USEFUL EQUATIONS FOR THE ABIH EXAMINATIONS

This list of equations is offered as assistance in taking the ABIH examinations. No assurance is given that this list is complete or that the use of this list will assure the successful completion of any examination. The variables used are the same as found in the reference source for the equation. No attempt has been made to standardize variables. [Metric (SI) equations are in brackets]

VENTILATION

1 $Q = VA$ 2 $V_1A_1 = V_2A_2$ 3 $TP = VP + SP$ 4 $SP_1 + VP_1 = SP_2 + VP_2 + \sum losses_{1-2}$ 5 $SP_h = -\left((F_h + 1)\mathrm{VP}_d\right)$

6 $V = 4005\sqrt{\frac{VP}{df}}$ 7 $\left[V = 1.29\sqrt{\frac{VP}{df}}\right]$ 8 $VP = \left(\frac{V}{4005}\right)^2 df$ 9 $\left[VP = \left(\frac{V}{1.29}\right)^2 df\right]$ 10 $hood\ entry\ loss = F_h x VP_d$

11 $C_e = \sqrt{\frac{VP}{|SP_h|}}$ 12 $VP_r = \left(\frac{Q_1}{Q_3}\right)VP_1 + \left(\frac{Q_2}{Q_3}\right)VP_2$ 13 $Q = 4005(Ce)\sqrt{\frac{|SP_h|}{df}}(A)$ 14 $\left[Q = 1.29(Ce)\sqrt{\frac{|SP_h|}{df}}(A)\right]$

15 $Q = 4005C_eA\sqrt{|SP_h|}$ 16 $Q_{corr} = Q_{lower}\sqrt{\frac{SP_{gov}}{SP_{lower}}}$ 17 $Q' = \frac{Q}{m_i}$ 18 $t_2 - t_1 = -\frac{V_r}{Q'}ln\left(\frac{C_{g2}}{C_{g1}}\right)$

19 $ln\frac{(G - Q'C_{g2})}{(G - Q'C_{g1})} = -\frac{Q'(t_2 - t_1)}{V_r}$ 20 $Q = \frac{(403)(SG)(ER)(m_i)(10^6)}{(MW)(C_g)}$ 21 $\left[Q = \frac{(24)(SG)(ER)(m_i)(10^6)}{(MW)(C_g)}\right]$

22 $N_{changes} = \frac{60Q}{V_r}$ 23 $C_{g2} = \frac{G\left(1 - e^{-\left(\frac{Q'\Delta t}{V_r}\right)}\right)}{Q'}$ 24 $C_{g2} = C_{g1}e^{-\left(\frac{Q'\Delta t}{V_r}\right)}$ 25 $Q_2 = Q_1\left(\frac{d_2}{d_1}\right)^3\left(\frac{RPM_2}{RPM_1}\right)$

26 $P_2 = P_1\left(\frac{d_2}{d_1}\right)^2\left(\frac{RPM_2}{RPM_1}\right)^2$ 27 $PWR_2 = PWR_1\left(\frac{d_2}{d_1}\right)^5\left(\frac{RPM_2}{RPM_1}\right)^3$ 28 $FSP = SP_{out} - SP_{in} - VP_{in}$ 29 $FTP = TP_{out} - TP_{in}$

NOISE

1 $SPL\ or\ L_p = 20\ log\left(\frac{P}{P_0}\right)$ 2 $L_I = 10\ log\left(\frac{I}{I_0}\right)$ 3 $SPL_2 = SPL_1 + 20\ log\left(\frac{d_1}{d_2}\right)$ 4 $L_w = 10\ log\left(\frac{W}{W_0}\right)$

5 $W_0 = 10^{-12} watts$ 6 $L_{eq} = 10\log\left(\frac{1}{T}\sum_{i=1}^{N}\left(10^{\frac{L_i}{10}}t_i\right)\right)$ 7 $L_{PT} = 10\ log\left(\sum_{i=1}^{N}10^{\frac{L_{Pi}}{10}}\right)$ 8 $TL = 10\log\left(\frac{1}{\tau}\right)$

9 $L_p = L_w - 20\log r - 0.5 + DI + CF$ 10 $[L_p = L_w - 20\log r - 11 + DI + CF]$ 11 $DI = 10\log\ Q$

