ELHAMD

Central Air Conditioning System

Factory: Al Qanatir Al Khayrih - Al Qlyubiyah - Egypt
Tel : +2 01150713317
Mail: mohamed.khedr0205@icloud.com

ABOUT US …

- For over 4 decades, ELHAMD . has been designing, manufacturing, and installing SMACNA standard air conditioning and ventilation ducts. With our team of more than 100 expert engineers, we provide excellent services and products to serve customers in a variety of industries, ranging from department stores to accommodations and industrial factories.

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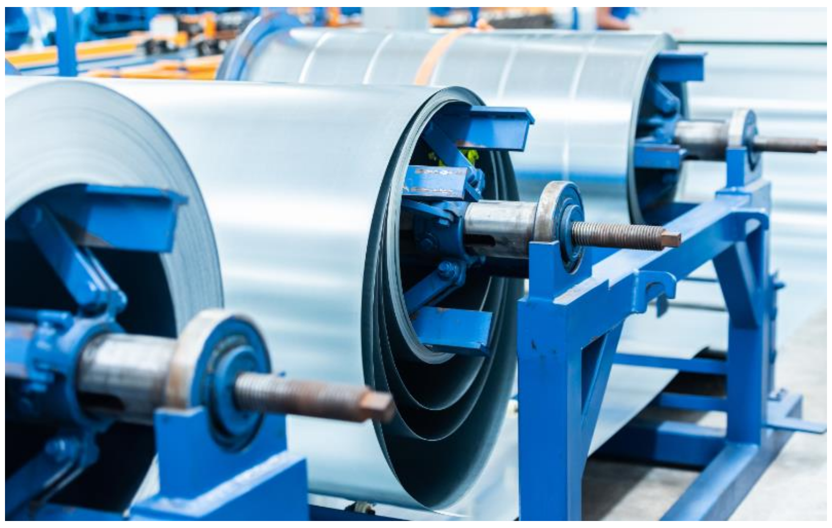
ELHAMD

Central Air Conditioning System

OUR FACTORY …

- ELHAMD is a recognized manufacturer and distributor of air ducts and equipment related to air conditioning and ventilation works



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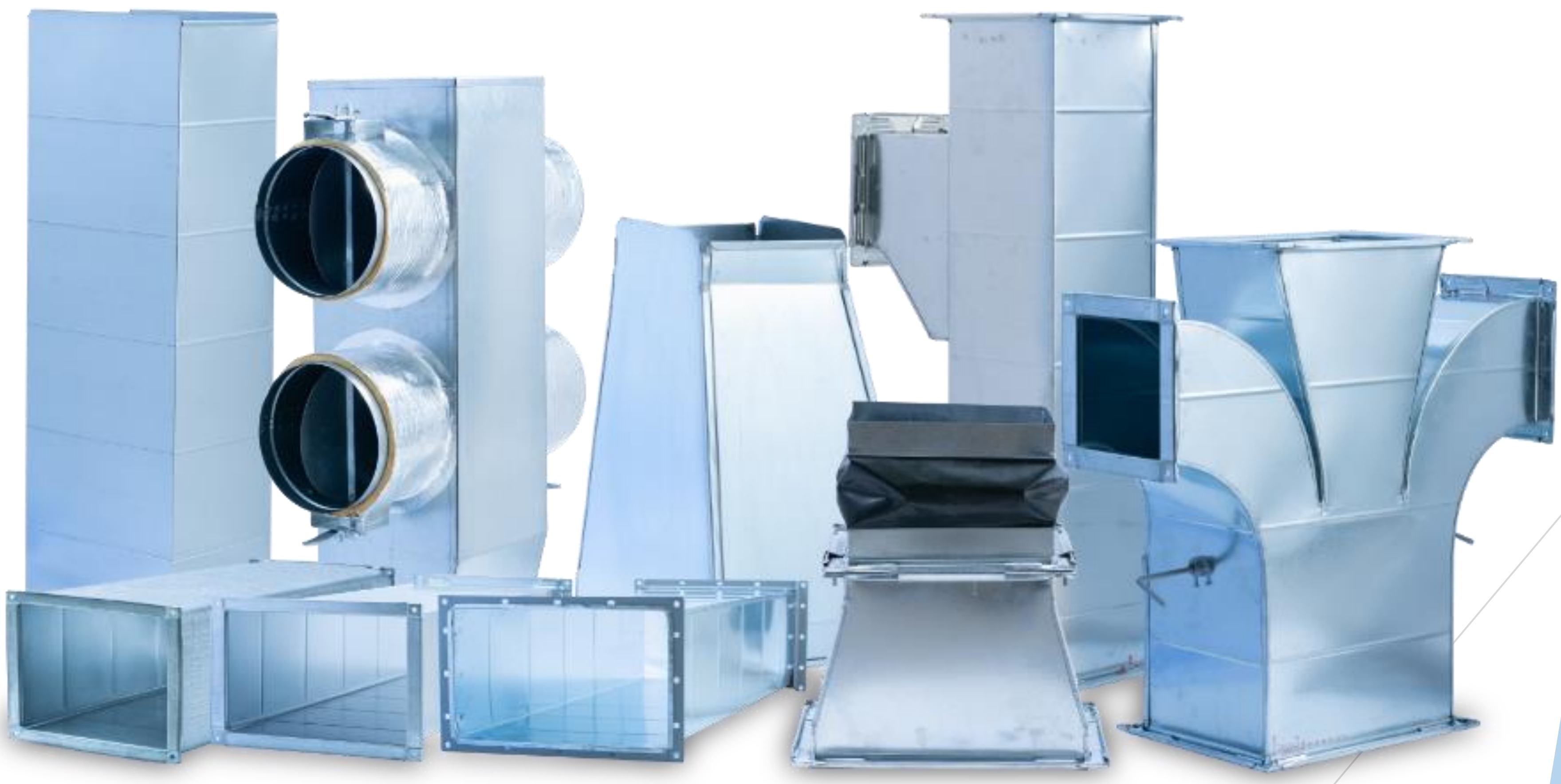
Central Air Conditioning System

Rectangular Duct

- Rectangular ducts are made from galvanized or stainless steel. The sheets are cut and folded into the desired shape using automated machines controlled by computers for the highest precision. Moreover, customers can order the ducts to be sprayed with oil paint or powder color into the tone they wish. It can be lined with heat insulation both on the inside and on the outside, making it suitable for air duct and ventilation systems. All processes adhere to SMACNA and ASHRAE standards.



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ELHAMD
Central Air Conditioning System

Rectangular Duct

- Rectangular ducts are made from galvanized or stainless steel. The sheets are cut and folded into the desired

Material	Galvanized sheet, stainless steel
Thickness	0.45-1.2 mm,0.4-1.2 mm
Size	100×100 to by order, 4000×4000 to by order
Insulation	Inside and outside
Pressure	2-10 inch of water
Other	Power paint and normal paint
Using Guide	Galvanized Duct is suitable for normal using Stainless Steel is suitable for food industry Distribute the cold air Distribute the hot air Smoke exhausting Smell exhausting

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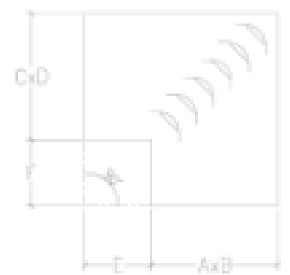
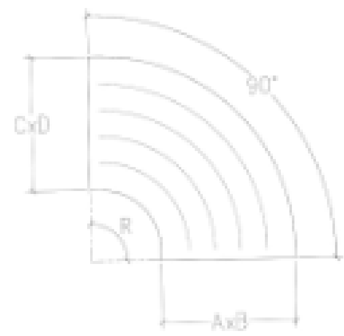
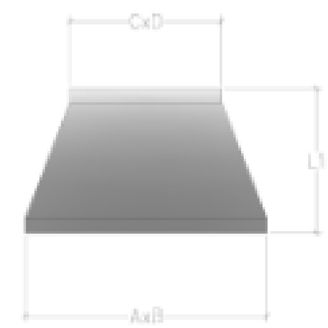
Fitting Rectangular Duct



DEGREE ELBOW
90°C
[RE-03]



CENTER REDUCER
[RR-05]



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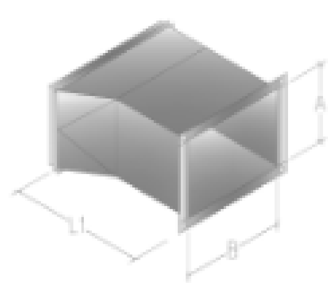
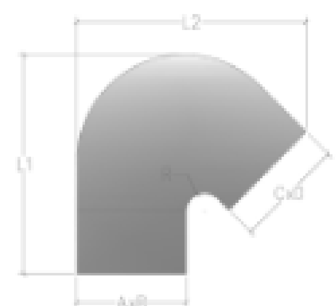
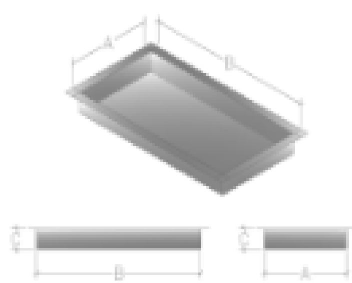


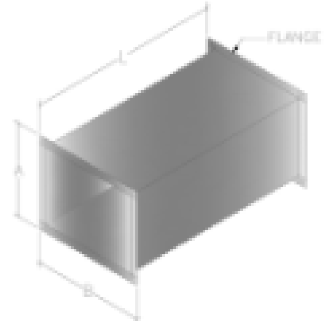
ANGLE TRAP
[RT-15]



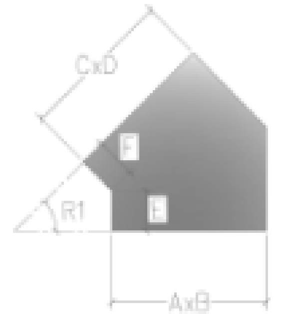
GOOSE NECK
[RN-16]



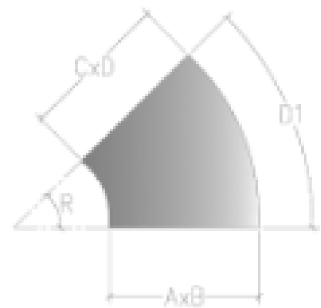
END CAP
[RE-17]



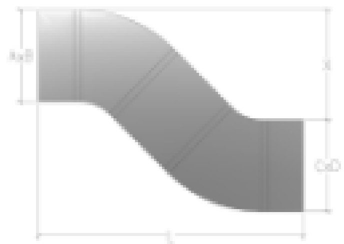
RECTANGULAR DUCT



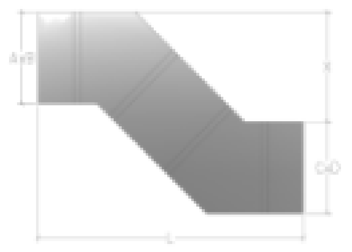
DEGREE ELBOW
45°C
[RE-01]



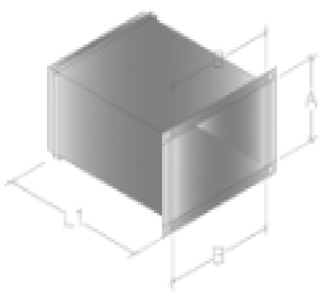
REDIUS ELBOW 45°C
[RE-02]



OFFSET
[RO-12]



DOG-LEG OFFSET
[RO-13]



STRAIGHT TRAP
[RT-14]

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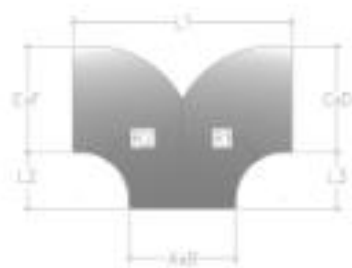
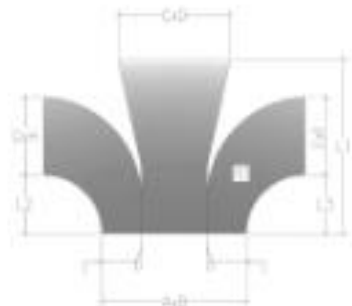
Fitting Rectangular Duct

T-BRANCE
[RT-09]

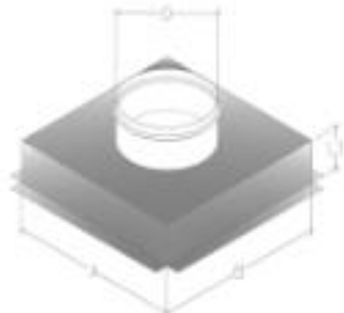


T-BRANCE
[RT-10]

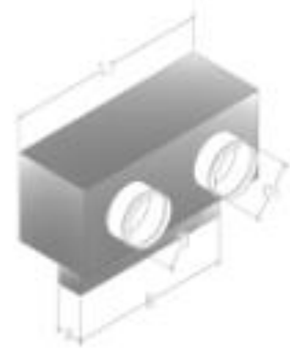


CROSS
[R-11]

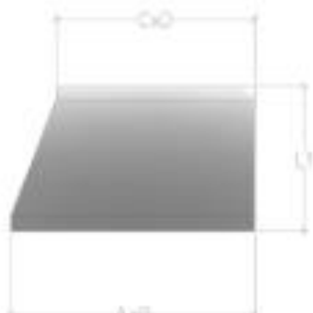
FLANCE
[RF-23]



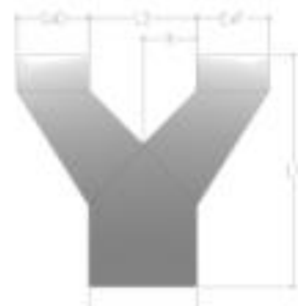
GRILL BOX
[RB-24]



LINEAR PLENUM
[RB-25]

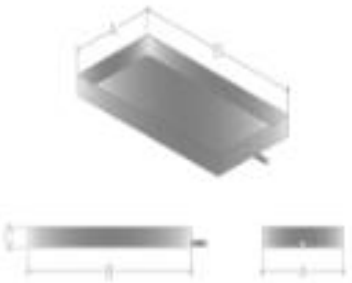


SIDE REDUCER
[RR-06]



Y BRANCE
[RY-07]

Y BRANCE
[RY-08]



PAN
[R-19]

RAIN HOOD
[RR-21]

SERVICE DOOR
[RS-22]

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Spiral Round Duct

- Spiral Tube is manufactured by an imported machine from japan. We have been using this machine for more than 20 years. It forms up the double seam lock between two sides of the sleeve metal sheet then it is rolled as a spiral. The production is controlled under computer to reach SMACNA and ASHRAE standard.

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Spiral Round Duct

- Spiral Tube is manufactured by an imported machine from japan.

Material	Galvanized sheet, stainless steel
Thickness	0.45-1.2 mm,0.4-0.8 mm
Size	DIA 4”-60”, DIA 4”-60”
Insulation	Inside and outside
Pressure	2-6 inch of water
Other	Power paint and normal paint
Using Guide	Galvanized Duct is suitable for normal using Stainless Steel is suitable for food industry Distribute the cold air Distribute the hot air Smoke exhausting Smell exhausting

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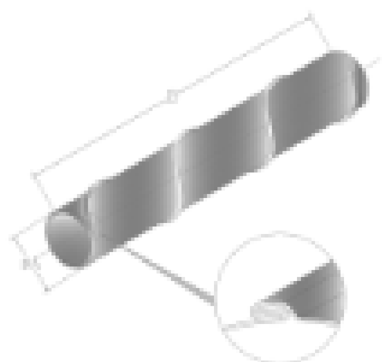
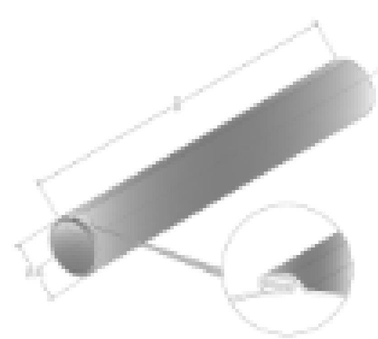
Central Air Conditioning System

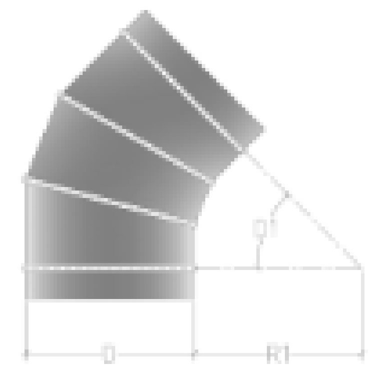
Fitting Spiral Round Duct



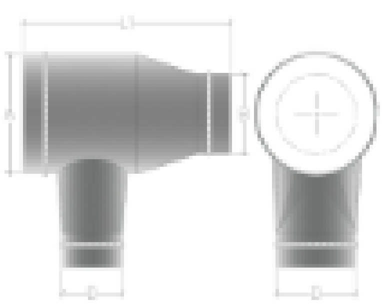
SPIRAL DUCT



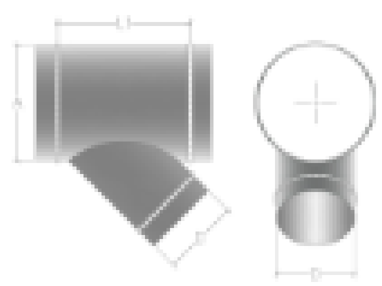
ROUND DUCT



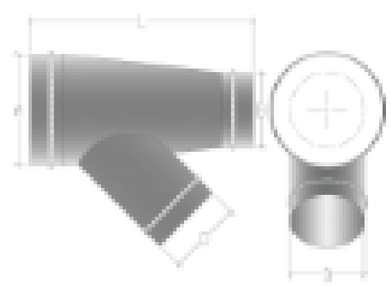
ELBOW 45°C
[SE-01]



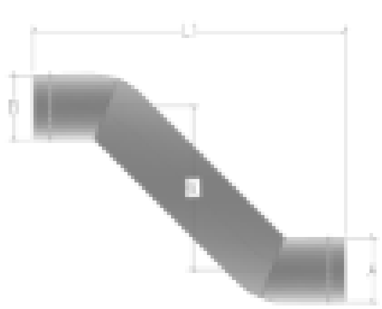
CONICAL REDUCING TEE
[SR-11]



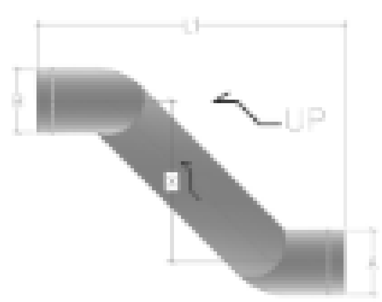
45°C LATERAL
[SL-13]



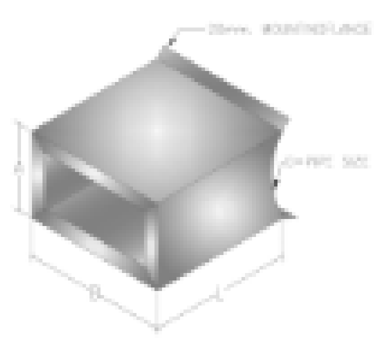
TAPERED REDUCING LATERAL
[SL-14]



OFFSET
[SO-25]



OFFSET (UP)
[SO-25-1]



REGISTER SADDLE
[SS-26]

