LINE SIZING PROJECT

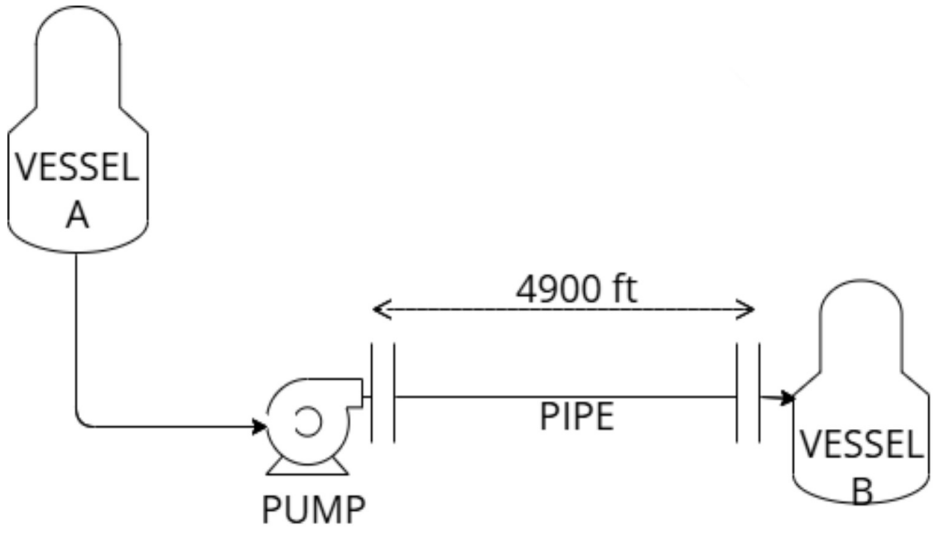

FIG 1: Problem Statement

Hydrocarbon Condensate has to be transported from Vessel A to Vessel B in order to transport the condensate product from Vessel A, a pump is installed at Vessel A. The distance between the Pump at Vessel A to the nozzle of Vessel B is 4900 feet. Following is the instructions about fittings:

	GV	NRV	ELBOW	TEE
A-B	0	0	4	0

The required amount to be transported is 150,000 kg/h. The density of the oil transported is 850 kg/m³. Viscosity of oil is 0.4 cP. The roughness of the pipe can be taken to be 45.2 um. The required pressure at Vessel B Inlet Nozzle is 2 bar(g)

Your Task:

1. What would be the minimum Pipe Size (ID) required for an allowable pressure drop of 0.1 bar/100m across the pipe for a pump flow rate of 150,000 kg/h. Assume your client's requirement of commercial pipe sizes is per ANSI/ASME B36.10M. Use Schedule 40 pipe (Sch 40)

2. For the flow rate of 150,000 kg/h & the pipe size chosen, what is the inlet pressure required at the pipe inlet at Vessel A Pump discharge. (This determines what is the pump discharge pressure required)

3. For various pipe sizes between 4 to 20"Plot a graph Pressure drop (Y-axis Vs Pipe OD (X-Axis) for a flow rate of 150,000kg/h.

4. What is the velocity of the condensate in the pipe for the selected pipe.

5. If Pipe Roughness is 100 µm, what is the pipe size required for an allowable pressure drop of 0.1 bar/100m,

Company Name	Chemical Engg Pvt Ltd					Project Name		HYDROCARBON PUMPING					
						Project Number		ADS002514		SHEET	1	OF	1
Project location	Mumbai					REV NO	PREPAIRED		CHECKED		APPROVED		COMMENTS
							DATE	BY	DATE	BY	DATE	BY	
Line sizing Calculation						1	XX/XX/XXXX	BHV	XX/XX/XXXX	GJL	XX/XX/XXXX	NBV	
						2	XX/XX/XXXX	BHV	XX/XX/XXXX	GJL	XX/XX/XXXX	NBV	
PID no	AFSG-5456-KLEND-JD44114												
line from		A											
line to		B											
physical property data													
fluid		Hydrocarbon											
viscosity	cP	0.4											
liquid density	kg/cu.m	850											
temperature data													
normal	C	35											
minimum	C	30											
maximum	C	38											
pressure data													
upstream pressure	bar(g)	4.1211152											
pipe data	ASMEB36.10M												
nominal line diameter	inches	8											
pipe schedule		40											
pipe material type		SS											
inside diameter	inches	7.981											
inside diameter	mm	202.85042											
Reynolds number		653564.14											
k/D		0.0002228											
friction factor	SWAMEE&JAIN	0.0152034											
flowrates													
mass flow	kgph	150000											
design volumetric flow	cu.m/hr	176.47059											
line velocity	m/s	1.5161891											
pressure drop	bar/100mtr	0.0732254											
line lossess													
pipe length	m	1493.52											
90 bends	eqv,D	160											
valves	eqv,D	0											
exit	eqv,D	25											
entry loss	bar	0											
total	eqv,D	185											
line loss	bar	1.1211152											
elevation increases	m	0											
other pressure drops	bar	0											
summary													
line losses	bar	1.1211152											
static pressure gain/loss	bar	0											
other pressure drops	bar	0											
total pressure drop	bar	1.1211152											
Downstream pressure	bar(g)	3											

