Duct Design and Installation

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Duct Design

- ACCA Manuals J, T, and D or Equivalent

Proper Design & Selection – Estimate Loads

1. Determine Design Heating Loads
2. Determine Design Cooling Loads – Sensible and Latent
3. Determine the airflow required to each room

Proper Design

1. Determine the best locations for the air terminals (registers)

   Use ACCA Manual T

2. Design the duct system to the available pressure and minimize the effective length

   Use ACCA Manual D or Equivalent

A Good Duct Design Provides

- Quiet
- Efficient
- Comfort

Recommended Velocity (in fpm)

	Supply		Return	
Duct Type	Rigid	Flex	Rigid	Flex
Trunk	700	600	600	600
Branch	600	600	400	400
Outlet	Size for Throw			
Return Grille Face			<500	
Filter Grille			<300	

Efficient

- **FAN WATT DRAW REDUCTION**
- **SUFFICIENT AIRFLOW**
- **LOW DUCT LEAKAGE**
  - **SEAL WITH MASTIC OR SNAP-DUCT**
  - **PUT INSIDE THE CONDITIONED SPACE**
- LOW CONDUCTION LOSS
  - SHORT RUNS
  - FEWER LARGER DIAMETER RUNS
  - PUT INSIDE THE CONDITIONED SPACE
  - USE METAL DUCT AND FITTINGS

Comfort

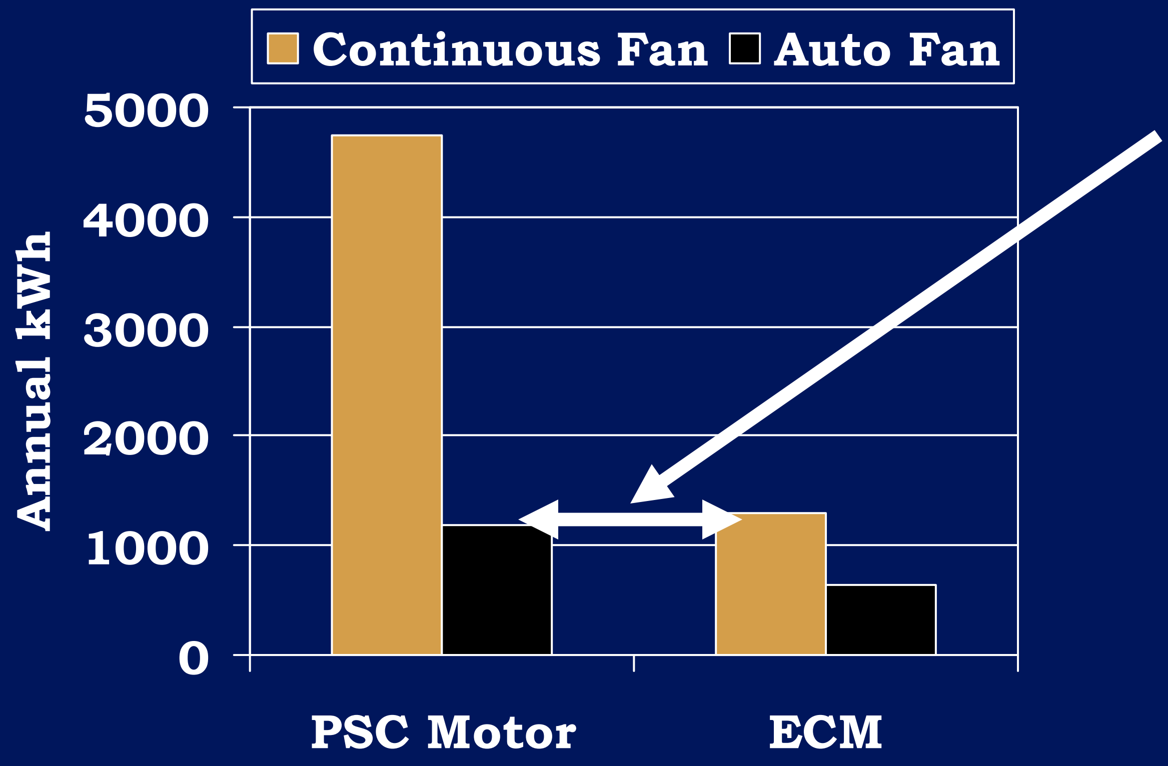
TEMPERATURE DIFFERENCE BETWEEN ROOMS

< 2 ° F IDEAL

4 ° F MAXIMUM

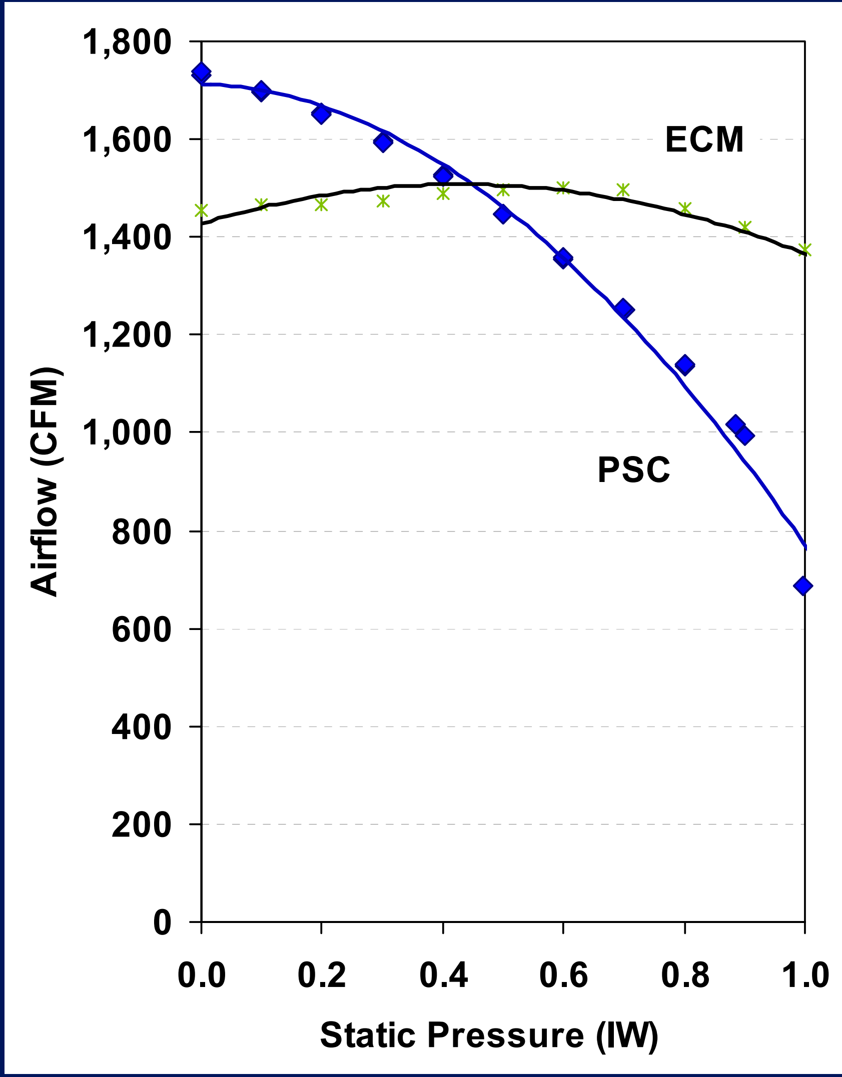
SO USE A CONTINUOUS FAN? **NO**

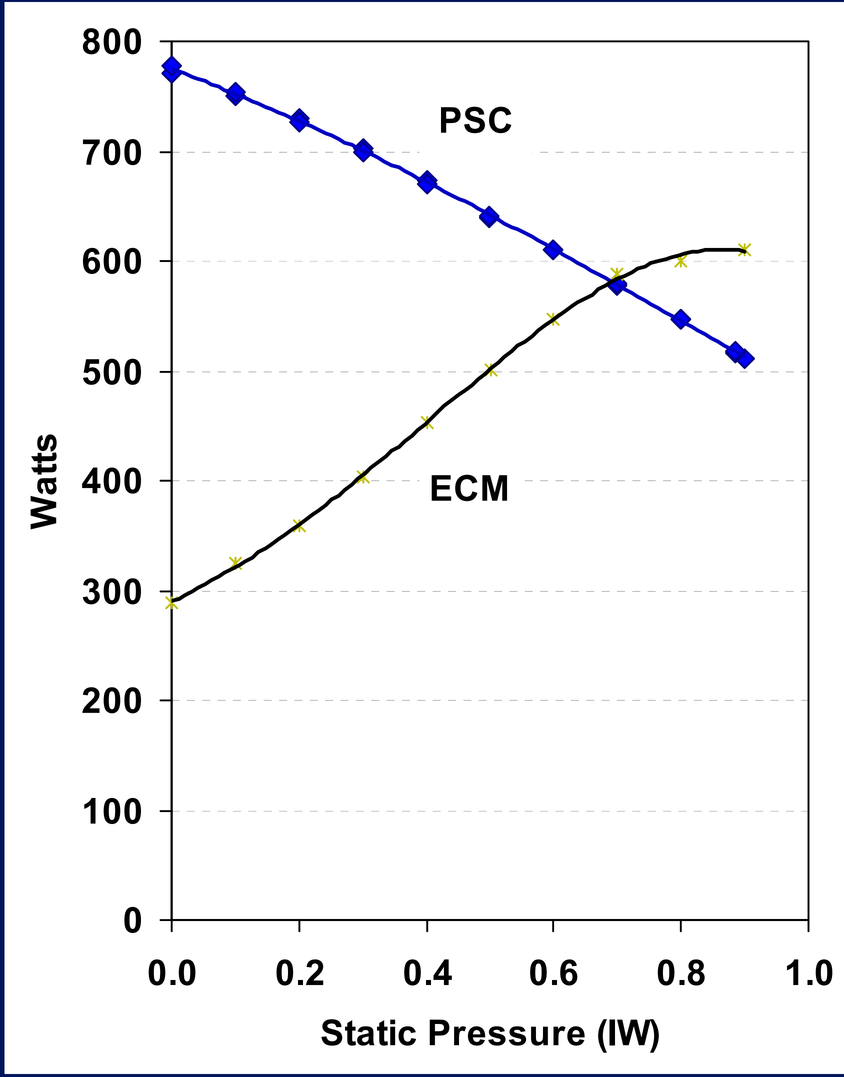
Why not just add an Electrically Commutated Motor (ECM) and use a continuous fan?