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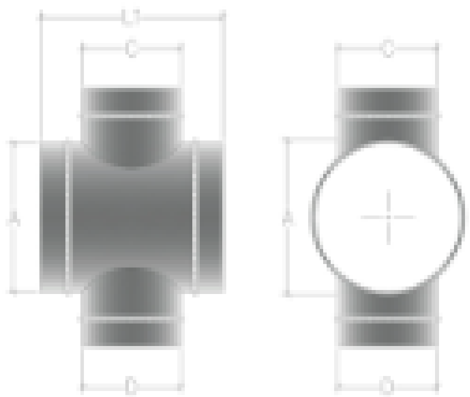
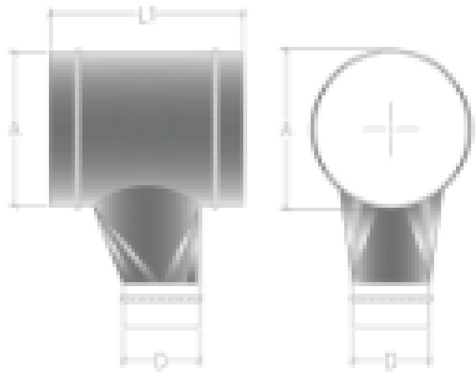
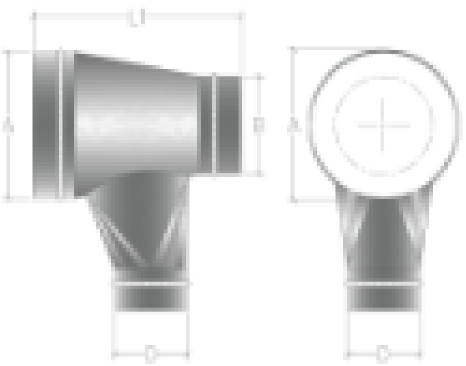
Fitting Spiral Round Duct



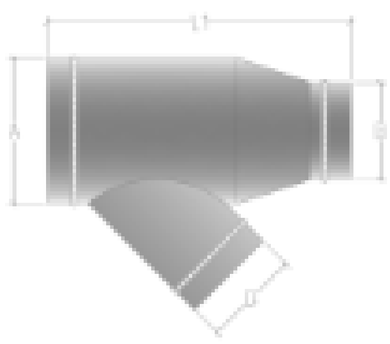
180°C CROSS TEE [SC-04]



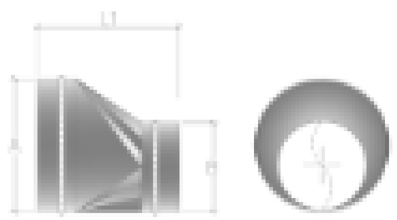
AIRFLOW TEE [SA-08]



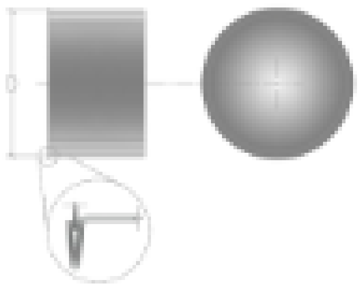
REDUCING AIRFLOW TEE [SR-09]



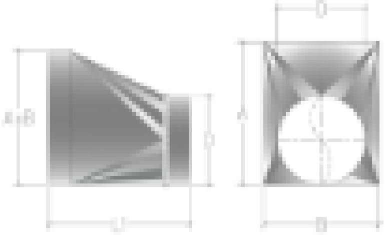
ECCENTRIC REDUCER [SR-22]



END CAP [SE-23]



SOCKET [SC-24]



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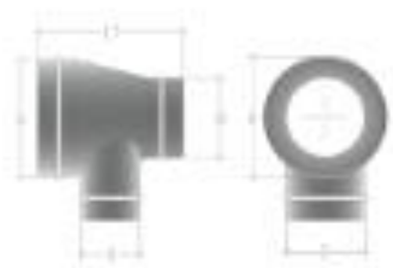
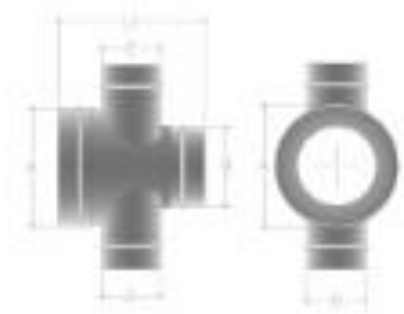
Fitting Spiral Round Duct

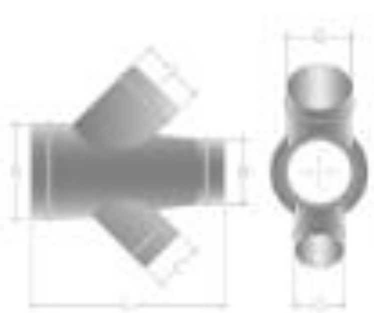
135°C CROSS TEE
[SC-05]



REDUCING TEE
[SR-06]

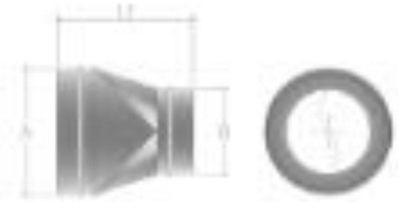


180°C REDUCING TEE
[SR-07]



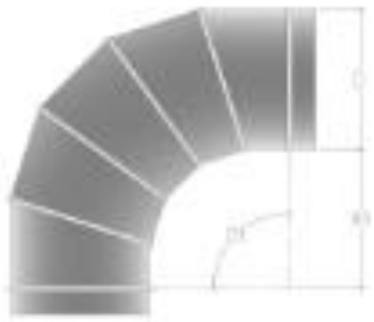
DEDUCING LATERAL CROSS
[SL-18]

Y-BRANCH
[SY-19]

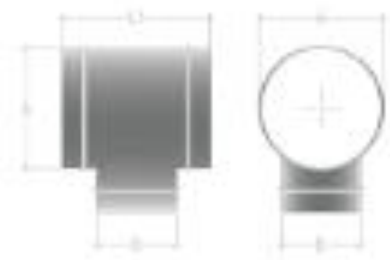


CONCENTRIC REDUCER
[SR-21]

FLEXIBLE BELT
[SF-30]



ELBOW 90°C
[SE-02]



PLAIN TEE
[SP-03]

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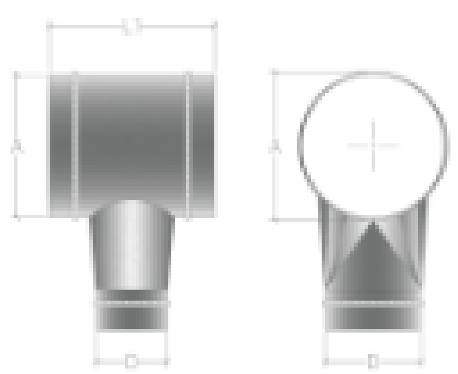
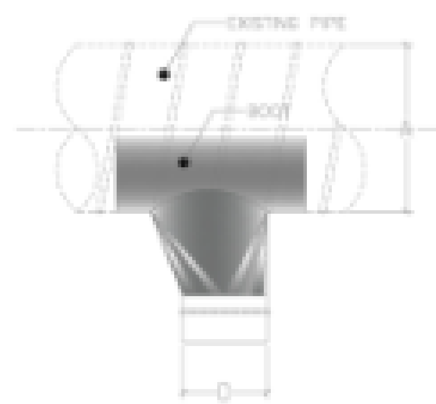
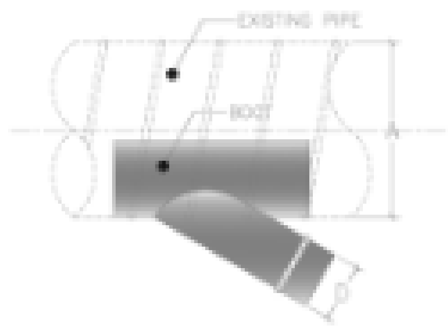
Fitting Spiral Round Duct



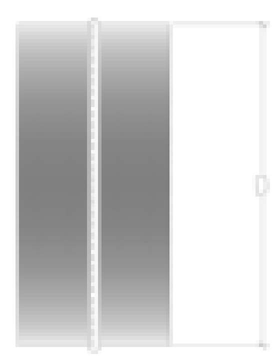
CONICAL TEE [SC-10]



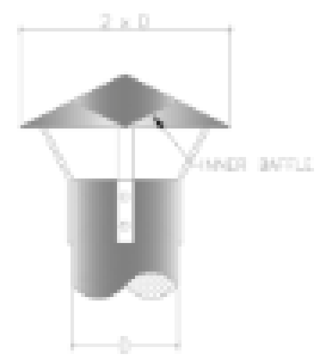
SADDLES [SS-15]



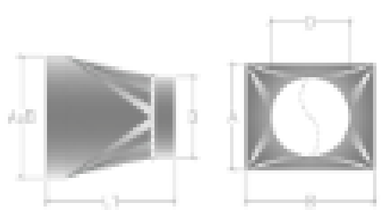
OPTIONAL 5°C REDUCING LATERAL [SL-17]



RAIN CAP [SR-27]



TRANSITION [ST-28]



TRANSITION OFFSET [ST-29]

Black Steel Welding Duct

- Black steel welding ducts are preferable for ventilating air and smoke from kitchens. They are also called Kitchen Air Ducts (KAD). Because these ducts are made from black steel, they are more durable towards heat, especially when coated with rockwool or Hi-Temp.

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Black Steel Welding Duct

- Black steel welding ducts are preferable for ventilating air and smoke from kitchens.

Material	Black Steel sheet
Thickness	1.2-4 mm
Size	100×100 to by order
Insulation	Inside and outside
Pressure	2-6 inch of water
Other	Power paint and normal paint
Using Guide	For high pressure Duct Distribute hot air Smoke exhausting Smell exhausting

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ELHAMD

Central Air Conditioning System

ELHAMD – HOW TO SIZE AND DESIGN DUCTS

Air flow problems have plagued the ELHAMD industry for years. No matter how much money

you spend on a high-quality ELHAMD system, the equipment won't work at its best without

properly designed and installed ductwork. Ducts that are not well designed result in

discomfort, high energy costs, bad air quality, and increased noise levels.

A well-designed ductwork system should deliver maximum interior comfort at the lowest

operating cost while also preserving indoor air quality. The chief requirements of an air

conditioning duct system are:

1. It should convey specified rates of air flow to prescribed locations.

2. It should be economical in combined initial cost, fan operating cost and cost of

building space.

3. It should not transmit or generate objectionable noise.

A primary issue is the tradeoff between the initial cost of the duct system and the energy cost

of the air distribution system. Larger ducts require a larger initial investment, but result in

lower fan energy costs over the life of the system. Other issues include space restrictions,

noise level, capacity for expansion, appearance, etc.

This course will discuss the basic fundamentals and principles of air conditioning duct design

and layout.

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1.0. DUCTWORK DESIGN PRINCIPLES

Starting with the basics, let's start at the most elementary level of air flow fundamentals.

1.1 Basic Definitions

The following basic terminology is extensively used in this course.

• cfm: volume of air flow; cubic feet/minute

• fpm: velocity or speed of air flow; feet/minute

• sq.ft: duct size or cross-sectional area; square feet

Air volume in cfm can be calculated by multiplying the air velocity by the cross-sectional

area of the duct in square feet.

• cfm = fpm x Area

Given any two of these three quantities, the third can be readily determined:

• fpm = cfm/area

• Area = cfm/fpm

Gauge and Absolute Pressures:

Gauge pressure is indicated on the gauge; absolute pressure is the total of the indicated

gauge pressure plus atmospheric pressure. The general equation for absolute pressure

is:

Gauge pressure + atmospheric pressure = absolute pressure

For example, if the gauge reads 10 psig then, using the above equation, the absolute

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pressure would be 24. 7 psia:

10 psig + 14.7 psi = 24.7 psia

Ordinary heating, ventilating, and air conditioning duct systems read air pressures at 0.4

psi or less, often much less. 1 psi equals 27.7 inches of water gauge; a common duct

pressure of 0.25 inches water column is equal to (0.25 divided by 27.7 in-wc/psi) = 0.009

psi.

Duct Pressure:

Duct system is pressurized by three pressures:

• Static pressure: It is the air pressure in the duct, which is used for fan selection.

• Velocity pressure: It is the pressure generated by the velocity and weight of the

air, which is used for measuring the flow (cfm) in a system.

• Total pressure: It is used to find velocity pressure. Static pressure plus velocity

pressure equals total pressure.

Pressure in the ductwork is measured in inches of water column (in-wc).

Standard Air Density:

Air has mass. Standard air has a density of 0.075 lbs/ ft3

.

System capacity is directly affected by changes in air flow. As air is heated or humidified,

its specific volume increases and its density decreases. If the air density is low, more

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cfm is required to keep the mass flow rate the same. If air density is not considered,

many systems will have very low air flow.

Correction for the density is however not needed in air conditioning or cooling applications, if the temperature is between 40˚F to 100˚F and up to 1000 ft. in elevation.

Fan Capacity:

The volume of air will not be affected in a given system because a fan will move the

same amount of air regardless of the air density. In other words, if a fan will move 3,000

cfm at 70˚F, it will also move 3,000 cfm at 250˚F

Volumetric Air Flow Rate:

The volumetric flow rate of air that will be conveyed through the duct in an air conditioning system is determined by the cooling/heat load and the desired supply air

temperature. Since we are not conditioning cfms of air but rather pounds of it, we need a

mass-balance equation:

$$Q\,[\frac{Btu}{h}] = \dot{m}\left[\frac{lb}{hr}\right] c_p [\frac{Btu}{^\circ F * lb}] \Delta T[^\circ F]$$

$$Q\left[\frac{Btu}{h}\right] = CFM * \left(60\,\frac{min}{hr}\right) * (\frac{049lbm}{ft^3})0.24[\frac{Btu}{^\circ F * lb}]\Delta T[^\circ F]$$

air conditions at 70°F and 1 atm.

$$Q\left[\frac{Btu}{h}\right] = 1.08 * CFM * \Delta T[^\circ F]$$

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It is important that the air conditioning ductwork system delivers and return the right

amount of air from each room and provide comfort year round. This implies room by

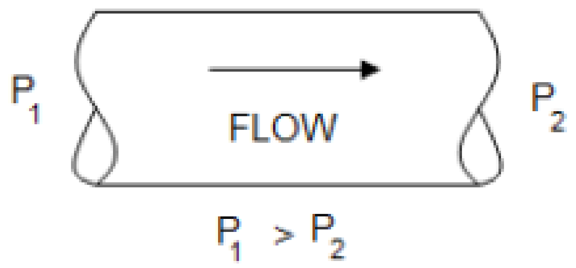
room heat loss and heat gain calculations.

1.2 Air Flow Principles

Flow of air is caused as a result of pressure differential between two points. Flow will

originate from an area of high energy (or pressure) and proceed to area(s) of lower

Energy



Air moves according to three fundamental laws of physics: conservation of mass, conservation of energy, and conservation of momentum.

1. Conservation of mass: It simply states that an air mass is neither created nor destroyed. From this principle it follows that the amount of air mass coming into a junction in a ductwork system is equal to the amount of air mass leaving the junction, or the sum of air masses at each junction is equal to zero. In most cases the air in a duct is assumed to be incompressible, an assumption that overlooks the change of air density that occurs as a result of pressure loss and flow in the ductwork. In ductwork, the law of conservation of mass means a duct size can be recalculated for a new air velocity using the simple equation:

$V2 = (V1 * A1)/A2$

where V is velocity and A is Area

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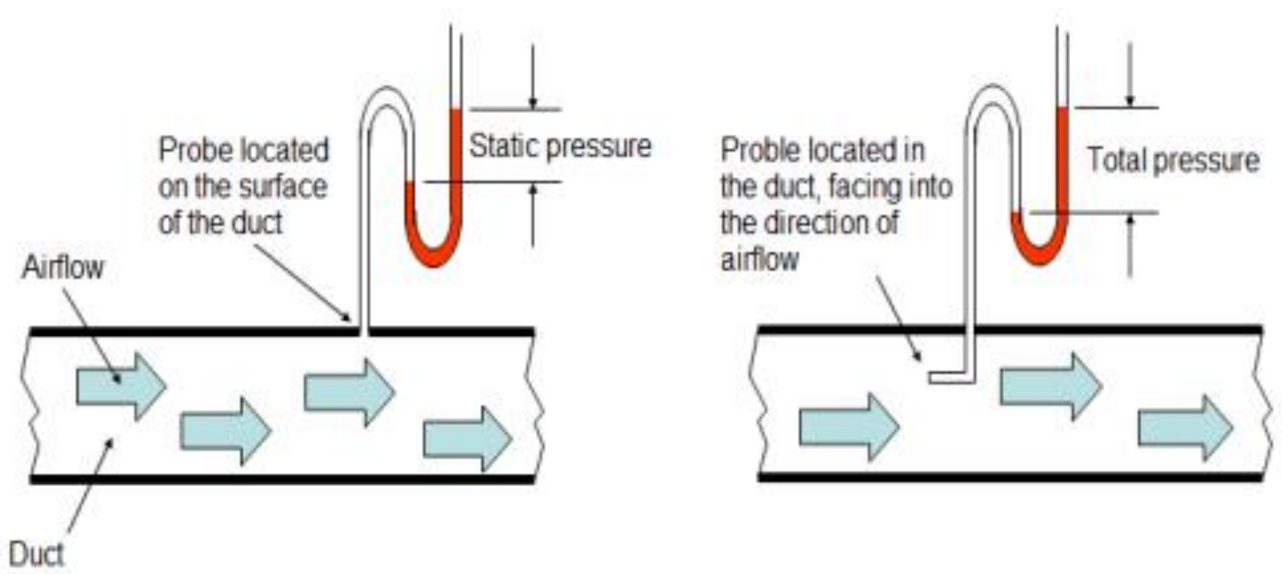
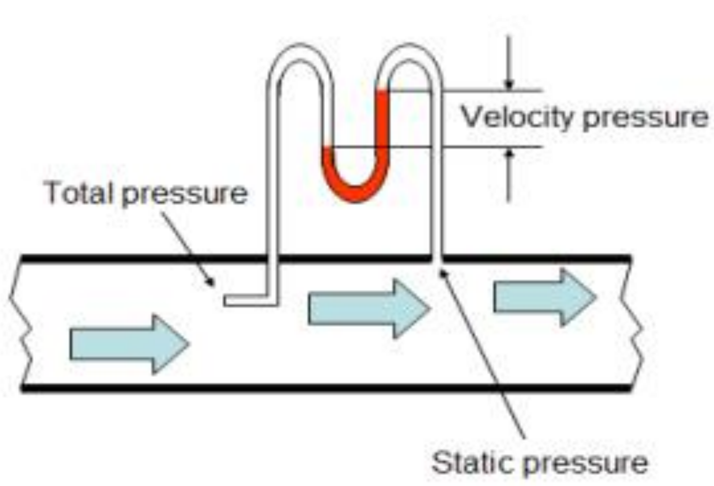
Air Flow Characteristics in Duct

1. At any point, the total pressure is equal to the sum of the static and velocity pressures.

2. The static pressure is exerted equally in all directions and the velocity pressure is exerted only in the direction of air flow. This makes it difficult to directly measure velocity pressure in a duct. Simply put, because static pressure is also pushing in the direction of air flow, you can never measure just velocity pressure. Practically, velocity pressure is calculated by measuring pressure perpendicular to the air flow (Static Pressure) and also measuring pressure parallel to the air flow (Total Pressure).