Problem solved on Excel Sheet

Solution:

Fluid properties:

Fluid properties and operating conditions can be found on PFD

fluid		Hydrocarbon
viscosity	cP	0.4
liquid density	kg/cu.m	850

Client Requirements:

1. ASME B36.10M to be used
2. allowable pressure drop 1bar/100m
3. schedule 40 pipe to be used
4. flowrate of 150,000 kgph required
5. downstream pressure at inlet of vessel b should be 2 bar(g)

Assumption for nominal size:

Flowrate required: 150,000 kgph > 176.47059 cu.m/hr > 0.049 cu.m/s

Erosional velocity (with 20% margin): $\frac{122}{\sqrt{density}} \times 0.8$ > 3.347652 m/s

Momentum criteria: density x (velocity)^2 > 9525.76

Momentum criteria require to be below 6000 for liquids.

Speed of 3.35 m/s not under criteria.

For erosional velocity 2.5 m/s criteria is met.

Area of pipe (continuity equation): $\frac{volumetric\ flowrate}{velocity}$ > 0.019 sq.m

Diameter of pipe: $\sqrt{\left(\frac{4\ x\ area}{\pi}\right)}$ > 0.157 m > 6 in

Lets assume Nominal Pipe size to be 6 inches

From ASME B36.10M :

NPS	6	in
Schedule number	40	
Outer Diameter	6.625	in
thickness	0.28	in

Inside diameter: outer diameter – 2 x (thickness) > 6.065 inches > 154.15208 mm

Velocity: $\frac{volumetric\ flowrate}{area\ of\ cross\ section}$ > 2.10 m/s (20% margin)

Reynolds number: $\frac{\rho \times Diameter \times Velocity}{viscosity}$ > 688025.77

Flow is turbulent,

Swamee and jain equation can be used to predict friction factor

$\frac{\epsilon}{D} = \frac{roughness}{diameter} = 0.0002932$

$\frac{\epsilon}{D}$ is greater than 10^{-4} hence Haaland correction is to be used

$f = \frac{0.3086}{\left\{log\left[\frac{6.9}{Re} + \left(\frac{\epsilon}{3.7\,D}\right)^{1.11}\right]\right\}^2} = 0.0158007$

pressure drop can be predicted using Darcy Weisbeck equation

$\Delta P = \frac{fx100xV^2}{2gD} = 0.1921806$ bar/100 m

Pressure drop is twice the requirement,

Next available size is 8 inches.

Calculation for 8 inches pipe give pressure drop of 0.0476058 bar/ 100 m

It is half of the requirement

Hence accepting the size lets calculate other losses

Only 4 elbows are present

Equivalent length for four elbows = 4 x 160 inches

Pressure drop due to entry into tank B (equivalent length) = 25 in

Length of pipe > 4900 ft > 1493.52 m

Line losses = 0.7288674 bar

Downstream pressure = 2 bar (g) = 3.013 bar(a)

Upstream pressure = pressure at pump discharge = Line losses + downstream pressure = 3.74 bar

