# Why is Everyone Trying to Change My Duct System?

*Bob Reid*

# Who wants change?

- ASHRAE
- Building & Energy Codes
- USGBC --- “green” construction
- Duct manufacturers
- Equipment manufacturers
- Duct accessory manufacturers
- Progressive contractors

# Reasons for Change

- Lower leakage
- Reduce costs
- Duct cleaning / eliminate contaminants
- New products and processes
- Tighter timelines
- Changes to the labor force

# The goal of the engineer is to ……..

…….provide environmental comfort to the occupants in a manner that is efficient to operate, easy to maintain, and gives value through the expected life of the building.

- Meets codes and standards
- Meets requirements of owner
- Meets sustainability commitments
- Reasonable first cost

# The goal of the contractor is to ……

…….Meet the requirements of the contract documents in the most efficient manner possible to maximize profitability.

# What should happen ……..

The engineer and installing contractor work together in partnership to produce the best performing duct system.

- The engineer knows the full picture of the building design needs
- The contractor knows what everything costs

# What really happens …….

- No review of duct system cost before the bid
- Potential savings are greatly diluted after the bid (blame the GC…..)
- No reward for risk to the designer --- why let the contractor change anything?
- Great risk for the contractor in changes --- he becomes responsible for the design
- General contractors and owners get involved --- and who wants that?
- Speaking of general contractors, they don't really want a subcontractor rocking the boat, nor are they usually going to allow time for major changes

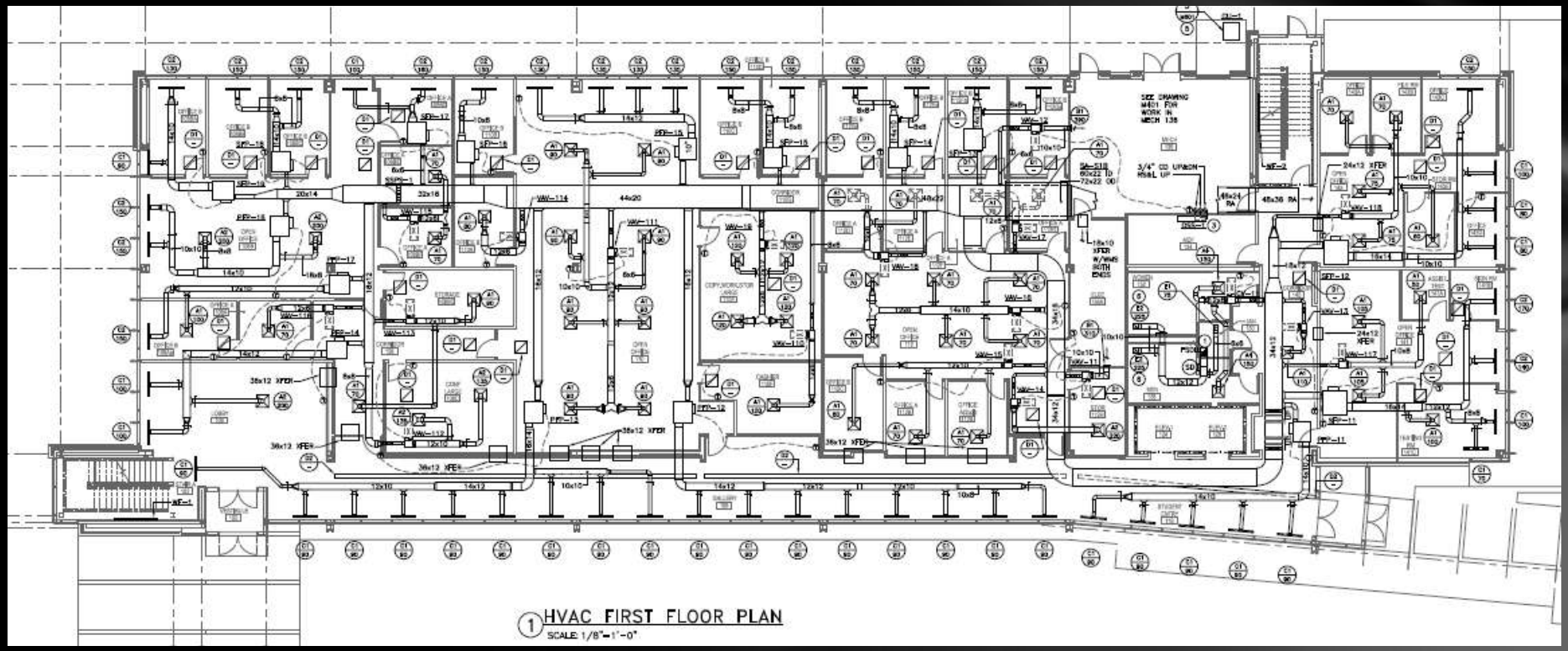
***It will usually require  a bold contractor and a big profit potential for a proposed change to a design.***

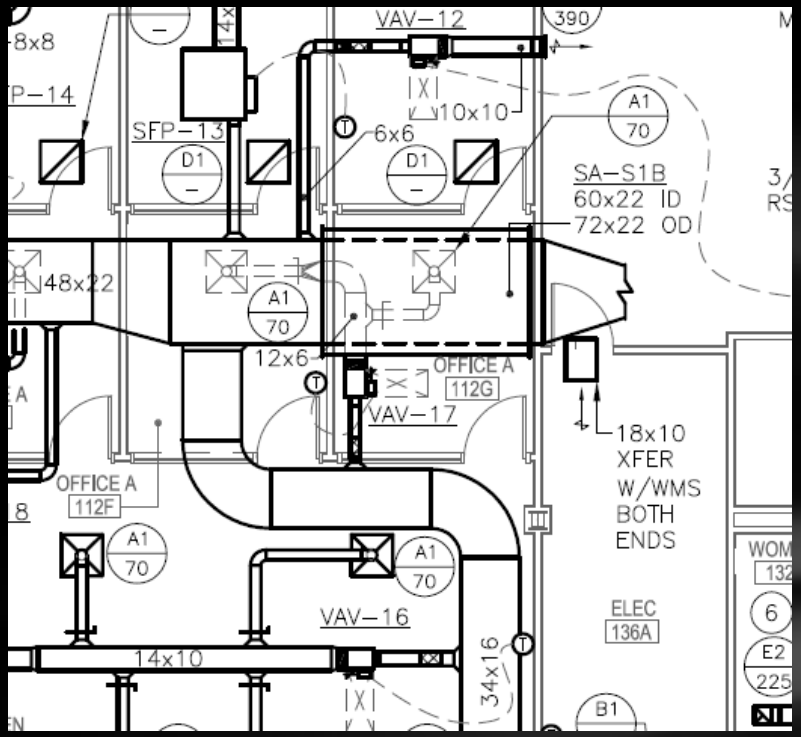
# The “Re-Designer”

