CHAPTER 4
DUCT SIZING AND CONSTRUCTION

1. Introduction

- IMost air conditioning and heating systems require some form of duct work to channel or direct the air to places where the conditioned air is needed. There are many types of ductwork available and often times the ductwork. It is important that the ductwork is designed and installed correctly.
- A poor installation job will result in poor performance, bad air flow, leaky duct systems, and higher heat loss. Another important factor in the installation process is to make sure the duct work is sized properly. Over sizing systems cost more and does not maintain the desired air flow and undersized duct work causes the system to strain mechanically and can be noisy.
- The purpose of a duct system is to transmit air from the central air source to the air diffusers located in the building control zones.
- Aduct system is a network of round or rectangular tubes—generally constructed of sheet metal, fiberglass board, or a flexible plasticand-wire composite—located within the walls, floors, and ceilings.A

Ducts are pipe or passages used in HVAC to deliver and remove air ,For example, *supply air*, *return air*, and *exhaust* .As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort.

The duct are mostly classified on basis of velocity ,pressure and shape.

Types of Duct

Based On Shape

- Rectangular duct
- Round duct
- Oval duct
- Squared duct

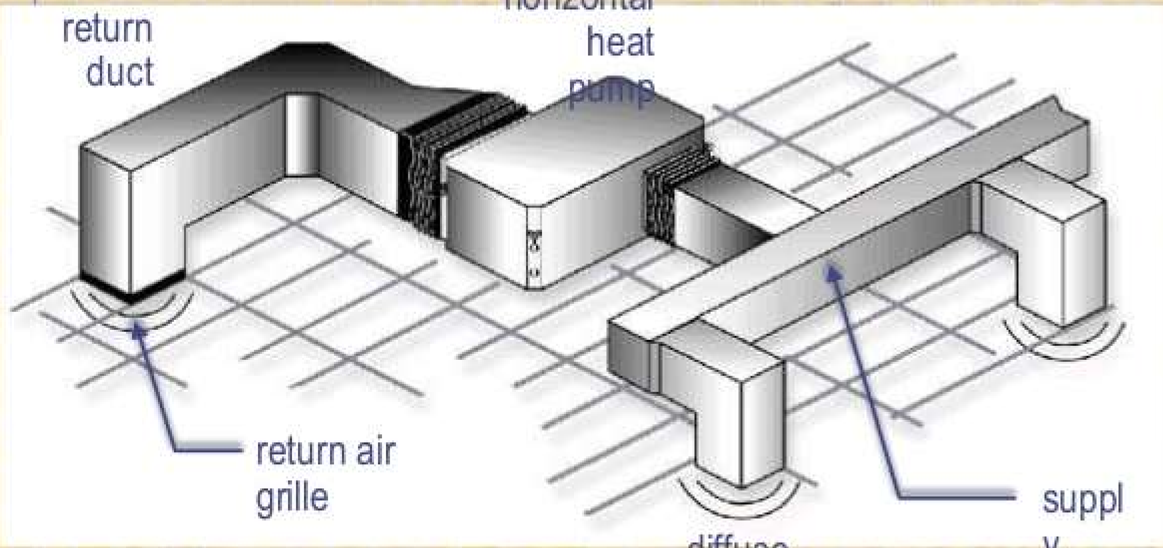
Based on Pressure

- High Pressure
- Medium Pressure
- Low Pressure

Based on Velocity

- High Velocity
- Low Velocity

Above Ceiling Distribution System



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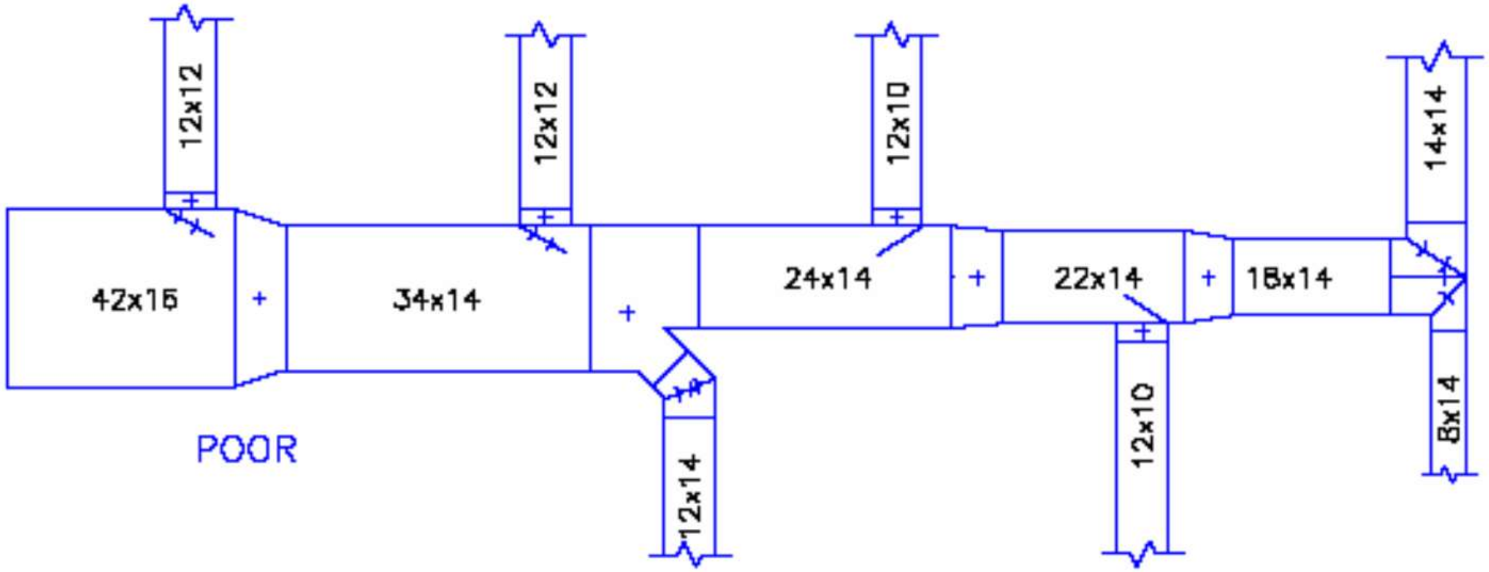
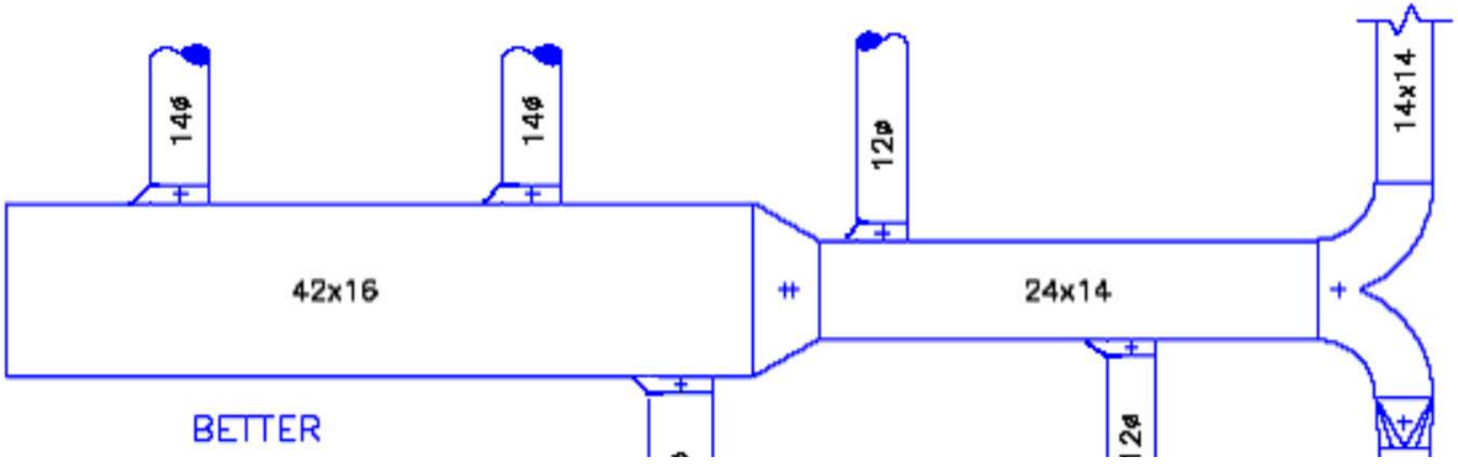
Example of Poor and Good Duct Design