1. An ECM uses as much power running continuously as a PSC motor does running on Auto
   (Scott Pigg, Wisconsin Study)
2. Continuous duct leakage losses and conduction losses
3. ECM motors are not magic – When pressures are too high they can use more electricity and burnout

ECM Motors Maintain Airflow (up to a point) but can use more watts than a PSC





Comfort comes from a designed system

Duct System Must Be Designed to Deliver Correct Amount of Air to Each Supply Terminal

AND

Each Supply Terminal Must Be Carefully Sized and Located

AND

Each Supply Terminal Must Be Chosen With Adequate Mixing and Throw

AND

There Must Be an Adequate Return Path for Each Supply

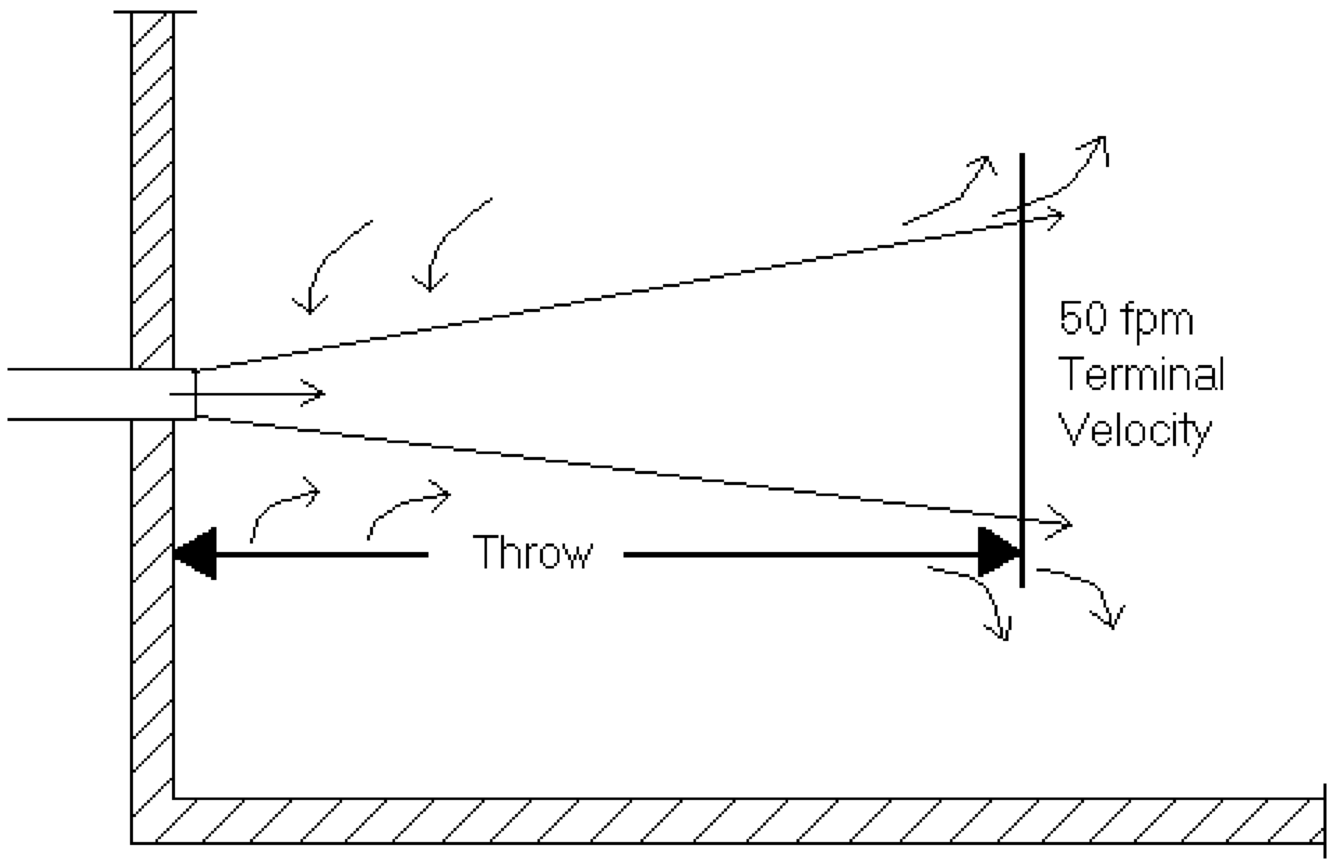
Terminals

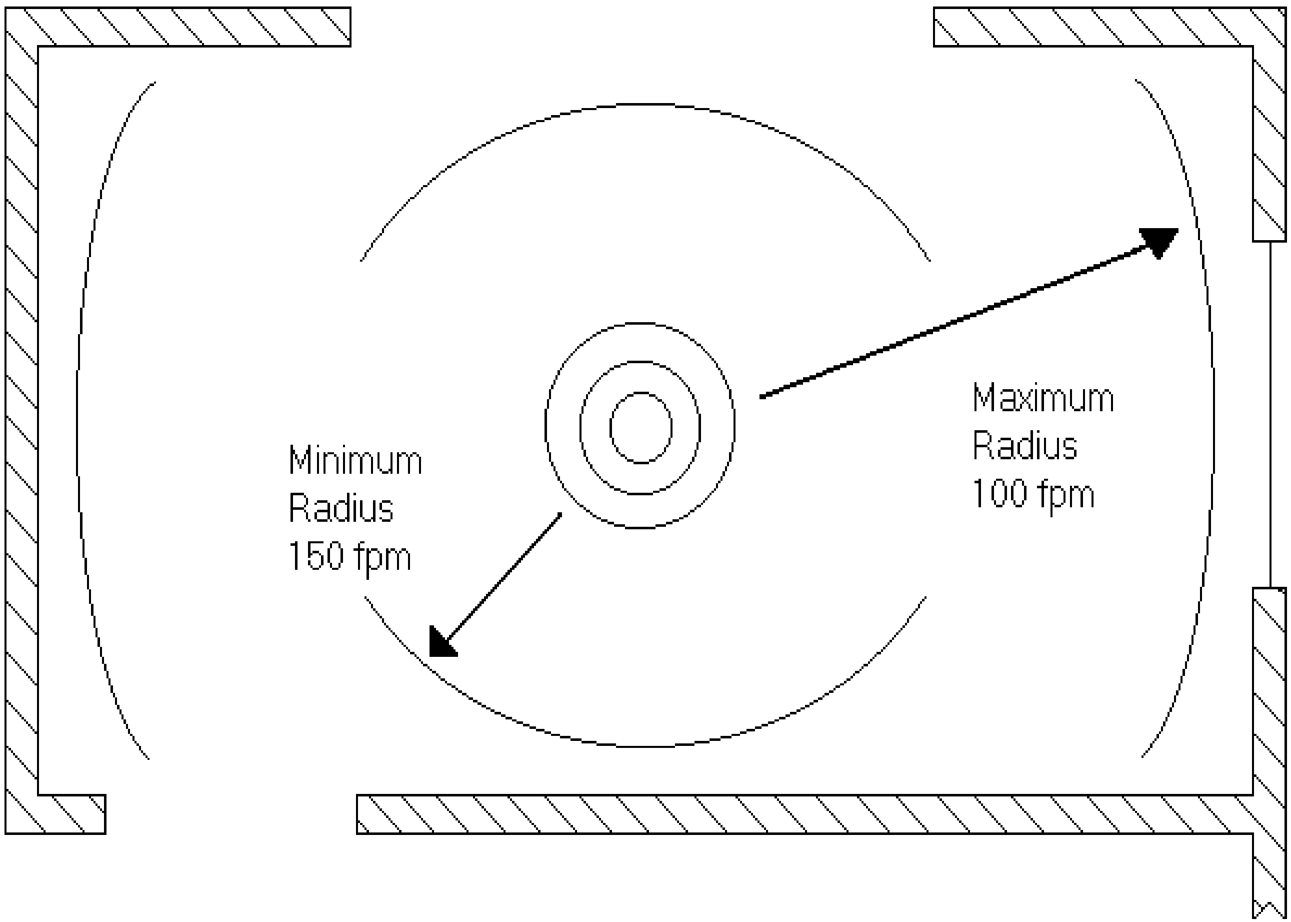
- SUPPLY LOCATION (old recommendation)

