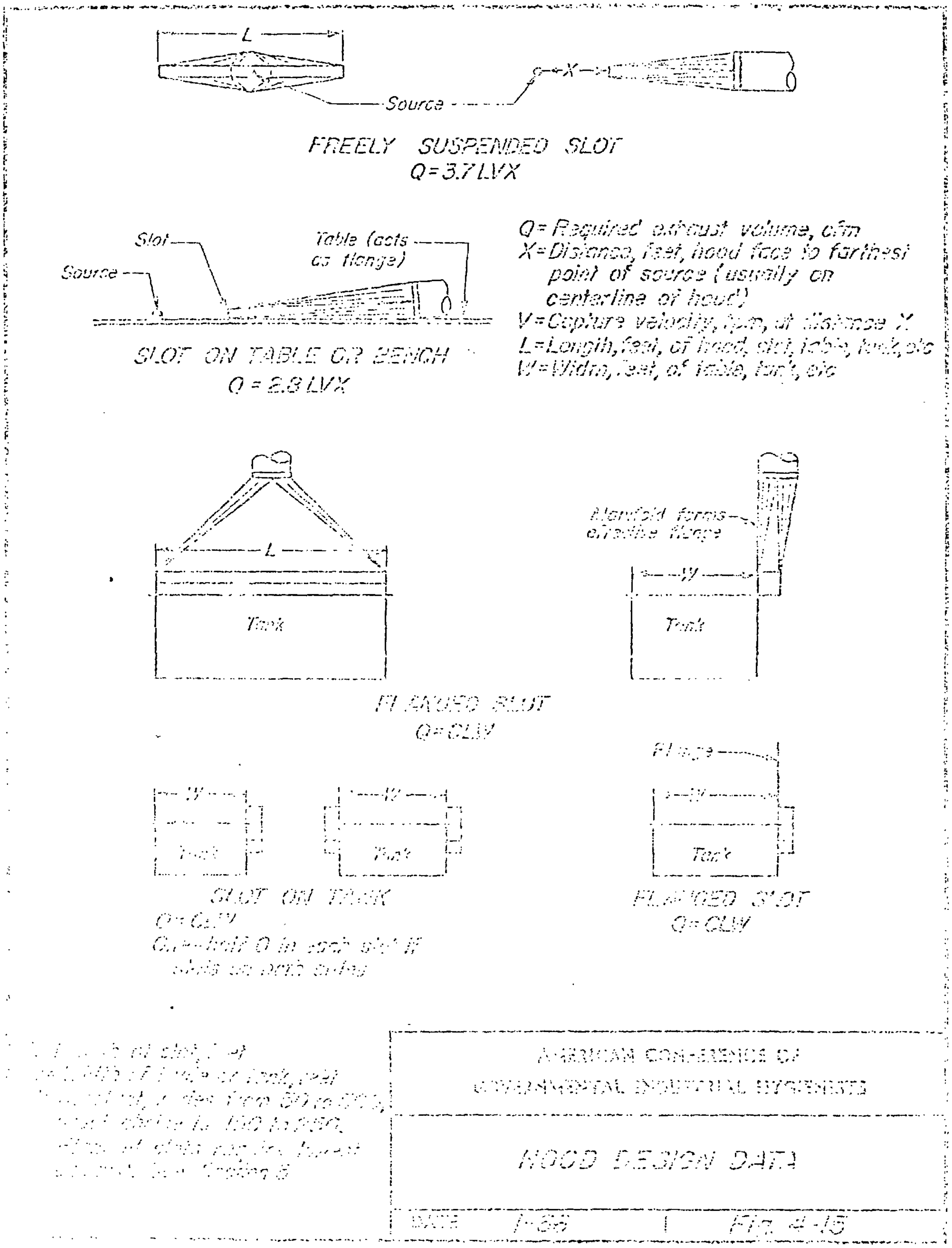
HOOD DESIGN DATA

| DATE 1-65 | Fig. 4-14 |
|---|---|

CAPCO KIN 0000491


L
Source
X
FREELY SUSPENDED SLOT
Q=3.7LVX
Q=Required exhaust volume, cfm
X=Distance, feet, hood face to farthest point of source (usually on centerline of hood)
V=Capture velocity, fpm, at distance X
L=Length, feet, of hood, slot, table, tank, etc
W=Width, feet, of table, tank, etc
