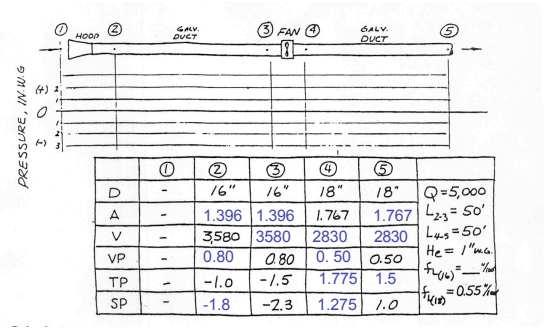
System design - 2

System balancing &
Multi-branch systems

Take home problem

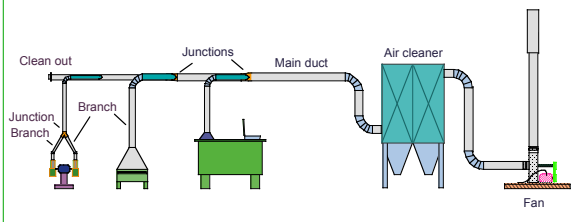


	①	②	③	④	⑤	
D	-	16"	16"	18"	18"	Q = 5,000
A	-	1.396	1.396	1.767	1.767	L_{2-3} = 50'
V	-	3580	3580	2830	2830	L_{4-5} = 50'
VP	-	0.80	0.80	0. 50	0.50	H_e = 1" w.g.
TP	-	-1.0	-1.5	1.775	1.5	$f_{L(4)}$ = ___ %/m
SP	-	-1.8	-2.3	1.275	1.0	$f_{K(18)}$ = 0.55 %/m

System Overview

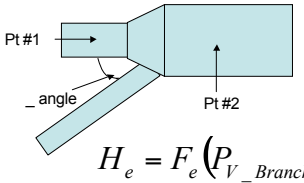
- Hood installation
- Connecting ducts to hoods
- Where to run ducts
- Selecting duct materials
- Important considerations in duct layout
- Important considerations in fan installation
- Stacks

A Simple System



Junctions

- Junction loss depends on angle of entry and P_V in the controlling branch

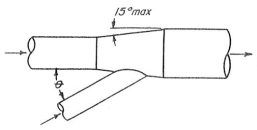


$$P_{T1} = P_{T2} + losses$$

$$H_e = F_e\left(P_{V\_Branch}\right)$$

$$P_{T1} = P_{T2} + F_e P_{V\_Branch}$$

DESIGN PROCEDURE



Angle θ Degrees	Loss Fraction of VP in Branch
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

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

Do not include an enlargement regain calculation for branch entry enlargements.

BRANCH ENTRY LOSSES

Branches and balancing

- Junctions join 2 or more duct branches
- At the junction, the system is "balanced" when the static pressure in each branch is the same
  - All systems will naturally be balanced since Ps must be uniform across the duct
  - However, for design of a system, we must insure that the branches match or have sufficient Ps to give the desired results (within some error)
- To account for this we choose in the design process a "governing static pressure" at the junction. The governing static pressure is the max{P_s} that will be required to give at least the desired Q in <u>all</u> branches

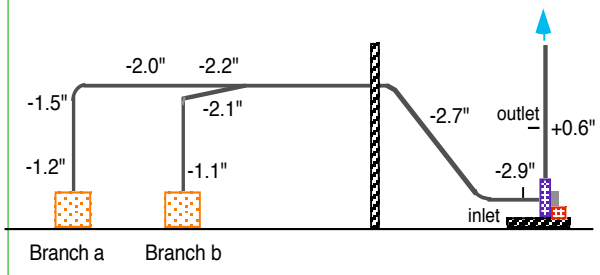
Design Balancing Rules

- Compute $P_{s(ratio)} = P_{s(higher)}/P_{s(lower)}$
- If $P_{s(ratio)} < 1.05$ ➔ Acceptable use $P_{s(higher)}$ as the governing static pressure at the junction
- If $1.05 < P_{s(ratio)} < 1.2$ ➔ Increase Q in the $P_{s(lower)}$ branch with:

$$Q_{adj} = Q_{original\ design}\sqrt{\frac{P_{S(higher)}}{P_{S(lower)}}}$$

- If $P_{s(ratio)} > 1.2$ ➔ Resize the duct in the $P_{s(lower)}$ branch

Static Pressure Changes in Parallel Flow



ACGIH: Pressures downstream of a junction

$$TP_m = TP_J$$

$$TP_m = SP_J + VP_r$$

$$SP_m = SP_J + VP_r - VP_m$$

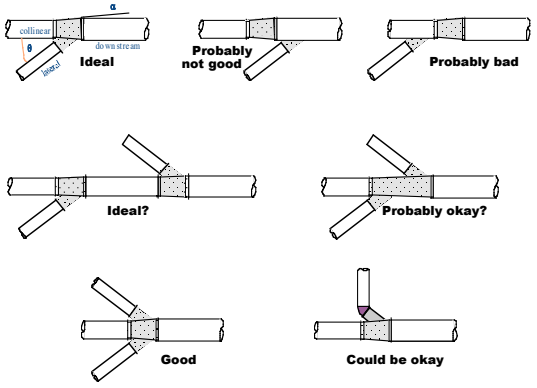
where: $$VP_r = \left(\frac{Q_m}{4005(A_a + A_b)}\right)^2$$