  PERIMETER
  UP OUTSIDE WALL (HEATING)

  CEILING
  PARALLEL TO CEILING OUT TO WALLS
  (COOLING)

  HIGH INSIDE WALL
  PARALLEL TO CEILING TO OUTSIDE WALL (COOLING)


50 fpm
Terminal
Velocity
Throw


Minimum
Radius
150 fpm
Maximum
Radius
100 fpm

Returns – Adequate Air Pathways

Return Type	Advantages	Disadvantages
Single	■Low Cost ■Provides Accessible Filter Location ■Low Surface Area	■Potential for Inadequate Return Pathways (Pressure) ■Potential for Noise
Every Room	■Adequate Return Paths	■High Cost ■Excessive Duct Leakage ■Unnecessary in Open Floor Plan

Return Location

- Mixing in a Room is Largely Unaffected by Return Location
- Return Location MAY Have a Small Effect on House Level Stratification
- House Level Stratification is More Affected by AC Size

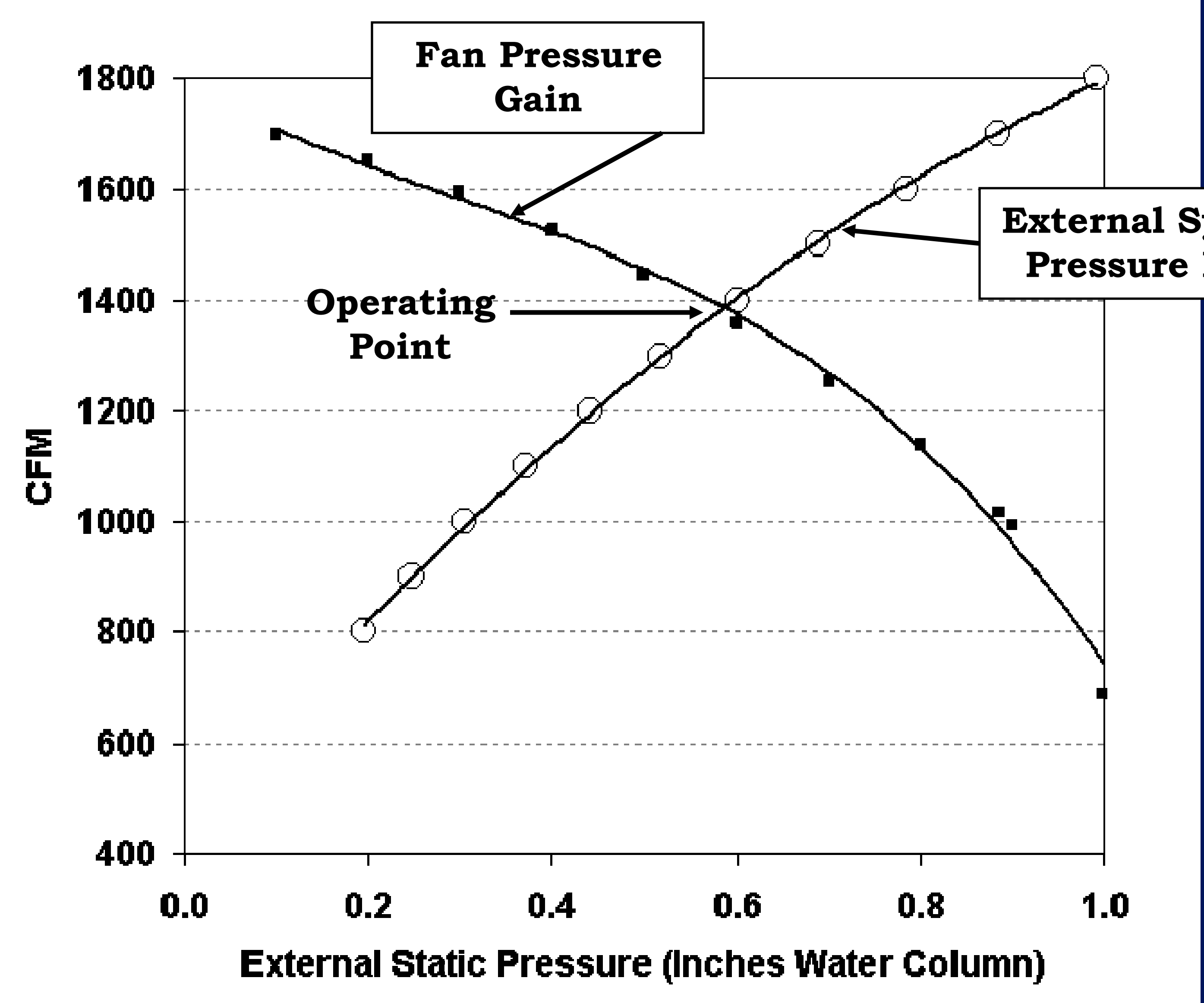
Duct Design Considerations

WHAT DETERMINES FLOW THROUGH UNIT?

EXTERNAL SYSTEM PRESSURE DROP	=	EQUIPMENT PRESSURE GAIN

AT DESIRED FLOW

External System Pressure Drop = Equipment Pressure Gain



Generic External System Pressure Drops

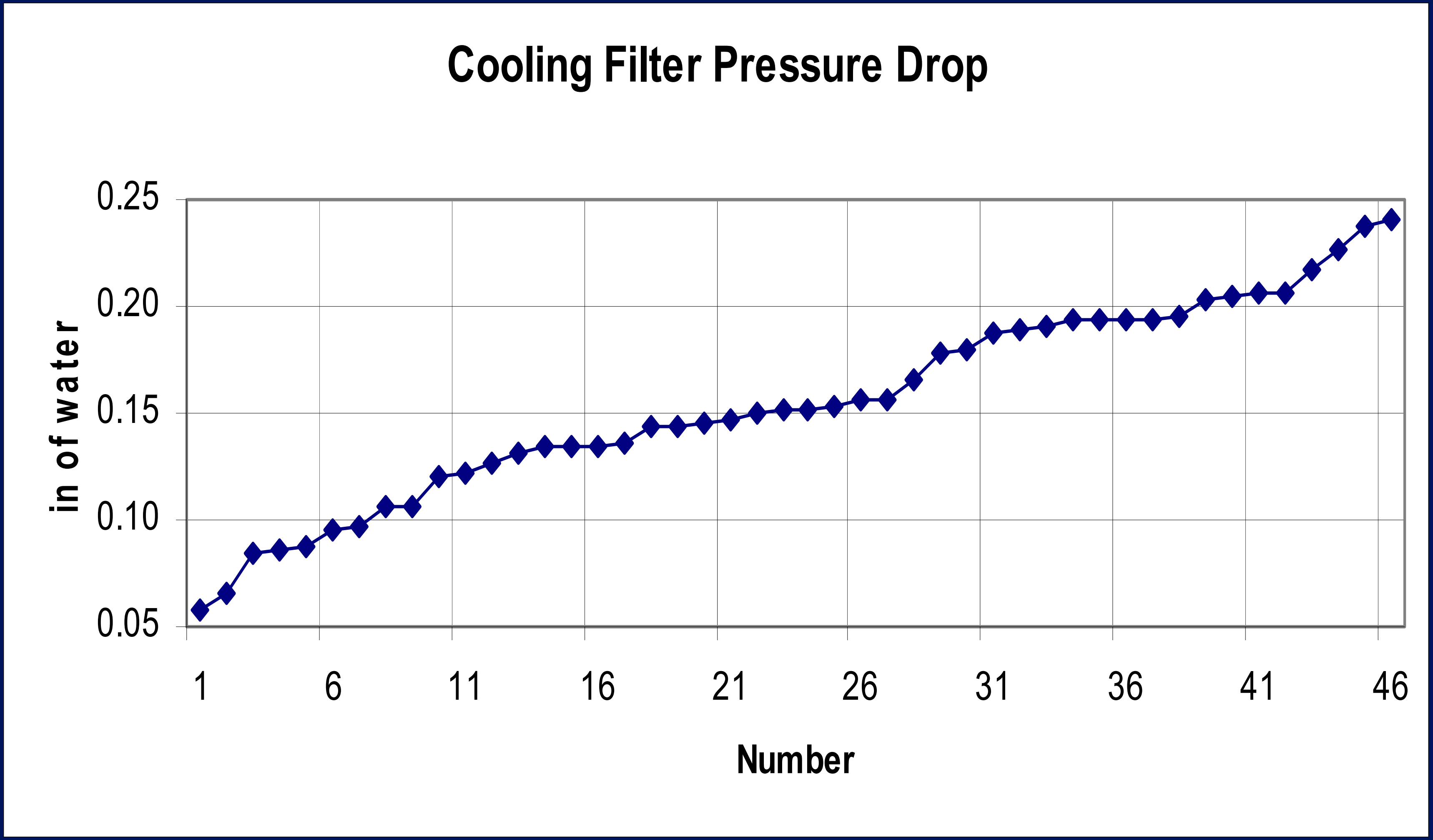
DEVICE	PRESSURE DROP
Standard Filter	.10 Clean
High Efficiency Filter	.20 Clean
Humidifiers/Electric Heaters	.10 to .20
Supply Outlet	.03
Return Grille	.03
Balancing Damper	.03 Open
Coil	.15 to .45 wet coil
Duct System	***What is left***