Once you have these two values you can just subtract static pressure from the total pressure and derive the velocity pressure. VP = TP - SP



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3. Static and velocity pressure are mutually convertible. The magnitude of each is dependent on the local duct cross-section which determines the flow velocity. The following pressure changes are affected in the ducts:

− Constant cross-sectional areas: Total and static losses are equal.

− Diverging sections (increase in duct size): Velocity pressure decreases, total pressure decreases, and static pressure may increase (static regain).

− Converging sections (decrease in duct size): Velocity pressure increases in the direction of flow, total and static pressure decrease.

4. The total pressure generally drops along the air flow because of frictional and turbulence losses.

Confusion in the use of the terms “Static Pressure”, “Velocity Pressure” and “Total Pressure” is widely prevalent among HVAC engineers and contractors. The term “Static Pressure” is typically used for fan selection; “Velocity Pressure” is used for

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measuring cfm in a system, and “Total Pressure” is used to find the velocity pressure. Total Pressure determines the actual mechanical energy that must be supplied to the system.

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2.0. DUCT COMPONENTS & MATERIALS

The air distribution system will have a designation depending on the function of the duct. Broadly, there are five designations of ducts:

1. Supply air ductwork supplies conditioned air from the air handling unit to the conditioned area.
2. Return air ductwork removes air from the conditioned building spaces and returns the air to the air handling unit, which reconditions the air. In some cases, part of the return air in this ductwork is exhausted to the building exterior.
3. Fresh air ductwork supplies outdoor air to the air handling unit. Outdoor air is used for ventilating the occupied building space.
4. Exhaust (relief) air ductwork carries and discharges air to the outdoors. Exhaust air is taken from toilets, kitchen, laboratories and other areas requiring ventilation.
5. Mixed air ductwork mixes air from the outdoor air and the return air then supplies this mixed air to the air handling unit.

2.1 Duct Components

The figure below shows a schematic and a 3-D representation of supply and return air ductwork. The central air handling unit (AHU) is connected to the air plenum at the starting point. AHU fans draw in air through grilles called returns and force air through the plenum and into the conditioned space through supply registers.

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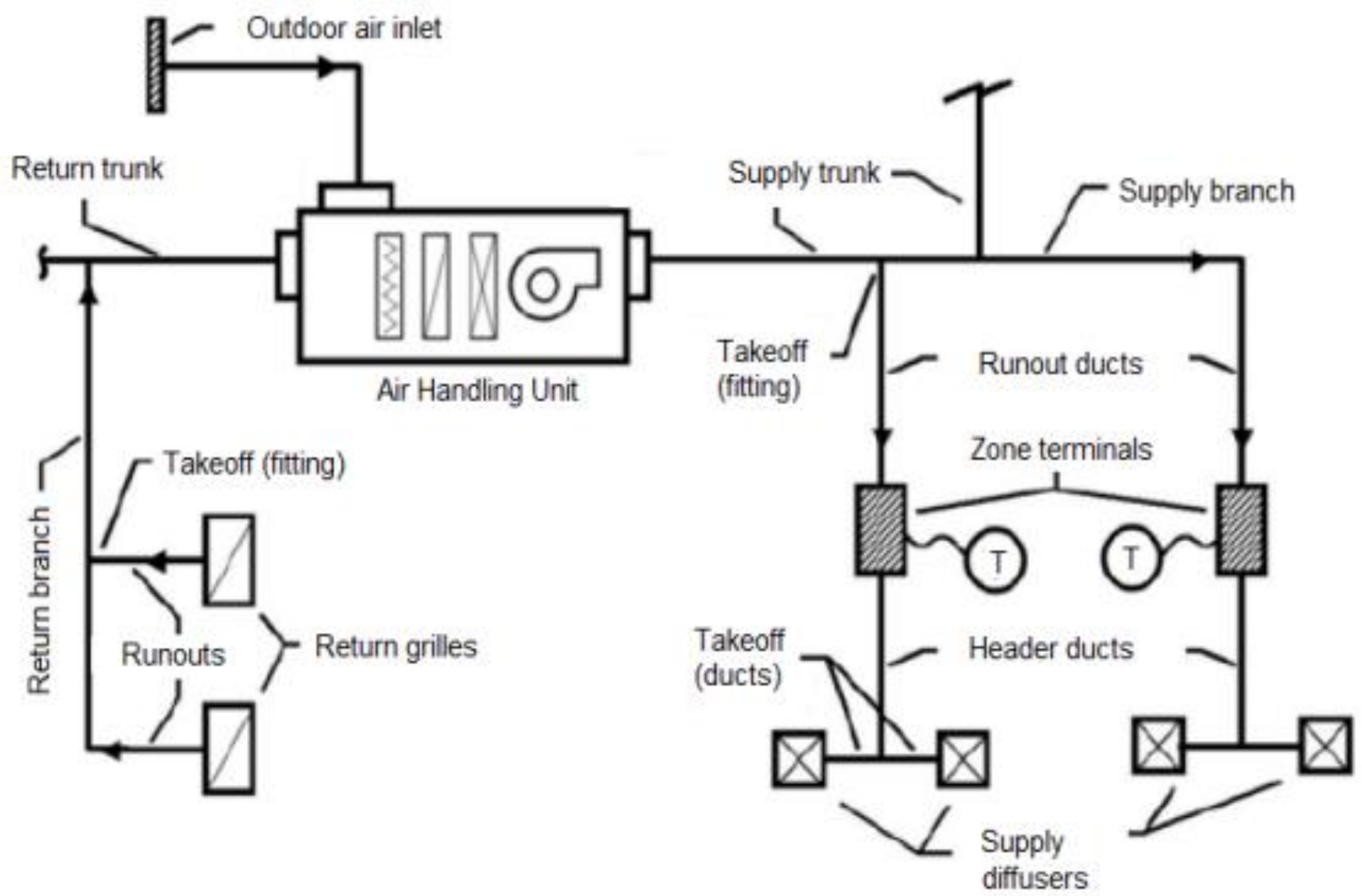
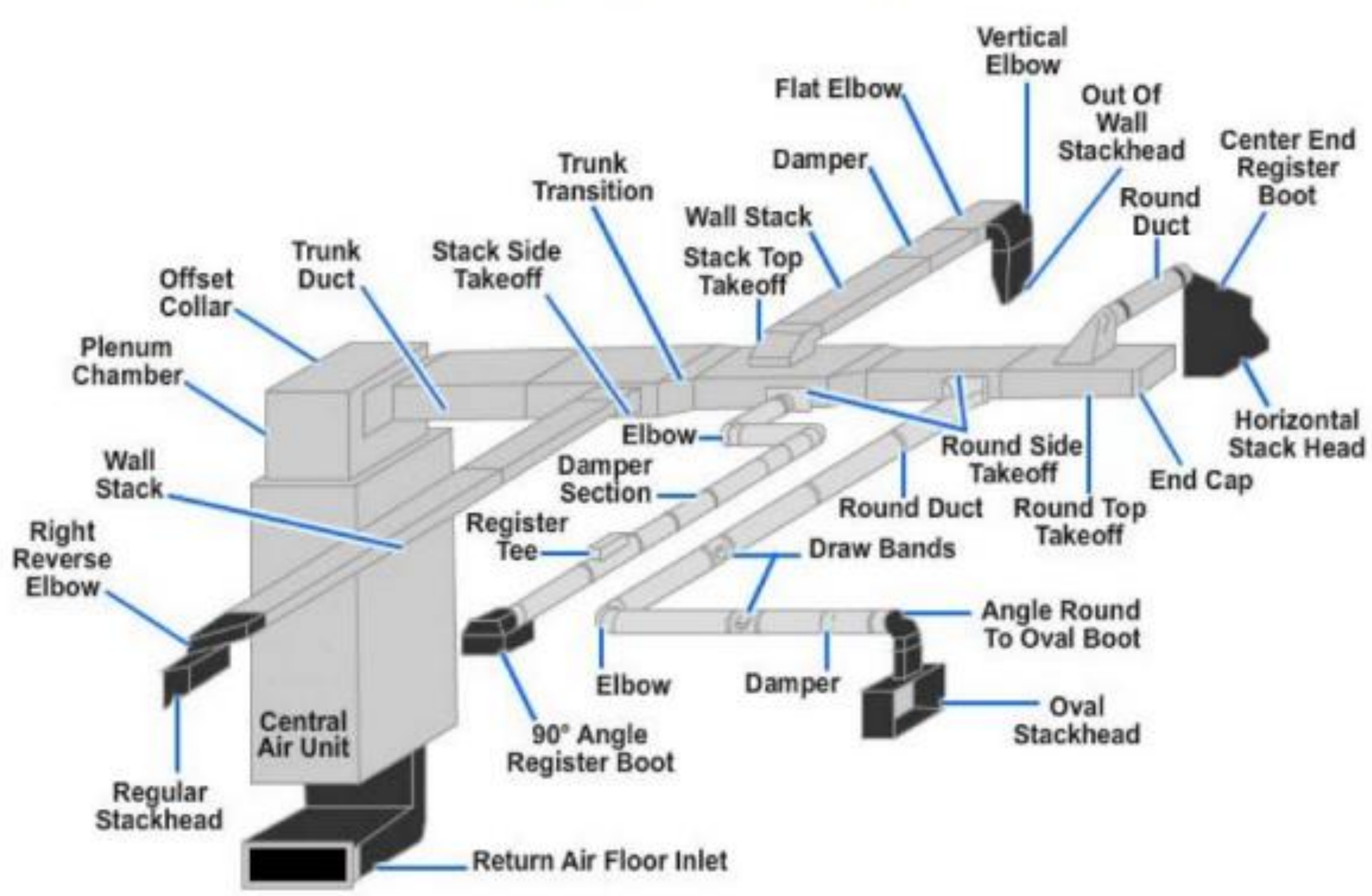


Air conditioning Schematic Drawing



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The duct components are as follows:

Plenum or Main Trunk: The plenum is the main part of the supply and return duct system that goes directly from the air handler to the "Trunk Duct".

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Trunk Duct: A duct that is split into more than one duct is called a "trunk", just like a tree. Ducts that are on the end of a trunk and terminate in a register are called branches.

Take Off: Branch ducts are fastened to the main trunk by a takeoff-fitting. The takeoff encourages the air moving the duct to enter the takeoff to the branch duct.

Air Terminals Devices: Air terminals are the supply air outlets and return or exhaust air inlets. For supply, diffusers are most common, but grilles and registers are also used widely. A diffuser is an outlet device discharging supply air in a direction radially to the axis of entry. A register is a grille equipped with a volume control damper. A grille is without a damper.

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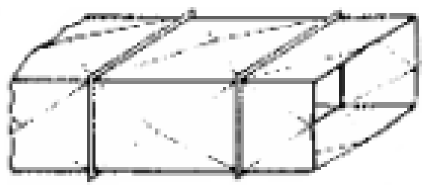
3.3 Velocity Classification vs. Pressure Classification

1. Duct pressure classification influences the duct strength, deflection and air leakage.

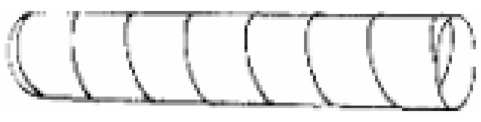
2. Duct velocity classification influences noise, vibration, friction losses and fan power.

4.0. DUCT SHAPES

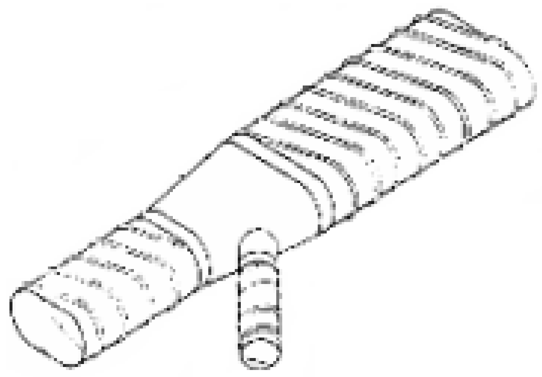
Ducts commonly used for carrying air are of round, square, or rectangular shape. All have advantages and disadvantages, and find applications where one is definitely superior to the other.



Rectangular Duct



Round Duct



Oval Duct

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4.1 Round Ducts

The duct shape that is the most efficient (offers the least resistance) in conveying moving air is a round duct, because it has the greatest cross-sectional area and a minimum contact surface. In other words, it uses less material compared to square or rectangular ducts for the same volume of air handled.

An 18 inch diameter duct, for example, has the same air-carrying capacity as a 26” x 11” rectangular duct. The round duct has a cross-sectional area of 254.5 sq.-in and a perimeter of 4.7 ft., while the rectangular duct has a 286 sq.-in area and a perimeter of 6.2 ft. The rectangular duct thus has 32% more metal in it and would cost proportionately more. Also the insulation, supports and labor are higher for rectangular ducts of similar capacity.

Some of the advantages of round ductwork include:

• Round shape results in lower pressure drops, thereby requiring less fan horsepower to move the air and, consequently, smaller equipment.

• Round shape also has less surface area and requires less insulation when externally wrapped.

• Round ducts are available in longer lengths than rectangular ducts, thereby eliminating costly field joints. Spiral lock-seams add rigidity; therefore, spiral ducts can be fabricated using lighter gauges than longitudinal seam ducts. Spiral ducts leak less and can be more easily sealed compared to rectangular ducts.

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• The acoustic performance of round and oval ducts is superior because their curved surfaces allow less breakout noise. The low-frequency sound is well contained in round ducts.

• Round ducts can help promote healthier indoor environments. Less surface area, no corners and better air flow reduce the chance of dirt and grime accumulating inside the duct and, therefore, becoming a breeding ground for bacterial growth.

While round air ducts have great advantages, there are some disadvantages to them.

One of the most notable drawbacks of round air ducts is that they need more clear height for installation. If the net clear height of a furred space above a suspended

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ceiling is 14 inches, an 18-in diameter duct cannot be installed therein; however, its

equivalent 26” x 11” rectangular duct will fit the space easily. A combination of a rectangular plenum and round branches sometimes is a good compromise.

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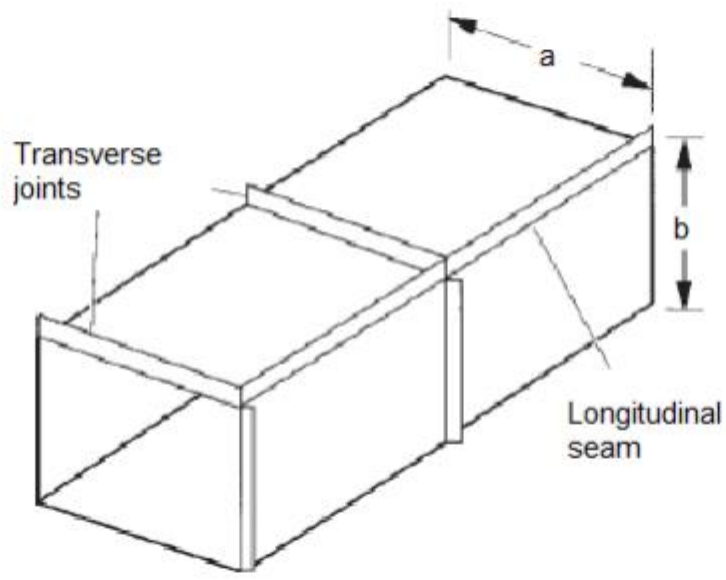
• 4.2 Rectangular Ducts

Square or rectangular ducts fit better to building construction. They fit above ceilings and into walls, and they are much easier to install between joists and studs.



When rectangular ducts must be used due to space limitations, keep the width-toheight ratio (aspect ratio) low. A rectangular duct section with an aspect ratio close to

1 yields the most efficient rectangular duct shape in terms of conveying air. A duct with an aspect ratio above 4 is much less efficient in use of material and experiences great pressure losses. Aspect ratios of 2 to 3 are ideal in trading off added duct cost of material and fan energy for headroom savings.

Disadvantages of rectangular ducts are as follows:

1. They create higher pressure drop;
2. They use more pounds of metal for the same air-flow rate as round ducts;
3. Their joint length is limited to the sheet widths stocked by the contractor;
4. Their joints are more difficult to seal;

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5. Those with high aspect ratio can transmit excessive noise if not properly supported

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4.3 Oval Ducts

Flat oval ducts have smaller height requirements than round ducts and retain most of

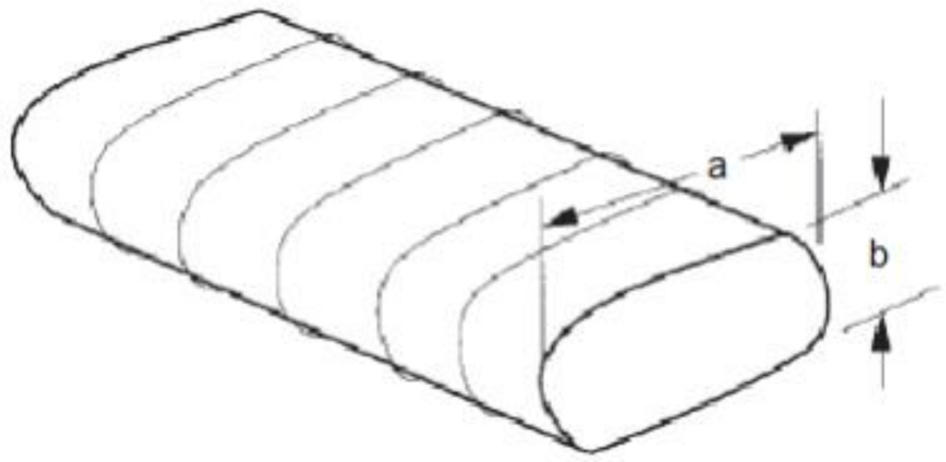
the advantages of the round ducts. However, fittings for flat oval ducts are difficult to

fabricate or modify in the field. Other disadvantages include:

1. Difficulty of handling and shipping larger sizes;

2. Tendency of these ducts to become more round under pressure; and,

3. In large aspect ratios, difficulties of assembling oval slip joints.



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4.4 Equivalent Diameter

Since both round and rectangular ducts are extensively used in air conditioning

systems, it is quite possible that a contractor may wish to substitute one for the other

while working on new construction or modifying an existing system. With this

likelihood, there is the general tendency to substitute cross-sectional areas of round

and rectangular ducts. This is improper and will affect air distribution system

performance. Therefore, it is necessary for the HVAC designer to fully understand

the conditions under which round and rectangular ducts can be interchanged. The

important thing is the duct pressure drop and that's where the concept of "equivalent

diameter" comes into picture.

By definition, equivalent diameter (Deq) is the diameter of a circular duct that will give

the same pressure drop at the same air flow as the rectangular duct.

