Lift with Gas from Offset Well and its Appliction

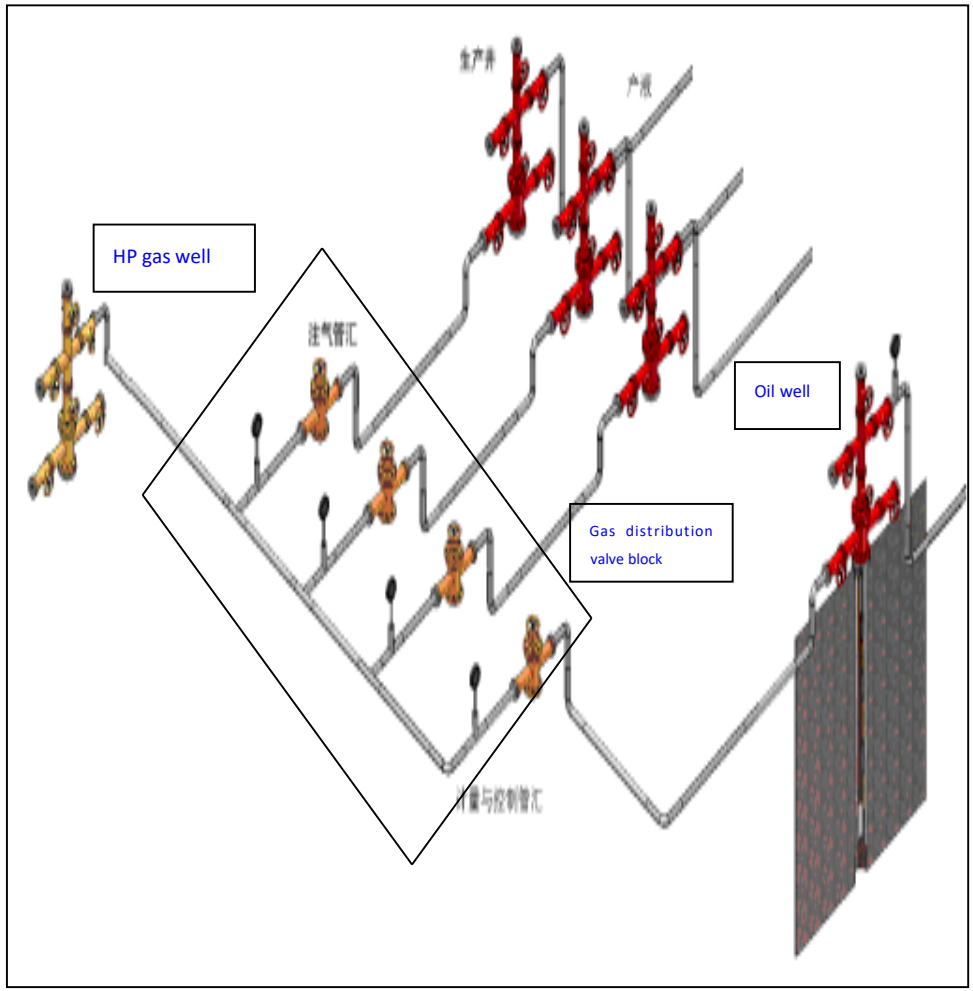
CNPC Gas Lift Center

June, 2018

Content

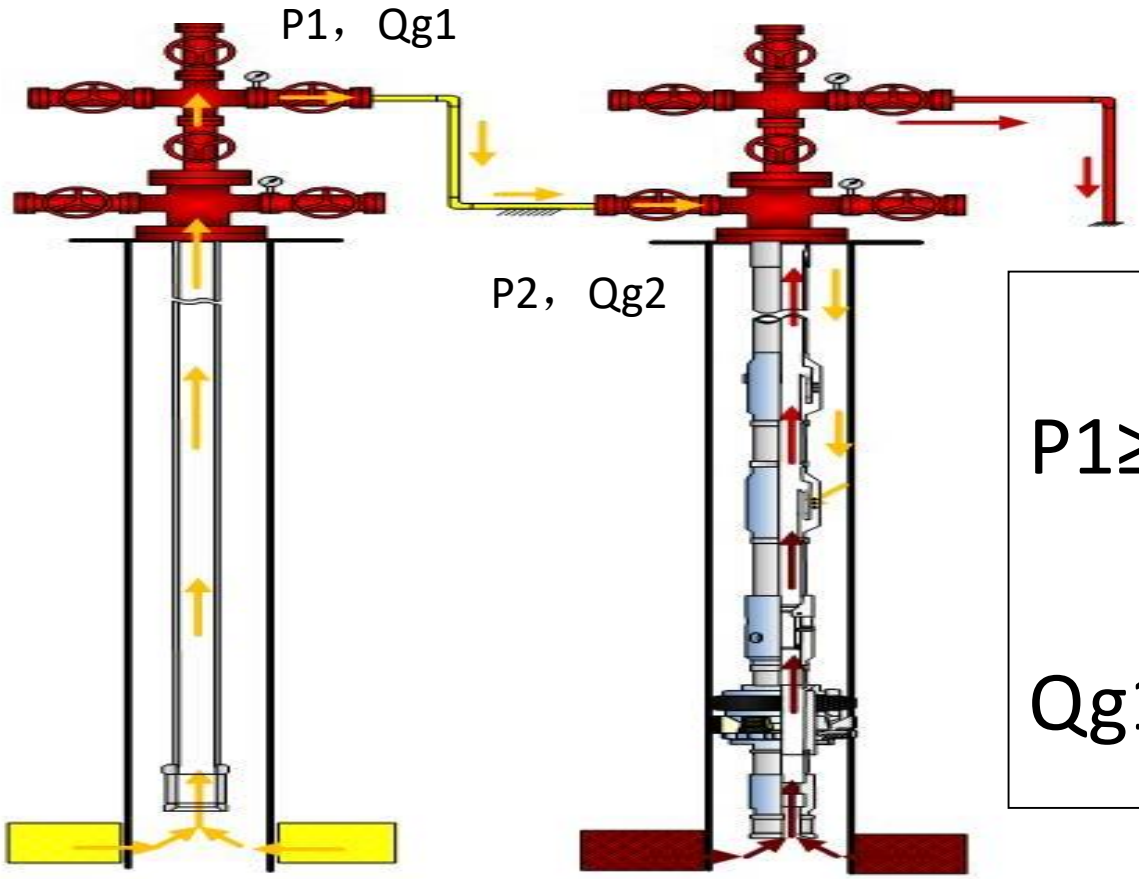
1. Preface

Lift with gas from offset well follows principle of continuous gas lift. For block with high pressure gas well, the HP gas well is used to replace compressor as source of lift gas for production. No need for construction of surface