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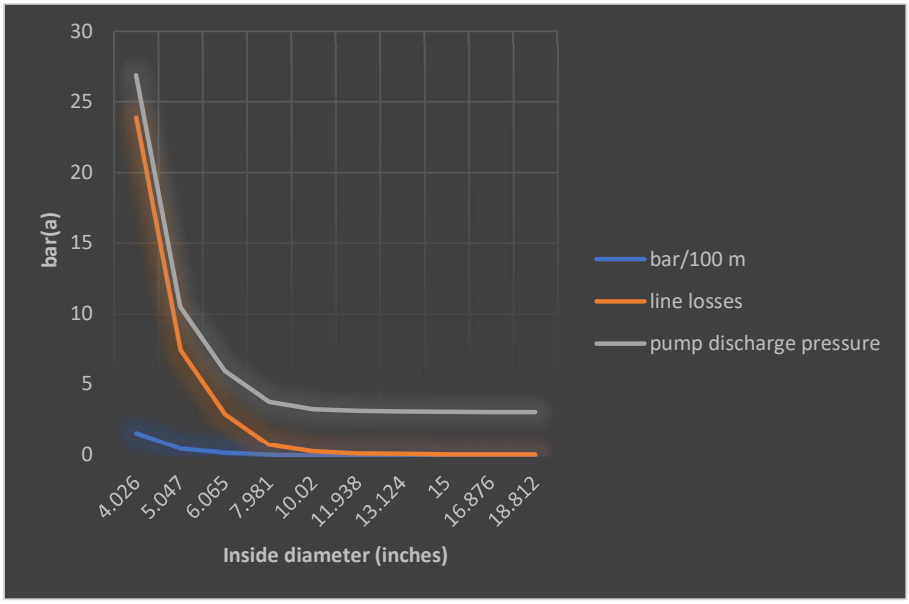
						2	XX/XX/XXXX	BHV	XX/XX/XXXX	GJL	XX/XX/XXXX	NBV	
PID no	AFSG-5456-KLEND-JD44114												
line from		A	A	A	A	A	A	A	A	A	A		
line to		B	B	B	B	B	B	B	B	B	B		
physical property data													
fluid		Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon	Hydrocarbon		
viscosity	cP	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4		
liquid density	kg/cu.m	850	850	850	850	850	850	850	850	850	850		
temperature data													
normal	C	35	35	35	35	35	35	35	35	35	35		
minimum	C	30	30	30	30	30	30	30	30	30	30		
maximum	C	38	38	38	38	38	38	38	38	38	38		
pressure data													
upstream pressure	bar(g)	26.891268	10.476644	5.9256539	3.7291571	3.2335845	3.0980963	3.0615596	3.0320188	3.0180514	3.0108092		
pipe data	ASMEB36.10M												
nominal line diameter	inches	4	5	6	8	10	12	14	16	18	20		
pipe schedule		40	40	40	40	40	40	40	40	40	40		
pipe material type		SS	SS	SS	SS	SS	SS	SS	SS	SS	SS		
inside diameter	inches	4.026	5.047	6.065	7.981	10.02	11.938	13.124	15	16.876	18.812		
inside diameter	mm	102.3275	128.27792	154.15208	202.85042	254.675	303.42417	333.56833	381.25	428.93167	478.13833		
Reynolds number		1036481.9	826803.31	688025.77	522851.31	416454.72	349545.68	317957.66	278191.75	247266.91	221819.92		
k/D		0.0004417	0.0003524	0.0002932	0.0002228	0.0001775	0.000149	0.0001355	0.0001186	0.0001054	9.453E-05		
friction factor	SWAMEE&JAIN	0.0167394	0.0161656	0.0158007	0.015444	0.0153324	0.0153626	0.0154201	0.0155483	0.0157048	0.0160844		
flowrates													
mass flow	kgph	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000		
design volumetric flow	cu.m/hr	176.47059	176.47059	176.47059	176.47059	176.47059	176.47059	176.47059	176.47059	176.47059	176.47059		
line velocity(20% margin)	m/s	4.766619	3.0331324	2.1003727	1.2129513	0.7695247	0.5421193	0.4485652	0.3433804	0.2712807	0.2183172		
pressure drop	bar/100mtr	1.5796396	0.4927339	0.1921806	0.0476058	0.0151516	0.006324	0.0039531	0.0020437	0.0011452	0.0006814		
line lossess													
pipe length	m	1493.52	1493.52	1493.52	1493.52	1493.52	1493.52	1493.52	1493.52	1493.52	1493.52		
90 bends	eqv,D	160	160	160	160	160	160	160	160	160	160		
valves	eqv,D	0	1	2	3	4	5	6	7	8	9		
exit	eqv,D	25	25	25	25	25	25	25	25	25	25		
entry loss	bar	0	0	0	0	0	0	0	0	0	0		
total	eqv,D	185	186	187	188	189	190	191	192	193	194		
line loss	bar	23.891268	7.4766442	2.9256539	0.7291571	0.2335845	0.0980963	0.0615596	0.0320188	0.0180514	0.0108092		
elevation increases	m	0	0	0	0	0	0	0	0	0	0		
other pressure drops	bar	0	1	2	3	4	5	6	7	8	9		
summary													
line losses	bar	23.891268	7.4766442	2.9256539	0.7291571	0.2335845	0.0980963	0.0615596	0.0320188	0.0180514	0.0108092		
static pressure gain/loss	bar	0	0	0	0	0	0	0	0	0	0		
other pressure drops	bar	0	0	0	0	0	0	0	0	0	0		
total pressure drop	bar	23.891268	7.4766442	2.9256539	0.7291571	0.2335845	0.0980963	0.0615596	0.0320188	0.0180514	0.0108092		
Downstream pressure	bar(g)	3	3	3	3	3	3	3	3	3	3		

