Surface Gathering Systems

in most oil and gas production installations ,the flow from several wells will be gathered at central processing station(separators) or combined in to common pipe line. Surfaces gathering system is composed of several flow lines,main pipe line(Header),valves,and fittings.

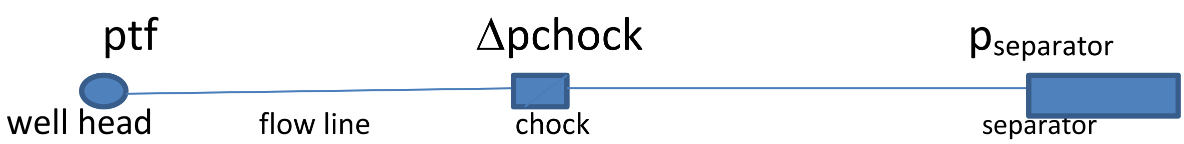
Types of surface Gathering systems

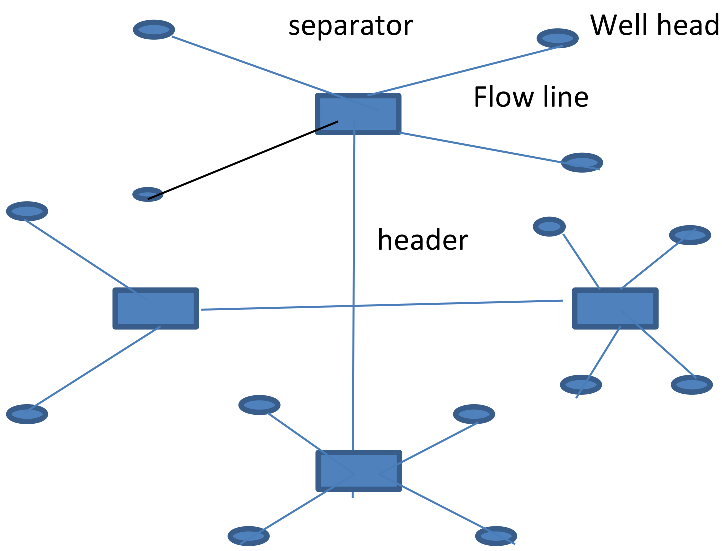
There are two common types of Gathering systems which are:

1-Radial Gathering System

In this system,the flow line that transported the hydrocarbon from wells are jointed together at common point(Separator).This system of pipe is used in small area where the lengths of flow line are short.In this system ,the flowing tubing head pressure (Ptf) of individual well(i) is summation of separator pressure(P_{sep}) plus pressure loss in flow line(ΔP_l), plus pressure loss through chock(ΔP_{ckock}) and pressure loss through fittings($\Delta P_{fitting}$) as written in the following equation:

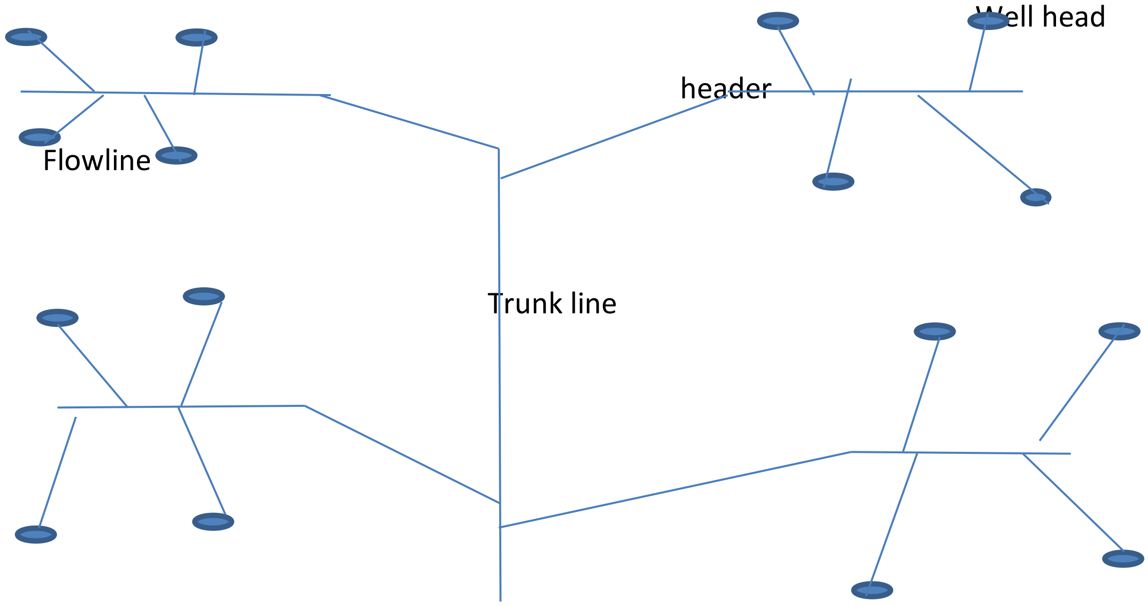
$$Ptf = Psep + \Delta P_l + \Delta P_{ckock} + \Delta P_{fitting}$$





2-Axial (Trunk line) Gathering System

In this system ,the flow lines of individual wells are tied into common pipeline called (Header),so that the pipe line flow rate is the sum of the upstream well flow rates and each well has more direct effects on its neighbors wells.This system is used for large area where the lengths of flow lines are long and with high cost.



