[A-15] SEAT No._____ No. of Printed Pages : 02+17

Sardar Patel University –V V Nagar

M. Sc. (Industrial Hygiene and Safety)
PS02CIHS21: INDUSTRIAL VENTILLATION
Total Marks: 70 Time 2:00 PM to 5:00 PM Date: 18/3/2019, MONDAY

Note: Figures to the right indicate maximum marks.
: Assume the figure in any of the question wherever it is not given.

Q1. ***Multiple Choice Questions-*** ***[8]***

(1) A device which measures velocity of air is _____ [1]
(a) Crater b) Anemometer c) Pitot Tube d) Manometer

(2) ASHRAE is related to ____ [1]
(a) IAQ b) Cooling c) Heating d) None

(3) Natural Ventilation is a good option where chemical works are being done. [1]
(a)False b)True c) Doubtful d) None

(4) TP is also called impact pressure. [1]
(a)True b) False c)Unknown d) None

(5) The forward curved wheel(fans) is rarely used. [1]
(a) False b)True c) Regularly d)None

(6) _____can be used as air cleaning device for gases and vapors . [1]
(a) False b) Clock Tower c) Distilled Shower d) Packed tower

(7) The Average velocity pressure is about _____%of center line Velocity Pressure. [1]
(a) 71 b)81 c) 91 d)None

(8) Heating and Cooling are found in _____system. [1]
(a) Mixing b) Heating c) HVAC d) None

Q2. ***Short answer type questions — attempt any 7*** ***[14]***

(a) Terminal Velocity. [2]
(b) Plenum System. [2]
(c) Full form of HVAC [2]
(d) Capture Velocity [2]
(e) Pressure sensing devices for Testing of Ventilation [2]
(f) Types of Fan [2]
(g) Smoke Tubes [2]
(h) Write about Hood Entry Loss i.e He [2]
(i) Tracer Gas Method [2]

Descriptive questions- ***[30]***

Q3. (a) Explain in detail the purpose of ventilation. [6]

OR

(a) Explain Psychometric chart and various related aspects studied. [6]

Q4. (a) Draw a local exhaust ventilation system and explain its parts in detail. [6]

OR

(a) Explain with a diagram Pressure relationship in Air stream of Duct. [6]

Q5. (a) Comparison with advantages and disadvantages of Dilution Ventilation and LEV [6]

(b) Explain Major components of HVAC in detail with a diagram. [6]

OR

(b) Explain Walk Through Survey related to HVAC system. [6]

Q6. (a) Explain testing of Ventilation system in detail. [6]

OR [6]

(a) Explain main types of Hoods with figure and mention where the measurements be carried out in Hoods.

(a) ***Descriptive questions*** [18]

A problem has been characterized with a suggestion of need of LEV system . Following raw data has being collected by Industrial Hygienist as shown in raw data worksheet .Design system as under.

.................Loss Factor

K...........................

Run	Q	Vt	L	Hood	Elbows	Tee	SEF	R
A-B	2050	3000	25'	0.25	0.39	-	-	1.0
B-C	1510	3000	25'	0.50	-	0.28	-	2.4
C-D	?	3000	40'	-	1.95(5 - Elbows)		-	1.0
D-E	?	3000	20'	-	-		-	1.0

Other :Air Cleaner loss in C-D =2 inches w.g; All elbows R=1.5D ,3-piece ;Tee (branch entry)=45degrees; use modified –ACGIH method of branch entry losses ;slot velocity =2000fpm;flex duct correction factor R=2.4 (obtained from manufacturer). Settling Chamber C-D (As Other K Loss) =4, Fan Efficiency=0.55,Kdl=1.10,d=1

Balance the LEV system and find duct Actual Q, determine static pressure in the system .What rhp motor we choose? Conclude your statement about system.

Assume the figure in the question if it is not given.
Perform in Worksheet only.

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—x—

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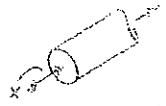
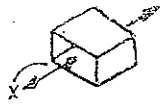
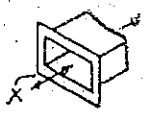
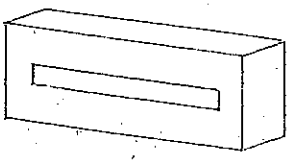
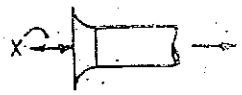
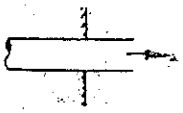
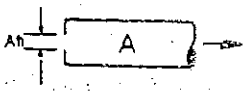
VP Design Worksheet — Chart No. 12

[A-15] SEAT No._____ P502CIH521

Name		Project						
Row	Item	Source	Units (US/SI)					
1	Duct ID	Plans	FROM-->TO					
2	Design Q	Chart 11	cfm or cms					
3	Transport vel.	Chart 9,11	fpm or mps					
4	Slotted hood?	[Yes--> row 5; no--> row 12]						
5	Slot velocity	Chart 11	fpm or mps					
6	Slot area	[row 2 / row 5]	sq ft or sq meter					
7	Slot VP	Chart 7	inch or mm w.g.					
8	Slot entry loss factor		(1.78)					
9	Acceleration factor		(1.0)					
10	Plenum loss factor	[row 8 + row 9]	(2.78)					
11	Plenum SP	[row 7 x row 10]	inch or mm w.g.					
12	Duct diameter	Chart 5	inch or cm					
13	Duct area	Chart 5	sq ft or sq meter					
14	Duct velocity	[row 2 / row 13]	fpm or mps					
15	Duct VP	Chart 7	inch or mm w.g.					
16	Duct length	From plans	feet or meters					
17	Friction R	Chart 10	--					
18	Friction K	Chart 5	--					
19	Friction K, duct	[row 16 x row 17 x row 18]						
20	Hood entry	Chart 11	--					
21	Acceleration	[1.0 at hoods]	--					
22	Elbows	Chart 13	--					
23	Branch entry	Chart 14	--					
24	System effect	Chart 15	--					
25	Other K loss	( )	--					
26	Total K	[sum rows 19-25]	--					
27	Duct SP	[row 26 x row 15]	inch or mm w.g.					
28	SP at FROM location	(row 33)	inch or mm w.g.					
29	Junction VP change at **FROM**	Chart 14	inch or mm w.g.					
30	Other SP loss	( )	inch or mm w.g.					
31	Total SP at TO	[sum rows 11 + 27-30]	inch or mm w.g.					
32	In this Governing SP?		(yes or no)					
33	Governing SP	[at **TO** location]	inch or mm w.g.					
34	Actual Q	[row 2 x (row 33/row 31)$^{0.5}$]	cfm or cm					
35	SPh	[row 11 + row 15 x (rows 20+21)]	inch or mm w.g.					
36	Total slot length	plans	feet or meters					
37	Slot width	y(row 6 / row 36)	inch or cm					
		US: y = 12; SI: y = 100						