Coil Pressure Drop

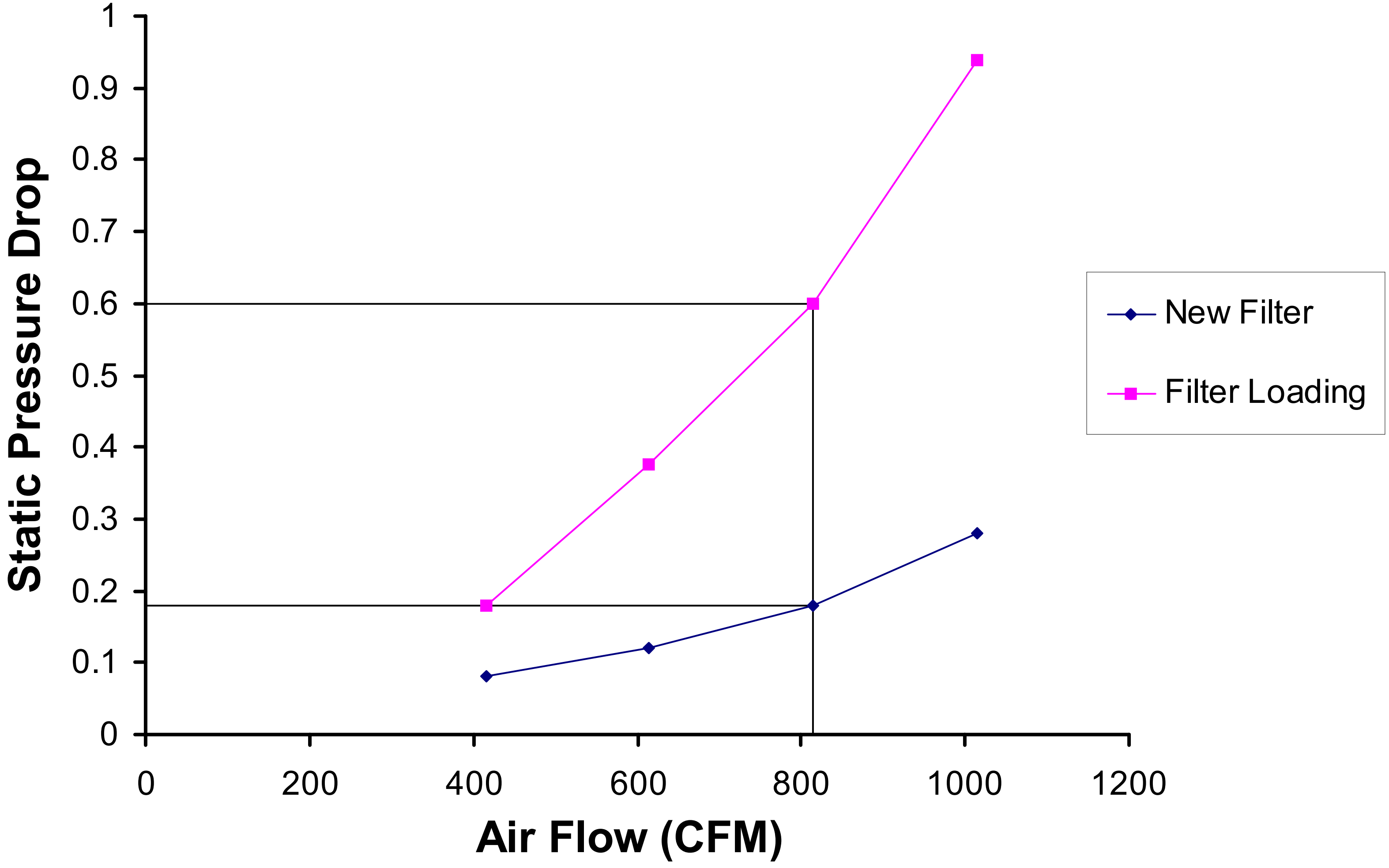
G2FD036(S,H)21(T)

CFM	Static Pressure (Wet Coil)
1000	0.23
1200	0.33
1400	0.45

Filter pressure drop is .05 – 0.24 in H2O
Median is 0.15



20" X 20" MERV 8 Air Filter



DX Coil Resistance (IWC)		
CFM	**Dry**	**Wet**
1000	0.11	0.18
1200	0.15	0.26
1400	0.22	0.35
1600	0.28	0.46

Electric Filter Resistance	
CFM	**IWC**
1000	0.06
1200	0.08
1400	0.12
1600	0.15

Heater Resistance	
CFM	**IWC**
1000	0.09
1200	0.13
1400	0.18
1600	0.23

Example Pressure Drop

DEVICE	PRESSURE DROP
Supply Register	.03
Return Grille	.03
Balancing Damper	.03
Coil	.33 wet coil
Total EXCLUDING DUCTS	*.42*

Equipment Pressure Gain

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE CARRIER	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc)							
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
060-12	1 side or bottom	High	1490	1450	1400	1345	1275	1190	1080	960
		Med-High	1190	1180	1155	1120	1070	1005	915	810
		Med	1015	1010	995	965	920	875	800	715
		Med-Low	870	860	840	820	780	735	670	580
		Low	685	670	645	620	595	545	495	420
080-12	1 side or bottom	High	1605	1560	1510	1450	1380	1300	1195	1045
		Med-High	1305	1290	1265	1225	1175	1100	995	895
		Med	1135	1125	1110	1080	1030	965	885	800
		Med-Low	990	980	965	930	880	825	760	685
		Low	805	780	745	700	660	630	575	495
		High	1810	1755	1690	1640	1565	1495	1410	1330
	[illegible]	Med-High	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

.45 IWC at 1200 cfm

Cannot work – only .03 IWC available for duct system

WHAT DETERMINES FLOW THROUGH UNIT?

EXTERNAL SYSTEM PRESSURE DROP	=	EQUIPMENT PRESSURE GAIN
0.42 IWC + Ducts		**0.45 IWC**

AT DESIRED FLOW

1200 cfm

Stick with Smaller Air Handler – Smaller Fan Motor

Performance data

UNIT SIZE	060-12	08[illegible]12	080-16
DIRECT-DRIVE MOTOR Hp (PSC)	1/3	1/3	1/2
MOTOR FULL LOAD AMPS	5	5	7.4
RPM (Nominal) — SPEEDS	1075—5	1075—5	1075—5
BLOWER WHEEL DIAMETER X WIDTH (In.)	10 x 7	10 x 7	11 x 8
FILTER SIZE (In.) — (Washable)	(1) 16 x 25 x 1		

PSC—Permanent Split Capacitor

Solution

- Keep smaller air handler
- Use a less restrictive coil (0.21 IWC)
- Drop the dampers
- External system pressure drop becomes:
  - Return Grille .03
  - Supply Register .03
  - Coil .21
  - TOTAL .27 + Ducts
- Equipment Pressure
  - at Med. Hi and 1200 cfm 0.45
- Available for ducts 0.45 – 0.27 = 0.18

Now we need to know the friction rate (IWC/100 ft.)

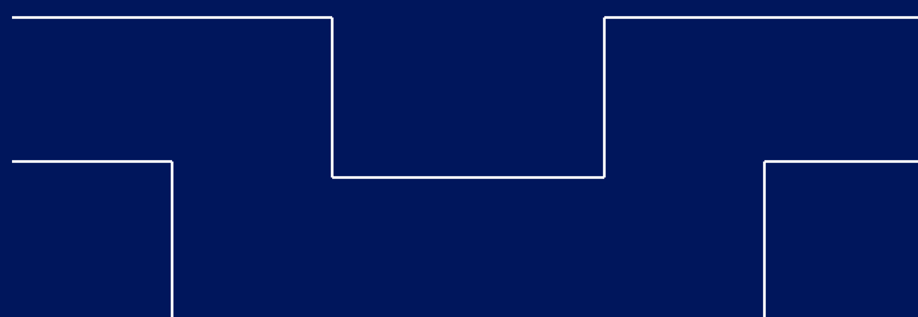
- We have an available static pressure of 0.18 Inches of Water Column
- What do we want to divide that by to get the friction rate?

