System Design by computer

Spreadsheet tools

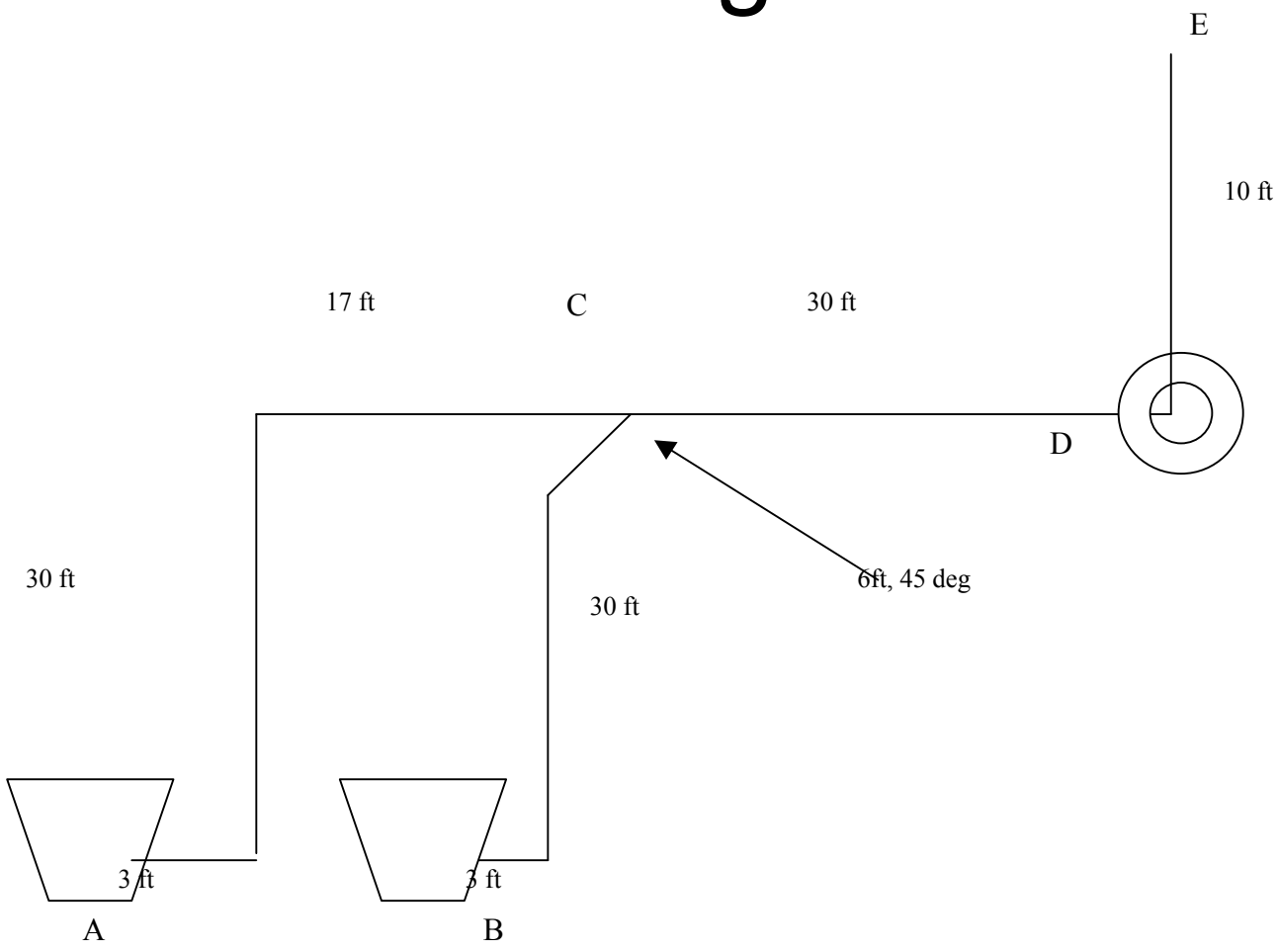
Velocity Pressure Method

- The velocity pressure method is commonly used on LEV systems
  - Assumes losses ~ F*Pv
  - Assumes volume flow rate is conserved
- Each branch becomes a column in the worksheet
- Each device or segment is a worksheet column
- Typically applies the ‘balanced by design’ technique for multiple branches, where balancing is done at each junction to determine branch airflows/losses
- Alternative: use blast gates to trim/adjust branches

