Green Ductwork Done Right

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Ingersoll Rand

EDUCATION PROVIDER

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Course title: Green Ductwork Done Right **Course ID: 0090007998**

Approved for 1.5 GBCI hours for LEED professionals

Today's Agenda

- Review Fundamentals of High Velocity, Static Regain Duct Design
- Key Advantages over Low-Med Velocity Rectangular Duct Design
- Do's and Don'ts
- Examine Cost of 6 Real World Projects
- Review SPIDA Duct Layout Examples
- Summary

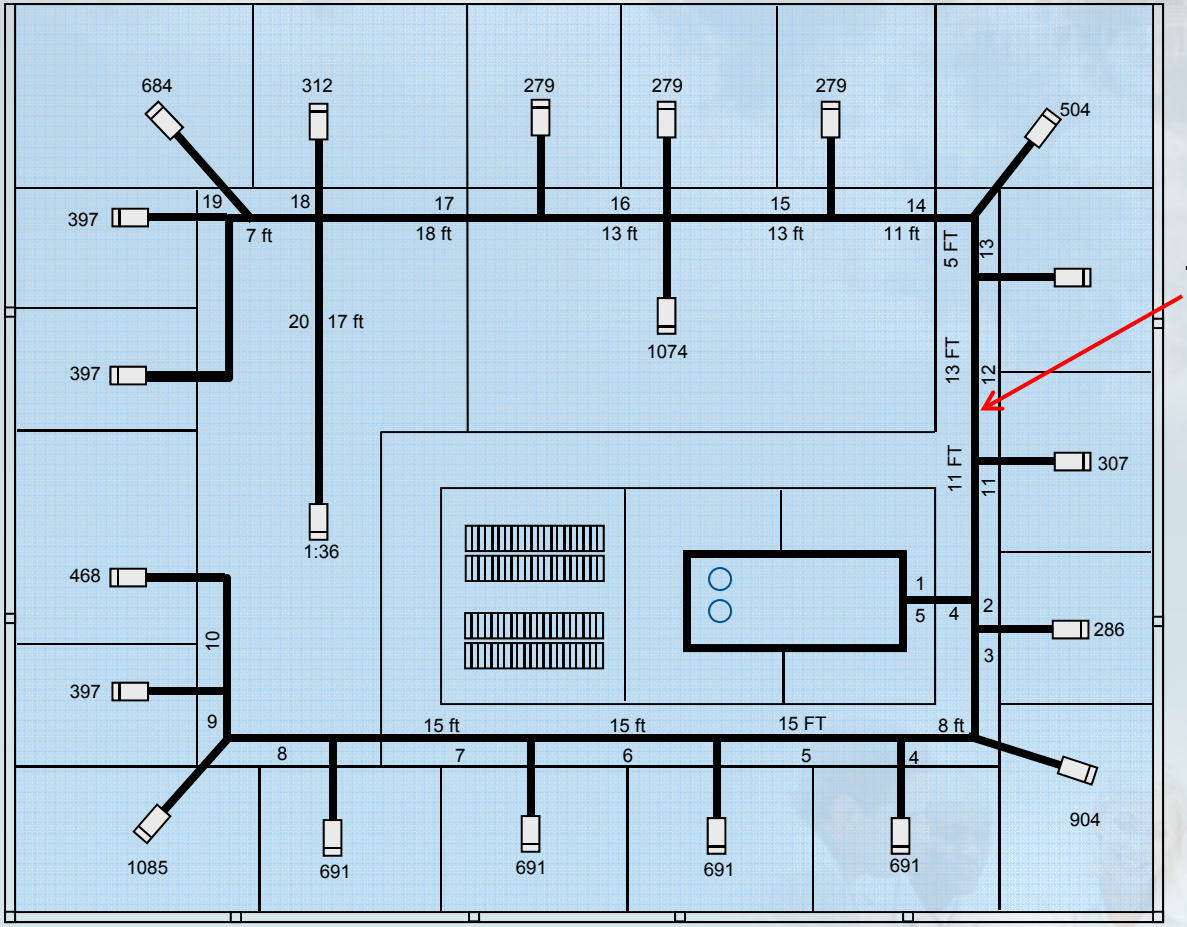
Associations Involved

- ASHRAE
- SMACNA
- SPIDA

Today's Goal: How to obtain $0.25-$1.00/sq.ft. Installed Cost Savings

- Rectangular Duct 0.5#/sq.ft.
- Rectangular Duct $3.00 - $3.50/sq.ft.
- High Velocity Static Regain Round Duct 0.25#/sq.ft. (50% less)
- Round Duct $2.00 - $2.50/sq.ft.
- Saving of at least $0.25 to $1.00/sq.ft. ($100 to $400/ton)

Duct Layout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5 FT
13
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397
13 FT
12
Trunk Ducts
307
11 FT
11
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468
1
5
4
2
286
10
3
397
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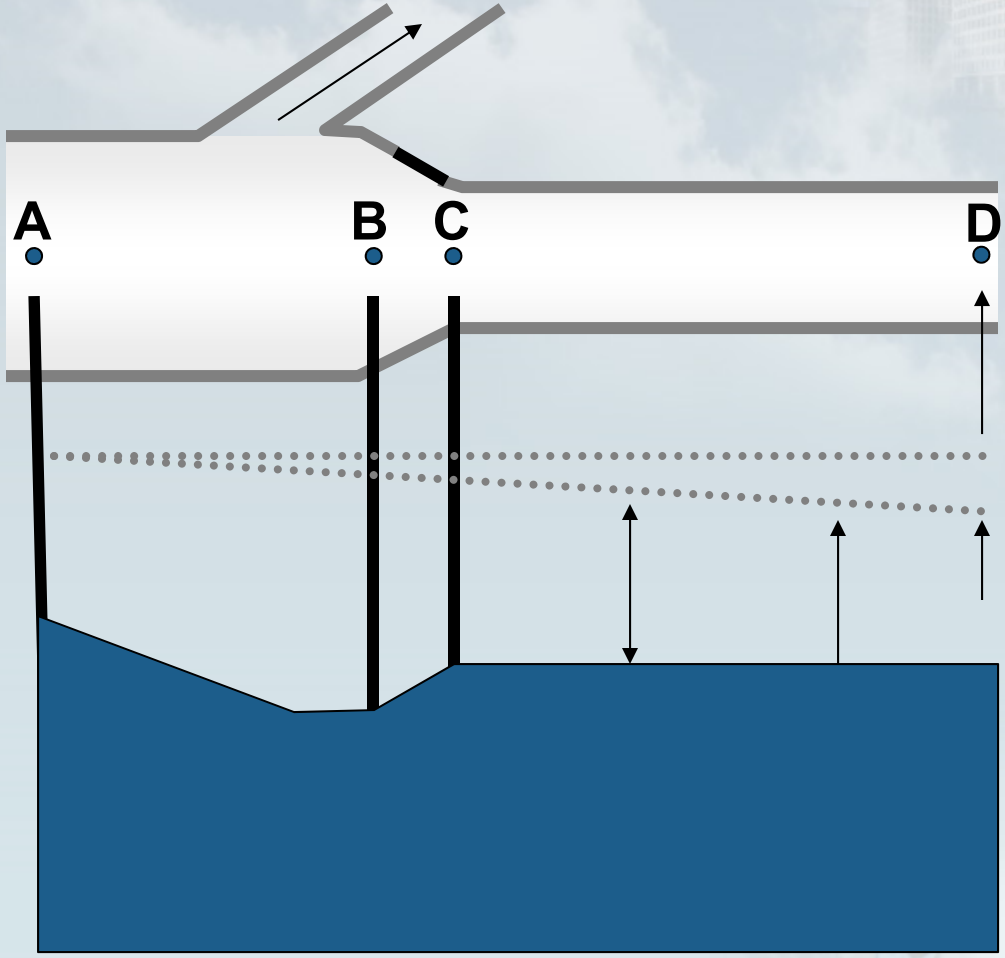
691

Fundamentals of Static Regain



$Tp = Vp + Sp - h_f$

h_f

SP

VP

Limitation of Type of Ductwork

Rectangular – No

Round – Yes

Why?

Recommended and Maximum Duct Velocities for Rectangular Duct

Table 6 ASHRAE Handbook, 1972, page 481

Recommended velocities, fpm

Designation	Residences	Schools, theaters, public buildings	Industrial buildings
Main ducts[b]	700-900	1000-1300	1200-1800
Branch ducts[b]	600	600-900	800-1000
Branch risers[b]	500	600-700	800

$$Vp = (fpm/4005)^2$$

Recommended and Maximum Duct Velocities for Round Duct

Table 7 ASHRAE Handbook, 1972, page 481

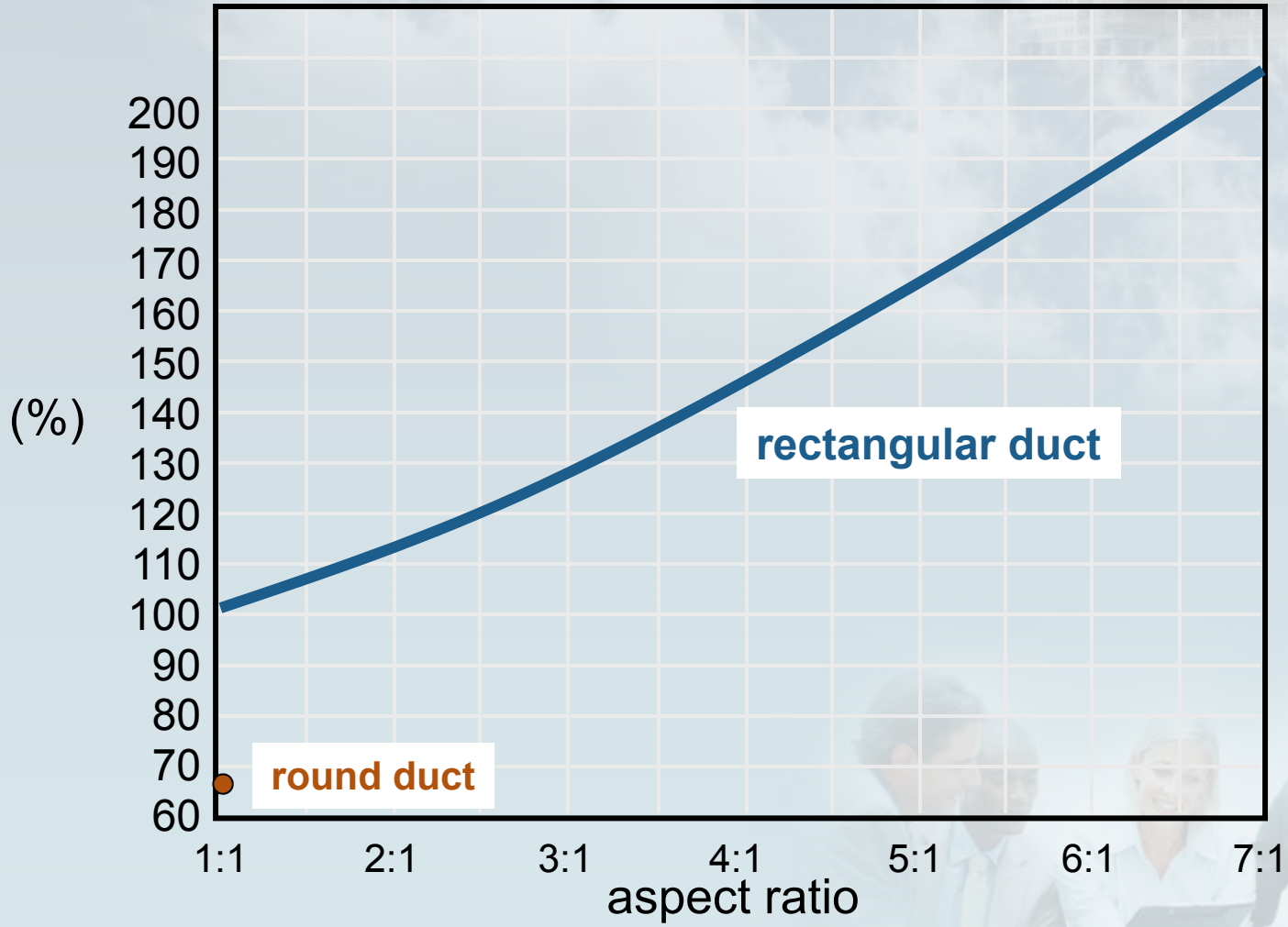
Recommended maximum duct velocities for high-velocity systems

CFM carried by the duct			Maximum FPM
60,000	to	40,000	6,000
40,000	to	25,000	5,000
25,000	to	15,000	4,500
15,000	to	10,000	4,000
10,000	to	6,000	3,500
6,000	to	3,000	3,000
3,000	to	1,000	2,500