Slot
Table (acts as flange)
Source
SLOT ON TABLE OR BENCH
Q = 2.8 LVX
L
Tank
Manifold forms effective flange
W
Tank
FLANGED SLOT
Q=CLW
Flange
W
Tank
Tank
Tank
SLOT ON TANK
Q=CLW
FLANGED SLOT
Q=CLW
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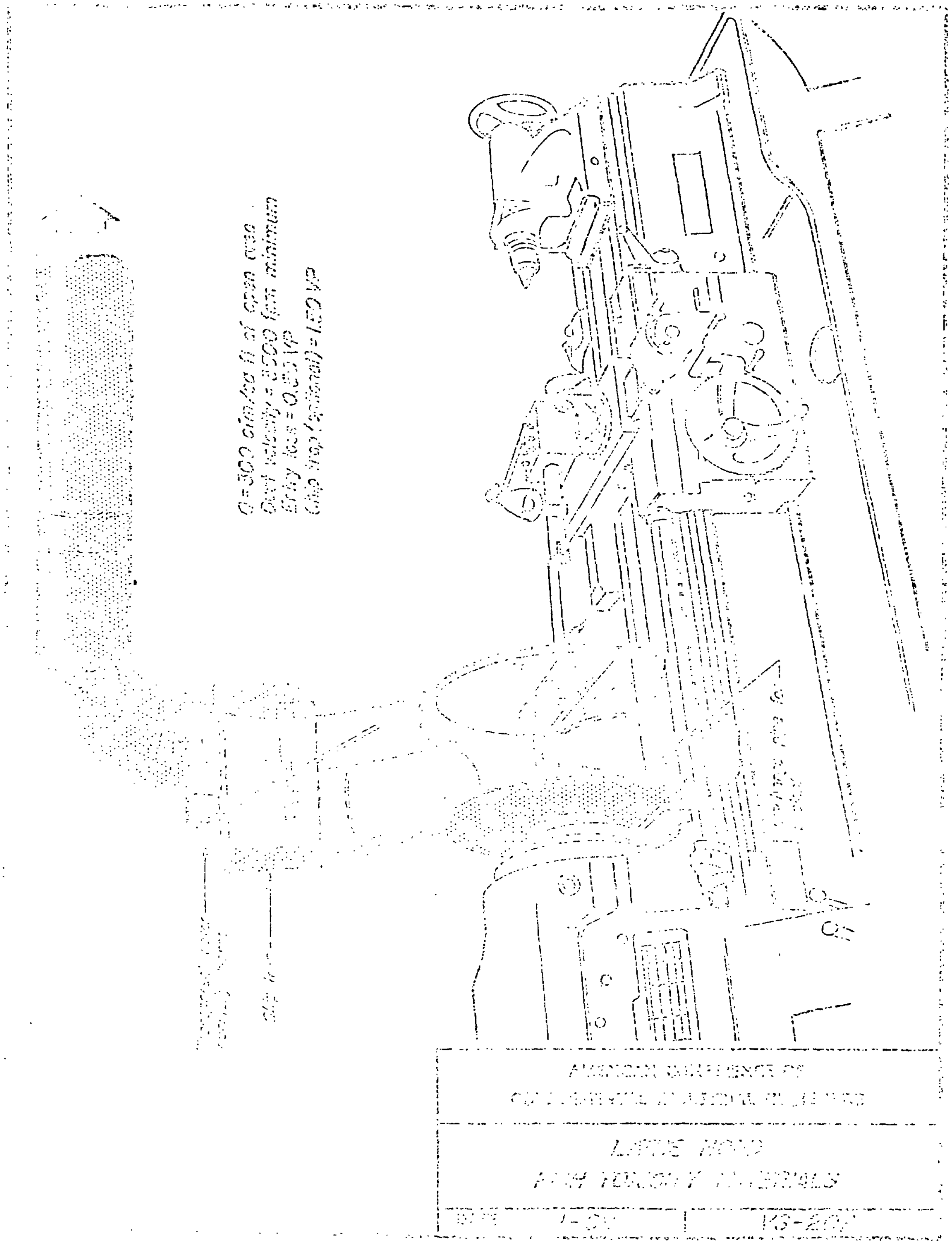
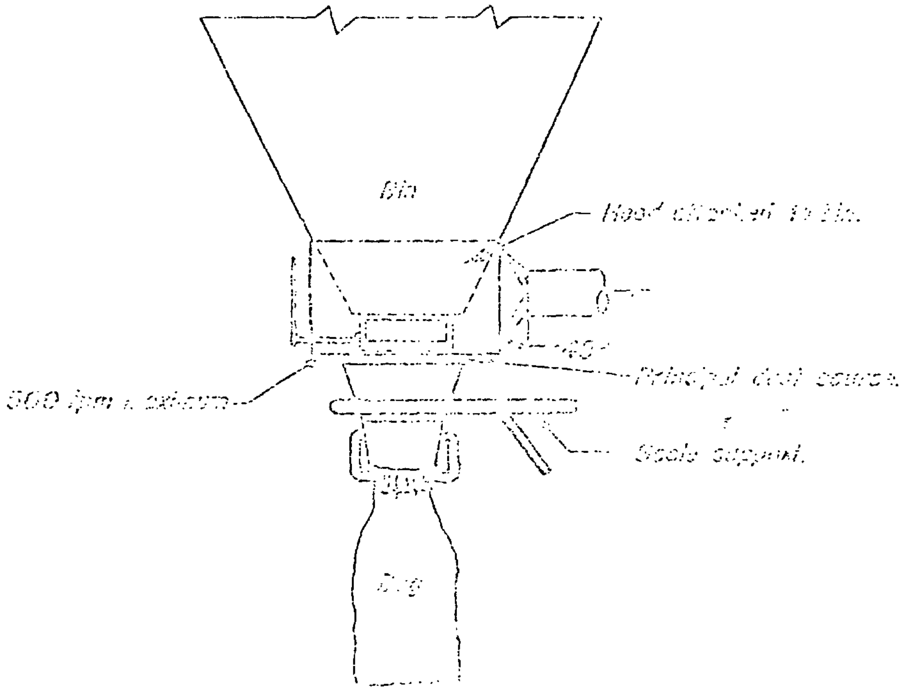
HOOD DESIGN DATA
DATE 1-58
Fig 4-15



