Artificial Lift R&D Council

Weatherford

Understanding Multi Point Injection Advantages / Disadvantages

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ALRDC Gas Lift Workshop

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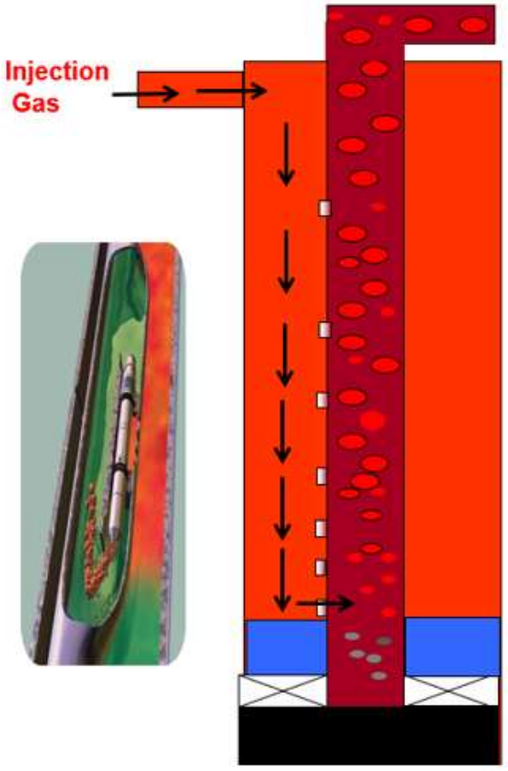
Gas Lift provides one of two purposes

1. **To reduce the flowing pressure in the tubing to produce more fluids from reservoir**
2. **To stabilize flowing pressure in the tubing commonly caused by "slugging" inflow from HZ section to tubulars**

Continuous Flow Gas Lift



- Continuous flow gas lift is when gas is injected into the production stream continuously and the well is produced continuously
- The black arrows show injection gas being injected from the surface and entering the tubing through a gas lift valve downhole
- The injection gas enters the fluid in the tubing and aerates the fluid. Since gas is lighter than the fluid, the gas naturally flows to the surface and allows the fluid to be produced
- Helps achieve critical velocity for gas well dewatering

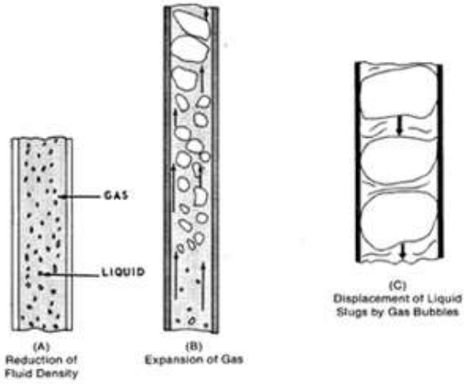


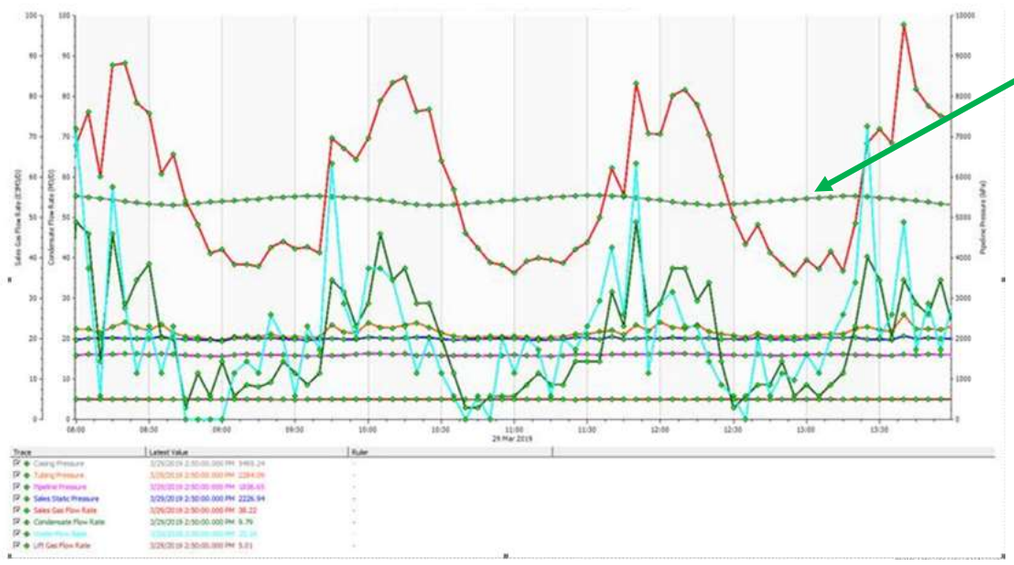
Fig. 1-4 — Three effects of gas in a gas lift well

Gas lift increases the superficial gas velocity and changes the multiphase flow to a more stable flow regime.

What is Multi Pointing

- Gas lift injection through more than 1 valve
- PetroWiki defines as “when two or more gas lift valves are flowing gas at once”
- API 19GLHB First edition does not define in it's glossary Terms & Definitions
- Most Multi Pointing gas lift wells have a stable Casing pressure trend

Injecting through orifice – water slugs every ~90 minutes –note casing pressure smooth



Casing Pressure

What causes Multi Pointing

- Lack of operating pressure differential
  - May cause changing / unstable flow patterns
- Port sizing – inaccurate valve performance understanding
- Excessive gas injection - what volume is required –Optimize
- Higher than designed for production rate (tubing friction pressure at depth)
- Higher than designed flowing temperature at valve depth (N2 IPO valve)
- Tubing sized to small for production rate / Casing size restrictions

- Lack of solid IPR development – moving target in unconventional shale plays
- Operations training understanding of critical velocity –higher performing wells
- Conventional gas lift equipment – inability to install efficient orifice valve at optimal injection depth – was wireline retrievable for decades
- Improper unloading practices could be the #1 root cause for valve damage
- Inaccurate surface production measurement – LGR assumptions
- Packer less completions – repeated unloading's –susceptibility to valve leaks / valve fatigue
- Unstable inflow –non uniform 3 phase flow –tubing fluid slugs
- Tubing set depth – 45 / 60 / 90 degrees
- Results in slugging / surface heading - wellhead chokes solution ???

Determination of Multi Pointing

- Flowing Pressure / temperature surveys
- Flowing spinner surveys
- DTS surveys (Distributed Temperature Sensing)
- CO2 or N2 tracer tests
- Diagnostics -VPC / DynaLift well simulation
- Gradient stimulation with matching fluid levels

Advantages

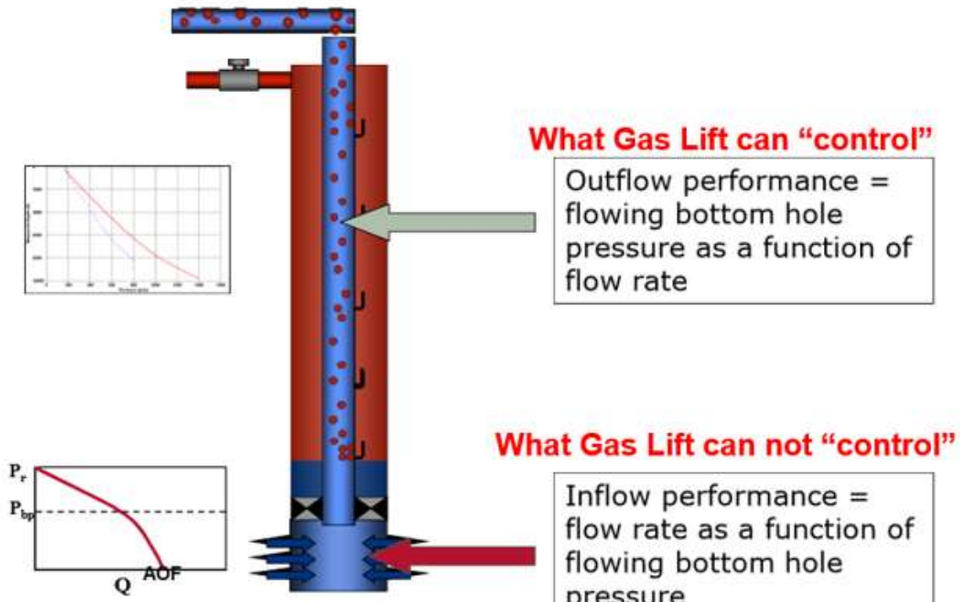
- Cost savings on reduced wellbore
  - Tubing
  - Casing
  - Cement
  - Rig cost to pull frac string
  - Using conventional vs SPM equipment