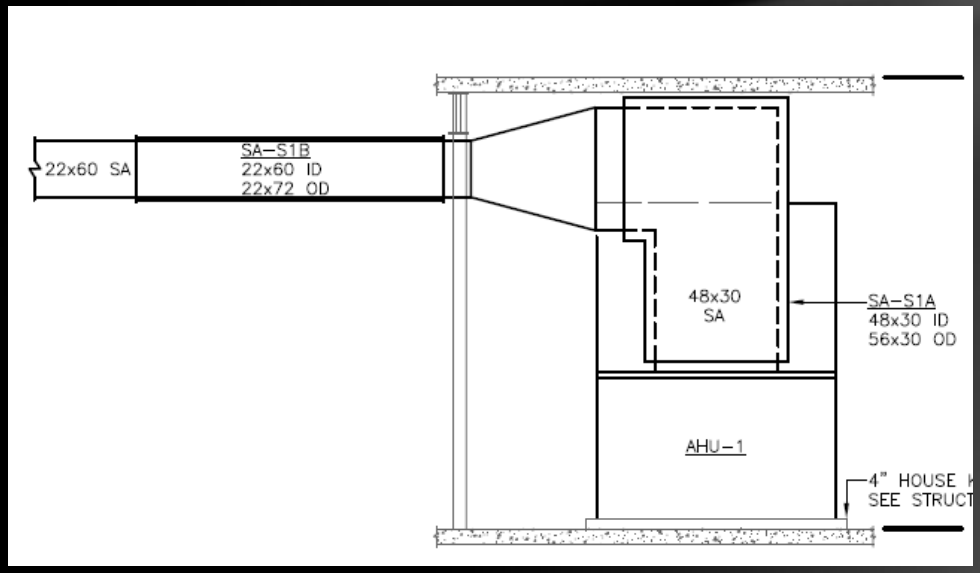
- Sometimes it’s a new technology or product available to the contractor
- Third-party re-designers --- equipment or duct manufacturers
- Value engineering --- diluted savings, but still savings
- Trained contractors

# Changing the Duct System

1. **Look for cost savings close to the AHU** --- small changes will make a disproportionate difference in cost.


1 HVAC FIRST FLOOR PLAN
SCALE: 1/8"=1'-0"


VAV–12
390
8x8
P–14
SFP–13
D1
6x6
10x10
A1
70
SA–S1B
60x22 ID
72x22 OD
48x22
12x6
OFFICE A
112G
VAV–17
18x10
XFER
W/WMS
BOTH
ENDS
OFFICE A
112F
VAV–16
14x10
34x16
ELEC
136A
B1
WOM
132
6
E2
225


22x60 SA
SA–S1B
22x60 ID
22x72 OD
48x30
SA
SA–S1A
48x30 ID
56x30 OD
AHU–1
4" HOUSE K
SEE STRUCT

# First 25’ from AHU

Cost of duct, silencers and transitions ----- $4,987.00

Cost for the rest of the duct system (upstream of boxes) ----- $7,261.00

Total medium pressure duct cost ----- $12,248.00

% cost for the first 25’ ----- 40%

# Changing the Duct System

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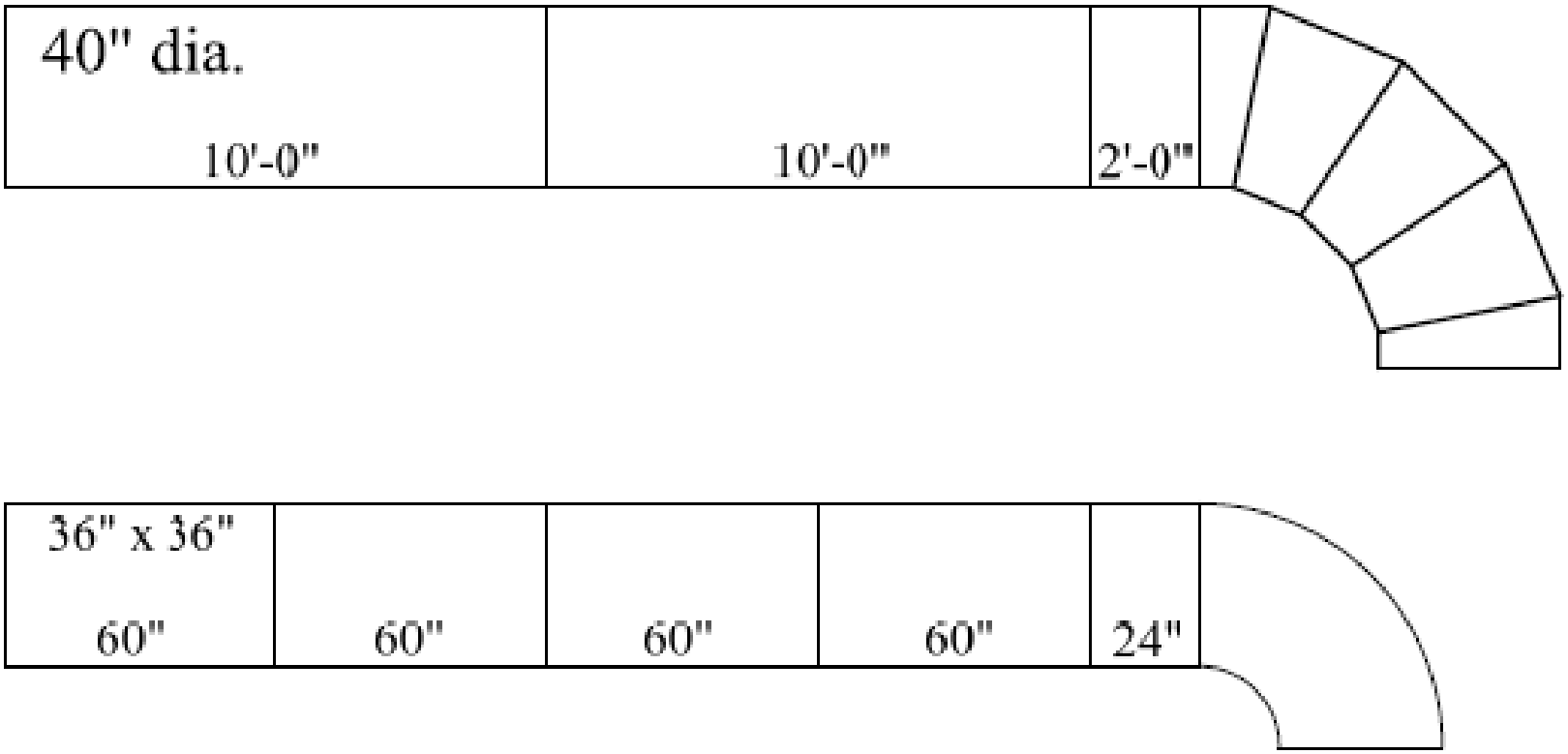
2. **Use your space --- aspect ratios cost money**