gas boosting system and investment can be saved significantly.



1. Preface

In order to satisfy gas lift production, wellhead tubing pressure of gas well must not be smaller than oil well gas injection pressure and the gas volume must not be smaller than the gas demand of oil well.



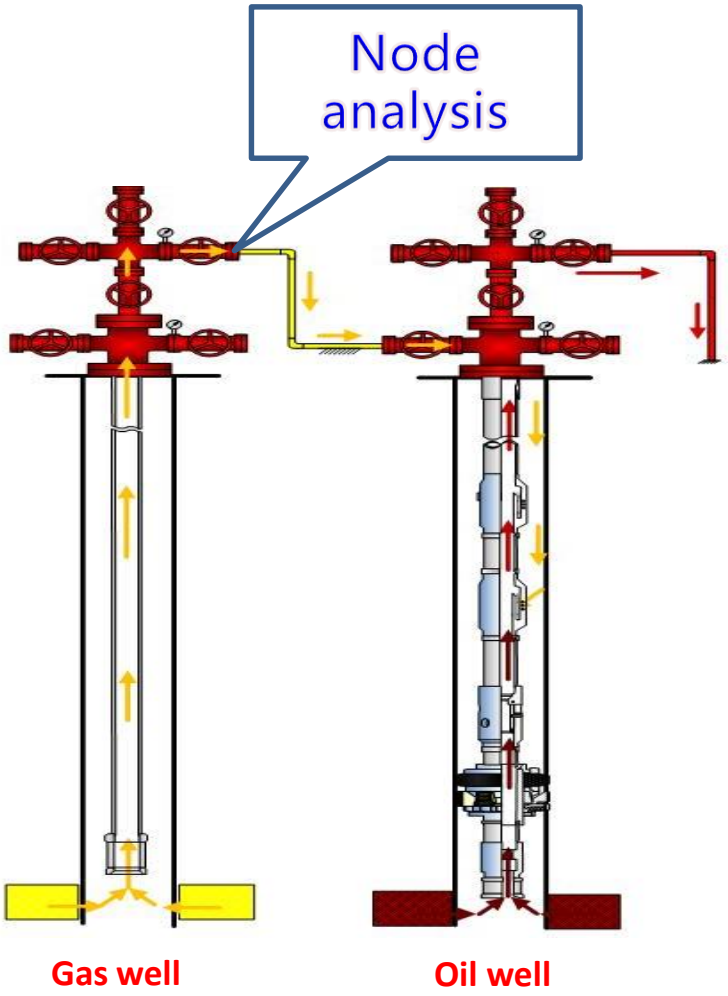
P1≥P2

Qg1≥Qg2

2. Analysis on lift with gas from offset well

Technical thinking:

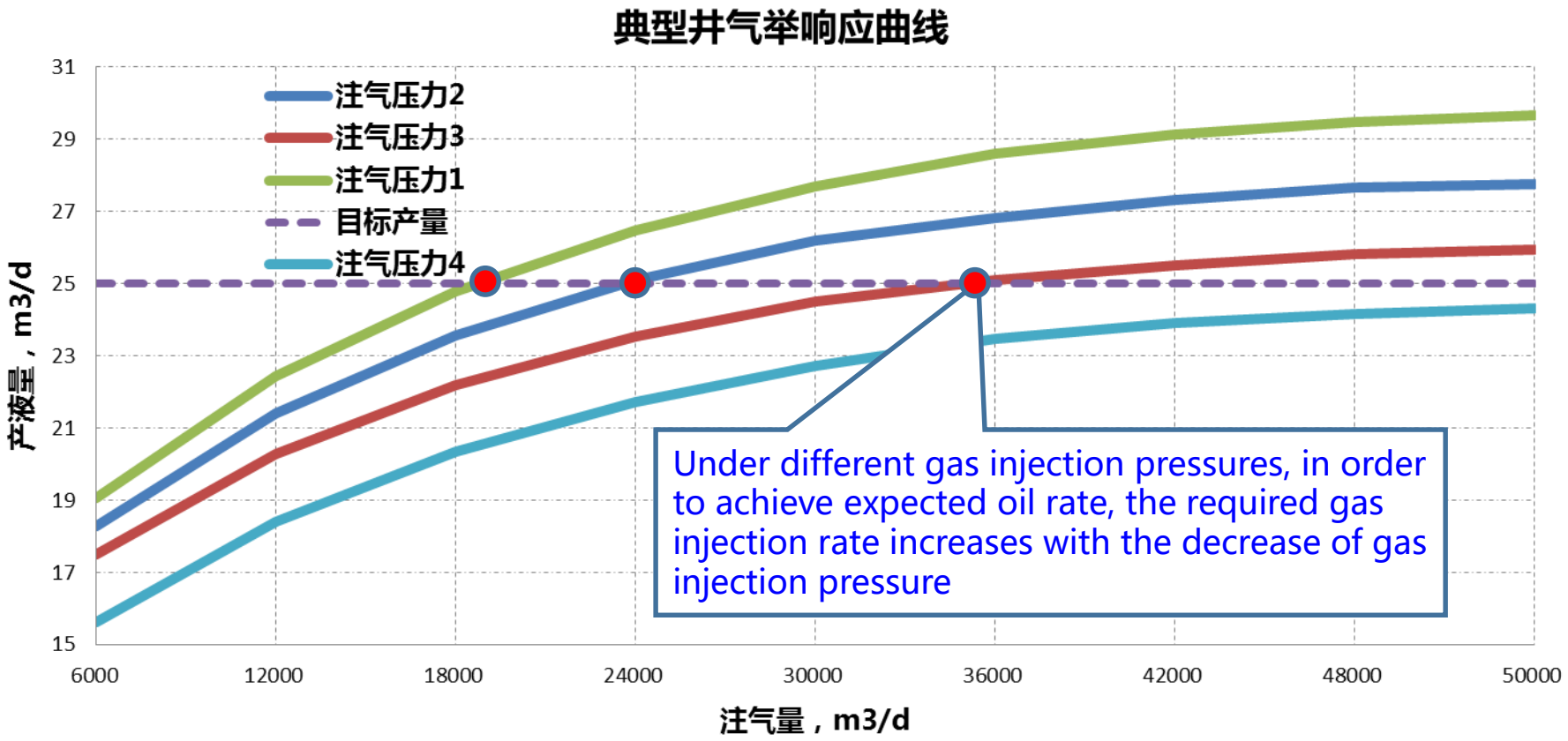
1. Gas well and oil well should be taken as one system for integrated consideration;
2. The production rate of oil well is taken as target and the choke of gas well is taken as node. The production characteristics of oil and gas wells are analyzed respectively and then a coordination point is to be achieved, so that the gas injection pressure and injection rate of oil well can be obtained;
3. As per oil well target oil rate, gas injection pressure, and gas injection rate, the gas lift process design and gas well production system design shall be conducted.