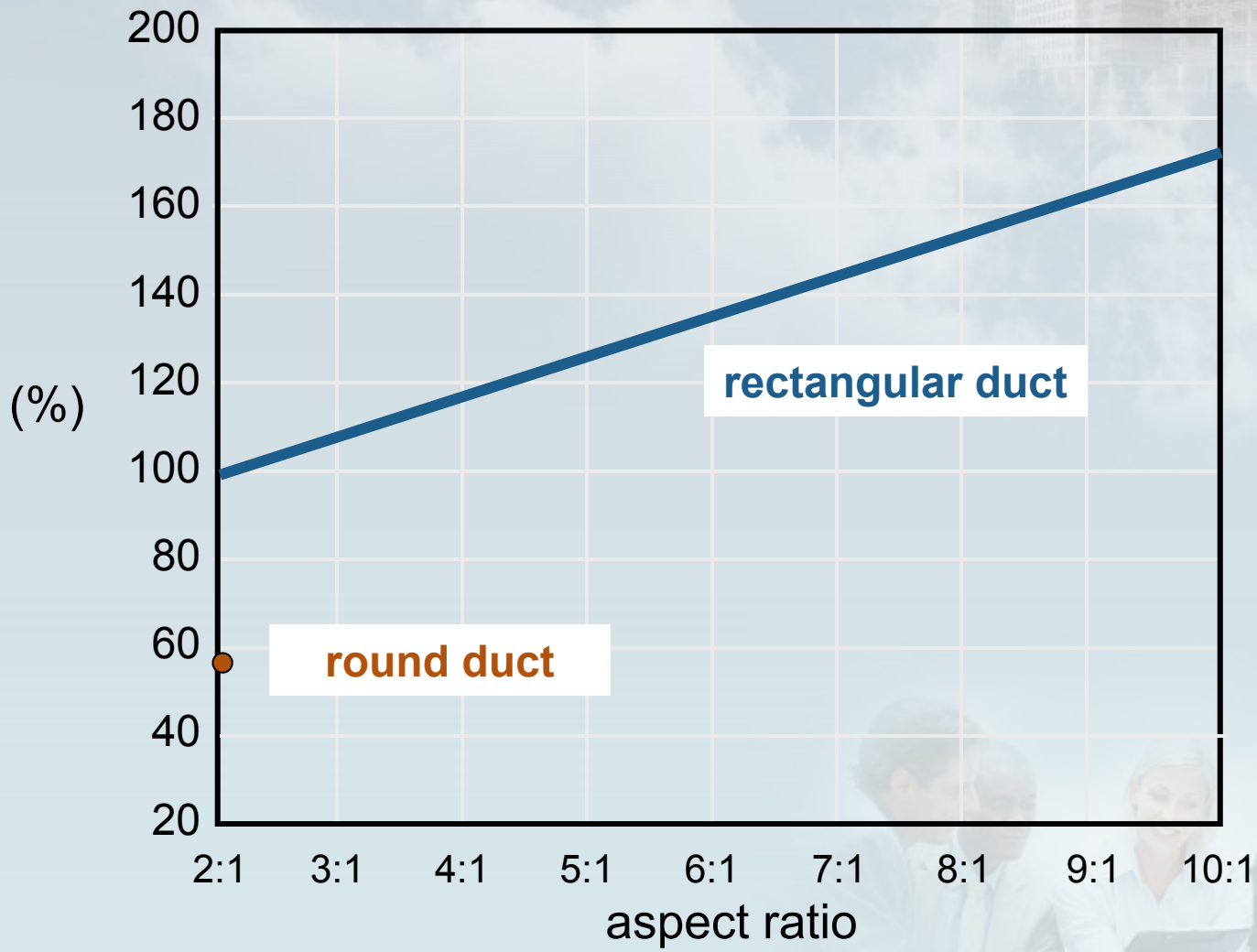
Key Advantages

- Lower cost
- Lower duct heat pick up
- Less duct leakage
- Less space

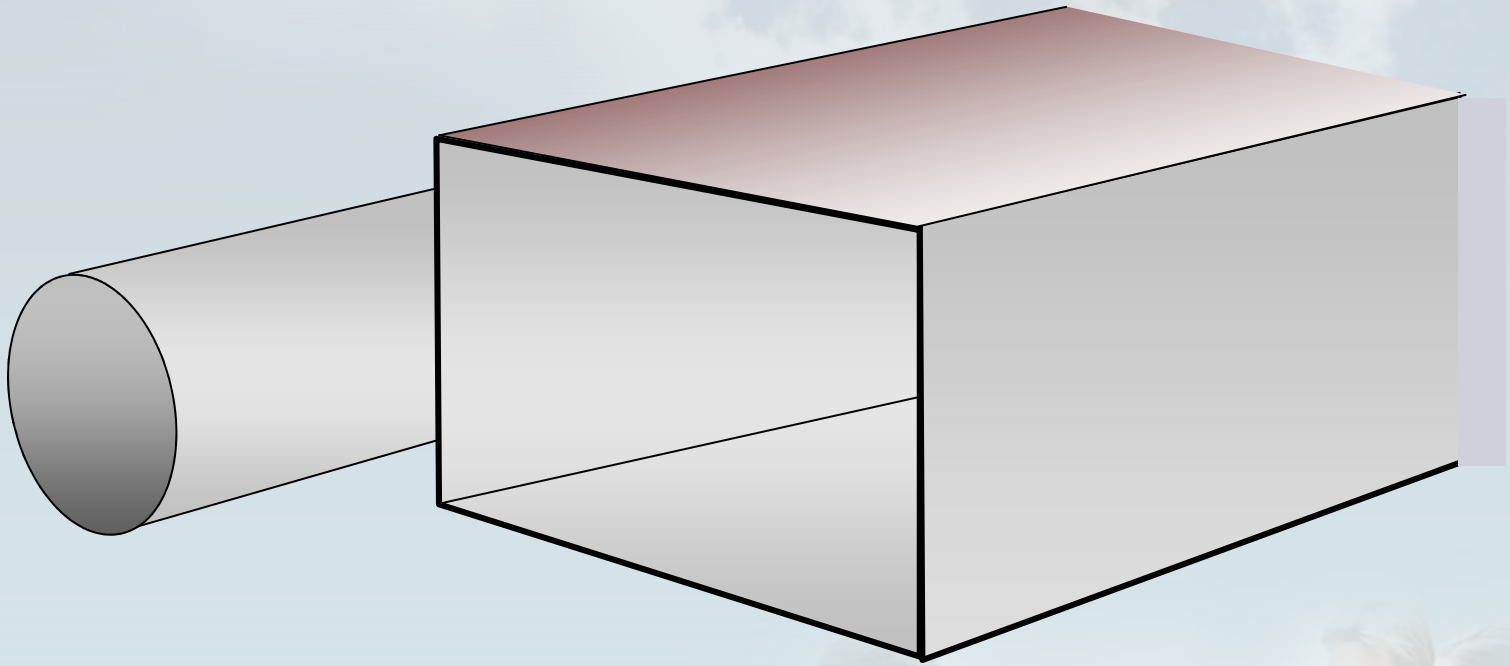
Relative Installed Cost vs. Aspect Ratio



Duct Heat Gain vs. Aspect Ratio



Duct Heat Pickup



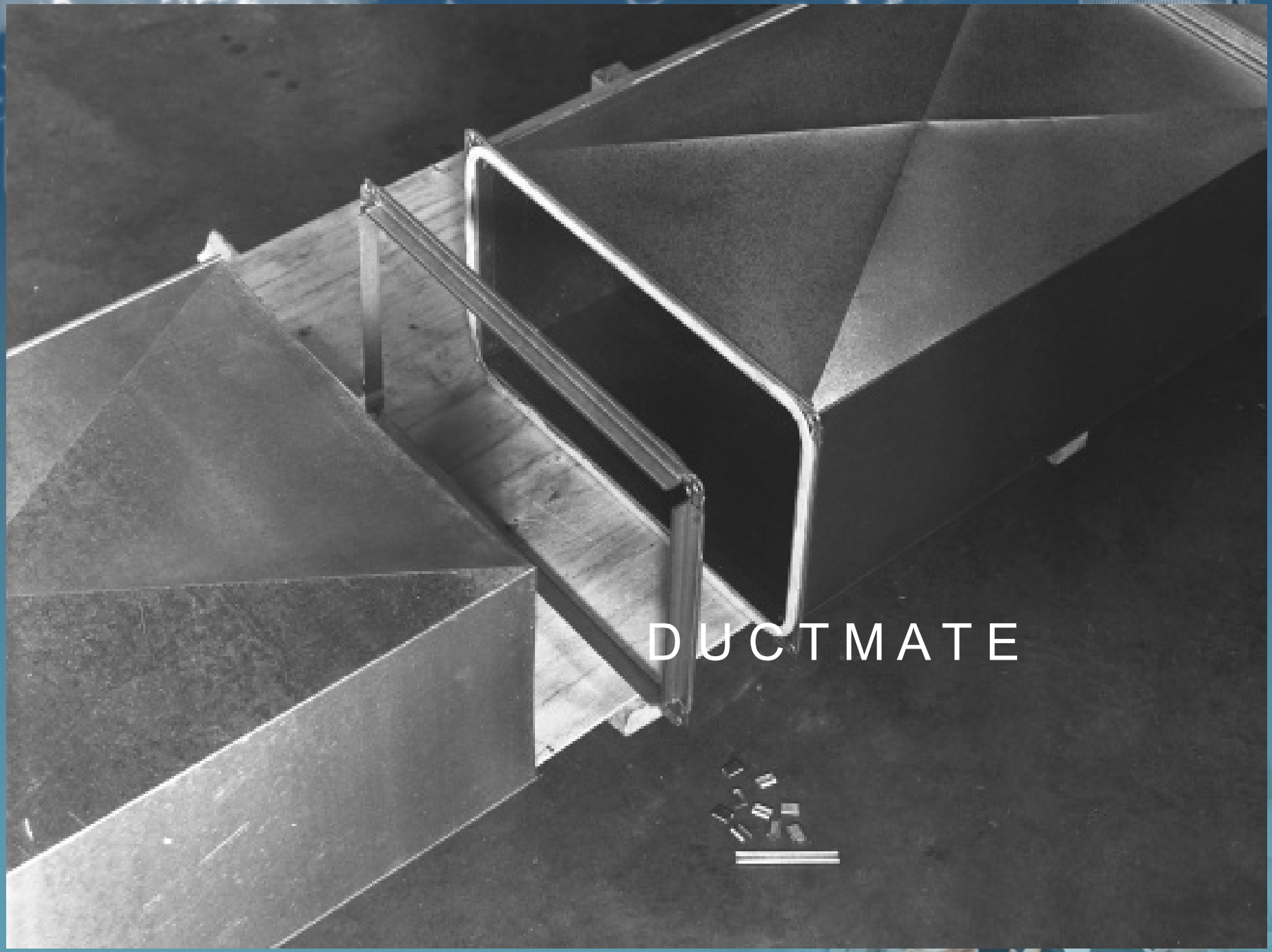
Duct Leakage

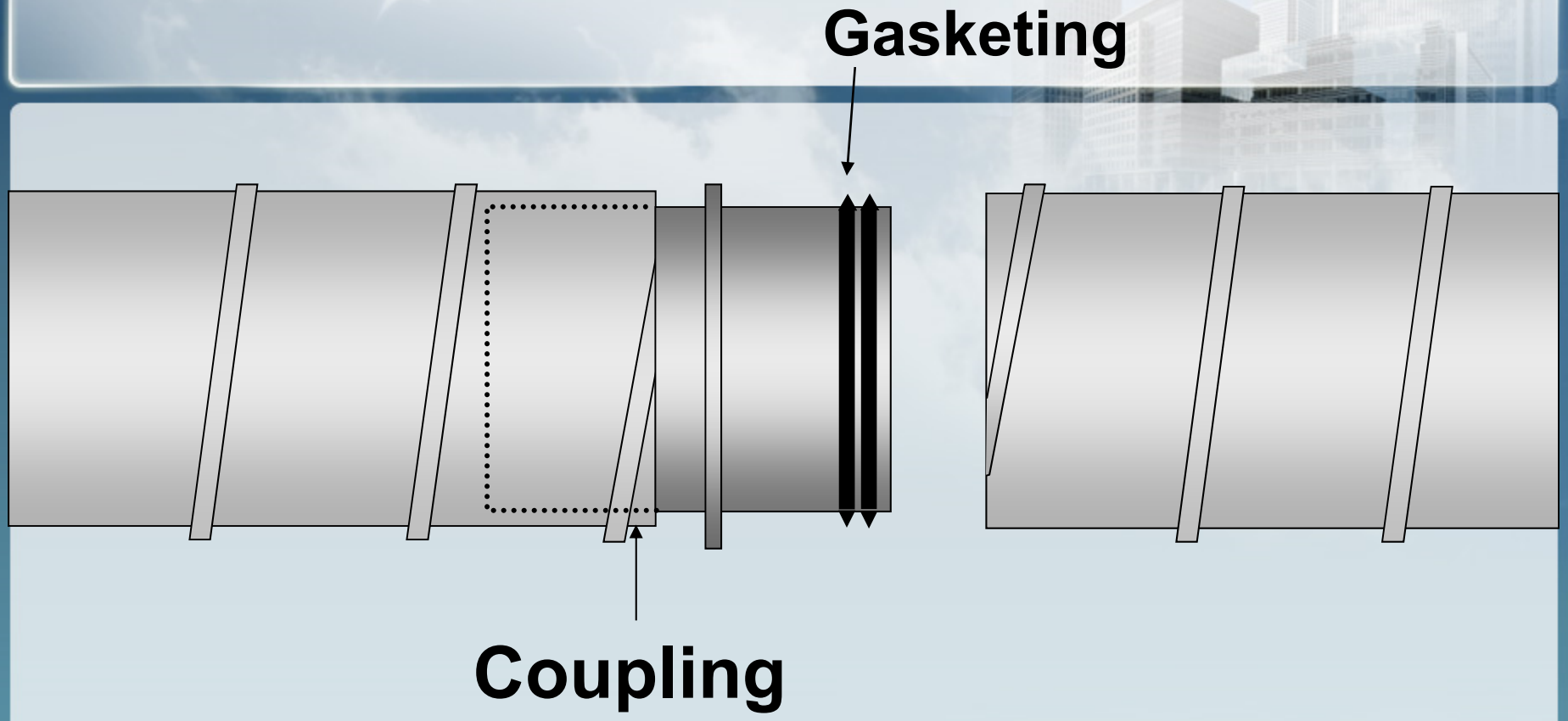
Leakage:

- **Rectangular Duct**
  - **traditionally hard to get below 10%**
  - **today it's hard to get below 3%**
- **Round Duct – can get below 1%**

Fan BHP Savings Approximated By:

- $(CFM_2/CFM_1)^3 = BHP_2/BHP_1$
- $(110/101)^3$ = 29% increase in fan brake horsepower
- $(103/101)^3$ = 6% increase in fan brake horsepower


DUCTMATE


Gasketing
Coupling

Why is Leakage So Important?