2. Duct sizing

- By selecting an appropriate **pressure drop**, the required duct diameter can be selected for any given air volume. When using Figure1 any resistance per unit length can be selected.
- Some designers use values as shown below.
- 1. **Quiet** - Pressure drop 0.4 Pa/m.
- 2. **Commercial** - Pressure drop 0.6 Pa/m.
- 3. **Industrial** - Pressure drop 0.8 Pa/m.
- However, we l use a pressure drop of **1.0 Pa/m**, always bearing in mind that the designer may wish to use alternative values as listed above.

Duct Sizing Using Equal Pressure Drop Method

- 1. Choose a rate of pressure drop and keep this constant for the whole system e.g. 0.6 **Pa per metre run.**
- 2. **Size ductwork** using Duct Sizing Chart if the volume flow rate of air is known.
- This will give the duct diameter.
- 3. Determine the equivalent size of **rectangular** duct if required by calculation or by using Table
- 4. Calculate the actual air velocity from:
- **Air velocity (m/s) = Volume flow rate (m^3/s) / CSA**

2. Design Methodology

When considering ventilation design the following approach could be adopted before sizing begins and the following questions should be considered:

1. What areas need ventilation?

   The contaminants should be listed for these areas.

2. What type of system should be used, supply, extract or balanced?
3. Are there any alternative systems to consider?
4. Is air conditioning necessary in the building?

- If air conditioning is necessary then should it be incorporated into the ventilation system?

Duct sizing

Example 1

- Size the ventilation ductwork in an extract system, which removes 0.8 m^3/s from a kitchen.
- Use a duct pressure drop per metre of 1.0 Pa/m.
- The ductwork should be square.
- From figure,The corresponding **duct diameter** can be read between 0.40, and 0.45 metres diameter.
- Careful examination will reveal that the design point is is about 0.41 metres.
- This is **410 mm** diameter.