ACGIH: Balancing Pressures at a junction

$$Q_a = Q_{reqa}\left(\frac{SP_J}{SP_{J\_path_a}}\right)^{0.5}$$

$$Q_b = Q_{reqb}\left(\frac{SP_J}{SP_{J\_path_b}}\right)^{0.5}$$

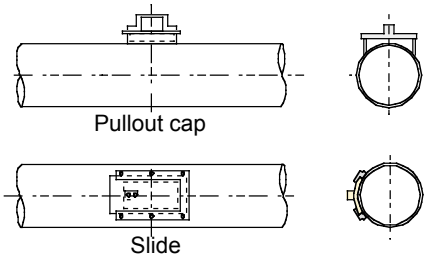
Okay Junction Fittings



Elbows at junction fittings okay?

Cleanouts

- Every 10 ft of horizontal duct or every elbow, whichever comes first
- Crucial for some systems



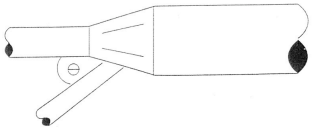
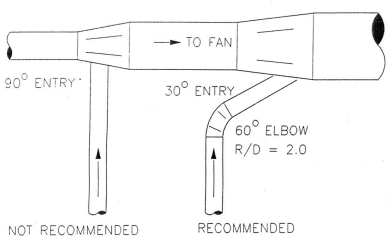


Figure 2.14 In a branch entry, the static pressure loss attributable to the fitting is attributed to the entering branch and is proportional to the velocity pressure there. The loss can be reduced by maintaining a small angle of entry.



Cleanouts

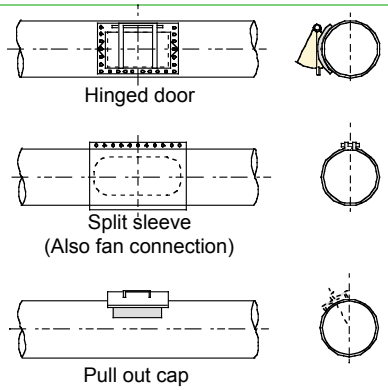


TABLE 4-2. RANGE OF DESIGN VELOCITIES

Nature of Contaminant	Examples	Design Velocity
Vapors, gases, smoke	All vapors gases and smokes	Any desired velocity (economic optimum velocity usually 1000-1200 fpm)
Fumes	Zinc and aluminum oxide fumes	1400-2000
Very fine light dust	Cotton lint, wood flour, litho powder	2000-2500
Dry Dusts and powders	Fine rubber dust, Bakelite molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings	2500-3500
Average industrial dust	Sawdust (heavy and wet), grinding dust, buffing lint (dry), wool jute dust (shaker waste), coffee beans, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries	3500-4000
Heavy dusts	Metal turnings, foundry tumbling barrels and shakeout, sand blast dust, wood blocks, hog waste, brass turnings, cast iron boring dust, lead dust	4000-4500
Heavy or moist dusts	Lead dust with small chips, moist cement dust, asbestos chunks from transite pipe cutting machines, buffing lint (sticky), quick-lime dust	4500 and up

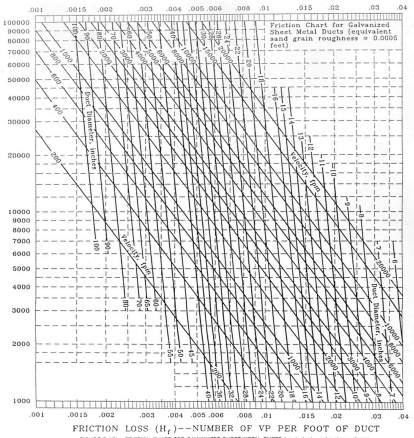


FIGURE 5-15b. FRICTION CHART FOR GALVANIZED SHEET METAL DUCTS (equivalent sand grain roughness height = 0.0005 feet).[11] Graph courtesy of J-Square Ventilation Company.