From ASHRAE Fundamentals Handbook, the following equations may be used to

convert rectangular and flat oval ducts to and from round.

$$\text{Rectangular ducts: } D_{eq} = \frac{1.30\,(ab)^{0.625}}{(a+b)^{0.250}}$$

$$\text{Flat oval ducts : } D_{eq} = \frac{1.55\,A^{0.625}}{p^{0.250}}$$

$$A = \frac{\pi b^2}{4} + b(a-b)$$

$$p = \pi b + 2(a-b)$$

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Equivalent Diameter vs. Equivalent Cross-sectional Area Approach

Consider an air flow rate of 7,500 cfm and compare a 30” diameter round duct to

equivalent rectangular and oval duct options.

Equivalent Diameter Approach

For a given round duct diameter (30 inches), the dimensions for rectangular and flat

oval ducts must be solved for by trial and error. Fix one dimension and substitute in

the equations above. Let’s use 16 inches for the minor axis, then the equivalent

rectangular duct dimension will be 16”X 51”, and flat oval ducts with a 16-in. minor

axis will be 16” X 53”.

What this means is that all three ducts, 30” round, 16” x 51” rectangular, and 16” x 53”

flat oval will have the same friction loss for a given cfm. The table below summarizes

the equivalent diameter approach.

Duct shape	Exact converted dimensions (inches)	Rounded dimensions	Cross sectional area (sq.-ft.)	Velocity (fpm)	Friction loss (in.-WC/100ft)
Round		30	4.91	1528	0.10
Flat oval	16 x 52.5	16 x 53	5.51	1361	0.10
Rectangular	16 x 51	16 x 51	5.67	1362	0.10

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Friction loss is estimated from the duct friction charts for a given air flow rate and velocity (refer to the “duct sizing” section below for details).

The table below summarizes the equivalent cross-sectional area approach.

Duct shape	Air flow, (Q) cfm	Exact converted dimensions (inches)	Rounded dimensions	Cross sectional area (A) sq.-ft.	Velocity (v) fpm v = Q/A	Friction loss (in.-WC/100ft)
Round	7500		30	4.91	1528	0.10
Flat oval	7500	16 x 47.6	16 x 48	4.95	1514	0.12
Rectangular	7500	16 x 44.2	16 x 44	4.89	1534	0.14

You can see the frictional loss increases with increasing velocity and lower crosssectional area.

In Conclusion

The equivalent diameter approach will retain the same pressure drop but will result in

higher cross-sections of rectangular and oval ducts compared to round ducts.

The equivalent area approach will increase the pressure drop of the duct run while

keeping the cross-sectional area the same.

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Procedure:

Equal friction method uses a duct slide rule, duct calculator, or friction rate chart to

determine the relationship between duct size and air flow, i.e. how much air will come out of a given size duct. The methodology is as follows:

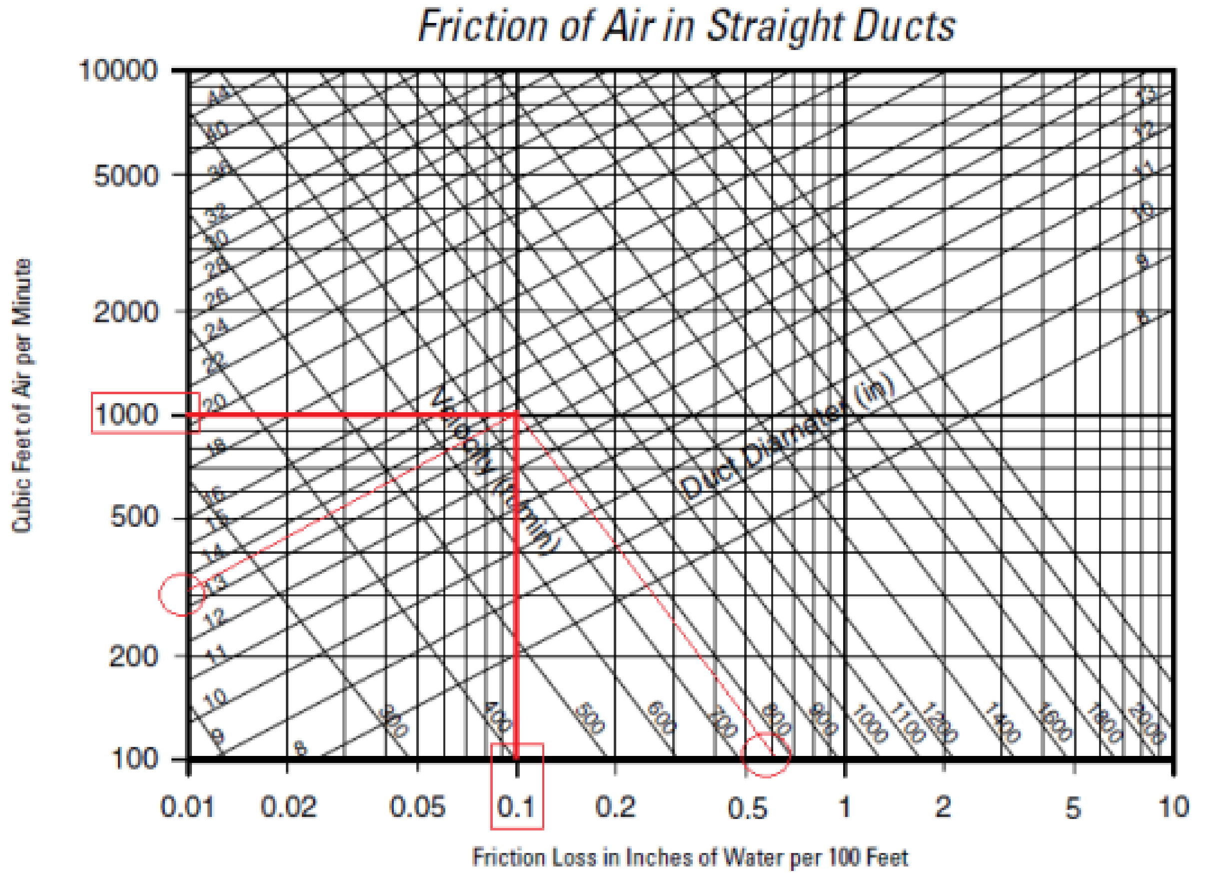
a. Select maximum air velocity in main duct after fan outlet.

b. Enter the friction chart knowing the cfm and velocity to determine the friction rate per 100 feet of duct length and select the diameter (refer to chart below).

c. From the friction rate obtained in the previous step, use the same value to determine diameters for all other sections of the ductwork.

d. The total friction loss in the duct system is then calculated by multiplying the friction loss per 100-foot of length to the equivalent length of the most critical path of the ductwork having maximum resistance.

Friction of Air in Straight Ducts



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The Concept of Duct Equivalent Length

Equivalent length refers to the number of feet of straight duct that imposes the same

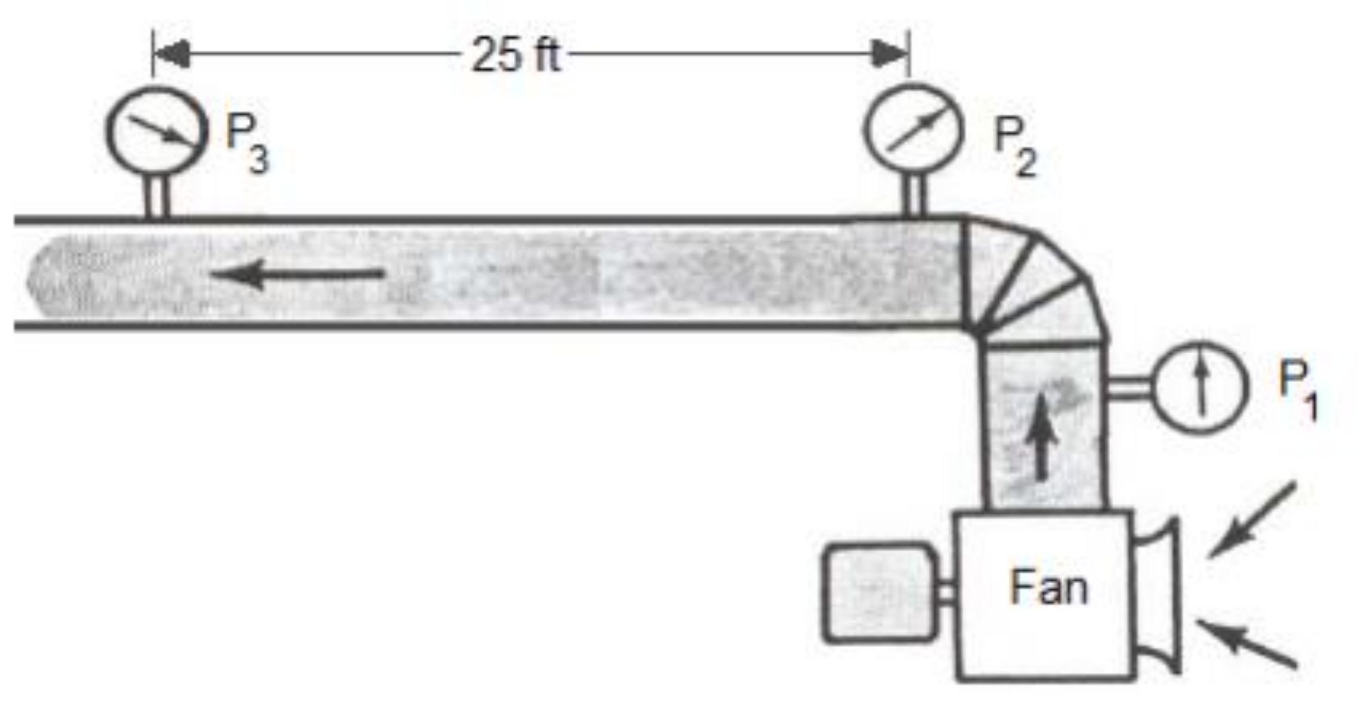
resistance to the air flow as a particular fitting. Suppose we have a blower duct set up

as shown in the figure below, and we can measure the static pressure before (P1) and

after (P2), the elbow. In addition, we have a third gauge (P3) which we can locate

anywhere along the length of the duct. Let's say the duct system is made up of 7-inch

round pipe, including the elbow.



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Fan Selection Example

The fan must be selected to deliver a specific volumetric flow rate (cfm) and generate

static pressure (in - H_2O) to overcome the pressure losses due to ducts, fitting, and the

components of an air handling unit (AHU). The total static pressure (TSP) is the sum of

the external static pressure (ESP) and internal static pressure (ISP).

TSP = ESP + ISP

where,

• ESP is the static pressure created downstream of the AHU and it includes all the duct losses from the fan until it reaches the discharge point. This could include a negative static pressure on the pull side of the fan and a positive pressure on the push side, or any combination of pressures the fan must overcome. It is estimated by the HVAC design engineer as he lays out the ductwork, diffusers, and terminal devices.

• ISP, as it pertains to the HVAC AHU, is the static pressure loss across the filters, coils, louvers, dampers, and twists and turns inside the AHU casing. ISP is usually provided by the supplier, but for custom designs, the HVAC design engineer estimates the pressure loss across the various components of the AHU.

Below is a simple model to calculate the total pressure loss (using the equal friction

method) and the selection of fan.

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Example

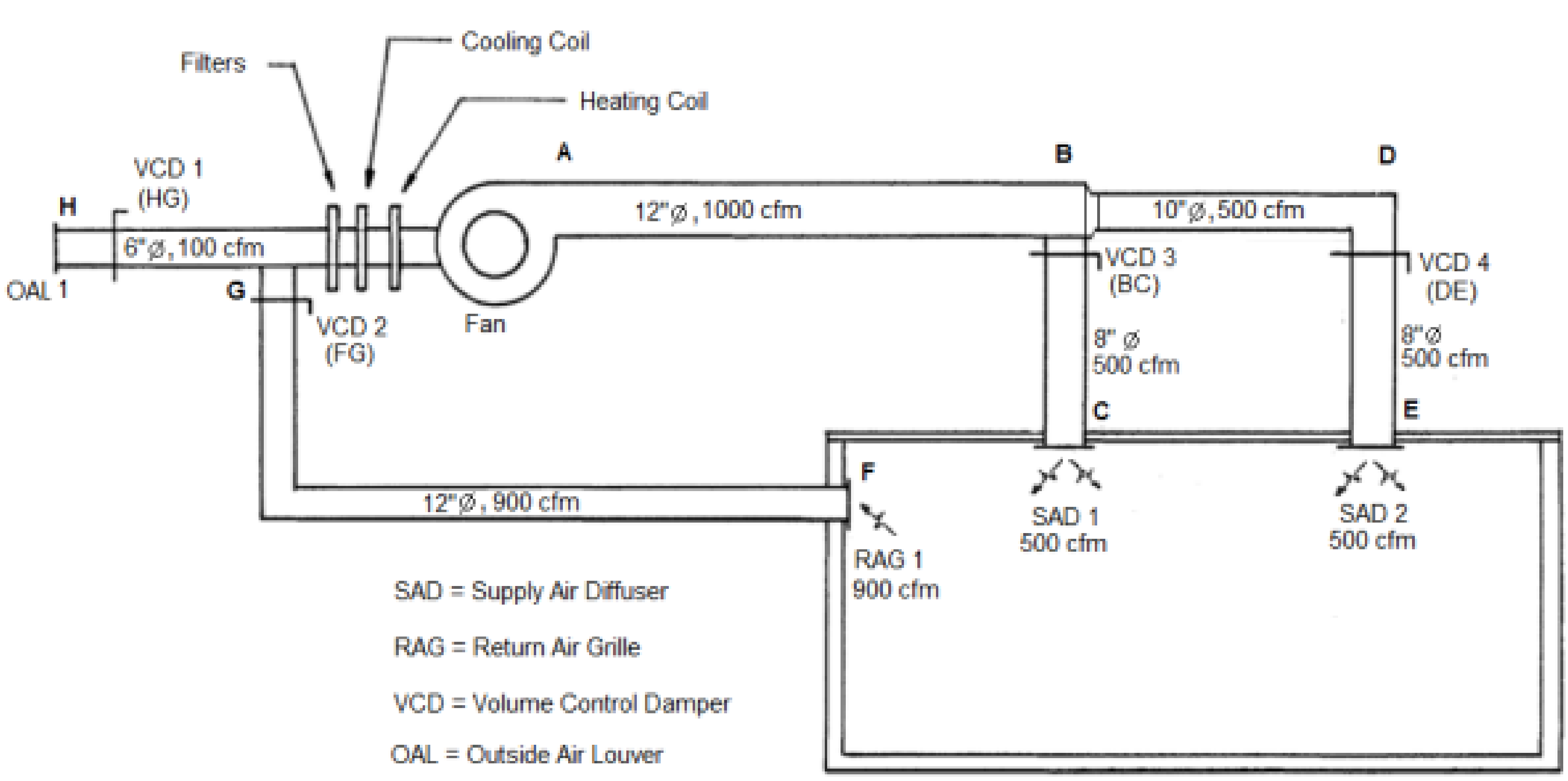
An air conditioning layout below depicts an air handling unit (AHU) supplying cool air to

an office space. The supply air fan discharges to supply air diffusers SAD -1 & SAD - 2

through the supply duct and draws air through the return duct via the return air grille

(RAG -1). It also draws fresh air through a louver (OAL -1). Estimate the total pressure

loss for sizing the fan.



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Fan System Effect

Typically the fan performance curves are developed by laboratory measurements with

the fan installed under ideal conditions. However, when the duct system is connected

to the fan, the fan operating conditions are influenced and the fan performance will

get altered. The figure below shows the air velocity profiles in a duct at various

distances from the outlet of a housed centrifugal fan. The air in the fan is pushed

against the outside of the housing by the movement of the fan wheel. Therefore, at

the fan outlet, there is a high velocity at the top of the fan outlet. However, at the

bottom of the fan outlet there is a negative velocity, because the air is swirling

back to the fan at the cut-off plate, attempting to re-enter the fan.

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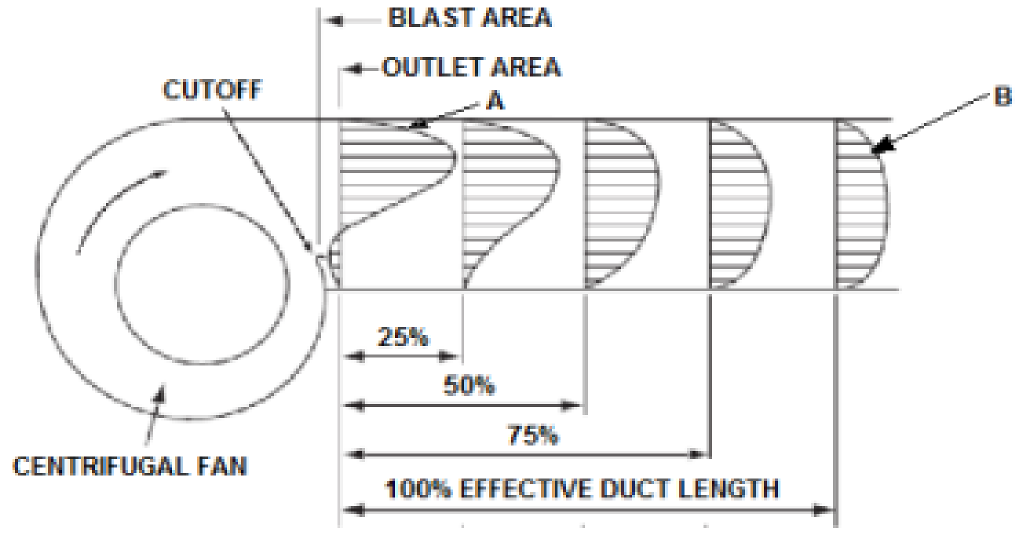
At point A in the figure, the velocity pressure is high and the available static

pressure is low. As the air moves down the duct, the velocity of the air becomes

more uniform across the duct, and the static pressure increases as the velocity

pressure decreases. At point B in the figure, the air velocity is uniform across the

duct, and low compared to the outlet velocity (point A).