***Source: Study done by Lawrence Berkeley National Laboratory for the Department of Energy**

Top faults causing energy inefficiencies in commercial buildings (Top 13 of 100+ faults identified)*

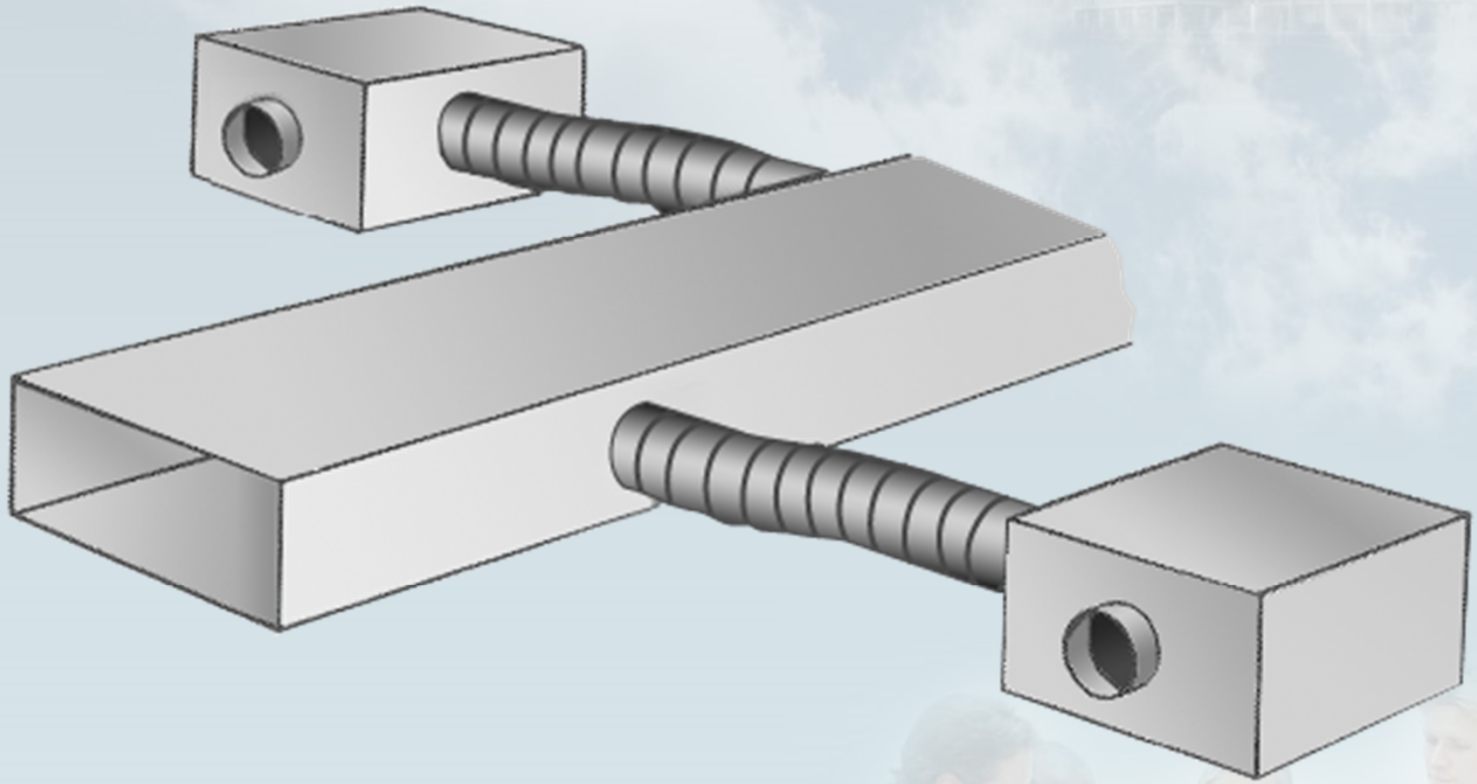
	National Energy Waste (Quads, primary/year)	Electricity equivalent (BkWh/year)	Cost ($billion/year)
Duct leakage	0.3	28.6	2.9
HVAC left on when space unoccupied	0.2	19.0	1.9
Lights left on when space unoccupied	0.18	17.1	1.7
Airflow not balanced	0.07	6.7	0.7
Improper refrigerant charge	0.07	6.7	0.7
Dampers not working properly	0.055	5.2	0.5
Insufficient evaporator airflow	0.035	3.3	0.3
Improper controls setup / commissioning	0.023	2.2	0.2
Control component failure or degradation	0.023	2.2	0.2
Software programming errors	0.012	1.1	0.1
Improper controls hardware installation	0.01	1.0	0.1
Air-cooled condenser fouling	0.008	0.8	0.1
Valve leakage	0.007	0.7	0.1
Total (central estimate)	1.0	94.6	9.6
Total (range)	0.34-1.8	32.4-171.4	3.3-17.3

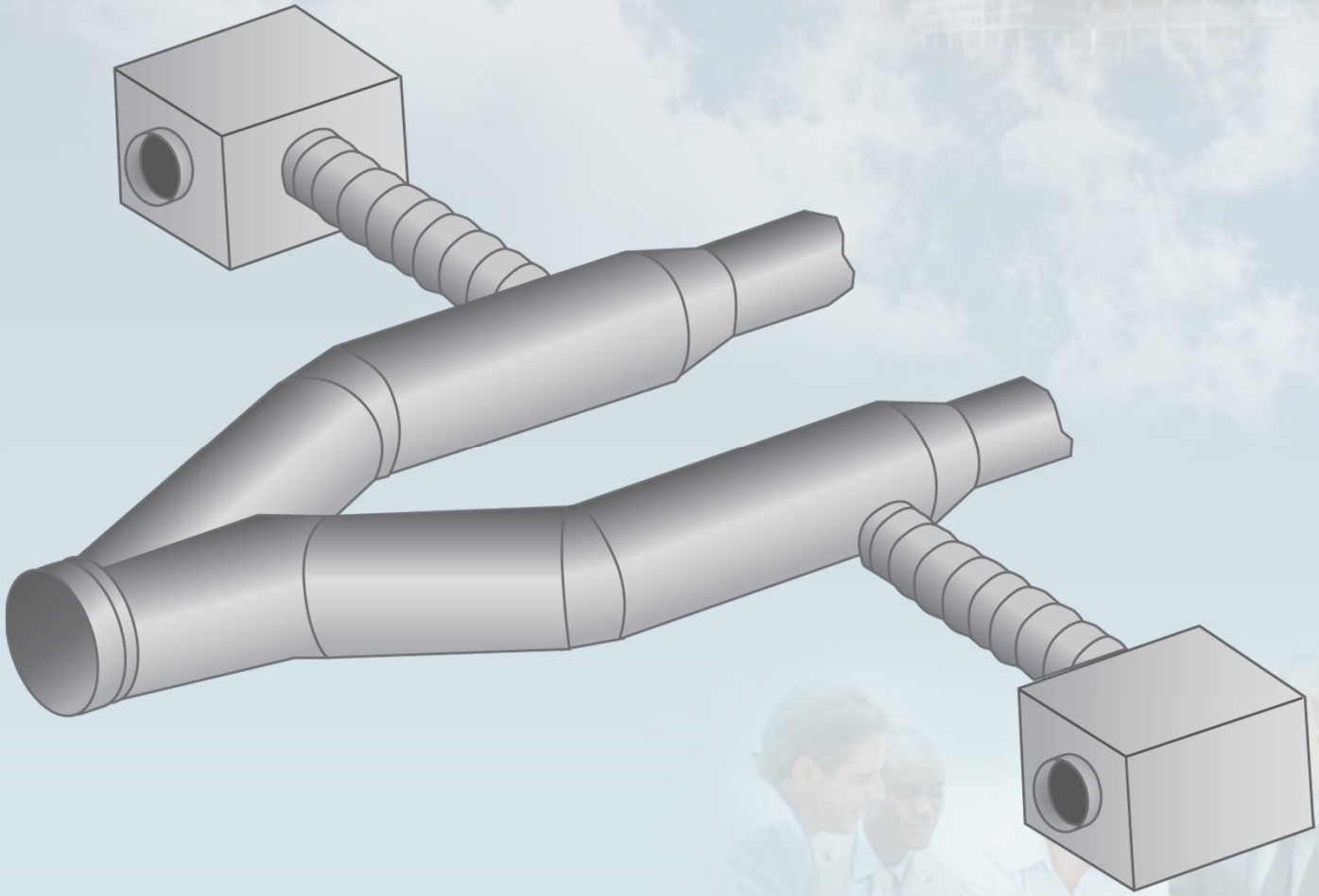
Adapted from Roth et al. (2005) assuming 10,500 BTU/kWh, and $0.10/kWh

Less Space

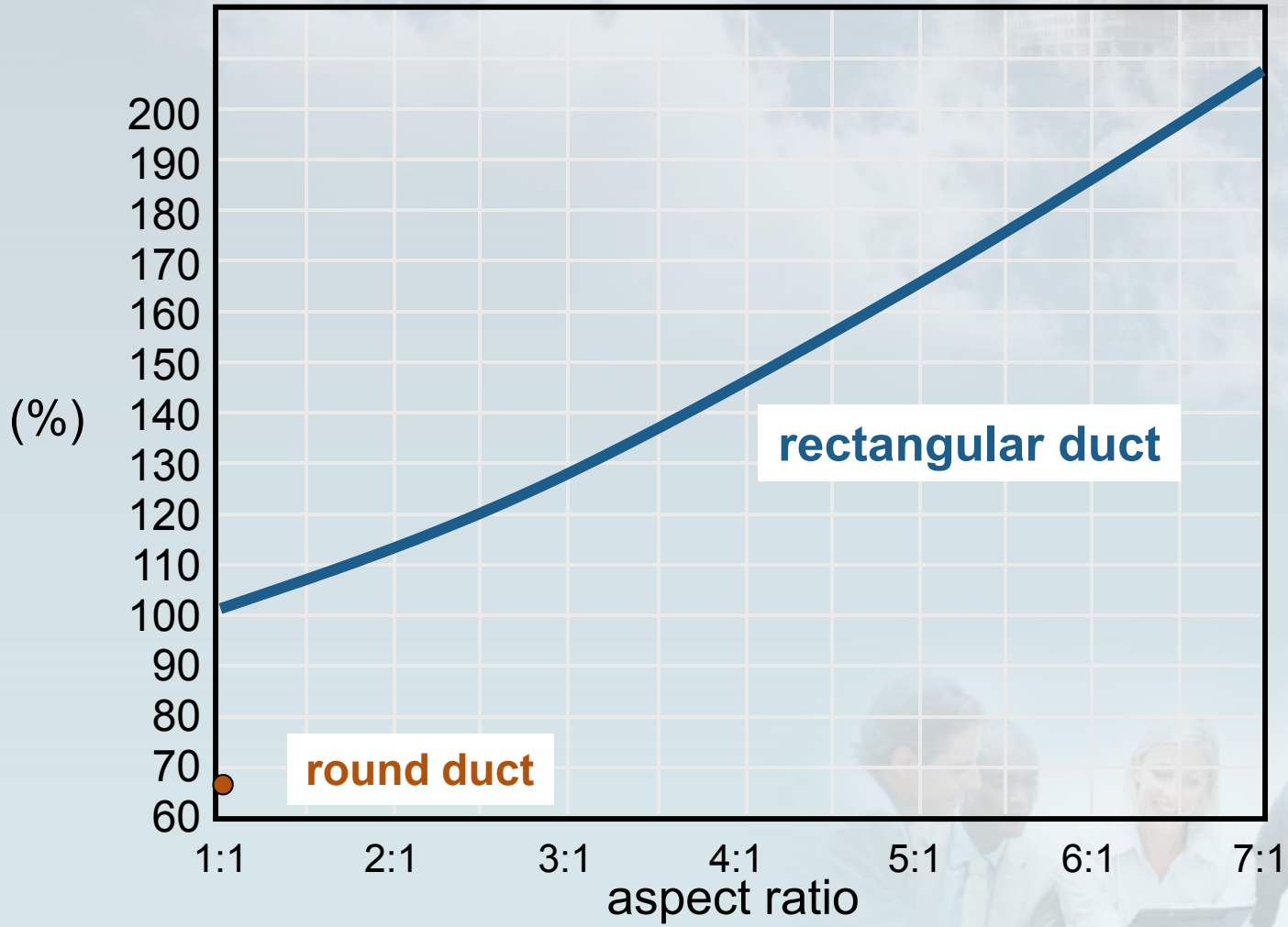
Biggest Misconception

I can't use round duct because it won't fit!

