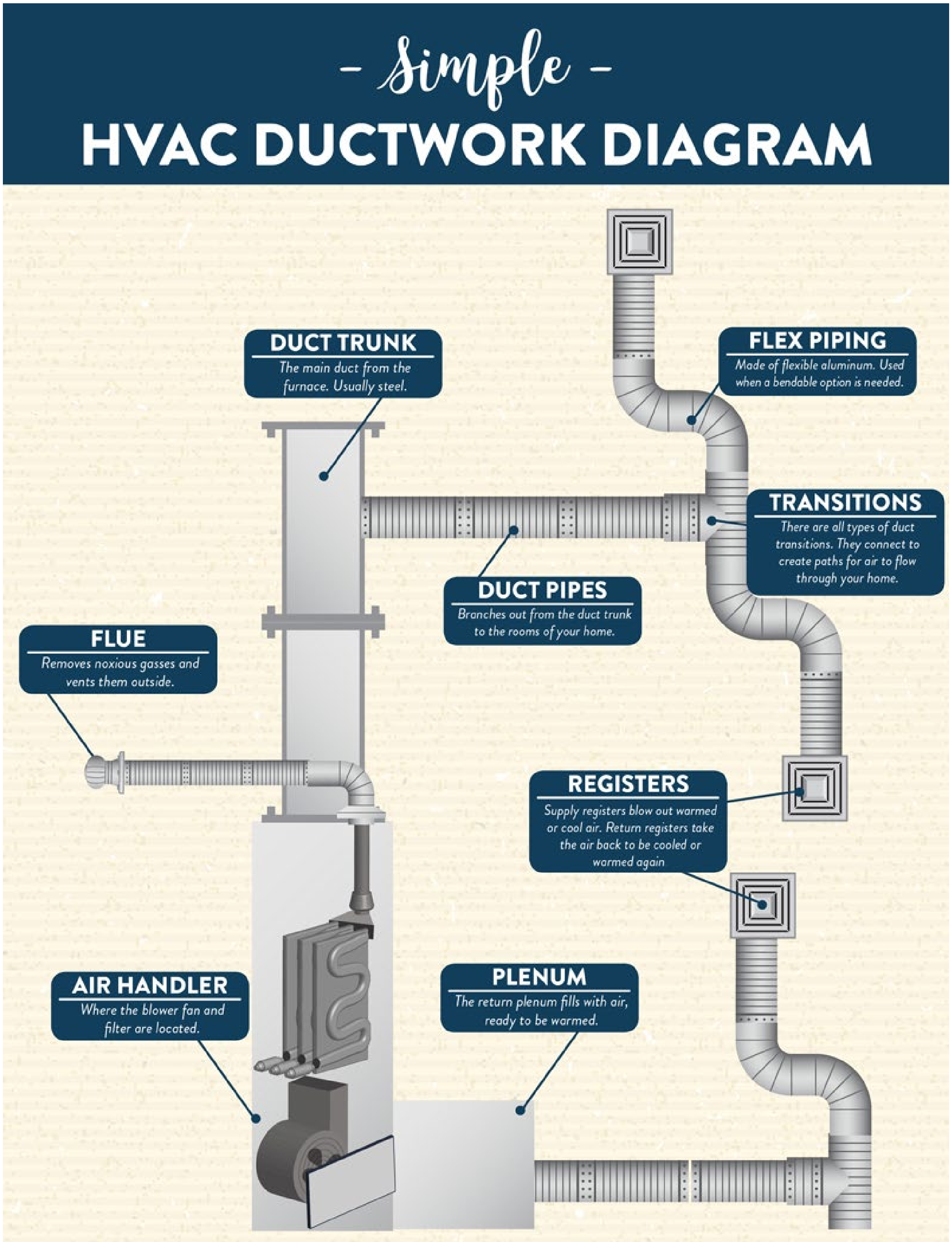
Air Distribution Systems



Duct Design

Step 1. Heating and Cooling Load Calculation
ACCA's Manual J
ASHRAE Handbook of Fundamentals

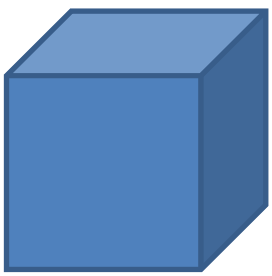
Determine the amount of heating and cooling needed for each room in BTUH or BTU/hr
BTUH translates to room-by-room air flow requirements in cubic feet per minute (cfm)