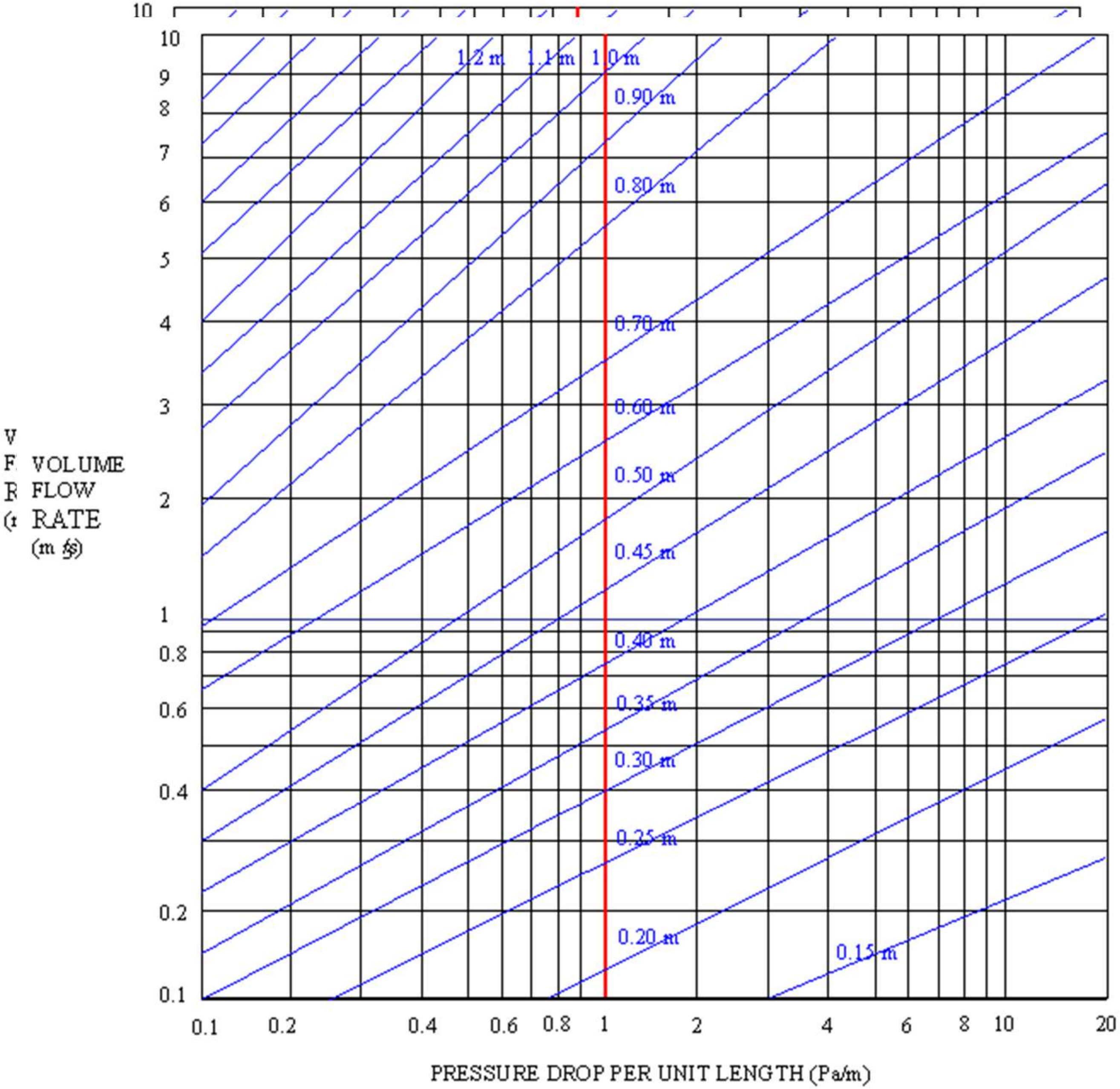


FIGURE 1
FLOW OF AIR IN CIRCULAR DUCTS

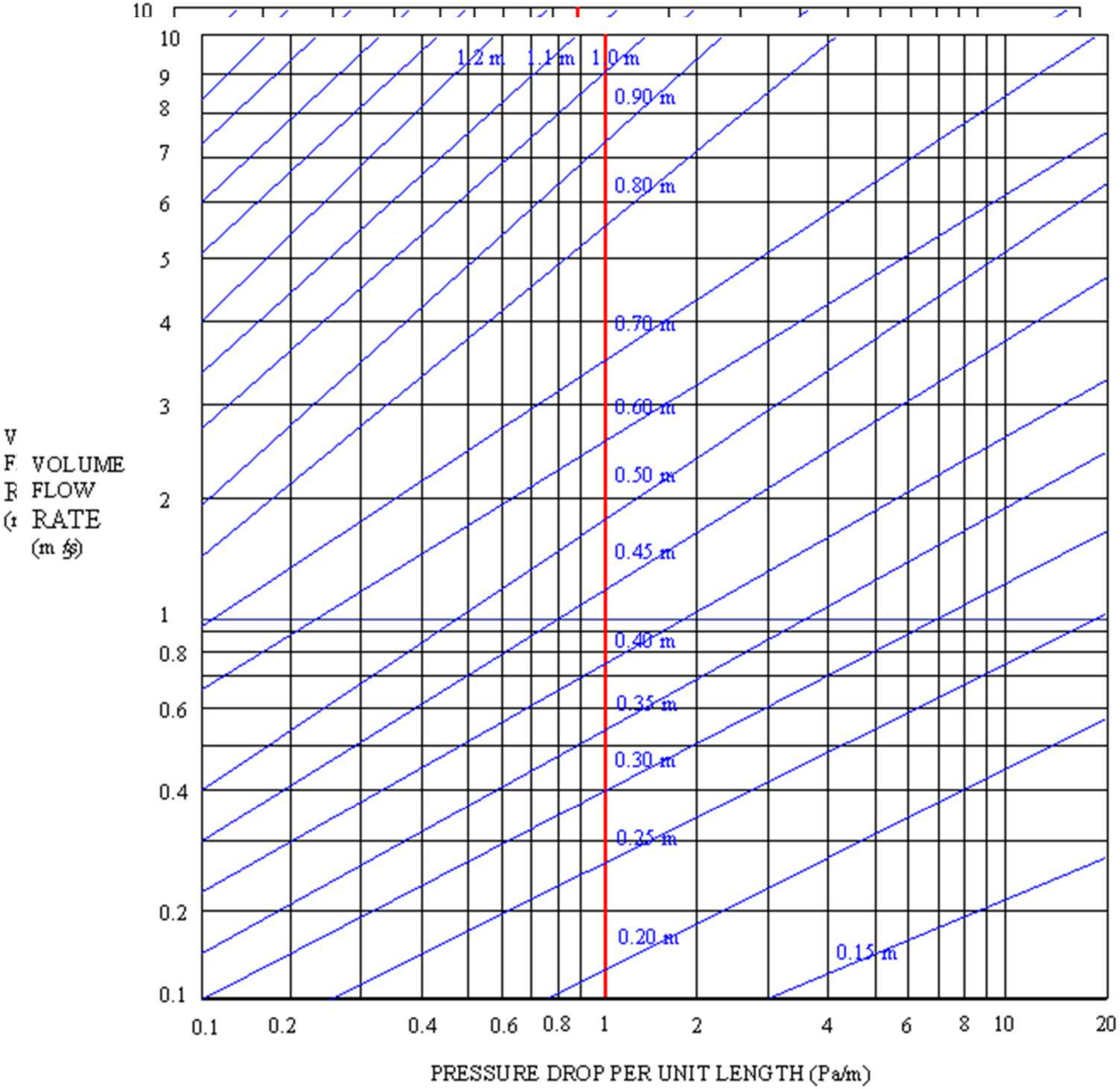


FIGURE 1
FLOW OF AIR IN CIRCULAR DUCTS

Duct sizing

Convert this to an appropriate square size.

- Area (Circle) = p x r^2
- Cross Sectional Area of Duct (CSA) = p x 0.205^2
  = 0.132 m^2
- For square duct of same CSA, one side =
  $(0.132)^{0.5}$ = 0.363 m

The next standard size of galvanised sheet metal ductwork would be **400mm x 400mm.**

Duct sizing with software

Duct sizing can be done with software . One simple software MacQuay software

- Copy the director of the software to your laptop
- Run the software
- Select units Meteric

Inorder to size the software

- Give pressure drop which will 0.6 pafor commercial buildings like office, hotel and hospital. It can be 0.8 for supermarket , malls, cafeteria and 1 for factories.).
- Constain the height of duct based on ceiling spce as first dimensions.