40" dia.
10'-0"
10'-0"
2'-0"
36" x 36"
60"
60"
60"
60"
24"

| Size | Construction | Perimeter | % change | Weight | % change | Cost | % change |
|---|---|---|---|---|---|---|---|
| 40"ϕ | 24 ga. Pipe / 22 ga. Fittings | 126 | --- | 451 | --- | $ 633.00 | --- |
| | | | | | | | |
| 36 x 36 | 20 gauge | 144 | 114% | 585 | 130% | $ 692.00 | 109% |
| 42 x 32 | 20 gauge w/ joint tie rods | 148 | 117% | 655 | 145% | $ 848.00 | 134% |
| 44 x 30 | 18 gauge w/ joint tie rods | 148 | 117% | 865 | 192% | $ 1,119.00 | 177% |
| 48 x 28 | 18 gauge w/ joint tie rods | 152 | 121% | 912 | 202% | $ 1,164.00 | 184% |
| 52 x 26 | 18 gauge w/ joint tie rods | 156 | 124% | 986 | 219% | $ 1,238.00 | 196% |
| 56 x 24 | 18 gauge w/ joint tie rods | 160 | 127% | 1037 | 230% | $ 1,286.00 | 203% |
| 64 x 22 | 20 ga. w/ JTR & (2) MTR | 172 | 137% | 899 | 199% | $ 1,149.00 | 182% |
| 72 x 20 | 20 ga. w/ JTR & (2) MTR | 184 | 146% | 1008 | 224% | $ 1,264.00 | 200% |
| 88 x 18 | 18 ga. w/ JTR & (2) MTR | 212 | 168% | 1662 | 369% | $ 1,976.00 | 312% |