(Watch units carefully) Chart No. 11A

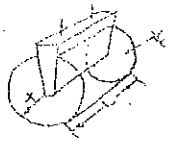
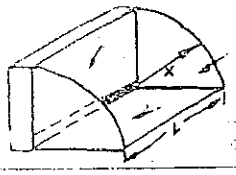
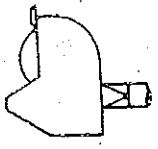
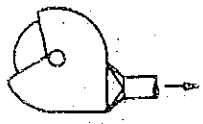
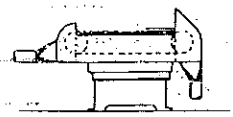
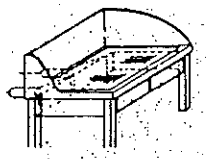
Type of Hood	Sketch	K	Ce	V_{trans}	Q	Notes
Duct End (round)		0.93	0.72	AR	$4\pi X^2V_c$ or $(10X^2+A_f)V_c$	Flange if possible (see notes below)
Duct End (square)		1.25	0.67	AR	$4\pi X^2V_c$ or $(10X^2+A_f)V_c$	Avoid square ducts
Flanged Duct End (round)		0.50	0.82	AR	$3\pi X^2V_c$ or $0.75(10X^2+A_f)V_c$	Flange width = W (see notes below)
Flanged Duct End (square)		0.70	0.77	AR	$3\pi X^2V_c$ or $0.75(10X^2+A_f)V_c$	
Plain Slot		1.78	0.60	AR	See specific operation	Also, sharp edged orifice
Bell mouth		0.04	0.98	AR	$3\pi X^2V_c$ or $0.75(10X^2+A_f)V_c$	Flare to W (see notes below)
Hood thru wall		0.80	0.75	AR	$3\pi X^2V_c$ or $0.75(10X^2+A_f)V_c$	
Hole in duct end		Ah/Af 0.1 0.2 0.3 0.4 0.5 0.6	 2.5 1.9 1.4 1.2 1.0 0.9	 0.53 0.59 0.65 0.67 0.71 0.72	AR	$4\pi X^2V_c$ or $(10X^2+A_f)V_c$	Ah = area of hole in duct end sq ft or sq meters.

Notes for hood tables: V_{trans} = air velocity necessary to move dry particles along duct, fpm or mps; AR = As Required for transport (see Chart No. 9), fpm or mps; K = hood-to-duct loss factor, unitless; Ce = Coefficient of Entry, unitless; Q = volume flow rate required at hood, cfm or cu. m/sec; X = distance to emission source from hood face, feet or meters; V_c = capture velocity at X, fpm or mps (see Chart 8); A_f = hood face area, sq ft or sq meters; W = X -0.5D where W is flange width, D is duct diameter, feet or meters;

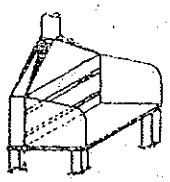
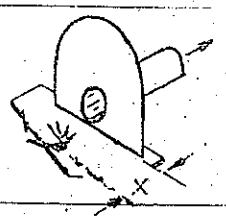
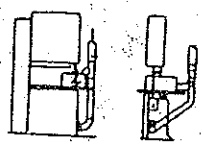
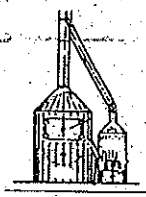
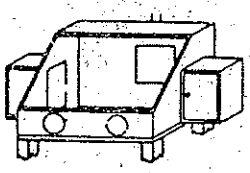
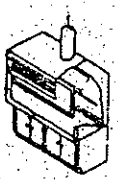
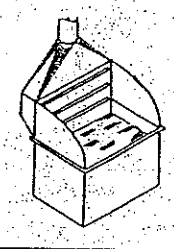
Type of hood	Sketch	K	Ce	V_{grate}	Q	Notes
Punched screen on end of duct	Percent Free Area: 50% / 60% / 70% / 80%	50%: 5.0; 60%: 3.2; 70%: 2.3; 80%: 1.8	50%: 0.41; 60%: 0.49; 70%: 0.55; 80%: 0.60	AR	$4\pi X^2V_c$ or $(10X^2 + A_f)V_c$	Flange if possible. Flange width, W (see notes on Chart 11A)
Booth hood w/STO		0.5	0.82	AR	$V_f A_f$	See Chart No. 8 for velocity information
Booth hood w/TTO		0.25	0.89	AR	$V_f A_f$	See Chart No. 8 for velocity information
Tapered Hood	Included angle: 30° / 45° / 60° / 90° / 120°	Rd: .08 / .06 / .08 / .15 / .26; Sq: .17 / .15 / .17 / .25* / .35	Rd: .96 / .97 / .96 / .93 / .89; Sq: .92 / .93 / .92 / .89 / .86	AR	$3\pi X^2V_c$ or $0.75(10X^2 + A_f)V_c$	
Open-surface tank canopy hood	TTO	0.25	0.89	AR	$1.4PXV_{control}$	See Chart No. 8 for control velocity
Canopy hood with insert	TTO	0.25	0.89	AR	$1.4PXV_{control}$	$V_{control}$ is not Vc
Slot and bend hood		1.6	0.62	AR	See specific application	
Free standing slot hood, no end flanges	STO / TTO	slot: 1.78 / 1.78; duct: 0.50 / 0.25	NC	AR	$3\pi XLV_c$	Slot velocity: 1500-2000 fpm 7.5-10 mps

Notes for hood tables: Q = volume flow rate required at hood, cfm or cu m/sec; X = distance to emission source from hood face, feet or meters; V_c = capture velocity at X, fpm or mps (see Chart 8); A_f = hood face area, sq ft or sq meters; STO = straight takeoff (duct to hood); TTO = tapered takeoff (duct to hood); V_f = face velocity, fpm or mps; P = perimeter of source, ft or meters; $V_{control}$ = control velocity between source and hood (open surface tanks), fpm or mps; L = slot length, feet or meters; NC = cannot be estimated without knowing slot and duct velocities.