Step 2. Once you know the BTUH and cfm numbers for the building, you need to select the right equipment.
ACCA's Manual S protocol
Equipment selected must meet the total heating and cooling loads for the home or building
Adjustments for indoor and outdoor design conditions must be considered.
Manufacturer's performance tables

Step 3. Duct Design

The Weight of Air

- Air has weight
  1 cubic foot of air weighs 0.0807 lb at standard temperature and pressure



Example 1.
What is the weight of the air (lb/minute) for a 2.5-ton air conditioner?

The Physics of Air Flow

- Air produced by a fan confined to a channel has to work against the pressure that builds up in that space. The smaller the tube or make it longer or turn the air with it, the more static pressure builds up. This reduces air flow.

- Two Factors Involved in Reducing air flow in ducts:
  Friction – air interacts with the surfaces. Smoother the inner surface, the better it is for air flow. Rougher slows down the air.

  Turbulence – arises when you move air through fittings, or when you turn the air.
  Rigid ducts use fittings
  Flexible ducts not always the case

  Whenever air encounters a filter, coil, heat exchanger (if there's a furnace), registers, grilles, balancing dampers, and the ducts themselves, it loses pressure.

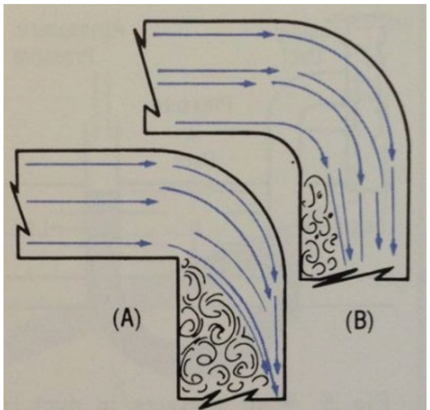
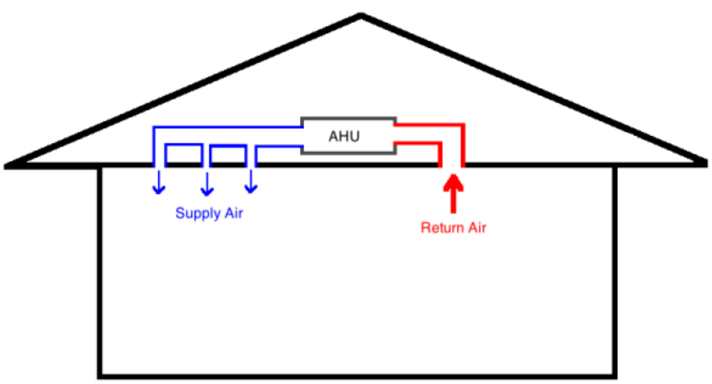


Fig. 3 Effect of elbow throat on turbulence within a duct system. The sharp throat of (A) creates more turbulence than the rounded throat of (B).

  Must start out at a high pressure from the blower at the AHU

AHU – Air Handling Unit

- The blower is inside the AHU
  Air gets pulled back to the AHU through the return ducts
  The AHU conditions the air and sends it back into the building through the supply ducts
  The high pressure at the supply has “driving potential” to force the air into the space and flow to the area of lower pressure at the return
  The farther from the blower, the closer the static pressure in the ducts gets to zero, or room pressure



Blower Capacity

- To get a certain amount of air flow, a blower needs to operate against a certain pressure and at a certain blower speed setting. Here's a table from one unit.

BLOWER SPEED	0.10	0.20	0.30	0.40	0.50	0.60
Tap 5	1108	1090	1065	1034	1009	974
Tap 4	1026	1000	969	938	899	865
Tap 3	1026	1000	969	938	899	865
Tap 2	909	873	842	799	762	724
Tap 1	825	795	757	722	674	634