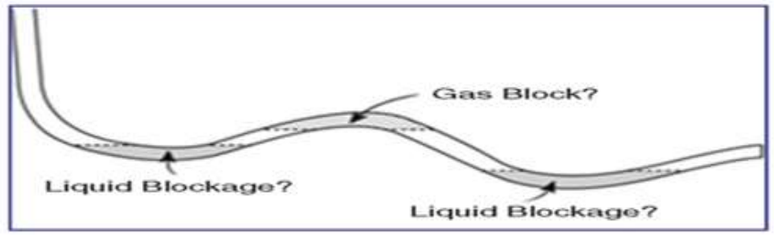
Disadvantages

- Potential:
  - Decreased production
  - Excessive injection gas
- Damaged equipment
  - Unloading / startup
  - Valve chattering

This presentation will focus more on the gas lift valve performance aspect of multipoint gas injection

Well Performance





Hydrodynamic slug flow occurs near HZ flow at lower velocities . Surges may completely disrupt movement into the pipe . When this happens alternating slugs of liquid and gas enter the tubing

This is separate from two or more valves intermitting between themselves – historical use of term multi pointing (below)

Valve Interference

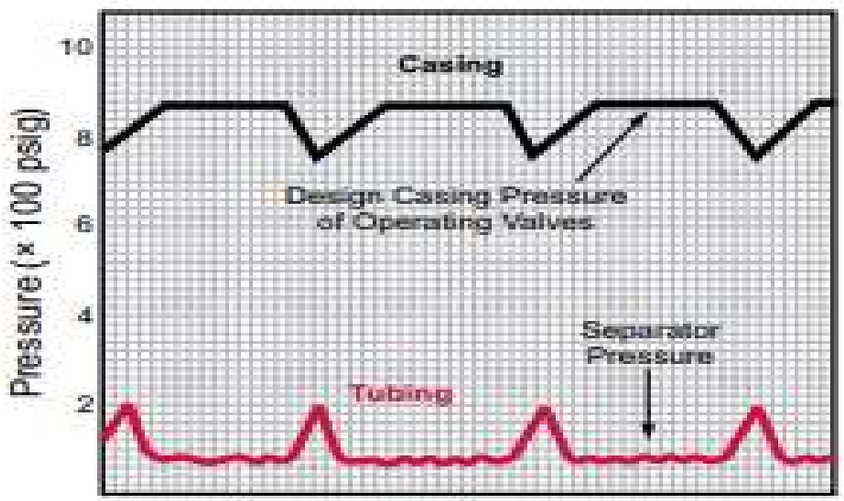
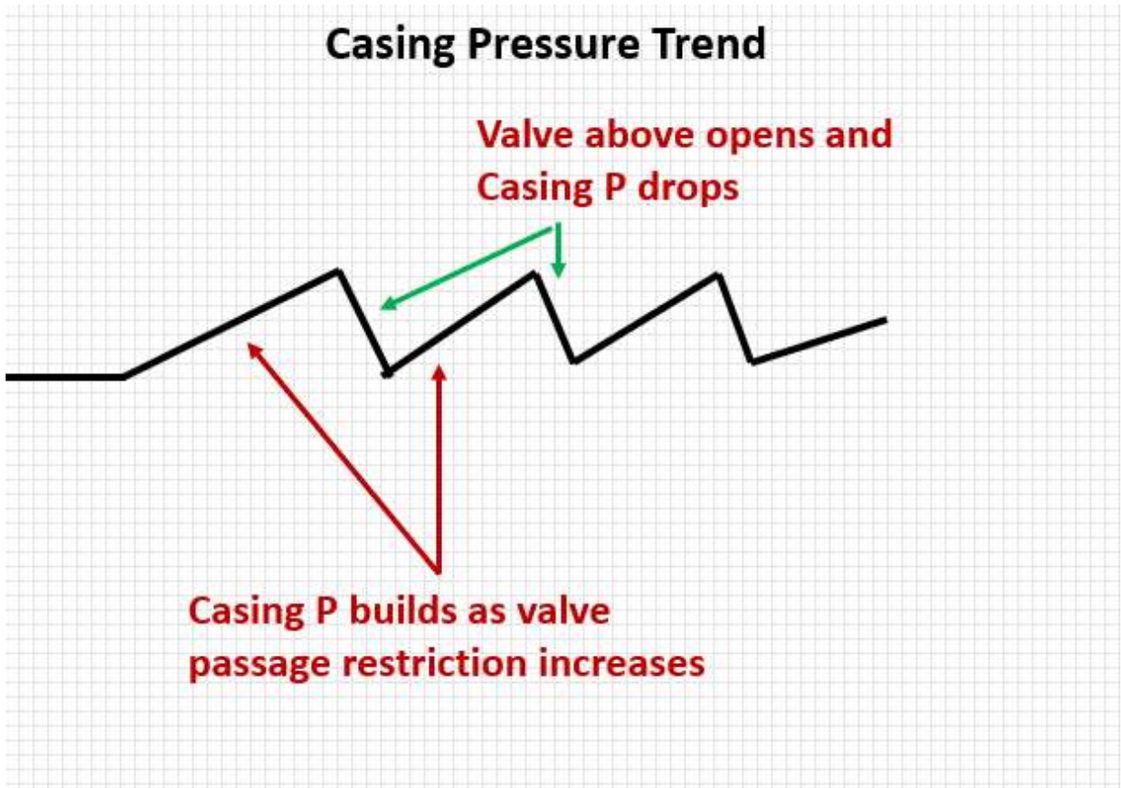