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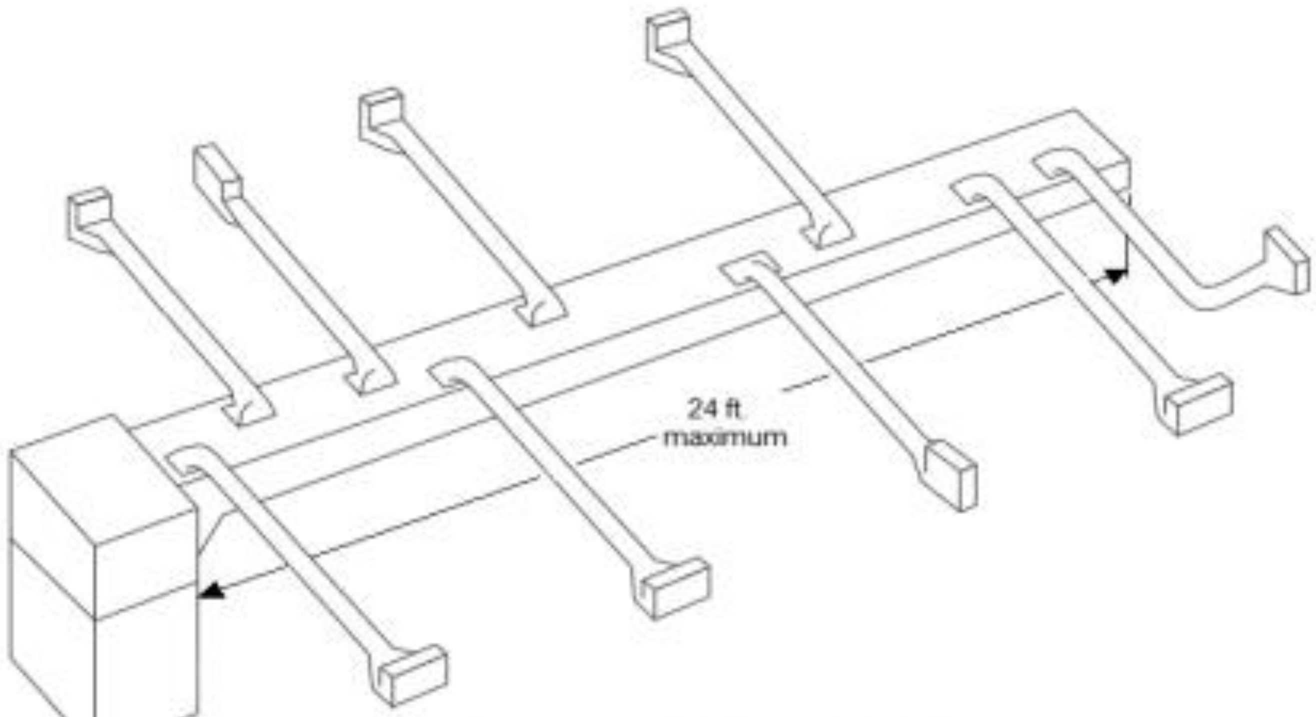
THE SUPPLY DUCT SYSTEM

The two most common supply duct systems are the ‘extended plenum’ system and the ‘radial’ system. The other options are spider and perimeter loop systems.

Extended Plenum Systems

In the extended plenum systems, a large main supply trunk of equal size is connected directly to the air handler. Smaller branch ducts and run-outs are connected to the trunk. The arrangement provides air flows that are easily balanced and can be easily designed to be located inside the conditioned space of the building.



Extended Plenum System

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The principal design limitation of the extended plenum is the maximum length of the

main supply trunk (of single size), which is usually limited to about 24 feet. When this

length is exceeded, pressure tends to build up toward the end of the duct, resulting in

too much air flow near the ends and insufficient air flow in branches closer to the air

handler.

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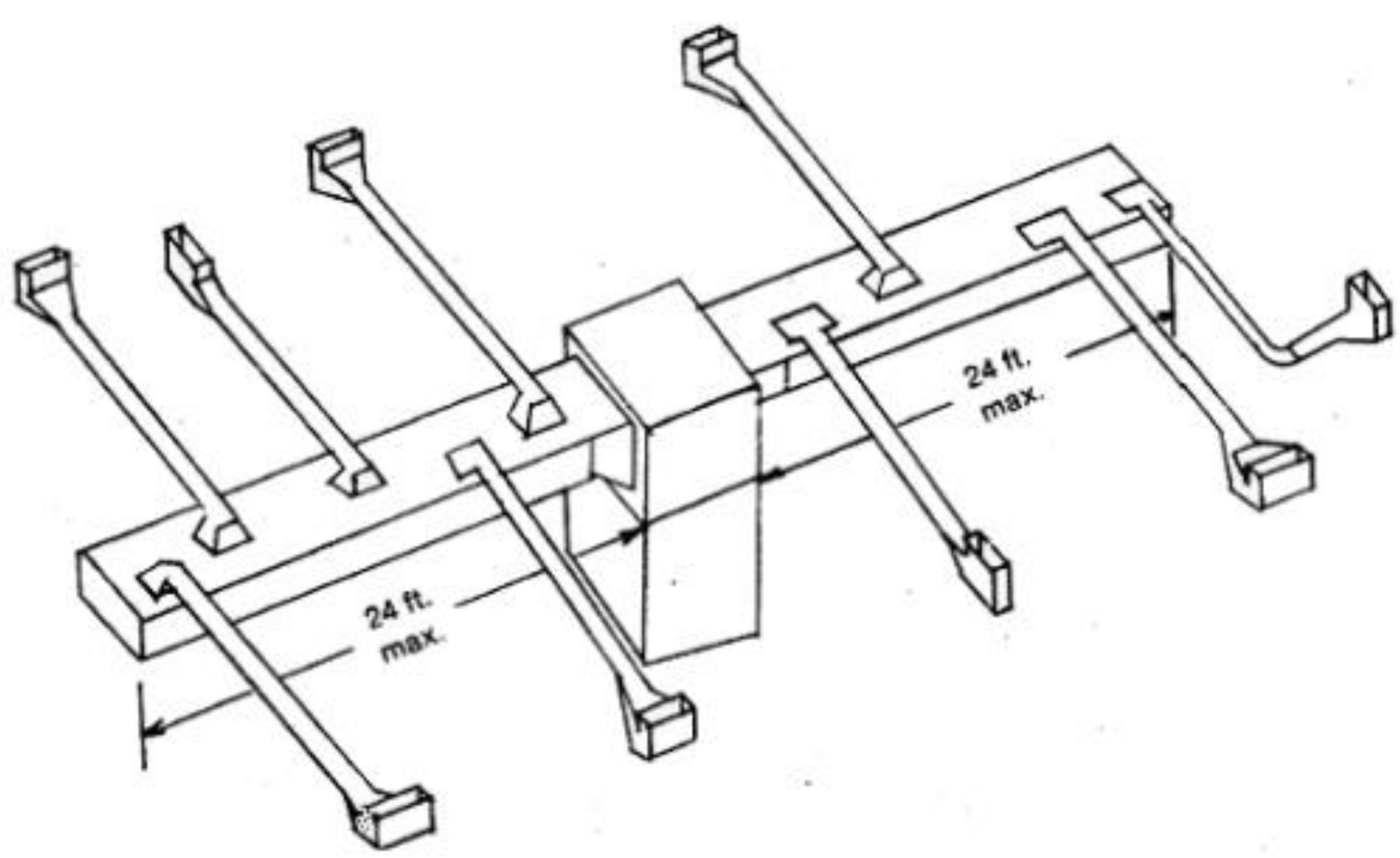
However, the extended plenum system can be modified to provide a double span, up

to 48 feet long, when the equipment is centrally located. See the figure below.



Extended Plenum System (Double Plenum, Equipment Centrally Located)

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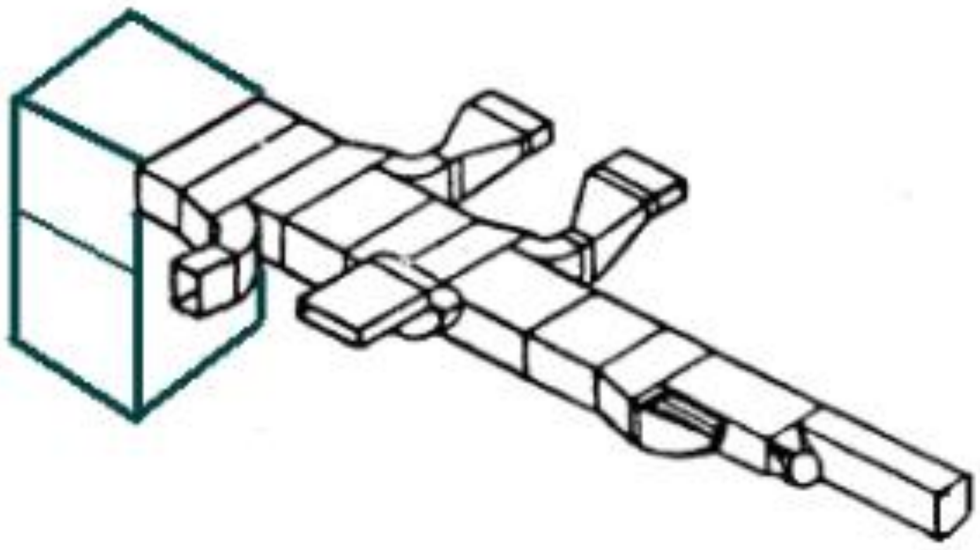
Reducing Trunk System

The reducing trunk duct system is very similar to the reducing plenum system, with

the exception that the trunk run is reduced in size after each branch takeoff. The reducing trunk system reduces the cross-sectional area of the trunk periodically after every branch duct or run-out. The arrangement maintains a more uniform pressure and air velocity in the trunk, which improves air flow in branches and runouts closer to the air handler. The system is well-balanced since each branch is specifically engineered. Effective design of reducing trunk systems requires precise determination of supply or extract air quantities for each terminal device (diffuser, register, and grille) in the room. The figure below illustrates the concept.



Reducing Trunk Duct System

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Pressure Balancing

The return openings will need to be 2 to 3 times the size of the supply duct depending

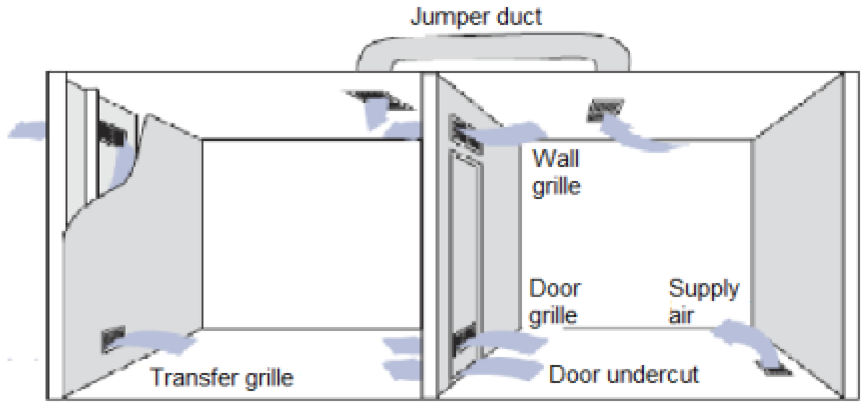
on system design velocities. This can take the form of transfer grille and jump ducts.

1. Transfer Grilles: They allow air to move from one space to another to alleviate pressure differences. For example, a transfer grille installed above a bedroom door enables air to move between the bedroom and the hallway, regardless of whether the door is open or closed. Door undercutting can help as well (for example ¾ inch undercut of a 32” door will create 24 sq. in. open area) but isn't normally sufficient on its own. A transfer grille and/or jump ducts are often required to equalize pressure and prevent over pressurization of

46

spaces. A “Rule of Thumb” considers 1 square inch of wall opening per cfm delivered to the room.

2. Jump ducts: They are short ducts that connect adjacent rooms and help balance air flow between rooms in cases where there’s one shared return grille serving the whole floor. As a general rule, no room will have less than a 6” diameter jump duct and, if more than 250 cfm needs to be transferred back to the main return area, it may be advisable to run a dedicated return duct to that area instead.



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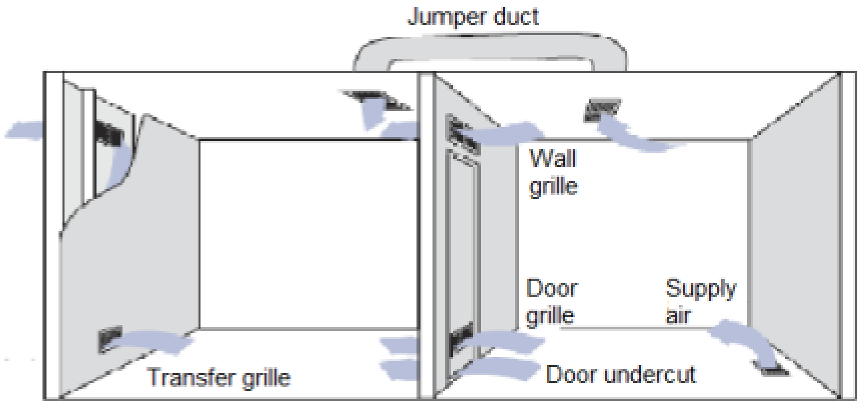

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ELHAMD – HOW TO SIZE AND DESIGN DUCTS

DUCT FITTINGS AND TERMINAL UNITS

Duct Fittings and Transitions

Duct losses occur across fittings and transitions. While SMACNA standards are

almost always the guiding document for construction, the experience has shown that

proper techniques are not always followed during fabrication and installation. Design

engineers often do not allow sufficient room to install proper sized transitions or

offsets. Often during installation, there is insufficient room and the fittings are

squeezed into tighter spaces. Good engineering practices include:

• Unless a reduction of two inches can be made, the original duct size should be

maintained.

• The slope of transition shall be 8 degrees to a maximum of 14 degrees. When

the duct area is increased, the slope is not to exceed eight degrees.

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• Use radius elbows rather than square elbows whenever space allows.

Where a full radius elbow cannot fit, a part-radius elbow or square elbow

with one or more splitters should be used.

• Turning vanes should only be used on low velocity systems where radius

elbows will not fit.

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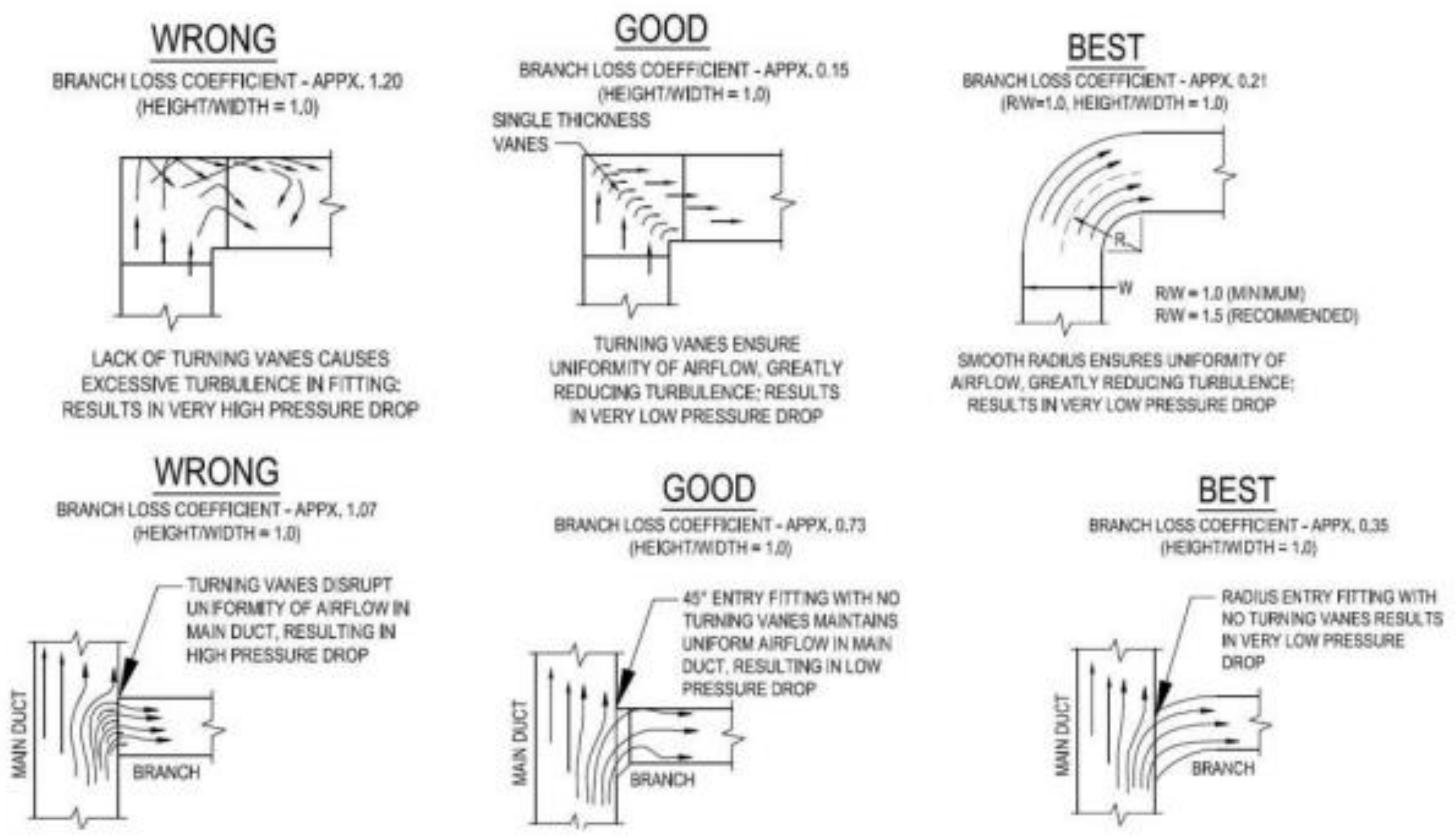


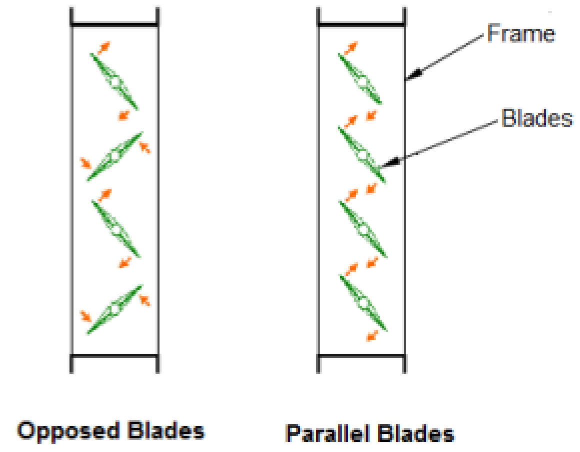
Volume Control Dampers

Dampers are used to control air flow. They may be required to fully shut off air flow or

regulate flow. Two main types are in use: parallel blades where the blades rotate in

one direction, or opposed blades where the adjacent blades rotate in opposite

directions.



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Steps for Selecting Air Terminals:

a. Determine the air flow requirement and room size.

b. Select the appropriate diffuser.

c. Determine the velocity, throw, noise and pressure drop across the diffuser.

Let's check the characteristics of diffuser (item c) with a help of an example. Table

below provides performance conditions of typical diffusers:

Air flow (cfm)	50	60	70	85	95	110	120
Velocity (fpm)	400	500	600	700	800	900	1000
Pressure drop (in.-wc)	0.056	0.090	0.131	0.175	0.225	0.290	0.355
Noise (NC)	14	20	24	28	32	35	38
Throw (ft)	5-8-13	7-9-12	8-12-19	9-13-18	10-15-21	12-17-24	13-19-31

Air velocity: It is the normal air velocity used for comfortable air distribution is **50 fpm** while the acceptable range is from 25 to 75 fpm.

Pressure drop: It is the pressure drop across the diffuser increases at higher velocities.

Noise Criteria (NC): NC increases at higher velocities. If a typical space requires a NC rating of 28-32, the corresponding maximum air flow is somewhere between 85 and 95 cfm.

Throw: Throw is defined as the horizontal distance from a diffuser at a specified velocity. For example, T50 = 15', indicates that at a distance of 15' from the diffuser, the velocity of the air will be 50 feet per minute. T100 = 10', indicates the distance at

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DUCT CONSTRUCTION & REINFORCEMENT

The Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

defines the duct construction standards for rectangular, round and oval ductwork for

positive or negative pressure classes up to 10" water column. Duct construction

standards allow an estimator to specify what gauges, connections, reinforcing and tie

rods are to be used for rectangular, round and oval ducts.