MacQuay software Example

- Run the software
- Select units Meteric
- Give duct section flow rate in this case 900lps
- Give pressure drop which will be constsnt for all section in this case we assume 0.6 pa
- Give height of duct which is usually constrained by available ceiling spa. In this cas let us say 350 mm for ceiling spce of 450 mm
- See the result in next slide: 325x600 mm size
- Check the velocity is less than the allowable for main duct office/hotel/hospital is 6 m/s

Duct sizing with MacQuay Software

20°C Air STP

Fluid density	1.2014	kg/m3
Fluid viscosity	0.0643	kg/m·h
Specific Heat	1.0048	kJ/kg°C
Energy factor	1.21	W/°C·L/s

☑	Flow rate	900	L/s		
☑	Head loss	0.6	Pa/m		
☐	Velocity	5.008	m/s		
☐	Equivalent diameter	478.4	mm		
	Duct size	325	mm X	600	mm

Equivalent Diameter	477.18	mm
Flow Area	0.1788	m2
Fluid velocity	5.034	m/s
Reynolds Number	161,585	
Friction factor	0.01896	
Velocity Pressure	15.2236	Pa
Head Loss	0.605	Pa/m

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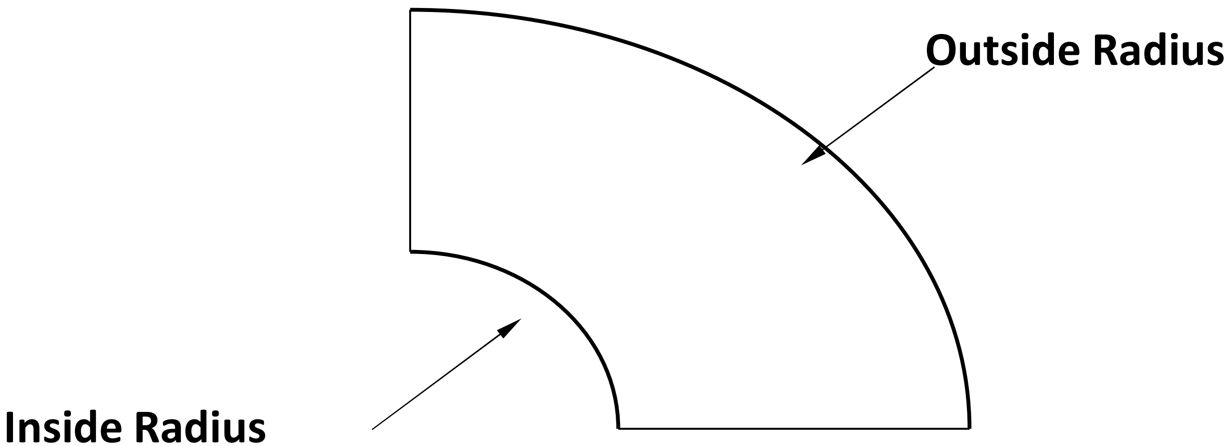
3. Pressure Loss in Ducts and Fittings

- **Zeta (z)** factors are to be used with the **Velocity Pressure** to find fittings resistances.
- **Zeta (z)** factors are pressure loss factors.
- These allow for the resistance of fittings in ductwork systems which can be quite significant compared to straight runs of duct.
- **Pressure Loss (or resistance) (Pa) = zeta factor x Velocity Pressure (Pa)**

  $\Delta = \zeta\ \rho\ v^2/2$

Examples of Zeta Factors

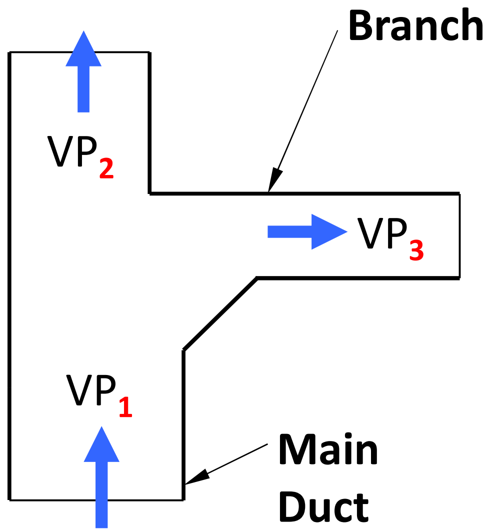
- **1. Bend** – mitred and radiused on both inside and outside.



Zeta factor = 0.67

Examples of Zeta Factors

- **2. Rectangular Duct Branch**

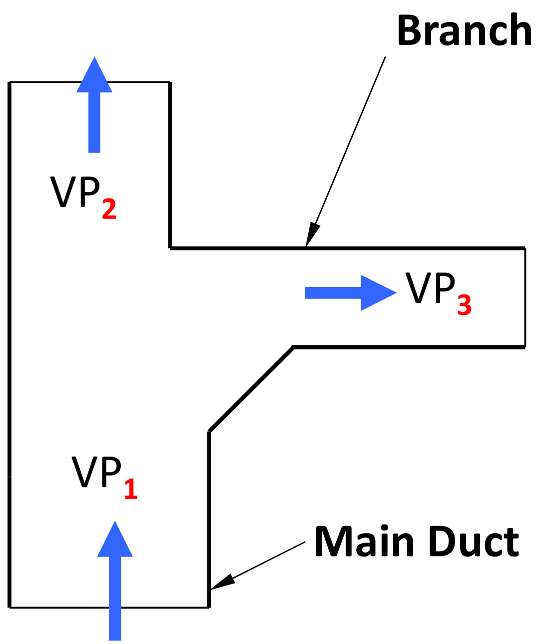


Zeta factor = 0.67

Examples of Zeta Factors

2. Rectangular Duct Branch

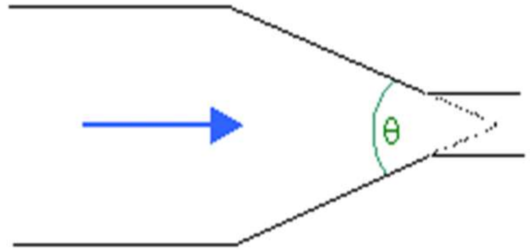
Straight Through' 1 to 2		To Branch 1 to 3	
Velocity pressure ratio VP_2/VP_1	Zeta factor (ζ)	Velocity pressure ratio VP_3/VP_1	Zeta factor (ζ)
0.6	0.44	0.6	1.60
0.8	0.09	0.8	0.78
1.0	0.04	1.0	0.55
1.2	0.02	1.2	0.45



Examples of Zeta Factors

3. Tapered Reduction

Included angle θ	Zeta factor	
	Taper both sides	Taper one side
30°	0.02	0.07
45°	0.04	0.20
60°	0.07	0.40