Fig. 8

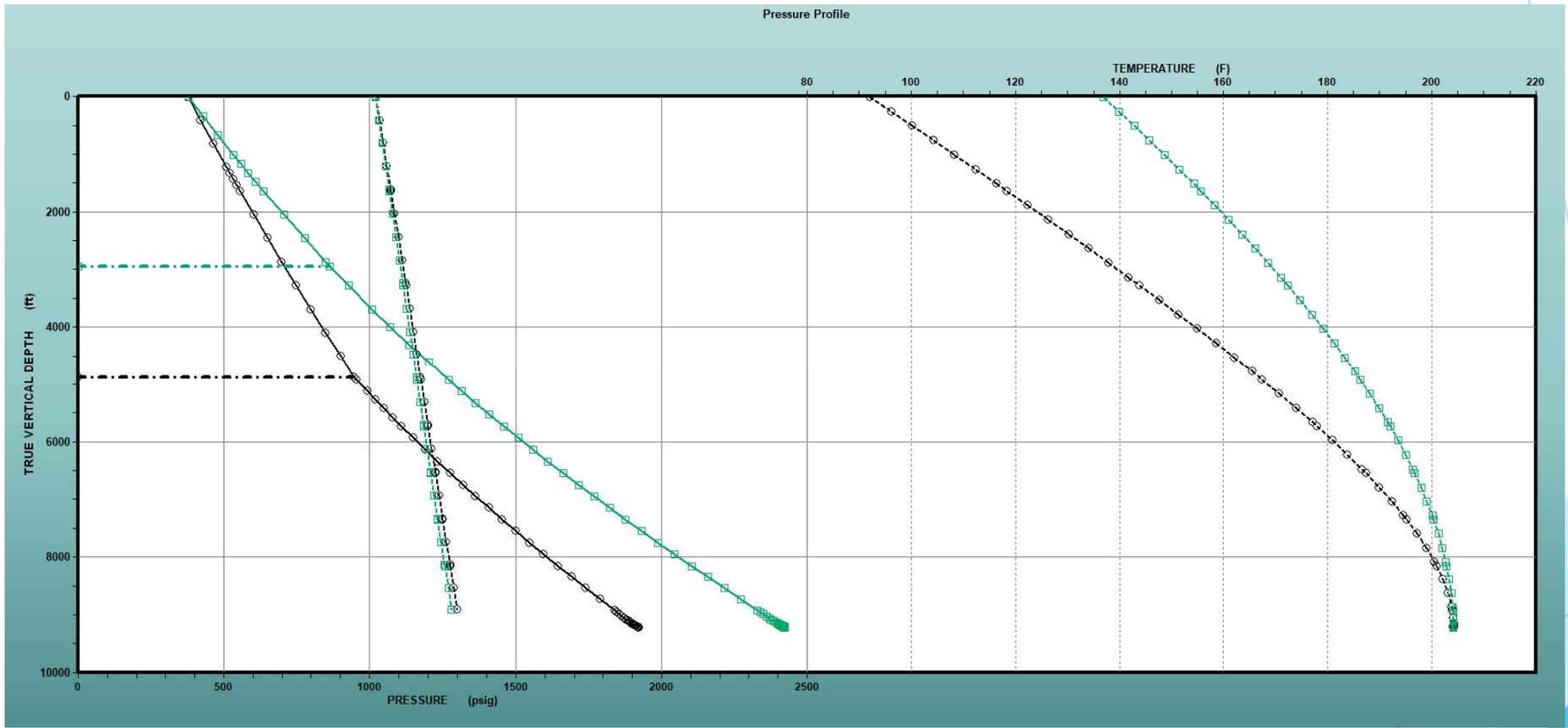
Trouble
Valve opening periodically on tubing pressure effect **(Fig. 8)**.

Remedy
Correct wellbore problems that are restricting feed-in, or redesign gas-lift string for lower producing rate.

Intermitting / Multi Pointing

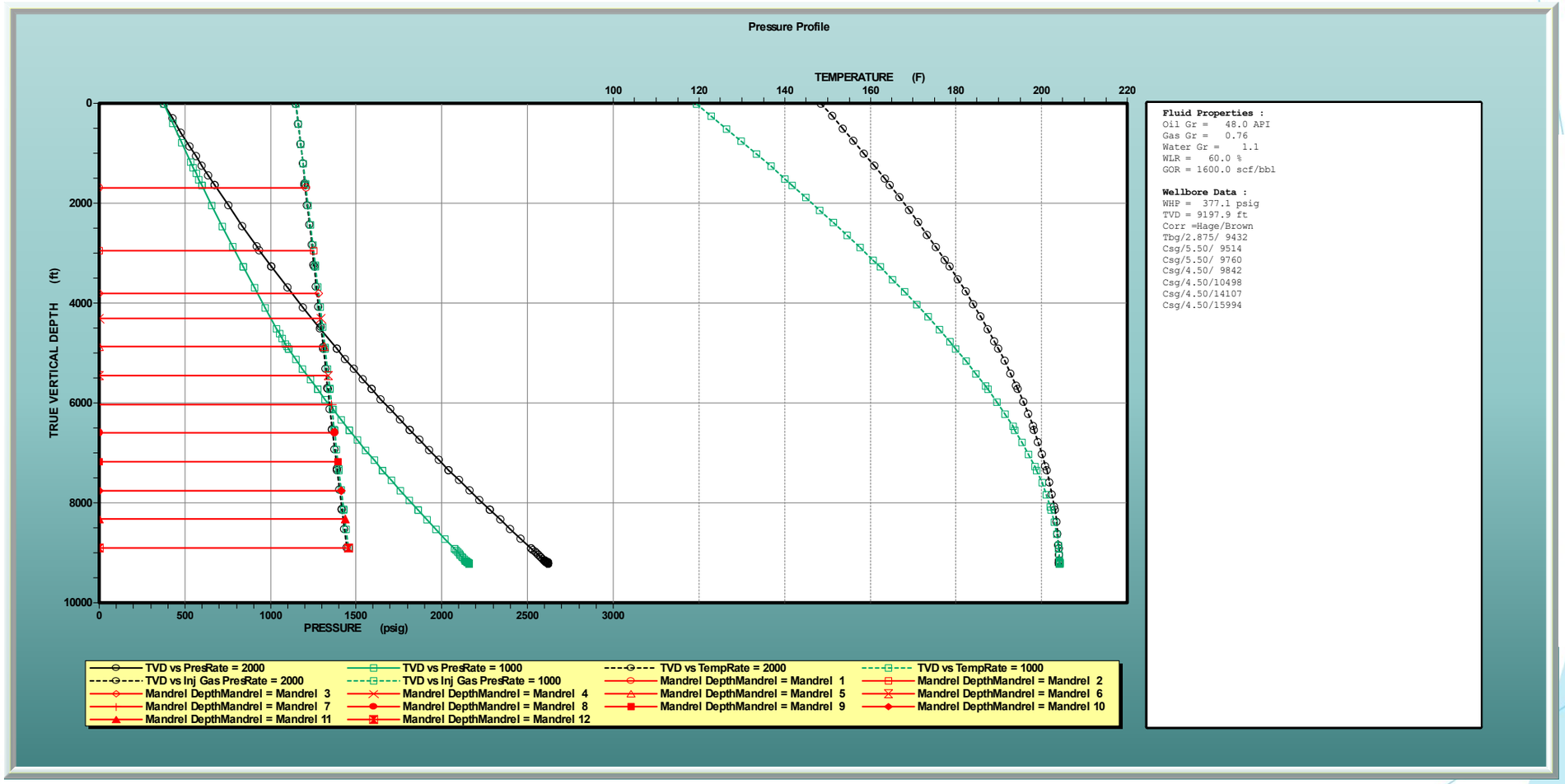


What we imagine Multi Pointing is or what it could be intermitting between valves 2000 feet apart