The Total Effective Length

How Long is the Duct System? (from an air molecule's view)

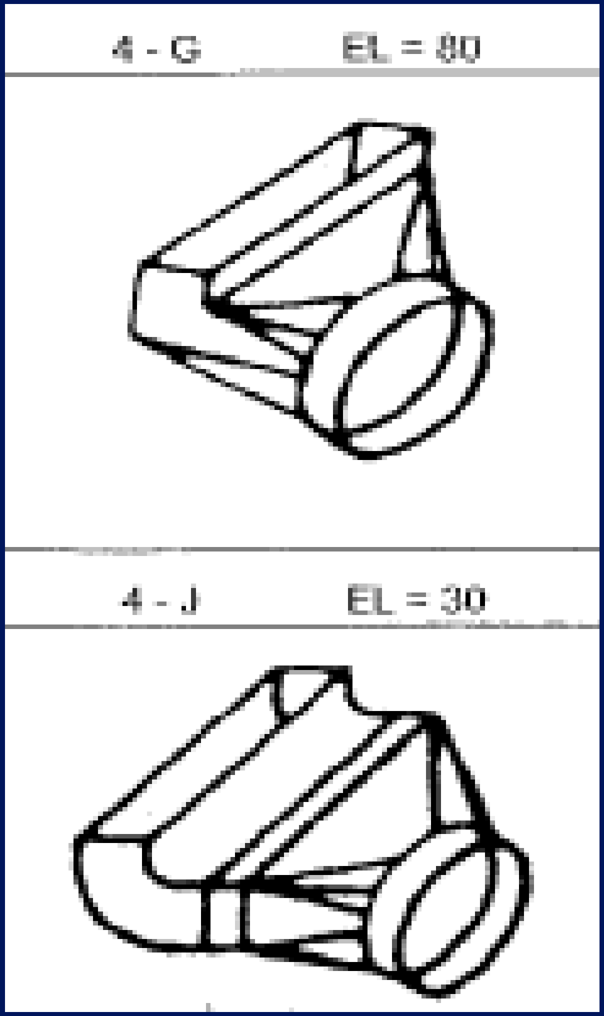
- A 200 ft. straight pipe is 200 feet long

- This 4 ft. section of pipe is how long?



330 Feet

Supply Boots

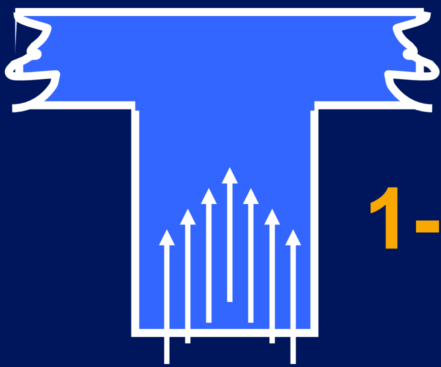


4-G

4-J

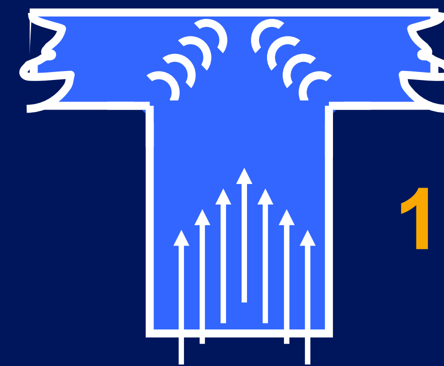
Fitting Number	Effective Length
4-G	80 ft.
4-J	30 ft.

Supply Plenums and Takeoffs

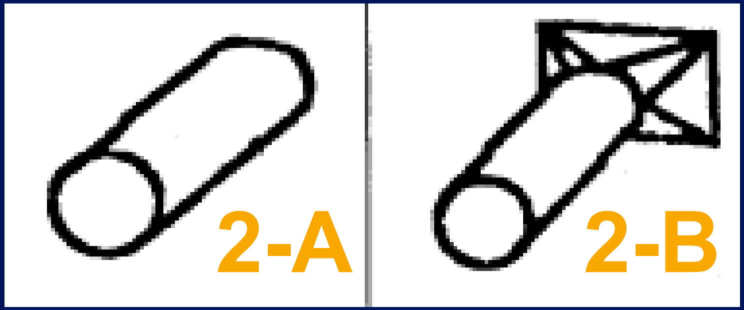


1-O

Fitting Number	Effective Length
1-O	60 ft.
1-P with Vanes	40 ft.

