HVAC & Refrigeration PE Exam Errata

This product has been updated to incorporate all changes shown in the comments below and email comments as of January 1, 2020. If you have purchased this product prior to this date and wish for the latest version then please email Justin Kauwale at contact@engproguides.com.

PROBLEM 1 - BASIC ENGINEERING PRACTICE

Honey has a dynamic viscosity of 1000 poise, a specific heat capacity of 0.6 cal/g-^{o}C, and a density of 0.05 oz/mL. The kinematic viscosity of honey, in ft^2/sec, is most nearly?

(A) 0.76

(B) 7.1

(C) 25

(D) 30

PROBLEM 2 - BASIC ENGINEERING PRACTICE

An 1800 RPM motor operates on 208 volts, 3 phase, 60 hertz power. The motor is providing 3 HP of mechanical power. Assume a power factor of 0.9 and a service factor of 1.15. If the motor is 85% efficient, how many amps must be supplied to the motor?

(A) 7

(B) 8

(C) 14

(D) 16

$$P_{mech\ work,pump[HP]} = \frac{100 * 300 * (1)}{3956}$$

$$P_{mech\ work,pump[HP]} = 7.58\ HP$$

Next, remember that additional electricity will be required to run the pump and motor due to the inefficiencies in the equipment

$$P_{electricity\ [HP]} = \frac{7.58\ HP}{0.65 * 0.95}$$

$$P_{electricity\ [HP]} = \frac{7.58\ HP}{0.65 * 0.95}$$

$$P_{electricity\ [HP]} = 12.3\ HP$$

Now convert HP to KW.

$$P_{electricity\ [KW]} = 9.2\ KW$$

Find kWh by multiplying kW by run time (hours per year)

$$P_{electricity\ [KWH]} = 9.2 * 8 * 365$$

$$P_{electricity\ [KWH]} = 26{,}864\ kWh$$

Finally, use the utility rate to determine the cost of running the pump.

$$Yearly\ cost = 26{,}864\ kWh * \left(\frac{\$0.15}{kwh}\right) = \$4{,}030$$

Correct answer is D.

(D) $\$4,030$

SOLUTION 4 – BASIC ENGINEERING PRACTICE

A new machine is installed in order to increase productivity. This new machine costs $75,000 and has an ongoing operating and maintenance cost of $500 per month. The new machine will save $2,000 per month and will have a salvage value of $10,000 after 10 years. If the interest rate is 5%, then what is the annual cost of the new machine?

This problem involves finding the total annual cost. First, convert all your terms to an annual value. You will need the interest rate tables located in the Basic Engineering Practice section of the NCEES Mechanical PE Reference Handbook.

Initial Cost [Negative value = money lost at the beginning of the lifetime]

You need to use the engineering economics equations.

(D) $5,970 per year

SOLUTION 71

A 22" X 10" galvanized steel duct is used to convey 2,000 CFM of industrial exhaust. What is the pressure drop in units of IN. WG per 100 ft.

Density = 0.075 lb/ft^3; roughness factor = 0.0003 ft.

In order to calculate the pressure drop through a duct, use the equivalent diameter equation.

$$Find\ your\ hydraulic\ diameter \rightarrow D_H = \frac{4(Area)}{Perimeter} = \frac{4(22\ x\ 10)}{(2 * 22 + 2 * 10)} = 13.75"$$

Find 22" X 10": The equivalent circular duct is 16" D.

$$Find\ your\ velocity \rightarrow v = \frac{2{,}000\ ft^3/min}{(\frac{22}{12} * \frac{10}{12})} * \frac{60s}{1min} = 78{,}545\frac{ft}{s} = 1309\ fpm$$

$$Find\ your\ Reynolds\ Number \rightarrow Re = \frac{V * D}{v} = \frac{(78{,}545\frac{ft}{s}) * (\frac{16}{12})}{15.8\ x\ 10^{-5}\ ft^2/s} = 6.628\ x\ 10^9$$

Next use your Darcy Equation and the friction factor form the Moody Diagram. Galvanized steel has a roughness of 0.0002 to 0.0008. The problem says to use 0.0003 ft.

$$Relative\ Roughness = \frac{0.0003\ ft}{(13.75)/12} = 0.000262$$

$$f = 0.015$$

$$Darcy = \frac{12fL}{D_e} * \rho * \frac{V}{1097} = \frac{12(0.015)(100\ ft)}{13.75\ in} * 0.075\frac{lb}{ft^3} * \left(\frac{1{,}309\ fpm}{1097}\right)^2$$

$$= 0.14\ in\ wg\ per\ 100\ ft$$

Friction loss = 0.14 in. wg per 100 ft.

The correct answer is most nearly, (C) 0.14 in. WG per 100 ft.

(A) 0.07 in. WG per 100 ft

(B) 0.10 in. WG per 100 ft

(C) 0.14 in. WG per 100 ft

(D) 0.19 in. WG per 100 ft

SOLUTION 72

A new steam boiler provides 100 lb/hr of steam at 30 PSIA, 0 degrees super heat to various hot water heaters. If the hot water heaters are designed to provide a 40 degree delta to incoming water at 80 F, then what is the total GPM of hot water that the boiler can support?

Create an energy balance equation between the steam and the hot water.

$$Q_{steam} = \dot{m} * h_{fg}$$

Find h_{fg} in the NCEES Mechanical PE Reference Handbook, Steam Tables as a function of pressure, Navigate to 30 PSIA. Read the enthalpy of evaporation.

$$Q_{steam} = 100\frac{lb}{hr} * 945.2\frac{Btu}{lb} = 94{,}520\frac{Btu}{h}$$

$$Q_{hot\ water} = \dot{m} * c_p * \Delta T$$

$$Q_{hot\ water} = 500 * GPM * \Delta T$$

$$Q_{steam} = 94{,}520\frac{Btu}{h} = Q_{hot\ water} = 500 * x\ GPM * 40\ °\text{F}$$

$$x = 4.73\ GPM$$

The correct answer is most nearly, (A) 4.73 GPM.