500 psig swing in FBHP

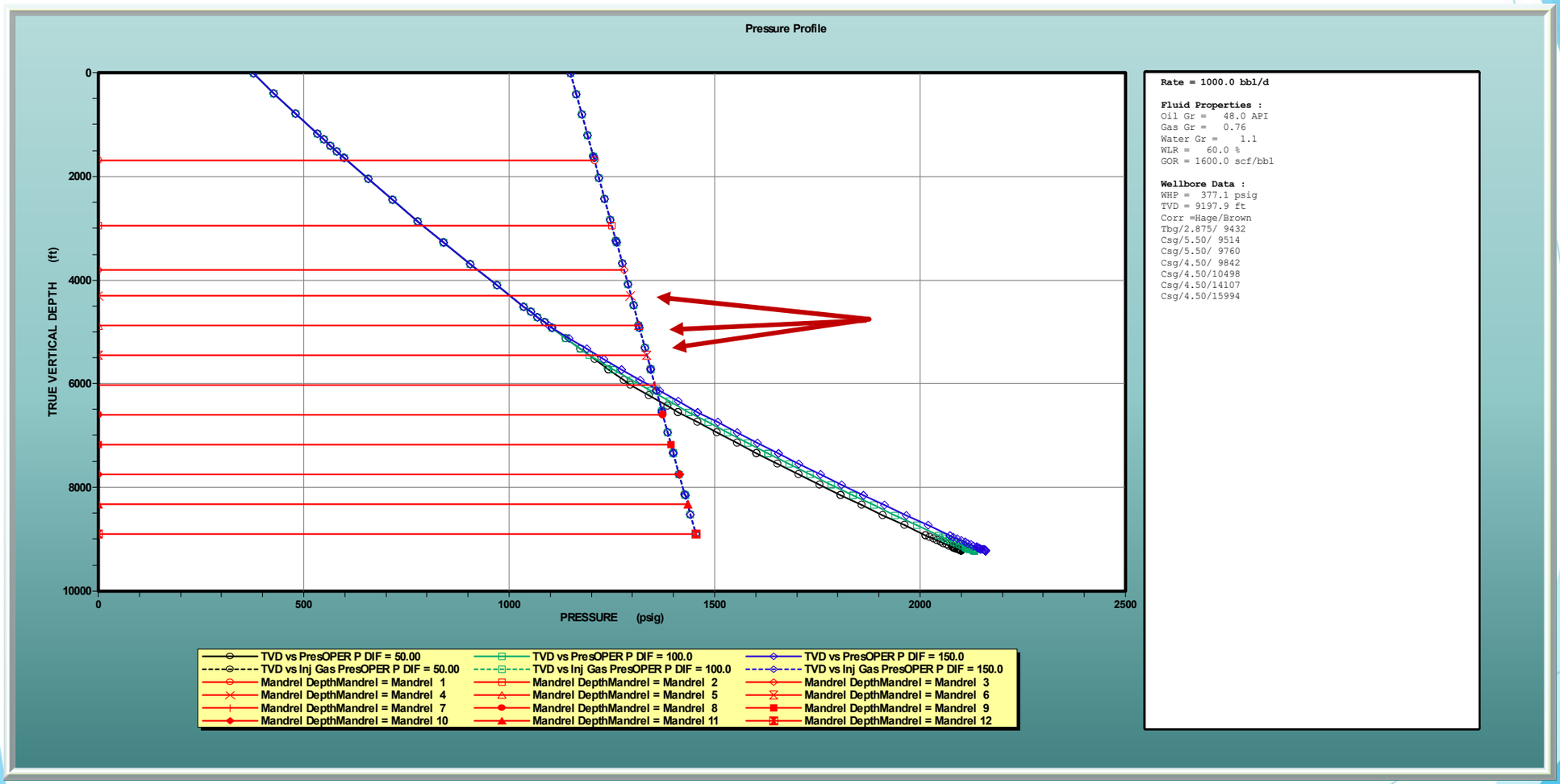
Design Conditions 1000-2000 BLPD



Fluid Properties :
Oil Gr = 48.0 API
Gas Gr = 0.76
Water Gr = 1.1
WLR = 60.0 %
GOR = 1600.0 scf/bbl

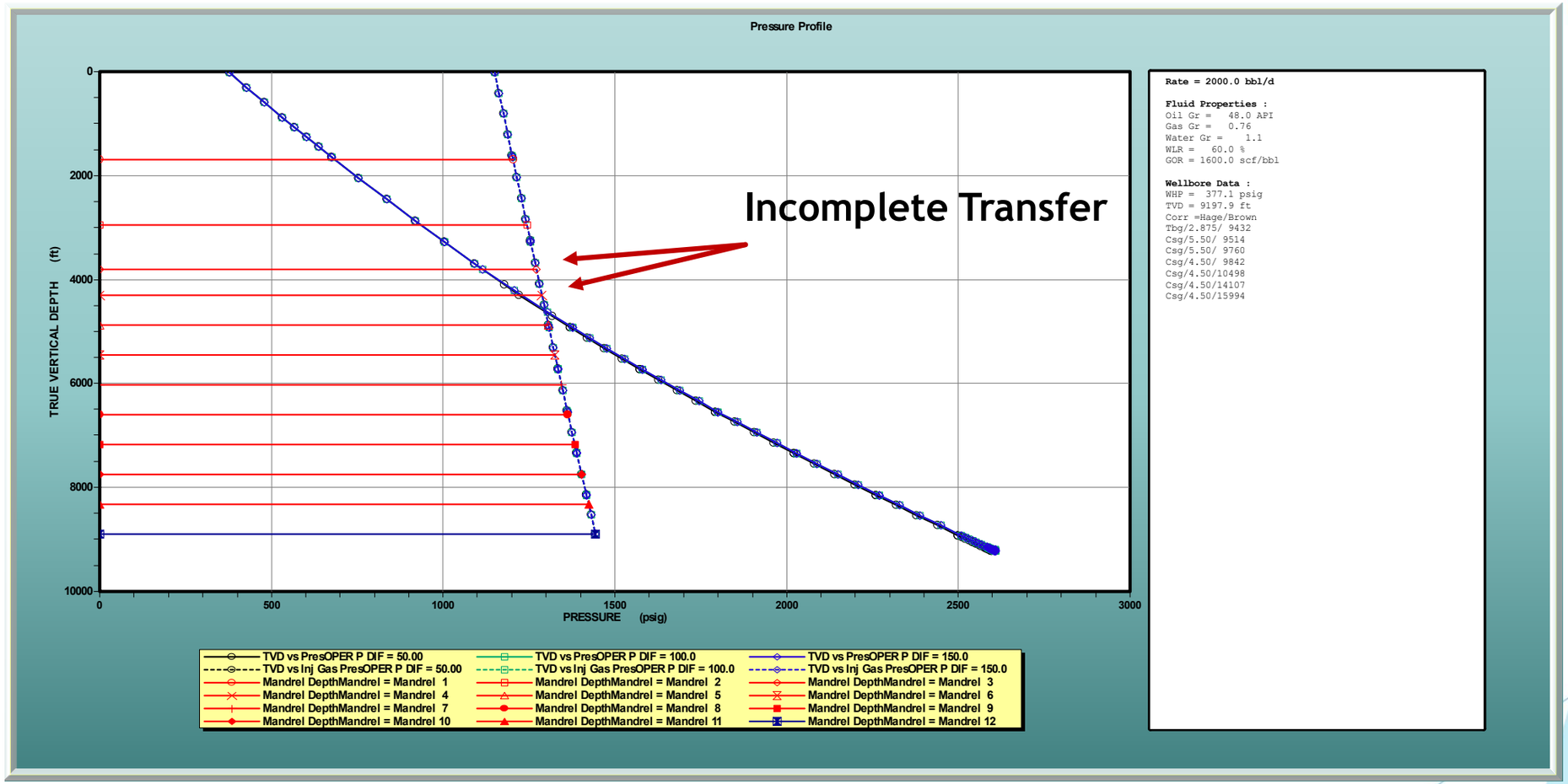
Wellbore Data :
WHP = 377.1 psig
TVD = 9197.9 ft
Corr =Hage/Brown
Tbg/2.875/ 9432
Csg/5.50/ 9514
Csg/5.50/ 9760
Csg/4.50/ 9842
Csg/4.50/10498
Csg/4.50/14107
Csg/4.50/15994