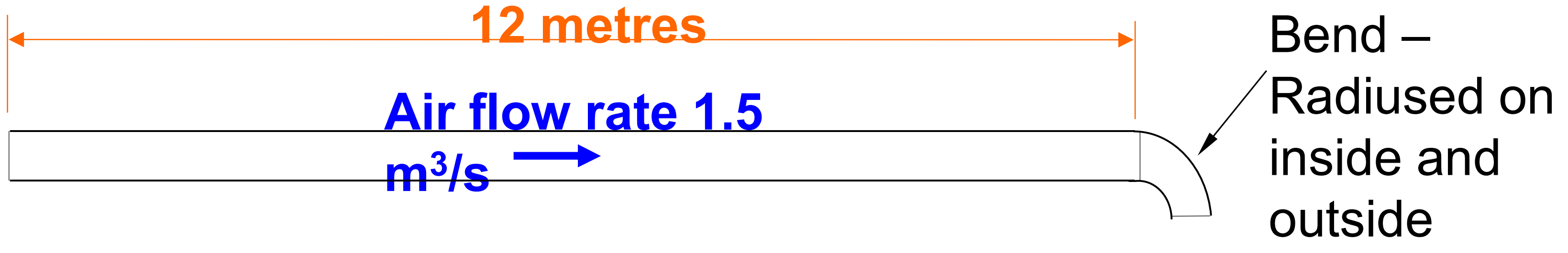
TAPER BOTH SIDES

TAPER ONE SIDE

Example of Duct Pressure Drop Calculation

NOTES:

1. Keep one side 300 mm high.
2. Ductwork to be rectangular galvanised steel.
3. There are no additional pressure losses.
4. Neglect entry or exit losses from the section.



Duct Sizing Table

1	2	3	4	5	6	7	8	9	10	11	12
								Pressure Loss			
Section	Length (m)	Flow Rate (m^3/s)	Pressure drop per metre (Pa/m)	Duct Size (mm)	Velocity (m/s)	Velocity Pressure (Pa)	Fittings pressure loss factor or ζ (zeta) factor	Fittings (Pa)	Straight Duct (Pa)	Total Pressure Loss (Pa)	Cumulative Pressure Loss (Pa)
A	12	1.5	1.0	0.51 metres dia. CSA = 0.204 m^2 Rectangular Width = 0.204 / 0.3 = 0.681 m say duct size is; 700mm x 300 mm high	Vel = vol/CSA = 1.5 / 0.7 x 0.3 = 7.14 m/s	VP = 0.5 x 1.2 x 7.14^2 = 30.6 Pa	1 . ζ factor = 0.67 from (EXAMPLES OF ζ zeta FACTORS) TOTAL ζ factor = 0.67	30.6 x 0.67 = 20.5	12 x 1.0 = 12.0	20.5 + 12.0 = 32.5	= 32.5

Pressure Drop Calculation Table

Duct Sizing Table											
1	2	3	4	5	6	7	8	9	10	11	12
Section	Length (m)	Flow Rate (m^3/s)	Pressure drop per metre (Pa/m)	Duct Size (mm)	Velocity (m/s)	Velocity Pressure (Pa)	Fittings pressure loss factor or ζ (zeta) factor	Pressure Loss		Total Pressure Loss (Pa)	Cumulative Pressure Loss (Pa)
								Fittings (Pa)	Straight Duct (Pa)		

NOTES ON DUCT PRESSURE DROP CALCULATION

NOTES:

1. Divide the system into sections. A section is from one branch to another or in parts of the system with a steady volume flow rate.

2. Size the index circuit first, that is the circuit with the highest resistance to air flow. Normally the index circuit is the longest circuit, but not always so check if necessary.

4. Branches should be included in the downstream section.

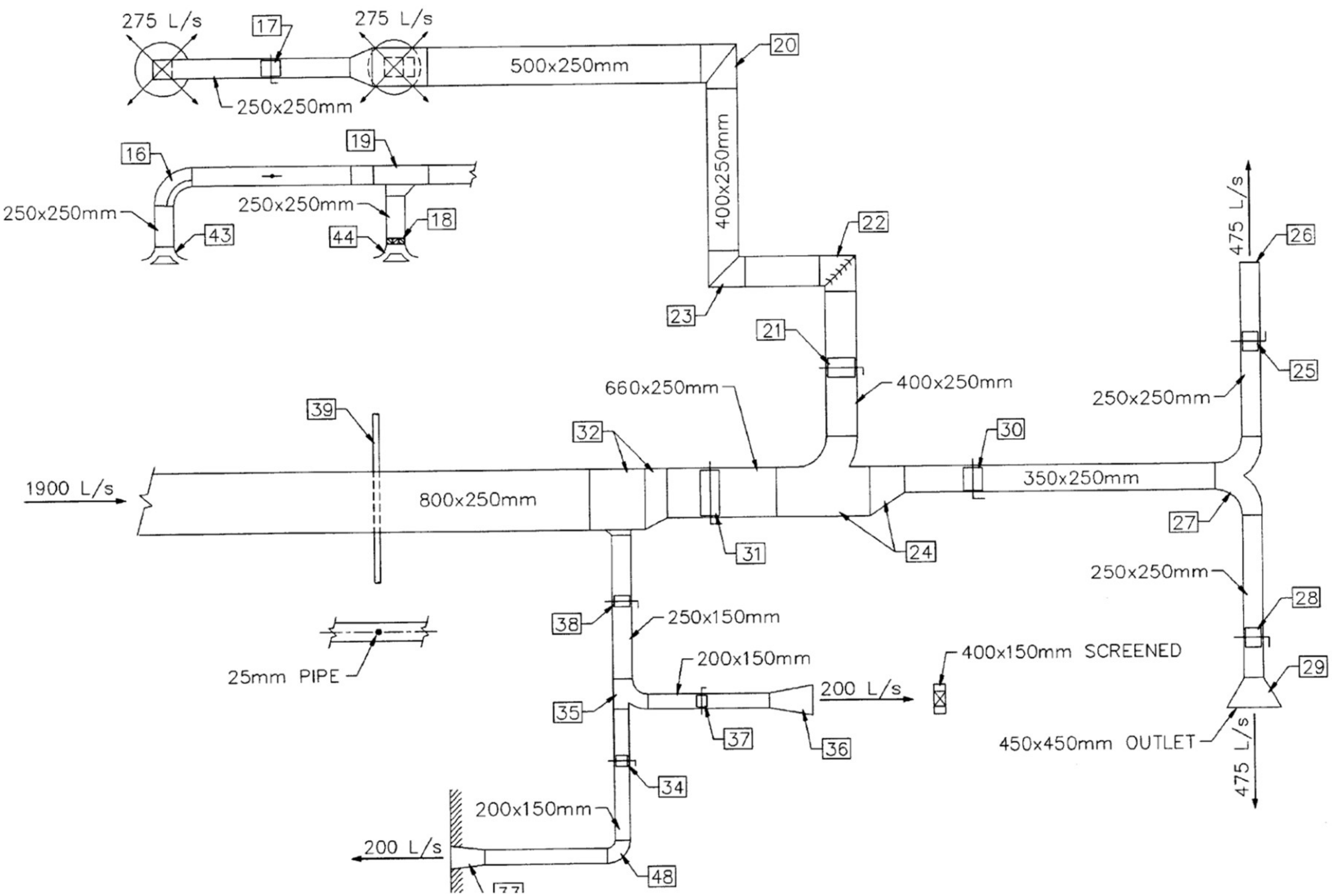
4. Contractions should be included in the downstream section rather than the upstream section for the same reason as in part 4.

