CAE 464/517 HVAC Systems Design

Spring 2023

March 9, 2023

Air distribution systems: Ductwork in practice

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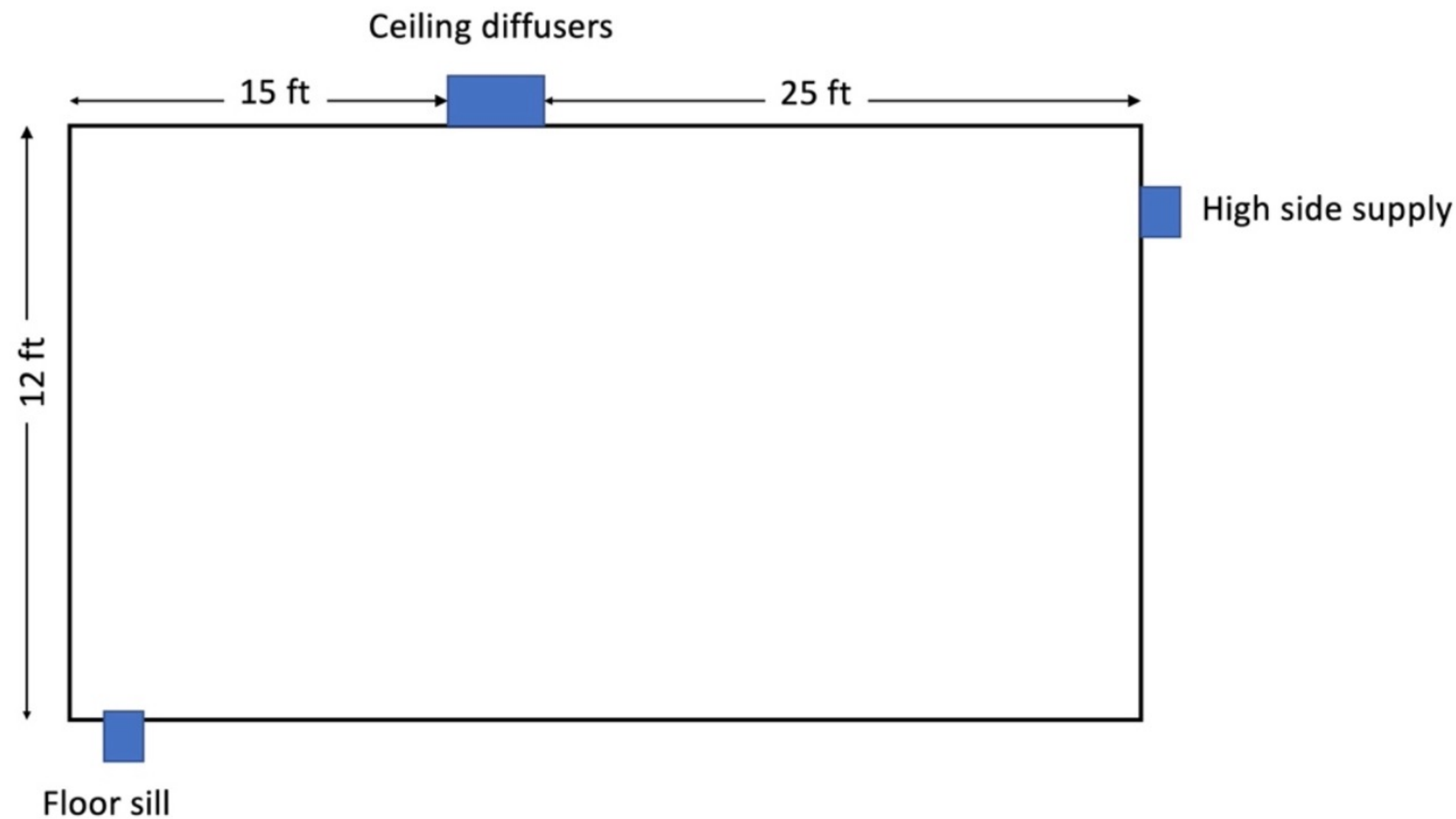
ANNOUNCEMENTS

Announcements

- The midterm exam 1 is graded
- Solutions are posted on Blackboard

Announcements

- Let’s look at this exam’s problem:



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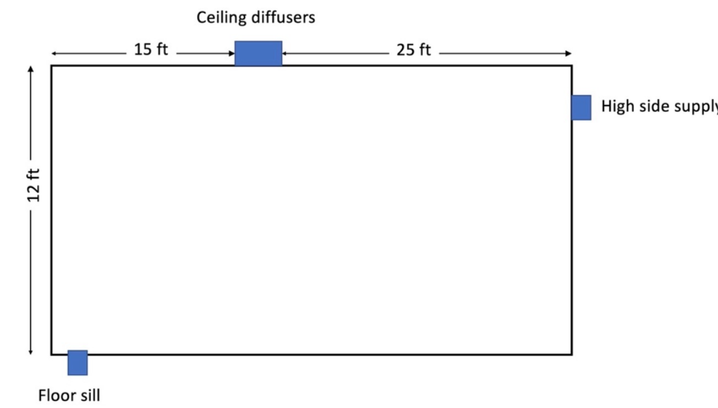

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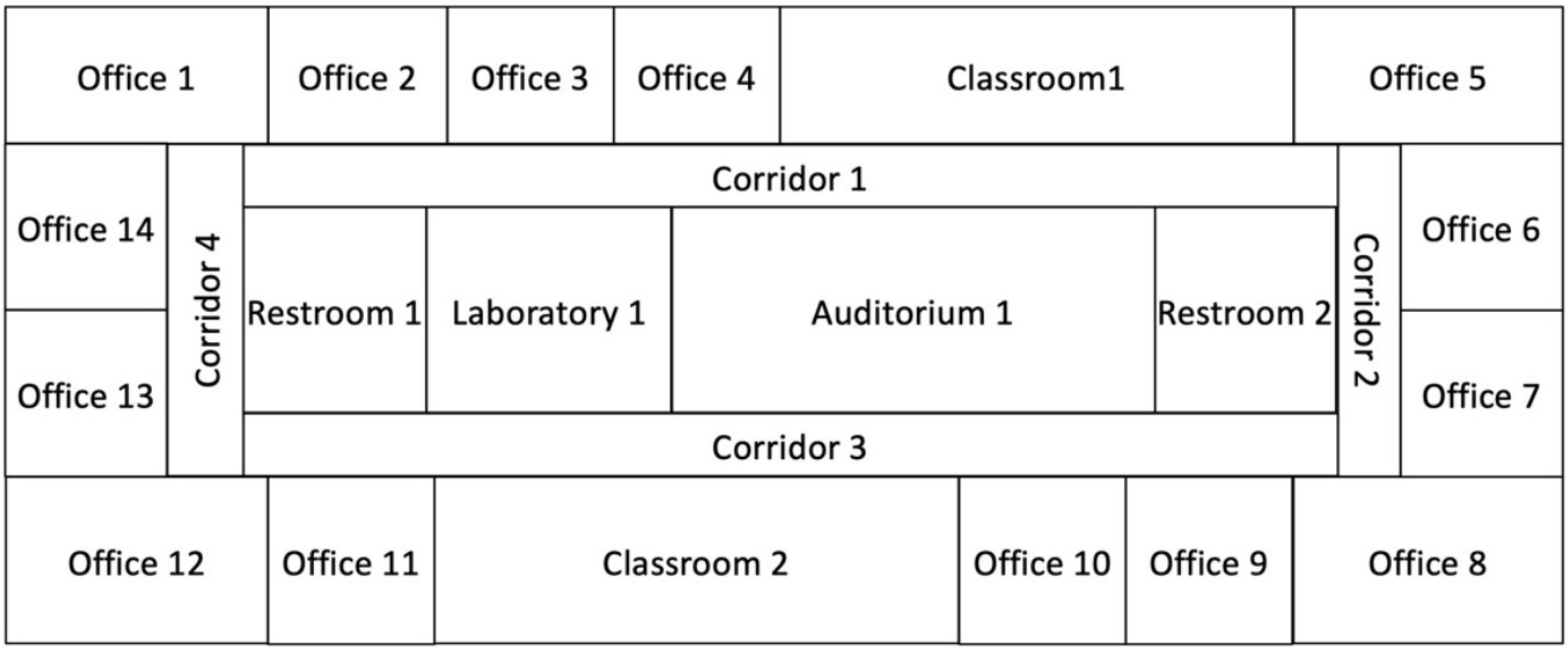


