gr. HI – 17 – 5i ,
HI – 17 – 4i

2021 y.

Calculation task № 15 (individual) Example .
(INDIVIDUAL – DIFFERENT VARIANTS in the table)

Determine the flow capacity of the gathering line if its length is 9360 m; the diameter is 120 mm, pressure at the wellhead (inlet pressure) is 14.2 MPa; gas treatment unit inlet pressure (pressure at the end of the gathering line) is 13 MPa; absolute density of gas at standard conditions is 0.79 kg/m^3; inlet temperature is 306 K; temperature at the end of the gathering line is 301 K; coefficient of hydraulic resistance of the pipes is 0.023. Coefficient of decrease of the flow capacity of the gathering line is 0.9 (production of the well is gas with liquid).

Determine average gas compressibility factor (at average pressure and average temperature in the gathering line) by means of empirical formula.

$P_1 = 14.2$ MPa

$P_2 = 13$ MPa

$L = 9360$ m

$d_{in} = 120$ mm

$\lambda = 0.023$

$\rho_{g.} = 0.79 \ \frac{kg}{m^3}$

$T_1 = 306$ K

$T_2 = 301$ K

$E_d = 0.9$

Determine : the flow capacity of the gathering line

Q_g – ?

Solution

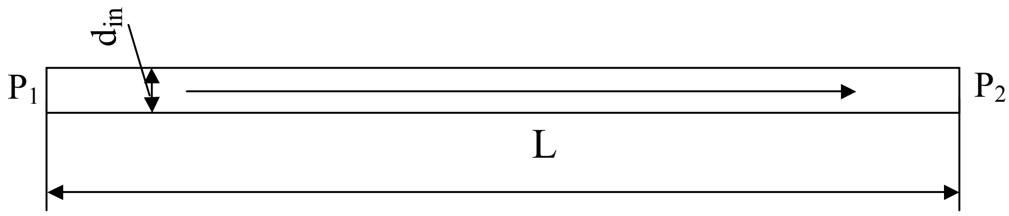
The flow capacity of the gathering line :

$$Q_g = 103.15 \cdot E_d \sqrt{\frac{\left(P_1^2 - P_2^2\right) \cdot d_{in}^5}{\lambda \cdot \rho_{g.r.} \cdot Z_{avr} \cdot T_{avr} \cdot L}} \qquad (1)$$

Explanation to the formula (1) :

Q_g is the flow capacity of the gathering line, **m^3/day**; d_{in} is inner diameter of the gathering line, **cm**; P_1 is the pressure at the beginning of the gathering line (pressure at the inlet of the gathering line), **atm.**; P_2 is the pressure at the end of the gathering line (pressure at the outlet of the gathering line), **atm.**; E_d is the coefficient of the decrease of the flow capacity of the gathering line, without units ($E_d = 1$ or sometimes $E_d = 0.8 – 0.95$), according to the data of calculation task $E_d = 0.9$; L is the length of the gathering line, **km**; λ is coefficient of hydraulic resistance of the pipes, without units; Z_{avr} is gas compressibility factor (at average pressure and average temperature in the gathering line), without units; $\rho_{g.r.}$ is relative density of gas, without units; T_{avr} is the average temperature in gathering line, K.

Figure.



Relative density of gas

$\rho_{g.r.} = \dfrac{\rho_{g.}}{\rho_{air.st.}}$ where $\rho_{air.st} = 1.205$ kg/m^3 is the density of air at standard conditions (standard pressure $P_{atm} = 0.1$ MPa, standard temperature $T_{st} = 293$ K).

$$\rho_{g.r.} = \frac{0.79}{1.205} = 0.6556$$

Gas compressibility factor Z_{avr} :

$$Z_{avr} = \left(0.4 \cdot \log\left(T_{red.avr.}\right) + 0.73\right)^{P_{red.avr.}} + 0.1 \cdot P_{red.avr.} \qquad (2)$$

$T_{red.s.}$ is reduced temperature of gas, without units; $P_{red.s.}$ is reduced pressure of gas, without units.

$$P_{red.avr.} = \frac{P_{avr.}}{P_{cr.}} \quad ; \quad T_{red.avr.} = \frac{T_{avr.}}{T_{cr.}}$$

where $P_{cr.}$ is critical pressure of gas, MPa; $T_{cr.}$ is critical temperature of gas, K.

$$P_{cr.} = 4.892 - 0.4048 \cdot \rho_{g.r.} \quad , \text{ MPa.}$$

$$T_{cr.} = 170.8 \cdot \rho_{g.r.} + 94.717 \quad , \text{ K.}$$

$$P_{cr.} = 4.892 - 0.4048 \cdot 0.6556 = 4.627 \quad \text{MPa.}$$

$$T_{cr.} = 170.8 \cdot 0.6556 + 94.717 = 206.69 \quad \text{K}$$

We have to determine average pressure and average temperature in the gathering line.

Average pressure in the gathering line :

$$P_{avr.} = \frac{2}{3}\left(P_1 + \frac{P_2^{\,2}}{P_1 + P_2}\right) \qquad P_{avr.} = \frac{2}{3}\left(14.2 + \frac{13^2}{14.2 + 13}\right) = 13.61 \quad \text{MPa}$$

Average temperature in the gathering line :

$$T_{avr.} = \frac{T_1 - T_2}{\ln\left(\frac{T_1}{T_2}\right)} \qquad T_{avr.} = \frac{306 - 301}{\ln\left(\frac{306}{301}\right)} = 303.49 \quad \text{K}$$

Reduced pressure of gas and reduced temperature of gas :

$$P_{red.avr.} = \frac{P_{avr.}}{P_{cr.}} = \frac{13.61}{4.627} = 2.941$$

$$T_{red.avr.} = \frac{T_{avr.}}{T_{cr.}} = \frac{303.49}{206.69} = 1.468$$

$$Z_{avr} = \left(0.4 \cdot \log\left(T_{red.avr.}\right) + 0.73\right)^{P_{red.avr.}} + 0.1 \cdot P_{red.avr.} =$$

$$= (0.4 \cdot \log(1.468) + 0.73)^{2.941} + 0.1 \cdot 2.941 = 0.807$$

It is very important to remember that into the formula (1) , that is formula for determination of the flow capacity of the gathering line we put : P_1 and P_2 in **atm.**, d_{in} – in **cm**, L – in **km** and then we get Q_g in **m³/day**.

Conversion of units :

$$P_1 = P_1 \cdot 10 = 14.2 \cdot 10 = 142 \text{ atm} \quad ; \quad P_2 = P_2 \cdot 10 = 13 \cdot 10 = 130 \text{ atm} \; ;$$

$$L = 9.36 \text{ km} \quad ; \quad d_{in} = 12 \text{ cm} .$$

Calculation of the flow capacity of the gathering line :

$$Q_g = 103.15 \cdot 0.9 \sqrt{\frac{\left(142^2 - 130^2\right) \cdot 12^5}{0.023 \cdot 0.6556 \cdot 0.807 \cdot 303.49 \cdot 9.36}} = 446.06 \times 10^3 \frac{m^3}{day} =$$

$$= 446.06 \frac{thm^3}{day}$$

Answer : $Q_Г = 446.06 \dfrac{thm^3}{day}$