TYPICAL AIR VELOCITIES FOR DUCTS

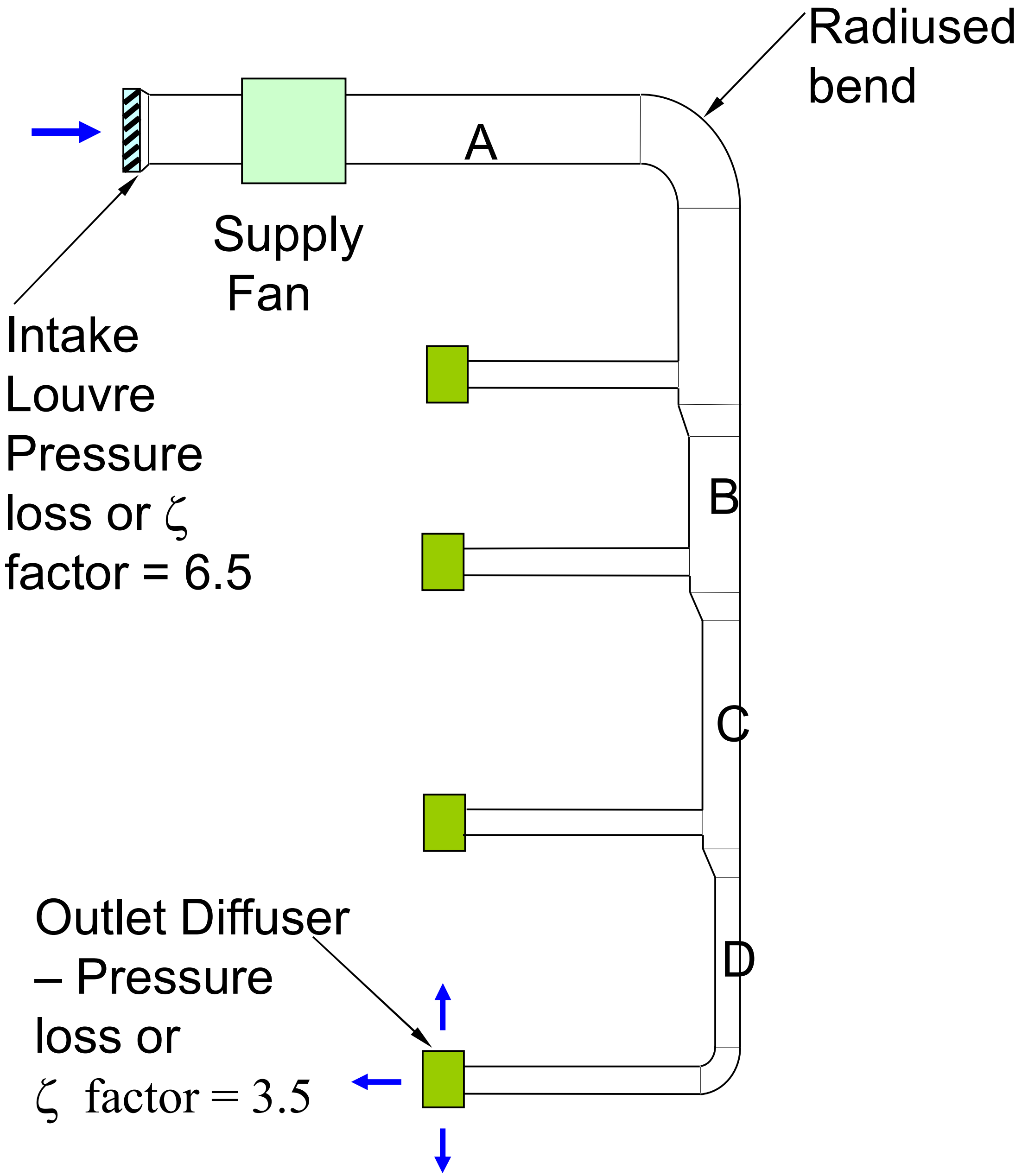
Building	Air Velocity (m/s)	
	Main Duct	Branch
Domestic	3	2
Auditoria	4	3
Hotel bedroom, Conference hall	5	3
Private office, Library, Hospital ward	6	4
General office, Restaurant, Dept. store	7.5	5
Cafeteria, Supermarket, Machine room	9	6
Factory, Workshop	10-12	7.5

EXAMPLE OF DRAWING OF DUCT NETWORK

Identify the following: Straight duct, transition, elbow . T-branch, Y-branch, volume damper at each branch



EXAMPLE CAFETERIA OF DUCT PRESSURE DROP CALCULATION



Branch A Sizing as Main Duct

20°C Air STP

Fluid density	1.2014	kg/m3
Fluid viscosity	0.0643	kg/m·h
Specific Heat	1.0048	kJ/kg°C
Energy factor	1.21	W/°C·L/s

☑	Flow rate	1200	L/s		
☑	Head loss	0.6	Pa/m		
☐	Velocity	5.372	m/s		
☐	Equivalent diameter	533.3	mm		
	Duct size	350	mm X	700	mm

Equivalent Diameter	533.18	mm
Flow Area	0.2233	m2
Fluid velocity	5.374	m/s
Reynolds Number	192,759	
Friction factor	0.01836	
Velocity Pressure	17.3521	Pa
Head Loss	0.598	Pa/m