12 $\%D = 100\left(\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_i}{T_i}\right)$ 13 $T_p = \frac{T_c}{2^{(L_{AS} - L_c/ER)}}$ 14 $TWA_{eq} = 10\ log\left(\frac{\%D}{100}\right) + 85dBA$

15 $TWA = 16.61\ log\left(\frac{\%D}{100}\right) + 90dBA$ 16 $f = \frac{(N)(RPM)}{60}$ 17 $f = \frac{c}{\lambda}$ 18 $f_2 = 2f_1$ 19 $f_c = \sqrt{f_1f_2}$ 20 $f_2 = \sqrt[3]{2}f_1$

USEFUL EQUATIONS FOR THE ABIH EXAMINATIONS

This list of equations is offered as assistance in taking the ABIH examinations. No assurance is given that this list is complete or that the use of this list will assure the successful completion of any examination. The variables used are the same as found in the reference source for the equation. No attempt has been made to standardize variables. [Metric (SI) equations are in brackets]

GENERAL SCIENCES, STATISTICS, STANDARDS

1 $ppm = \frac{V_{contam}}{V_{air}} x10^6$ 2 $ppm = \frac{P_v}{P_{atm}} x10^6$ 3 $ppm = \frac{mg/m^3 x24.45}{m.w.}$ 4 $\frac{P_1V_1}{nRT_1} = \frac{P_2V_2}{nRT_2}$ 5 $V_{TS} = \frac{g{d_p}^2(\rho_p - \rho_a)}{18_\eta}$

6 $R_e = \frac{\rho dv}{\eta}$ 7 $\log\frac{I_o}{I} = abc$ 8 $pH = -\log_{10}[H^+]$ 9 $K_a = \frac{[H^+]x[A^-]}{[HA]}$ 10 $K_b = \frac{[BH^+]x[OH^-]}{[B]}$

11 $P_{total} = X_1P_1 + X_2P_2 + \ldots + X_iP_i$ 12 $vapor/hazard\ ratio = \frac{sat.concentration}{exposure\ guideline}$ 13 $TLV_{mix} = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \ldots + \frac{C_n}{TLV_n}$

14 $TLV_{mix} = \frac{1}{\frac{F_1}{TLV_1} + \frac{F_2}{TLV_2} + \cdots + \frac{F_n}{TLV_n}}$ 15 $RF = \frac{8}{h} x \frac{24-h}{16}$ 16 $RF = \frac{40}{h_w} x \frac{168-h_w}{128}$ 17 $C_{asb} = \frac{(C_s - C_b)A_c}{1000A_fV_s}$

18 $C_{asb} = \frac{EA_c}{1000V_s}$ 19 $E_{fiber\ density} = \frac{\frac{f}{N_f} - \frac{B}{N_b}}{A_f}$ 20 $d = \frac{0.61\lambda}{\eta \sin\alpha}$ 21 $SD = \sqrt{\frac{\sum(\overline{x} - x_i)^2}{n-1}}$ 22 $GM = \sqrt[n]{(x_1)(x_2)\ldots(x_n)}$

23 $GM = 10^{\frac{\sum(\log x)}{n}}$ 24 $GSD = \frac{84.13\%\ tile\ value}{50\%\ tile\ value}$ 25 $GSD = \frac{50\%\ tile\ value}{15.87\%\ tile\ value}$ 26 $SAE = 1.645CV_{total}$ 27 $CV = \frac{SD}{\overline{X}}$

28 $E_c = \sqrt{E_1^2 + E_2^2 + \ldots + E_n^2}$ 29 $t = \frac{\overline{x}_1 - \overline{x}_2}{SD_{pooled}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$ 30 $SD_{pooled} = \sqrt{\frac{(n_1-1){SD_1}^2 + (n_2-1){SD_2}^2}{n_1+n_2-2}}$

31 $LCL = \frac{C_A}{PEL} - \frac{SAE\sqrt{{T_1}^2{C_1}^2 + {T_2}^2{C_2}^2 + \ldots + {T_n}^2{C_n}^2}}{PEL(T_1 + T_2 + \ldots + T_n)}$ 32 $RWL = LCxHMxVMxDMxAMxFMxCM$ 33 $LI = \frac{L}{RWL}$