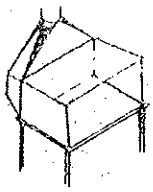
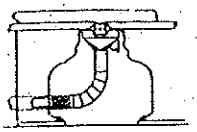
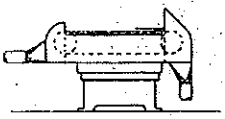
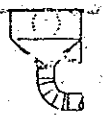
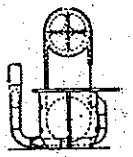
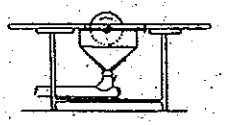
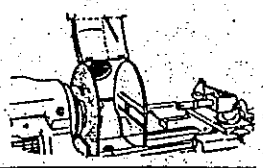
*The loss factor for any square/rectangular tapered hood with an included angle of 90° can also be approximated by the following formula: $K_{hood} = (1.9 / AR^2) + 0.17$ where AR is the ratio of hood face area to duct area.

Type of hood	Sketch		K	Ce	Chart	Q	Notes
			slot duct	NC	AR	$0.5\pi XLV_c$	Slot velocity: 1500-2000 fpm 7.5-10 mps
Free standing dust hood, end flanges installed		STO TTO	1.78 0.50 1.78 0.25				
Slotted hood with sides and back		STO TTO	slot duct 1.78 0.50 1.78 0.25	NC	AR	$0.5\pi XLV_c$	Slot velocity: 1500-2000 fpm 7.5-10 mps
Grinder hood, low surface velocity (< 6500 sfm)		STO TTO	0.65 0.40	0.78 0.85	4500 fpm 23 mps	$35W_d$ - 50 (cfm) $0.0066W_d$ - 0.023 (cu. m/sec)	Empirical formula for Q; W_d = wheel diameter, inches or cm
Grinder hood, high surface velocity (> 6500 sfm)		STO TTO	0.65 0.40	0.78 0.85	4500 fpm 23 mps	$50W_d$ - 50 (in cfm) $0.0093W_d$ - 0.023 (cu. m/sec)	Empirical formula for Q; W_d = wheel diameter, inches or cm
Buffing and polishing wheel		STO TTO	0.65 0.40	0.78 0.85	3500 fpm 18 mps	$35W_d$ - 50 (in cfm) $0.0066W_d$ - 0.023 (cu. m/sec)	Empirical formula for Q; W_d = wheel diameter, inches or cm
Abrasive cutoff saw hood, metal		STO TTO	0.50 0.25	0.82 0.89	3500 fpm 18 mps	$250A_o$ (cfm) $1.26A_o$ (cu. m/sec)	A_o = open area on equipment, sq ft or sq meters
Metal polishing belt hood		STO TTO	0.65 0.40	0.78 0.85	3500 fpm 18 mps	$50W_b$ +100 (cfm) $0.0093W_b$ + 0.047 (cu. m/sec)	Empirical formula for Q; W_b = belt width, inches or cm
Hand grinding table hood			0.50	0.82	3500 fpm 18 mps	$250A_t$ (cfm) $1.26A_t$ (cu. m/sec)	A_t = area of top of table, sq ft or sq meters

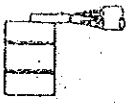
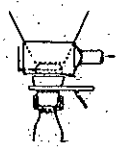
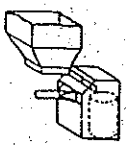
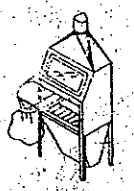
Notes for hood tables: K = loss factor, unitless; Ce = Coefficient of Entry, unitless; Q = volume flow rate required at hood, cfm or cms; X = distance to emission source from hood face, feet or meters; V_c = capture velocity at X, fpm or mps (see Chart 8); STO = straight takeoff (duct to hood); TTO = tapered takeoff (duct to hood); V_f = face velocity, fpm or mps; L = slot length, feet or meters; NC = cannot be estimated without knowing slot and duct velocities.

Type of hood	Sketch	K	Ce	V_{min}	Q	Notes
Welding table hood		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	3000 fpm 18 mps	$350L_t$ (cfm) or $0.54L_t$ (cu. m/sec)	L_t = table leng, feet or meters; flange ends; plenum ht ≥ 2'; table depth ≤ 2'; Slot velocity: 1500-2000 fpm 7.5-10 mps
Welding hood, portable (flange on table top)	 STO	0.50	0.82	3000 fpm 23 mps	140X - 400 (cfm) 2.6X - 0.19 (cu. m/sec)	Empirical formula for Q; X = inch or cm X ≥5" or 12 cm
Metal cutting bandsaw hood		1.75	0.60	4000 fpm 20 mps	$250A_o + 350$ (cfm) $1.26A + 0.17$ (cu. m/sec)	Ao = open area on equipment, sq ft or sq meters
Melting furnace hood	 TTO	0.25	0.89	3500 fpm 18 mps	$250A_o$ (cfm) $1.26A_o$ (cu. m/sec)	Ao = open area on equipment, sq ft or sq meters
Glovebox hood	 STO	0.50	0.82	AR	$100A_o$ (cfm) $0.5A_o$ (cu. m/sec)	Ao = open area on equipment, sq ft or sq meters
Lab Fume hood		slot duct STO 1.78 0.50 TTO 1.78 0.25 --- *---> or - 2.0	NC --- 0.58	2000 fpm 10 mps	80A to $120A_o$ (cfm) 0.4A to $0.6A_o$ (cu. m/sec)	Avoid drafts at hood face; provide good work practices
General dip tank hood		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	2000 fpm 10 mps	$125A_s$ (cfm) $0.63A_s$ (cu. m/sec)	As = surface area of tank, flange ends; plenum ht ≥ 2'; tank depth ≤ 2'; Slot velocity: 1500-2000 fpm 7.5-10 mps

Notes for hood tables: K = loss factor, unitless; Ce = Coefficient of Entry, unitless; Q = volume flow rate required at hood, cfm or cms; V_c = capture velocity at X, fpm or mps; STO = straight takeoff (duct to hood); TTO = tapered takeoff (duct to hood); V_f = face velocity, fpm or mps; L = slot length, feet or meters; NC = cannot be estimated without knowing slot and duct velocities; *Typical commercial lab fume hood data.