Hood installation

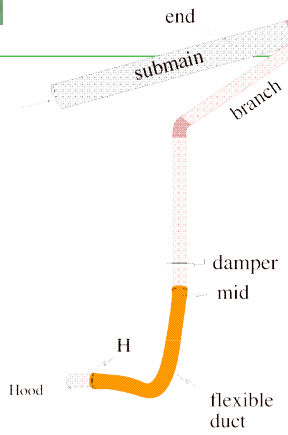
- Hoods should be designed to avoid jerry-rigging (i.e., make convenient and accessible).
- Protect hoods from traffic with barriers: walls, bump rails, etc.
- Reinforce hoods with angle iron or pipes and construct at least two gauges heavier than ducts
- Consider explosive hazards in wiring and fixtures
- Consider drainage for wet processes and chip traps for particulates
- Use perforated or expanded metal plenum face to avoid sucking in large objects

Selecting duct materials

- Industrial Ventilation's Construction Guidelines
- Materials:
  - Black iron: welded, flanged and gasketed
  - Galvanized steel sheet: welded, T<400F
  - Plastic, fiberglass, stainless for corrosive
    Specify fire-retardant if plastic
- Shape: round inherently stronger, easier to seal and less fatigue. Rectangular should be as square as possible.
- Gauge
  - Abrasive dusts: heavier gauges give greater wear time
  - Larger ducts weaker, need heavier gauge

Connecting ducts to hoods

- Use 45 degree tapered take-off if at all possible.
- Make it relatively easy to disconnect and re-connect the duct to the hood
- Be sure there is a good SPH measurement location
- Avoid kinking or excessive lengths in flexible ducts
- Consider pressure taps and SP sensors

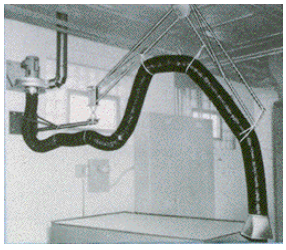


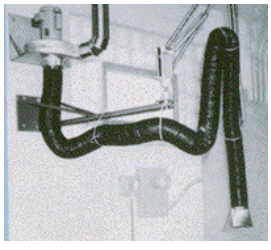
Measurement & Damper Locations

Where to run ducts

- Consider how will be supported
- Avoid highly desirable spaces
  - Run along walls or perpendicular to walls
  - Keep above traffic and process apparatus, but not so high that difficult to access
- If must penetrate wall, make hole larger, don't decrease the size of the duct

Flexible ducts

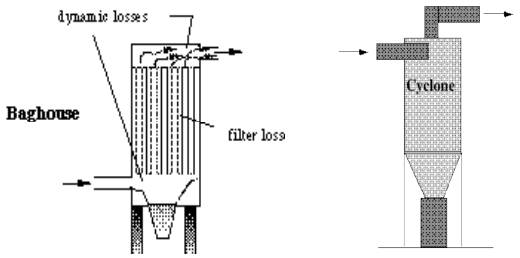




Important considerations in duct installation

- Make cleanouts and measurement locations accessible
- Should look neat (or invite destructive disrespect)
- Should be easy to take apart where plugging likely
- Put dampers at least 2D downstream of SPH location and as far as possible upstream of SPend location
- If wide temperature fluctuations, use expansion joints
- Elbows and junction fittings at least 2 gauges heavier
- Elbows smooth or 5 (D< 7") or 7 section (D≥7") with R/D ≥ 2D. Small smooth elbows can be R/D=1.5
- Junction lateral angles should be 30 or 45 degrees

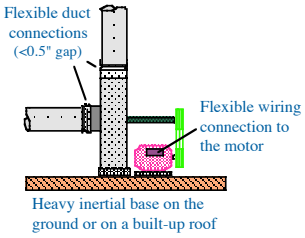
Air-Cleaner Losses



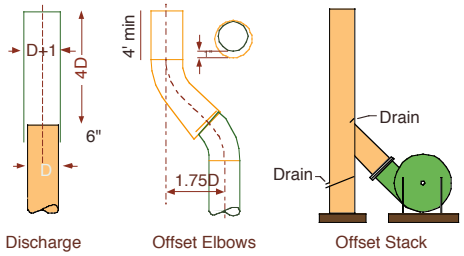
Filter loss linear with Q
Dynamic losses Q squared

Important considerations in fan installation

- Install outside or on built up roof, allowing for access for maintenance
- Consider how ducts will be run when installing base and ordering the fan. Arrange to have at least 5D of straight duct same diameter as inlet/outlet
- Use over-sized electrical wires with flexible connection to motor. Different circuit from lights.
- Should have heavy inertial base, well-chosen springs and vibration insulation
- Canvas, leather, or other flexible connection to inlet and outlet ducts
- Use offset stack



Weather Stacks



Weather caps deflect contaminant down to the roof, have significant losses, and do a poor job of keeping out the rain.

The offset stack should be used whenever possible since it takes the stack off of the fan. Also, open drain hole in fan.

END HERE