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Branch B Sizing as Main Duct

20°C Air STP

Fluid density	1.2014	kg/m3
Fluid viscosity	0.0643	kg/m·h
Specific Heat	1.0048	kJ/kg°C
Energy factor	1.21	W/°C·L/s

☑	Flow rate	900	L/s		
☑	Head loss	0.6	Pa/m		
☐	Velocity	5.008	m/s		
☐	Equivalent diameter	478.4	mm		
	Duct size	350	mm X	550	mm

Equivalent Diameter	476.6	mm
Flow Area	0.1784	m2
Fluid velocity	5.045	m/s
Reynolds Number	161,751	
Friction factor	0.01896	
Velocity Pressure	15.2919	Pa
Head Loss	0.609	Pa/m

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Branch C Sizing as Main Duct

20°C Air STP

Fluid density	1.2014	kg/m3
Fluid viscosity	0.0643	kg/m·h
Specific Heat	1.0048	kJ/kg°C
Energy factor	1.21	W/°C·L/s

☑ Flow rate	600	L/s		
☑ Head loss	0.6	Pa/m		
☐ Velocity	4.533	m/s		
☐ Equivalent diameter	410.5	mm		
Duct size	350	mm X	400	mm

Equivalent Diameter	408.8	mm
Flow Area	0.1323	m2
Fluid velocity	4.535	m/s
Reynolds Number	125,243	
Friction factor	0.01985	
Velocity Pressure	12.358	Pa
Head Loss	0.598	Pa/m

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Branch D Sizing as Main Duct

20°C Air STP

Fluid density	1.2014	kg/m3
Fluid viscosity	0.0643	kg/m·h
Specific Heat	1.0048	kJ/kg°C
Energy factor	1.21	W/°C·L/s

☑ Flow rate	300	L/s		
☑ Head loss	0.6	Pa/m		
☐ Velocity	3.819	m/s		
☐ Equivalent diameter	316.3	mm		
Duct size	350	mm X	250	mm

Equivalent Diameter	322.23	mm
Flow Area	0.0786	m2
Fluid velocity	3.817	m/s
Reynolds Number	81,217	
Friction factor	0.02155	
Velocity Pressure	8.7531	Pa
Head Loss	0.597	Pa/m

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EXAMPLE CAFETERIA OF DUCT PRESSURE DROP CALCULATION

Section	Air Flow Rate (m^3/s)	Length (m)
A	1.20	10
B	0.90	3
C	0.60	6
D	0.30	8

NOTES:

1. Keep one side 350 mm high.
2. Ductwork to be rectangular galvanised steel.
3. There are no additional pressure losses.
4. Tapered reductions are at 45 degrees.

DUCT PRESSURE DROP CALCULATION

The velocity for the main ducts, section A,B,C do not exceed 9 m/s from the Table.

The velocity for the branch duct, section D also does not exceed the value of 6 m/s from the Table

The fan should be capable of delivering **1.2 m^3/s** against a pressure of **305 Pa.**

A percentage addition may be added to these figures for a design margin

DUCT INTAKE AND DISHARGE LOCATION

- Air ducts shall be made substantially air tight throughout, and shall have no openings other than those required for proper operation and maintenance of the system.
- Access openings shall be provided where debris, paper or other combustible materials may accumulate in plenums and ducts.

- Outdoor air intakes shall be covered with an insect screen and protected from rain entrainment. Screening shall be of corrosion resistant material not larger than 10mm mesh.
- Outdoor air intakes should be protected from water droplets such that no water droplet can enter the ventilation air stream.

EXAMPLE CAFETERIA OF DUCT PRESSURE DROP CALCULATION

Locations of intakes and return air openings

Openings for the intakes of outdoor air to all air handling systems, mechanical ventilation systems, pressurization systems of exit staircases and internal corridors, and smoke control systems shall be no less than 5m from any exhaust discharge openings.

Outdoor air intakes shall not be within 5m of exhaust discharges from any buildings, kitchens, toilets, car parks, cooling towers, laundries, rubbish dumps or plant rooms

DUCT CONSTRUCTION AS PER SMACNA STANDRAD

Allowable Galvanized Steel Duct Thickness

upto 300mm 0.5 mm
300- 750 mm 0.6mm
750-1200 mm0.8 mm
Above 1200 mm 1mm

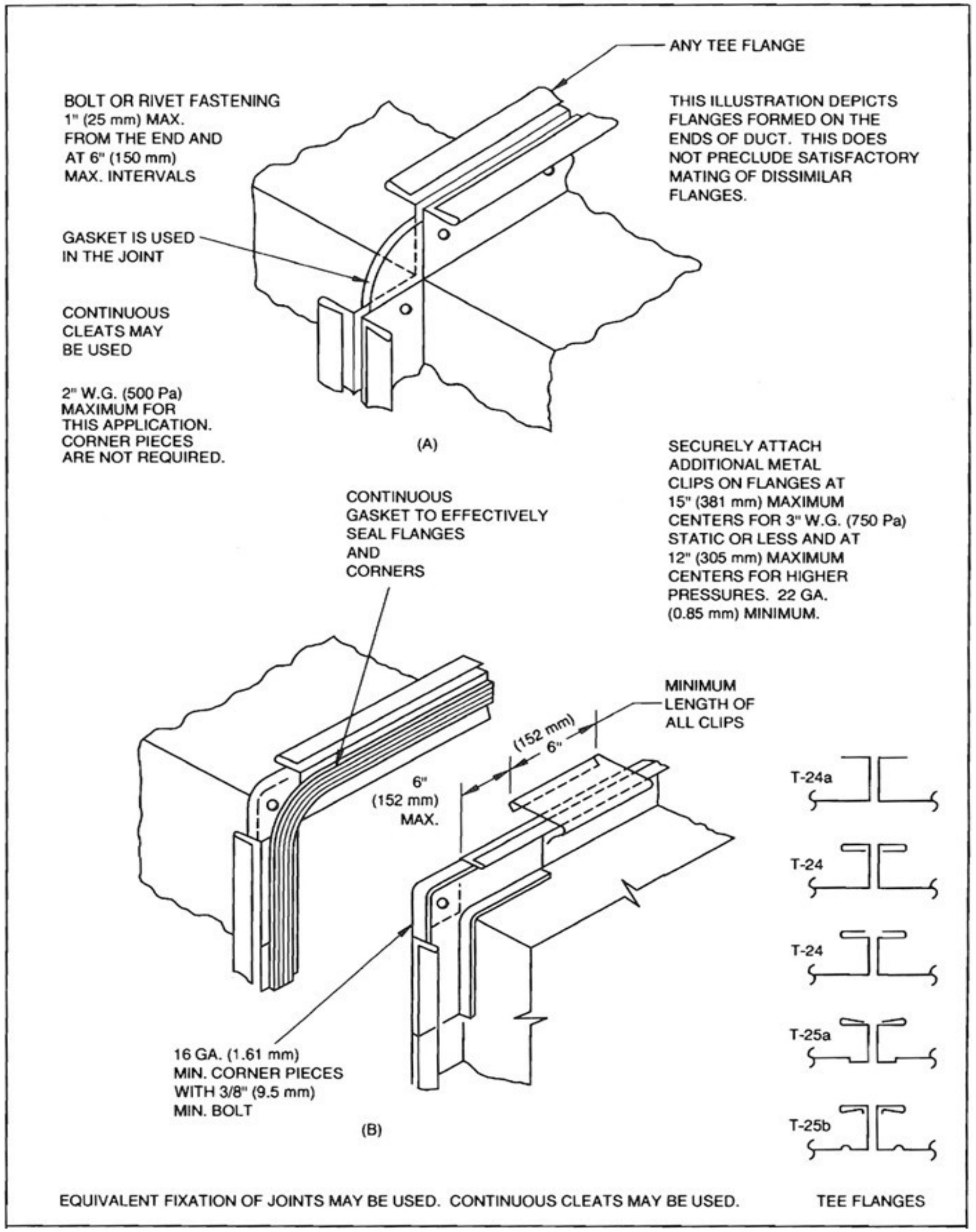
DUCT CONSTRUCTION AS PER SMACNA STANDRAD