Use of hood	Sketch	K	Ce	V_{trans}	Q	Notes
Small paint booth hood		0.50 - 1.0	0.71-0.82	3000 fpm 15 mps	100A (cfm) 0.5A (cu. m/sec)	Check supplier data for actual K, Ce
Wood jointer hood		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	3500 fpm 23 mps	$25Y_k + 200$ (cfm) $0.0044Y_k + 0.094$ (cu. m/sec)	Empirical formula for Q; Y_k = knife length, inches or cm
Horizontal belt sander hood		STO	0.5	0.82	3500 fpm 18 mps	$80Y_b + 400$ (cfm) $0.014Y_b + 0.19$ (cu. m/sec)	Empirical formula for Q; Y_b = belt width, inches or cm
Single drum sander hood		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	3500 fpm 23 mps	$85A_d + 400$ (cfm) $0.44A_d + 0.19$ (cu. m/sec)	Empirical formula for Q; A_d = drum surface area, sq ft, sq meter
Wood bandsaw hood		1.75	0.60	3500 fpm 18 mps	$250Y_b + 300$ (cfm) $0.045Y_b + 0.14$ (cu. m/sec)	Empirical formula for Q; Y_b = blade width, inches or cm
Tablesaw hood		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	3500 fpm 23 mps	$10Y_b + 200$ (cfm) $0.0018Y_b + 0.094$ (cu. m/sec)	Empirical formula for Q; Y_b = blade diameter, inches or cm
Wood lathe hood		STO	0.5	0.82	3500 fpm 18 mps	300A (cfm) 1.5A (cu. m/sec)	A = open area, sq ft or sq meters

Notes for hood tables: K = loss factor, unitless; Ce = Coefficient of Entry, unitless; Q = volume flow rate required at hood, cfm or cms; X = distance to emission source from hood face, feet or meters; V_c = capture velocity at X, fpm or mps; A = hood face area, sq ft or sq meters; W = X -0.5D where D is duct diameter in inches or meters; A_h = area of hole in duct end, sq ft or sq meters; STO = straight takeoff (duct to hood); TTO = tapered takeoff (duct to hood); V_f = face velocity, fpm or mps; P = perimeter of source, ft or meters; $V_{control}$ = control velocity between source and hood (open surface tanks); L = slot length, feet or meters; NC = not able to be calculated without knowing slot and duct velocities.

Type of hood	Sketch	K	Ce	V_{trans}	Q	Notes
Barrel filling hood (from side)		slot duct STO 1.78 0.50 TTO 1.78 0.25	NC	3500 fpm 23 mps	$150A_b$ (cfm) $0.75A_b$ (cu. m/sec)	A_b = barrel surface area, sq ft, sq meter; Flange
Bag filling hood	 TTO	0.25	0.89	3500 fpm 23 mps	Toxic dust: 1500 cfm/0.7 cms Nontoxic dust: 500 cfm/0.24 cms	Flange; avoid cross drafts; provide good work pract.
Barrel filling hood (spout enclosure)	 TTO	0.25	0.89	3500 fpm 18 mps	400 cfm 0.19 cms	Flange; avoid cross drafts; provide good work pract.
Barrel filling hood (cover)	 TTO	0.25	0.89	3500 fpm 18 mps	$12Y_d$ (cfm) $0.0022Y_d$ (cu. m/sec)	Empirical formula for Q; Y_d = barrel diameter, inches or cm
Barrel filling hood (full enclosure)	 TTO	0.25	0.89	3500 fpm 18 mps	$150A_o$ (cfm) $0.75A_o$ (cu. m/sec)	A_o = open area on equipment, sq ft or sq meters
Bag opening hood	 TTO	0.25	0.89	3500 fpm 18 mps	$250A_o$ (cfm) $1.25A_o$ (cu. m/sec)	A_o = open area on equipment, sq ft or sq meters

Notes for hood Tables: Ce = Coefficient of Entry, unitless; Q = volume flow rate required at hood, cfm or cms; X = distance to emission source from hood face, feet or meters; V_c = capture velocity at X, fpm or mps; STO = straight takeoff (duct to hood); TTO = tapered takeoff (duct to hood); V_f = face velocity, fpm or mps; L = slot length, feet or meters; NC = cannot be estimated without knowing slot and duct velocities.

Chart No. V

Scrubbing Velocities for Dry Particles in Round Ducts*

Non-specific materials	Velocity	
	fpm	mps
Very fine, very light dusts	2000	10
Fine dusts and powders	3000	15
Medium industrial dusts	3500	18
Coarse dusts	4000 - 4500	20-23
Heavy dusts	5000	25

Specific materials

	Velocity			Velocity	
	fpm	mps		fpm	mps
Abrasive blasting dust	4000	20	Limestone dust	3500	18
Aluminum dust, coarse	4000	20	Lint	2000	10
Barrel filling and dumping	4000	20	Magnesium dust, coarse	4500	23
Belt conveyors	3500	18	Metal fumes	2500	13
Bins and hoppers	3500	18	Metal turnings	5000	25
Brass turnings	4000	20	Metalizing booth	3500	18
Bucket elevators	3500	18	Paper dust	3500	18
Cast iron boring dust	4000	20	Plastics buffing dust	4000	20
Ceramics, glaze spraying	2500	13	Rubber dust, find	2500	13
other operations	3500	18	coarse	4000	20
Carbon black	3500	18	Sandblast dust	4000	20
Clay	3500	18	Sander dust	3000	15
Coal, fine powder	4000	20	Silica dust	4000	20
Cork, ground	2500	13	Soap dust	3000	15
Cotton dust	3000	15	Soapstone dust	3500	18
Flour dust	2500	13	Soldering and tinning	2500	13
Foundry, general	4000	20	Tailpipe exhaust	3000	15
tumbling mills	5000	25	Wood dust: flour	2500	13
Grain dust	3000	15	light dry sawdust	2500	13
Grinding, general	4000	20	shavings	3500	18
Lead dust	4500	23	heavy chips	4000	20
Lead dust with chips	5000	25	Wool	3000	15
Leather dust	3500	18	Zinc oxide fumes	2500	13

* "Scrubbing" velocities are those velocities with sufficient turbulence to lift particles off the duct surface as settling occurs;
also, "transport" velocity;
also, "target" velocity.

For wet and sticky materials, provide cleanouts, sloping ducts, and drains for periodic cleanout. For air with no industrial particles, duct velocities of 1800-2000 fpm (9-10 mps) are considered optimum, considering initial and operating costs, noise control, and naturally-occuring dust transport. Sources: 1,2,8,11

D. Jeff Burton

Chart No. 7A

Velocity Pressure to Velocity Conversion

at standard conditions rounded for US units

(For non-standard conditions, multiply V by $d^{-0.5}$; see Chart No. 6 for d. For example, if VP = 1.00"w.g. and d = 0.86, then V = 4,005 x $(0.86)^{-0.5}$ = 4,005 x 1.078 = 4,320 actual fpm.)