Design Process

- Start with a drawing of system including lengths and all hoods/junctions
- Label all segments sequentially
  - Identify all junctions with a label
- Create a new column for each branch with a hood; specify the minimum Q in the hood
  - Include elbows, slots expansions etc.
- Sum the Q's at each junction and for main(s)
- Specify the air cleaner and the loss factor
- Balance all the junctions
- Determine the fan specifications

System Drawing
Class Design Problem

- 

Design problem worksheet

	B	C	D	E	F	G
1	B	C	D	E	F	F
2	-DUCT DESIGN SPECIFICATIONS	-	-	-	-	-
3	Duct branch number or label	A->C	B->C	C->D	E->D	E->D
4	Dry air volume flow, SCFM	300.00	320.000	620.00	620.00	620.00
5	Dry air mass flow, lbs/min	22.476	23.974	46.450	46.450	46.450
6	Air pres.@ branch start, "Hg	29.921	29.921	29.328	29.172	29.921
7	Dry bulb temp, 'F	70.000	70.000	70.000	70.000	70.000
8	Humidity ratio, lbH2O/lb air	0.008	0.008	0.008	0.008	0.008
9	Humid air vol. cuft/lb air	13.520	13.520	13.793	13.867	13.520
10	Moist air density, lb/cuft	0.075	0.075	0.073	0.073	0.075
11	Density correction factor	0.995	0.995	0.975	0.970	0.995
12	Enthalpy, BTU/lb air	25.542	25.542	25.542	25.542	25.542
13	Actual volume flow rate, ACFM	303.87	324.127	640.69	644.13	628.00
14	slot area, sqft	#N/A	#N/A	#N/A	#N/A	#N/A
15	slot velocity, fpm	#N/A	#N/A	#N/A	#N/A	#N/A
16	VP slot, "H2O	#N/A	#N/A	#N/A	#N/A	#N/A
17	Acceleration loss, 1 VP					
18	Slot entry loss, VP/slot					
19	Plenum loss factor, VP	0.000	0.000	0.000	0.000	0.000
20	Plenum SP, "H20		#N/A			
21	Duct length, ft	50.000	39.000	30.000	0.000	10.000
22	Duct dia. inches	3.500	3.500	5.000	5.000	5.000
23	Duct area, sqft	0.067	0.067	0.136	0.136	0.136
24	Duct Velocity, fpm	4548.034	4851.236	4698.710	4723.927	4605.642
25	Duct VP, "H2O	1.282	1.459	1.341	1.348	1.315
26	St. Duct friction, VP/100ft	8.197	8.144	5.293	5.291	5.298
27	Elbow curvature, R/dia	2.000	2.000			
28	Elbow loss factor, VP/elbow	0.270	0.270			
29	Number of elbows in branch	2.000	1.500			

Data Inputs

System branch inputs

- Duct Length & diameter
- Slot area: A_{slot}
- Elbow curvature & F_e
- Number of elbows
- Acceleration loss
- Slot entry loss
- Hood entry loss
- Branch entry loss