# Aspect Ratio

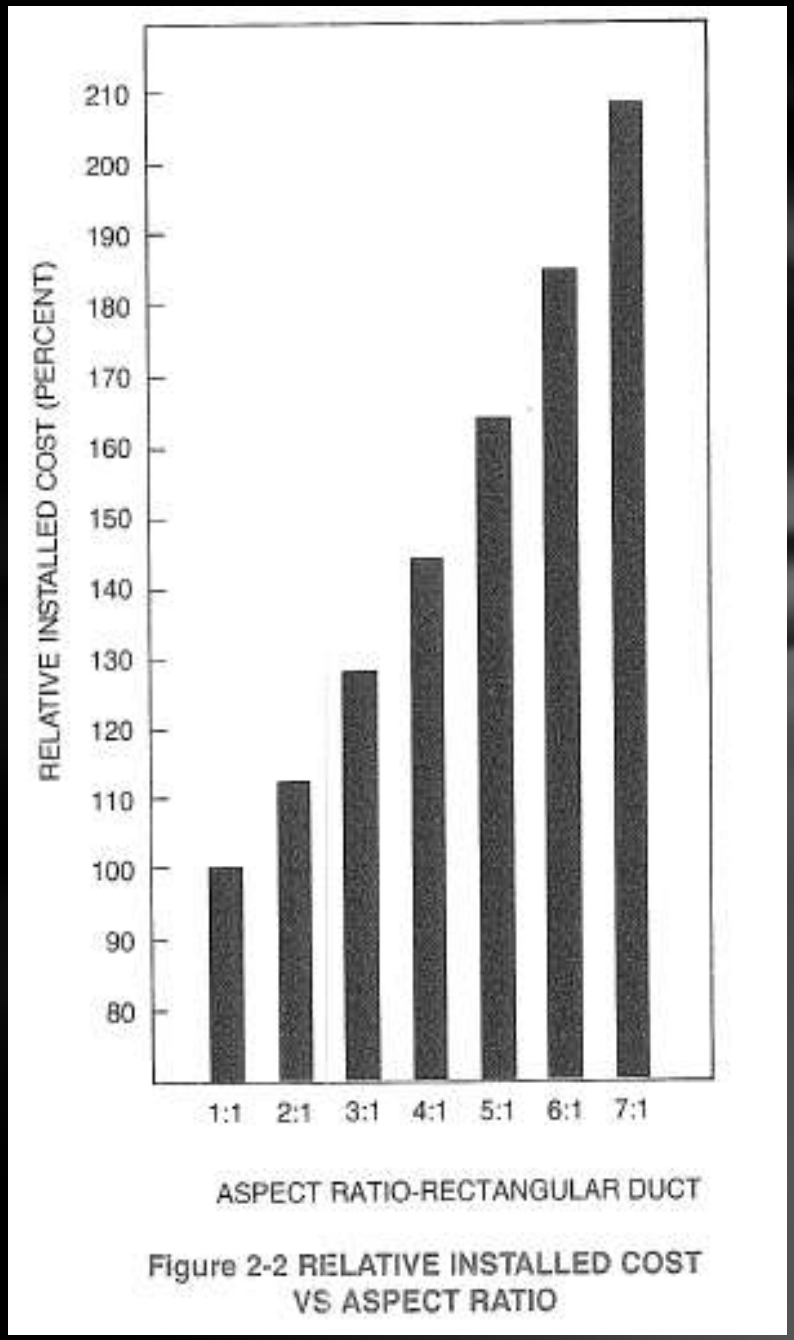



Figure 2-2 RELATIVE INSTALLED COST VS ASPECT RATIO

# Aspect Ratio

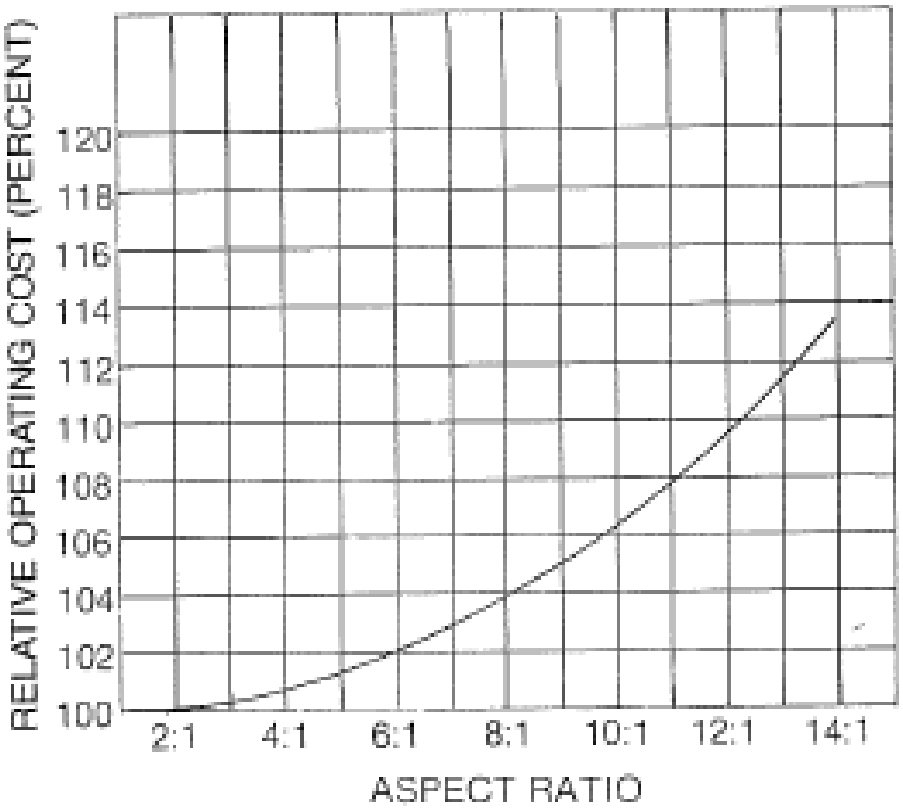



**Figure 2-3 RELATIVE OPERATING COST VS ASPECT RATIO (based on equal duct area)**

# Changing the Duct System

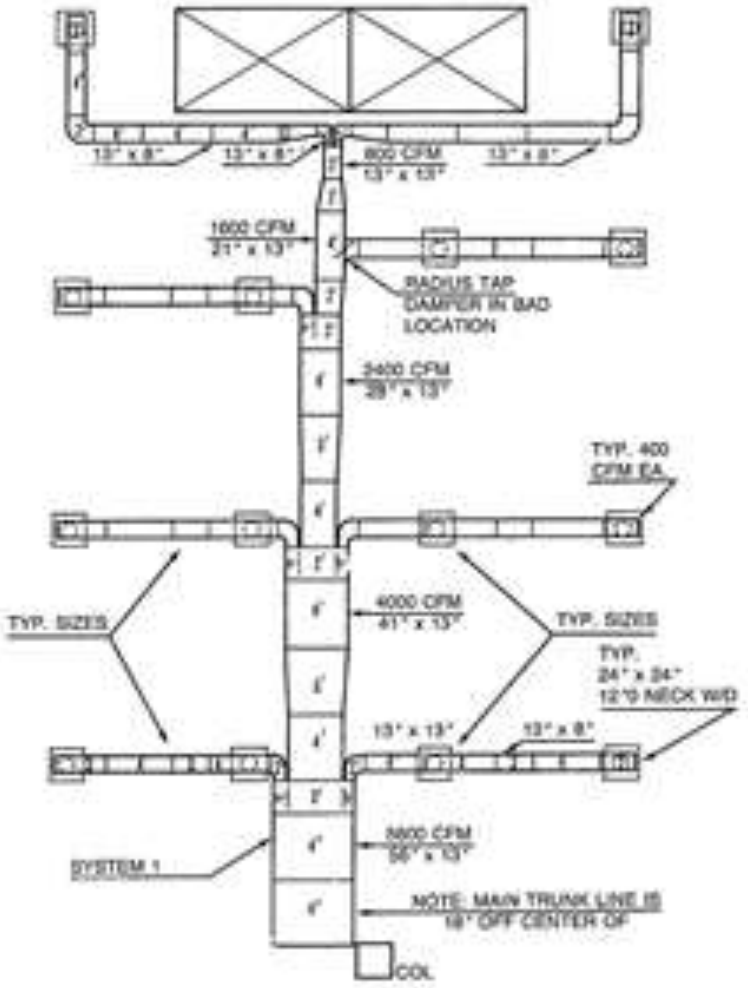
1. Look for cost savings close to the AHU --- small changes will make a disproportionate difference in cost.
2. Use your space --- aspect ratios cost money
3. **Use Circular Logic --- everyone agrees round duct costs less. Change to round as soon as you can.**