2. Analysis on lift with gas from offset well

1. Analysis of oil well

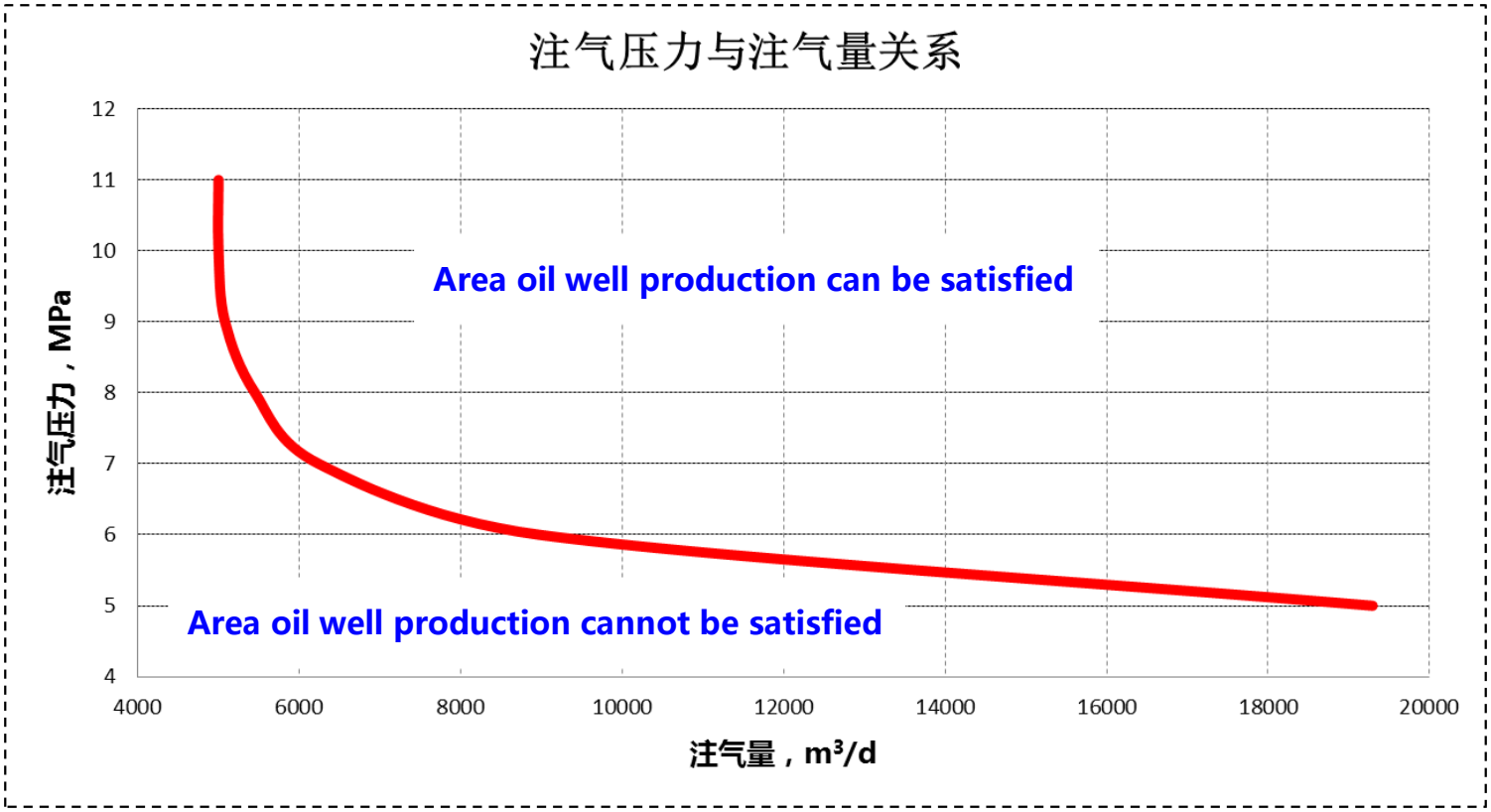
Oil rate of producer is taken as target to obtain the oil well gas lift response characteristics curve and achieve the required gas injection rate under different gas injection pressures.