Duct support spacing

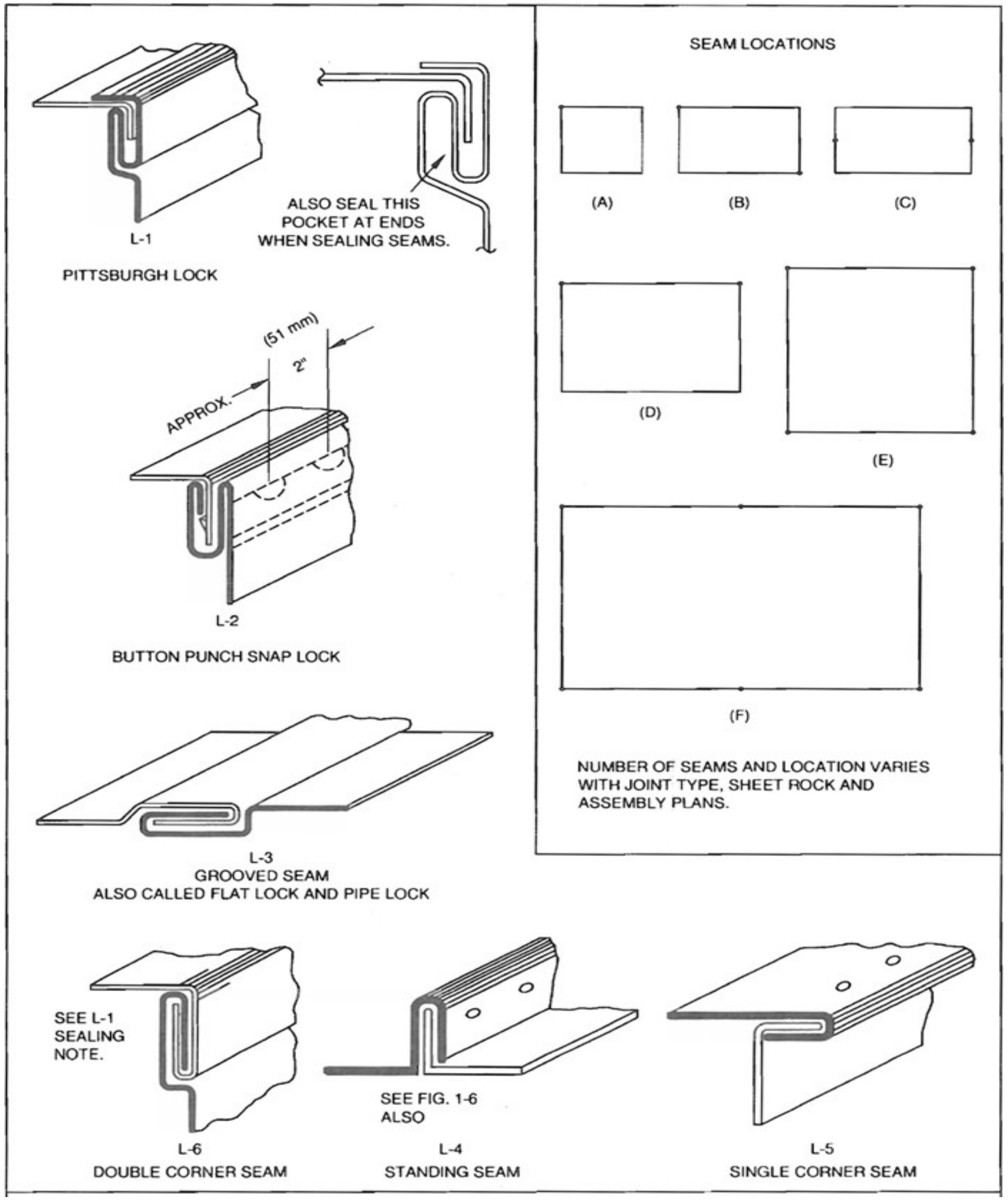
1000x 800 mm   10mm rod every 3m

1500x 1000   10mm every 2.5 m

DUCT CONSTRUCTION AS PER SMACNA STANDRAD



DUCT CONSTRUCTION AS PER SMACNA STANDRAD



SUMMARY

1. How is duct sized
2. Which of the following are duct fittings
   Elbow, T-branch Y-branch, Reducer (transition)

3. Which of the following are duct acessoriess
   Volume damper, Fire damper
4. What is allowable velocity in duct and whereit is specified.
5. What is supply duct, return duct and exhust duct.
6. How is pressure drop in aduct detrmined
7. Size duct and sketch kiten exhust duct for three adjacent toilettes of 1.5 m2 area and 2.8 m height according ES.