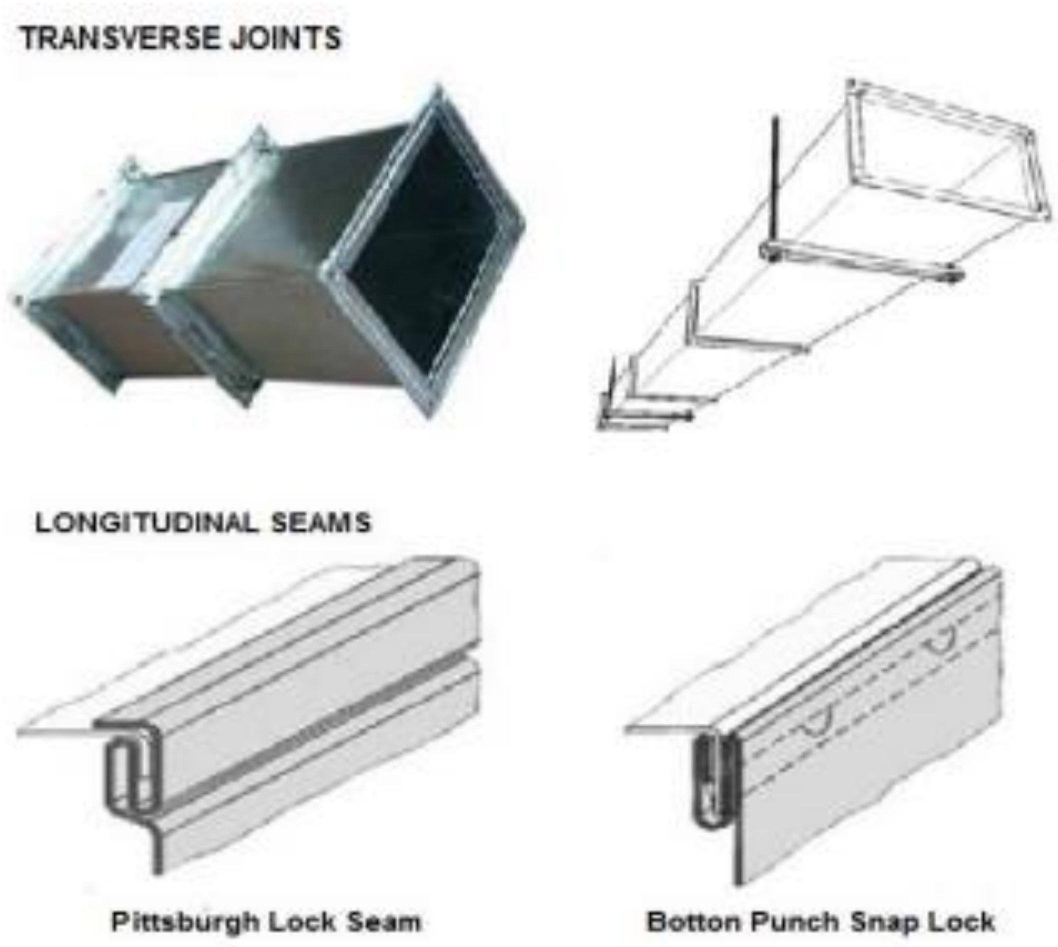
11.1 Duct Construction

Duct walls, transverse joints, longitudinal seams and reinforcements at or between

joints make up the basic elements of duct construction. Each size in a pressure class

has a minimum duct wall thickness and a minimum specification for joints and

reinforcements. The details are available in SMACNA 3rd edition 2005 guides.



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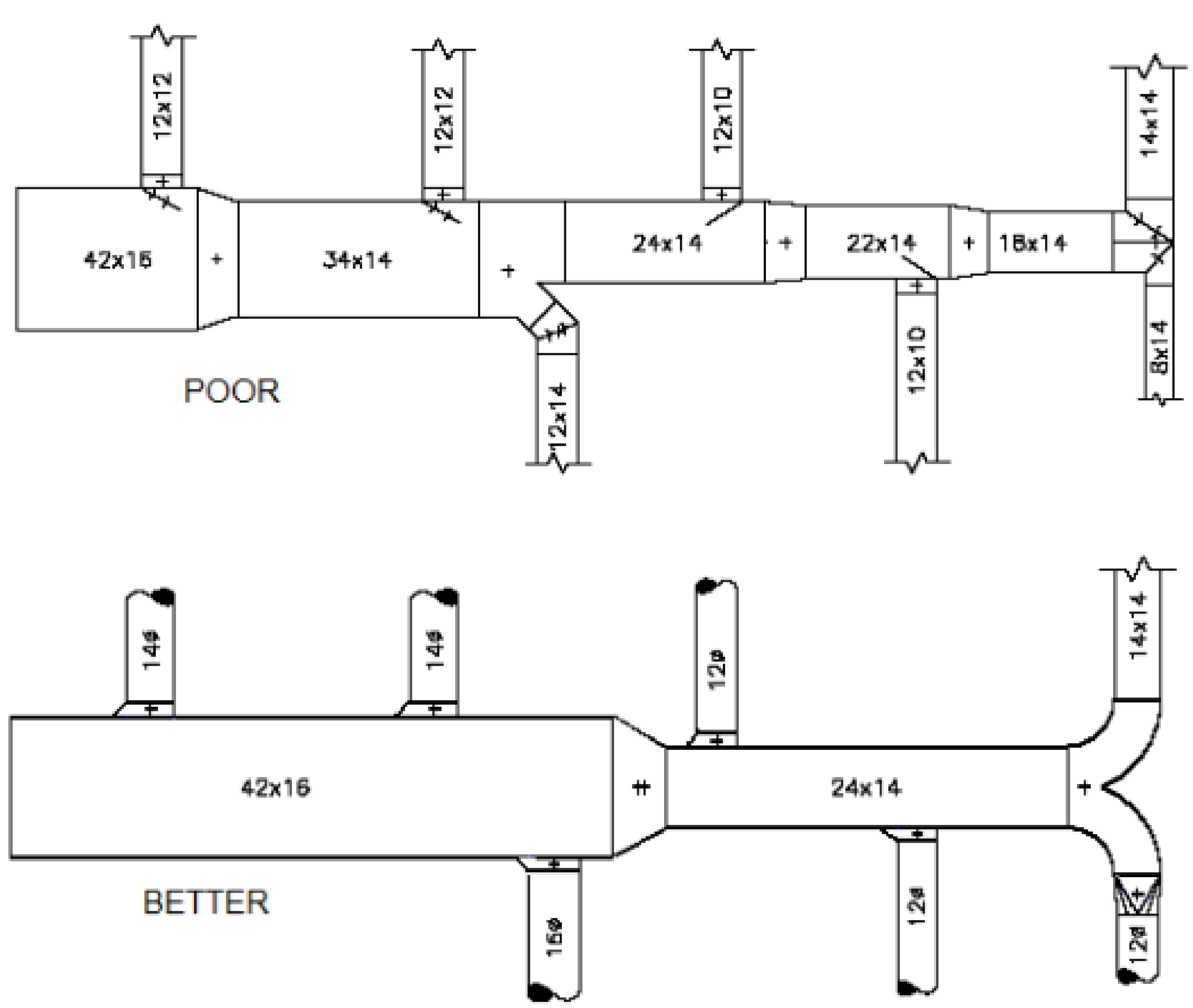
ELHAMD – HOW TO SIZE AND DESIGN DUCTS

Duct Fabrication and Lengths

Straight, standard length ducts cost less since duct machines, such as coil lines for rectangular ducts, automatically produce duct sections usually 5 feet long. Any rectangular duct that is not a standard length is technically a fitting since it cannot be made by the coil line. While a spiral round duct can virtually be of any length, it is commonly cut to 20-foot sections to fit in a standard truck. Oval duct standard lengths vary depending on the fabricator but manufactured ducts are typically 12 feet long. It is not uncommon for an inexperienced designer to include too many duct size reductions with the false impression that reducing duct sizes will reduce costs

Examples of Poor and Better Duct Design



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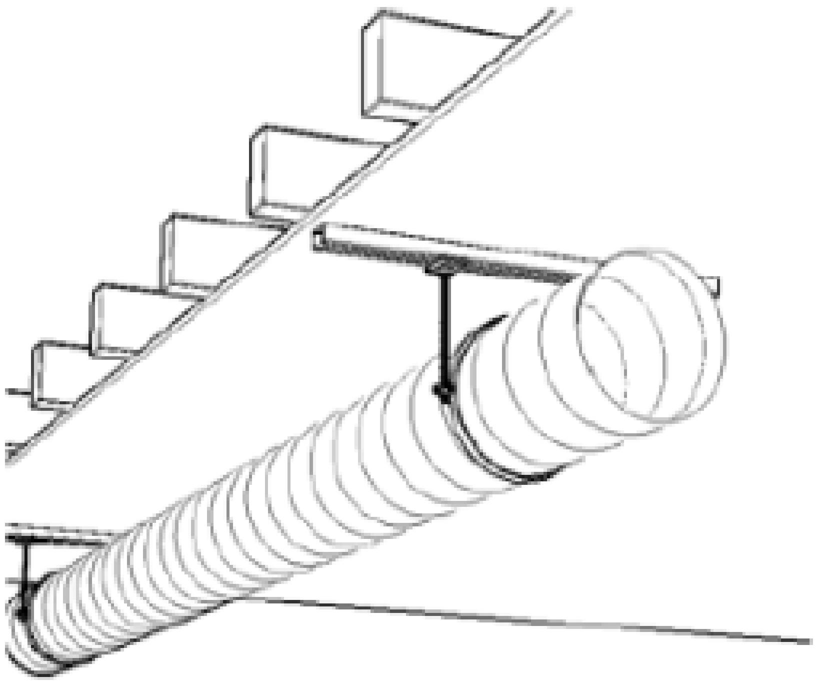
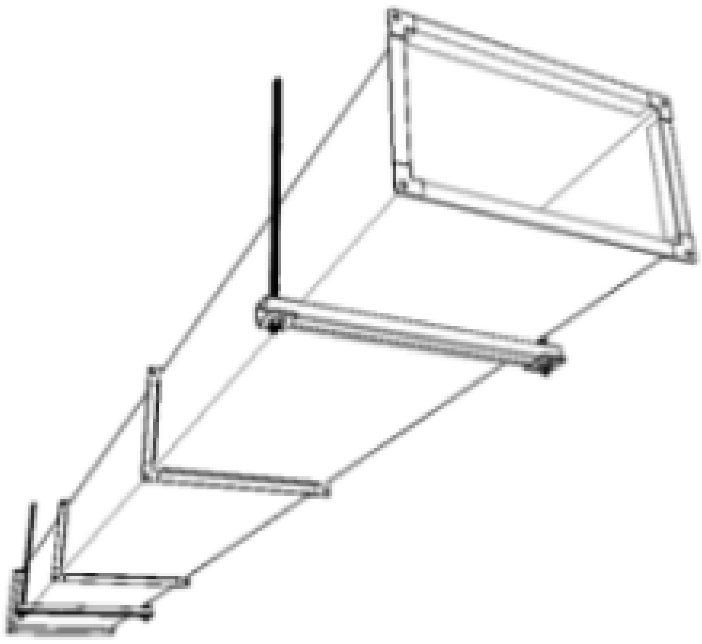
Duct Hanger Spacing

Cross-Sectional Perimeter of Duct	Maximum Spacing between Hangers
Horizontal ducts less than 4 ft.	8 ft.
Horizontal ducts 4 ft. to 10 ft.	6 ft.
Horizontal ducts greater than 10ft.	4 ft.





Duct Hanger

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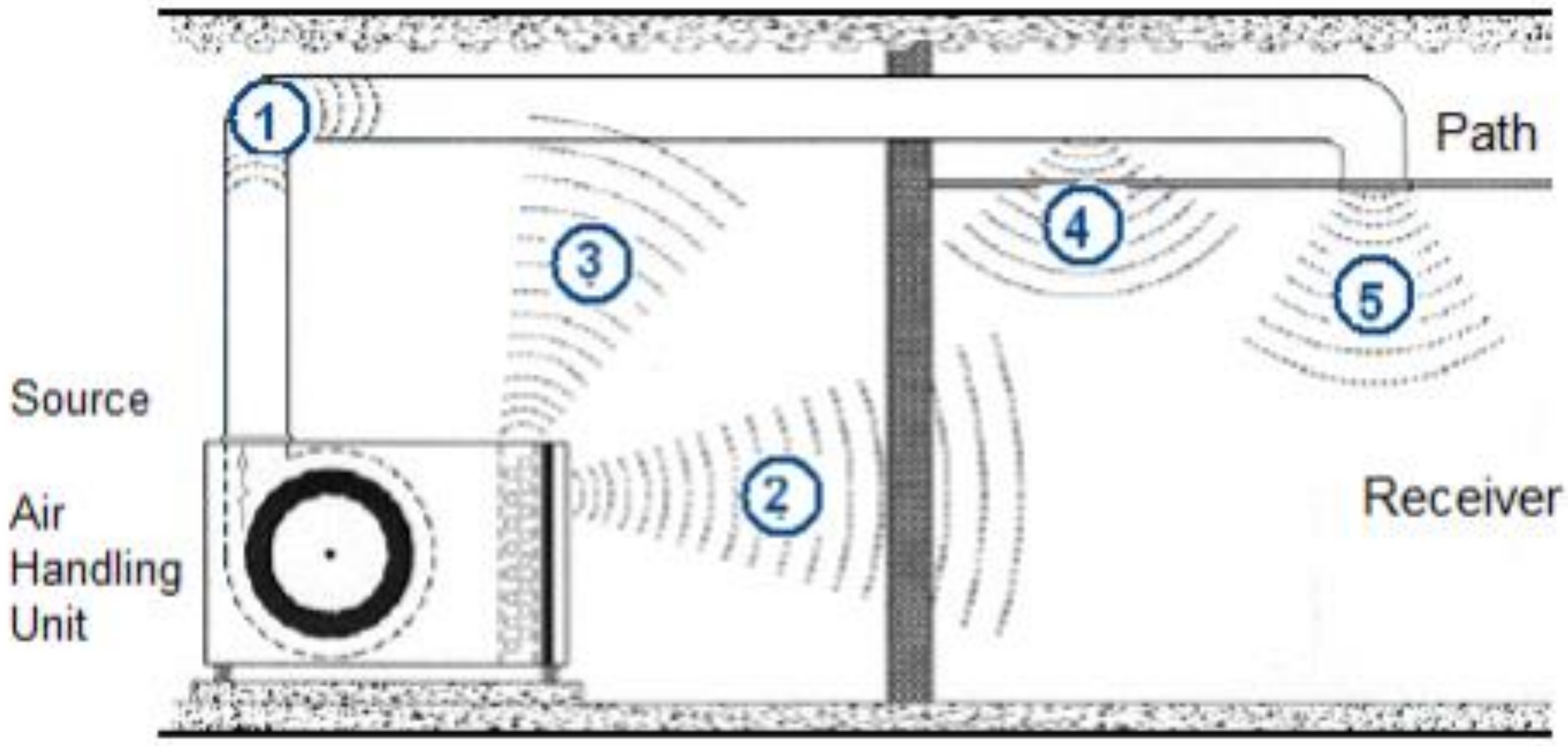
. DUCT ATTENUATION AND NOISE CONSIDERATIONS

The HVAC industry has established noise criteria (NC) values for evaluating the acceptability of sound levels. NC values for different types of buildings range from 30 to 40 decibels. A decibel is a unit of comparative sound measurement (a whispered conversation at a distance of 6 ft. from the ear, for example, has a sound pressure level of 30 decibels).

HVAC Noise Points

The figure below shows the noise points from a typical HVAC system.



TYPICAL MECHANICAL SYSTEM NOISE COMPONENTS

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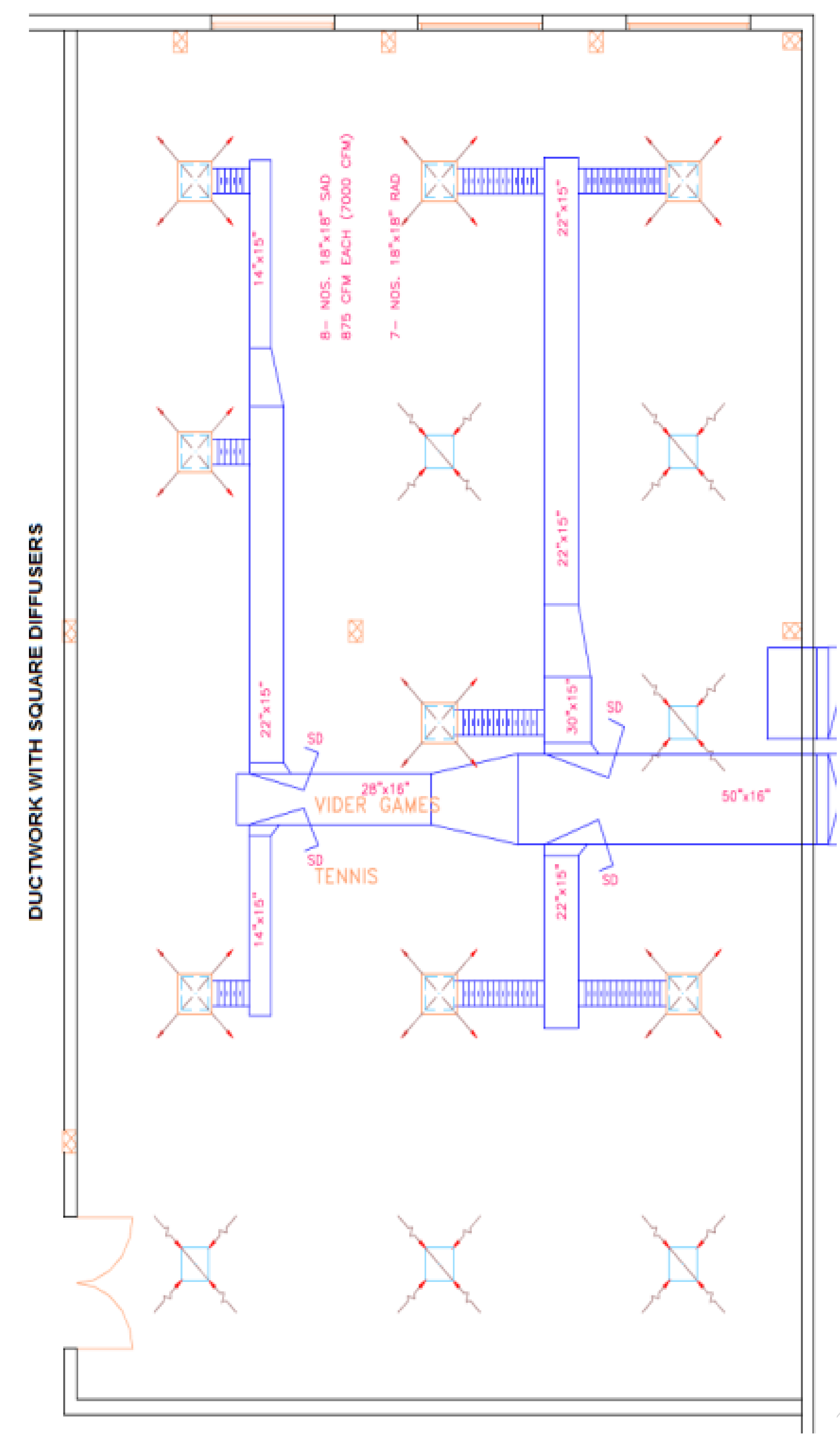
TYPICAL DUCT LAYOUTS