2. Analysis on lift with gas from offset well

1. Analysis of oil well

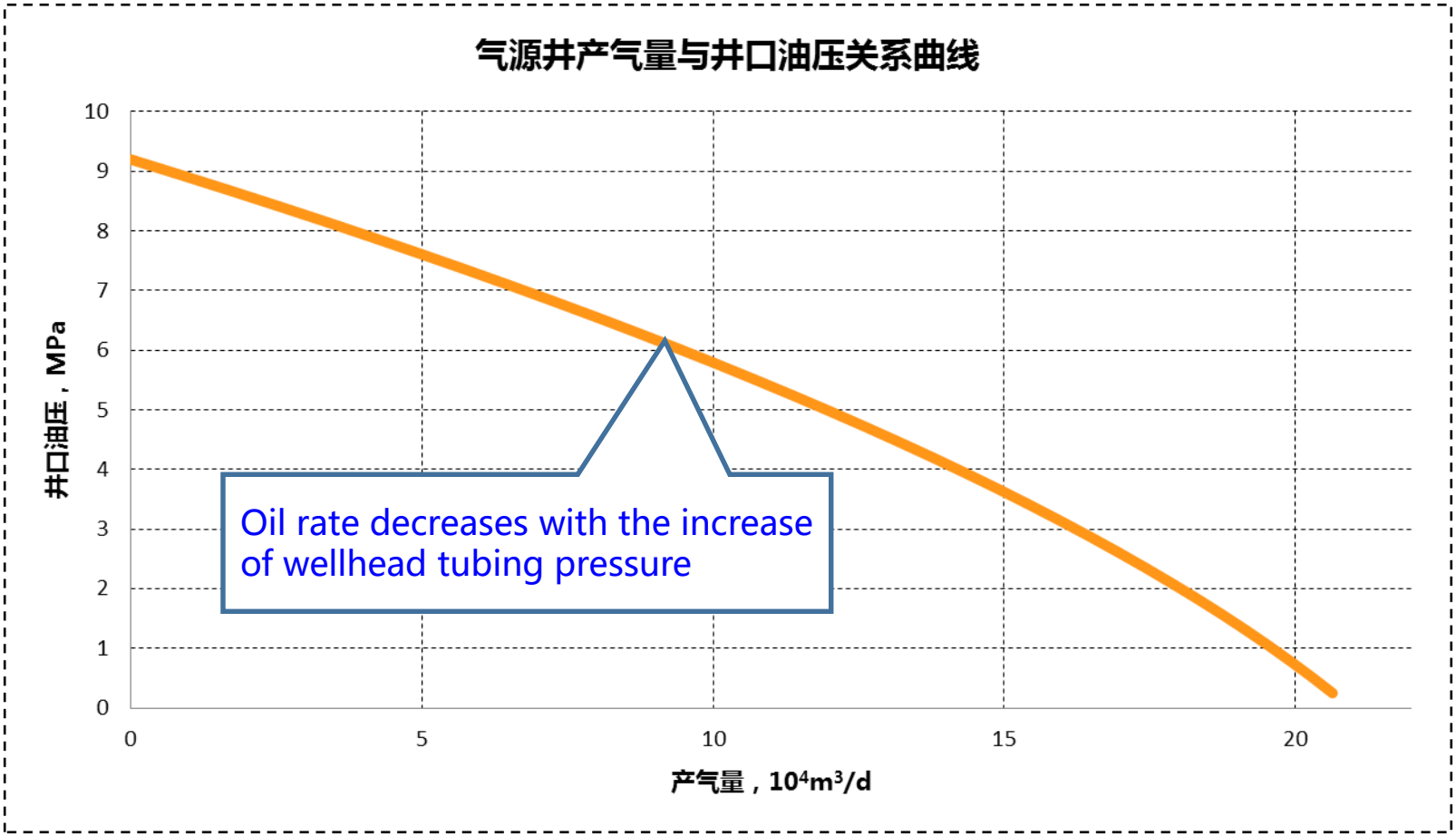
According to the required gas injection rate for different gas injection pressures, the relationship plot between gas injection pressure and gas injection rate can be obtained. This plot is the critical condition that oil well can achieve the expected target oil rate.



2. Analysis on lift with gas from offset well

2. Analysis of gas well

According to the gas well production status, the wellhead tubing pressure and gas production rate of gas source well shall be obtained.