34 $90\%Conf\ Interval = \overline{X} \pm 1.645\frac{SD}{\sqrt{n}}$ 35 $95\%Conf\ Limit = \overline{X} + 1.645\frac{SD}{\sqrt{n}}$

HEAT STRESS

1 $WBGT = 0.7t_{nwb} + 0.2t_g + 0.1t_{db}$ 2 $WBGT = 0.7t_{nwb} + 0.3t_g$ 3 $\Delta S = (M - W) \pm C \pm R - E$

4 $Q_s = \frac{H_s}{1.08x\Delta T}$ 5 $\left[Q_s = \frac{H_s}{20x\Delta T}\right]$

USEFUL EQUATIONS FOR THE ABIH EXAMINATIONS

This list of equations is offered as assistance in taking the ABIH examinations. No assurance is given that this list is complete or that the use of this list will assure the successful completion of any examination. The variables used are the same as found in the reference source for the equation. No attempt has been made to standardize variables.

RADIATION

1 $I_2 = I_1\left(\frac{d_1}{d_2}\right)^2$ 2 $Rem = (RAD)(QF)$ 3 $D = \frac{\Gamma A}{d^2}$ 4 $A = A_i(0.5)^{\frac{t}{T_{1/2}}}$ 5 $A_i = \frac{0.693}{T_{1/2}}N_i$ 6 $A = A_i e^{\frac{-0.693t}{T_{1/2}}}$

7 $I = (1/2)^A I_0$ 8 $I = (1/10)^B I_0$ 9 $I_2 = \frac{I_1}{2^{\frac{X}{HVL}}}$ 10 $I_2 = \frac{I_1}{10^{\frac{X}{TVL}}}$ 11 $X = 3.32\log\left(\frac{I_1}{I_2}\right)(HVL)$ 12 $I = I_0 B e^{-ux}$

13 $\frac{1}{T_{1/2eff}} = \frac{1}{T_{1/2rad}} + \frac{1}{T_{1/2bio}}$ 14 $T_{1/2eff} = \frac{\left(T_{1/2rad}\right)\left(T_{1/2bio}\right)}{T_{1/2rad} + T_{1/2bio}}$ 15 $S = \frac{E^2}{3770}$ 16 $S = 37.7H^2$ 17 $S = \frac{4P}{A}$

18 $r = \left(\frac{PG}{4\pi EL}\right)^{1/2}$ 19 $r_{NHZ} = \frac{1}{\emptyset}\left(\frac{4\Phi}{\pi EL} - a^2\right)^{1/2}$ 20 $r_{NHZ} = \frac{f_0}{b_0}\left(\frac{4\Phi}{\pi EL}\right)^{1/2}$ 21 $r_{NHZ} = \left(\frac{\rho\Phi\cos\theta}{\pi EL}\right)^{1/2}$

22 $D_s = \frac{1}{\emptyset}\left(\frac{4\Phi}{\pi TL} - a^2\right)^{1/2}$ 23 $spatial\ ave = \left(\frac{\sum_{i=1}^{N} FS_i^{\,2}}{N}\right)^{1/2}$ 24 $\mathrm{t} = \frac{0.003J/cm^2}{E_{eff}}$ 25 $t = \frac{EL}{ML}x0.1h$ 26 $O.D. = \log\frac{I_0}{I}$

27 $D_L = \sqrt{a^2 + \emptyset^2 r^2}$ 28 $G = 10^{g/10}$

CONSTANTS AND CONVERSIONS

°F=9/5(°C)+32 °R=°F+460 K=°C+273.15 molar volume at 25°C, 1 atm=24.45L $1ft^3$ =28.32L

1 ft^3 =7.481 U.S. gal 1L=1.0566 qt 1 inch = 2.54 cm 1 lb=453.6 grams 1 gram=15.43 grains

1 atm=14.7 psi=760 mm Hg=29.92 in Hg=33.93 ft water=1013.25 mbar=101,325 pascals

1 Curie=$3.7x10^{10}$ disint/sec (Becquerel)= $2.2x10^{12}$ dpm 1 Gray=100 Rad 1 Sievert=100 Rem

1 Tesla=10,000 Gauss 1 BTU=1054.8 joules=0.293 watt hr 1 cal=4.184 joules

speed of sound in air at 68°F (20°C)=1130 fps (344 m/s) speed of light=$3x10^8$ m/s