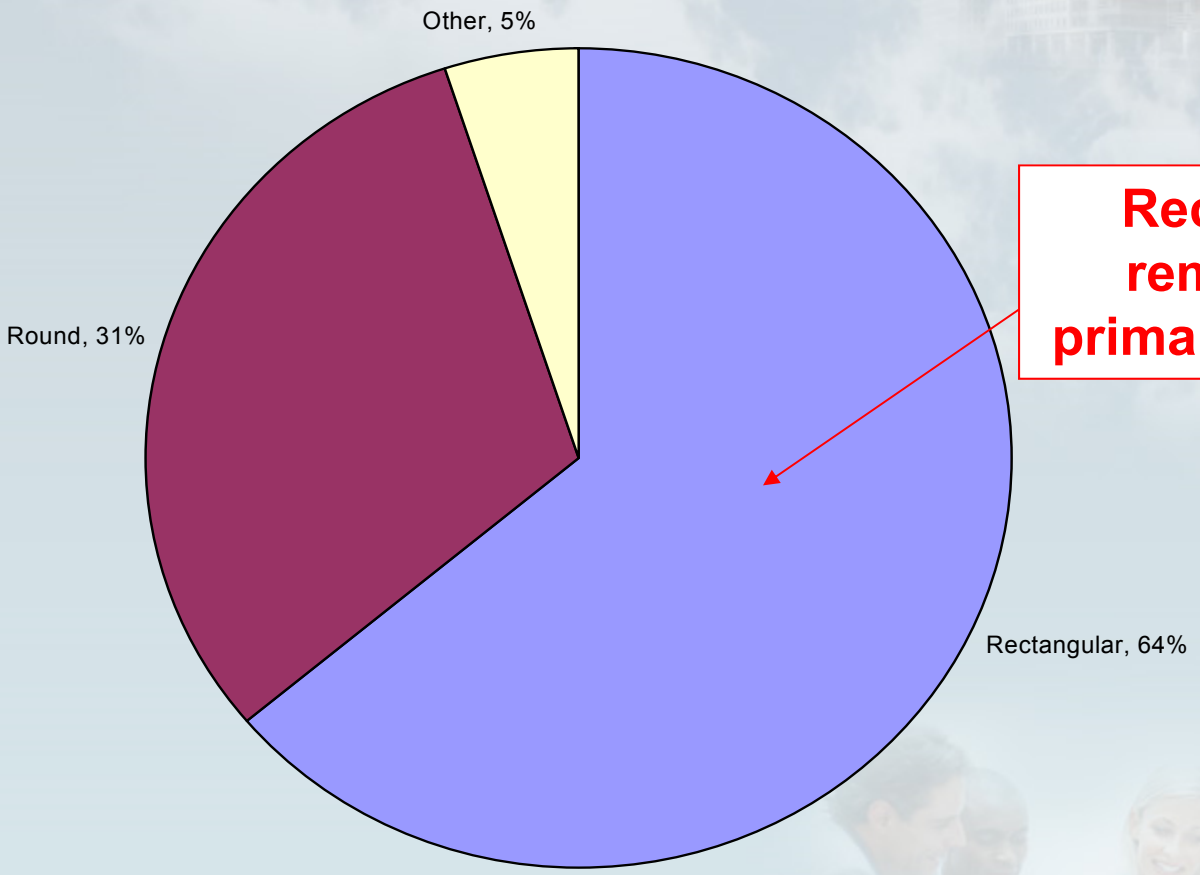




Relative Installed Cost vs. Aspect Ratio



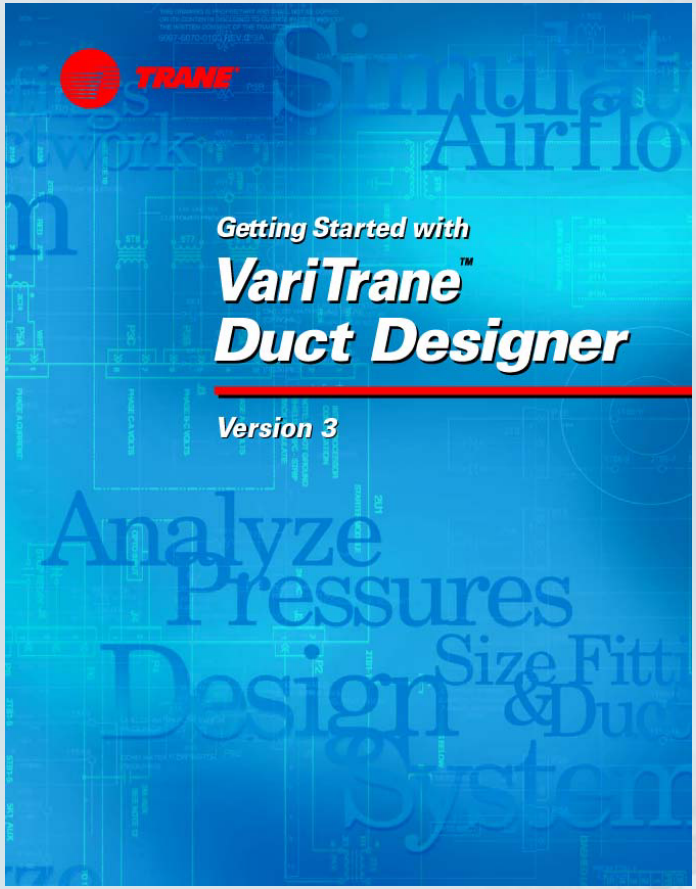
U.S. Market



Rectangular remains the primary ductwork

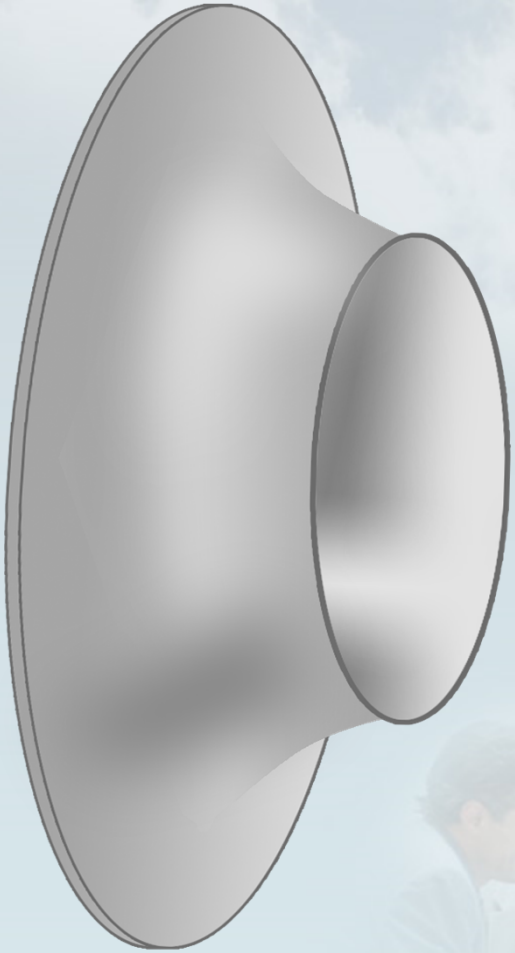
Trane *Ductulator*®

Whereas, High Velocity, Static Regain, Round Duct Requires a Computerized Program



Do’s

Bellmouth Fitting



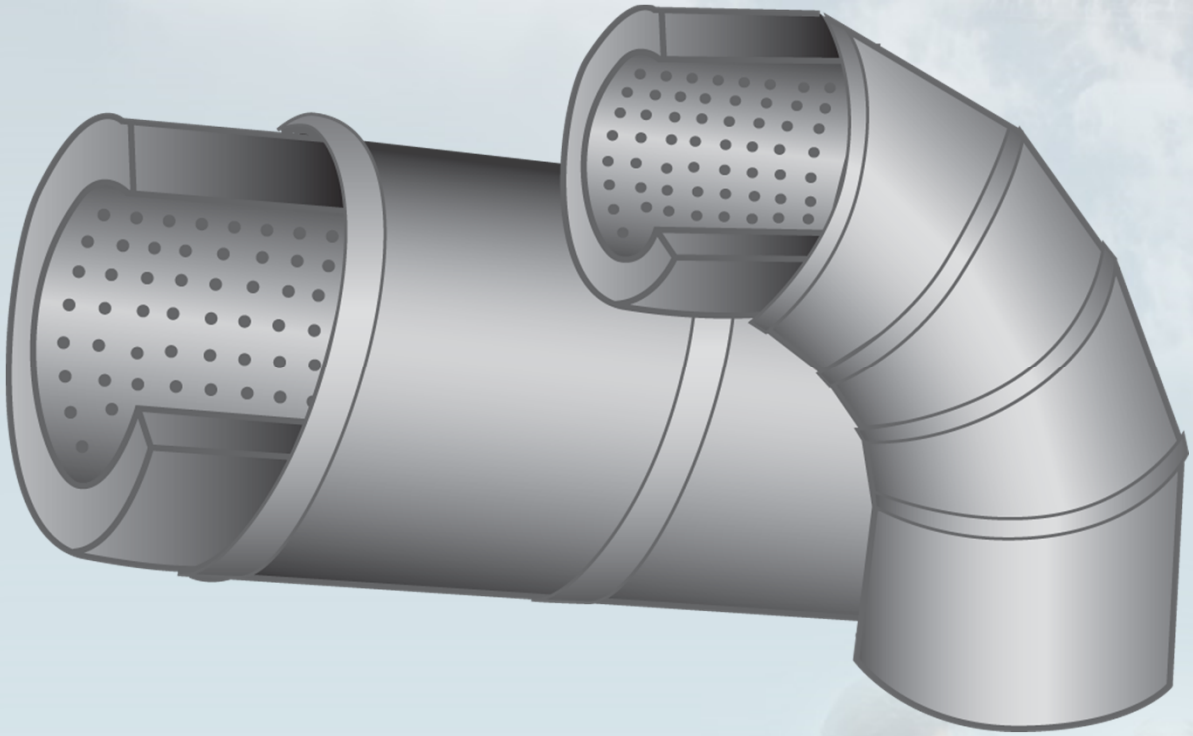
RTU connections

Rooftop Sound Attenuation

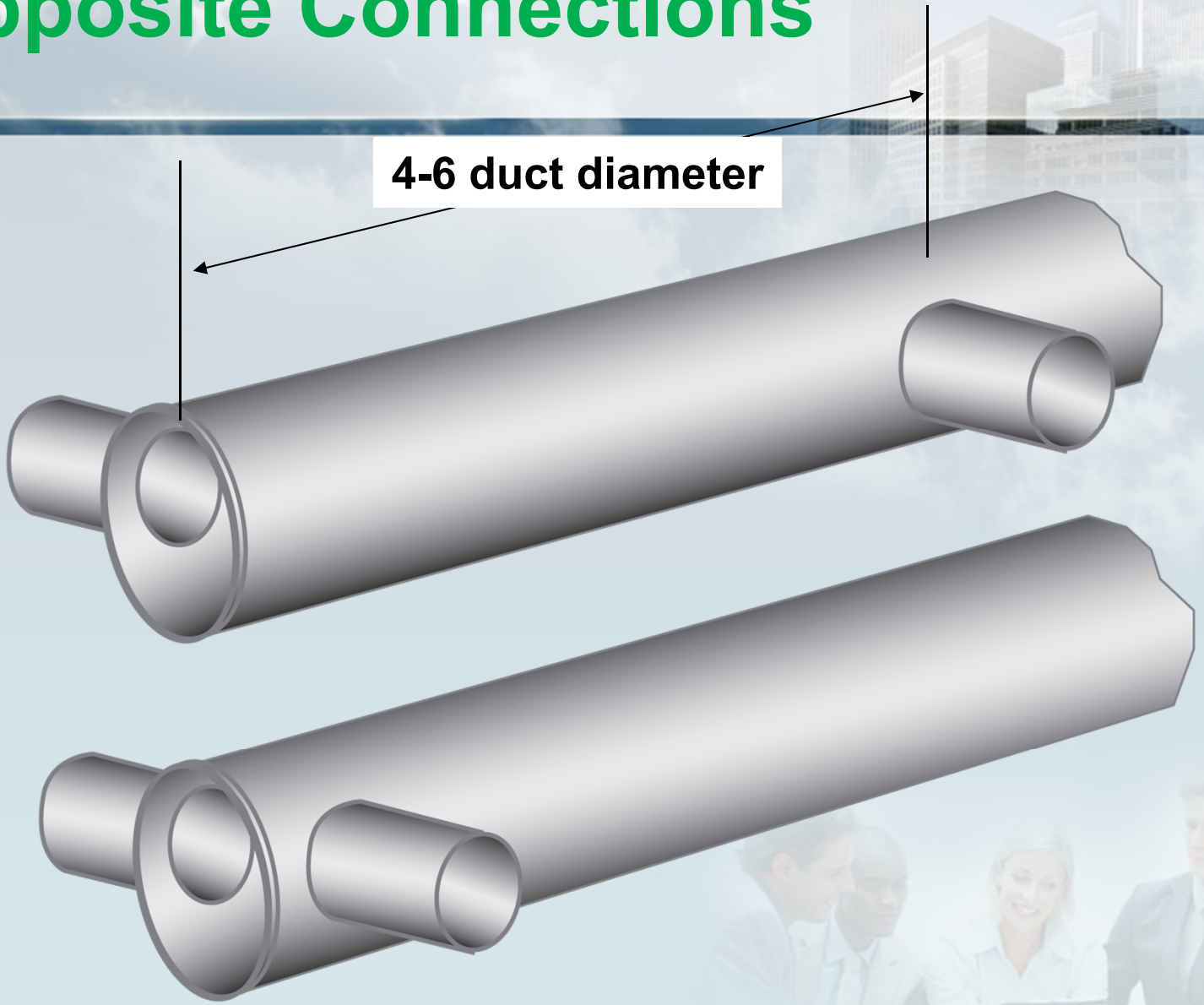
“Sound transmission below 250 Hz via duct breakout is often a major acoustical limitation for many rooftop installations. Excessive low-frequency noise associated with fan noise and air turbulence in the region of the discharge section of the fan and the first duct elbow results in duct rumble, which is difficult to attenuate. This problem is often worsened by the presence of a high-aspect-ratio duct at the discharge section of the fan. Rectangular ducts with duct lagging are often ineffective in reducing duct breakout noise. Using either a single- or dual-wall round duct with a radiused elbow coming off the discharge section of the fan can reduce duct breakout. If space does not allow for the use of a single duct, the duct can be split into several parallel round ducts”.