Velocity pressure inch	mm w.g.	Velocity fpm	mps
0.01	0.25	400	2.04
0.02	0.51	566	2.88
0.03	0.76	694	3.53
0.04	1.02	801	4.08
0.05	1.27	896	4.56
0.06	1.52	981	4.99
0.07	1.78	1060	5.39
0.08	2.03	1132	5.76
0.09	2.29	1202	6.11
0.10	2.54	1266	6.44
0.11	2.79	1328	6.76
0.12	3.05	1387	7.06
0.13	3.30	1444	7.35
0.14	3.56	1499	7.62
0.15	3.81	1551	7.89
0.16	4.06	1602	8.15
0.17	4.31	1651	8.40
0.18	4.57	1699	8.64
0.19	4.83	1746	8.88
0.20	5.08	1791	9.11
0.22	5.59	1879	9.56
0.24	6.10	1962	9.98
0.26	6.60	2040	10.4
0.28	7.11	2120	10.8
0.30	7.62	2190	11.2
0.32	8.13	2270	11.5
0.34	8.64	2330	11.9
0.36	9.14	2400	12.2
0.38	9.65	2470	12.6
0.40	10.16	2530	12.9
0.42	10.67	2600	13.2
0.44	11.13	2660	13.5
0.46	11.68	2720	13.8
0.48	12.19	2775	14.1
0.50	12.7	2830	14.4

Velocity pressure inch	mm w.g	Velocity fpm	mps
0.52	13.2	2890	14.7
0.54	13.7	2945	15.0
0.56	14.2	2995	15.2
0.58	14.7	3050	15.5
0.60	15.2	3100	15.8
0.62	15.7	3155	16.0
0.64	16.3	3205	16.3
0.66	16.8	3255	16.6
0.68	17.3	3300	16.8
0.70	17.8	3350	17.0
0.72	18.3	3400	17.3
0.74	18.8	3445	17.5
0.76	19.3	3490	17.8
0.78	19.8	3535	18.0
0.80	20.3	3580	18.2
0.85	21.6	3690	18.8
0.90	22.9	3800	19.3
0.95	24.1	3905	19.9
1.00	25.4	4005	20.4
1.05	26.7	4105	20.9
1.10	27.9	4200	21.4
1.15	29.2	4295	21.9
1.20	30.5	4385	22.3
1.25	31.8	4480	22.8
1.30	33.0	4565	23.2
1.35	34.3	4655	23.7
1.40	35.6	4740	24.1
1.45	36.8	4825	24.5
1.50	38.1	4905	25.0
1.60	40.6	5065	25.8
1.70	43.2	5220	26.6
1.80	45.7	5375	27.3
1.90	48.3	5520	28.1
2.00	50.8	5665	28.8
2.50	63.5	6330	32.2

Velocity Pressure to Velocity Conversion

At standard conditions rounded for US units. Start with inches w.g.

(For non-standard conditions, multiply V by $d^{-0.5}$; see Chart No. 6 for d. For example, if VP = 1.00" w.g. and d = 0.86, then V = 4,005 x $(0.86)^{-0.5}$ = 4,005 x 1.078 = 4,320 actual fpm.)

Velocity pressure inch	mm w.g.	Velocity fpm	mps
0.01	0.25	400	2.04
0.02	0.51	566	2.88
0.03	0.76	694	3.53
0.04	1.02	801	4.08
0.05	1.27	896	4.56
0.06	1.52	981	4.99
0.07	1.78	1060	5.39
0.08	2.03	1132	5.76
0.09	2.29	1202	6.11
0.10	2.54	1266	6.44
0.11	2.79	1328	6.76
0.12	3.05	1387	7.06
0.13	3.30	1444	7.35
0.14	3.56	1499	7.62
0.15	3.81	1551	7.89
0.16	4.06	1602	8.15
0.17	4.31	1651	8.40
0.18	4.57	1699	8.64
0.19	4.83	1746	8.88
0.20	5.08	1791	9.11
0.22	5.59	1879	9.56
0.24	6.10	1962	9.98
0.26	6.60	2040	10.4
0.28	7.11	2120	10.8
0.30	7.62	2190	11.2
0.32	8.13	2270	11.5
0.34	8.64	2330	11.9
0.36	9.14	2400	12.2
0.38	9.65	2470	12.6
0.40	10.16	2530	12.9
0.42	10.67	2600	13.2
0.44	11.18	2660	13.5
0.46	11.68	2720	13.8
0.48	12.19	2775	14.1
0.50	12.7	2830	14.4
0.52	13.2	2890	14.7
0.54	13.7	2945	15.0
0.56	14.2	2995	15.2
0.58	14.7	3050	15.5
0.60	15.2	3100	15.8
0.62	15.7	3155	16.0
0.64	16.3	3205	16.3
0.66	16.8	3255	16.6
0.68	17.3	3300	16.8
0.70	17.8	3350	17.0
0.72	18.3	3400	17.3
0.74	18.8	3445	17.5
0.76	19.3	3490	17.8
0.78	19.8	3535	18.0
0.80	20.3	3580	18.2
0.85	21.6	3690	18.8
0.90	22.9	3800	19.3
0.95	24.1	3905	19.9
1.00	25.4	4005	20.4
1.05	26.7	4105	20.9
1.10	27.9	4200	21.4
1.15	29.2	4295	21.9
1.20	30.5	4385	22.3
1.25	31.8	4480	22.8
1.30	33.0	4565	23.2
1.35	34.3	4655	23.7
1.40	35.6	4740	24.1
1.45	36.8	4825	24.5
1.50	38.1	4905	25.0
1.60	40.6	5065	25.8
1.70	43.2	5220	26.6
1.80	45.7	5375	27.3
1.90	48.3	5520	28.1
2.00	50.8	5665	28.8
2.50	63.5	6330	32.2