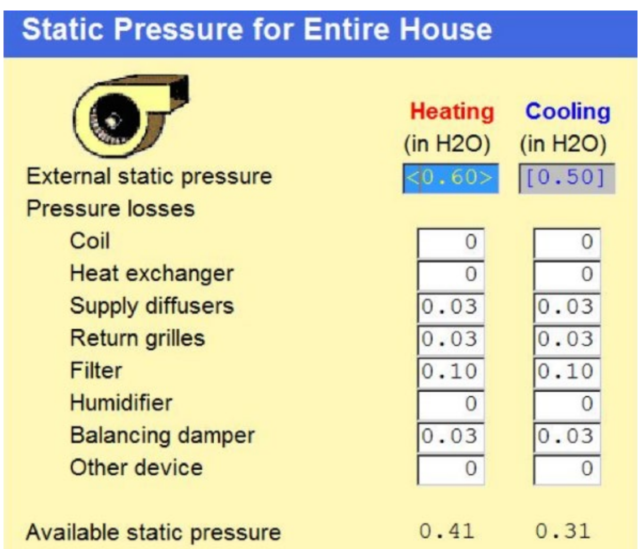
- The blower speed is set by moving wires to different taps. In this case, there are 5 of them. The row of numbers across the top is the total external static pressure (TESP) the AHU is rated for. That's the pressure change across the AHU when pushing and pulling air through the ducts.

- You generally want to design a system to operate on medium speed (tap 3 in the table above). That way you have some room for adjustment when you commission the system. Also, most systems are rated to operate at a total external static pressure of 0.50 inches of water column (iwc). For the system above, those parameters yield an air flow of 899 cfm. If that's the number you need, you just have to make sure you design your system to operate at 0.5 iwc.

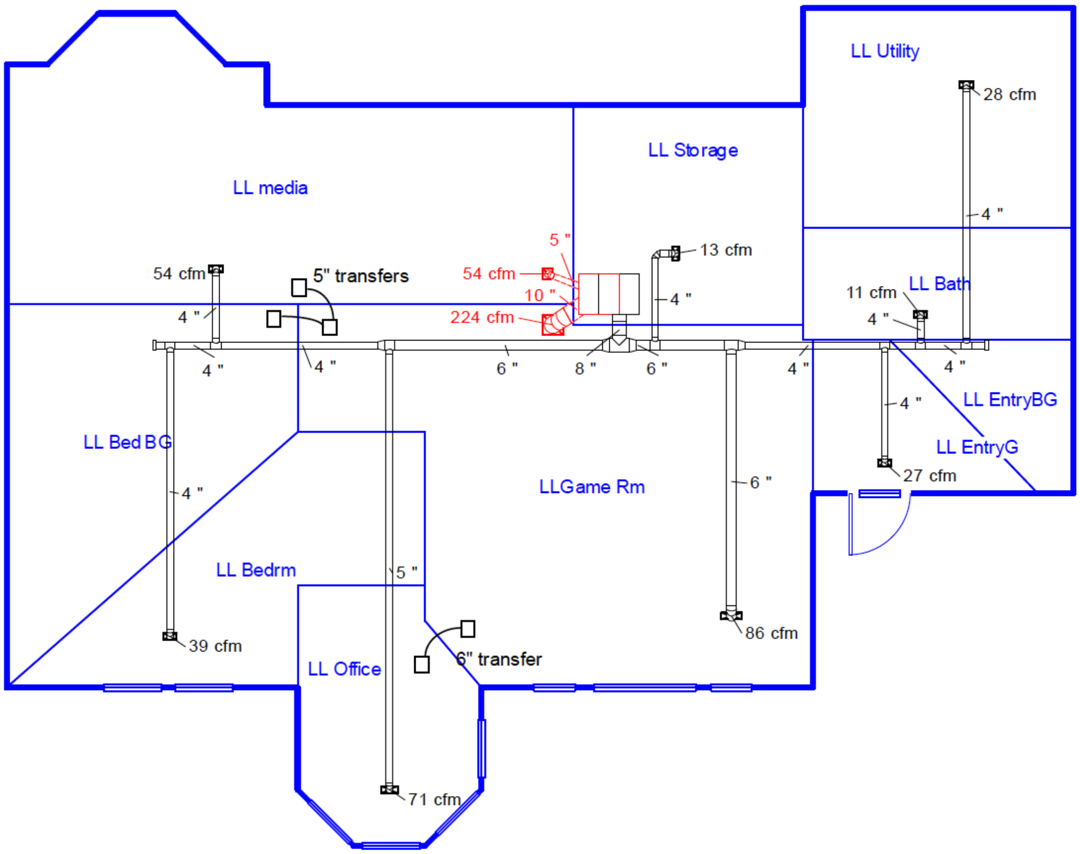
- From the return (most negative) side of the AHU to the supply (most positive), we want a total pressure change of no more than 0.5 iwc. (That's the typical number. Some air handlers are rated higher. Some are rated lower.) That's the total pressure change across the AHU. The actual pressure in the system will depend on the ducts and other components. As long as we're at or below 0.5 iwc in this case, we'll get good air flow.