Planck's constant=$6.626x10^{-27}$ erg sec Avogadro's number=$6.024x10^{23}$

gas constant, R=8.314 J/mole K=0.082 L atm/mole K density of air=1.29 g/L at atm, 0°C

g=981 cm/sec^2 =32 ft/sec^2 A_c =385 mm^2 for 25 mm filter Af=0.00785 mm^2

TABLE 6-3. Summary of Hood Airflow Equations

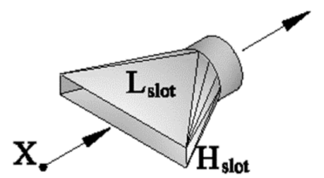
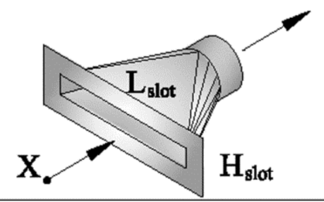
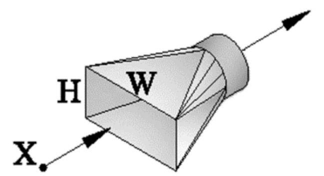
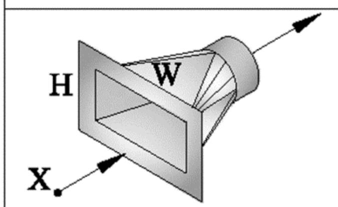
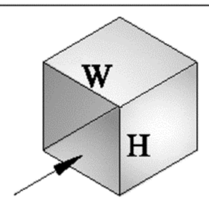
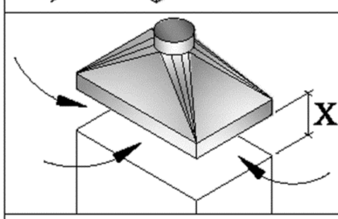
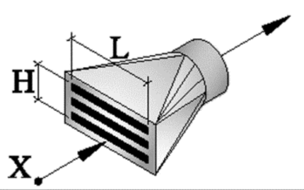
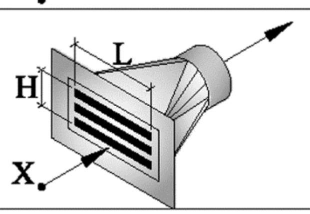
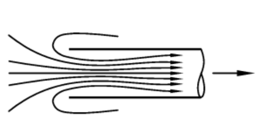
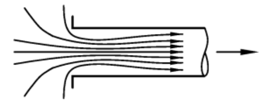
HOOD TYPE	DESCRIPTION	ASPECT RATIO, H/L	AIRFLOW
	Slot	0.2 or less	1 $Q = 3.7\ LV_xX$
	Flanged slot	0.2 or less	2 $Q = 2.6\ LV_xX$
	Plain opening	0.2 or greater and round	3 $Q = V_x(10X^2 + A_f)$ $A_f = WH$
	Flanged opening $W_f \geq \sqrt{A_f}$	0.2 or greater and round	4 $Q = 0.75V_x(10X^2 + A_f)$ $A_f = WH$
	Booth	To suit work	5 $Q = VA = V_fWH$
	Canopy	To suit work	$Q = 1.4\ PVX$ 6 P = Perimeter of work or tank X = Height above work
	Plain multiple slot opening (2) or more slots	0.2 or greater	7 $Q = V_x(10X^2 + A_s)$ $A_s = HL$
	Flanged multiple slot opening (2) or more slots	0.2 or greater	8 $Q = 0.75V_x(10X^2 + A_s)$ $A_s = HL$