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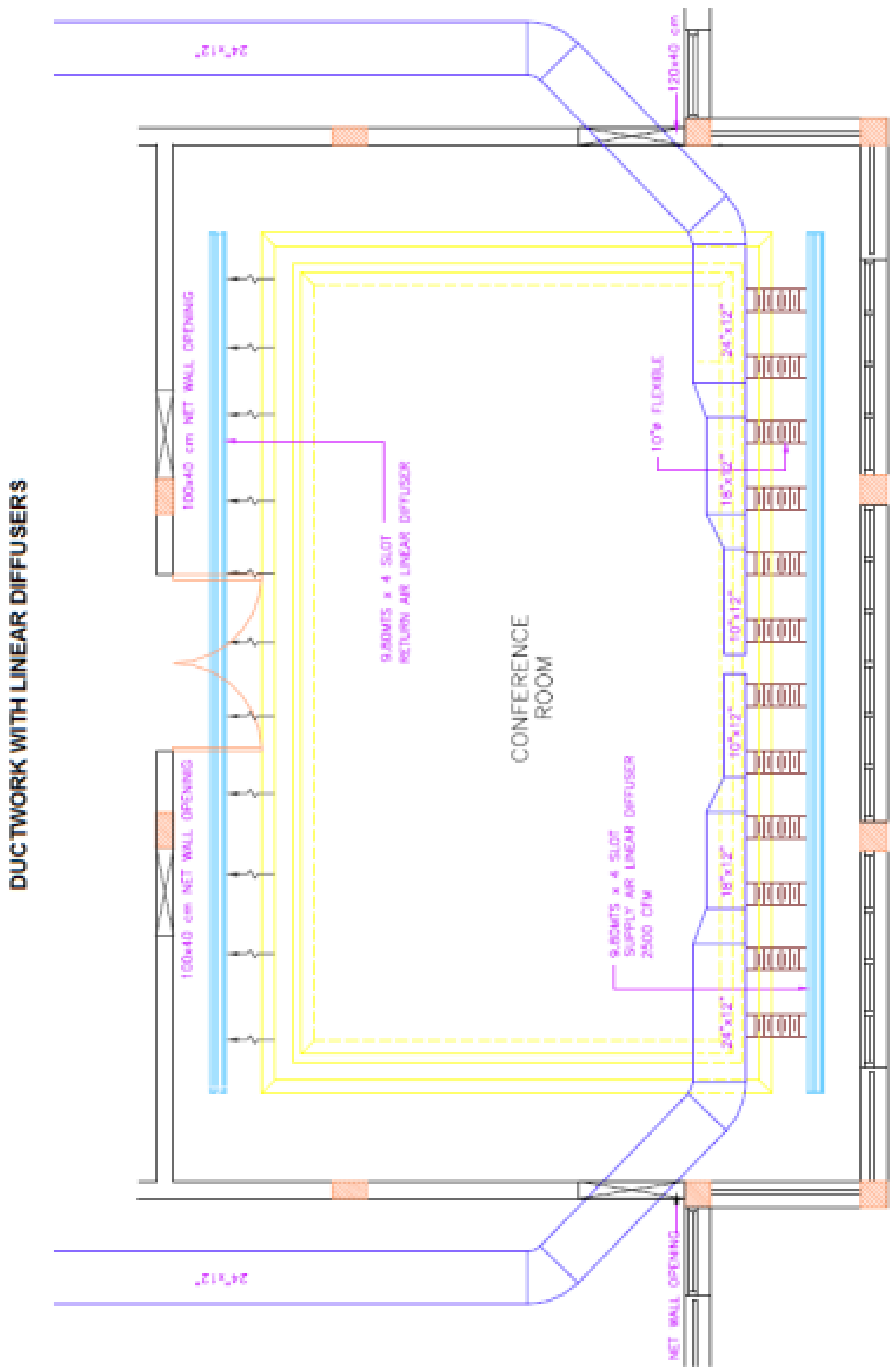

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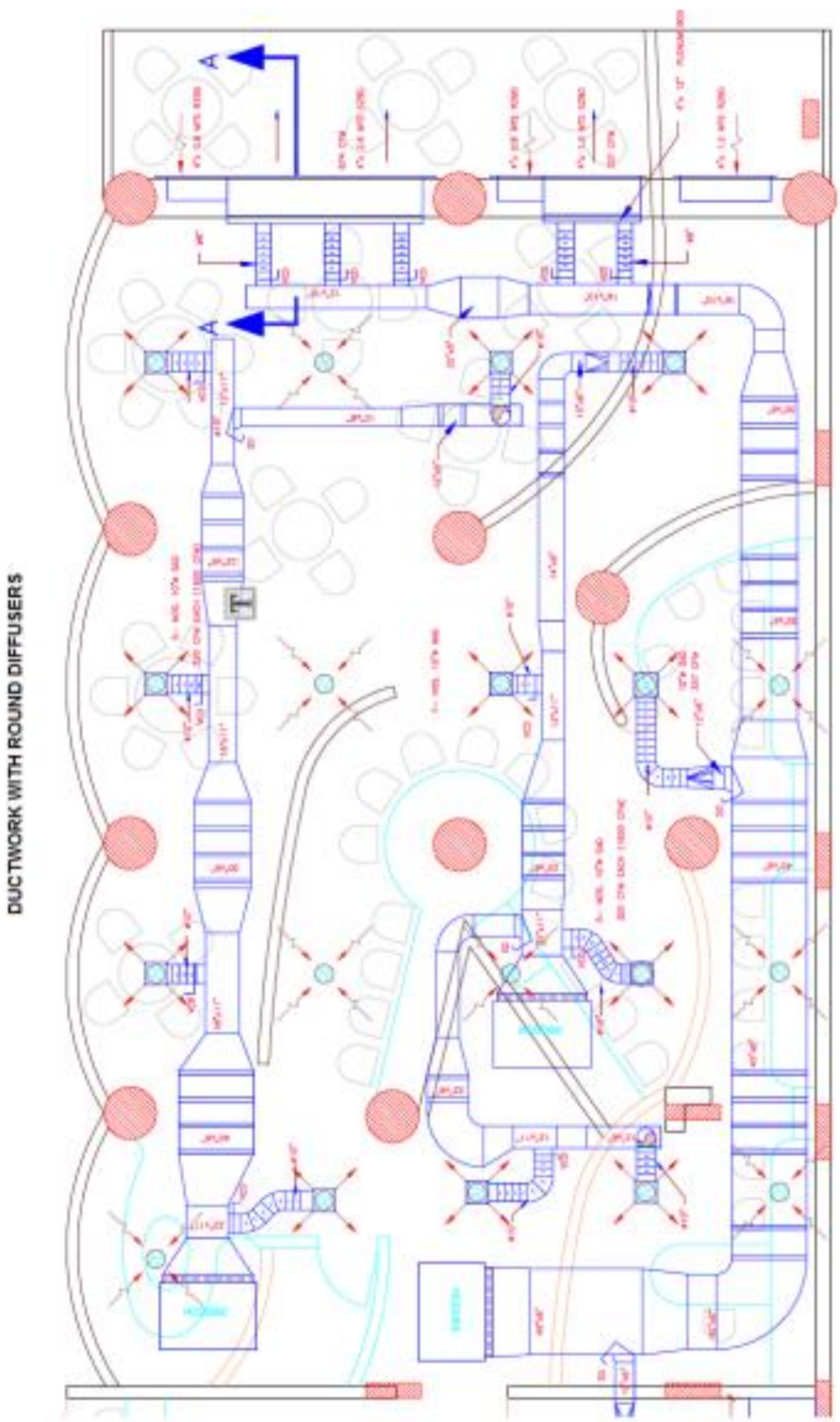

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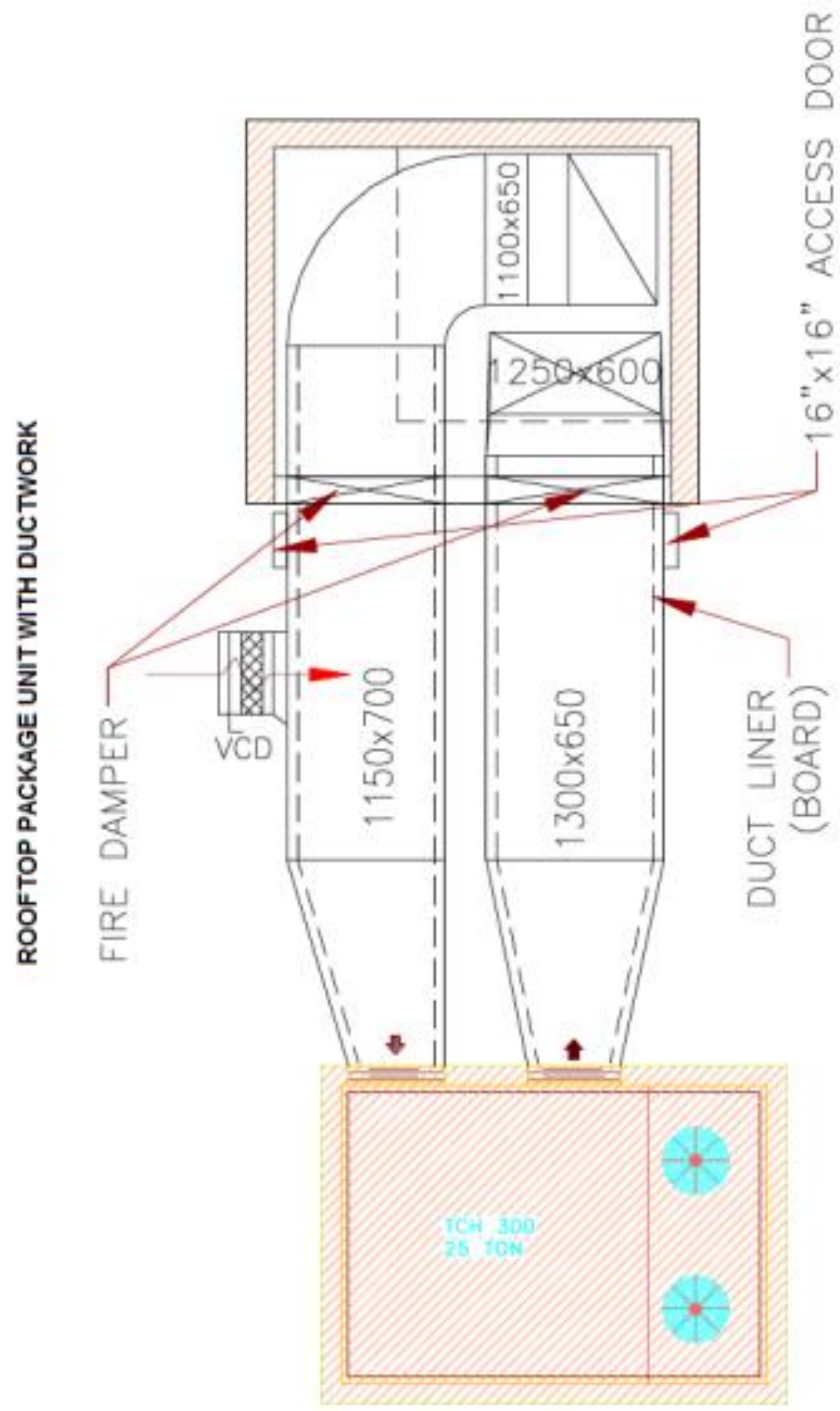

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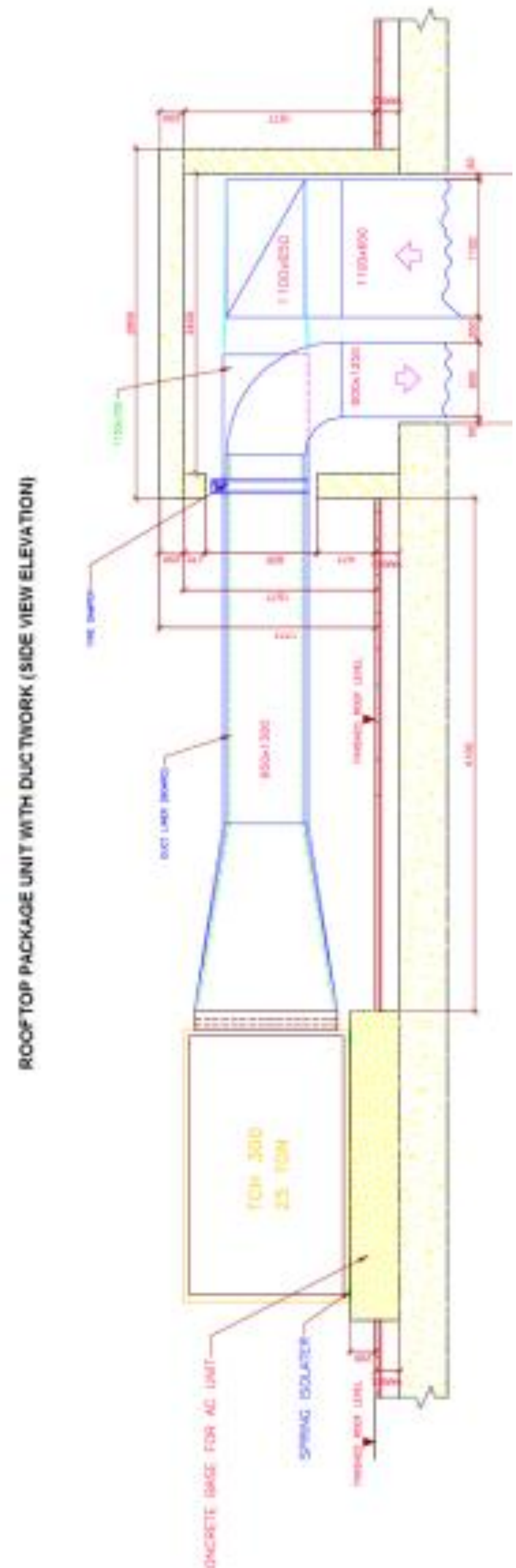

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TYPICAL DUCT LAYOUTS

Coordination between ductwork and structural element

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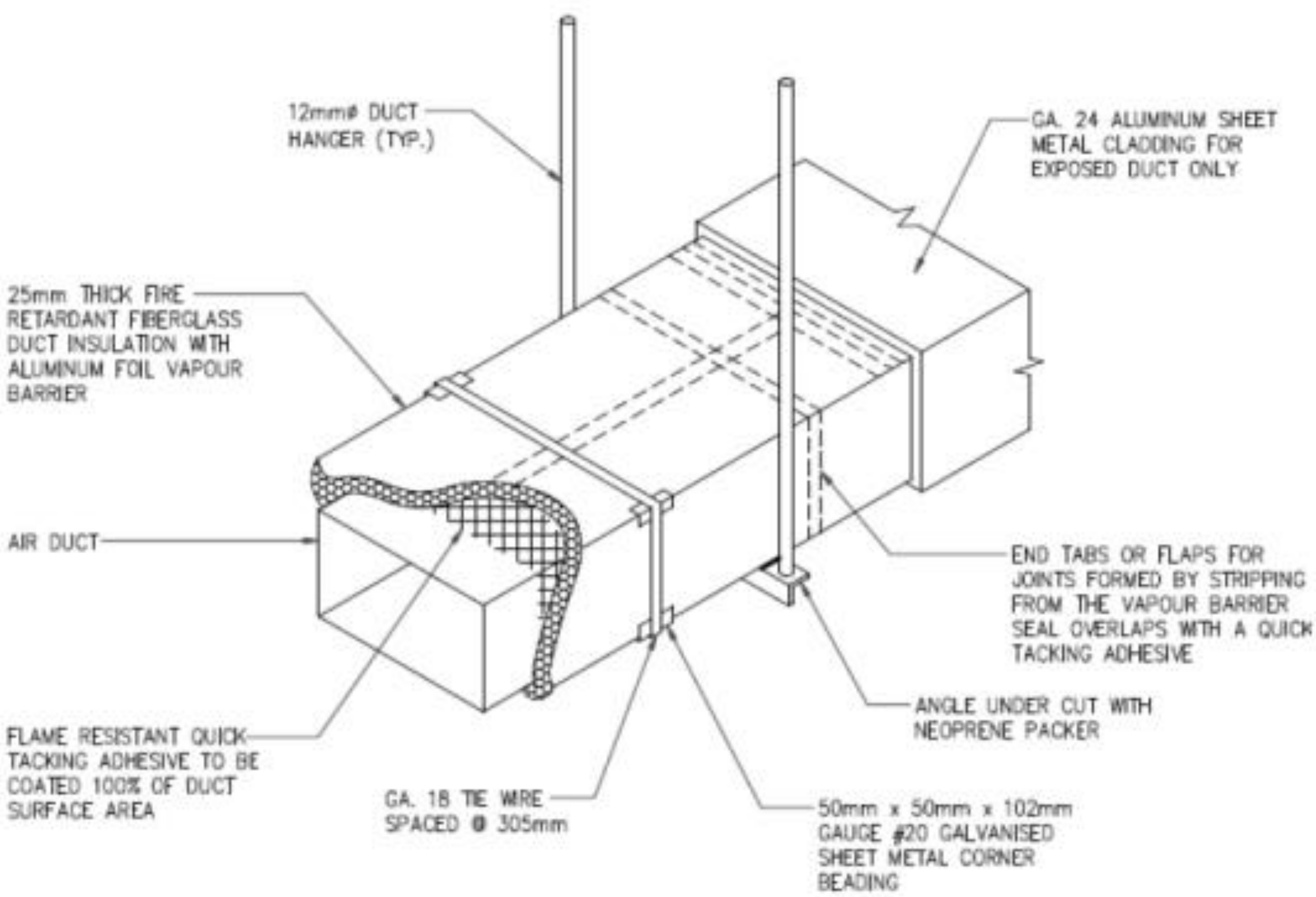
TYPICAL DUCT LAYOUTS

