Problems – Air and Water Distribution Systems

ME419
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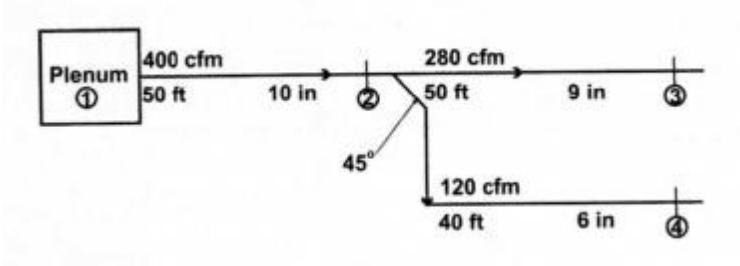
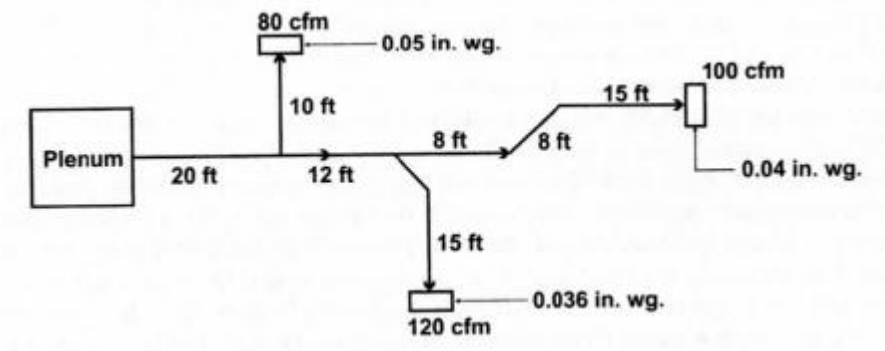
1. Cooled air at 1 atm, 50 F, and 10% relative humidity is transported in a 600 ft long circular sheet metal duct at a rate of 800 cfm. If the head loss is not to exceed 1.5 inches of water, determine the minimum diameter of the duct. You may assume the inside surface of the duct is smooth ($\varepsilon/D \approx 0$).

2. Heated air at 1 atm, 100 F, and 40% relative humidity is transported in a 300 ft long rectangular sheet metal duct at a rate of 400 cfm. If the head loss is not to exceed 1 inch of water, recommend the size of the rectangular duct.

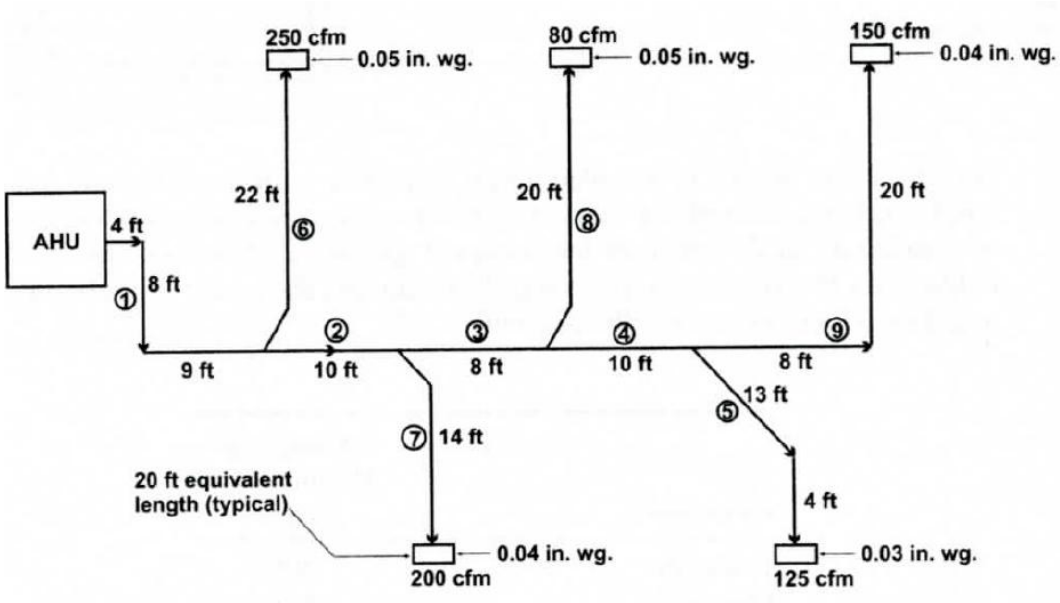
3. A design engineer wishes to select an appropriate fan for the following galvanized steel duct system. Estimate the pressure loss for each branch of the duct system.