Available Static Pressure (ASP)

- Two kinds of pressure drop occur in the duct system:
  Pressure drop of the components that are not ducts or fittings (e.g., registers, grilles, filters …)
  Pressure drop of the ducts and fittings

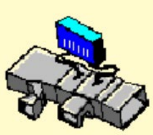


Total Effective Length (TEL)



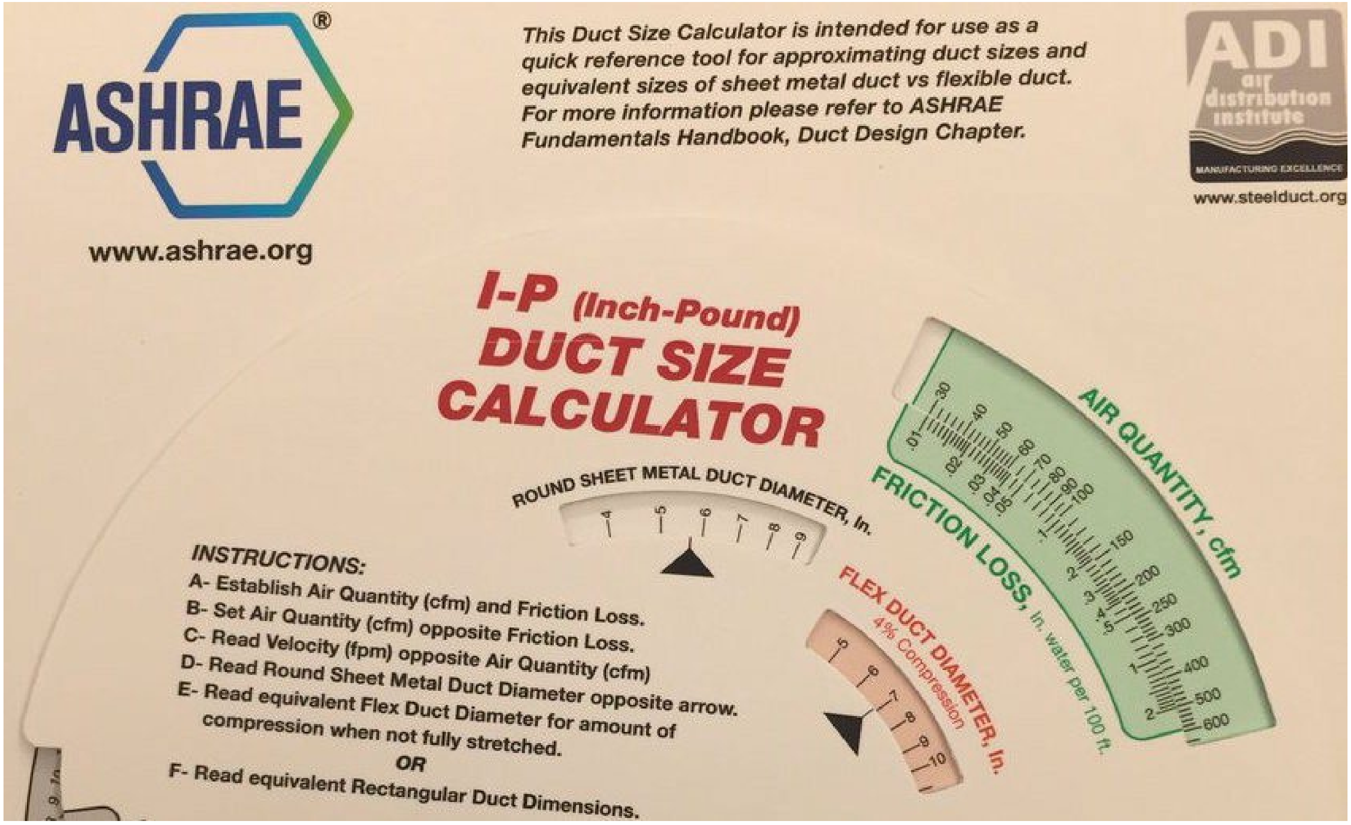
■ Each fitting has an effect on the pressure drop and total effective length (TEL)

