Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, Jan- 2021

Course: FLUID FLOW AND HEAT TRANSFER EQUIPMENT DESIGN
Semester: I
Program: M. TECH. CHEMICAL ENGINEERING (PDE) **Time: 03 hrs.**
Course Code: CHPD7005 **Max. Marks: 100**
Instructions: Attempt All Questions

SECTION A

S. No.	ATTEMPT ALL QUESTIONS- (5*6=30 MARKS)	Marks	CO
Q.1	Illustrate the term best efficiency point in Centrifugal pumps.	5	CO1
Q.2	Explain the term compressor ratio. What is the recommended values for compressor ratio for reciprocating and centrifugal compressors?	5	CO4
Q.3	Discuss the term 'Class Location 'in fluid carrying pipeline system	5	CO1
Q.4	Describe 'Affinity Law' for centrifugal pumps.	5	CO3
Q.5	Illustrate the difference between Recuperative and Regenerative type of Heat Exchangers.	5	CO4
Q.6	Review 'TEMA Analysis' for Heat Exchangers design. With an example, demonstrate the significance of the three letters in a typical TEMA code.	5	CO5

SECTION B
ATTEMPT ALL QUESTIONS(10*5=50)

Q.7	Derive the heat transfer, conduction equation in Cartesian coordinates.	10	CO4
Q.8	Explain performance curves for centrifugal pumps,	10	CO5
Q.9	Analyze and explain the algorithm used for Design of Shell and tube heat exchanger (Only steps required)	10	CO5
Q.10	Explain five significant points on –'selection criterion' for choosing a specific type of Heat Exchanger.	10	CO3
Q.11	Reproduce at least twenty main components of Heat Exchanger (only component names are required)	10	CO2

SECTION-C (ATTEMPT ANY ONE QUESTION) MISSING DATA ARE TO BE SUITABLY ASSUMED			
Q.12	The **Salaya – Mathura** oil pipeline is used for transporting oil from **Salaya** to **Mathura** refinery. There are two intermediate stations, one at **Viramgram** and the other one at **Koyli**. The length of **Salaya- Mathura** pipeline is 48 miles and is of 18 inch in diameter, with 0.281 inch wall thickness. It is constructed of 5LX-65 grade steel. At origin station **Salaya**, crude oil of specific gravity 0.85 and 10 cSt viscosity enters the pipeline at a flow rate of 6000 bbl./hr. At first intermediate station **Viramgram** (milepost 22) a new stream of crude oil with a specific gravity of 0.82 and 3.5 cSt viscosity enters the pipeline at a flow rate of 1000 bbl./hour. The mixed stream then continues to another intermediate station **Koyli** (milepost 32) where 3000 bbl. / hour is stripped off the pipeline. The remaining volume continues to the end of the pipeline at delivery station **Mathura**. **(a)** Evaluate the pressure required at origin station **Salaya** and the composition of the crude oil arriving at terminus **Mathura** at a minimum delivery pressure of 50 psi. Assume elevations at **Salaya, Viramgram, Koyli,** and **Mathura** to be 100, 150, 250, and 300 feet, respectively. Use the Modified Colebrook-White equation for pressure drop calculations and assume a pipe roughness of 0.002 inches. **(b)** Evaluate, the pump HP that will be required at **Salaya** to maintain this flow rate, assuming 50-psi pump suction pressure at Salaya and 80% pump efficiency? **(c)** If a positive displacement (PD) pump is used to inject the stream at **Viramgram,** solve for pressure and HP are required at **Viramgram**? **APPENDIX TABLE 1:** **1. Frictional Pressure drop equation in oil pipelines** $Pm = 0.0605fQ^2(Sg/D^5)$	**20**	**CO3**

Reynolds No. for Crude Oil Pipelines

a) **R=92.24 Q/ (ν D)**

Where: Q=Flow rate, bbl/day; D=Internal diameter, in.; ν = Kinematic viscosity, cSt

b) **R=353,678 Q/(νD)**

Where: Q=Flow rate, m^3/hr.; D=Internal diameter, mm; ν= Kinematic viscosity, cSt; D=Pipe internal diameter, in.

2. Modified Colebrook White Equation

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.825}{\text{Re}\sqrt{f}}\right)$$

3. Coversion Equations for SSU to Centistokes

$$Centistokes = 0.226(SSU) - \frac{195}{SSU} \qquad 32 \le SSU \le 100$$

$$Centistokes == 0.220(SSU) - \frac{135}{SSU} \qquad SSU \succ 100$$

4. BHP required to pump the liquid $$BHP = \frac{QP}{2449E}$$

Q = flow rate (barrel per hr.) **P** = Differentia pressure (psi)