## Example #1

Typical Rectangular Duct System

2-2

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

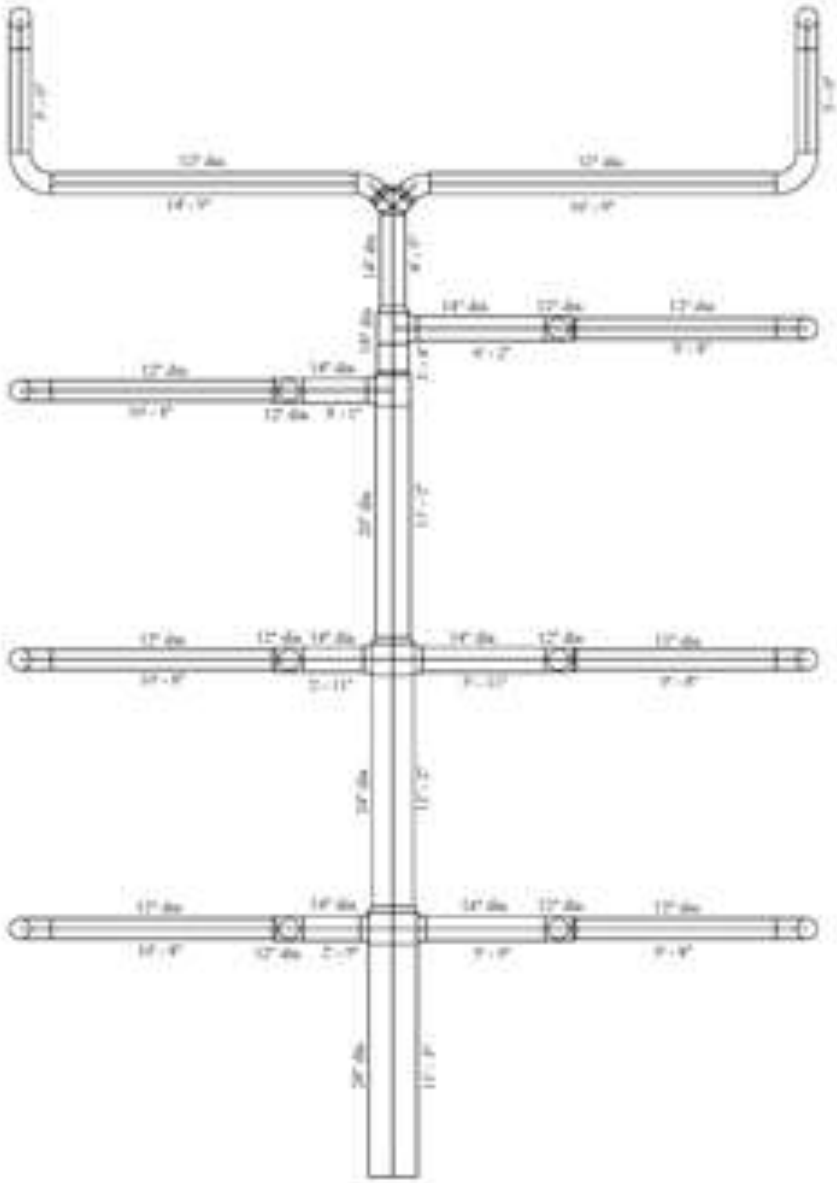


## Example #2

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

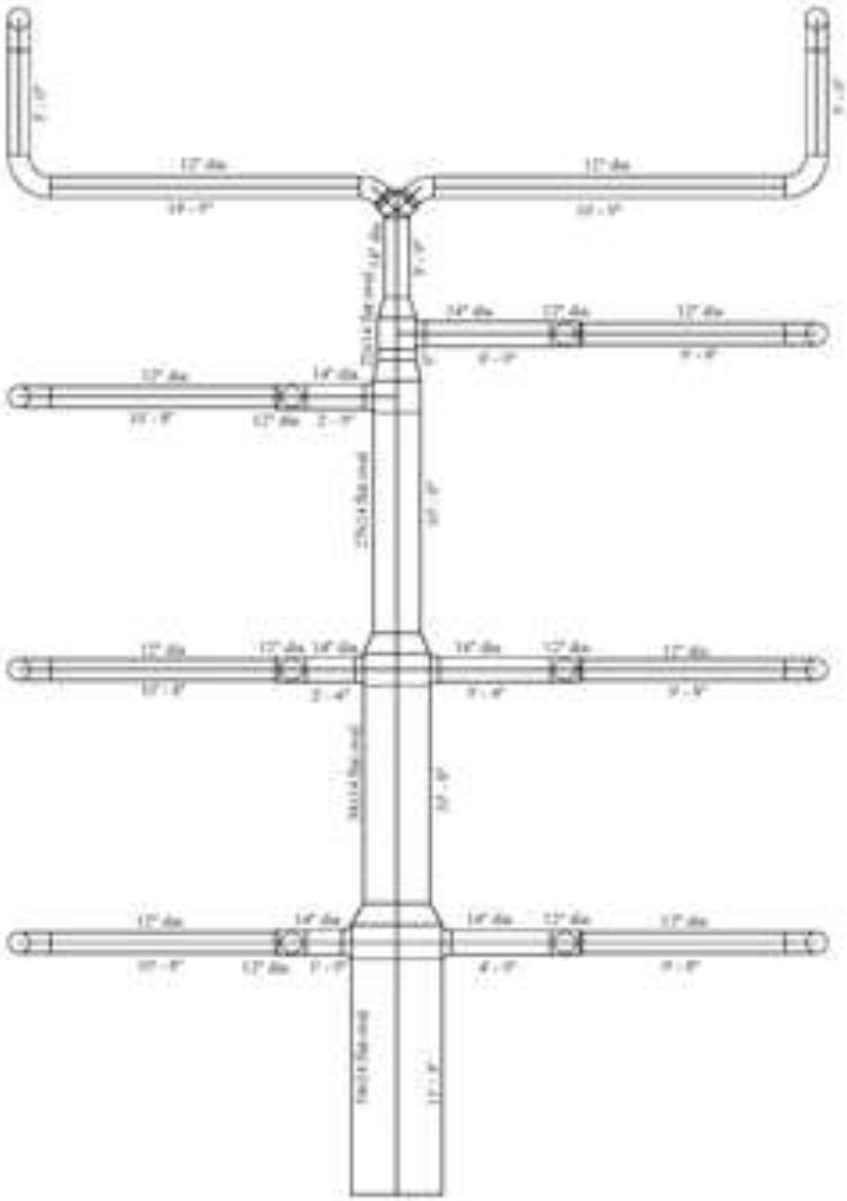
75% of the system could utilize standard stock components