** Selection of gathering system type will be depend on cost analysis and the topography of the region.

Flow in surface Gathering System

The flow of produced hydrocarbon fluids in surface gathering system should be laminar flow to reduce friction loss caused by friction with pipe wall(large pipe size will reduce the friction loss)

In some times slug flow of liquid and gas as sequence in pipes may occur and caused damaged of gathering system. Slug catcher tools may install in flow system to reduce slug effects.

Flow lines

Are pipe lines that transported the produced hydrocarbons from well heads to either separator or to the header line.These lines are generally of small diameter(2.5 cm to

10 cm) and made of steel or plastic welded or threaded coupling connect joints. Flow line usually are coated internally to minimize corrosion. Based on type of manufactured material, the following flow line are presented:

1- Steel pipe line 2- Fiberglass pipe line 3- Plastic pipe line 4-Asbestos pipe line

The internal pressure of flow line is determined by the well head pressure, pressure loss through chock, fitting and separator pressure. Based on the working pressure ,there are two types of flow line which are:

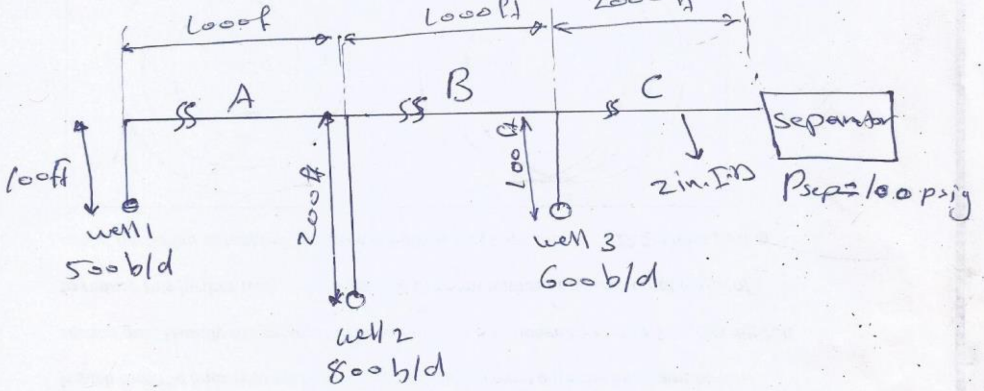
A-Low pressure flow line

The working pressure of this type is less than 125 psi

B-High pressure low line

The working pressure of this type is greater than 125 psi

Ex: The Liquid production from three rod-pumped wells is gathered in a common 2 in line. one inch flow lines connect each well to the gathering line, and each well line contains a ball valve and conventional swing check valve. well 1 is tied into the gathering line with standard 90° elbow, while wells 2 and 3 are connected with standard tees. The oil density is 0.85 gm/cc (53.04 lbm/ft3) and viscosity of 5 cp. The separator pressure is 100 psig. Assuming the relative roughness of all lines to be 0.001. Calculate the flowing tubing pressures of the three wells.



Solution: $N_R = 1.48 \frac{Q \rho}{D \mu}$, Q = bbl/d . ρ = lbm/ft3
D = in (ID) , μ = c.p

$$\frac{1}{\sqrt{F}} = -4 \log \left[\frac{\epsilon}{3.7065} - \frac{5.0452}{N_R} \cdot \log \left[\frac{\epsilon^{1.1098}}{2.8257} + \left(\frac{7.149}{N_R} \right)^{0.8981} \right] \right]$$

⇓ Chen Equ.

ϵ = relative roughness → Fanning friction fact

$$\Delta P = P_1 - P_2 = \frac{2F \rho u^2 L}{g_c \cdot D}$$

ΔP = lbf/ft^2
F = friction fact
u = velocity , ft/sec
L = Length, ft
g_c = 32.17 ft - lbm/lbf - sec^2
D = ft (ID)

$$\frac{1}{\sqrt{f}} = 1.14 - 2 \log \left(\frac{\epsilon}{D} + \frac{21.25}{N_R^{0.9}} \right)$$

(D ↓ ID)