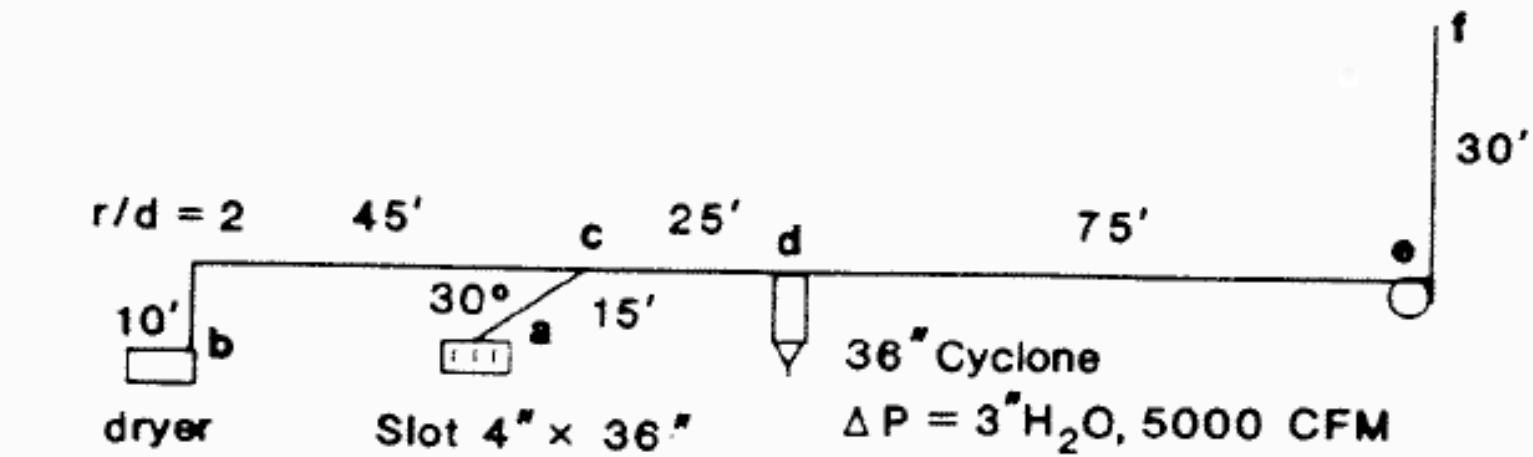
Conditions for Air Flow

- T_{db} Dry bulb temp
- P_b barometric pressure
- Q dry air volume
- w humidity ratio

Air Cleaner

- Air cleaner (loss coef)
- Rated flow rate
- Rated pressure drop

System Drawing
Koshland & Yost



$C_e = 0.88$

$V_{slot} = 1050$ fpm

$T_{db} = 400°F$

$he = 1.75\ VP_s + 0.25 VP_d$

$T_w = 128°F$

400 lb/hr H_2O

3	Duct branch number or label	A->C	B->C	C->D	E->D	E->D
4	Dry air volume flow, SCFM	1020.00	2250.000	3270.00	3270.00	3270.00
5	Dry air mass flow, lbs/min	76.418	168.570	244.988	244.988	244.988
6	Air pres.@ branch start, "Hg	29.921	29.921	29.832	29.673	29.921
7	Dry bulb temp, 'F	70.000	400.000	297.064	297.064	297.064
8	Humidity ratio, lbH2O/lb air	0.008	0.040	0.030	0.030	0.030
9	Humid air vol. cuft/lb air	13.520	23.055	20.049	20.157	19.989
10	Moist air density, lb/cuft	0.075	0.045	0.051	0.051	0.052
11	Density correction factor	0.995	0.602	0.686	0.682	0.688
12	Enthalpy, BTU/lb air	25.542	145.648	107.164	107.164	107.164
13	Actual volume flow rate, ACFM	1033.16	3886.457	4911.80	4938.12	4897.15
14	slot area, sqft	1.000	#N/A	#N/A	#N/A	#N/A
15	slot velocity, fpm	1033.156	#N/A	#N/A	#N/A	#N/A
16	VP slot, "H2O	0.066	#N/A	#N/A	#N/A	#N/A
17	Acceleration loss, 1 VP	1.000				
18	Slot entry loss, VP/slot	1.780				
19	Plenum loss factor, VP	2.780	0.000	0.000	0.000	0.000
20	Plenum SP, "H20	0.184	#N/A			
21	Duct length, ft	15.000	55.000	25.000	75.000	30.000
22	Duct dia. inches	8.000	14.000	16.000	16.000	16.000
23	Duct area, sqft	0.349	1.069	1.396	1.396	1.396
24	Duct Velocity, fpm	2959.775	3635.555	3517.824	3536.671	3507.327
25	Duct VP, "H2O	0.543	0.496	0.528	0.531	0.527
26	St. Duct friction, VP/100ft	3.121	1.584	1.342	1.341	1.342
27	Elbow curvature, R/dia		2.000			
28	Elbow loss factor, VP/elbow		0.270			
29	Number of elbows in branch		1.000			