Announcements

- Final project presentation:
  - ❑ May 4, 8 am to 10 am
  - ❑ Location: Hermann Hall
  - ❑ All students are are required to present

Announcements

- Do not forget to review the Q&A file:

SUMMARY +

OUTLINE

- CAE 464/517 Spring 2023 Q&As
- Project Part 1
- Assignment 3
- Assignment 2
- Assignment 1
- Midterm Exam 1

CAE 464/517 Spring 2023 Q&As

Project Part 1

Question: After class when we spoke with you, you mentioned that the maximum amount of space types we should use is 4. We came up with:
Corridor/Transition
Operating/Patient Room
Office
Lounge/Recreation
as per ASHRAE common space types for hospitals.

https://docs.google.com/document/d/1m6ezSI6Bi9wGQcjnaYj_iAXY2kzRICPYWkKfayNp5WE/edit#heading=h.7xv0zdhfny5a

Announcements

- Great opportunity

One of our alums shared this with me today. Elevate, a local nonprofit and close collaborator of mine focused on energy efficiency, access, and equity, started an engineering division a few years ago and started an intern program last year. They hired one of our students for a yearlong internship, and now seek another intern for the upcoming year.

The chosen candidate will perform duties such as utility data analysis, data review for their High-Performance Buildings projects, engineering based calculator spreadsheet creation, administrative work for several programs across Elevate, and may include site visits and shadowing our Senior Engineers. The position is paid at $20/hr and the commitment they are asking is for 20 hrs/wk and for 12 months (1 year).

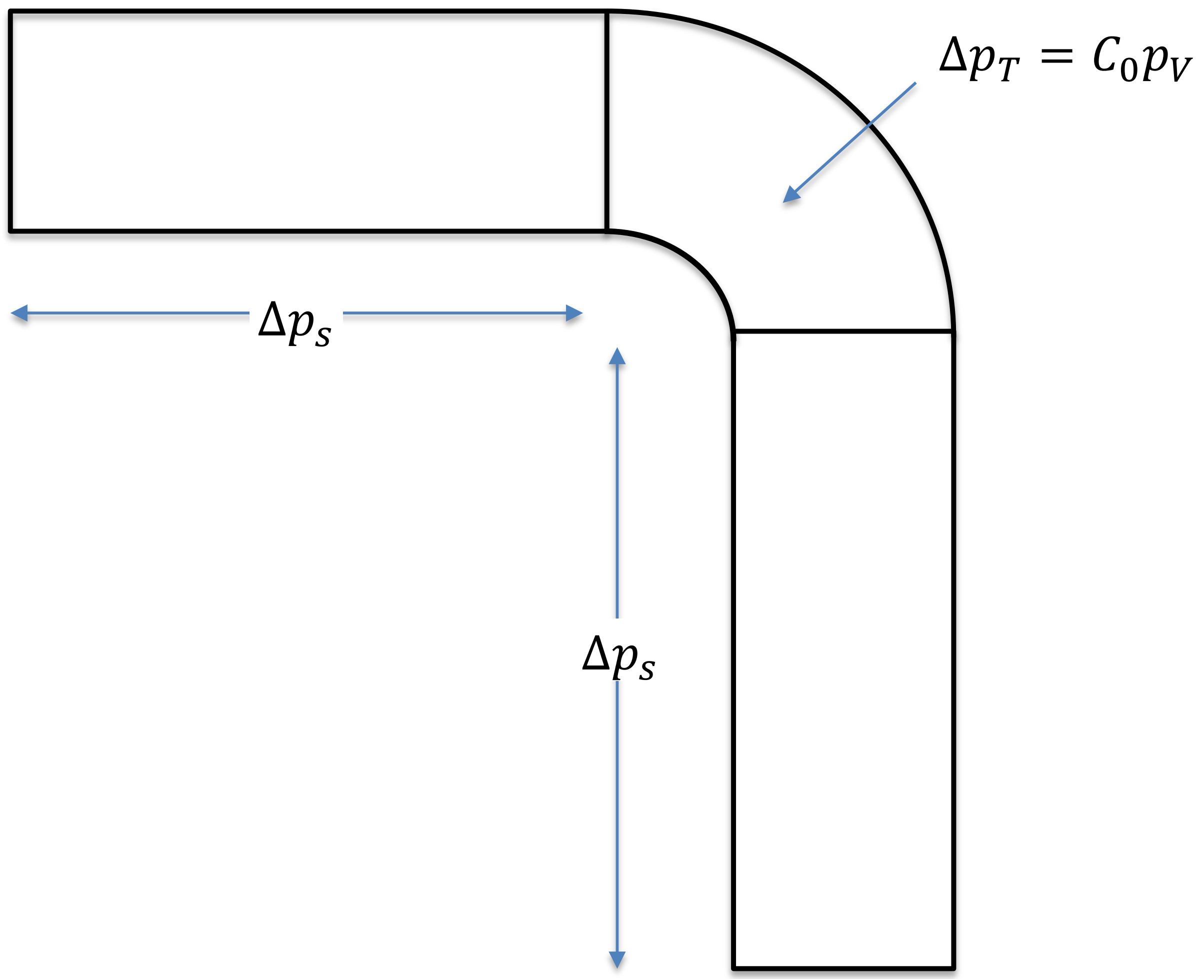
Applicants can review the job post at the following webpage https://www.elevatenp.org/careers/intern-engineering/ and follow the link at the bottom to submit their applications.

Please do let me know if you apply or if you have questions. They're a great organization to work for.