1000 BLPD – injecting at possibly 3 separate depths
What is injection volume required ?



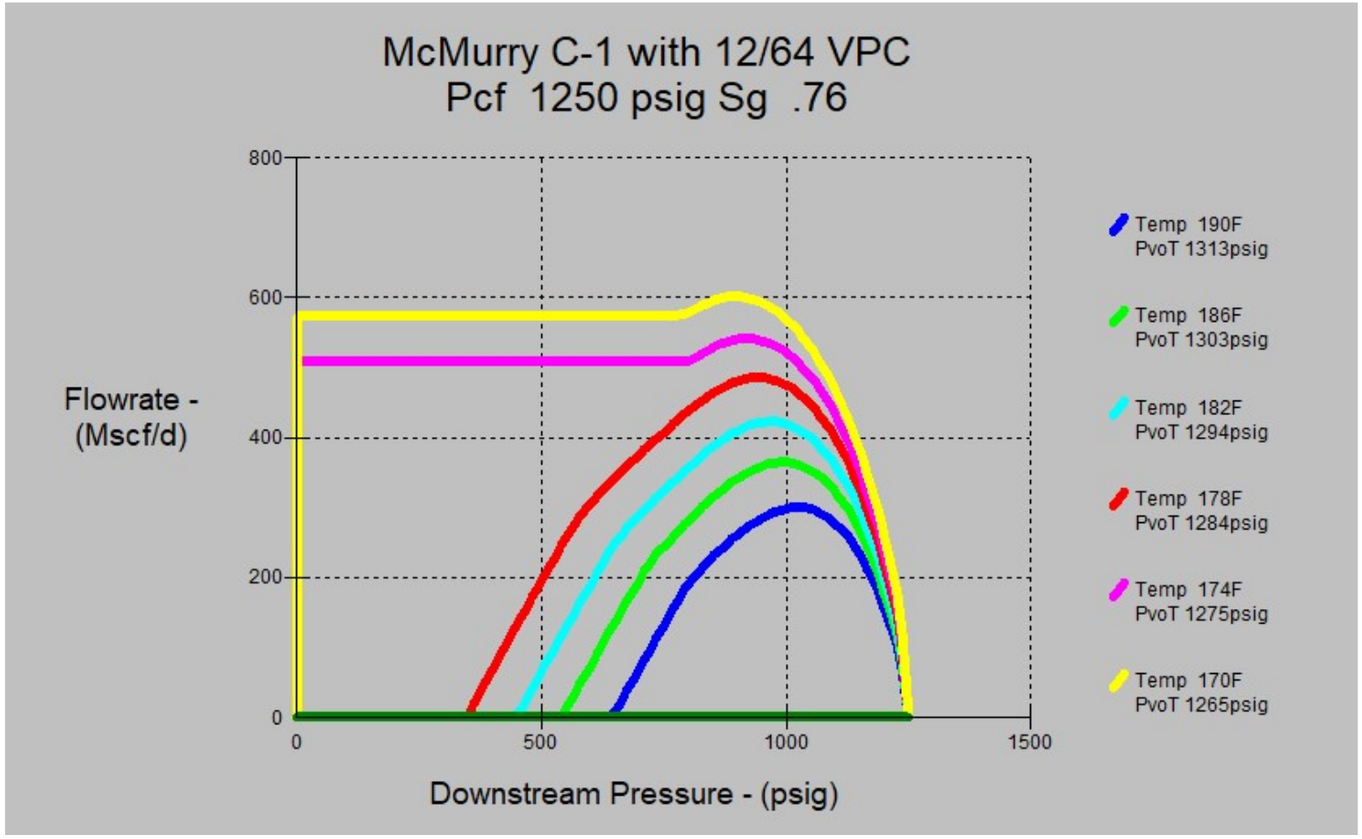
FBHP range ~ 75 psig or 4% variance

2000 BLPD injection at possible 2 -3 separate depths
Is injection gas even required

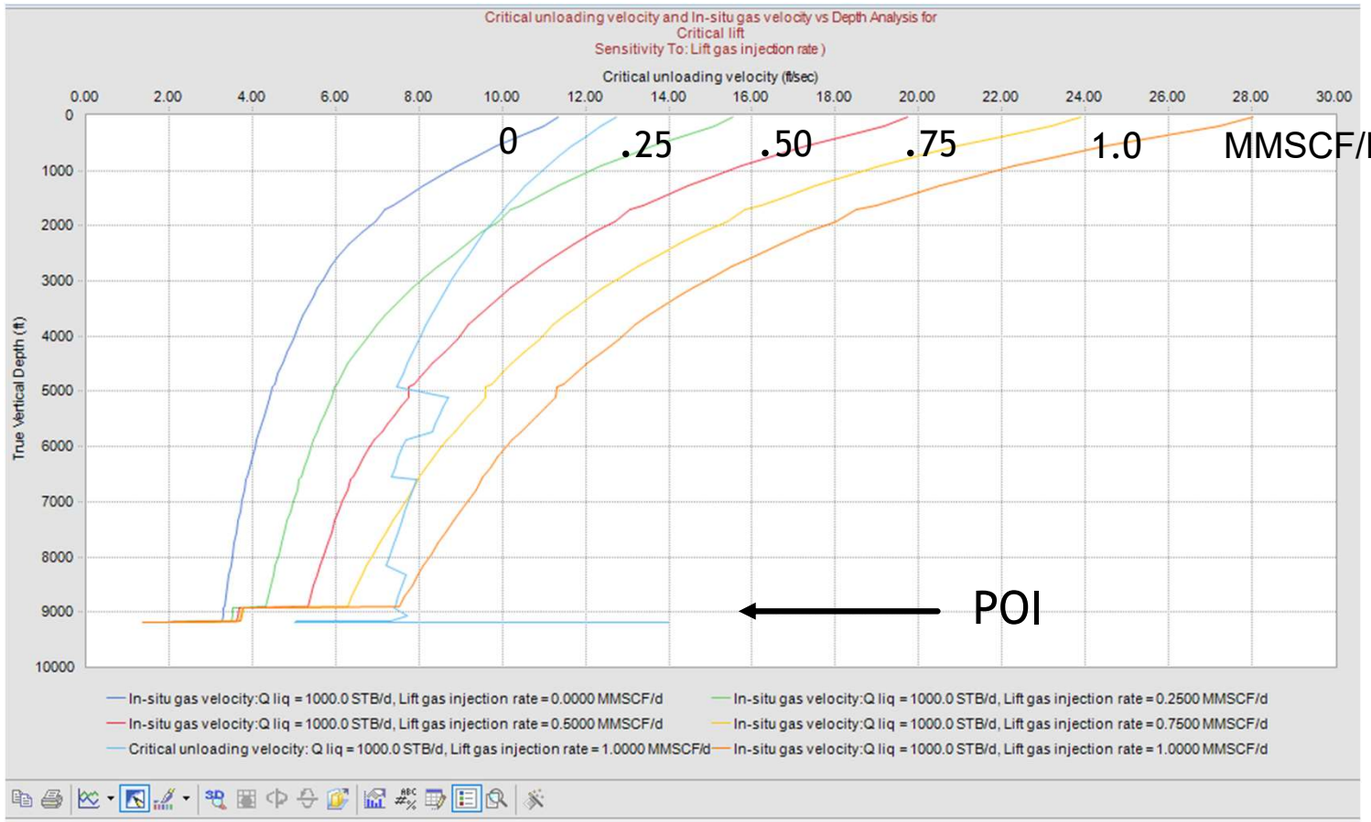


FBHP range ~ 20 psig or .15 % variance

Valve at 4300 ft
Gas passage range dependent upon temperature



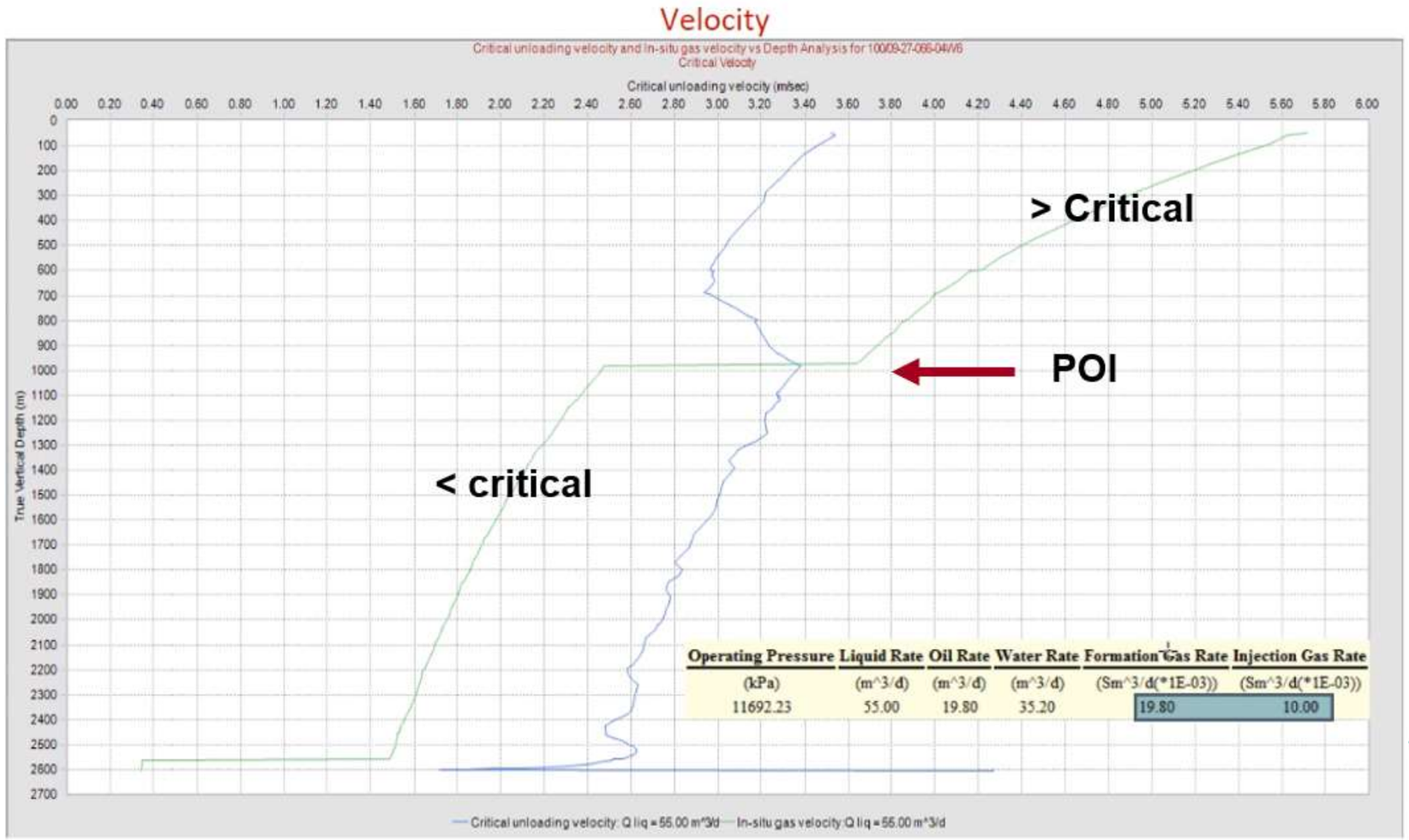
Gas Injection volume range / velocity simulation 1000 BLPD



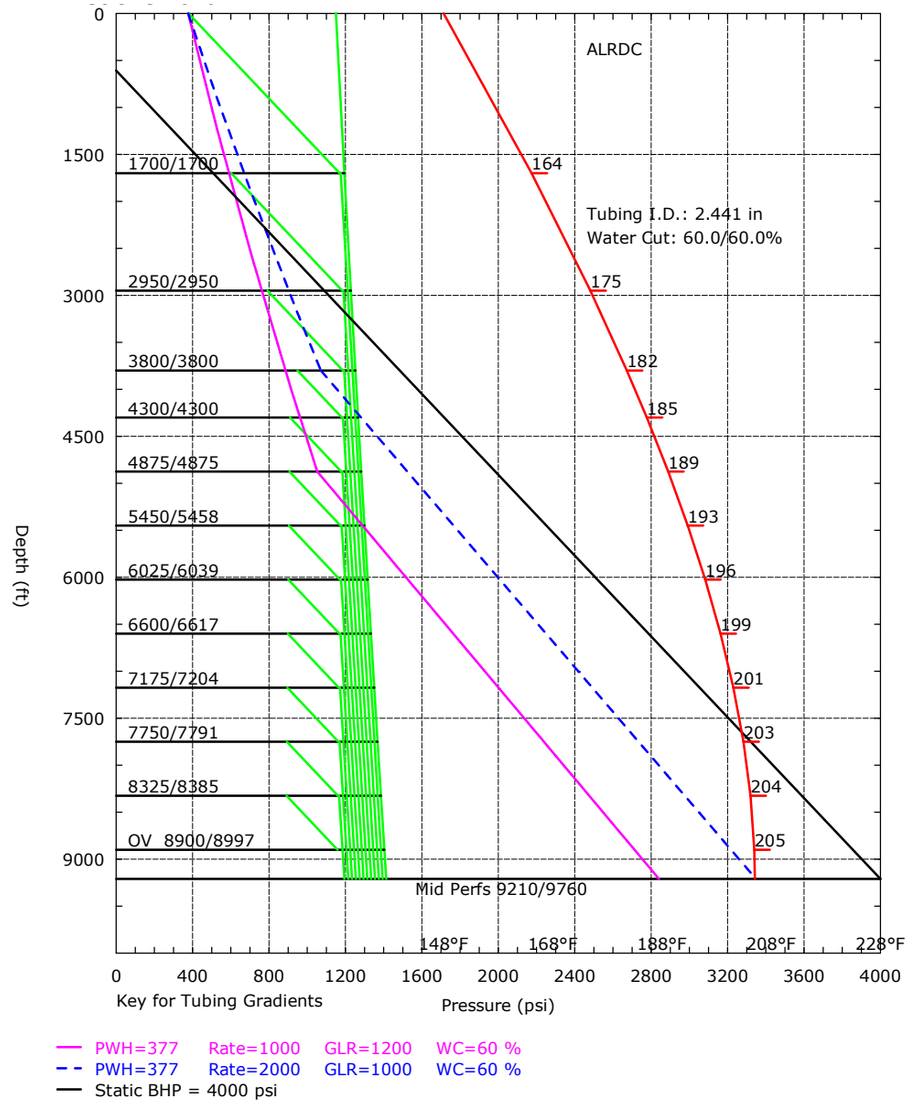
Liquid Rate (STB/d)	Oil Rate (STB/d)	Water Rate (STB/d)	Formation Gas Rate (MMSCF/d)	Injection Gas Rate (MMSCF/d)	Water Cut (Fraction)	Produced GOR (SCF/STB)	Injection MD (ft)	Solution Node Pressure (psig)	Sens 1:Lift gas injection rate (MMSCF/d)
1000.00	400.00	600.00	0.64	0.00	0.6000	1600.01	8996.90	2311.93	0.00
1000.00	400.00	600.00	0.64	0.25	0.6000	2225.01	8996.90	2010.12	0.25
1000.00	400.00	600.00	0.64	0.50	0.6000	2850.01	8996.90	1873.78	0.50
1000.00	400.00	600.00	0.64	0.75	0.6000	3475.01	8996.90	1816.58	0.75
1000.00	400.00	600.00	0.64	1.00	0.6000	4100.01	8996.90	1792.42	1.00

Compare to Gas Lift Performance Curve – they may be different

Pressure differential restricts depth of injection
So well may be loaded below POI