Solution ① gathering Line
For segment A

$$N_{Re} = 1.48 \frac{\rho Q}{D \mu}$$

$$= 1.48 \frac{53.04 * 500}{2 * 5} \simeq 3925$$

$$\frac{1}{\sqrt{F_m}} = 1.14 - 2 * \log \left(\frac{\epsilon}{D} + \frac{21.25}{N_R^{0.9}} \right)$$

$$= 1.14 - 2 \log \left(0.001 + \frac{21.25}{(3925)^{0.9}} \right)$$

$$\frac{1}{\sqrt{F_m}} = 4.89$$

$$F_m = 0.041$$

$$\therefore f_m = 4 f_f \Rightarrow F_f = \frac{0.041}{4} = 0.0104$$

$$u = 0.0119 \frac{Q}{ID^2}$$, Q = bbl/d
ID = inside diameter, in

$$u = 0.0119 \frac{500}{(2)^2} = 1.48 \text{ ft/sec}$$

$$\Delta p = \frac{2 * f_f * \rho * u^2 L}{g_c \cdot D * 144} = \frac{2 * 0.0104 * 53.04 * (1.48)^2 * 1000}{32.17 * \frac{2}{12} * 144}$$

$$\Delta p = 3.12 \text{ psi}$$

② Flow lines
For Flow line 2 [Ball valve + swing check valve + standard tee

From Tables
Ball valve = 3 D
Swing valve = 135 D
Tee (flow through branch) = 60 D

$$\text{Equ. Length of Flow line } 2 = (3_{in} + 135_{in} + 60_{in}) * \frac{1}{12 \text{ ft}} + 200 \text{ ft}$$
$$= 216.5 \text{ ft}$$

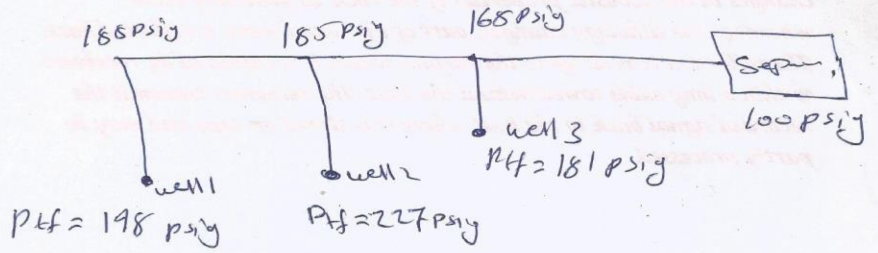
Pressure Drop Calculation

1- Gathering Line

Seg	Q (bbl/d)	NR	f	u (ft/sec)	ΔP (psi)
A	500	3930	0.0103	1.49	3
B	1300	10200	0.0081	3.88	17
C	1900	14900	0.0077	5.66	68

2- Flow lines

well No	NRe	f	u (ft/sec)	$(L/D)_{fittings}$	L (ft)	ΔP (psi)
1	7850	0.0086	5.96	168	114	10
2	12600	0.0077	9.54	198	216.5	42
3	4420	0.0082	7.16	198	116.5	13



* For flowline 2 From Table

1- Ball Valve = 3 D
2- check valve = 135 D
3- Tee (with flow through branch) = 60 D

~~∴ Total (L/D) fitting =~~ (L/D) fitting = 3 in + 135 in + 60 in = 198 in

The equivalent length of flowline 2 = $(3+135+60) * \frac{1}{12} \text{ ft} + 200 \text{ ft}$

= 216.5 ft

Table 10-1

Equivalent Lengths of Valves and Fittings[a]

		Description of Fitting		Equivalent Length in Pipe Diameters
Globe valves	Stem perpendicular to run	With no obstruction in flat, bevel, or plug type seat	Fully open	340
		With wing or pin guided disk	Fully open	450
	Y-pattern	(No obstruction in flat, bevel, or plug type seat)		
		—With stem 60° from run of pipe line	Fully open	175
		—With step 45° from run of pipe line	Fully open	145
Angle valves		With no obstruction in flat, bevel, or plug type seat	Fully open	145
		With wing or pin-guided disk	Fully open	200
Gate valves	Wedge, disk		Fully open	13
	Double disk or plug disk		Three-quarters open	35
			One-half open	160
			One-quarter open	900
	Pulp stock		Fully open	17
			Three-quarters open	50
			One-half open	260
			One-quarter open	1200
Conduit pipe line gate, ball, and plug valves			Fully open	3
Check valves	Conventional swing		Fully open	135
	Clearway swing		Fully open	50
	Globe life or stop; stem perpendicular to run or Y-pattern		Fully open	Same as globe
	Angle lift or stop			Fully open
	Same as angle			
	In-line ball		Fully open	150

Table 10-1 (Continued)

Equivalent Lengths of Valves and Fittings[a]

		Description of Fitting		Equivalent Length in Pipe Diameters
Foot valves with strainer		With poppet lift-type disk	Fully open	420
		With leather-hinged disk	Fully open	75
Butterfly valves (8 in. and larger)			Fully open	40
Cocks	Straight-through	Rectangular plug port area equal to 100% of pipe area	Fully open	18
	Three-way	Rectangular plug port area equal to 80% of pipe area (fully open)	Flow straight through	44
			Flow through branch	140
Fittings	90° standard elbow			30
	45° standard elbow			16
	90° long radius elbow			20
	90° street elbow			50
	45° street elbow			26
	Square corner elbow			57
	Standard tee	With flow through run		20
		With flow through branch		60
	Close-pattern return bend			50

[a]From Crane (1957).