(A) 4.73 GPM

SOLUTION 73

A new building with dimensions of 200' (L) X 150' (W) X 10' (H) is classified as having average construction tightness, which relates to 0.3 air changes per hour of infiltration. If outside air is at 88 F DB/80% RH and the indoor design conditions are 75 F DB/50% RH, then what is the total cooling load in tons added by infiltrated air?

First find the total amount of infiltrated air by first finding the total air volume.

$$200' * 150' * 10' = 300{,}000\ ft^3$$

$$300{,}000\ ft^3 * 0.3\frac{air\ changes}{hour} * \frac{1\ hour}{60\ minutes} = 1{,}500\ CFM$$

Find the enthalpies of the indoor and outside air in order to determine the total cooling load.

$$Q = 4.5 * CFM * \Delta h$$

$$Q = 4.5 * 1{,}500 * (46.57 - 28.14\ )$$

$$Q = 124{,}403\frac{Btu}{h}$$

QUESTION 8 –SUCTION LINE

A 1-1/4 inch, schedule 40, steel line is used as the discharge line in a 7.5 ton (R-134a) refrigeration system. The suction line has an equivalent length of 220 feet. There is no elevation change. The system operates at 100 F condensing temperature and 40 F evaporator temperature. Assume no superheating, what is the pressure drop along this line?

(A) 2 psi

(B) 6 psi

(C) 8 psi

(D) 11 psi

QUESTION 9 – AMMONIA VALVES

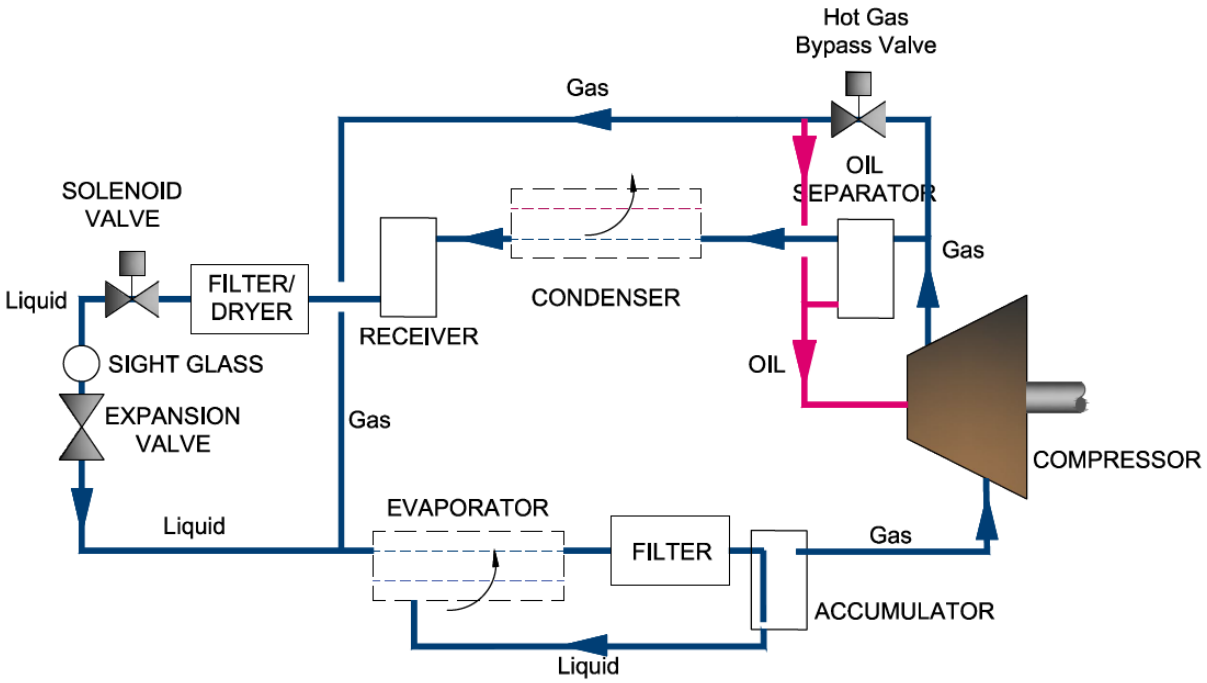
Which of the following valve connections is best suited for a 2", 150 psi, control valve that must be easily accessed and replaced? The valve is for ammonia service.

(A) Threaded flange

(B) Socket-weld flange

(C) Butt-weld in place

(D) Socket-weld in place



The correct answer is most nearly, (B) A hot gas bypass can be placed between the compressor discharge and the evaporator to create an artificial load.

SOLUTION 8 –SUCTION LINE

First, navigate to Suction Discharge and Liquid Line Capacities in Tons of R-134A. This table can be used to find the pressure drop due to a length of piping, given certain refrigerant properties.

A 1-1/4 inch, schedule 40, steel, line at 105 F condensing and 40 F evaporator will have a temperature drop of 2.0 F in saturation temperature for a 6.12 ton system and 100 feet of equivalent length. The corresponding pressure drop is 1.93 psi. Unfortunately, the system does not operate at these conditions and the table values must be changed to match the actual conditions.

First change the actual capacity with the condensing temperature correction factor.

$$Corrected\ Table\ \ Capacity = 6.12 * 1.032 = 6.32\ tons$$

Next, change the temperature drop of the saturation temperature.

Please note that the equation shown in the handbook is incorrect as of December 2019. The ASHRAE equation is shown and used below.