Depth of Injection related to changes in flowing conduit pressure



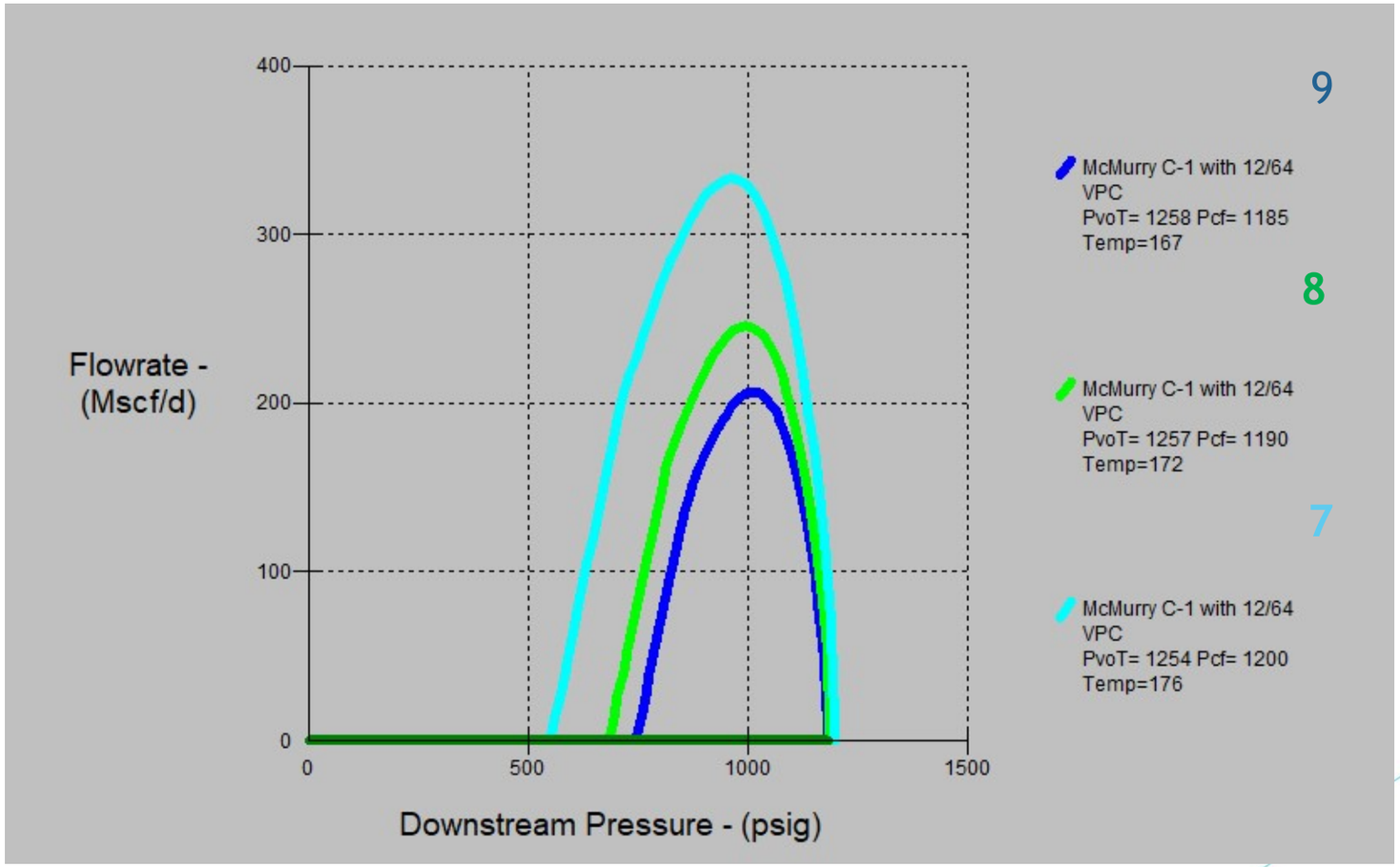
1000 BLPD .188 ports

#	TVD (ft)	MD (ft)	TV (°F)	TCF	Port Size (in)	R	DPC (psi)	PT (psi)	PSC (psi)	PVC (psi)	OP (psi)	PSO (psi)	PD @60F (psi)	PTRO (psi)
12	1700	1700	165	0.815	12	0.115	45	602	1080	1125	1193	1148	916	1035
11	2950	2950	175	0.799	12	0.115	79	792	1062	1141	1186	1107	912	1030
10	3800	3800	182	0.790	12	0.115	102	949	1041	1143	1168	1066	903	1020
9	4300	4300	186	0.785	12	0.115	116	910	1022	1139	1168	1052	894	1010
8	4875	4875	190	0.780	12	0.115	133	907	1002	1135	1164	1032	885	1000
7	5450	5458	193	0.775	12	0.115	149	904	981	1130	1160	1010	877	990
6	6025	6039	196	0.771	12	0.115	166	901	959	1125	1154	988	868	980
5	6600	6617	199	0.768	12	0.115	183	898	935	1119	1147	964	859	970
4	7175	7204	202	0.765	12	0.115	201	896	916	1117	1146	945	854	965
3	7750	7791	203	0.763	12	0.115	218	894	897	1115	1143	925	850	960
2	8325	8385	205	0.761	12	0.115	236	891	875	1111	1140	904	846	955
1	8900	8997			16	Orifice		871			1112			

Casing P can build to 1060 psig before reopening valve 10

TV : Temperature of Valve
TCF : Temperature correction Factor
R : Ap/Ab
DPC : Casing Press. at Depth - Casing Press. at Surface
PT : Tubing Pressure
PSC : Closing Pressure at Surface
PVC : Closing Pressure at Depth [PVC = PSC + DPC]
OP : Opening Pressure at Depth [OP = (PVC - PTR) / (1 - R)]
PSO : Suface Opening Pressure [PSO = OP - DPC]
PD AT F : Bellows Pressure at Base Temperature [PD AT F = TCF X PVC]
PTRO : Test Rack Opening Pressure [PTRO = (PD AT F) / (1 - R)]

1000 BLPD , injection restricted through valves at 7,8 and 9 Required 500 MSCF /dy injected through combination of valves