2003 ASHRAE Applications Manual, p. 47.7

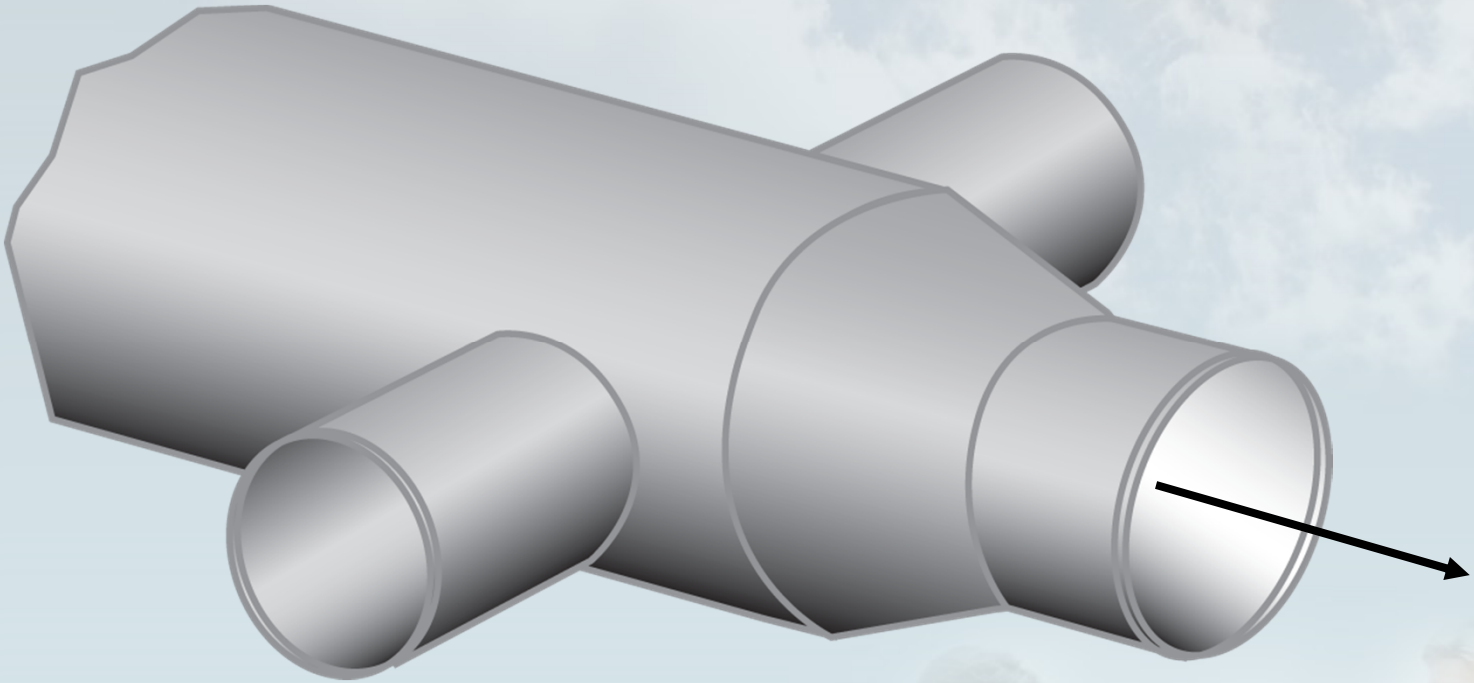
Attenuated Duct



Opposite Connections

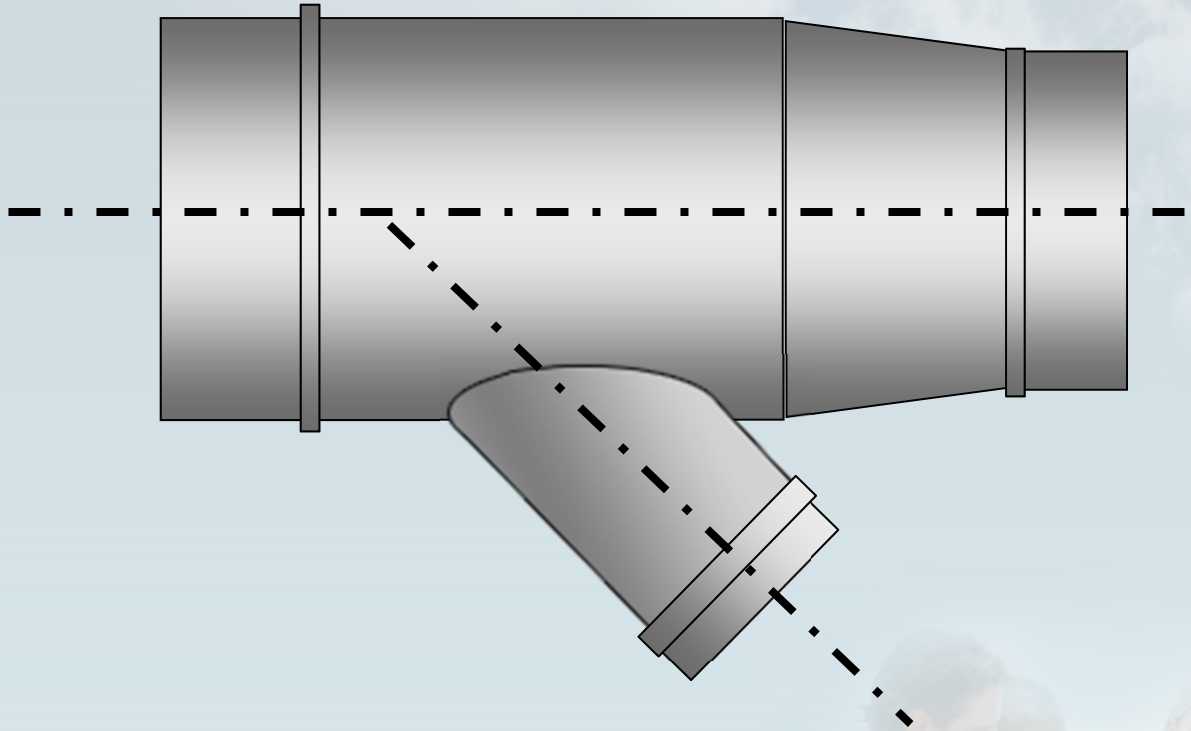


Flow Through Fittings

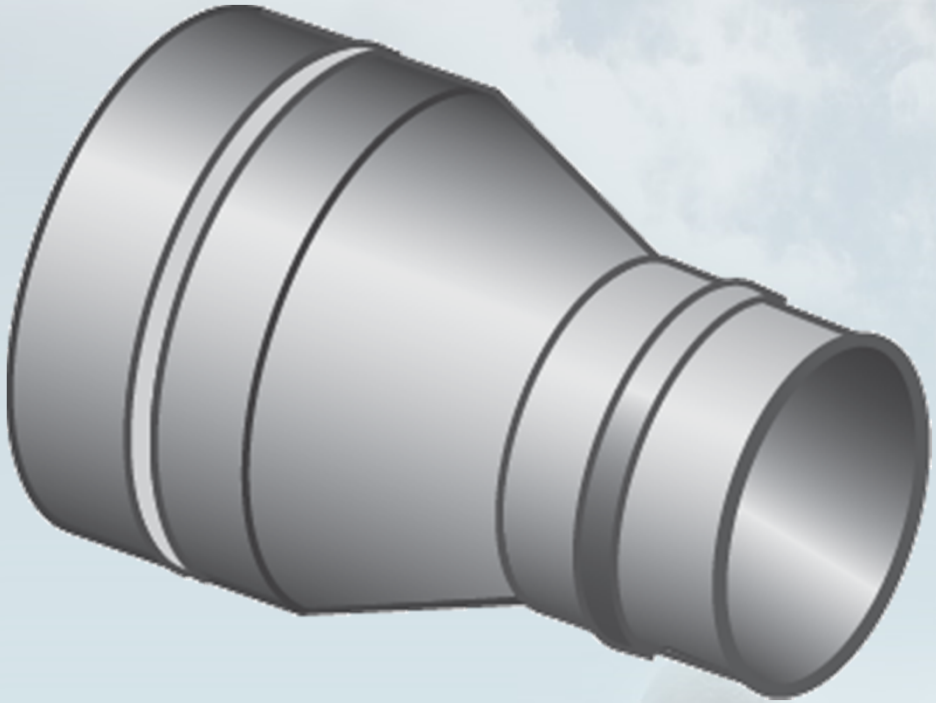


33% upstream flow

Fitting Efficiency

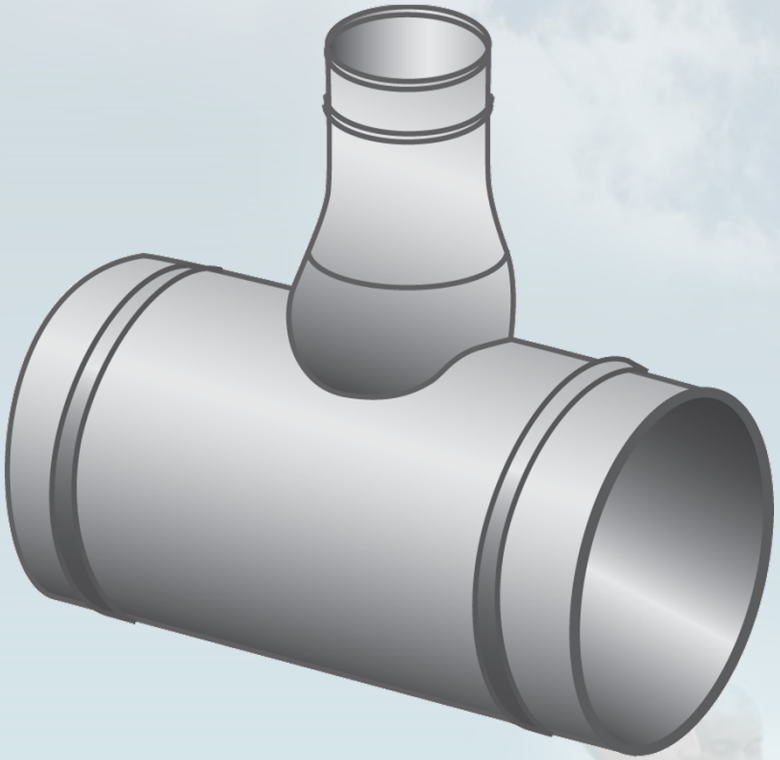


Reducer Fitting

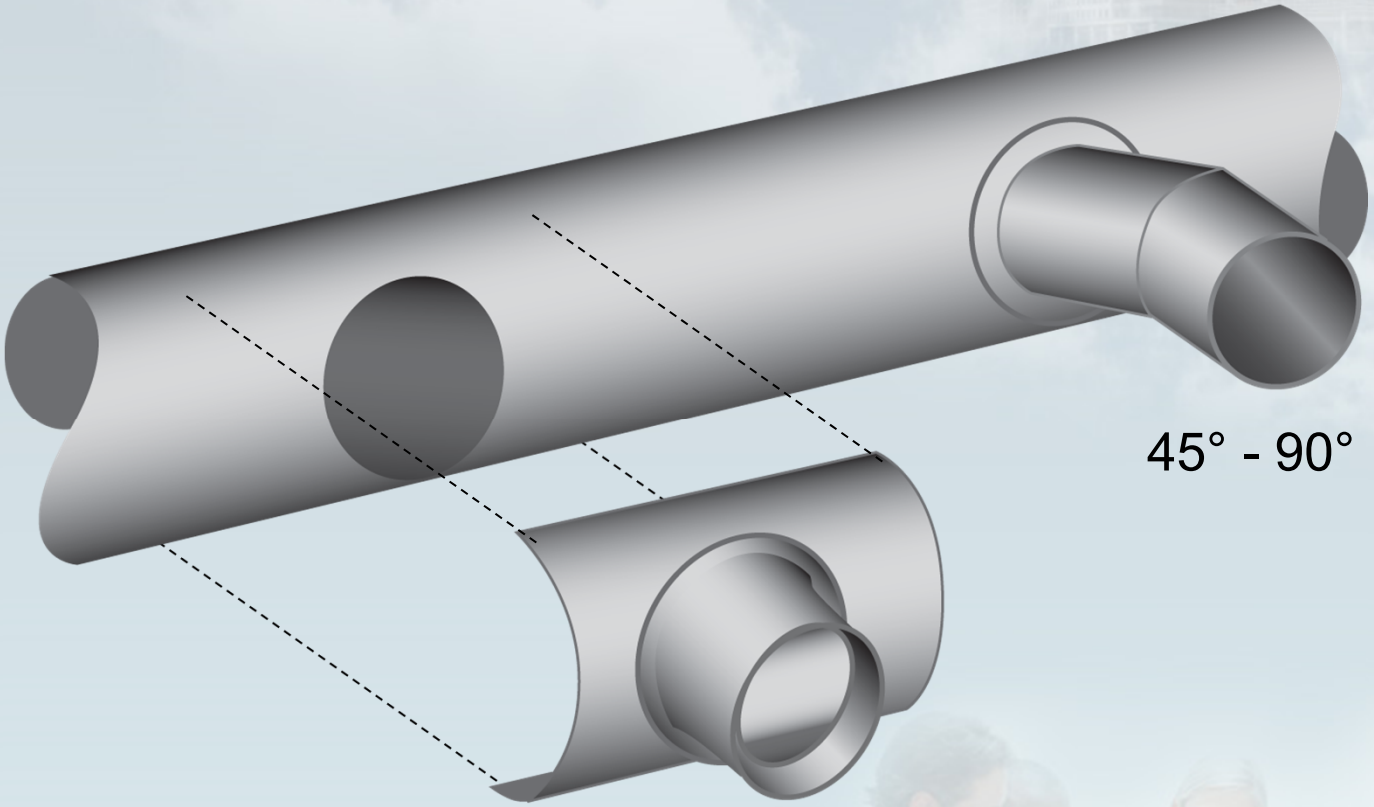


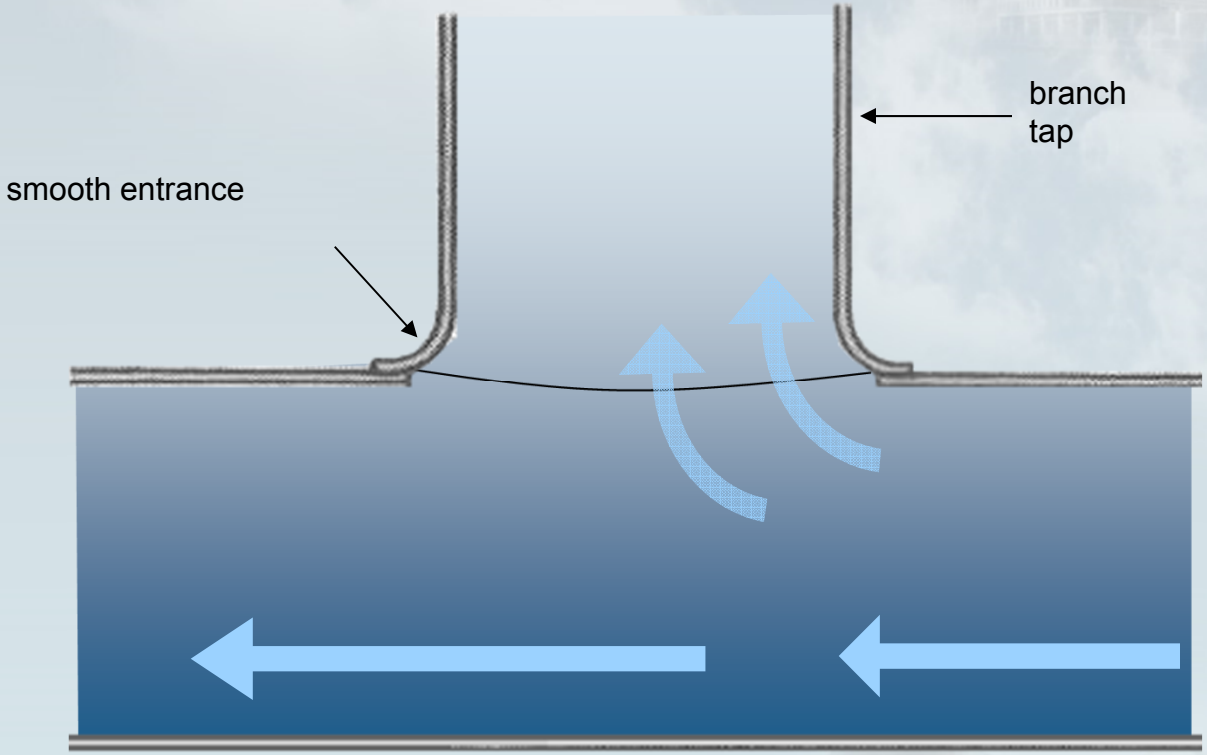
Y Fitting

Well-Rounded, 90-Degree Tee

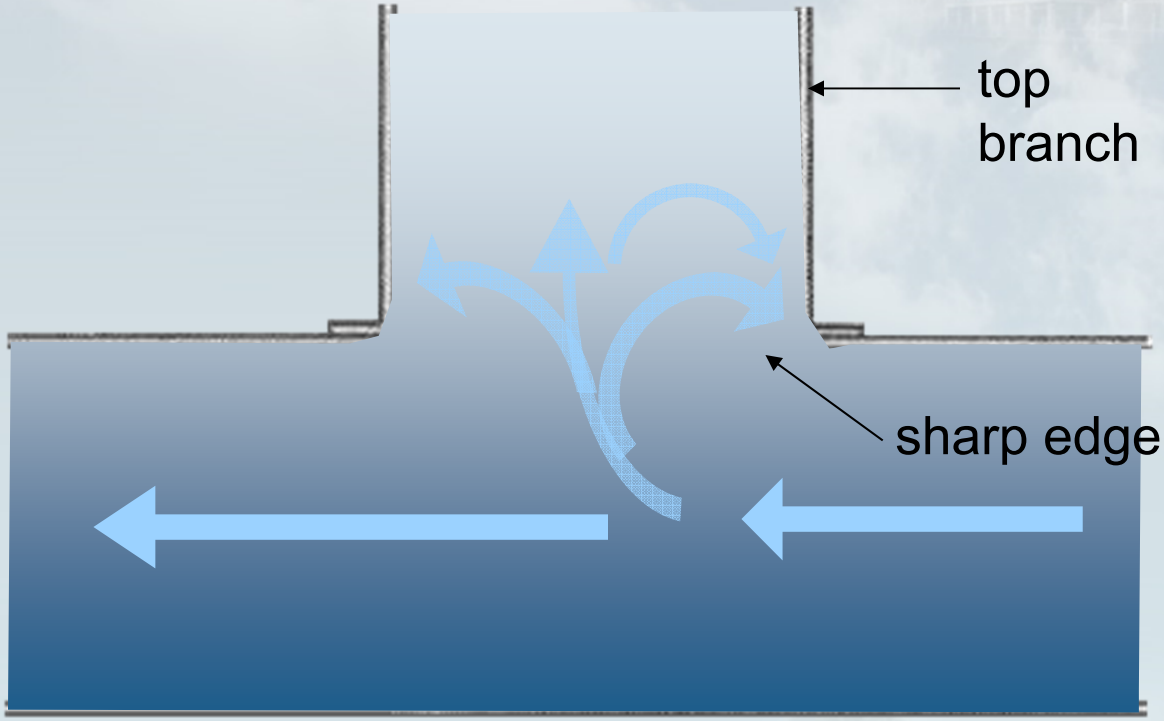


Saddle-Tap Fittings

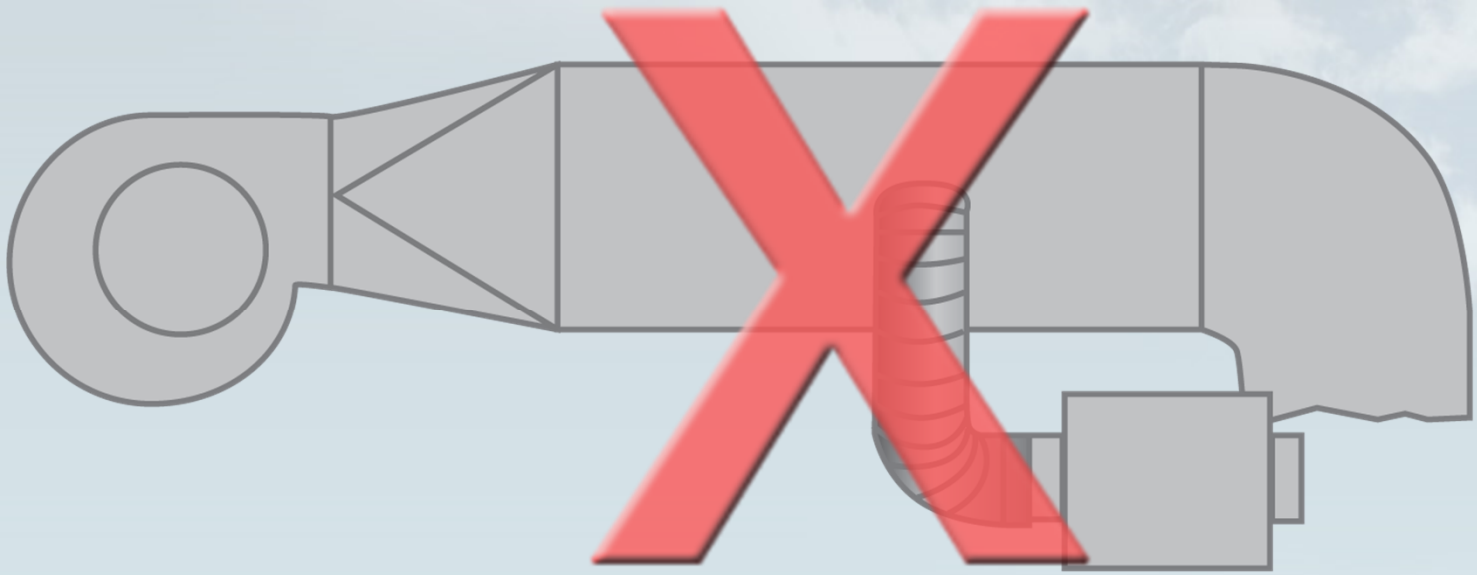



branch
tap
smooth entrance

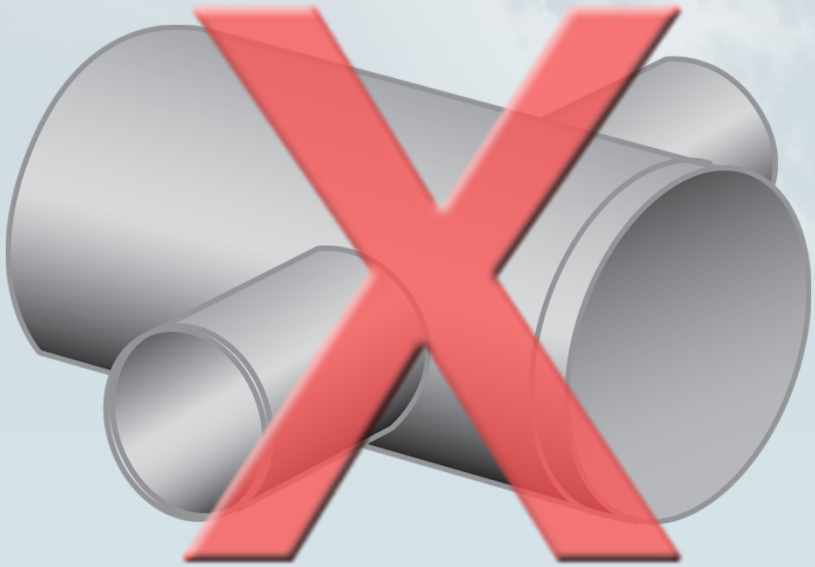
Don’ts


top
branch
sharp edge

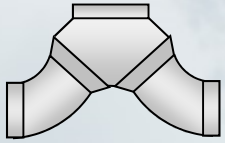