Q = 300 cfm/sq ft of open area
Duct velocity = 3500 fpm minimum
Entry loss = 0.25 VP
Chip trap (optional) = 1.50 VP

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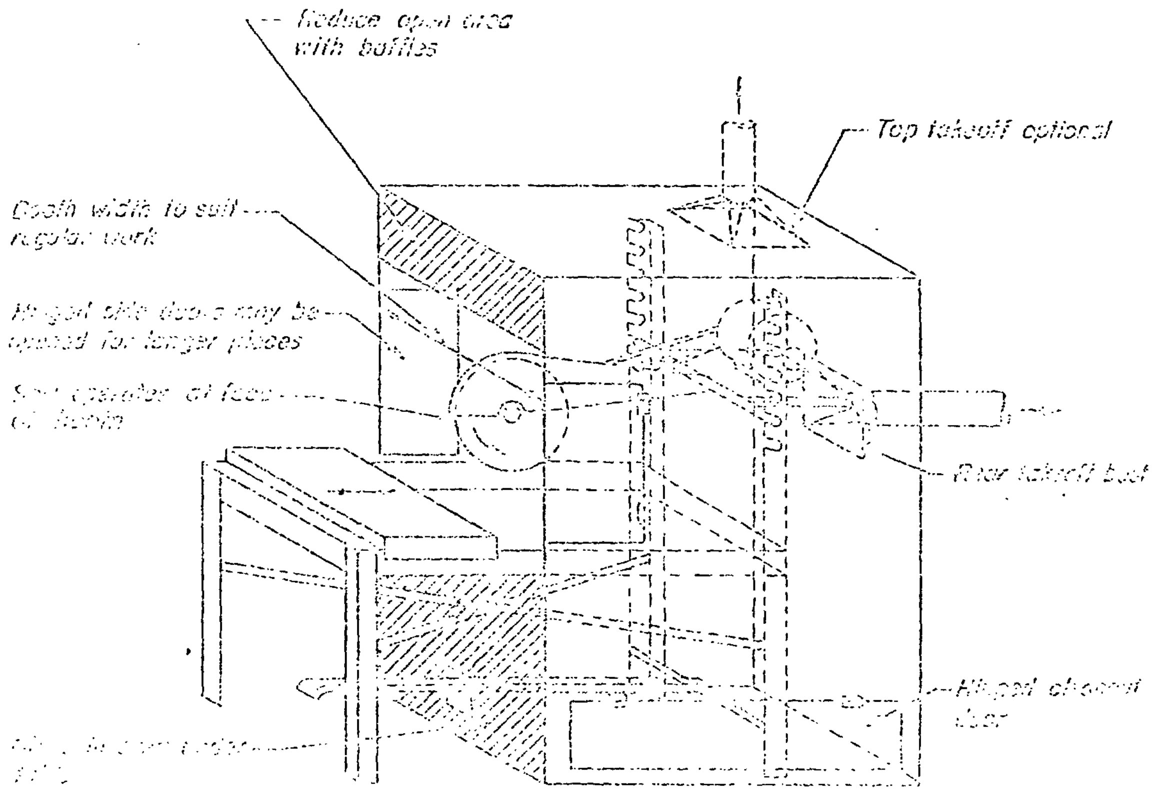
BAG FILLING