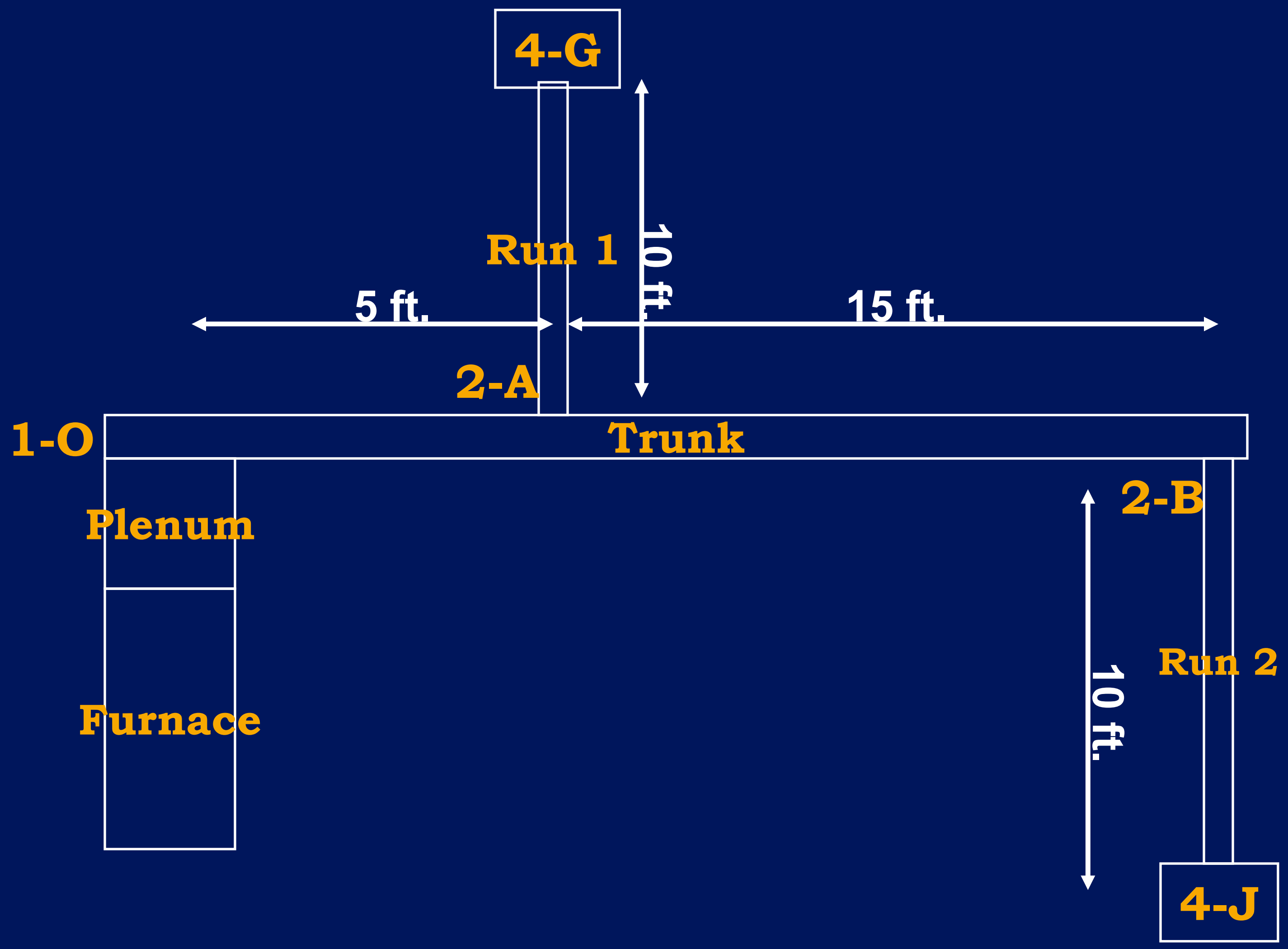


1-P

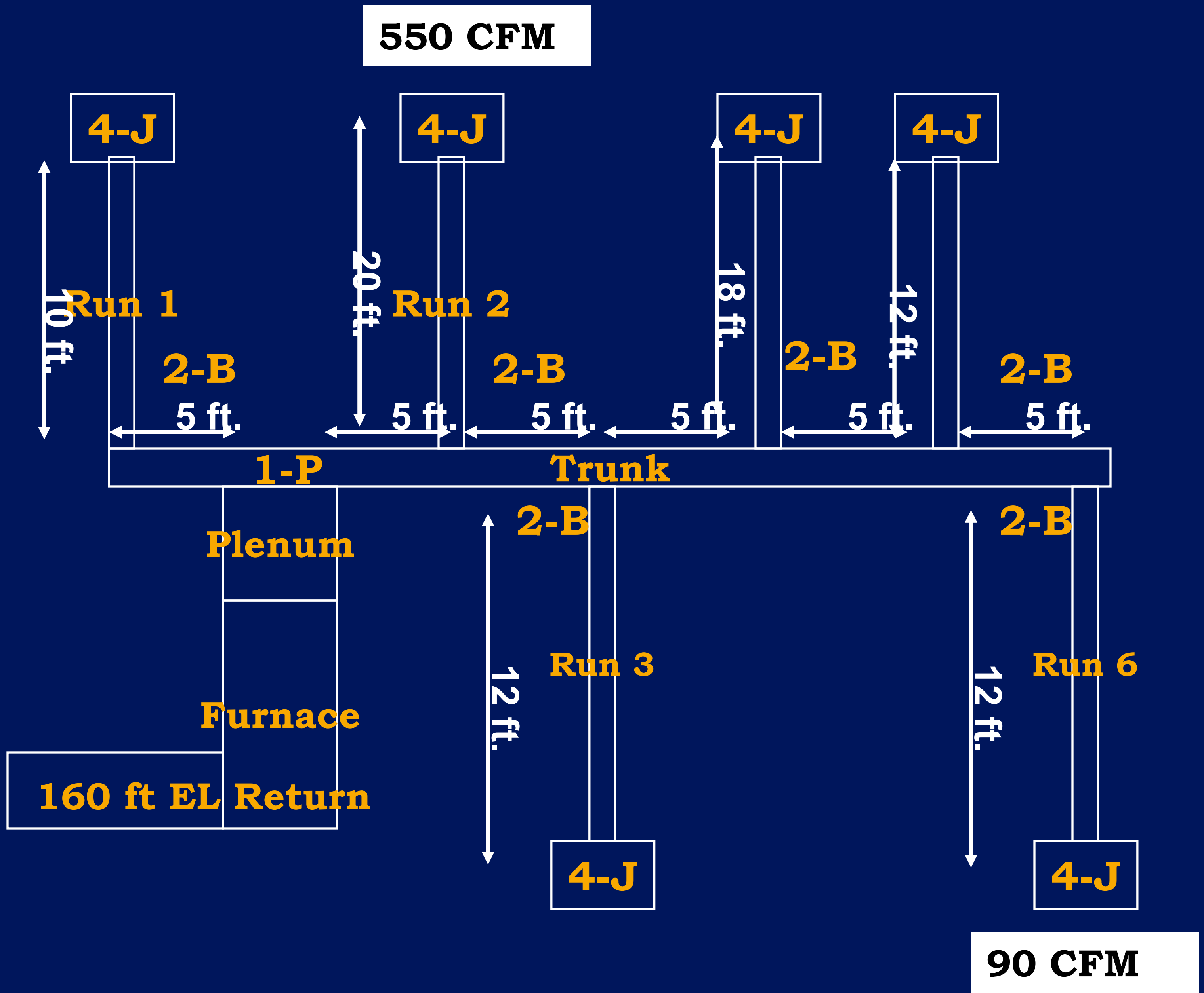


Downstream Branches	0	1	2	3	4	5 or +
2-A	35	45	55	65	70	80
2-B	20	30	35	40	45	50

A Simple Duct Design



A Less Simple Duct Design



Calculate the Total Effective Length from the return grille to the supply register

- A simple takeoff can be as little as 10 feet

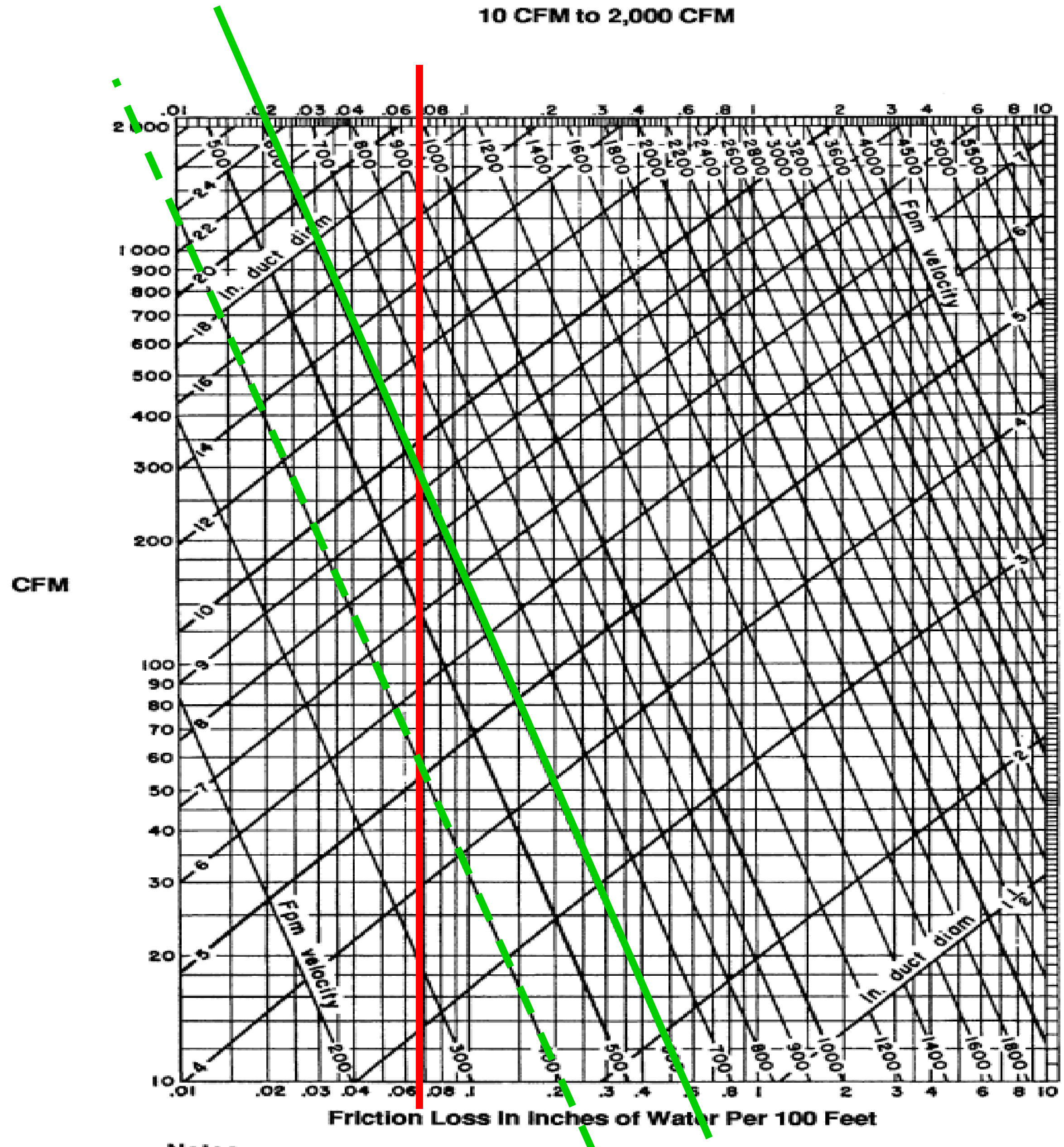
  Or as much as 115 feet

- Through good design we got the overall equivalent length to 300 feet

- So we have 0.18 IWC available static pressure over 300 ft.

  The friction factor is .06 IWC per 100 ft (0.18/300 = 0.06)

Chart 1
Round Galvanized Metal Duct
10 CFM to 2,000 CFM



Notes:
1) Correction required for nonstandard air
2) 40 joints per 100 feet
3) Roughness = 0.0005 feet

Recommended Velocity (in fpm)

	Supply		Return	
Duct Type	Rigid	Flex	Rigid	Flex
Trunk	700	600	600	600
Branch	600	600	400	400
Outlet	Size for Throw			
Return Grille Face			<500	
Filter Grille			<300	

Why not just use 0.10 IWC /100 ft. Friction Rate on a Ductalator?

BECAUSE

- DESIGN VALUE FOR FRICTION RATE IS NOT ARBITRARY
- FRICTION RATE DESIGN VALUE DEPENDS ON AVAILABLE STATIC PRESSURE AND TOTAL EFFECTIVE LENGTH