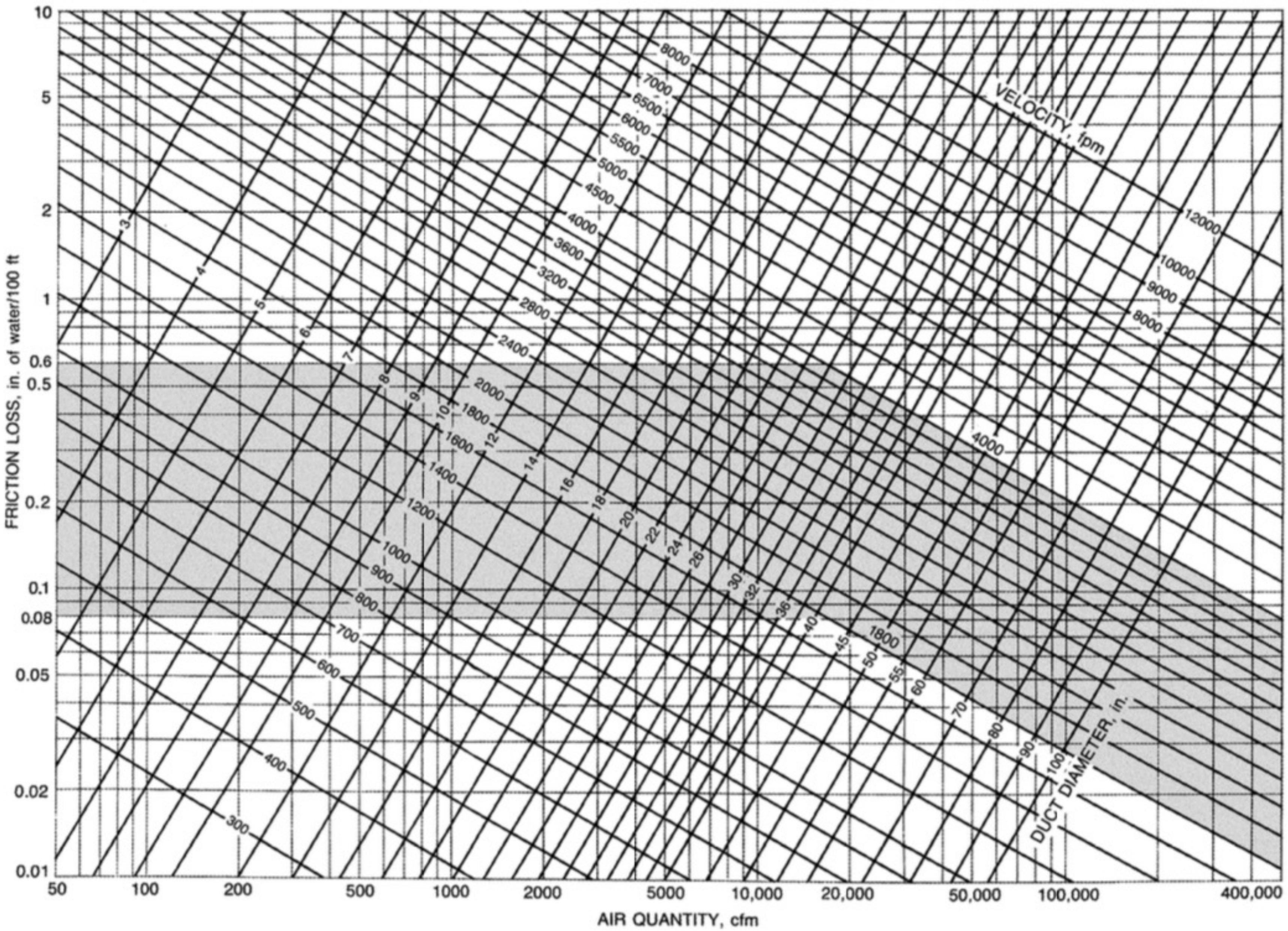
RECAP

Recap

- Pressure drop calculations (elbows and transitions)



Recap



FRICTION LOSS, in. of water/100 ft
AIR QUANTITY, cfm
VELOCITY, fpm
DUCT DIAMETER, in.
10
5
2
1
0.6
0.5
0.2
0.1
0.08
0.05
0.02
0.01
50
100
200
500
1000
2000
5000
10,000
20,000
50,000
100,000
400,000

Recap

$$p_{v,o} = \left(\frac{V_o}{4{,}005}\right)^2$$

Duct velocity V_o (fpm)	Duct pressure p_v (in w.c.)
4,000	1.00
3,000	0.56
2,000	0.25
1,000	0.06

Recap

- You can use other resources (e.g., Chapter 8 of the Price Industries Handbook)
- Older version of ASHRAE Handbook

https://utahashrae.org/images/meeting/011119/Slides/smacna_duct_design_fundamentals.pdf

http://ftp.demec.ufpr.br/disciplinas/TM184/VENTILACAO_LOCAL_EXAUSTORA/DUCT_DESIGN.pdf

DESIGN RULES

Design Rules

- The most important is that the duct fitting loss is a function of the velocity pressure in the duct ($\Delta p \sim V^2$)

  - The pressure losses associated with a poor fitting in a low velocity duct system will be much less than the losses associated with the same fitting in a higher velocity duct system

Design Rules

- A second important rule is that the ratio of perimeter to cross sectional area for a large duct is generally much smaller than it is for a small duct:
  - In practical terms, the velocities in a large duct will be much higher than they are in a smaller duct when designed at equal friction rates
  - As a result, the potential for a poor fitting to cause a static pressure problem is much higher in the larger ducts associated with an air handling system

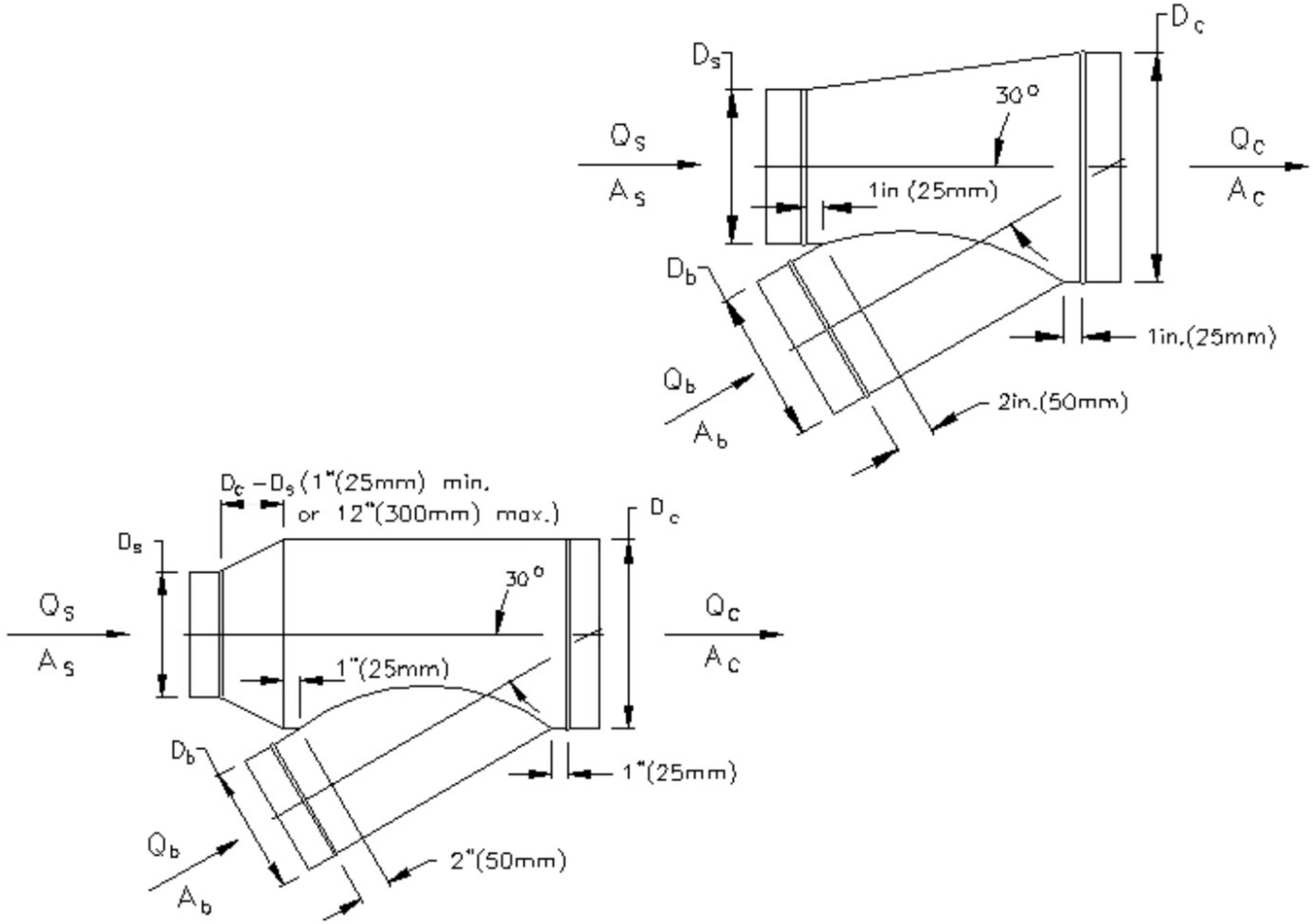
Design Rules

- Some common fitting terminology are:

Fitting Function	**Geometry**	**Category**	**Sequential Number**
S: **S**upply	D: Round (**D**iameter)	1. Entries	1, 2, 3, …
		2. Exits	
E: **E**xhaust / Return	R: **R**ectangular	3. Elbows	
		4. Transitions	
C: **C**ommon (supply/ return)	F: **F**lat oval	5. Junctions	
		6. Obstructions	
		7. Fan and system interactions	
		8. Duct-mounted equipment	
		9. Dampers	
		10. Hoods	