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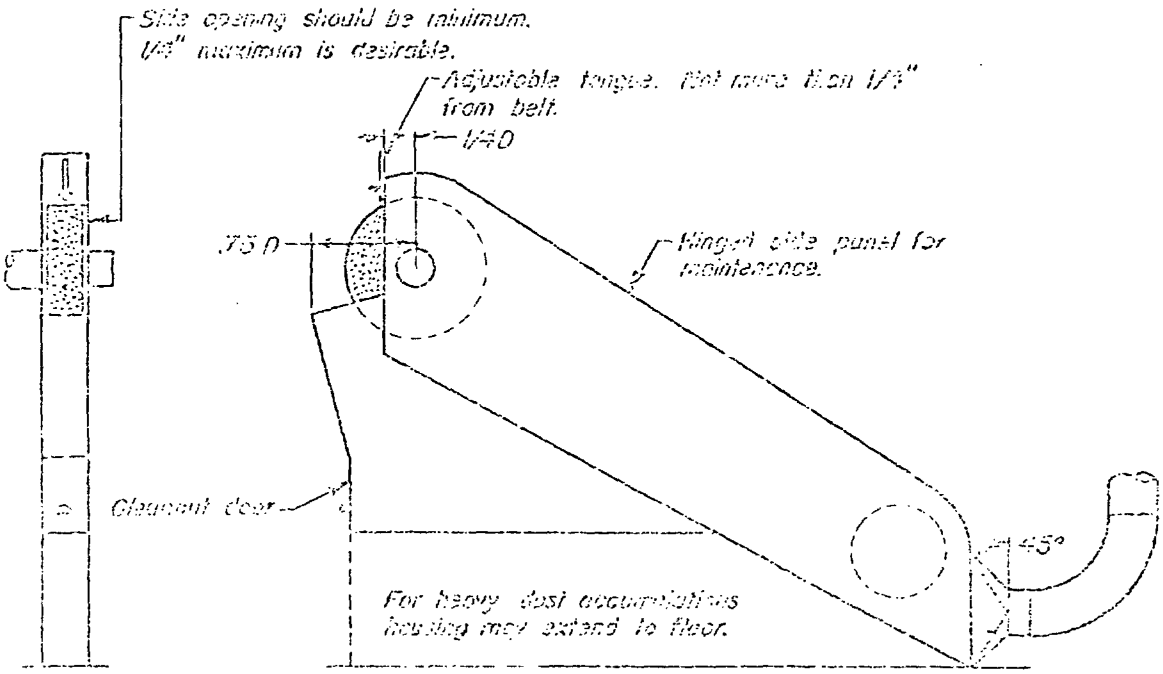
ABRASIVE CUT-OFF SAW VENTILATION




| Belt width inches | Exhaust volume cfm | Exhaust volume cfm |
|---|---|---|
| | Good enclosure * | Poor enclosure |
| 1 1/2 | 220 | [illegible] |
| 2 | 300 | [illegible] |
| 3 | 500 | 750 |
| 4 | 650 | 900 |
| 5 | 750 | [illegible] |
| 6 | 1000 | [illegible] |

* Hood as shown. No more than 25% of wheel exposed.

Entry loss = 0.40 VP

Duct velocity = 4500 fpm minimum

Note:

For titanium and magnesium eliminate hopper and use 5000 fpm through hood cross section.

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BACKSTAND IDLER POLISHING MACHINE

DATE 1-64 | VS-402