2. Analysis on lift with gas from offset well

3. Analysis and reckoning

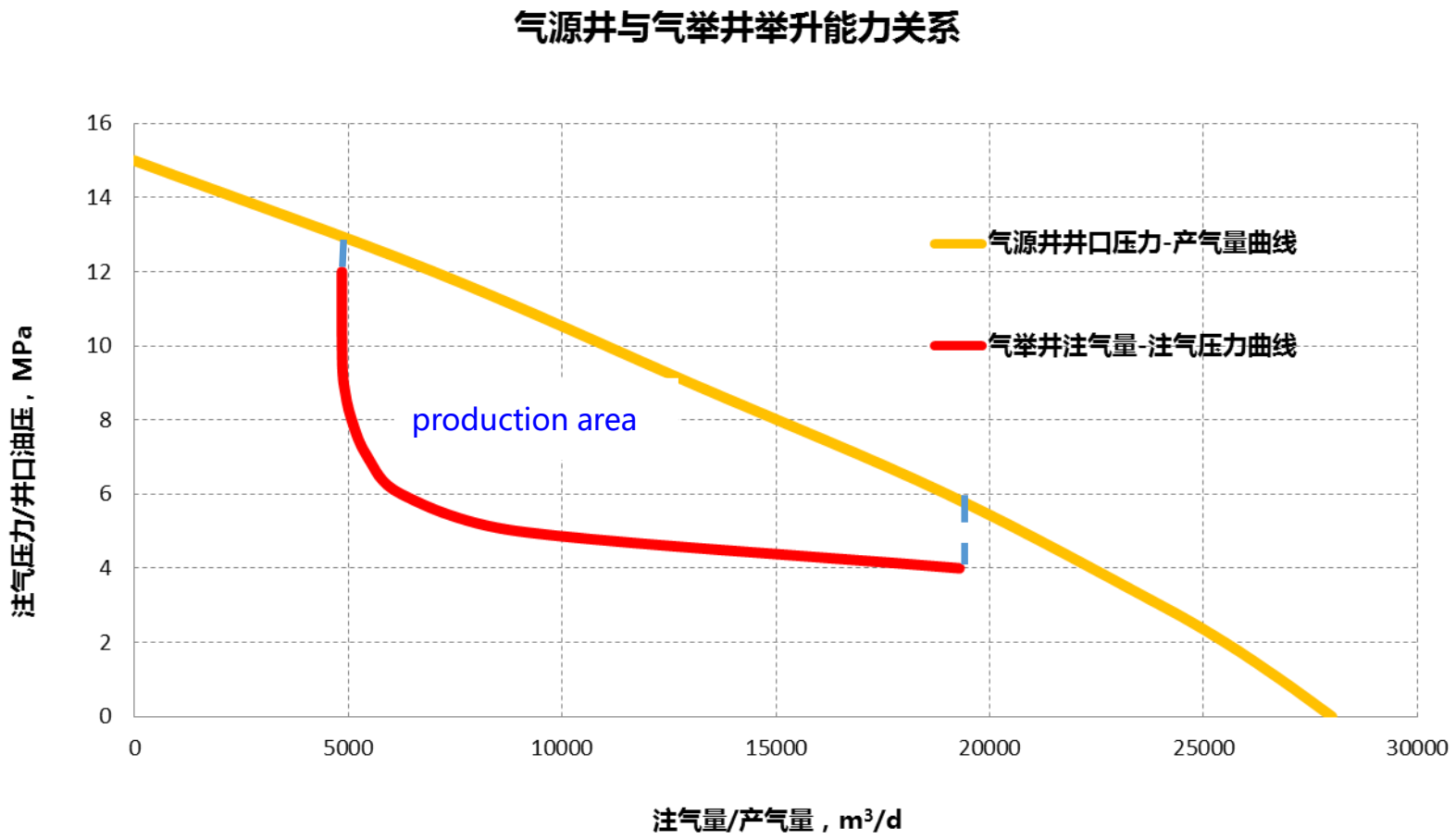
To obtain the relationship plot of gas injection pressure and gas injection rate of oil well and achieve the range of gas injection pressure and gas injection rate that satisfies oil well production

To obtain the relationship plot of wellhead tubing pressure vs. gas production rate of gas source well

Under the same coordinates, two plots shall be produced and analysis shall be made based on the relative location relationship

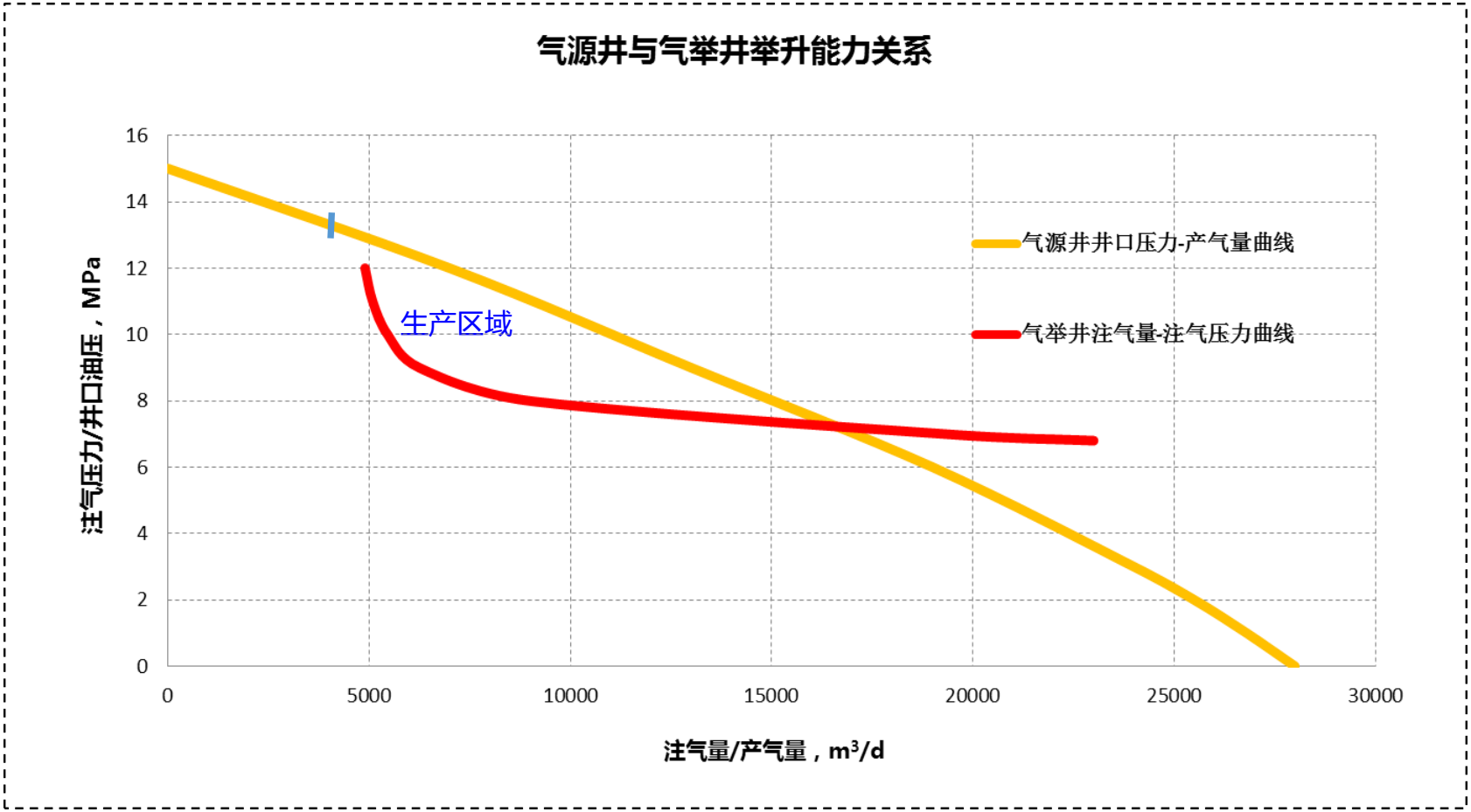
2. Analysis on lift with gas from offset well