5. Head to pressure conversion:

$$Head = \frac{2.31 psig}{G}(USCS)$$

6. Specific gravity of blended liquids

$$S_b = \frac{Q_1S_1 + Q_2S_2 + \ldots\ldots Q_nS_n}{Q_1 + Q_2 + \ldots . Q_n}$$

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7. Viscosity of blended liquids

$$\sqrt{v_b} = \frac{Q_1 + Q_2 + Q_3 \ldots.}{\left(\frac{Q_1}{\sqrt{v_1}} + \frac{Q_2}{\sqrt{v_2}} + \frac{Q_3}{\sqrt{v_3}} \ldots..\right)}$$

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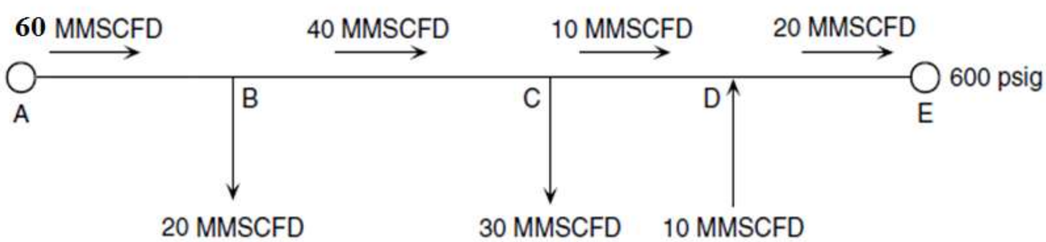
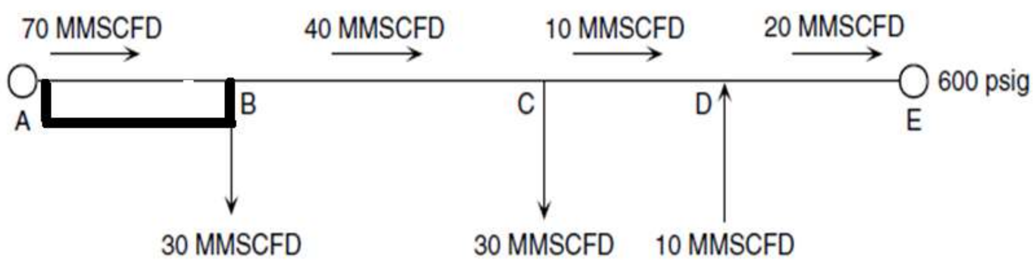
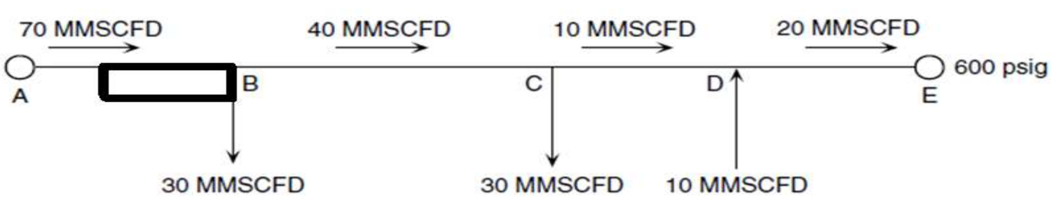
In a gas distribution pipeline, 60 MMSCFD enters the pipeline at A, as shown in Figure. If the delivery at B is increased from 20 MMSCFD to 30 MMSCFD by increasing the inlet flow at A, keeping all-downstream flow rates the same, ***calculate the looping necessary if entire length AB is looped to ensure pressures are not changed throughout the pipeline***. Pipe AB is NPS 14, 0.250 in. wall thickness; BC is NPS 12, 0.250 in. wall thickness;







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Pipe CD is NPS 10, 0.250 in. wall thickness; and DE is NPS 12, 0.250 in. wall thickness. The delivery pressure at E is fixed at 600 psig. The pipe lengths are as follow: AB = 12 miles; BC = 18 miles; CD = 20 miles; DE = 8 miles

The gas gravity is 0.60, and the flow temperature is 60°F. The compressibility factor and transmission factor can be assumed to be 0.85 and 20, respectively, throughout the pipeline. The base pressure and base temperature are 14.7 psia and 60°F, respectively. Also, calculate the loop length if a particular length of AB is looped with a diameter of 10 NPS and 0.25-inch wall thickness.

NPS12=12.75 inches; NPS10= 10.75 inches.

APPENDIX TABLE 2:

1. Equivalent diameter equation

$$D_e = D_1\left[\left(\frac{1+Const}{Const}\right)^2\right]^{1/5} \qquad Const = \sqrt{\left(\frac{D_1}{D_2}\right)^5\left(\frac{L_2}{L_1}\right)}$$

2. Pressure drop equation for gas pipelines

$$Q = 77.54\left(\frac{T_b}{P_b}\right)\left(\frac{P_1^2 - P_2^2}{GT_f LZf}\right)^{0.5} D^{2.5}$$

3. Reynolds Equation for Gas Pipelines

$$\mathrm{Re} = 0.5134\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \quad \text{(SI)}$$

$$\mathrm{Re} = 0.0004778\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \quad \text{(USCS)}$$