## Example #3

Sample layout converted to flat oval and round spiral duct

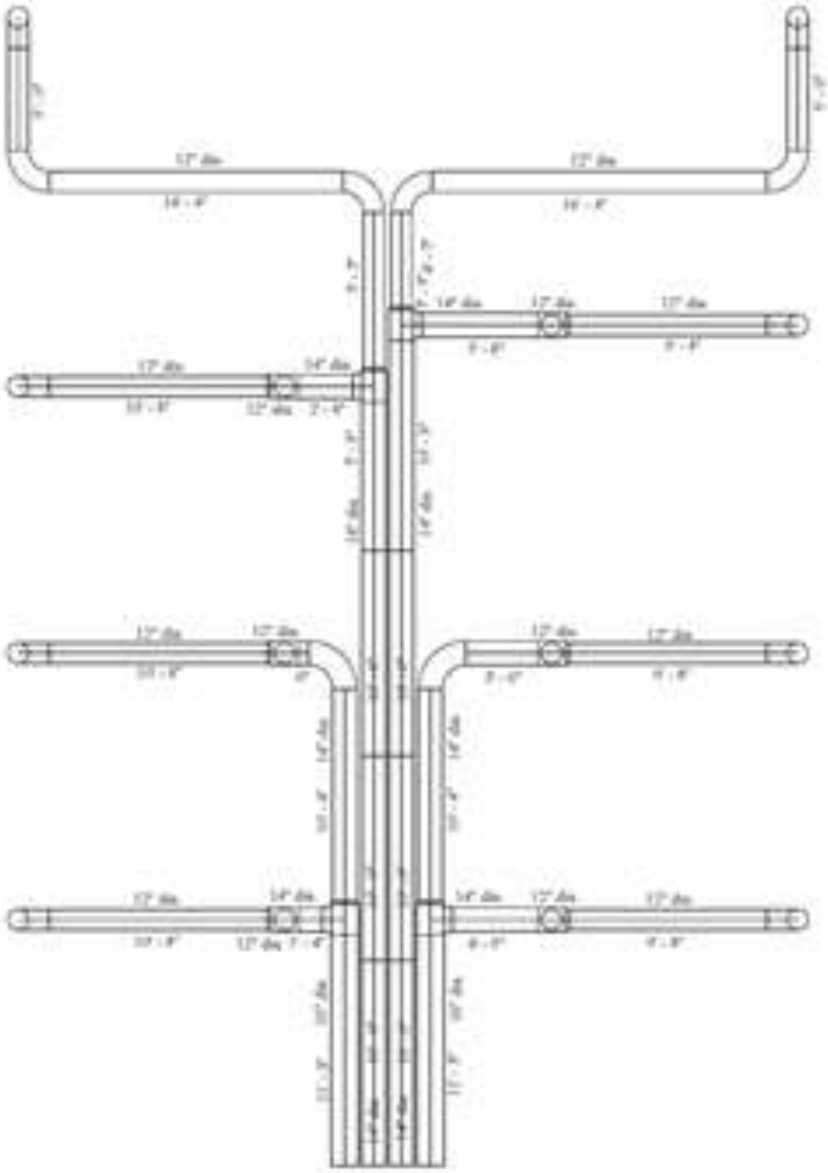
- 894 sq.ft. of duct
- 1,091 lbs. of metal
- 43 transverse joints
- 0 taps
- 168 lineal feet of joints to seal
- 0 feet of longitudinal seams to seal
- 24 hangers
- 2 gallons of sealant



## 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 |

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| # 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 !!!

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| #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%* |

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| Installation Labor Cost (@ $60/M H) | ***$ 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%* |