Design Rules

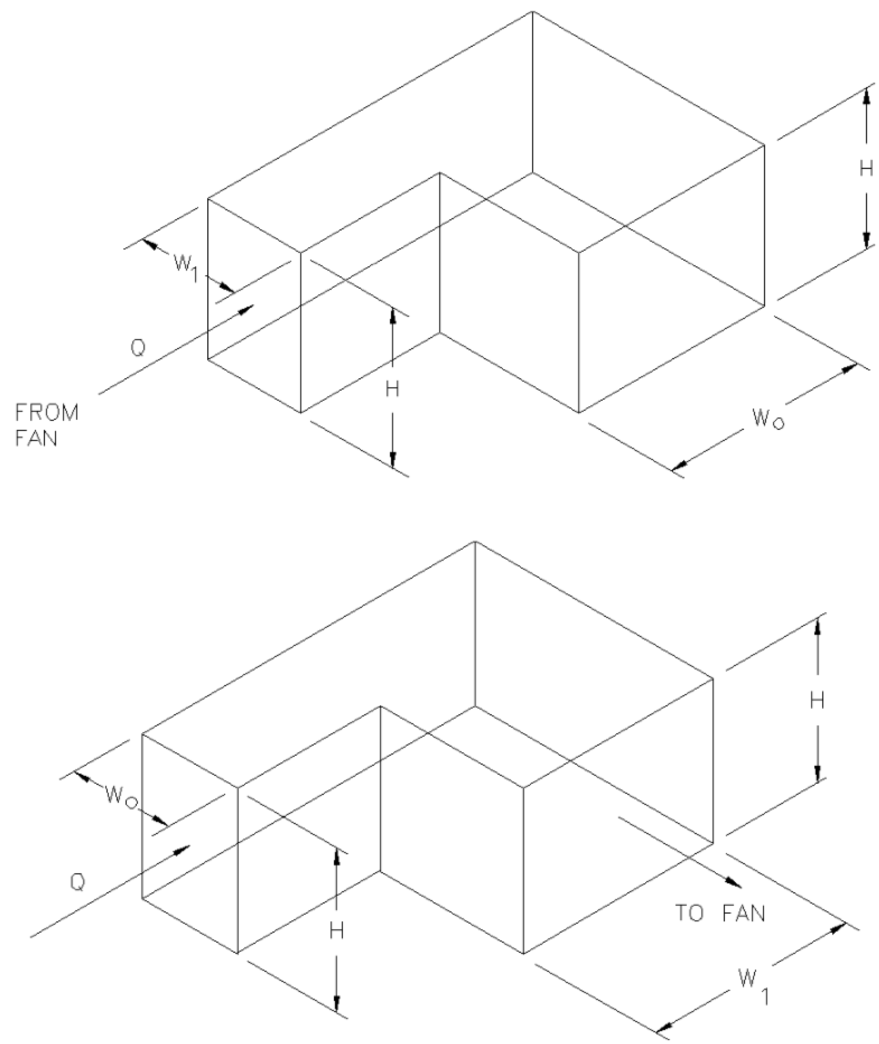
- Let's look at a few examples



30 Converging Wye (ED5-1)

Design Rules

- Let's look at a few examples



Unequal fitting (SR3-1 and ER 3-1)

Design Rules

- A few items to consider are:
  - ❑ Space pressure relationships
  - ❑ Fire and smoke control
  - ❑ Duct insulation
  - ❑ Duct system leakage
  - ❑ System and duct noise
  - ❑ Testing and balancing

Design Rules

- See Table 12 for the recommended maximum airflow velocities:

Table 12 Recommended Maximum Airflow Velocities to Achieve Specified Acoustic Design Criteria*

Duct Location	NC or RC Rating in Adjoining Occupancy	Maximum Airflow Velocity, fpm	
		Rectangular Duct	Round Duct
1	2	3	4
In shaft or above solid drywall ceiling	45	3500	5000
	35	2500	3500
	25 or less	1500	2500
Above suspended acoustical ceiling	45	2500	4500
	35	1750	3000
	25 or less	1000	2000
Duct within occupied space	45	2000	3900
	35	1450	2600
	25 or less	950	1700

Design Rules

- Look at Table 9 for different design criterion for recommended duct velocity and diameter:

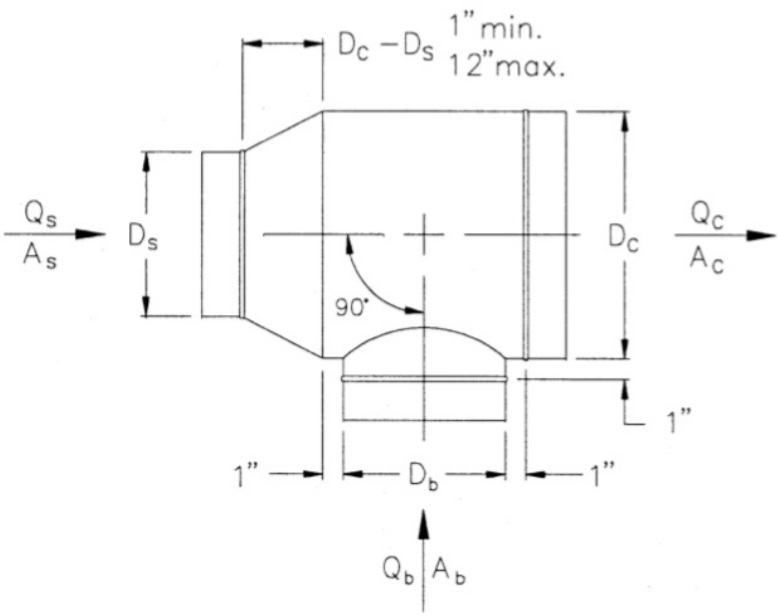
Table 9 Maximum Airflow of Round, Flat Oval and Rectangular Ducts as Function of Available Ceiling Space

A. Design Criterion: 0.08 in. of water per 100 ft or 2500 fpm Maximum						
Minimum Clearance for Duct, in.	**18**	**22**	**26**	**30**	**34**	**38**
Single Round Duct						
Duct diameter, in.	14	18	22	26	30	34
Airflow, cfm	950	1900	3200	4900	7300	10,000
Velocity, fpm	889	1075	1212	1329	1487	1586
Rectangular Duct with Aspect Ratio = 2						
Rectangular $W \times H$, in.	28 × 14	36 × 18	44 × 22	52 × 26	60 × 30	68 × 34
Airflow, cfm	2900	5500	9800	14,900	21,200	30,000
Velocity, fpm	1065	1222	1458	1587	1696	1869
Equivalent diameter D_e, in.	21.3	27.4	33.5	39.6	45.7	51.8
Flat Oval Duct with Aspect Ratio = 2						
Flat oval $A \times a$, in.	28 × 14	36 × 18	44 × 22	52 × 26	60 × 30	68 × 34
Airflow, cfm	2700	5400	9000	14,000	21,000	28,000
Velocity, fpm	1111	1344	1500	1670	1882	1954
Equivalent diameter D_e, in.	20.7	26.6	32.5	38.4	44.4	50.3
Two Round Ducts in Parallel						
Duct diameter, in.	Two 12	Two 16	Two 20	Two 24	Two 28	Two 32
Airflow, cfm	630 each	1350 each	2450 each	3950 each	5950 each	8500 each
Velocity, fpm	802	967	1123	1257	1391	1522

EXAMPLE

Example

- **Example:** Compute the loss in total pressure for a round 90-dgree branch and straight-through section, a tee. The common section is 12 in. in diameter, and the straight-through section has a 10 in. diameter with a flow rate of 1,100 cfm. The branch flow rate is 250 cfm through a 6 in. duct.



	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.20	0.62	0.80	1.28	1.99	2.92	4.07	5.44	7.02
0.2	4.10	1.20	0.72	0.62	0.66	0.80	1.01	1.28	1.60
0.3	8.99	2.40	1.20	0.81	0.66	0.62	0.64	0.70	0.80
0.4	15.89	4.10	1.94	1.20	0.88	0.72	0.64	0.62	0.63
0.5	24.80	6.29	2.91	1.74	1.20	0.92	0.77	0.68	0.63
0.6	35.73	8.99	4.10	2.40	1.62	1.20	0.96	0.81	0.72
0.7	48.67	12.19	5.51	3.19	2.12	1.55	1.20	0.99	0.85
0.8	63.63	15.89	7.14	4.10	2.70	1.94	1.49	1.20	1.01
0.9	80.60	20.10	8.99	5.13	3.36	2.40	1.83	1.46	1.20

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.13	0.16							
0.2	0.20	0.13	0.15	0.16	0.28				
0.3	0.90	0.13	0.13	0.14	0.15	0.16	0.20		
0.4	2.88	0.20	0.14	0.13	0.14	0.15	0.15	0.16	0.34
0.5	6.25	0.37	0.17	0.14	0.13	0.14	0.14	0.15	0.15
0.6	11.88	0.90	0.20	0.13	0.14	0.13	0.14	0.14	0.15
0.7	18.62	1.71	0.33	0.18	0.16	0.14	0.13	0.15	0.14
0.8	26.88	2.88	0.50	0.20	0.15	0.14	0.13	0.13	0.14
0.9	36.45	4.46	0.90	0.30	0.19	0.16	0.15	0.14	0.13