Validation of equations

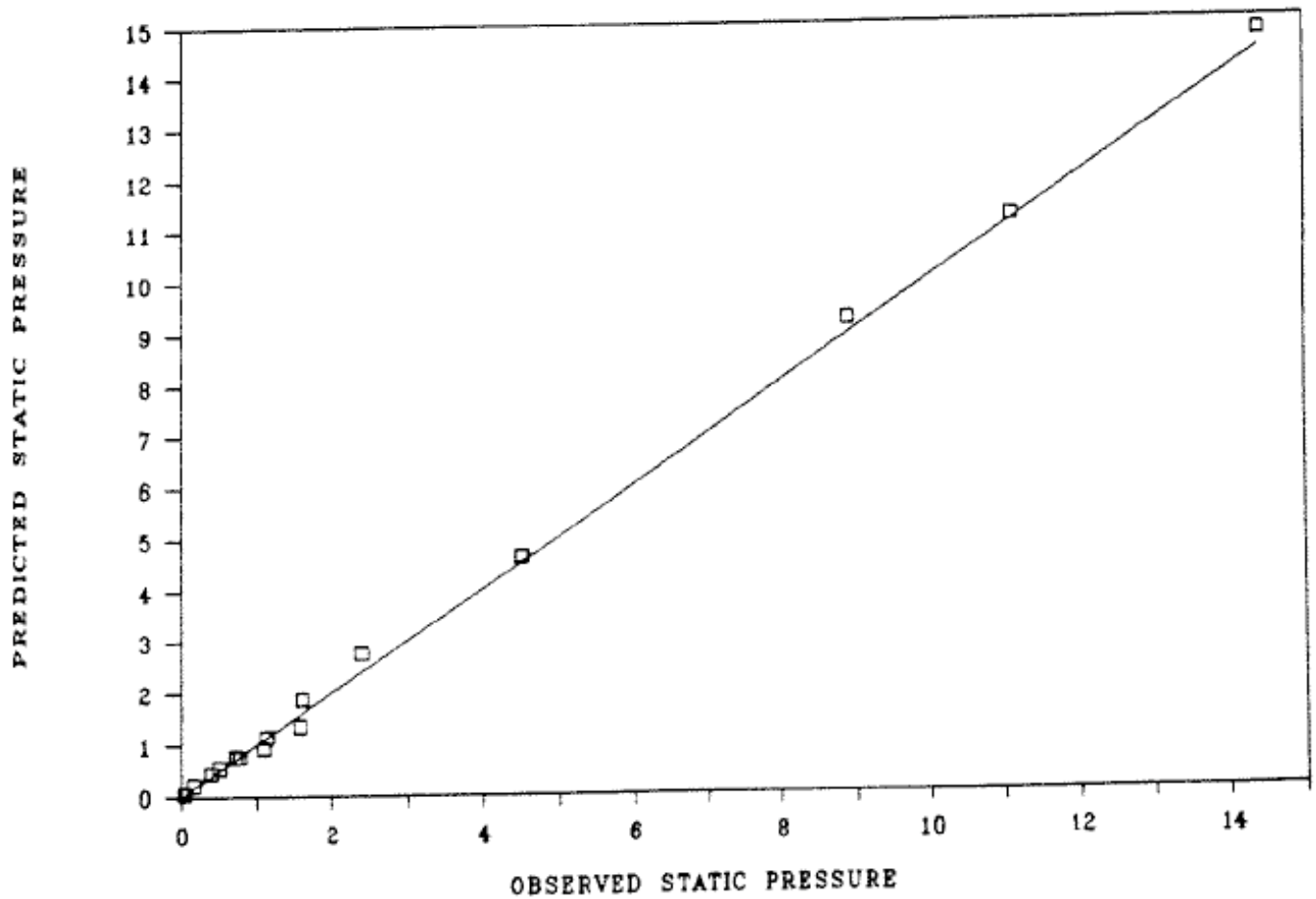
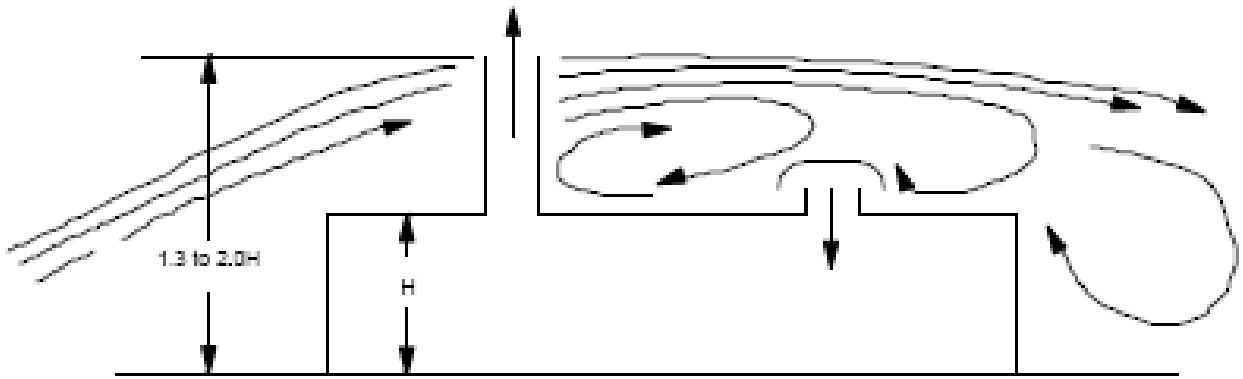