Scenario 1: If the plot of wellhead pressure vs. gas rate of gas well is all above plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate can be realized.



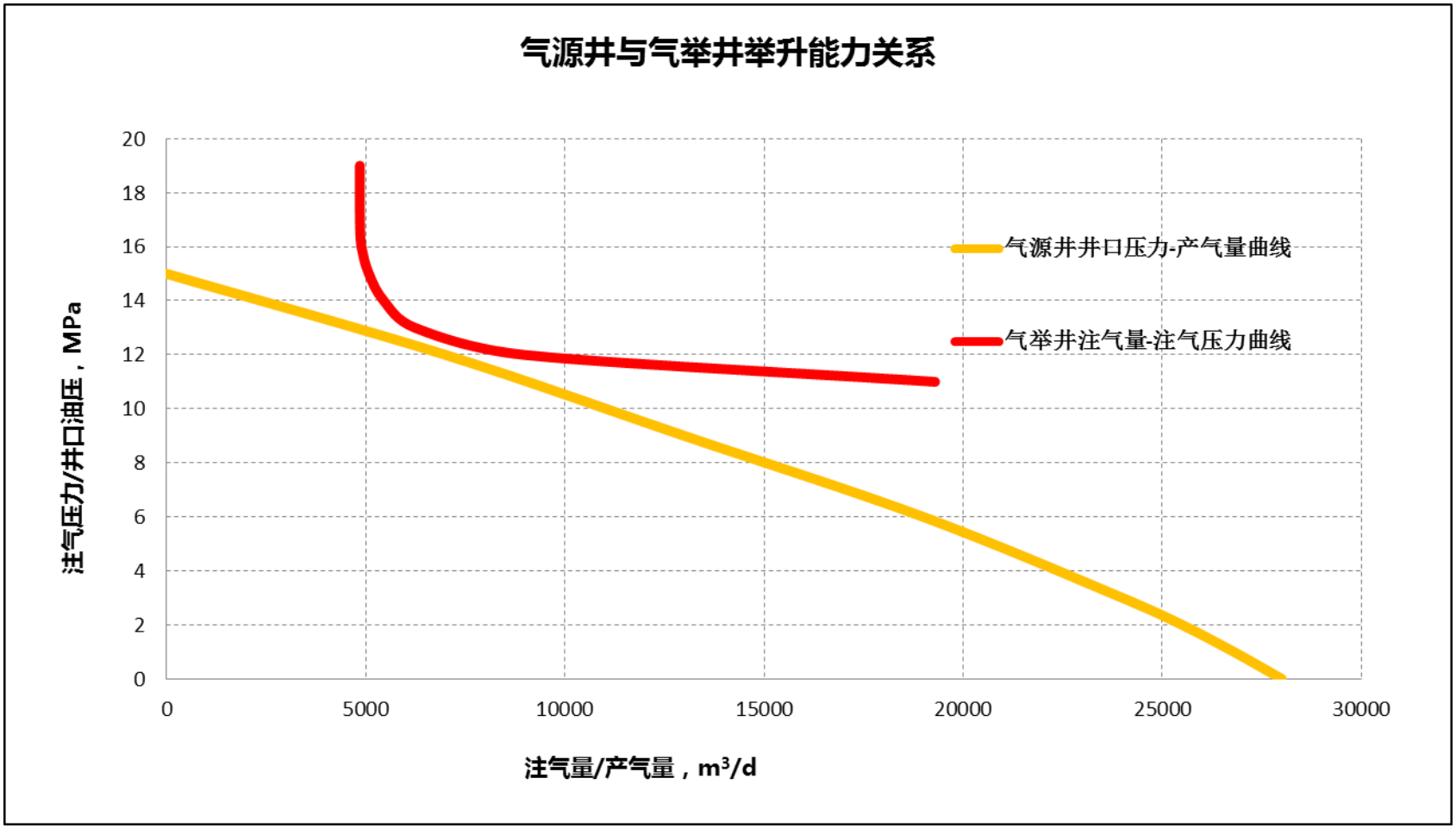
2. Analysis on lift with gas from offset well