TYPICAL DUCT FABRICATION AND SUPPORTING



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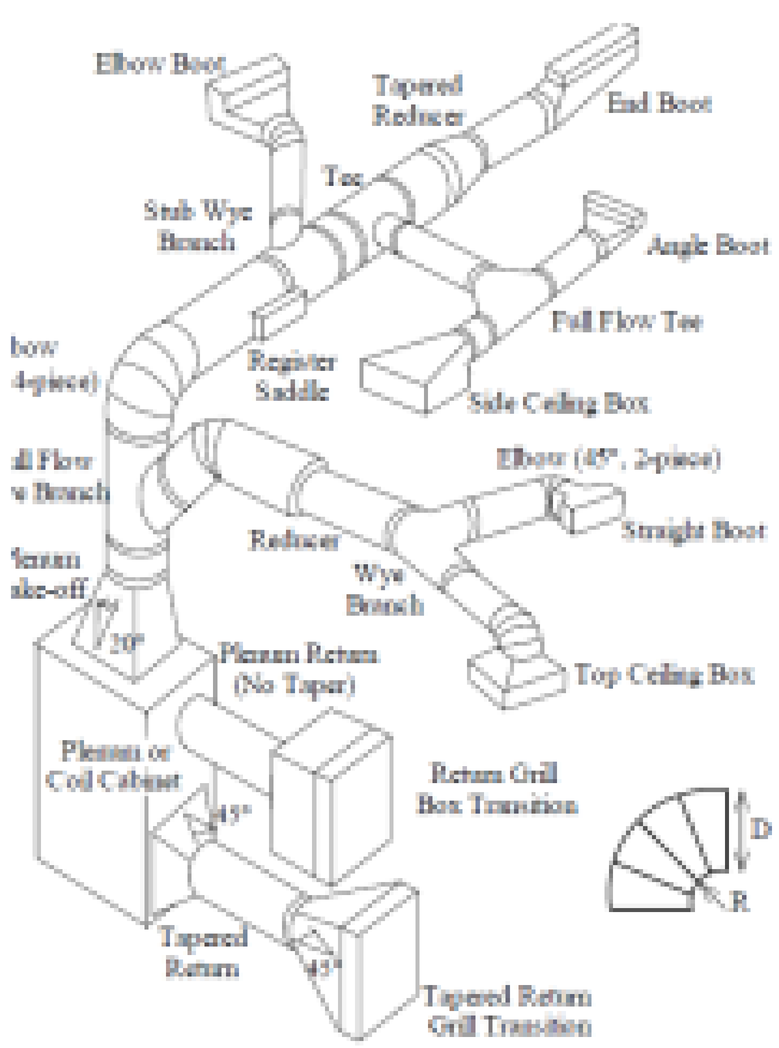
TYPICAL DUCT LAYOUTS

Round Duct Fittings and Transitions



ROUND DUCT FITTINGS & TRANSITIONS

Fitting Type	Eqv. Length @ Δh/L=0.1"/100'			Eqv. Length @ Δh/L=0.3"/100'		
	8"∅ Dia.	12"∅ Dia.	16"∅ Dia.	8"∅ Dia.	12"∅ Dia.	16"∅ Dia.
Std. 90°L (R/D=.75)	16	30	40	18	22	44
90°L (R/D=1.5)	8	15	21	10	16	24
Std. 45°L (R/D=.75)	11	18	27	12	21	30
45°L (R/D=1.5)	4	6	9	5	7	10
Tapered (45°) Reducer	4	5	10	4	6	11
Non-tapered Reducer	8	14	21	9	16	23
Tee (branch)	34	60	87	39	67	97
Full Flow Tee (branch)	13	22	32	14	24	35
Wye	8	8	13	14	19	21
Stub Wye	17	29	43	19	43	38
Full Flow Wye	14	24	35	16	27	39
Straight Boot	5	6	11	6	8	13
End Boot	30	55	80	35	60	90
Elbow Boot	20	30	48	21	30	53
Register Saddle	35	60	90	40	65	95
Top Ceiling Box	20	35	50	23	40	55
Plenum Take-off (20°)	13	22	32	14	24	35
45°Tapered Plen. Ret.	10	18	26	12	20	30
No-taper Return	28	50	70	31	55	80
Return Grill Box	13	23	33	15	25	37
Tapered (45°) Ret.Grill	6	10	15	7	11	17

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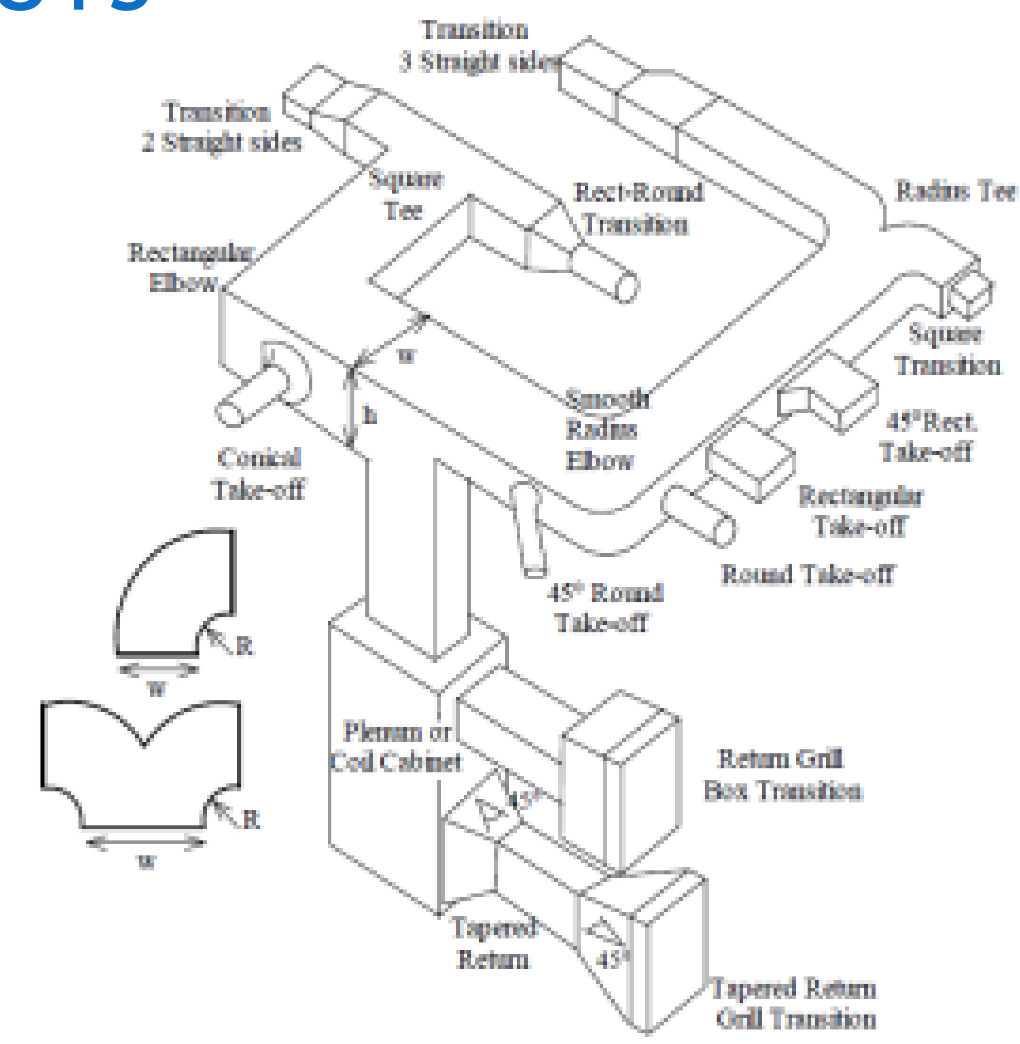
TYPICAL DUCT LAYOUTS

Rectangular Duct



Fitting	Eqv. Length @ $\Delta h/L$=0.1"/100'		Eqv. Length @ $\Delta h/L$=0.3"/100'	
Type	w/h=1	w/h=4	w/h=1	w/h=4
Rectangular Elbow	65	90	70	100
Rect. Elbow with Vanes	14	14	25	25
45° Rectangular Elbow	18	27	20	30
Radius Elbow (R/w=.75)	24	40	27	45
Radius Elbow w. Vanes	2	4	2	5
Square Tee	50	90	55	100
Square Tee w. Vanes	16	30	18	34
Radius Tee (R/w=1.5)	16	30	18	34
(Base L_{eqv} on outlet size)	A_{in}/A_{out}=2	A_{in}/A_{out}=4	A_{in}/A_{out}=2	A_{in}/A_{out}=4
Square Transition	12	13	19	21
3-Straight Side Transition	5	5	5	5
2-Straight Side Transition	5	5	5	5
Return Grill Box	19	20	21	22
Plenum Outlet (no radius)	40	40	44	44
Tapered (45°) Ret.Grill	8	9	9	10
	A_{in}/A_{out}=0.5	A_{in}/A_{out}=0.25	A_{in}/A_{out}=0.5	A_{in}/A_{out}=0.25
45°Tapered Plen. Ret.	15	29	17	32
No-taper Return	28	50	31	55
	8"∅ Dia.	12"∅ Dia.	8"∅ Dia.	12"∅ Dia.
Round Take-off	35	60	40	70
45° Round Take-off	17	30	20	40
Conical Take-off	25	43	28	48
	Q_{TO}/Q_{in}=.1	Q_{TO}/Q_{in}=.4	Q_{TO}/Q_{in}=.1	Q_{TO}/Q_{in}=.4
Rectangular Take-off	48	52	55	60
45° Rect. Take-off	50	55	60	65

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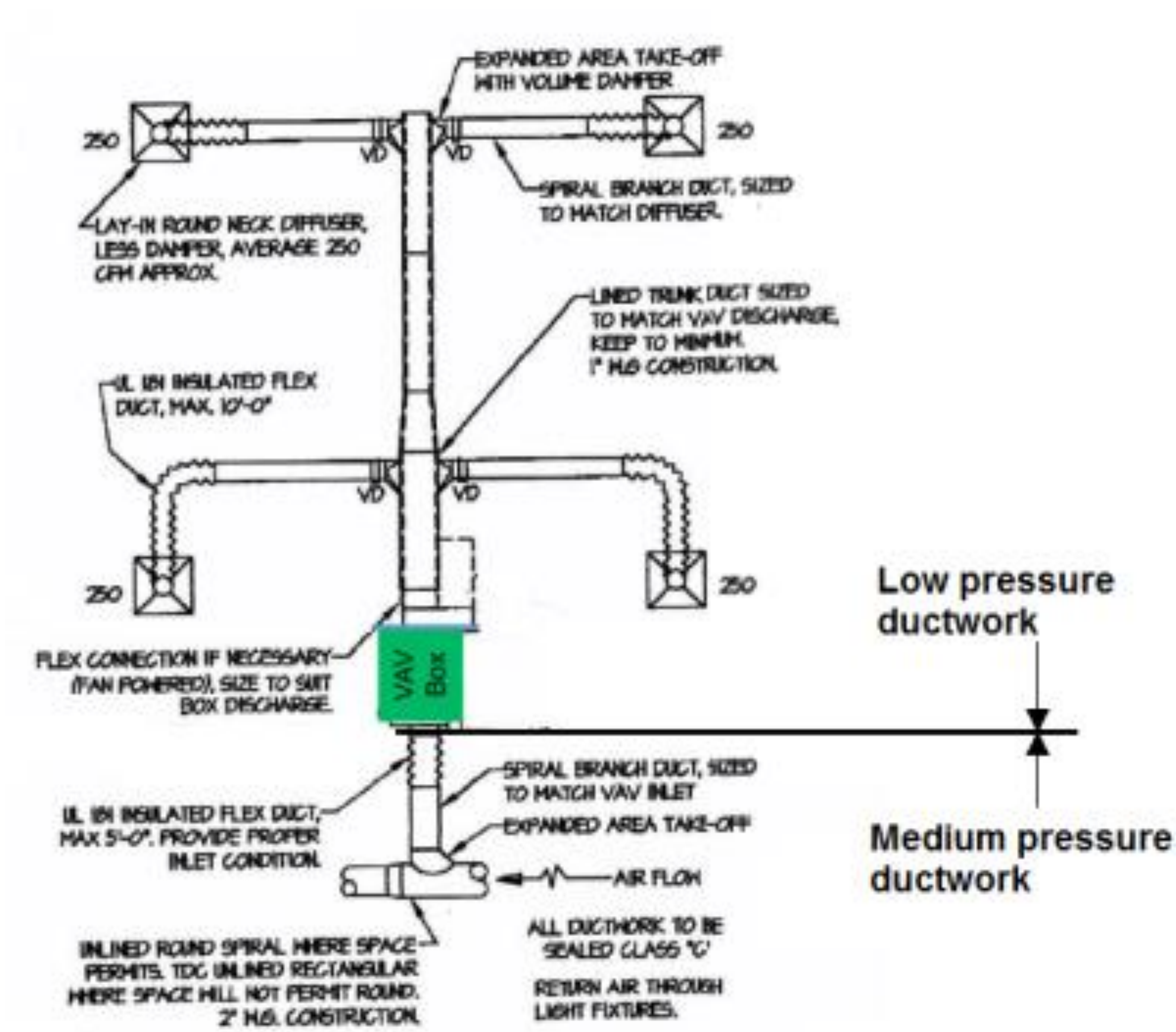
TYPICAL DUCT LAYOUTS

LOW PRESSURE DUCTWORK WITH VAV TERMINAL BOX



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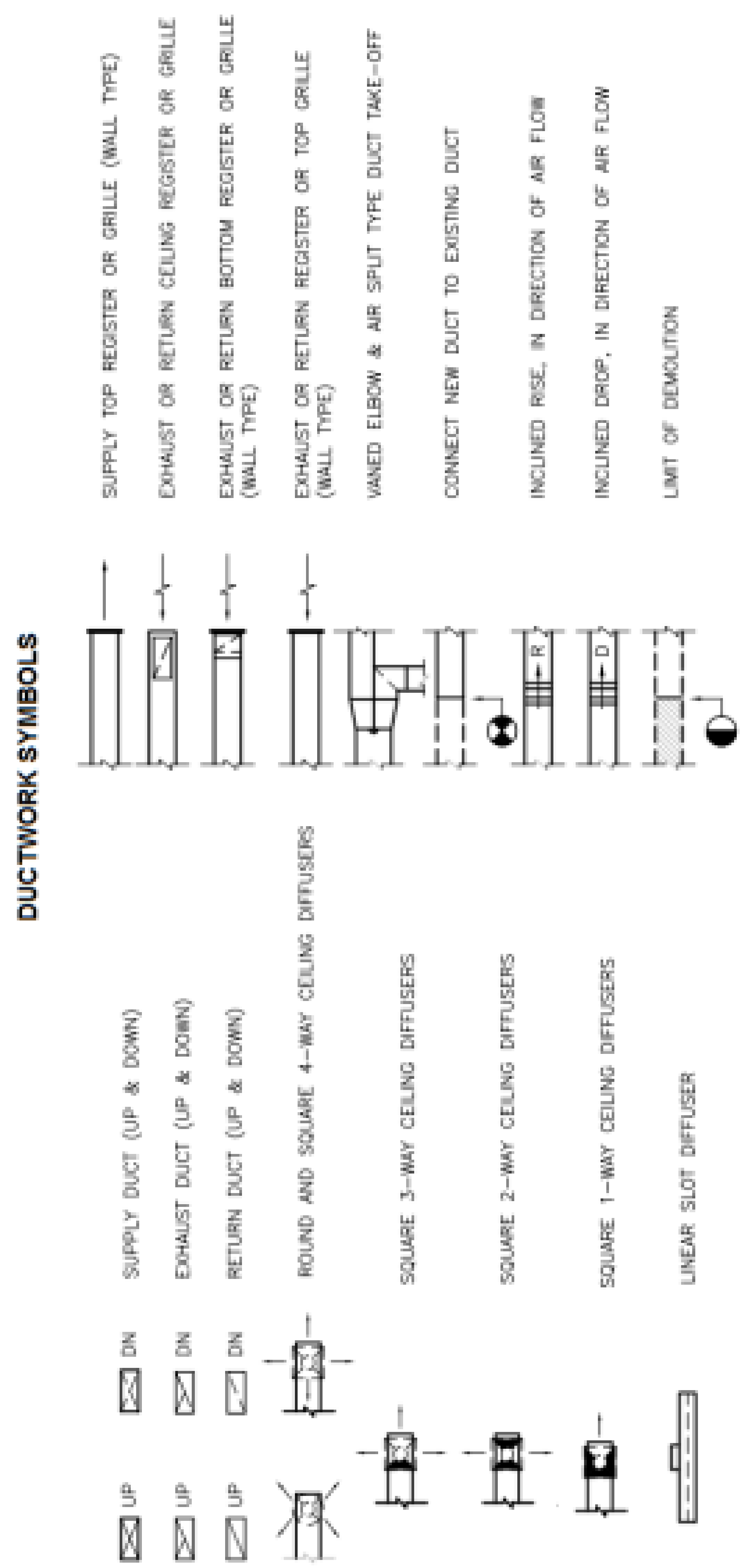

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TYPICAL DUCT LAYOUTS

Standard Sheet Metal Work Symbols

SYMBOL MEANING	SYMBOL	SYMBOL MEANING	SYMBOL
POINT OF CHANGE IN DUCT CONSTRUCTION (BY STATIC PRESSURE CLASS)		SUPPLY GRILLE (SG)	20 × 12 SG / 700 CFM
DUCT (1ST FIGURE, SIDE SHOWN 2ND FIGURE, SIDE NOT SHOWN)	20 × 12	RETURN (RG) OR EXHAUST (EG) GRILLE (NOTE AT FLR OR CLG)	20 × 12 RG / 700 CFM
ACOUSTICAL LINING DUCT DIMENSIONS FOR NET FREE AREA		SUPPLY REGISTER (SR) (A GRILLE + INTEGRAL VOL. CONTROL)	20 × 12 SR / 700 CFM
DIRECTION OF FLOW		EXHAUST OR RETURN AIR INLET CEILING (INDICATE TYPE)	20 × 12 GR / 700 CFM
DUCT SECTION (SUPPLY)	S 20 × 12	SUPPLY OUTLET, CEILING, ROUND (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	20 / 700 CFM
DUCT SECTION (EXHAUST OR RETURN)	E OR R 20 × 12	SUPPLY OUTLET, CEILING, SQUARE (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	12 × 12 / 700 CFM
INCLINED RISE (R) OR DROP (D) ARROW IN DIRECTION OF AIR FLOW	R	TERMINAL UNIT. (GIVE TYPE AND/OR SCHEDULE)	T.U.
TRANSITIONS: GIVE SIZES. NOTE F.O.T. FLAT ON TOP OR F.O.B. FLAT ON BOTTOM IF APPLICABLE		COMBINATION DIFFUSER AND LIGHT FIXTURE	
STANDARD BRANCH FOR SUPPLY & RETURN (NO SPLITTER)	S R	DOOR GRILLE	DG 12 × 6
SPLITTER DAMPER		SOUND TRAP	ST
VOLUME DAMPER MANUAL OPERATION	VD	FAN & MOTOR WITH BELT GUARD & FLEXIBLE CONNECTIONS	
AUTOMATIC DAMPERS MOTOR OPERATED	SEC MOD	VENTILATING UNIT (TYPE AS SPECIFIED)	
ACCESS DOOR (AD) ACCESS PANEL (AP)	OR AD	UNIT HEATER (DOWNBLAST)	
FIRE DAMPER: SHOW —◄ VERTICAL POS. SHOW —◆ HORIZ. POS.	FD AD	UNIT HEATER (HORIZONTAL)	
SMOKE DAMPER	SD AD	UNIT HEATER (CENTRIFUGAL FAN) PLAN	
CEILING DAMPER OR ALTERNATE PROTECTION FOR FIRE RATED CLG	C	THERMOSTAT	T
TURNING VANES		POWER OR GRAVITY ROOF VENTILATOR-EXHAUST (ERV)	
FLEXIBLE DUCT FLEXIBLE CONNECTION		POWER OR GRAVITY ROOF VENTILATOR-INTAKE (SRV)	
GOOSENECK HOOD (COWL)		POWER OR GRAVITY ROOF VENTILATOR-LOUVERED	
BACK DRAFT DAMPER	BDD	LOUVERS & SCREEN	36 × 24L

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