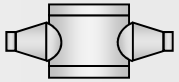
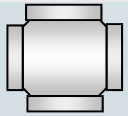
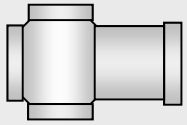
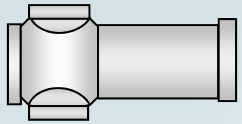
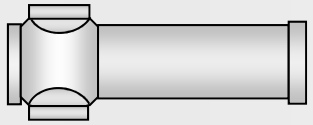
VAV Box Too Close to the Fan



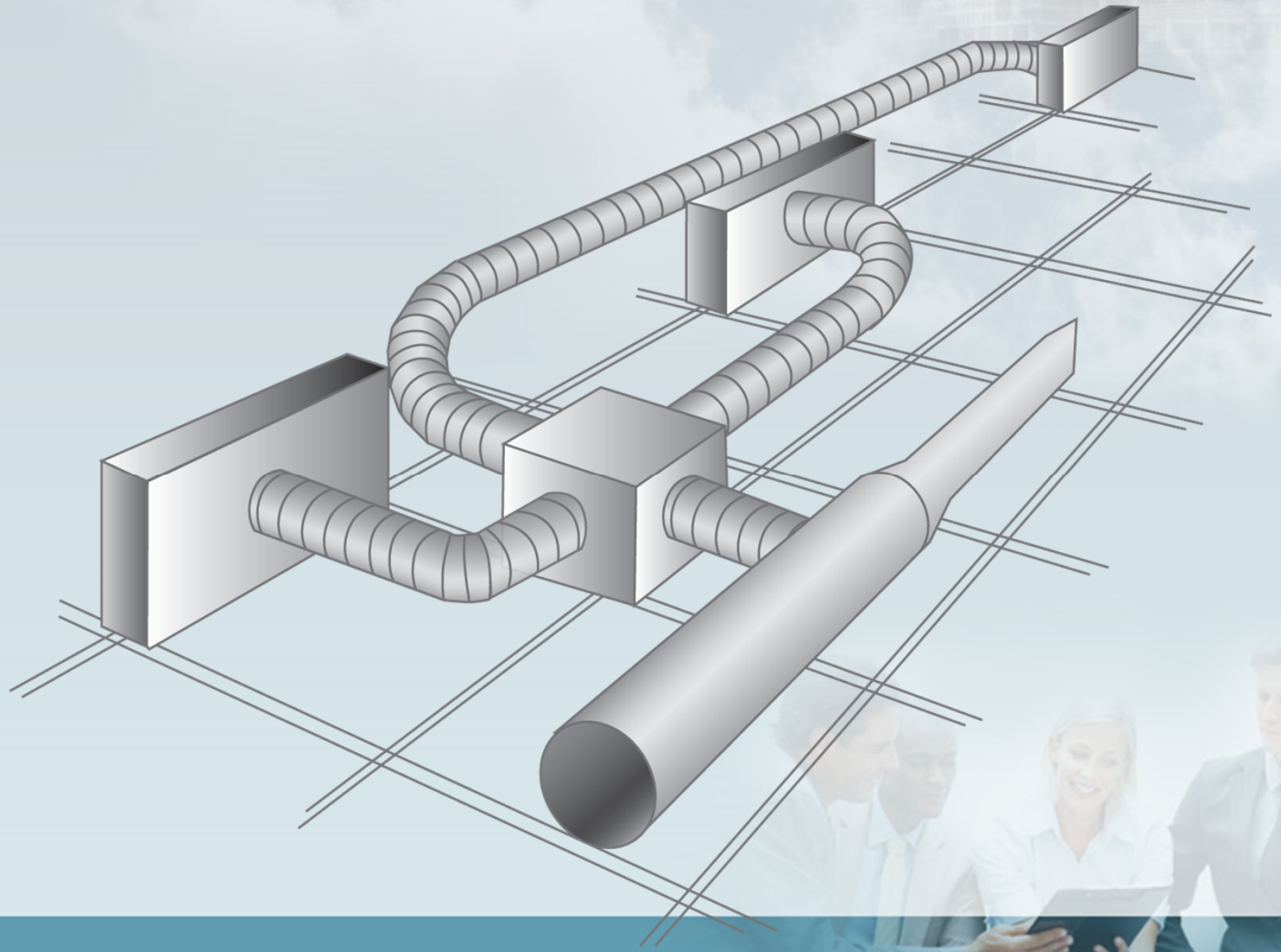
Capped Cross Fitting

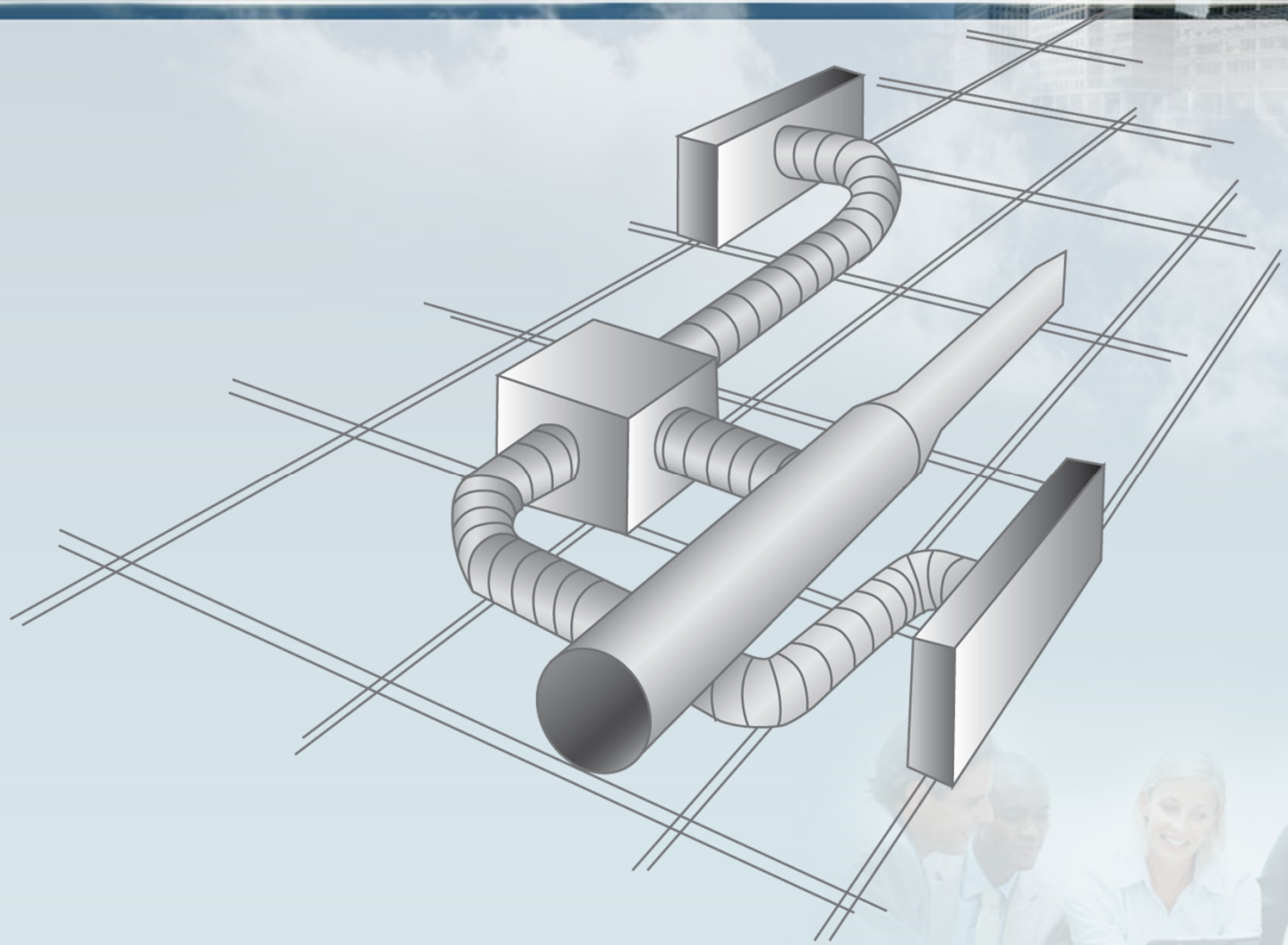


Divided Flow Fittings

Fitting		Loss Coefficient (2)
Y-2 plus 45 elbows		0.22
Capped cross with conical tabs		5.0
Capped cross		5.0
Capped cross with 1” cushion head		5.4
Capped cross with 2” cushion head		6.0
Capped cross with 3” cushion head		6.4

Balance Downstream Ductwork



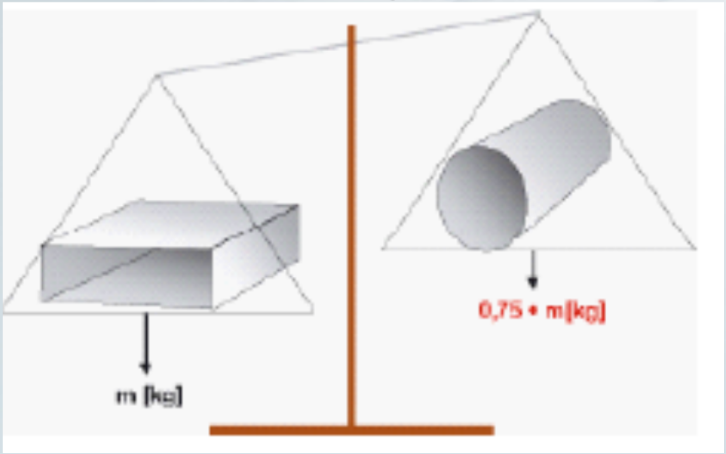


Experience Tells Us..