Velocity Pressure to Velocity Conversion

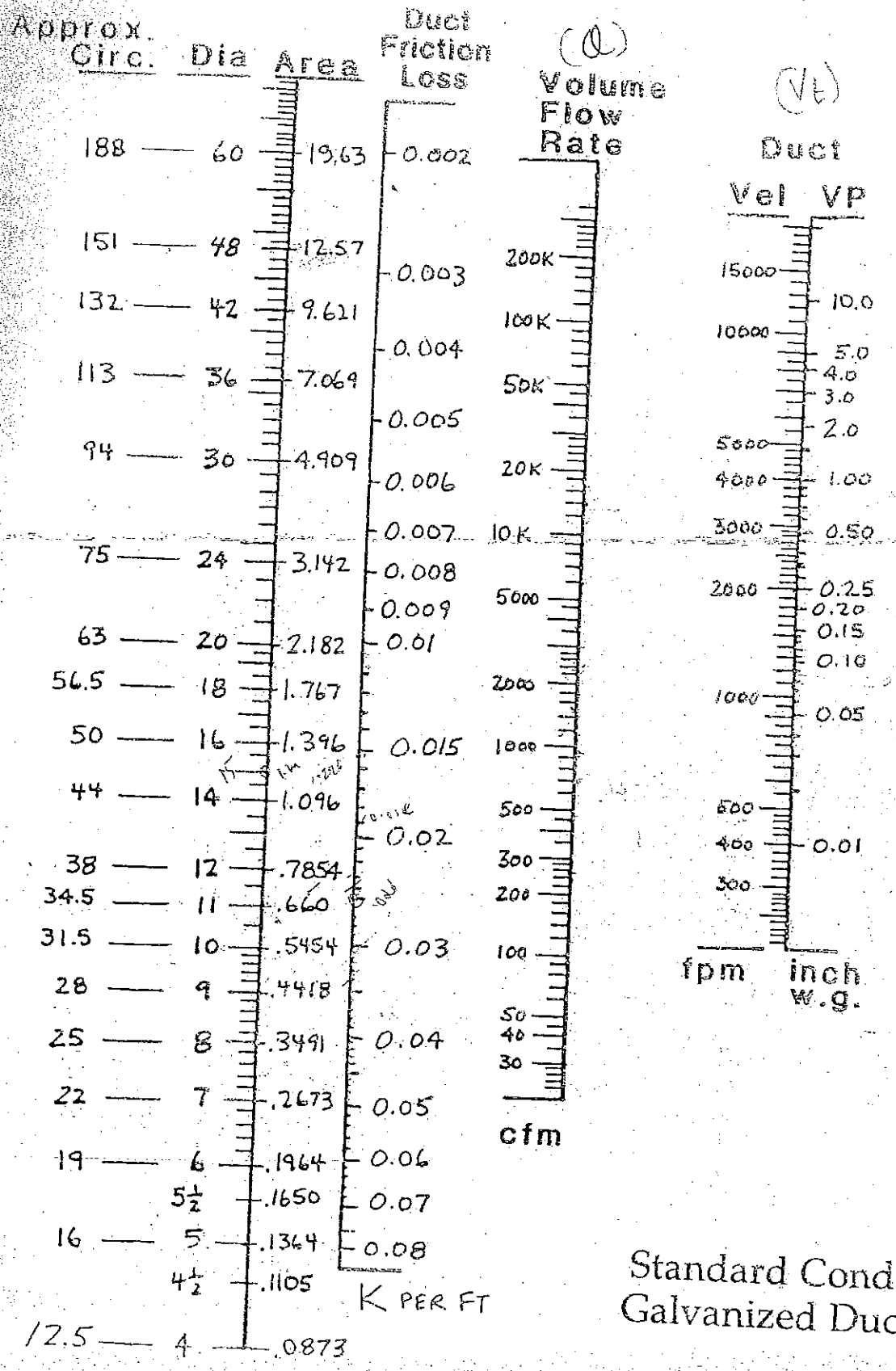
At standard conditions rounded for SI units. Start with mm w.g.

(For non-standard conditions, multiply V by $d^{-0.5}$; see Chart No. 6 for d. For example, if VP = 10 mm. and d = 0.86, then V = 12.8 x $(0.86)^{-0.5}$ = 12.8 x 1.078 = 13.8 actual mps.)

Velocity pressure inch	mm w.g.	Velocity fpm	mps
0.01	0.25	400	2.04
0.02	0.50	563	2.86
0.03	0.75	689	3.50
0.04	1.02	796	4.04
0.05	1.25	890	4.52
0.06	1.50	974	4.95
0.07	1.75	1053	5.35
0.08	2.00	1125	5.72
0.09	2.25	1193	6.06
0.10	2.50	1258	6.39
0.11	2.75	1319	6.70
0.12	3.00	1378	7.00
0.13	3.25	1434	7.29
0.14	3.50	1488	7.56
0.15	3.75	1541	7.83
0.16	4.00	1591	8.09
0.17	4.25	1640	8.33
0.18	4.50	1688	8.58
0.19	4.75	1734	8.81
0.20	5.0	1779	9.04
0.22	5.5	1866	9.48
0.24	6.0	1949	9.90
0.26	6.5	2029	10.3
0.28	7.0	2105	10.7
0.30	7.5	2179	11.1
0.31	8.0	2250	11.4
0.33	8.5	2320	11.8
0.35	9.0	2387	12.1
0.37	9.5	2452	12.5
0.39	10.0	2516	12.8
0.41	10.5	2578	13.1
0.43	11.0	2639	13.4
0.45	11.5	2698	13.7
0.47	12.0	2756	14.0
0.49	12.5	2813	14.3
0.51	13.0	2870	14.6
0.53	13.5	2925	14.9
0.55	14.0	2980	15.1
0.57	14.5	3030	15.4
0.59	15.0	3080	15.7
0.61	15.5	3130	15.9
0.63	16.0	3180	16.2
0.65	16.5	3230	16.4
0.67	17.0	3280	16.7
0.69	17.5	3330	16.9
0.71	18.0	3375	17.2
0.73	18.5	3420	17.4
0.75	19.0	3470	17.6
0.77	19.5	3515	17.9
0.79	20.0	3560	18.1
0.83	21.0	3650	18.5
0.87	22.0	3740	19.0
0.91	23.0	3820	19.4
0.94	24.0	3900	19.8
0.98	25.0	3980	20.2
1.06	27.0	4130	21.0
1.14	29.0	4280	21.8
1.22	31.0	4430	22.5
1.30	33.0	4570	23.2
1.38	35.0	4700	23.9
1.46	37.0	4840	24.6
1.54	39.0	4970	25.3
1.61	41.0	5090	25.9
1.69	43.0	5220	26.5
1.77	45.0	5340	27.1
1.85	47.0	5450	27.7
1.93	49.0	5570	28.3
2.00	51.0	5680	28.9
2.09	53.0	5790	29.4
2.17	55.0	5900	30.0