8A R/D	Round and Oval Elbow EL Values Smooth	4 or 5 Piece	3 Piece	Smooth Mitered	Easy Bend	Hard Bend	3-Piece 45°	2-Piece 45°
Mitered (R = 0)	—	—	—	75	4-Piece 25	4-Piece 30	10	15
0.75	20	30	35	—				
1.0	15	20	25	—	3-Piece 30	3-Piece 35		
1.5 or Larger	10	15	20	—				



	Supply (ft)	Return (ft)
Measured length of run-out	2	13
Measured length of trunk	34	0
Equivalent length of fittings	290	85
Total length	326	98
Total effective length		424

Calculating Friction Rate



$$FR = \frac{ASP}{TEL}$$

Example 2
ASP = 0.31 inches of water column (iwc)
TEL = 424 feet

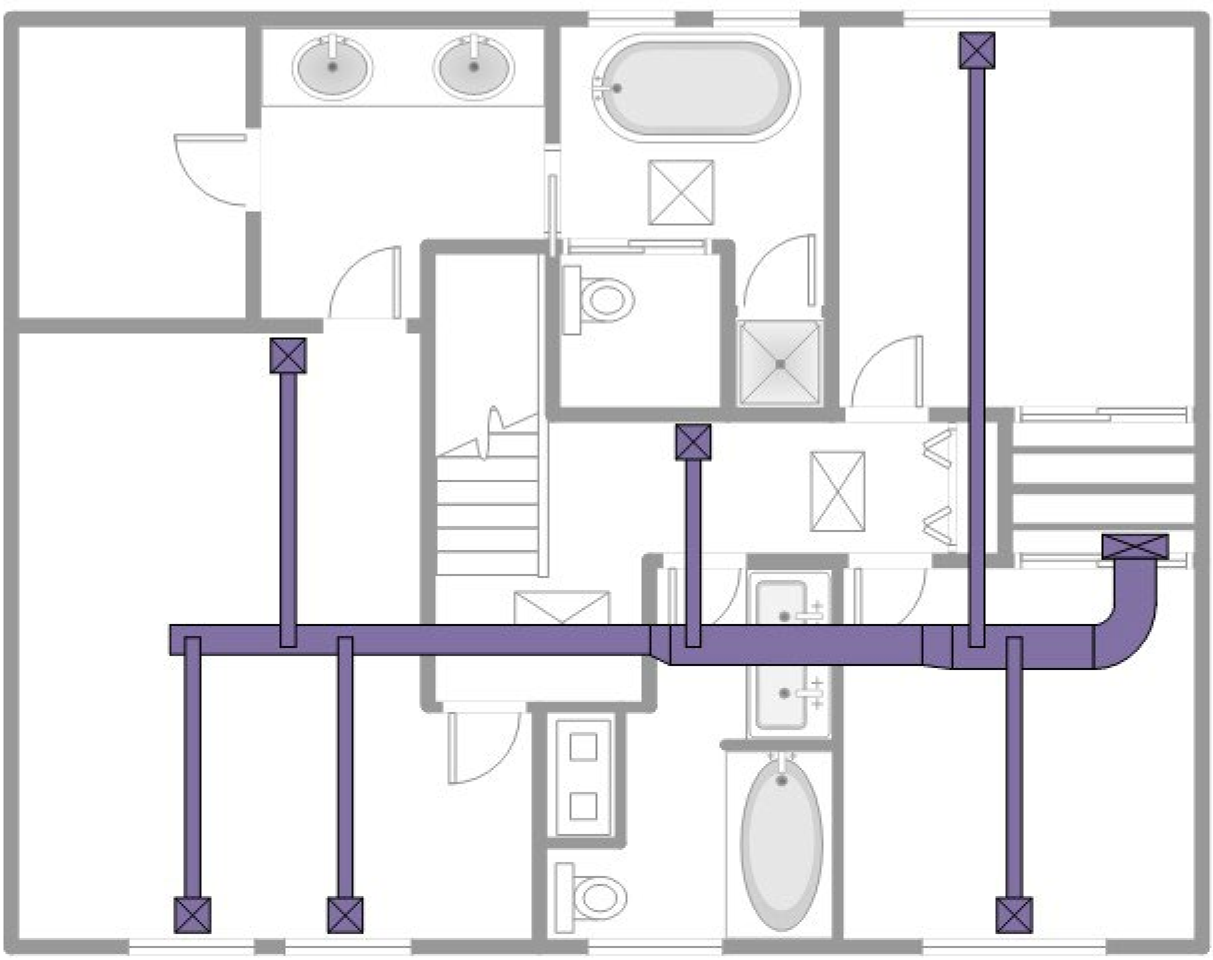
- This represents the amount of pressure drop to expect in each foot of duct run.