Calculations for NPS 4” to 20”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25
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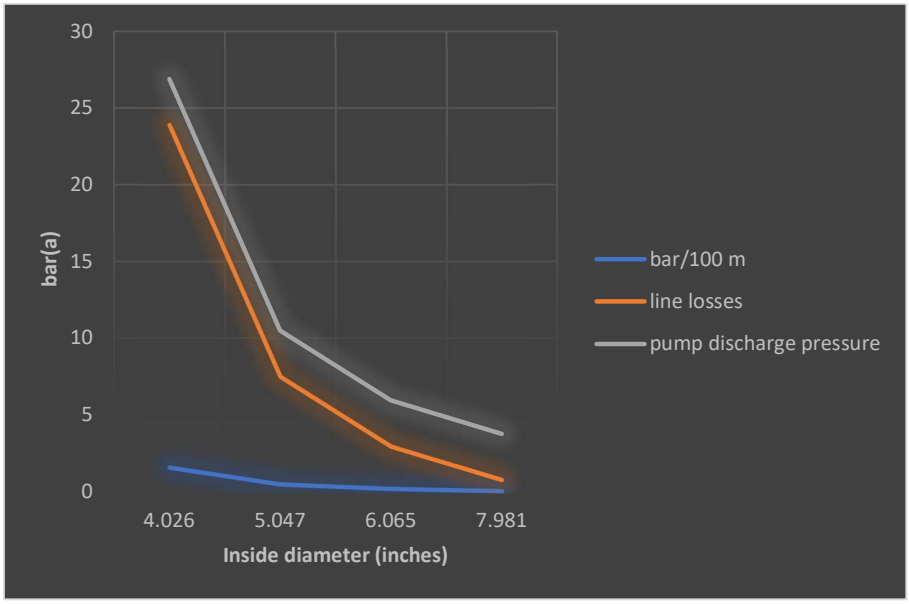
bar(a)
4.026
5.047
6.065
7.981
10.02
11.938
13.124
15
16.876
18.812
Inside diameter (inches)
bar/100 m
line losses
pump discharge pressure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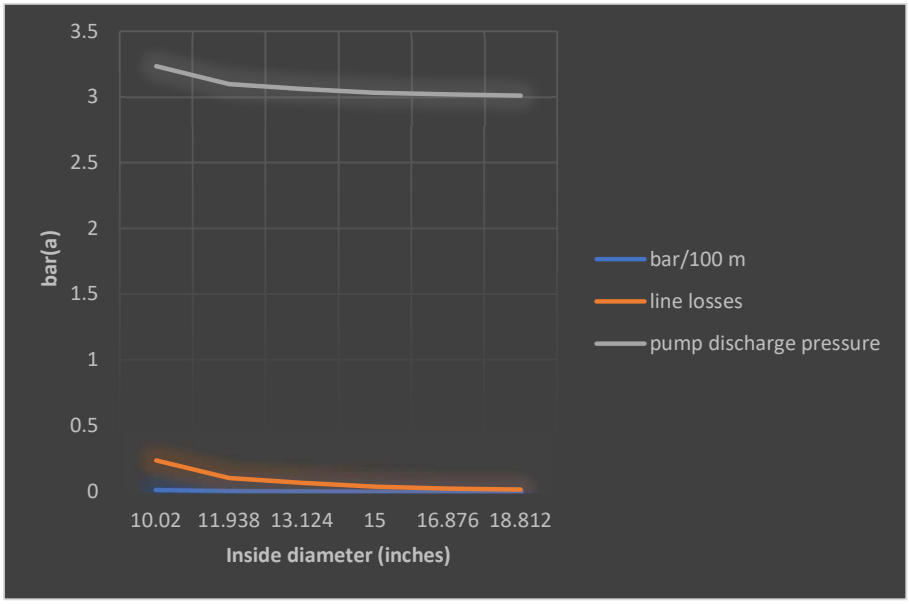
Inside diameter (inches)
bar/100 m
line losses
pump discharge pressure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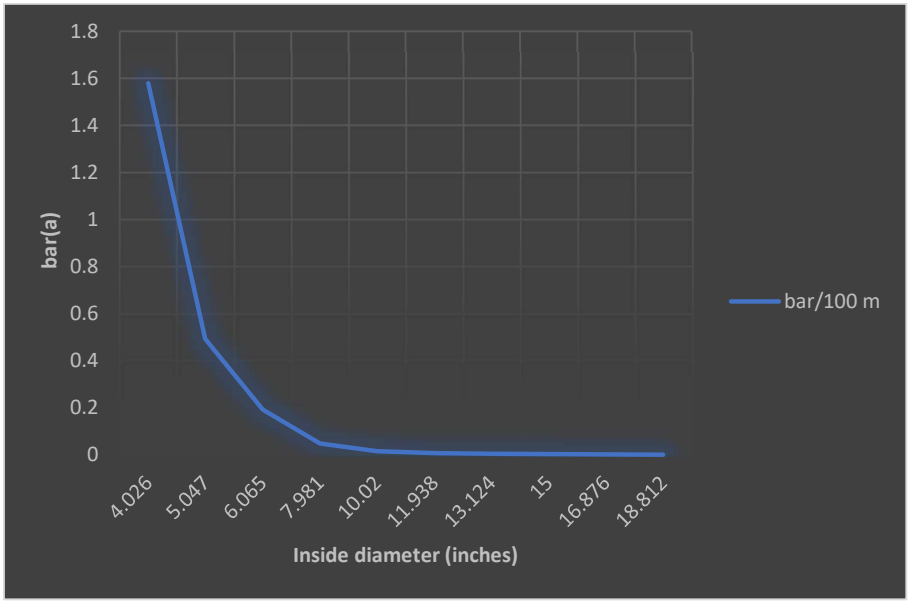
Inside diameter (inches)
bar/100 m
line losses
pump discharge pressure