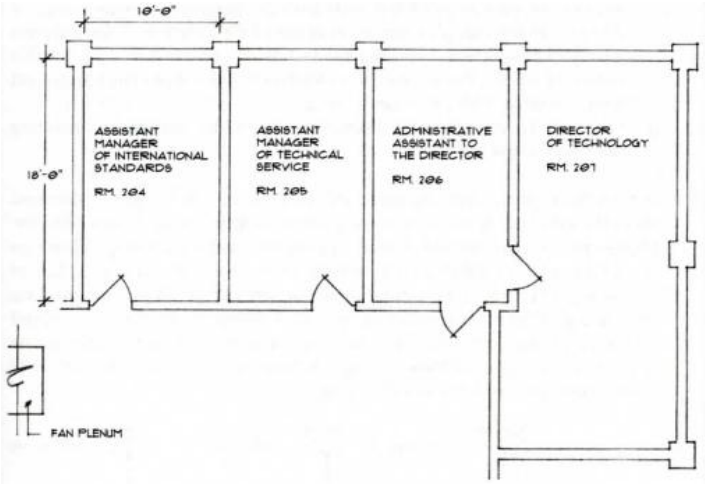
4. The duct system shown is one branch of a complete low-velocity air distribution system. The system is a perimeter type, located below the finished floor. The diffuser boots are shown, complete with the pressure losses. Design a round duct system, bearing in mind that a total pressure of 0.21 in. wg is available at the plenum.



5. A draw-through air-handling unit (AHU) will be used to supply conditioned air as shown in the schematic drawing below. Within the AHU assembly, the filter section has a pressure loss of 0.10 in. wg, the heating/cooling coil section has a pressure loss of 0.20 in. wg, arid the casing has a miscellaneous loss of 0.05 in. wg. The AHU is a modular unit complete with a fan that can produce 0.60 in. wg of total pressure at the required design flows. Design a round ductwork system, ensuring that the location of and pressure drops across appropriate dampers for balancing the system is clear for the convenience of the mechanical contractor and the client.



6. For most building design projects, the architectural trade tends to be the consultant (i.e., the lead consultant for the project) who hires the mechanical and the electrical trades as subconsultants on the project. In most cases, the mechanical engineering subconsultant has expertise in the design of ductwork to transport air for the purposes of heating and /or cooling an occupied space. The following section of a second floor tenant plan of an office building has been given by an architect.



For the offices shown in the plan above (complete with the occupant and work function), the architect has requested the design of a ductwork system to provide air at 75 F to heat the occupied spaces. A HVAC engineer has determined the amount of air required to maintain the space temperature, and they are shown in the following table.

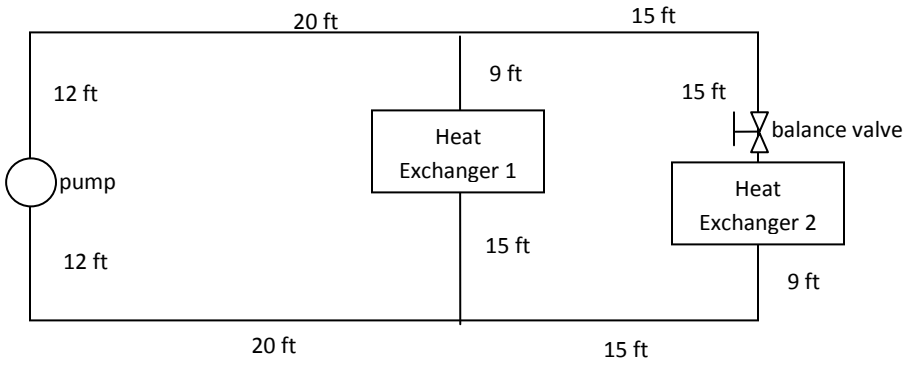
Office Space	Heating Air Requirement (cfm)
Office 204	310
Office 205	450
Office 206	170
Office 207	500

However the engineer missed the fact that ASHRAE Standard 62 requires that 20 cfm per person of fresh outdoor air must be provided.