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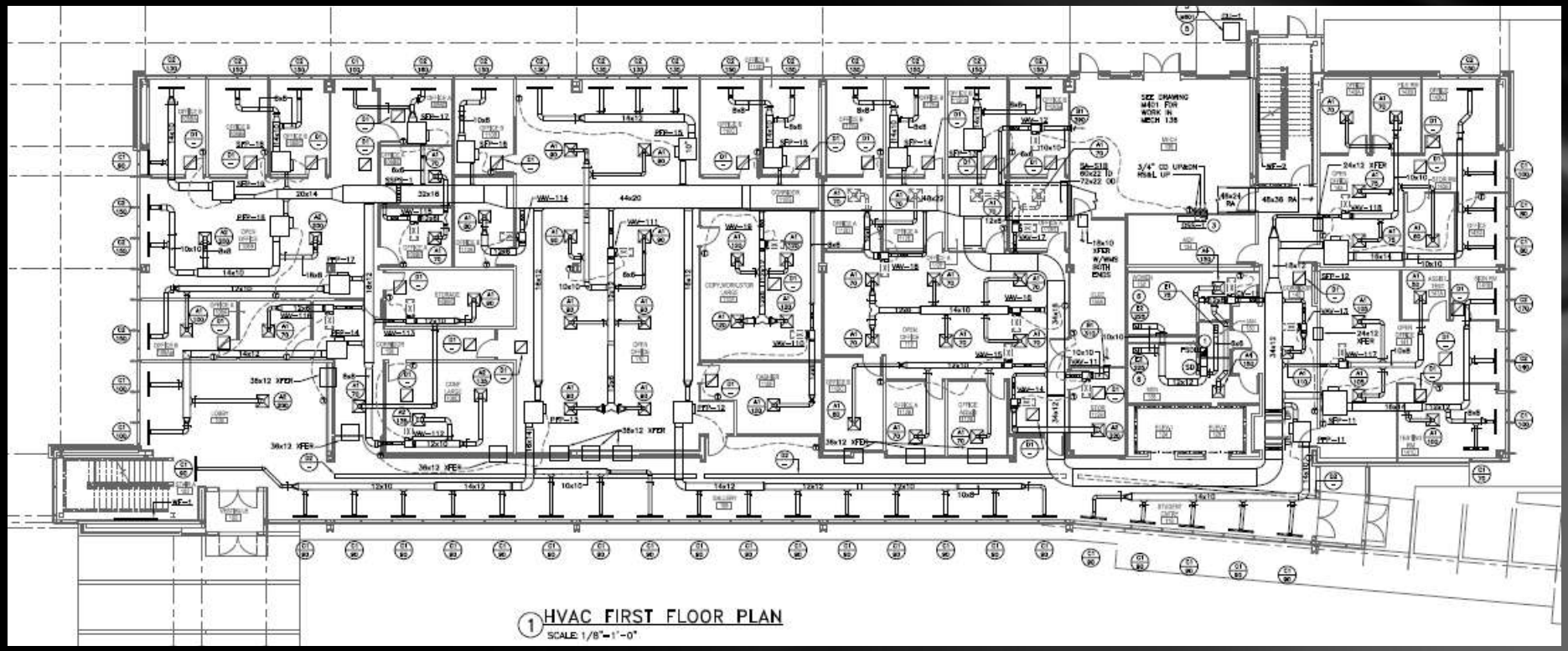
4. **Breaking up is hard to do --- fighting the urge to design "one big duct"**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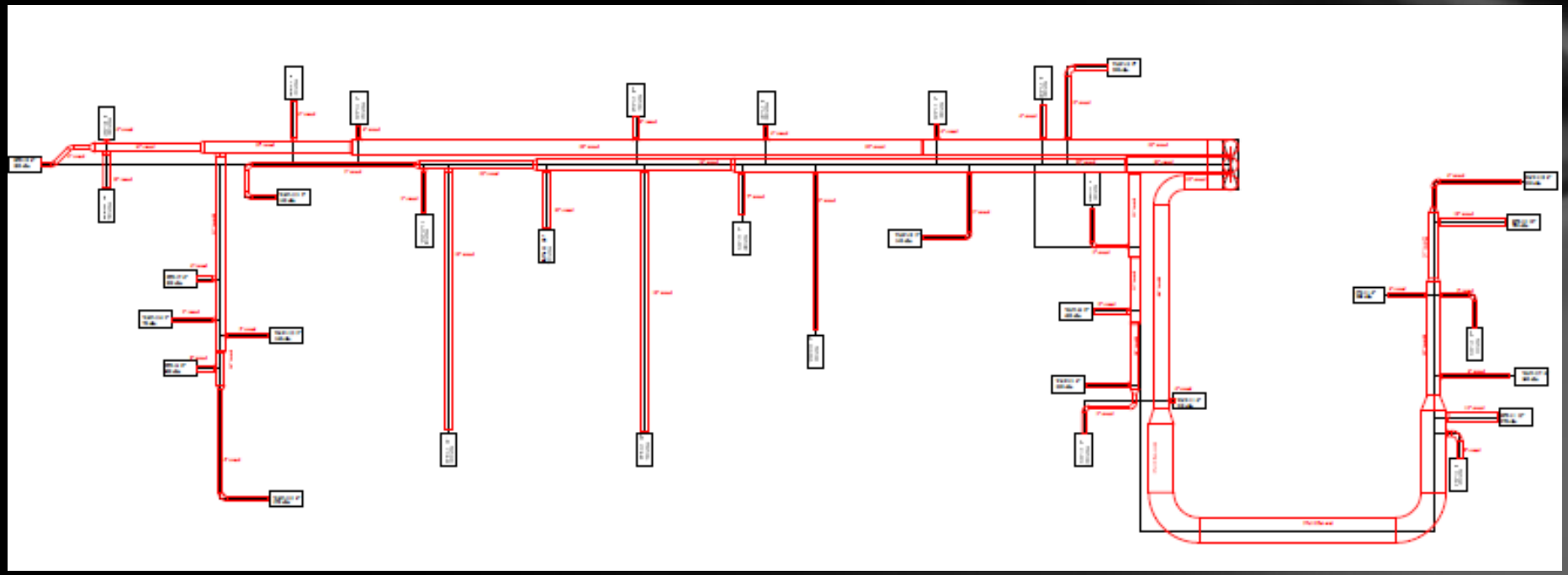