Example

- Solution:

- Calculate velocity in each section:

$$V_c = \frac{Q_c}{A_c} = \frac{Q_c}{\left(\frac{\pi}{4}\right) D_c^2} = \frac{1{,}100}{\frac{\pi}{4} \times \left(\frac{12}{12}\right)^2} = 1{,}400\ fpm$$

$$V_b = \frac{Q_b}{A_b} = \frac{Q_b}{\left(\frac{\pi}{4}\right) D_b^2} = \frac{250}{\frac{\pi}{4} \times \left(\frac{6}{12}\right)^2} = 1{,}273\ fpm$$

$$V_s = \frac{Q_s}{A_s} = \frac{Q_s}{\left(\frac{\pi}{4}\right) D_s^2} = \frac{850}{\frac{\pi}{4} \times \left(\frac{10}{12}\right)^2} = 1{,}558\ fpm$$

Example

- Solution:

- The ratio of the branch to the common flow rate is:

$$\frac{Q_b}{Q_c} = \frac{250}{1{,}100} = 0.23$$

- The ratio of the main to the common flow rate is:

$$\frac{Q_s}{Q_c} = \frac{850}{1{,}100} = 0.77$$

Example

- Solution:

- The ratio of the branch to the common are is:

$$\frac{A_b}{A_c} = \left(\frac{6}{12}\right)^2 = 0.25$$

- The ratio of the main to the common are is:

$$\frac{A_s}{A_c} = \left(\frac{10}{12}\right)^2 = 0.69$$

Example

- Solution:

- Using the loss coefficient for the branch, we have

$$\Delta p_{0b} = C_b\left(\frac{V_b}{4{,}005}\right)^2 = 1.55\left(\frac{1{,}273}{4{,}005}\right)^2 = 0.16\ in\ w.c.$$

$$\frac{A_b}{A_c} = 0.25$$

$$\frac{Q_b}{Q_c} = 0.23$$

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.20	0.62	0.80	1.28	1.99	2.92	4.07	5.44	7.02
0.2	4.10	1.20	0.72	0.62	0.66	0.80	1.01	1.28	1.60
0.3	8.99	2.40	1.20	0.81	0.66	0.62	0.64	0.70	0.80
0.4	15.89	4.10	1.94	1.20	0.88	0.72	0.64	0.62	0.63
0.5	24.80	6.29	2.91	1.74	1.20	0.92	0.77	0.68	0.63
0.6	35.73	8.99	4.10	2.40	1.62	1.20	0.96	0.81	0.72
0.7	48.67	12.19	5.51	3.19	2.12	1.55	1.20	0.99	0.85
0.8	63.63	15.89	7.14	4.10	2.70	1.94	1.49	1.20	1.01
0.9	80.60	20.10	8.99	5.13	3.36	2.40	1.83	1.46	1.20

Example

- Solution:

- Using the loss coefficient for the branch, we have

$$\Delta p_{0s} = C_s \left(\frac{V_s}{4{,}005}\right)^2 = 0.14 \left(\frac{1{,}558}{4{,}005}\right)^2 = 0.021\ in\ w.c.$$

$$\frac{A_s}{A_c} = 0.69$$

$$\frac{Q_s}{Q_c} = 0.77$$

C_s Values

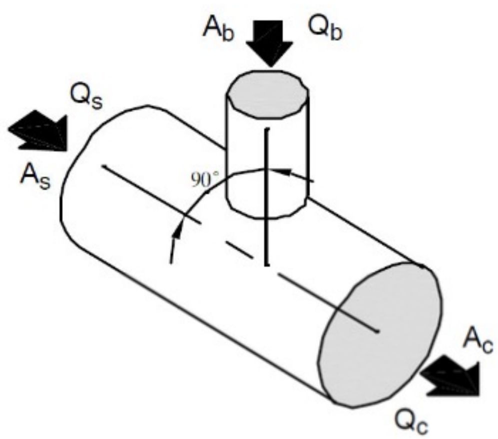
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.13	0.16							
0.2	0.20	0.13	0.15	0.16	0.28				
0.3	0.90	0.13	0.13	0.14	0.15	0.16	0.20		
0.4	2.88	0.20	0.14	0.13	0.14	0.15	0.15	0.16	0.34
0.5	6.25	0.37	0.17	0.14	0.13	0.14	0.14	0.15	0.15
0.6	11.88	0.90	0.20	0.13	0.14	0.13	0.14	0.14	0.15
0.7	18.62	1.71	0.33	0.18	0.16	0.14	0.13	0.15	0.14
0.8	26.88	2.88	0.50	0.20	0.15	0.14	0.13	0.13	0.14
0.9	36.45	4.46	0.90	0.30	0.19	0.16	0.15	0.14	0.13

EXAMPLE

Example

- Example: Converging Tee 90° Round Main and Branch. Main is 10”, Branch is 7”. Air flow Main is 1000 cfm. Air flow Branch is 500 cfm.

B. CONVERGING TEE, 90°, ROUND



Branch, Coefficient C (*See* Note 8)							
Q_b/Q_c	A_b/A_c						
	0.1	0.2	0.3	0.4	0.6	0.8	1.0
0.1	0.40	-0.37	-0.51	-0.46	-0.50	-0.51	-0.52
0.2	3.8	0.72	0.17	-0.02	-0.14	-0.18	-0.24
0.3	9.2	2.3	1.0	0.44	0.21	0.11	-0.08
0.4	16	4.3	2.1	0.94	0.54	0.40	0.32
0.5	26	6.8	3.2	1.1	0.66	0.49	0.42
0.6	37	9.7	4.7	1.6	0.92	0.69	0.57
0.7	43	13	6.3	2.1	1.2	0.88	0.72
0.8	65	17	7.9	2.7	1.5	1.1	0.86
0.9	82	21	9.7	3.4	1.8	1.2	0.99
1.0	101	26	12	4.0	2.1	1.4	1.1

Main, Coefficient C (*See* Note 8)										
Q_b/Q_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C	0.16	0.27	0.38	0.46	0.53	0.57	0.59	0.60	0.59	0.55

Example

- Solution

$$A_c = \frac{\left(\frac{\pi \times 10^2}{4}\right)}{144} = 0.55\ ft^2$$

$$A_b = \frac{\left(\frac{\pi \times 7^2}{4}\right)}{144} = 0.24\ ft^2$$

$$V_c = \frac{1{,}000}{0.55} = 1818\ fpm$$

$$V_b = \frac{2{,}083}{0.24} = 2083\ fpm$$

Example

- Solution

$$p_{v,c} = \left(\frac{1818}{4005}\right)^2 = 0.21\ in\ w.c.$$

$$p_{v,b} = \left(\frac{2083}{4005}\right)^2 = 0.27\ in\ w.c.$$

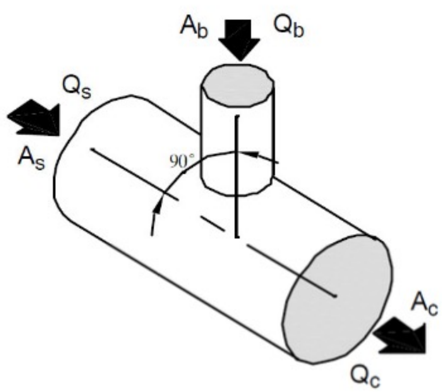
$$\frac{Q_b}{Q_c} = \frac{500}{1000} = 0.50$$

$$\frac{A_b}{A_c} = \frac{0.24}{0.5} = 0.44$$

Example

- Solution

B. CONVERGING TEE, 90°, ROUND



Branch, Coefficient C (*See* Note 8)							
Q_b/Q_c	A_b/A_c						
	0.1	0.2	0.3	0.4	0.6	0.8	1.0
0.1	0.40	-0.37	-0.51	-0.46	-0.50	-0.51	-0.52
0.2	3.8	0.72	0.17	-0.02	-0.14	-0.18	-0.24
0.3	9.2	2.3	1.0	0.44	0.21	0.11	-0.08
0.4	16	4.3	2.1	0.94	0.54	0.40	0.32
0.5	26	6.8	3.2	1.1	0.66	0.49	0.42
0.6	37	9.7	4.7	1.6	0.92	0.69	0.57
0.7	43	13	6.3	2.1	1.2	0.88	0.72
0.8	65	17	7.9	2.7	1.5	1.1	0.86
0.9	82	21	9.7	3.4	1.8	1.2	0.99
1.0	101	26	12	4.0	2.1	1.4	1.1