(a) To ensure an esthetically pleasing finish in the space, the architect has requested the design of a ductwork system based on round ducts. Because most of the occupants of this section of the floor are managers and/or directors in the complex hierarchy of the client's company, the architect would like to have a dedicated fan installed with the ductwork for this section of offices. The fan is to be located on the roof above the offices, and it will be fitted with a plenum section.

(b) Based on the design of the ductwork, specify the minimum operating condition of the fan.

7. Fred, an engineering student, has prepared the following piping schematic to supply water to two heat exchangers for a project in his garage. The lengths shown are in feet. Piping is Schedule 40, commercial steel. The balance valve is of the globe type. The head loss of each heat exchanger is 10 ft. The flow through heat exchanger 1 is 20 gpm. The flow through heat exchanger 2 is 8 gpm.



1. Is Fred's design correct (i.e., did he place the balance valve in the correct location)?

2. Complete the design of the piping system <u>using a single diameter pipe throughout.</u>

3. Determine the globe valve setting (in percent) following the linear charts below.

4. Find a suitable pump for the circuit using the Internet. Here is a suggestion:
   http://www.tacocomfort.com/#
   http://www.tacocomfort.com/product-category/pumps/

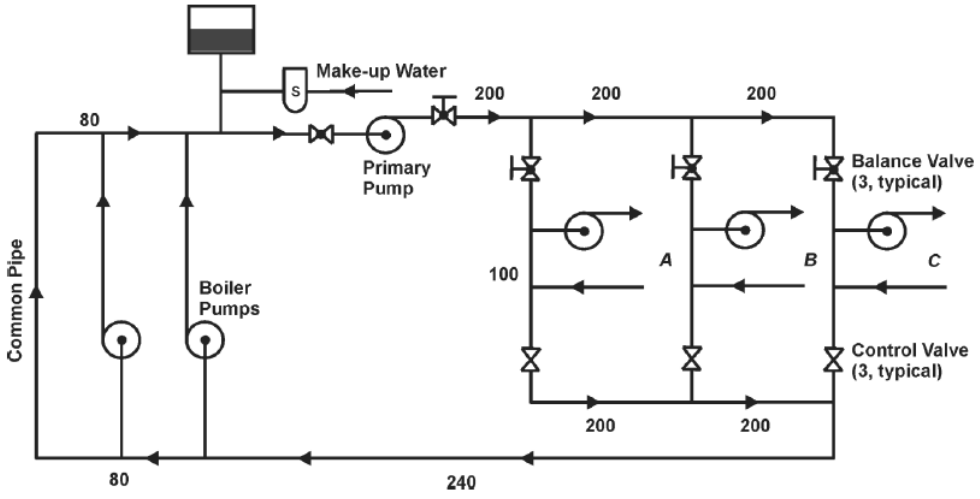
Globe Valve Setting Values

globe valve setting	head loss
fully closed	∞ K_L
20%	200 K_L
40%	140 K_L
60%	80 K_L
80%	20 K_L
fully open	1.0 K_L

Globe Valve Loss Coefficients

pipe nominal diameter (inches)	loss coefficient K_L
1/4	16
1/2	14
3/4	9.0
1	8.2
1 1/4	7.5
1 1/2	7.2

8. SD Consulting Engineers, Inc. has prepared the following piping schematic to supply water to a chemical plant. The lengths shown are in feet. Piping is Schedule 40, commercial steel.



Circuit	Flow Rate, gpm	Control Valve Head Loss, Ft
A	60	40
B	70	50
C	70	50

Complete the design of the primary circuit piping system. Determine the operating point of the primary pump.

9. The owner of a small office building has decided to design and install a piping network that includes 5 tankless water heaters to heat and transport water. The owner currently requires 18 gpm of hot water service. Cold water (feedwater) from the City will be supplied to each heater, and the piping connections were previously installed by the building contractor. The hot water, at 160 °F, from the heaters will be transported through a main header for distribution in the rest of the building. Each heater has been specified to provide a maximum of 4.6 gpm of water. The heater unit has a dedicated pump that serves only to circulate the cold water through its internal finned-coil system. Unfortunately, the City supplies the feedwater at a low pressure of 40 psia, and the owner needs hot water at 80 psia for complete distribution though the building. Based on the sketch provided below, complete the design of the hot water supply lines in this system.

Further Information: In practice, the lengths of the hot water supply piping that connect directly to the heaters are small in comparison to that of the main supply header. Heat exchanger losses are negligible.