Desirable Design

- SHORT DUCT RUNS
- LOW STATIC PRESSURES
- INSIDE CONDITIONED SPACE
- GOOD THROW ON REGISTERS

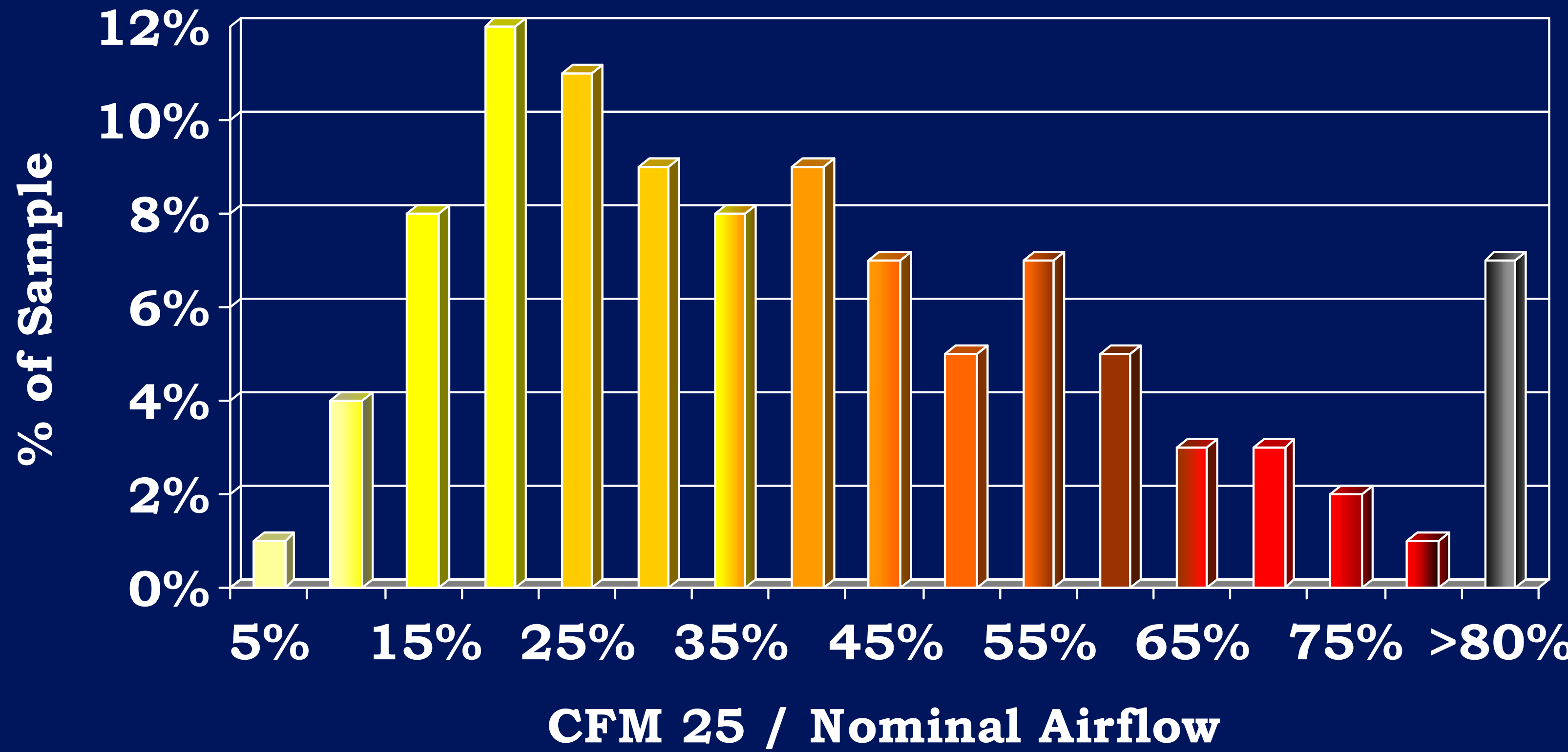
Duct Installation

- Put in what is designed
- Straight
- Leakless
- Proper Flow
- Proper Distribution

Duct Testing

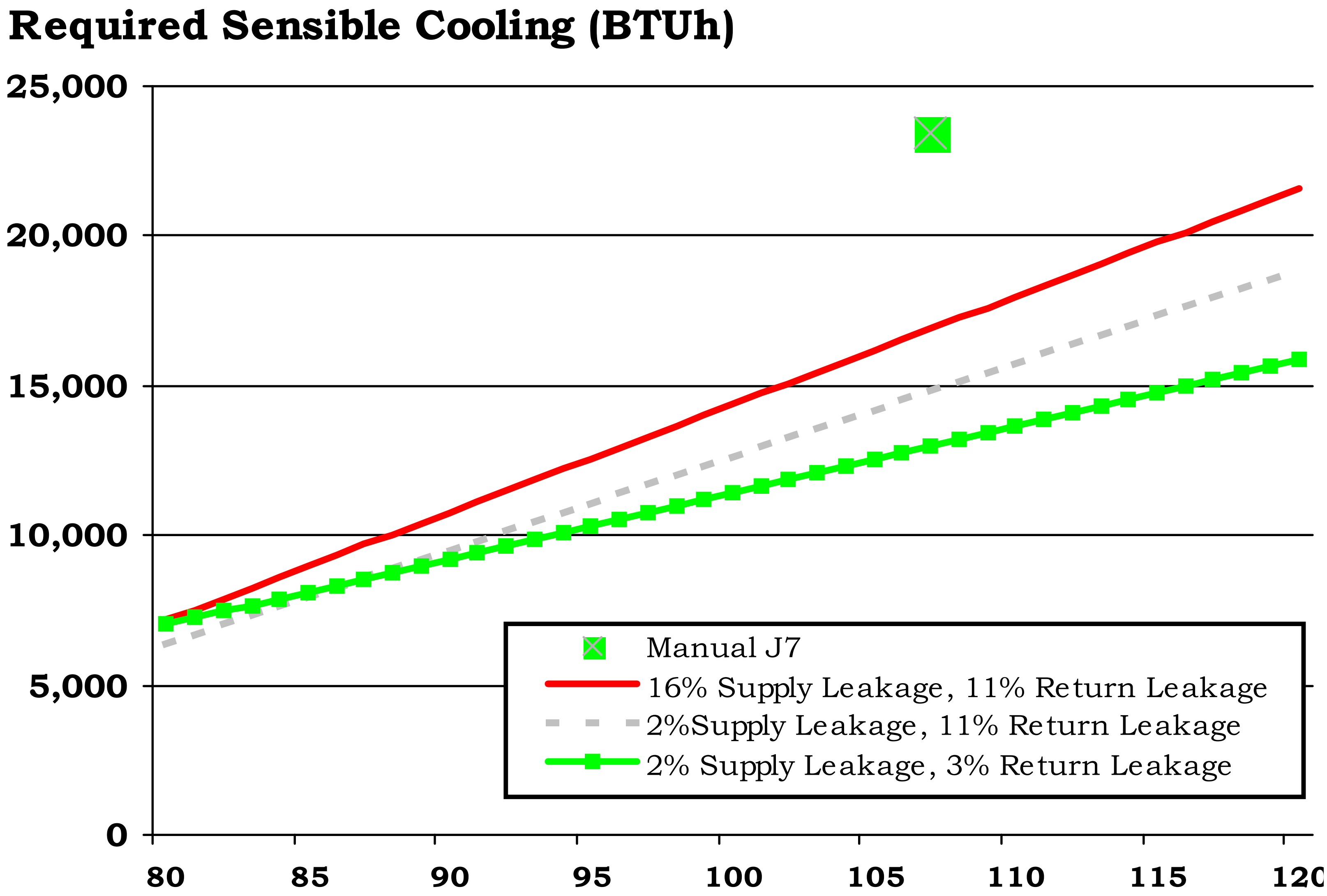
- Leakage
- Flow
- Distribution

Duct Leakage in Existing Homes



Sample size: 1210 (no mobile homes)
Test method: Duct Blaster® at 25 pa. (0.10"WC)
Source: CheckMe!® database

Duct Sealing Saves Energy and Peak



DUCT LEAKAGE TESTING

- Total Leakage
- Leakage to Outside
- Supply Side Leakage
- Return Side Leakage
- Operating Leakage

TOTAL LEAKAGE SET-UP

- REMOVE FILTERS
- MOUNT DUCT BLASTER™ @ AH OR RETURN GRILLE
- ALL SUPPLY REGISTERS COVERED
- ALL RETURN GRILLES COVERED
- DUCT TEST REFERENCE PRESSURE IN SUPPLY PLENUM (STATIC PRESSURE PROBE)

Duct Blaster® Test Method

- MEASURE CFM TO KEEP DUCTS AT 25 PA
- MEASURE CFM TO KEEP DUCTS AT 25 PA

DUCT TESTING PROCEDURE

- KEEP FAN PRESSURE ABOVE 30 PASCALS (SWITCH FLOW RING IF NEEDED)