$$FR = \frac{ASP}{TEL} \times 100$$

Friction Rate for a Design
If the FR is a higher number – you can use smaller, more restrictive ducts
If the FR is a lower number – you have to use larger ducts

Sizing the Ducts

- ACCA Manual D Protocol



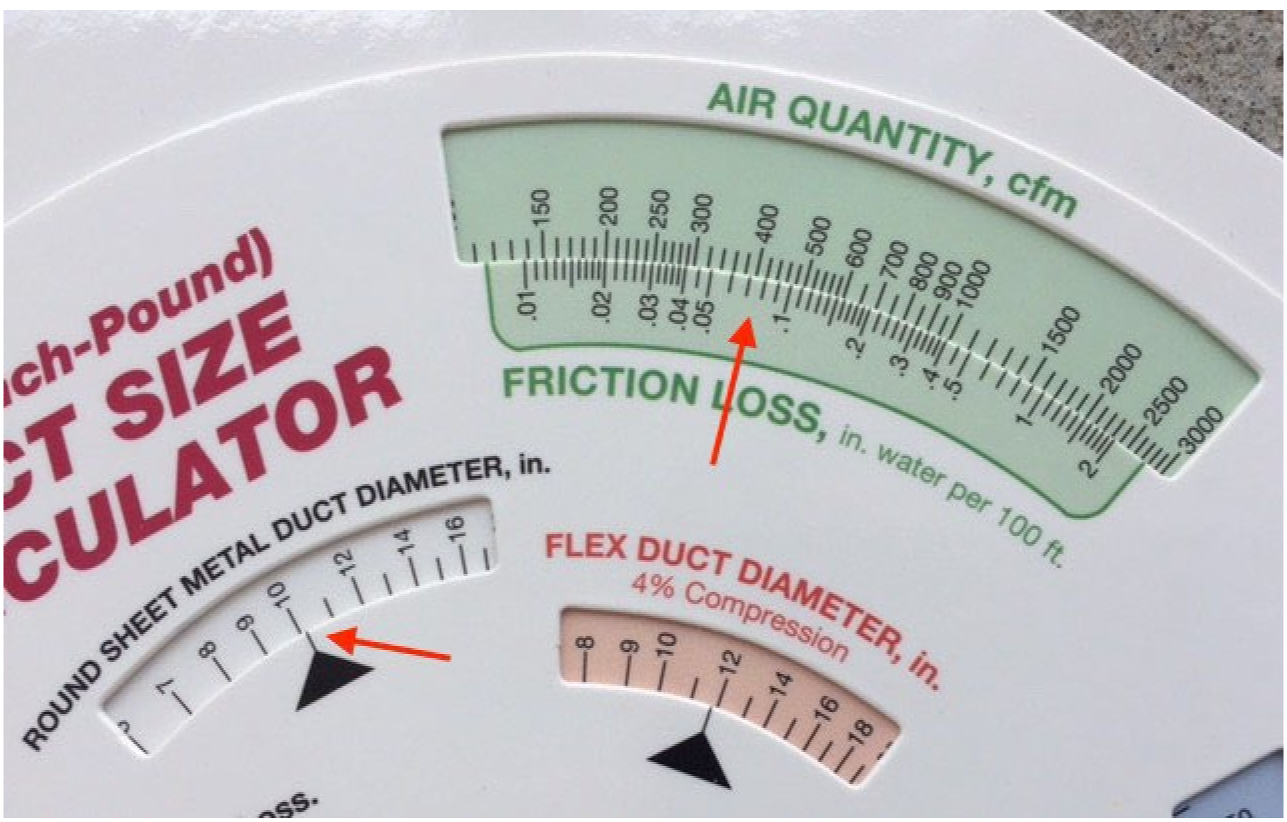
- Sizing the Ducts by Friction Rate
  The rate total external static pressure (TESP) tells how much resistance their can be across the furnace or air handler when it is delivering the rated air flow. To stay within the design value, you must control the resistance of the duct system