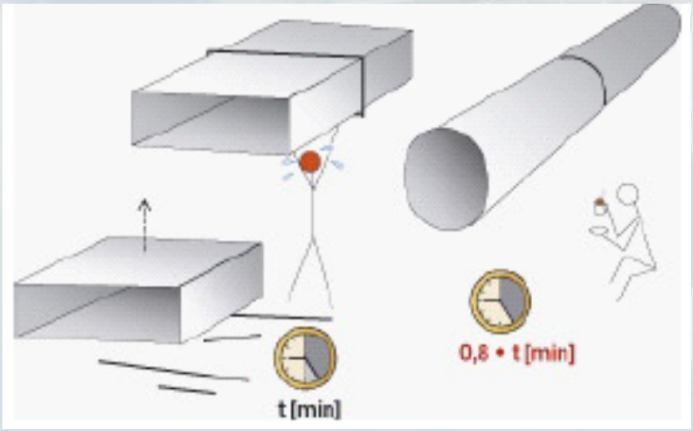
- Air to every box – quietly
- Plus $0.25 to $1.00/sq.ft. ($100 to $400/ton) savings

In Summary…

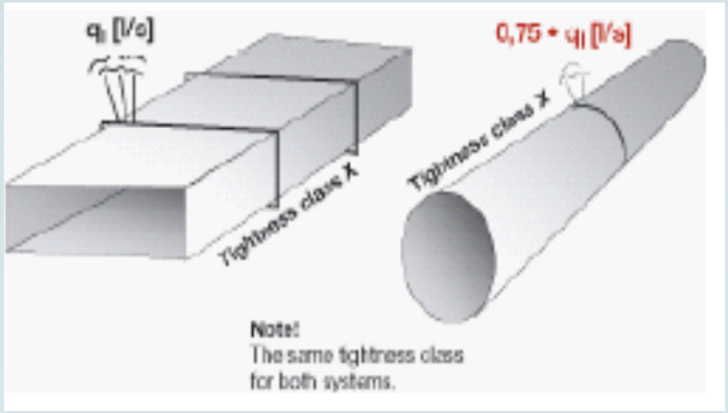
Lower weight 25+%



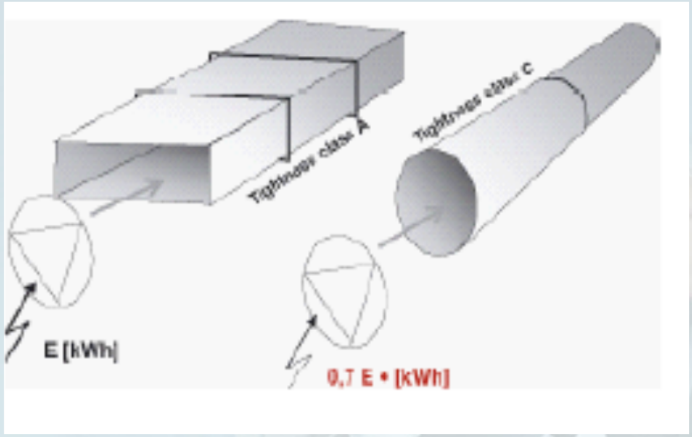
Shorter installation hours 30+%



Lower air leakage 2–10+%



Lower fan energy use 6-30+%



6 Real World Examples

2012 Ductwork Comparison for Rectangular versus Static regain

HVAC contractor project location	Project (ft^2)	Project (tons)	Supply (CFM)	installed						
				Rect. (lbs)	Spiral (lbs)	Rect. cost ($)	Spiral cost ($)	Savings ($)	Savings (%)	Savings ($/ton)
Pewaukee, WI	42,400	70	25,500	9,103	5,165	$47,094	$36,768	$10,326	22%	$148
Fort Worth, TX	12,000	40	15,000	3,504	2,090	$14,936	$13,169	$1,767	12%	$44
Atlanta, GA	22,500	58	19,500	5,749	2,551	$24,363	$15,452	$8,911	37%	$153
St. Louis, MO	98,000	240	80,000	32,533	19,804	$169,391	$115,479	$53,912	32%	$225
Orlando, FL	25,870	60	22,000	13,600	6,548	$117,078	$64,259	$52,819	45%	$880
Chicago, IL	23,000	60	20,100	6,320	2,455	$37,920	$17,185	$20,735	55%	$346
Average (6)	37,295	88	30,350	11,802	6,435	$68,463	$43,718	$24,745	36%	$281

Conclusion: Cut the lbs in half and save a lot on labor while delivering a quieter air delivery system.

Who Did We Work With?

- Brandt, Dallas … Brad Rogers*
- Ahern, Milwaukee … Phil Corbin
- Harper Limbach, Orlando … Kyle Davis
- McKenney, Atlanta … Rick Dustin
- Murphy, St. Louis … Mark Bengard

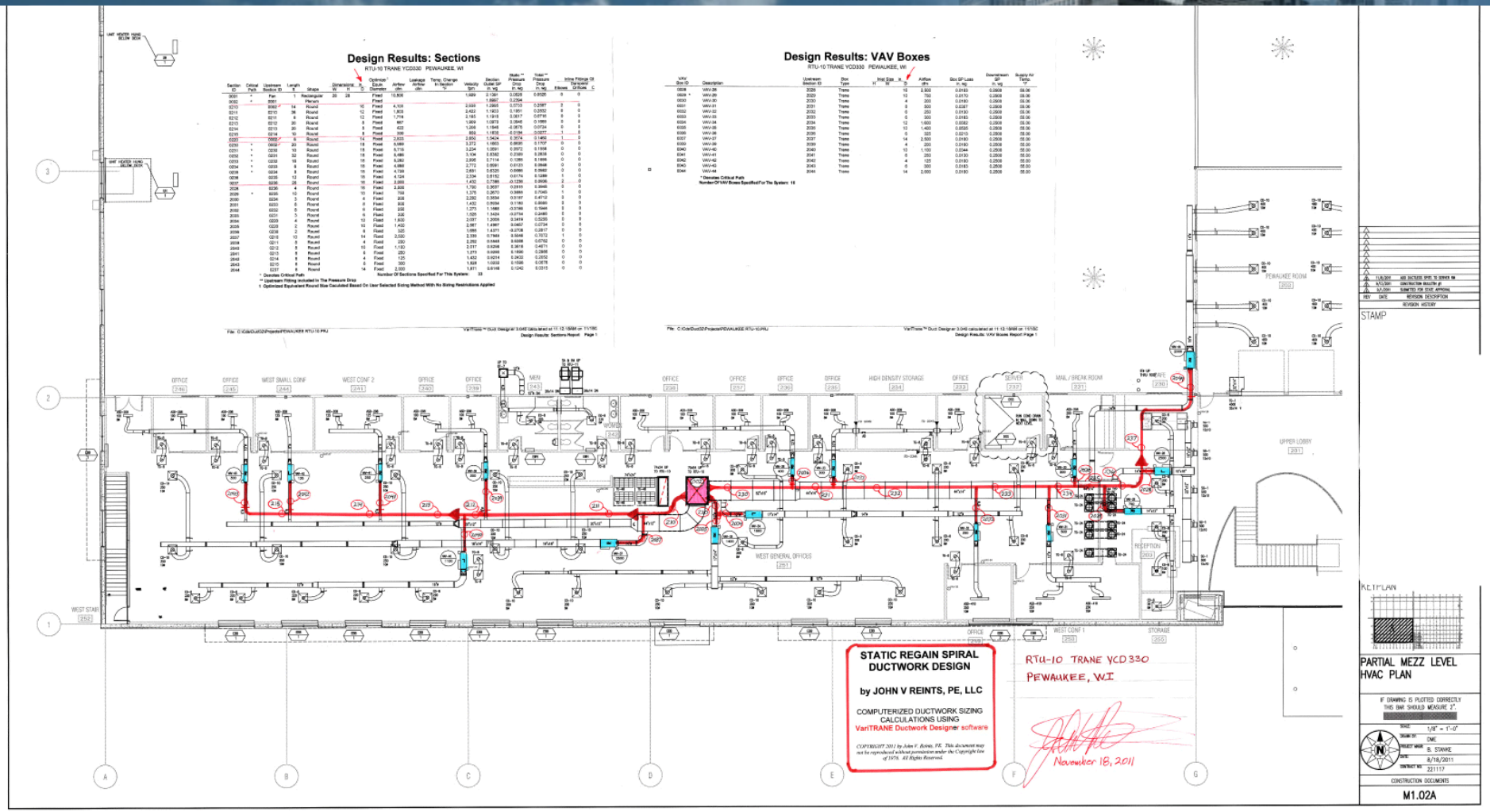
*Sponsor

John V Reints, PE

817 Dorken Lane
DeKalb, Illinois, 60115
(630)327-5425
jvrpellc@msn.com
www.staticregain.net

30+ Years of Designing High Velocity, Static Regain, Round Duct Systems

Pewaukee, WI Ductwork



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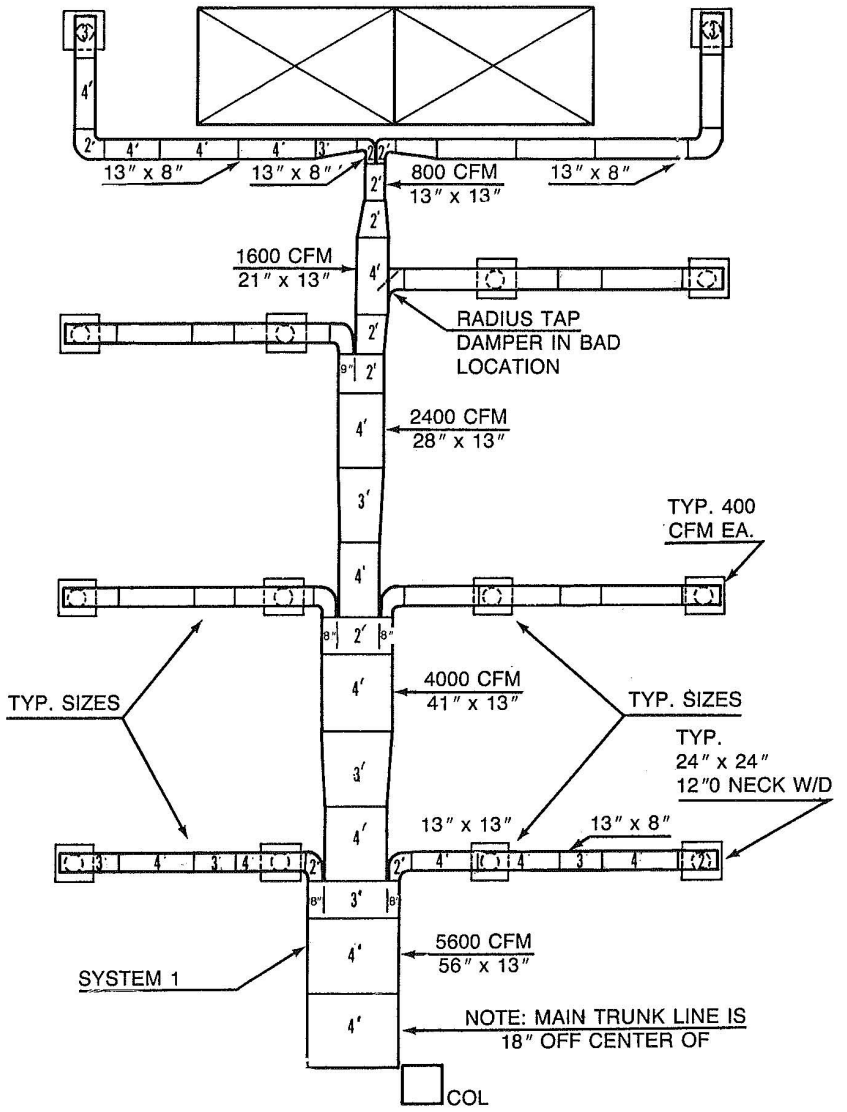
SPIDA

Example #1

Typical Rectangular Duct System

- 1,038 sq.ft. of duct
- 1,312 lbs. of metal
- 61 transverse joints
- 15 taps
- 275 lineal feet of joints to seal
- 371 lineal feet of longitudinal seams to seal
- 35 hangers
- 6 gallons of sealant

2-2

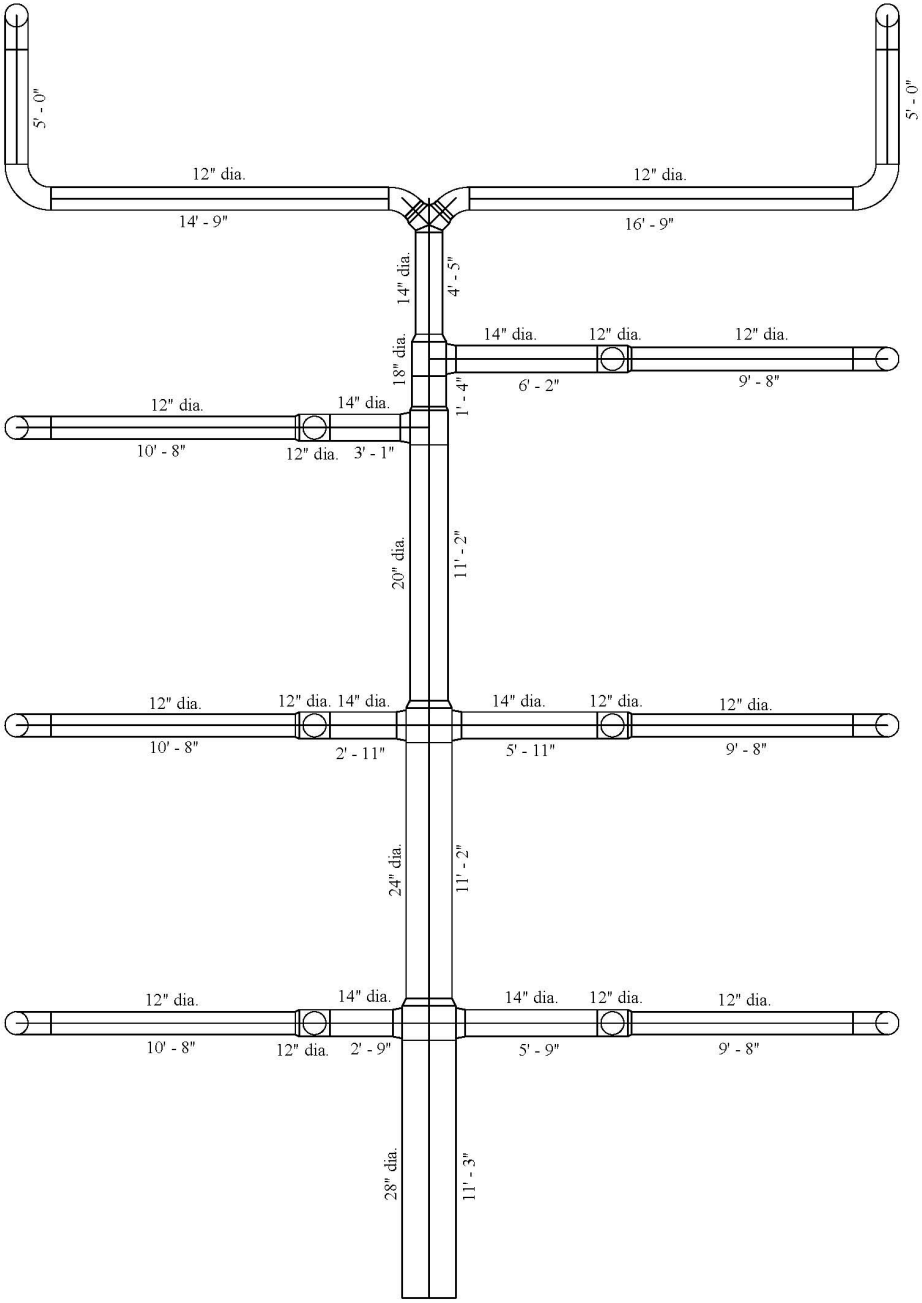


Example #2

Sample layout converted to round spiral duct

- 829 sq.ft. of duct
- 879 lbs. of metal
- 43 transverse joints
- 0 taps
- 160 lineal feet of joints to seal
- 0 lineal feet of longitudinal seams to seal
- 24 hangers
- 2 gallons of sealant