Main, Coefficient C (*See* Note 8)										
Q_b/Q_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C	0.16	0.27	0.38	0.46	0.53	0.57	0.59	0.60	0.59	0.55

$C_b = 1.0$

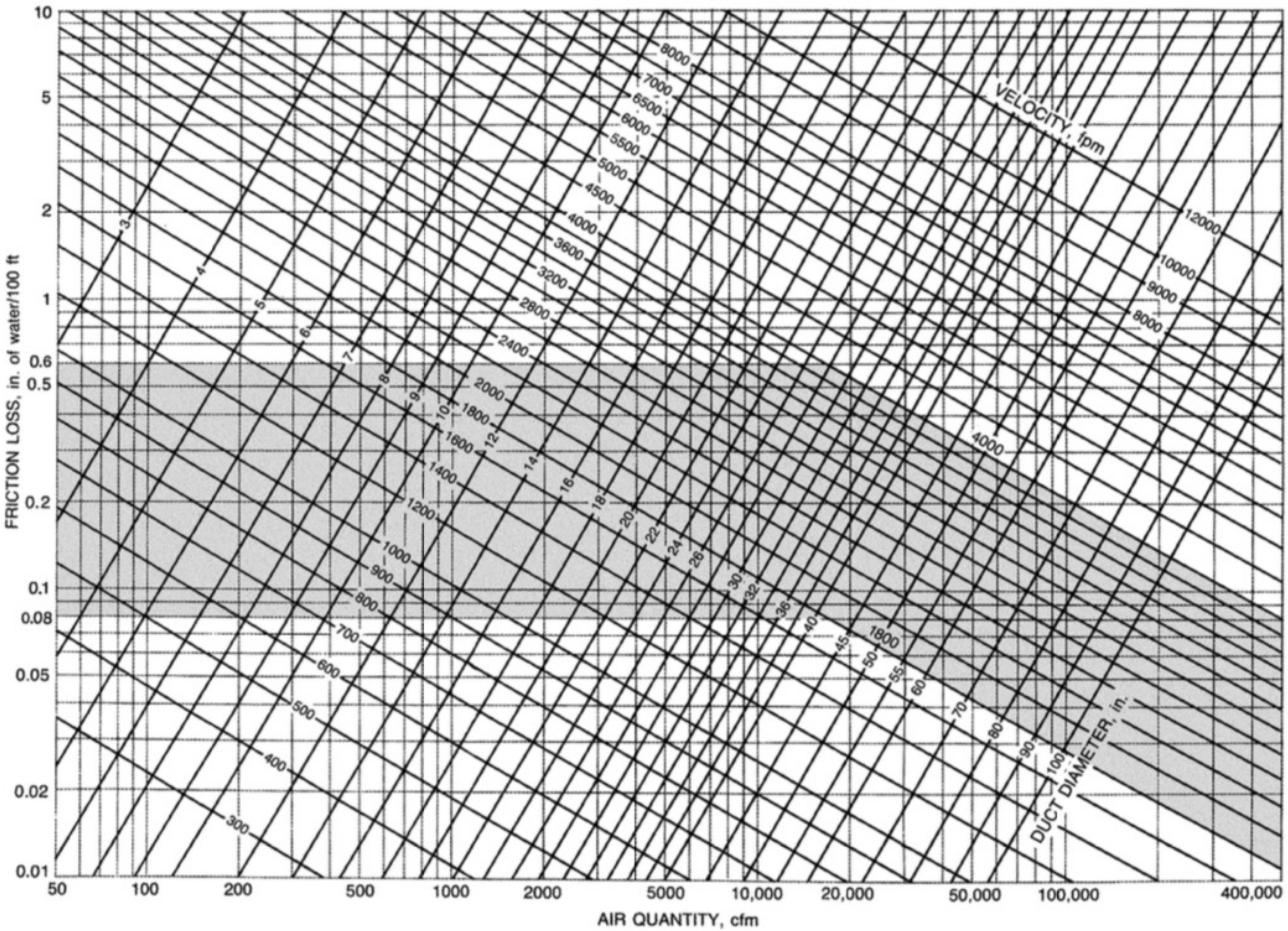
$$\Delta p_{t,b-c} = 1\times 0.21 = 0.21\ in\ w.c.$$

$$\Delta p_{t,b-c} = 053\times 0.27 = 0.14\ in\ w.c.$$

SMACNA Duct Design Fundamentals

DUCTWORK IN PRACTICE

Ductwork in Practice



Ductwork in Practice

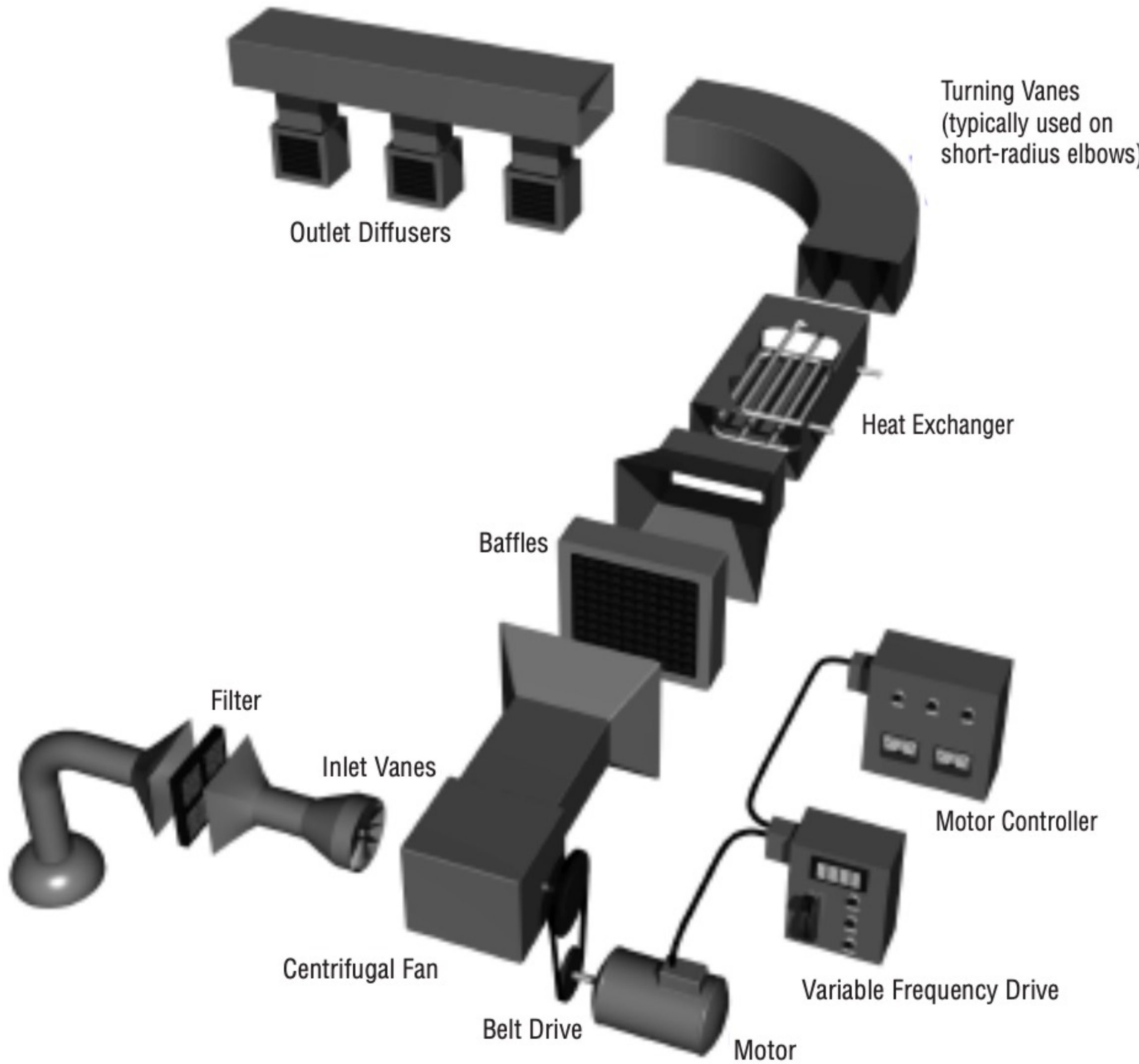
Circular Duct Diameter, in.	Length of One Side of Rectangular Duct (*a*), in.																				
	4	5	6	7	8	9	10	12	14	16	18	20	22	24	26	28	30	32	34	36
	Length Adjacent Side of Rectangular Duct (*b*), in.																				
5	5																				
5.5	6	5																			
6	8	6																			
6.5	9	7	6																		
7	11	8	7																		
7.5	13	10	8	7																	
8	15	11	9	8																	
8.5	17	13	10	9																	
9	20	15	12	10	8																
9.5	22	17	13	11	9																
10	25	19	15	12	10	9															
10.5	29	21	16	14	12	10															
11	32	23	18	15	13	11	10														
11.5		26	20	17	14	12	11														
12		29	22	18	15	13	12														
12.5		32	24	20	17	15	13														
13		35	27	22	18	16	14	12													
13.5		38	29	24	20	17	15	13													
14			32	26	22	19	17	14													
14.5			35	28	24	20	18	15													
15			38	30	25	22	19	16	14												
16			45	36	30	25	22	18	15												
17				41	34	29	25	20	17	16											
18				47	39	33	29	23	19	17											
19				54	44	38	33	26	22	19	18										
20					50	43	37	29	24	21	19										
21					57	48	41	33	27	23	20										