  Duct systems with greater total effective length (TEL) have greater resistance

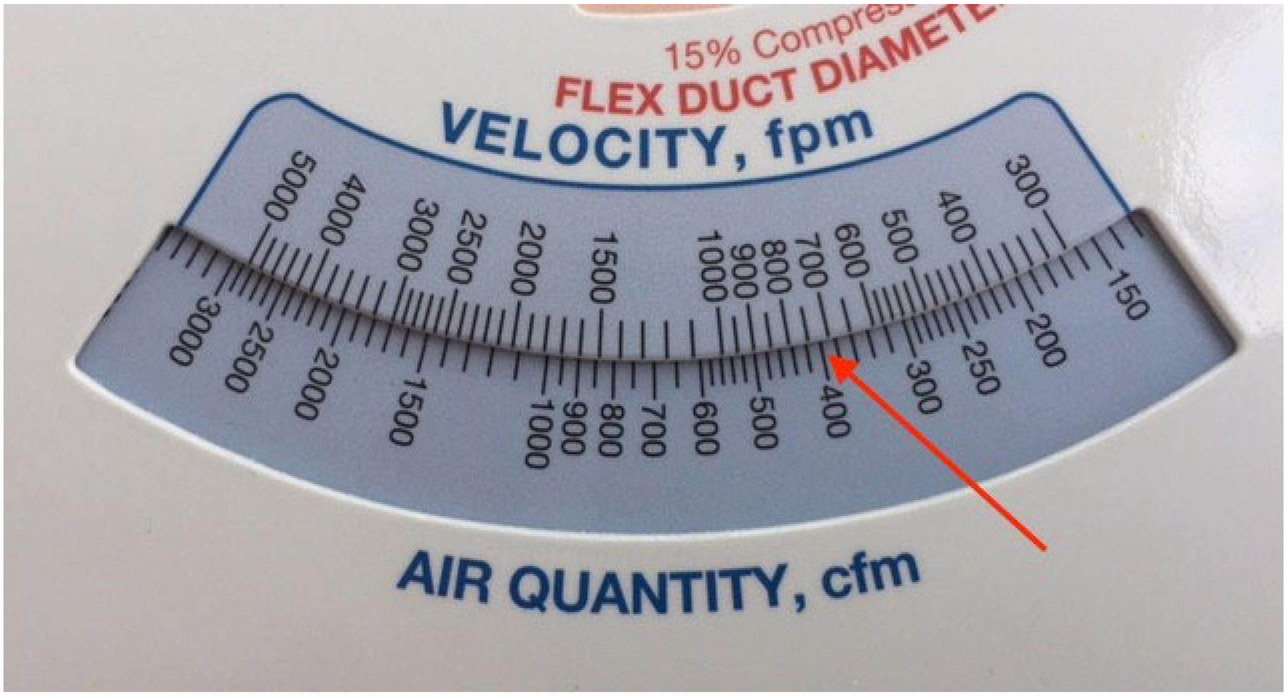
  It TEL is high, the duct area has to be increased
  It TEL is low, smaller diameter ducts can be used.

  Example
  FR = 0.073 iwc per 100 ft of total effective length

  Assume a section of ductwork needs 400 cfm



- Sizing the Ducts by Velocity
  Need to make sure the velocity of the air isn't too high
  400 cfm corresponds to a velocity of approximately 725 feet per minute (fpm)



Manual D, Table N3-1 specifies the maximum velocities for supply and return trunks and branches.

Supplies – 900 fpm
Returns – 700 fpm

- When sizing by the friction rate results in too high a velocity, you size by the velocity, which results in a larger duct.
- But larger ducts also result in less resistance, which means there may be too much air flow in that run.
- What do we do about that? Install balancing dampers.