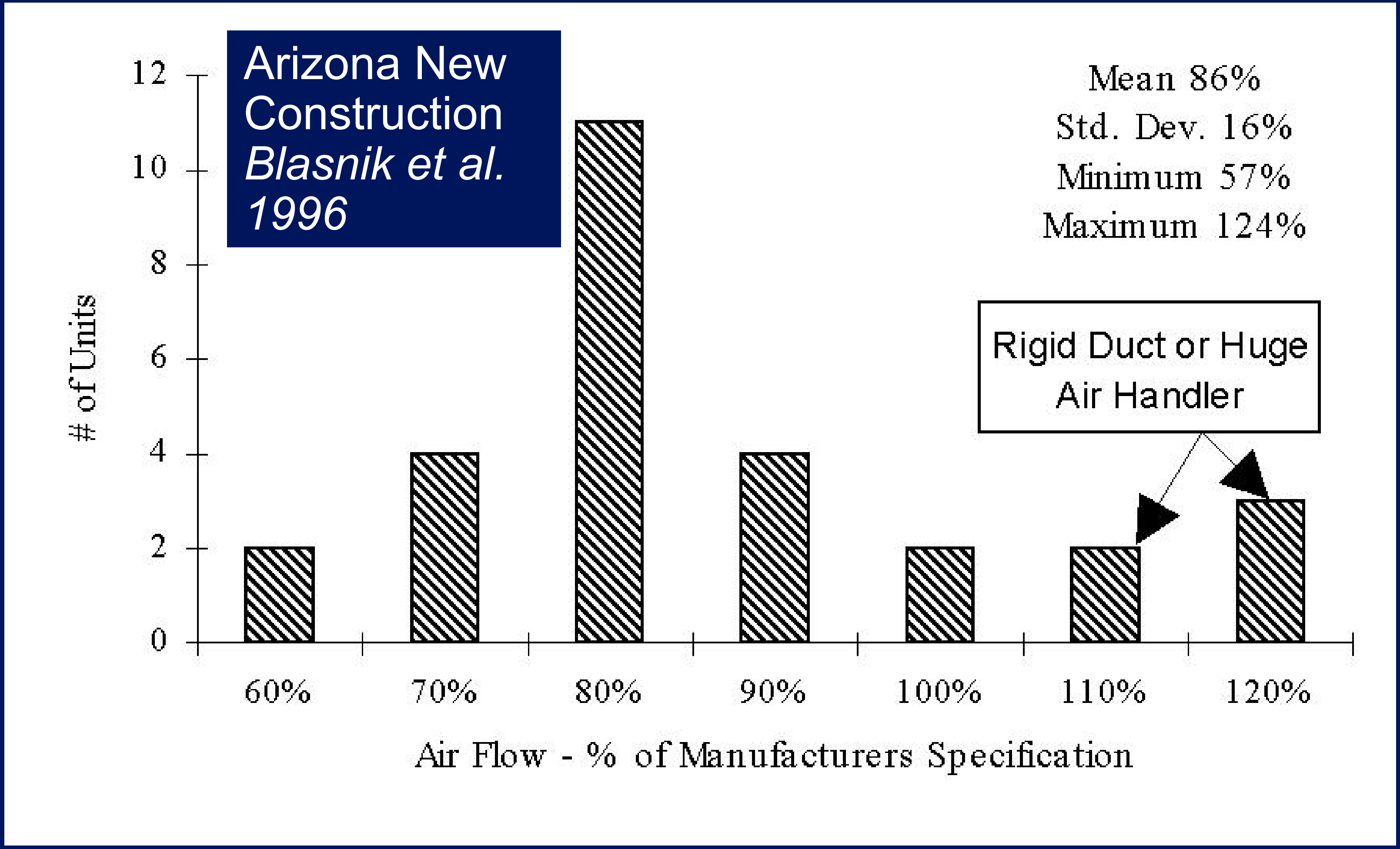
- FLOW RING SELECTION

OPEN	1,500 TO 500
RING 1	800 TO 200
RING 2	300 TO 75
RING 3	125 TO 30

Duct Leakage Standards

- CFM 25 as % of Cooling Nominal Flow
  - Nominal Flow as 400 CFM per ton
  - 5%, 6%, 8%
- CFM 25 as % of Actual Flow
- CFM 25 as % of Floor Area

Low Airflow



- All of the audited forced air systems showed low air handler flow

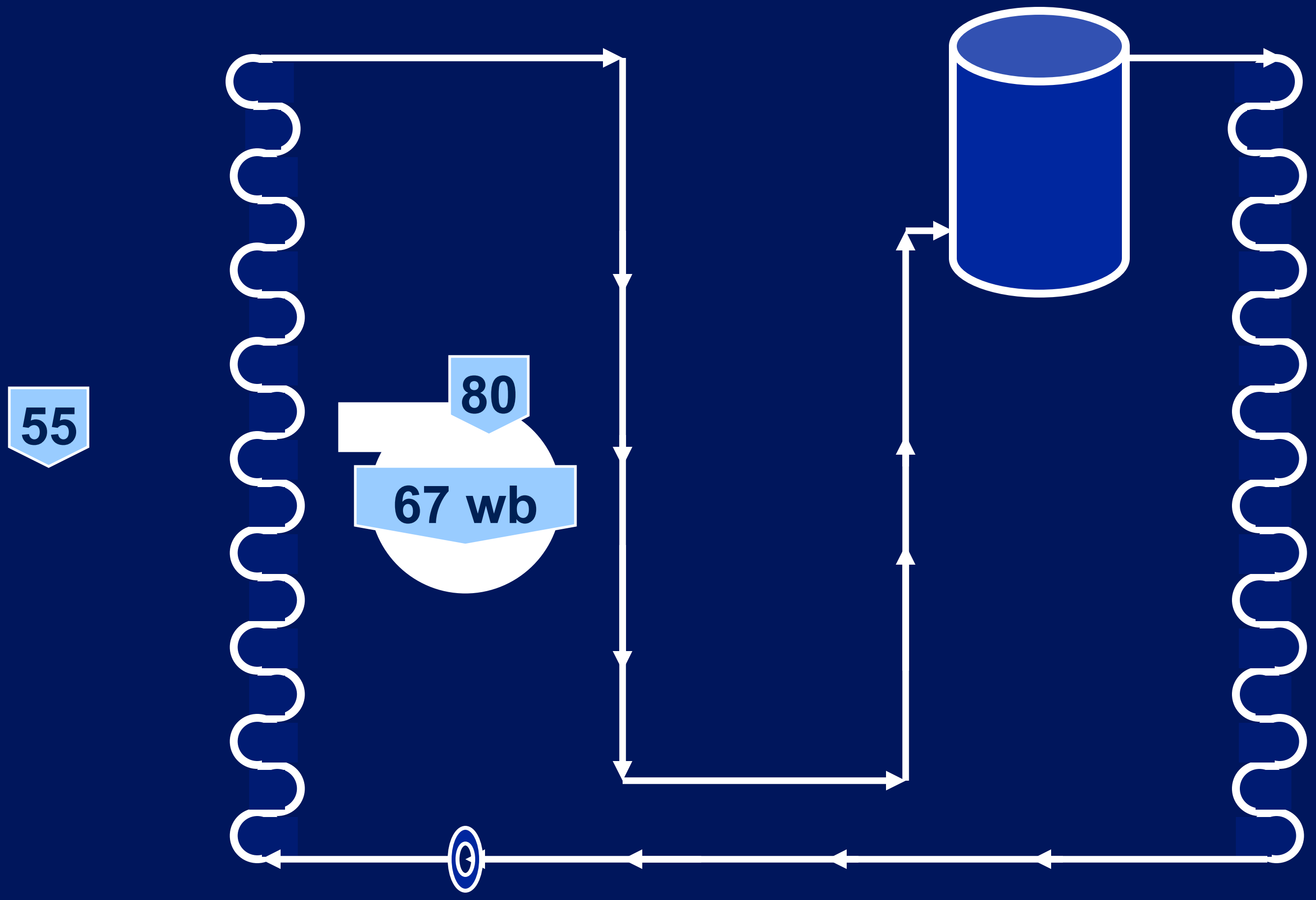
Danny Parker Florida Study 1997

Measuring Airflow

- Temperature Split Method
- **Duct Blaster™**
- **Flow Capture Hood**
- **Flow Grid**
- Coil Pressure Drop
- Fan Curve
- Pitot Tube Traverse
- Anemometer

AC Temperature Split

- Run to steady state (15 minutes)
- Measure return "wet bulb" and dry bulb temperatures
- Measure the supply dry bulb temperature
- This is the most critical part of the procedure
  - System stabilized
  - The measured temperatures as close to the mixed **PLENUM AIR TEMPERATURES**


55
80
67 wb

Determining Target Temperature Split

- Target temperature split is not constant
  - Target temperature split varies with
    - Return dry bulb
    - Return wet bulb

- Determine the target temperature split
  - Based on chart or “slide rule”

Maximum Temperature Split Table

Return Air Dry–Bulb (ºF)	Return Air Wet-Bulb (ºF)												
		50	52	54	56	58	60	62	64	66	68	70	72	74
	70	23.9	23.6	23.1	22.5	21.7	20.7	19.5	18.2	16.7	14.9	13		
	72	24.9	24.7	24.2	23.6	22.8	21.8	20.6	19.3	17.7	16	14.1	12	
	74	26	25.8	25.3	24.7	23.9	22.9	21.7	20.4	18.8	17.1	15.2	13.1	
	76	27.1	26.9	26.4	25.8	25	24	22.8	21.5	19.9	18.2	16.3	14.2	11.9
	78	-	-	27.5	26.9	26.1	25.1	23.9	22.5	21	19.3	17.4	15.3	13
	80	-	-	-	28	27.2	26.2	25	23.6	22.1	20.4	18.5	16.4	14.1
	82	-	-	-	-	28.2	27.2	26.1	24.7	23.2	21.5	19.6	17.5	15.2
	84	-	-	-	-	-	28.3	27.2	25.8	24.3	22.5	20.6	18.6	16.3

TrueFlow™ Flow Grid

Grid Installs in Filter Slot

Duct Blaster® Test Method

- Take supply static pressure with air conditioner running
- Block blower compartment from return system
- Install Duct Blaster® on the blower compartment door
- Turn on air handler
- Adjust Duct Blaster® speed to duplicate supply static
- Read airflow from Duct Blaster®

Desired Air Flow

SHR	CFM per Ton
Below 0.74	300
0.74 to 0.79	350
0.80 to 0.85	400
Above 0.85	450

Flow to Rooms

- Within +- 10%
- +- 20% Max.

Write the Specifications
Sign the Contract
Breathe Easy --- NOT

- Any equipment installed must perform as intended

These items are accomplished by human beings and are subject to error.

With Initial Feedback the Crews Learned Rapidly. With Continued Feedback They Maintained Good Savings When Feedback Was Removed the Savings Dropped to 30% of the Maximum