Ductwork in Practice

- The ratio of the rectangular ductwork is very important since the average velocity is different:
  - ❑ If space permitted, an aspect ratio of 4:1 or less are best
  - ❑ The ratio greater than 8:1 should be avoided

Ductwork in Practice

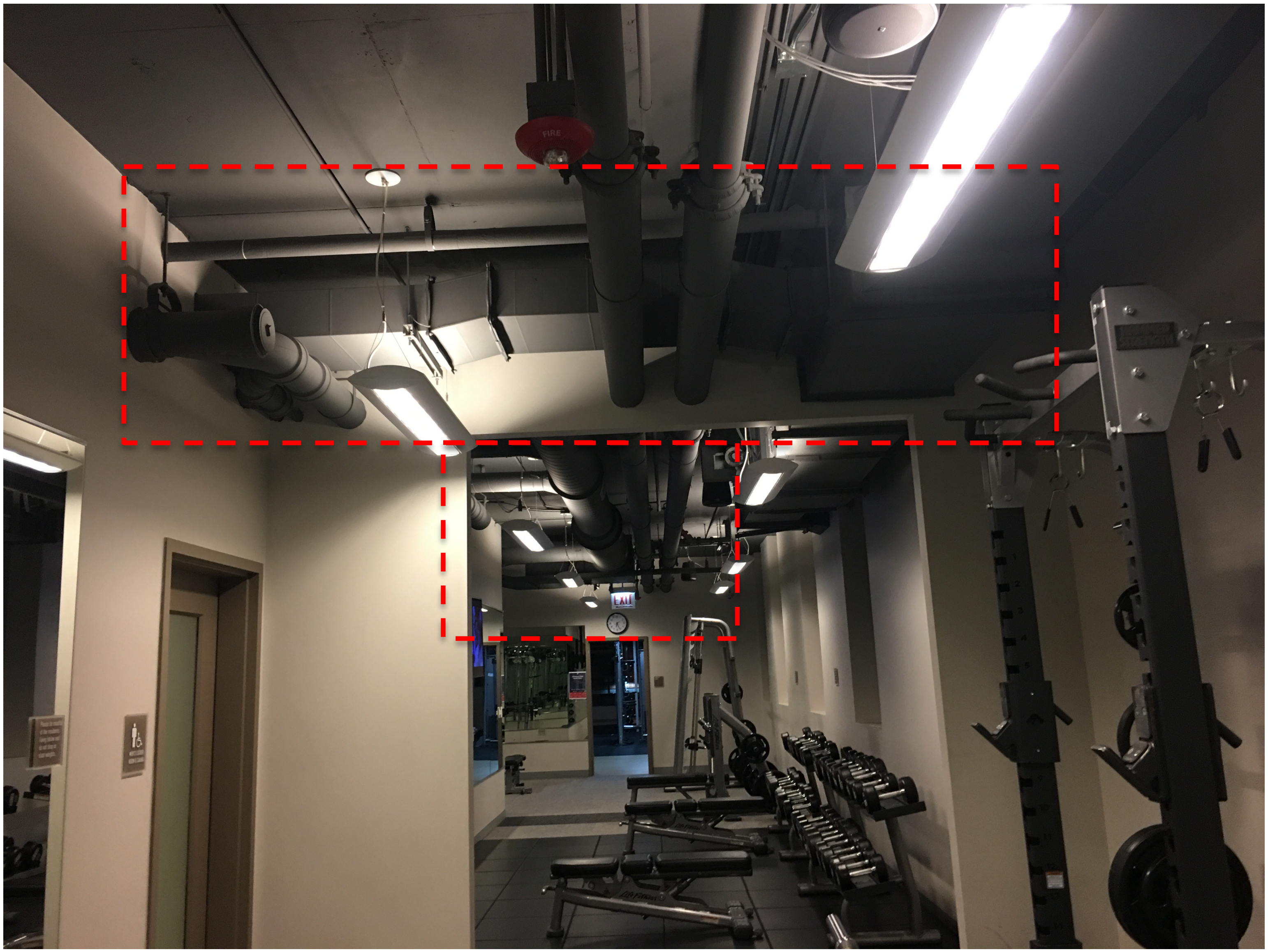
- The air distribution includes various components:



https://www.nrel.gov/docs/fy03osti/29166.pdf

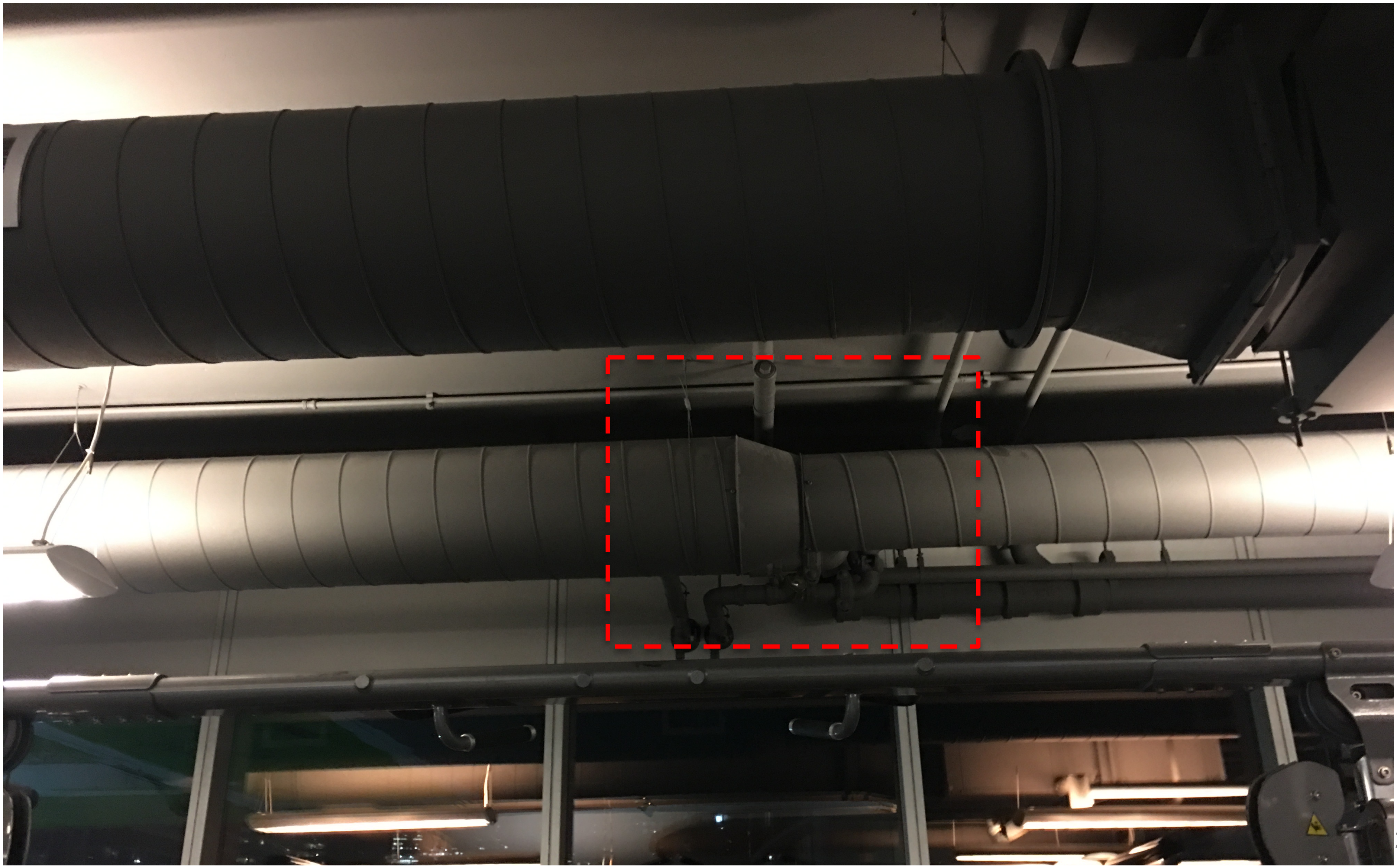
Ductwork in Practice

- Use separate design for return and supply



Ductwork in Practice

- Change of diameter



Ductwork in Practice

- Outdoor air intake

Ductwork in Practice

- Installation of supply and return outlets

Ductwork in Practice

- Adding interesting and daily application of HVAC systems:

  https://docs.google.com/presentation/d/15bvvZ0VVm9SgonCzZ5N07MBvl0YdVRYaph6Z3evveJA/edit#slide=id.g1f2938fcdac_0_0

PROJECT

Project

- Let's first look at ASHRAE 170

Table 7-1 Design Parameters—Inpatient Spaces *(Continued)*

Function of Space (ee)	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Unoccupied Turndown	Minimum Filter Efficiencies (cc)	Design Relative Humidity (k), %	Design Temperature (l), °F/°C
Operating/surgical cystoscopic rooms *(FGI 2.2–3.4 & Table T2.2-2; also see Class 3 Imaging)* (m), (o)	Positive	4	20	NR	No	Yes	MERV-16	20–60	68–75/20–24
Patient care area corridor	NR	NR	2	NR	NR	Yes	MERV-14	NR	NR
Patient room *(FGI 2.1–2.3.2)*	NR	2	4 (y)	NR	NR	Yes	MERV-14	Max 60	70–75/21–24
Patient toilet room *(FGI 2.1–2.3.5 & 2.1–2.3.6)*	Negative	NR	10	Yes	No	Yes (ff)	MERV-8	NR	NR
PE anteroom *(FGI 2.2–2.2.4.4)* (t)	(e)	NR	10	NR	No	No	HEPA	NR	NR
Phase I PACU and Phase II recovery *(FGI 2.1–3.4.4 & 2.1–3.4.5)*	NR	2	6	NR	No	Yes	MERV-14	20–60	70–75/21–24
Procedure room *(Table T2.2-1)* (o), (d)	Positive	3	15	NR	No	Yes	MERV-14	20–60	70–75/21–24
Protective environment room *(FGI 2.2–2.2.4.4)* (t)	Positive	2	12	NR	No	No	HEPA	Max 60	70–75/21–24
Radiology waiting rooms *(FGI 2.2–3.4.10.1)*	Negative	2	12	Yes (q), (w)	NR	Yes (ff)	MERV-8	Max 60	70–75/21–24
Seclusion room *(FGI 2.1–2.4.3)*	NR	2	4 (y)	NR	NR	Yes	MERV-14	Max 60	70–75/21–24
Sterile processing room *(FGI 2.2–3.3.6.15)*	NR	2	6	NR	No	Yes	MERV-8 (gg)	NR	NR
Treatment room *(FGI 2.2–3.1.2.6)* (p)	NR	2	6	NR	NR	Yes	MERV-8	20–60	70–75/21–24
Wound intensive care (burn unit)	Positive	2	6	NR	No	Yes	HEPA	40–60	70–75/21–24
BEHAVIORAL AND MENTAL HEALTH FACILITIES (k)									
Patient bedroom, resident room *(FGI 2.2–2.12.2 & 2.5–2.2.2)*	NR	2	2	NR	NR	Yes	MERV-8	NR	NR
Seclusion room *(FGI 2.1–2.4.3 & 2.2–2.12.4.3)*	NR	4	2	NR	NR	Yes	MERV-8	NR	NR
DIAGNOSTIC AND TREATMENT									
Bronchoscopy, sputum collection, and pentamidine administration *(FGI 2.2–3.9.2)* (n), (x)	Negative	2	12	Yes	No	Yes	MERV-14	NR	68–73/20–23
Class 1 imaging room *(FGI 2.2–3.4.1.2 & Table 2.2-2)*	NR (jj)	2	6	NR	NR	Yes	MERV-8	Max 60	72–78/22–26
Class 2 imaging room *(FGI 2.2–3.4.1.2 & Table 2.2-2)* (d), (p)	Positive	3	15	NR	No	Yes	MERV-14	Max 60	70–75/21–24
Class 3 imaging room *(FGI 2.2–3.4.1.2 & Table 2.2-2)* (m), (o)	Positive	4	20	NR	No	Yes	MERV-16 (hh)	20–60	68–75/21–24
Dialysis treatment area *(FGI 2.2–3.10.2)*	NR	2	6	NR	NR	Yes	MERV-8	NR	72–78/22–26
Dialyzer reprocessing room *(FGI 2.2–3.10.8.16)*	Negative	NR	10 (bb)	Yes	No	Yes (ff)	MERV-8	NR	NR

Informative Notes: (1) NR = no requirement; (2) FGI paragraph numbers are shown in parentheses in the "Function of Space" column.

Project

- Let's first look at ASHRAE 170

Table 7-1 Design Parameters—Inpatient Spaces *(Continued)*

Function of Space (ee)	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach
Operating/surgical cystoscopic rooms *(FGI 2.2–3.4 & Table T2.2-2; also see Class 3 Imaging)* (m), (o)	Positive	4	20
Patient care area corridor	NR	NR	2
Patient room *(FGI 2.1–2.3.2)*	NR	2	4 (y)
Patient toilet room *(FGI 2.1–2.3.5 & 2.1–2.3.6)*	Negative	NR	10
PE anteroom *(FGI 2.2–2.2.4.4)* (t)	(e)	NR	10
Phase I PACU and Phase II recovery *(FGI 2.1–3.4.4 & 2.1–3.4.5)*	NR	2	6
Procedure room *(Table T2.2-1)* (o), (d)	Positive	3	15
Protective environment room *(FGI 2.2–2.2.4.4)* (t)	Positive	2	12
Radiology waiting rooms *(FGI 2.2–3.4.10.1)*	Negative	2	12
Seclusion room *(FGI 2.1–2.4.3)*	NR	2	4 (y)
Sterile processing room *(FGI 2.2–3.3.6.15)*	NR	2	6
Treatment room *(FGI 2.2–3.1.2.6)* (p)	NR	2	6
Wound intensive care (burn unit)	Positive	2	6

Project

- Let’s first look at ASHRAE 170

Ventilation Rates for Health Care Facilities, Residential Buildings, and Vehicles

TABLE E-1*
Outdoor Air Requirements for Ventilation of Health Care Facilities (Hospitals, Nursing and Convalescent Homes)

Application	Estimated Maximum** Occupancy P/1000 ft^2 or 100 m^2	Outdoor Air Requirements cfm/person	L/s · person	cfm/ft^2	L/s · m^2	Comments
Patient rooms	10	25	13			Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency. Procedures generating contaminants may require higher rates.
Medical procedure	20	15	8			
Operating rooms	20	30	15			
Recovery and ICU	20	15	8			
Autopsy rooms	20			0.50	2.50	Air shall not be recirculated into other spaces.
Physical therapy	20	15	8			

* Table E-1 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.

** Net occupiable space.