| | |
|---|---|
| **Name:**<br><br>**Enrolment No:** | UPES<br>UNIVERSITY WITH A PURPOSE |

**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, May 2020**

**Course: Pipeline Transportation of Oil and Gas**
**Semester: VIII**
**Program: B. Tech. Chemical Engg. Spl. Refining & Petrochemicals** **Time 03 hrs.**
**Course Code: PTEG-443** **Max. Marks: 100**
**Instructions: Attempt All Questions**

**SECTION A**

| S. No. | | Marks | CO |
|---|---|---|---|
| **Q.1** | Illustrate the performance curves of a Centrifugal pump. | **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** | Explain the method used for calculating the number of compressors required to compress the gas in a cross country natural gas pipeline. | **5** | **CO1** |
| **Q.4** | Describe ‘Affinity Law’ for centrifugal pumps. | **5** | **CO3** |
| **Q.5** | Explain the difference between “Break Horse Power” and “Horse Power” in compressor stations. | **5** | **CO2** |
| **Q.6** | Discuss the term “Adiabatic efficiency”. | **5** | **CO2** |

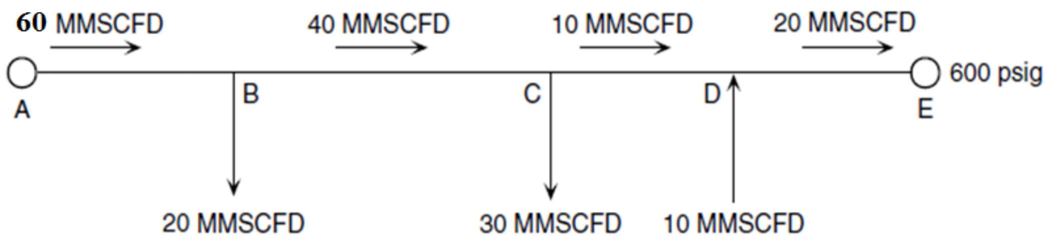
**SECTION B**

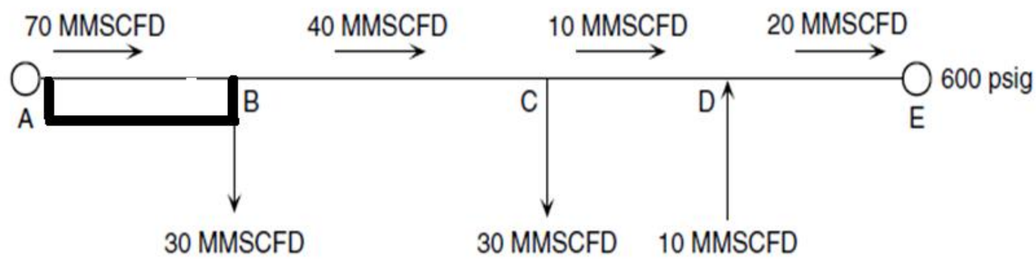
| | | | |
|---|---|---|---|
| **Q.7** | Illustrate Preliminary and Detailed Survey for selecting the pipe route. | **5+5** | **CO4** |
| **Q.8** | Explain the different types of ‘PIGS’ used in pipeline operations. | **10** | **CO5** |
| **Q.9** | Explain the difference between centrifugal and reciprocating pumps. | **10** | **CO4** |
| **Q.10** | Explain the term ‘Class Location ‘for cross- country pipelines. | **10** | **CO4** |

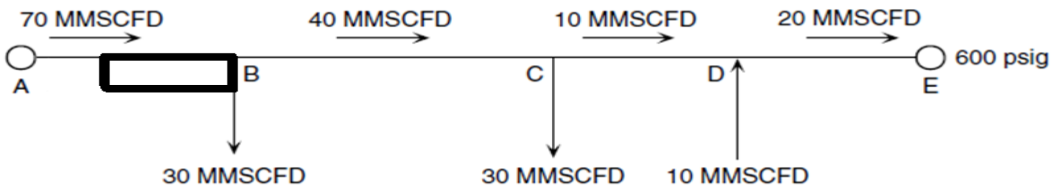
**SECTION-C**
**Attempt Any One**

| | | | |
|---|---|---|---|
| **Q.11** | The **Salaya – Mathura** pipeline is used for transporting oil from **Salaya** to **Mathura** refinery. There are two intermediate stations, one at **Viramgram** and the other one at | **10 + 10 +10** | **CO3** |

| | | | |
|---|---|---|---|
| | **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**.<br><br>**(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 in.<br><br>**(b)** Calculate 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?<br><br>**(c)** If a positive displacement (PD) pump is used to inject the stream at **Viramgram,** solve for pressure and HP that are required at **Viramgram**? | | |
| **Q12** | 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; | **10 + 10+10** | **CO5** |




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.

***All Notations have their usual meaning and units***

**1. Reynolds Equation for Gas Pipelines**

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

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

**2. 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.

**3. Modified Colebrook White Equation**

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

**4. Coversion Equations for SSU to Centistokes**

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

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

**5. Horsepower required to compress gas in compressor**

$$HP = 0.0857\left(\frac{\gamma}{\gamma-1}\right)QT_1\left(\frac{Z_1+Z_2}{2}\right)\left(\frac{1}{\eta_a}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right]$$

**6. Adiabatic Efficiency of Compressor**

$$\eta_a = \left(\frac{T_1}{T_2 - T_1}\right)\left[\left(\frac{z_1}{z_2}\right)\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]$$

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

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