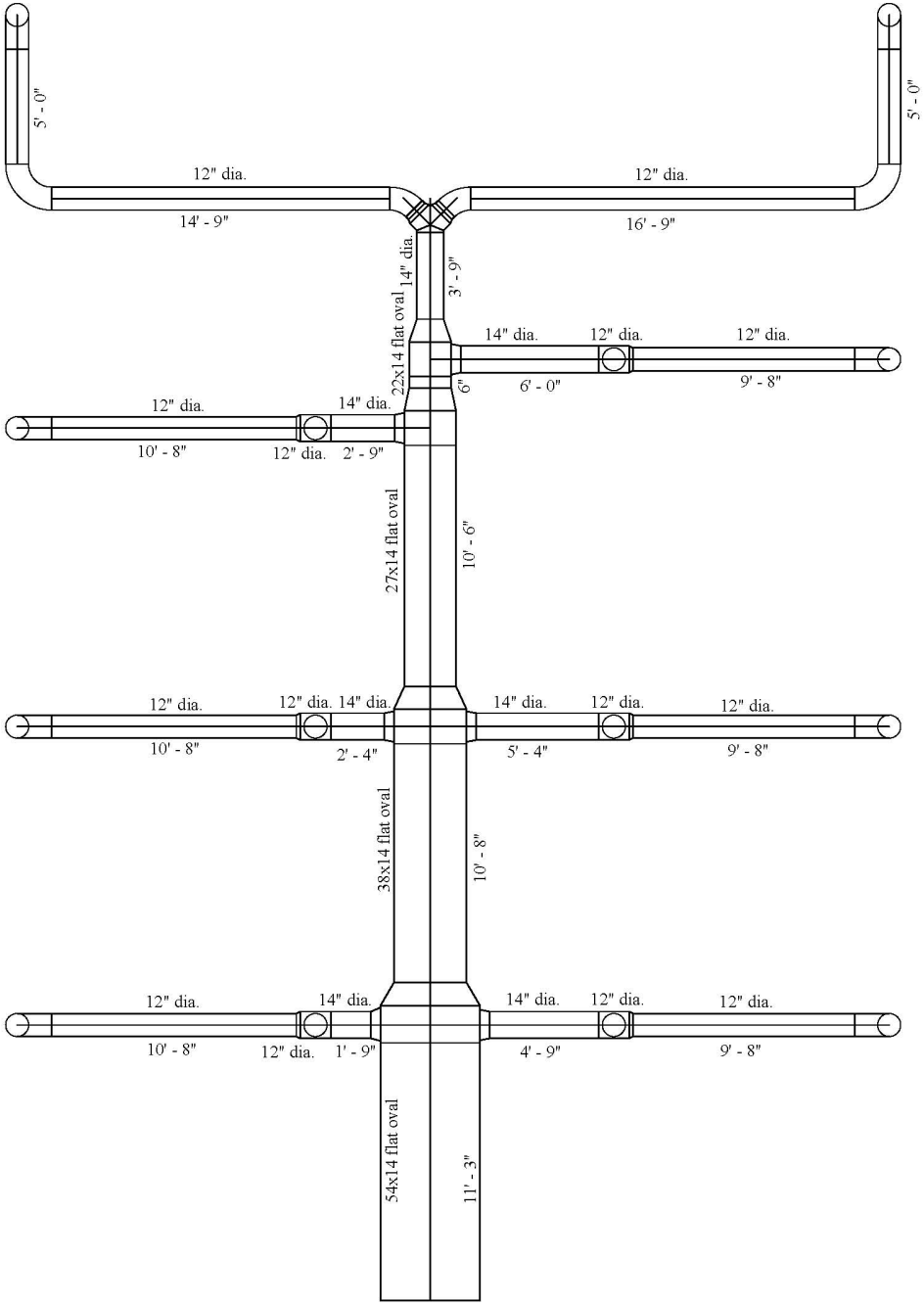
75% of the system could utilize standard stock components



Example #3

Sample layout converted to flat oval and round spiral duct

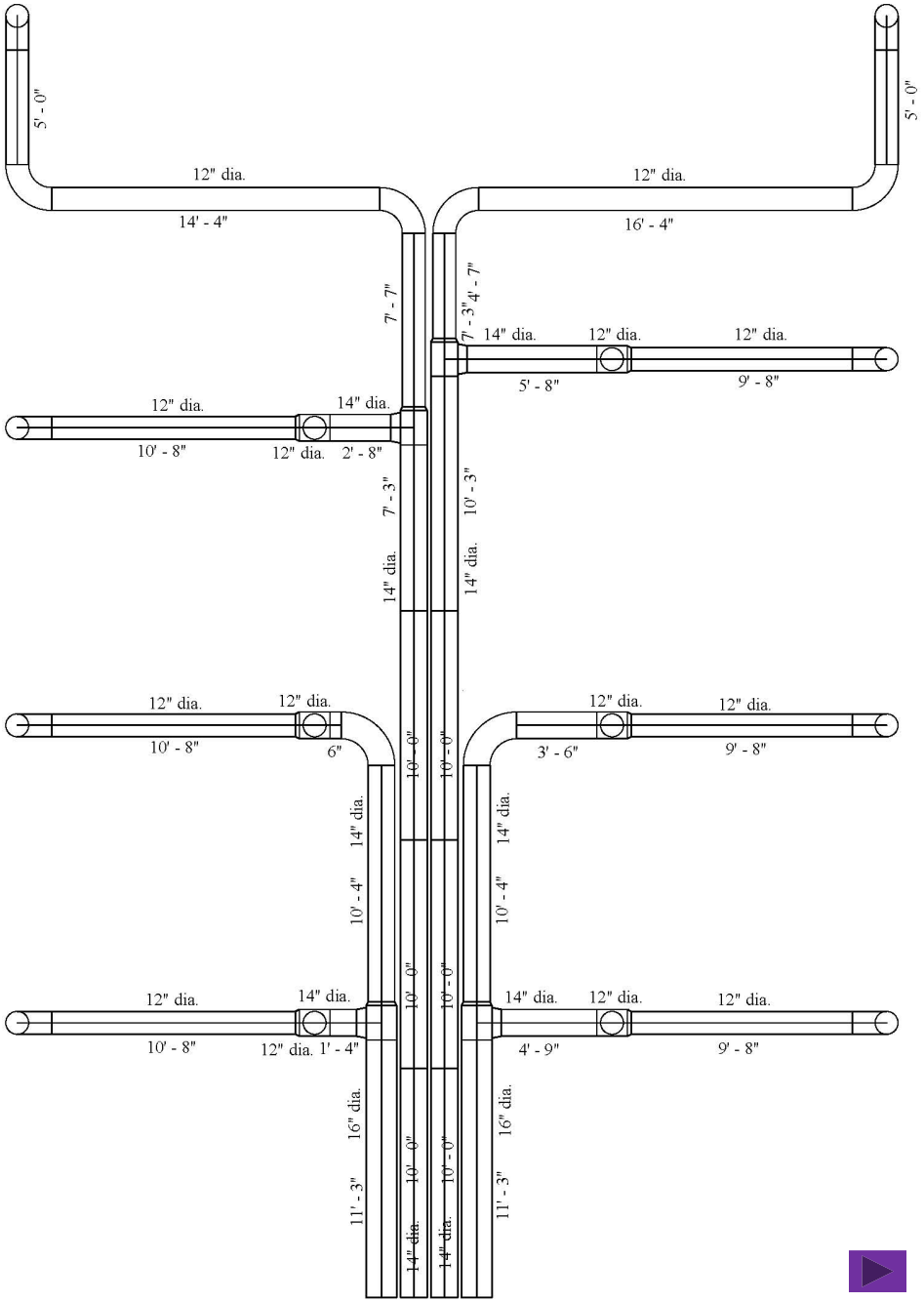
- 894 sq.ft. of duct
- 1,091 lbs. of metal
- 43 transverse joints
- 0 taps
- 168 lineal feet of joints to seal
- 0 feet of longitudinal seams to seal
- 24 hangers
- 2 gallons of sealant



Example #4

Sample layout converted to multiple runs of round spiral duct

- 1,003 sq.ft. of duct
- 975 lbs. of metal
- 50 transverse joints
- 0 taps
- 172 lineal feet of joints to seal
- 0 lineal feet of longitudinal seams to seal
- 36 hangers
- 2 gallons of sealant



Less Material !!!

	Example #1	Example #2	Example #3	Example #4
	Rectangular Duct	Round Spiral Duct	Flat Oval & Round Duct	Multiple Round Ducts
Sq.Ft. of Duct	1038	829	894	1003
Lbs. of Metal	1312	879	1091	975
# of Transverse Joints	61	43	43	50
# of Taps	15	0	0	0
Lineal Feet of Joints to Seal	275	160	168	172
Lineal Feet of Longitudinal Seams to Seal	371	0	0	0
# of Hangers	35	24	24	36
Gallons of Sealant	6	2	2	2

Less Material !!!

	Example #1	Example #2	Example #3	Example #4
	Rectangular Duct	Round Spiral Duct	Flat Oval & Round Duct	Multiple Round Ducts
Sq.Ft. of Duct	1038	829	894	1003
Lbs. of Metal	1312	879	1091	975
# of Transverse Joints	61	43	43	50
# of Taps	15	0	0	0
Lineal Feet of Joints to Seal	275	160	168	172
Lineal Feet of Longitudinal Seams to Seal	371	0	0	0
# of Hangers	35	24	24	36
Gallons of Sealant	6	2	2	2
Duct Cost $$$	***$2,896***	***$1,833***	***$2,717***	***$1,963***
Compared to Round	***158%***	***100%***	***148%***	***107%***

Less Labor !!!

	Example #1	Example #2	Example #3	Example #4
	Rectangular Duct	Round Spiral Duct	Flat Oval & Round Duct	Multiple Round Ducts
Sq.Ft. of Duct	1038	829	894	1003
Lbs. of Metal	1312	879	1091	975
# of Transverse Joints	61	43	43	50
# of Taps	15	0	0	0
Lineal Feet of Joints to Seal	275	160	168	172
Lineal Feet of Longitudinal Seams to Seal	371	0	0	0
# of Hangers	35	24	24	36
Gallons of Sealant	6	2	2	2
Duct Cost $$$	***$ 2,896.00***	***$ 1,833.00***	***$ 2,717.00***	***$ 1,963.00***
Compared to Round	***158%***	***100%***	***148%***	***107%***
Installation Man Hours	***54***	***45***	***56***	***50***
Installation Labor Cost (@ $60/MH)	***$ 3,240.00***	***$ 2,700.00***	***$ 3,360.00***	***$ 3,000.00***
Compared to Round	***120%***	***100%***	***124%***	***111%***

	Example #1	Example #2	Example #3	Example #4
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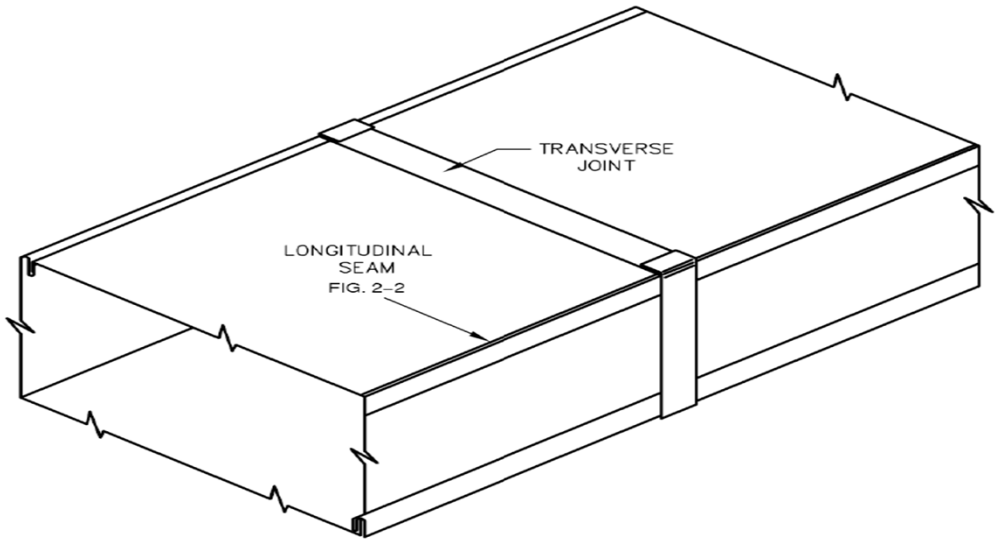
Compared to Round	***158%***	***100%***	***148%***	***107%***
Installation Man Hours	***54***	***45***	***56***	***50***
Installation Labor Cost (@ $60/MH)	***$ 3,240.00***	***$ 2,700.00***	***$ 3,360.00***	***$ 3,000.00***
Compared to Round	***120%***	***100%***	***124%***	***111%***
RAW INSTALLED COST	***$ 6,136.00***	***$ 4,533.00***	***$ 6,077.00***	***$ 4,963.00***
Compared to Round	***135%***	***100%***	***134%***	***109%***

SEAL CLASS	Sealing Requirements	Applicable Static Pressure Construction Class
A	All Transverse joints, longitudinal seams, and duct wall penetrations	4" wg and up (1000 Pa)
B	All Transverse joints and longitudinal seams only	3" wg (750 Pa)
C	Transverse joints only	2" wg (500 Pa)



ASHRAE Ductwork “Seal Class”:

90.1-2004 has seal class A,B,C
90.1-2007 has seal class A,B,C
90.1-2010 has seal class A only

“ASHRAE 90.1-2010 is the current standard and is adopted by reference in the International Energy Conservation Code 2012. Either 90.1 or IECC are typically used as the basis for state, and local codes, and this process follows a natural update cycle that takes 3 to 6 years.

LEED 2009 currently references the 90.1-2007 standard.

LEED 2012 is in the process of being finalized and is expected to reference 90.1-2010.

Goal: to Leave with a Path-forward Action Plan and…

- **Create that Path-Forward Action Plan.**
- **Acquire a computerized static regain duct design program.**
- **Reach out to John Reints if you need help.**

Thank you!

Questions?

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John Reints jvrpellc@msn.com