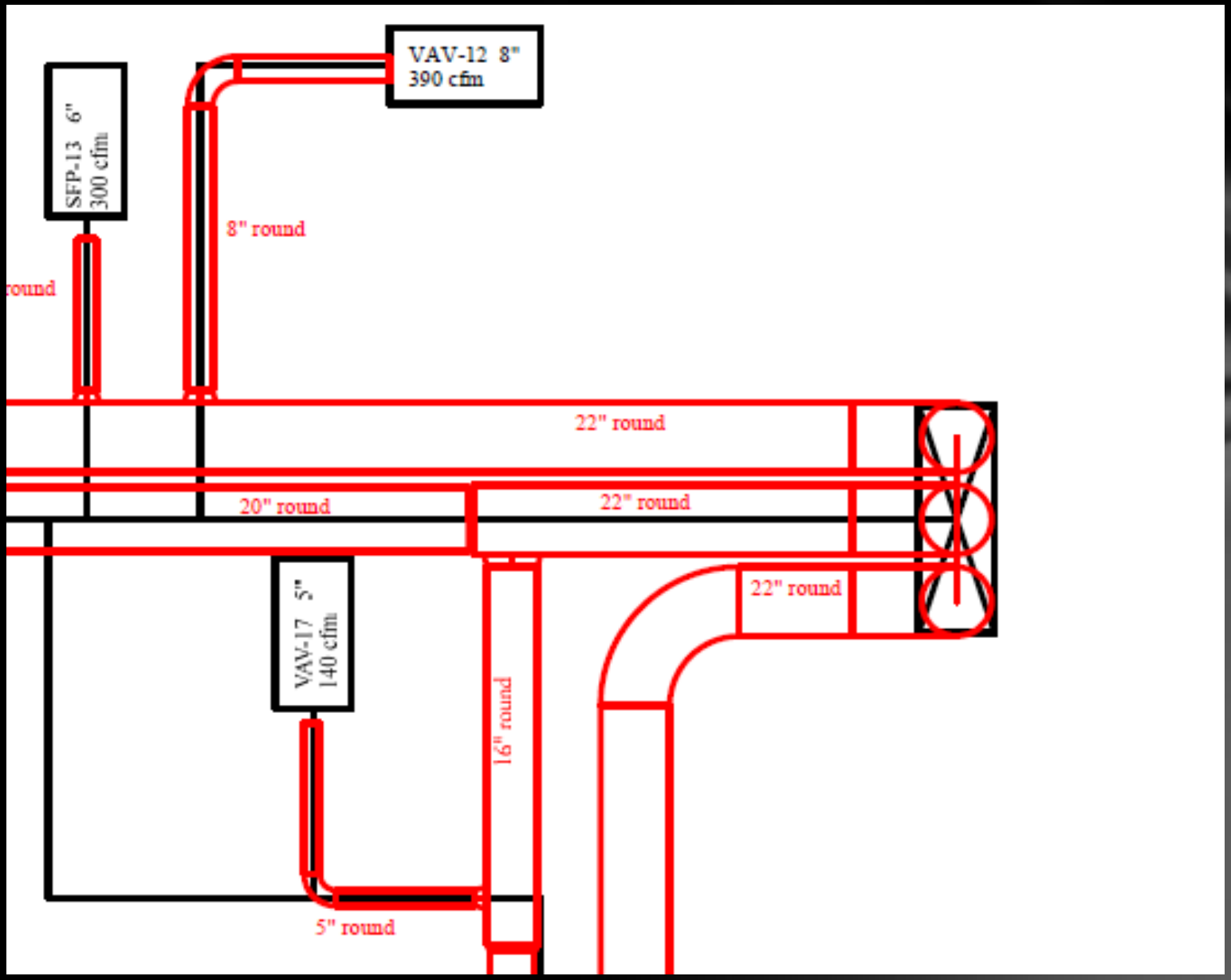
VAV-12 8"
390 cfm
SFP-13 6"
300 cfm
8" round
round
22" round
20" round
22" round
22" round
VAV-17 5"
140 cfm
16" round
5" round

# “One Big Duct” vs. 3 Round Ducts

Cost of original medium pressure ducts ----- $11,261.00

Cost of revised ducts (incl. double wall in mech room) ----- $8,805.00

Potential cost savings ----- 28%

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5. **Ductulator Disease --- it is based on equal friction loss in straight duct, not equal pressure loss in fittings**


AIR VOLUME - CFM
2000
2500
3000
4000
5000
6000
7000
8000
9000
10,000
15,000
20,000
.01
.02
.03
.04
.05
.08
0.1
0.2
0.3
0.4
FRICTION PER 100 FEET

Air D

The

# Fitting Comparison

From the ASHRAE Duct Fitting Database

- 40" dia. 90-degree 5-gore elbow (CLR=1.5) @ 14,000 CFM
  - $\Delta P$ = 0.02" WG
- 36x36 radius 90-degree elbow (CLR=1.5) @ 14,000 CFM
  - $\Delta P$ = 0.03" WG
- 36x36 mitered elbow with turning vanes @ 14,000 CFM
  - Double thickness ----- $\Delta P$ = 0.04" WG
  - Single thickness ----- $\Delta P$ = 0.05" WG

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6. **Duct Leakage --- if you want less leakage, have fewer joints**

# Common faults in commercial buildings

**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

## Energy-Saving Potential

Most smaller—and at least half of larger—commercial buildings have appreciable levels of duct leakage. Smaller commercial buildings appear to have duct leakage equal to 20% to 35% of system airflow.[2,5–7] More limited data indicate that larger commercial buildings with central air-handling units have lower leakage rates (between 5% and 20%) than smaller buildings with unitary-based ducting.[8–11]



11. Diamond, R., et al. 2003. "Thermal Distribution Systems in Commercial Buildings," Lawrence Berkeley National Laboratory Final Report, LBNL-51860. http://epb1.lbl.gov/Publications/lbnl-51860.pdf.

# Duct Leakage

## Where does duct leak?

- Duct leakage occurs throughout the system, not just in the "high pressure duct"
- VAV boxes, dampers, low pressure duct --- they all contribute to duct system leakage
- 25% leakage means the fan has to produce 25% more air --- regardless of where the leakage occurs
- Volume of leakage has nothing to do with "square footage of duct surface area". It is a function of the length and type of seams.
  - Approximately 15% of rectangular duct leakage occurs in the side seams, the rest in the transverse connectors
  - Spiral lockseams have virtually no leakage

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7. **What do ducts cost? --- remove weight and pieces, you'll almost certainly be removing cost**

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7. What do ducts cost? --- remove weight and pieces, you'll almost certainly be removing cost
8. **It's all important, low pressure and return air too**

# Getting the Duct System You Need

1. **Ask Questions**

# Get a Second Opinion

- Ask a contractor --- they've probably been dying to tell you what you've been doing wrong
  - They know the real installed cost
  - They aren't going to meet your changing design requirements for free, but you can rest assured they want to find the most efficient/least expensive way to do so
- "How are they doing it in _____?"
  - Peer groups within ASHRAE are a good way to see how others have tackled these issues
  - Northern Europe has been dealing with high energy costs and a shortage of skilled labor for decades.
- Ask a re-designer
  - It's always easier to criticize than to do, but some of these guys make some large profits for themselves and their companies by making some obvious (to them) changes to your duct systems.

# Getting the Duct System You Need

1. Ask Questions
2. **Dictate performance, not details**
   - Don’t compromise requirements
   - But encourage innovation

# Getting the Duct System You Need

1. Ask Questions
2. Dictate performance, not details
3. **Don't create a problem to fix a problem**

# Getting the Duct System You Need

1. Ask Questions
2. Dictate performance, not details
3. Don’t create a problem to fix a problem
4. **Follow up**