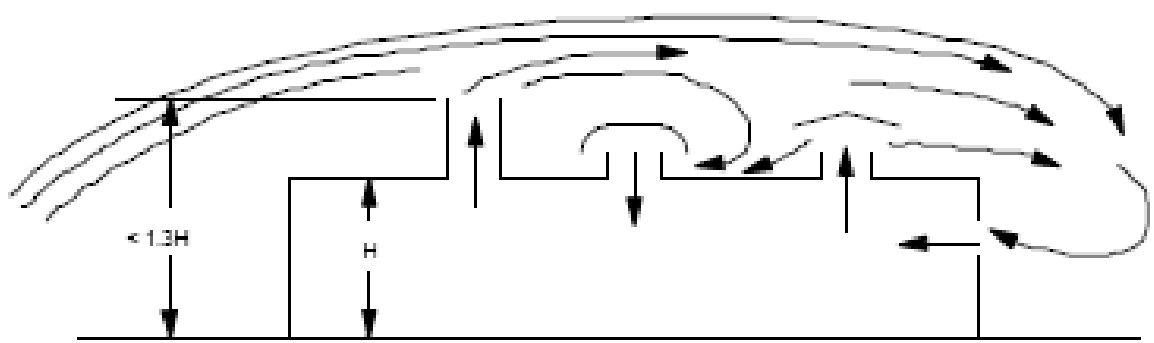
Figure 6—Results of spreadsheet validation showing predicted duct static pressures versus observed duct static pressures.



Good

Stack extends above eddy zone;

Effluent is dispersed and does not enter inlet.



Not Acceptable

Stack too short (left); stack has poor cap (right);

Effluent is not dispersed, and may enter inlets.

Ref: Clark JH, Heating piping & air conditioning 39: May 67 pp 145-154

Guidelines for low buildings w/o surrounding obstructions on reasonably level terrain.