1.8
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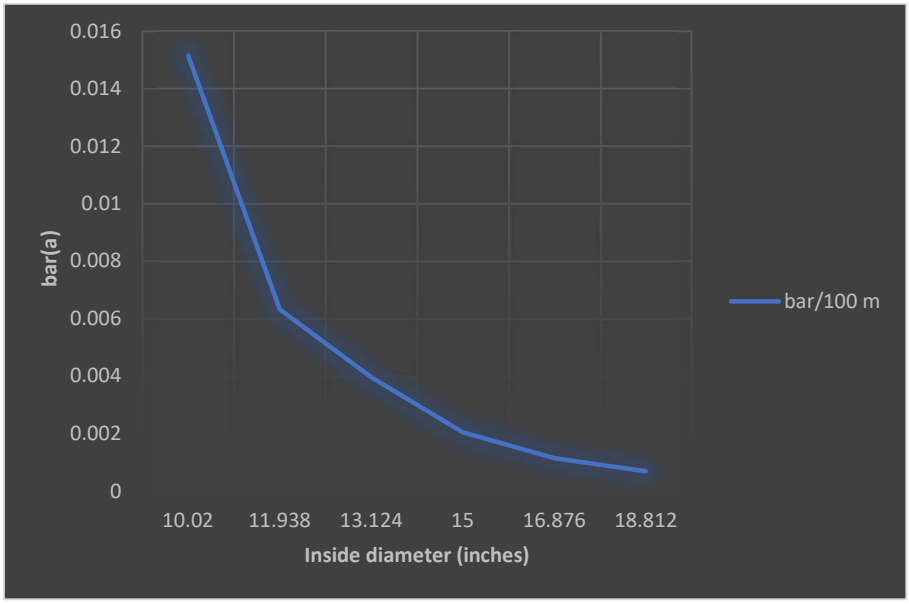
Inside diameter (inches)
bar/100 m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Inside diameter (inches)
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