Chart No. 5A

Round Duct Air Flow Nomogram: US units

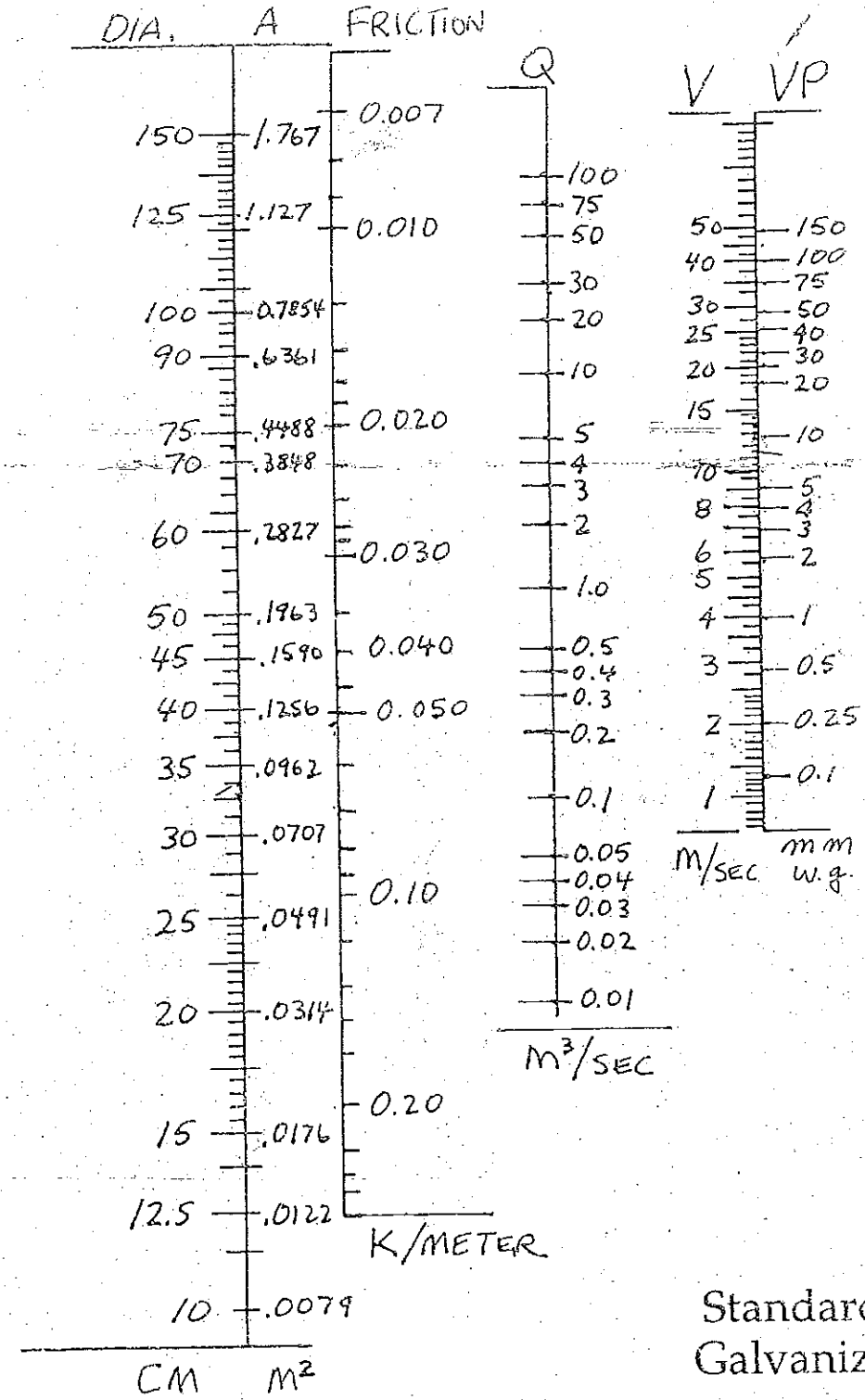


INCH INCH SQ FT 272

Standard Conditions, Galvanized Ductwork

Chart No 5B

Round Duct Air Flow Nomogram, SI units



Standard Conditions,
Galvanized Ductwork

Chart 10

Roughness Correction Factors

Absolute Roughness	Roughness Class	Typical Material	Roughness Correction Factor, R — Average Duct Velocity (STP) 1000 fpm / 5 mps	2000 fpm / 10 mps	4000 fpm / 20 mps	6000 fpm / 30 mps
0.02+	Extreme*	Flex duct	2.5	2.6	2.7	2.8
0.01	Very rough** surface	Riveted steel, Concrete	1.9	2.0	2.1	2.2
0.003	Medium rough surface	FRP (many strands showing); fibrous glass duct	1.4	1.5	1.5	1.6
0.0005	Average, common galvanized steel	Galv. steel, longit. seams, hot dipped	1.0	1.0	1.0	1.0
0.0004	Smooth common galv. steel	Rolled galv. steel, Spiral wound duct	0.97	0.96	0.95	0.95
0.0003	Medium smooth surface	Alum., stainless steel, glassy FRP	0.93	0.90	0.85	0.80
0.0001	Very smooth	PVC, ABS plastic	0.88	0.83	0.78	0.75

* Always check with supplier; flex duct diameters 4-12"; when extended.

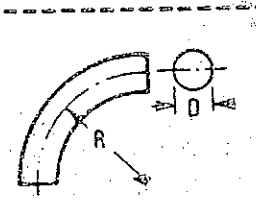
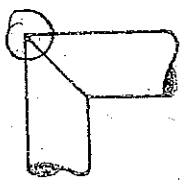
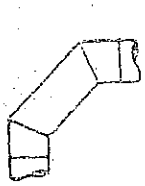
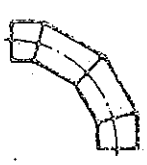
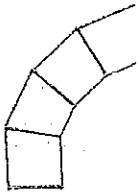
** Roughness factors for *Very Rough* and *Extreme* duct should be modified for diameter as follows:

$R_{actual} = R_{table} + Y_r$ where

Duct Diameter:	4-8"	9-12"	14-18"	20-30"	32-60"
Y_r :	0.1	0.0	-0.1	-0.2	-0.3

Other Roughness Correction Factors vary only slightly with diameter.