FIGURE 9-a

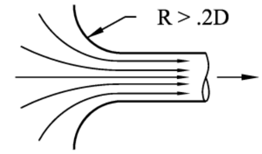


F_h = 0.93
C_e = 0.72
PLAIN DUCT END

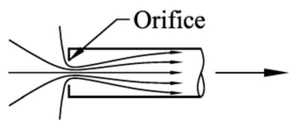


Conical	Rectangular
F_h = 0.56	F_h = 0.64
C_e = 0.80	C_e = 0.78

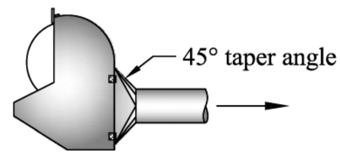
FLANGED DUCT END



F_h = 0.04
C_e = 0.98
BELLMOUTH ENTRY



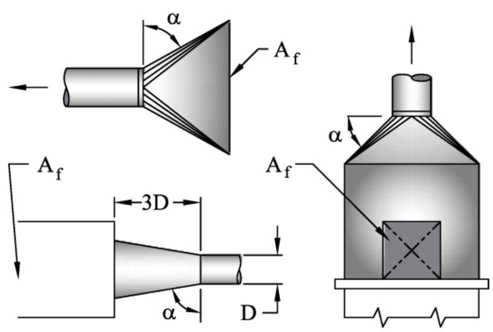
F_h = 1.78
C_e = 0.60
SHARP-EDGED ORIFICE



F_h = 0.4 (tapered take-off)
C_e = 0.85
F_h = 0.65 (no taper)
C_e = 0.78
STANDARD GRINDER HOOD

TAPERED HOODS

Flanged or unflanged; conical, square or rectangular. α is the major angle on rectangular hoods.

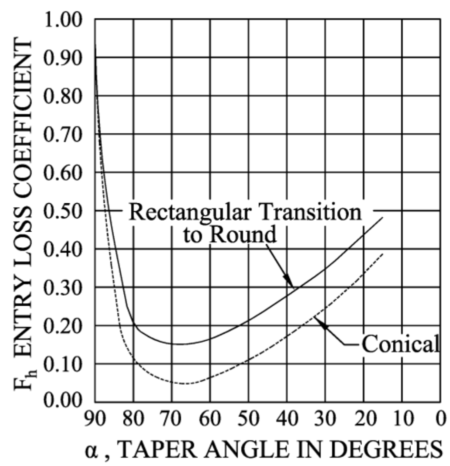


Face area (A_f) at least 2 times the duct area.

F_h Entry Loss Coefficient

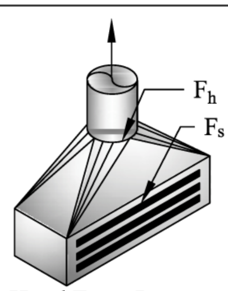
α	Conical	Rectangular
90	0.93	0.93
80	0.11	0.19
70	0.06	0.13
60	0.08	0.16
50	0.12	0.21
45	0.15	0.25
40	0.18	0.28
30	0.25	0.35
20	0.34	0.43
10	0.44	0.52
0	0.56	0.64

Note: 0° values represent round ducts butted into back of booth or hood without a rectangular to round transition.



COMPOUND HOODS

A compound hood, such as the slot/plenum shown to the right, would have 2 losses, one through the slot and the other through the transition into the duct.
The slot entry loss coefficient, F_s, would have a value typically in the range of 1.00 to 1.78 (see Chapters 6 and 13).
The duct entry loss coefficient is given by the above data for tapered hoods.



Hood Entry Loss = $F_sVP_s + F_hVP_d$
(See Chapter 6)

MISCELLANEOUS VALUES

HOOD	ENTRY LOSS COEFFICIENT F_h	HOOD FLOW COEFFICIENT C_e
Abrasive blast chamber	1.00	0.50
Abrasive blast elevator	2.30	0.31
Abrasive separator	2.30	0.31
Elevators (enclosures)	1.00	0.50
Flanged pipe plus close elbow	0.80	0.56
Plain pipe plus close elbow	1.60	0.38

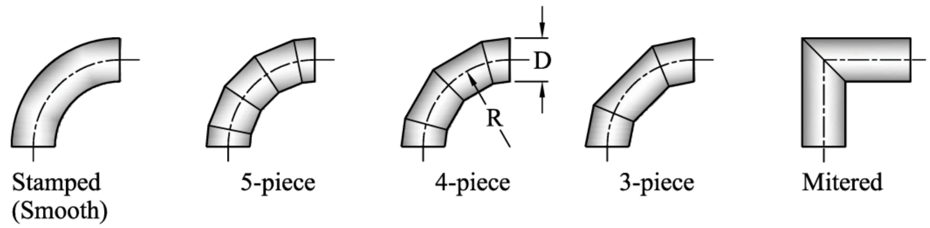
ACGIH®

TITLE
HOOD ENTRY
LOSS FACTORS

FIGURE 9-a

DATE 1-16

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL)
TO ENSURE THAT DESIGN IS COMPLIANT.