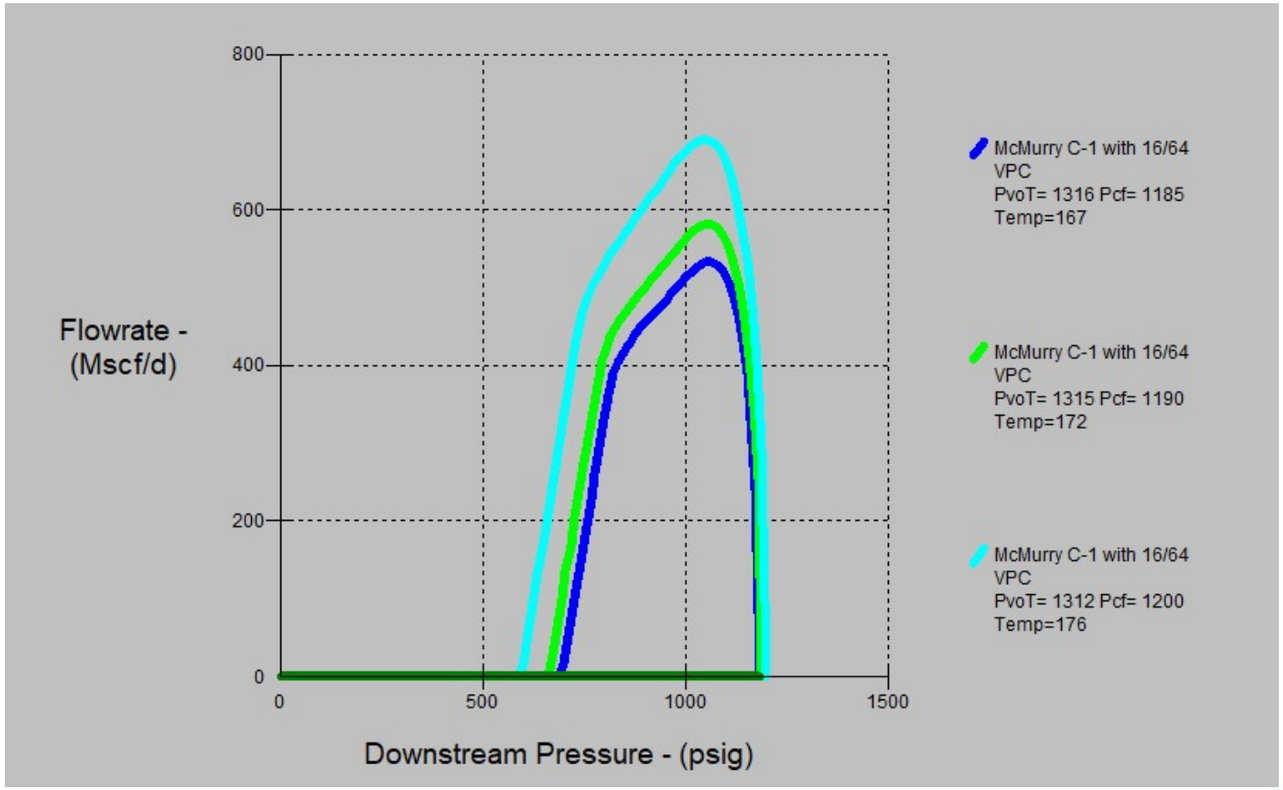
1000 BLPD .250 ports

#	TVD (ft)	MD (ft)	TV (°F)	TCF	Port Size (in)	R	DPC (psi)	PT (psi)	PSC (psi)	PVC (psi)	OP (psi)	PSO (psi)	PD @60F (psi)	PTRO (psi)
12	1700	1700	165	0.815	16	0.186	45	602	1040	1085	1195	1150	884	1085
11	2950	2950	175	0.799	16	0.186	79	792	1022	1100	1171	1092	880	1080
10	3800	3800	182	0.790	16	0.186	102	949	1001	1103	1138	1036	872	1070
9	4300	4300	186	0.785	16	0.186	116	910	978	1094	1136	1020	859	1055
8	4875	4875	190	0.780	16	0.186	133	907	958	1091	1133	1000	851	1045
7	5450	5458	193	0.775	16	0.186	149	904	938	1087	1129	979	843	1035
6	6025	6039	196	0.771	16	0.186	166	901	916	1082	1124	957	835	1025
5	6600	6617	199	0.768	16	0.186	183	898	893	1077	1117	934	827	1015
4	7175	7204	202	0.765	16	0.186	201	896	875	1076	1117	916	823	1010
3	7750	7791	203	0.763	16	0.186	218	894	855	1074	1115	896	819	1005
2	8325	8385	205	0.761	16	0.186	236	891	835	1070	1111	875	815	1000
1	8900	8997			16	Orifice		871			1066			

Casing P can build to 1030 before reopening valve 10

TV : Temperature of Valve
TCF : Temperature correction Factor
R : Ap/Ab
DPC : Casing Press. at Depth - Casing Press. at Surface
PT : Tubing Pressure
PSC : Closing Pressure at Surface
PVC : Closing Pressure at Depth [PVC = PSC + DPC]
OP : Opening Pressure at Depth [OP = (PVC - PTR) / (1 - R)]
PSO : Suface Opening Pressure [PSO = OP - DPC]
PD AT F : Bellows Pressure at Base Temperature [PD AT F = TCF X PVC]
PTRO : Test Rack Opening Pressure [PTRO = (PD AT F) / (1 - R)]

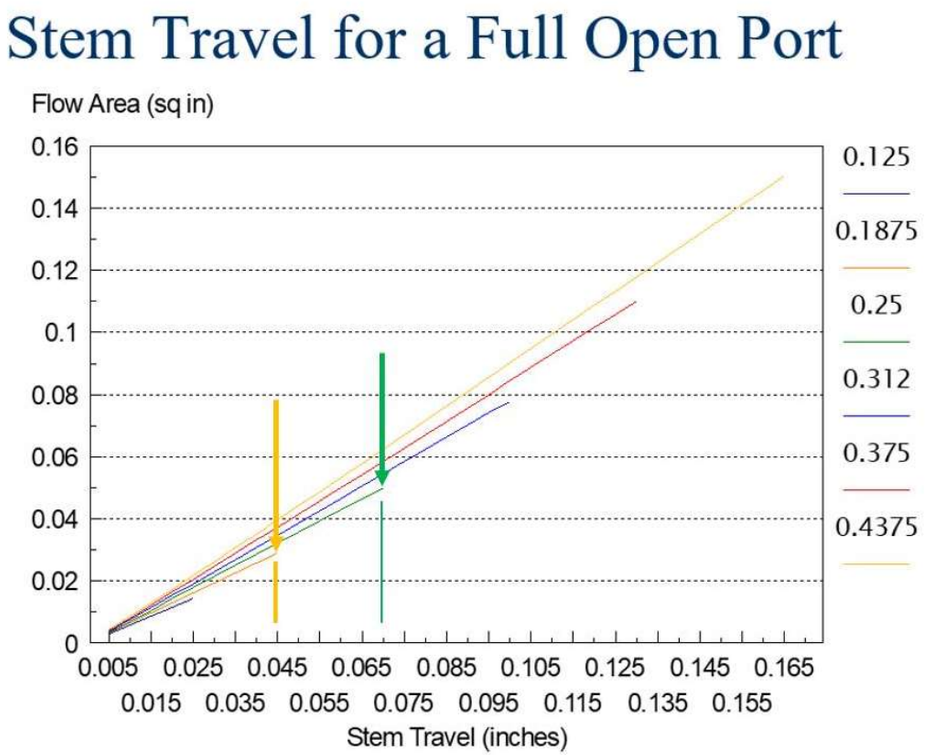
1000 BLPD ,
injection through valves at 7,8 or 9
Required 500 MSCF /day - injected through combination of valves if temperature does not increase



Don’t forget about Stem Travel …

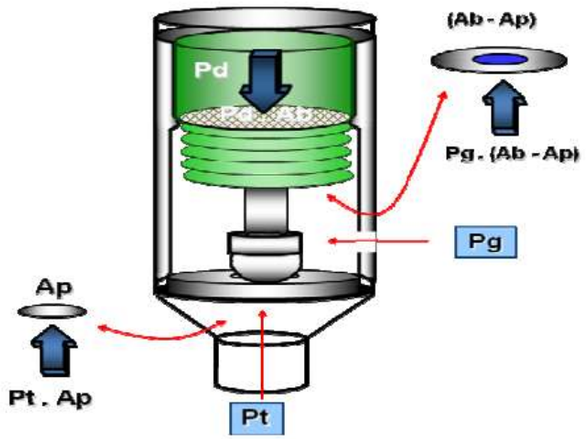
Effective stem travel is the amount the stem can move away from the seat within the linear portion of the loadrate curve.

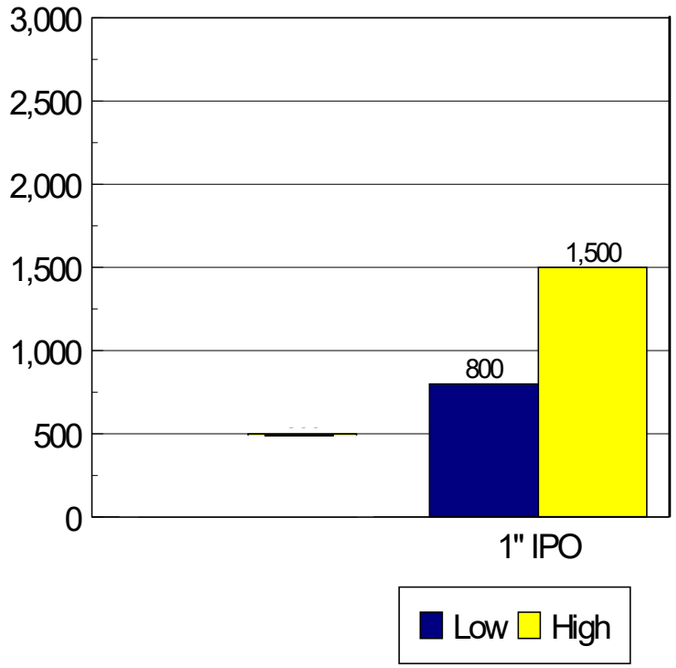
Effective stem travel is a function of set pressure for valves with internally charged bellows. The higher the set pressure, the lower the effective stem travel



Load Rate …

Loadrate is a measure of the valve stem's resistance to movement. The nitrogen dome and bellows act like a spring. The pressure acting across the full area of the bellows required to compress the nitrogen and bellows is the loadrate.
Loadrate is one of the MOST important gas lift valve performance parameters





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