Elbow Loss Factor, K
(Round 90° ducts at STP)

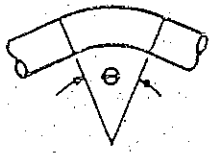
TYPE:	Smooth Transition (1)	Smooth Transition (2)	Mitre	3-piece	4-piece	5-piec
	K					
Round Duct *R/D						
Ø.5Ø	--	Ø.8Ø	1.2Ø	1.15	1.1Ø	Ø.9Ø
Ø.75	--	--	--	Ø.6Ø	Ø.55	Ø.5Ø
1.ØØ	--	Ø.35	--	Ø.45	Ø.4Ø	Ø.38
1.25	Ø.55	Ø.3Ø	--	Ø.42	Ø.38	Ø.33
1.5Ø	Ø.39	Ø.27	--	Ø.39	Ø.34	Ø.28
2.ØØ	Ø.27	Ø.24	--	Ø.41	Ø.33	Ø.28
2.5	Ø.22	Ø.24	--	--	Ø.37	Ø.3Ø

* Notes: R = radius of curvature as number of duct diameters, radius to center-line of duct.

(1) and (2) above represent range of sources.

Loss Factor K includes friction loss

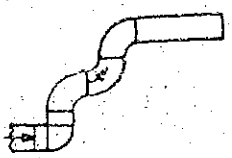
$SP_{loss} = K \times VP_d$



For angles < 90°, $K_\theta = (\frac{\theta}{90}) \times K_{90}$

For combined elbows in continuous ductwork:

$K_t = 1.25 \times$ (Sum of individual K factors)



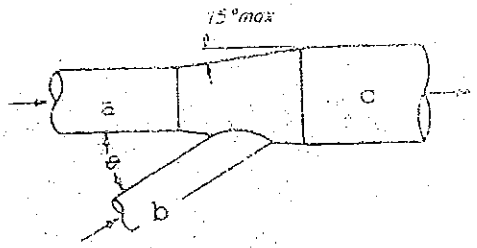
SOURCE: (1,2,9)

Branch Entry ("Tee") Loss Factors, K

Tee (Modified)

Loss occurs only in branch (b). Insert K in Row 23, Chart 12 [or, Row 11 of calculator/CASD form]

Ø	K
15	0.10
30	0.12
30	0.18
45	0.28
---------- *	
60	0.44
75	0.75
90	1.00



$$SP_{req} = 1.25\left[VP_c - \left(\frac{VP_aQ_a + VP_bQ_b}{Q_a + Q_b}\right)\right]$$: When $SP_{req} > 0$, insert in Row 29 of Chart 12 [or, Row 16 of CASD form]

*Angles greater than 45° should be avoided (30° is preferred); use Guffey method for Ø > 45°.

Guffey Method (Modified)

Loss or gain occurs in both main (a) and branch (b). Insert in Row 23, Chart 12. [CASD: Row 11]

	K, main a			K, branch b			
Db/Dc	30°	45°	90°	Db/Dc	30°	45°	90°
				≥0.3	0.16	0.15	-0.06
				0.4	0.15	0.15	-0.07
0.5	-0.32	-0.27	-0.15	0.5	0.14	0.13	-0.10
0.6	-0.30	-0.26	-0.15	0.6	0.12	0.11	-0.15
0.7	-0.26	-0.24	-0.14	0.7	0.09	0.07	-0.23
0.8	-0.20	-0.21	-0.14	0.8	0.03	0.01	-0.36
0.9	-0.12	-0.17	-0.12	0.9	-0.04	-0.08	-0.54
1.0	-0.11	-0.12	-0.11	--			

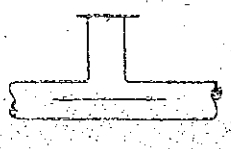
	Ea, main a			Eb, branch b			
Db/Dc	30°	45°	90°	Db/Dc	30°	45°	90°
≥0.5	0.67	0.61	0.24	≥0.5	0.78	0.72	-0.30
0.6	0.69	0.62	0.27	0.6	0.78	0.65	-0.39
0.7	0.71	0.64	0.32	0.7	0.76	0.57	-0.51
0.8	0.75	0.67	0.39	0.8	0.75	0.45	-0.71
0.9	0.80	0.71	0.49	0.9	0.72	0.27	-0.99
1.0	0.87	0.76	0.64	--			

where

$$SP_{req} = VP_c - \left(\frac{E_aVP_aQ_a + E_bVP_bQ_b}{Q_a + Q_b}\right)$$; Insert SP_{req} in Row 29, Chart 12 [or, Row 16 of CASD form]

Blanked Turns or entries

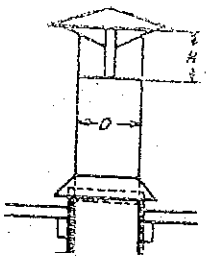
K = 1.3



K = Ø.1

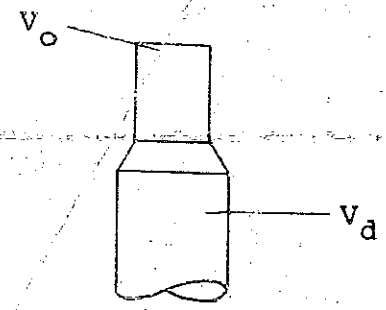
Stack Loss Factors, K

RAINCAP



H	K
1.ØØ D	Ø.1Ø
Ø.75 D	Ø.18
Ø.6Ø D	Ø.41
Ø.5Ø D	Ø.73
Ø.45 D	1.ØØ

STACK HEAD
(Narrowed to increase outlet velocity)

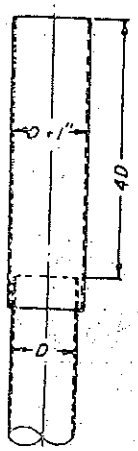


$K = Ø.25$ (where Loss $= K(VP_o - VP_d)$

EVASE
(Tapered outlet to regain static pressure)

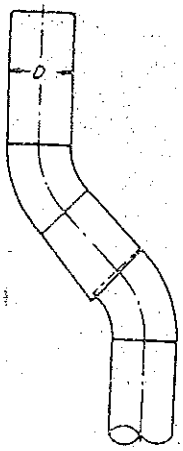
K = Ø (See Chart 17 for regain)

VERTICAL DISCHARGE



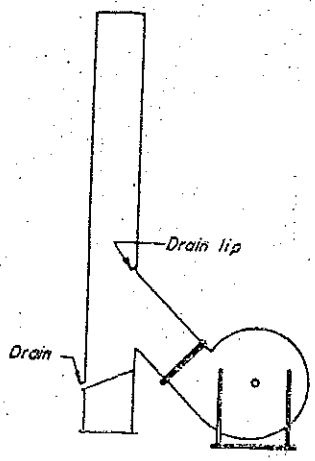
K = Ø

OFFSET ELBOWS



K = Ø.3Ø
(2-45° elbows)

OFFSET STACK



K = Ø.5
(Blanked turn)

SOURCE: (1,2)