	R / D				
	0.75	1.00	1.50	2.00	2.50
Stamped	0.33	0.22	0.15	0.13	0.12
5-piece	0.46	0.33	0.24	0.19	0.17*
4-piece	0.50	0.37	0.27	0.24	0.23*
3-piece	0.54	0.42	0.34	0.33	0.33*

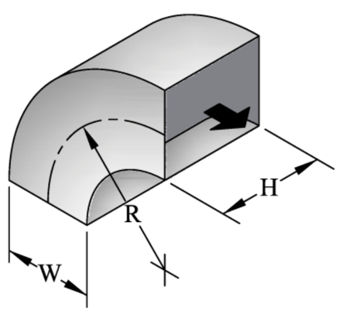
* extrapolated from published data

OTHER ELBOW LOSS FACTORS

Mitered, no vanes	1.2
Mitered, turning vanes	0.6
Flatback (R/D = 2.5)	0.05 (see Chapter 5, Figure 5-18)

NOTE: Loss factors are assumed to be for elbows of "zero length." Friction losses should be included to the intersection of centerlines.

ROUND ELBOW LOSS FACTORS

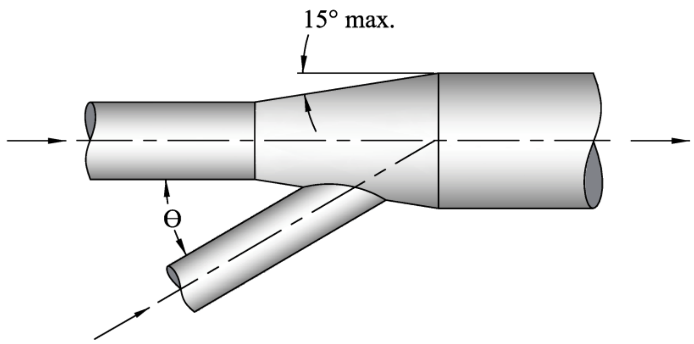


R/W	Aspect Ratio, H/W					
	0.25	0.5	1.0	2.0	3.0	4.0
0.0 (Mitered)	1.50	1.32	1.15	1.04	0.92	0.86
0.5	1.36	1.21	1.05	0.95	0.84	0.79
1.0	0.45	0.28	0.21	0.21	0.20	0.19
1.5	0.28	0.18	0.13	0.13	0.12	0.12
2.0	0.24	0.15	0.11	0.11	0.10	0.10
3.0	0.24	0.15	0.11	0.11	0.10	0.10

SQUARE & RECTANGULAR ELBOW LOSS FACTORS

ACGIH®	TITLE DUCT DESIGN DATA ELBOW LOSS FACTORS	FIGURE 9-e DATE 1-16

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.

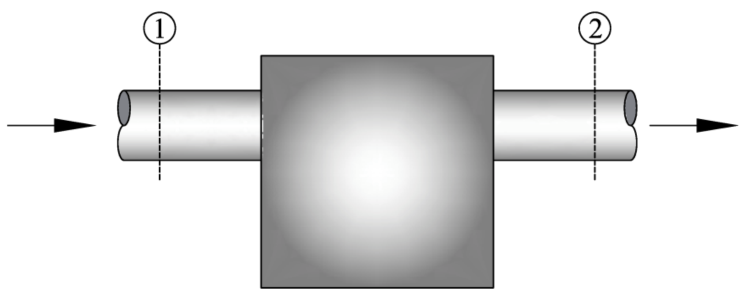


Note: Branch entry loss assumed to occur in branch and is so calculated.

Do not include a regain calculation for branch entry enlargements.

Angle Θ Degrees	Loss Factor
10	0.06
15	0.09
20	0.12
25	0.15
30	0.18
35	0.21
40	0.25
45	0.28
50	0.32
60	0.44
90	1.00

BRANCH ENTRY LOSS FACTORS



$$SP_2 - SP_1 = 1.5\ VP_2$$
$$F_h = 1.5$$
$$C_e = 0.8$$

TRAP OR SETTLING CHAMBER

ACGIH®	TITLE BRANCH ENTRY LOSS FACTORS AND LOSSES IN SETTLING CHAMBERS	FIGURE 9-f
		DATE 1-16

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.