Scenario 2: If the plot of wellhead pressure vs. gas rate of gas well is partially above plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate can be realized; or production of oil well under expected oil rate cannot be realized.



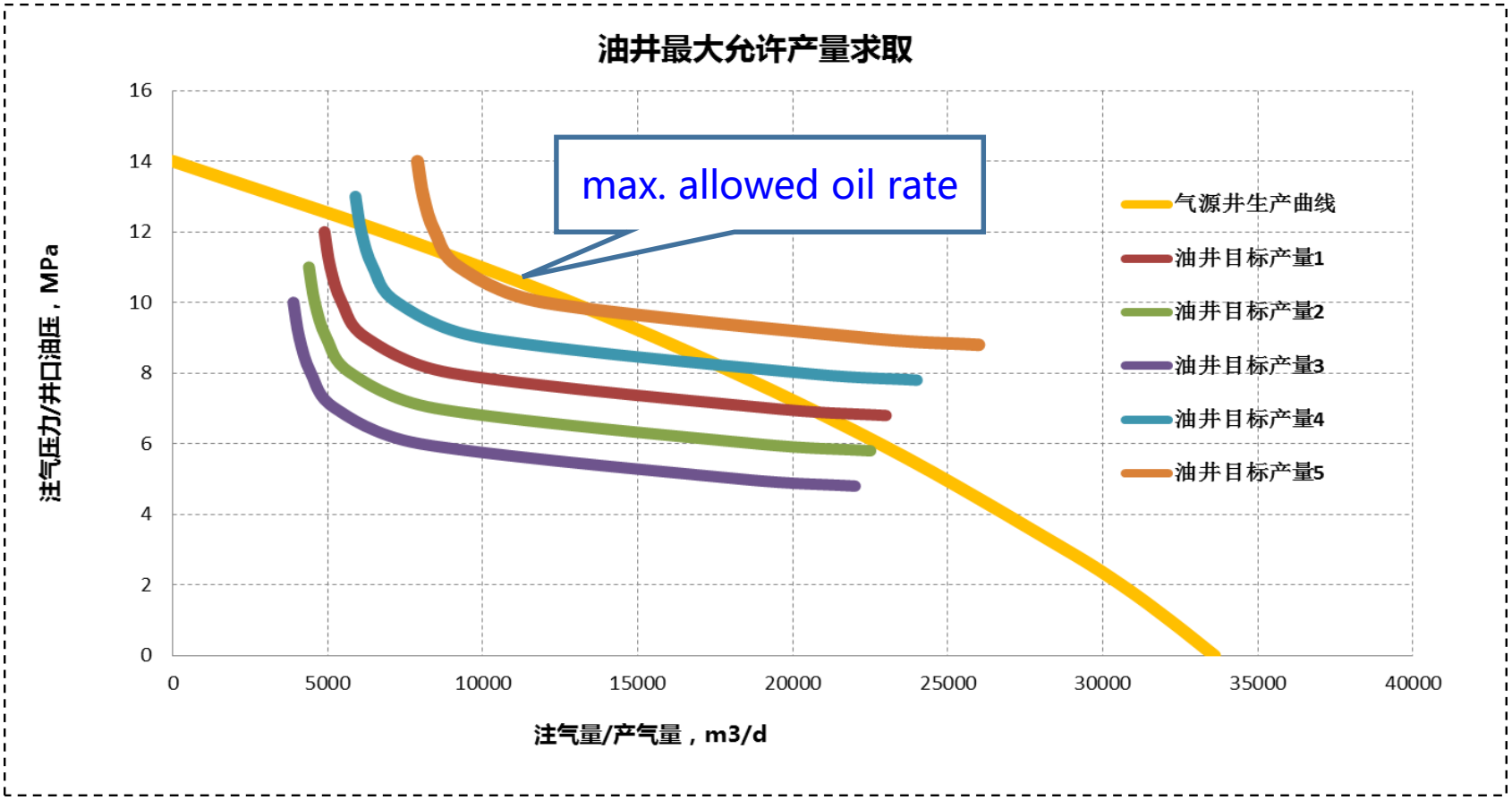
2. Analysis on lift with gas from offset well

Scenario 3: If plot of wellhead pressure vs. gas rate of gas well is all under plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate cannot be realized



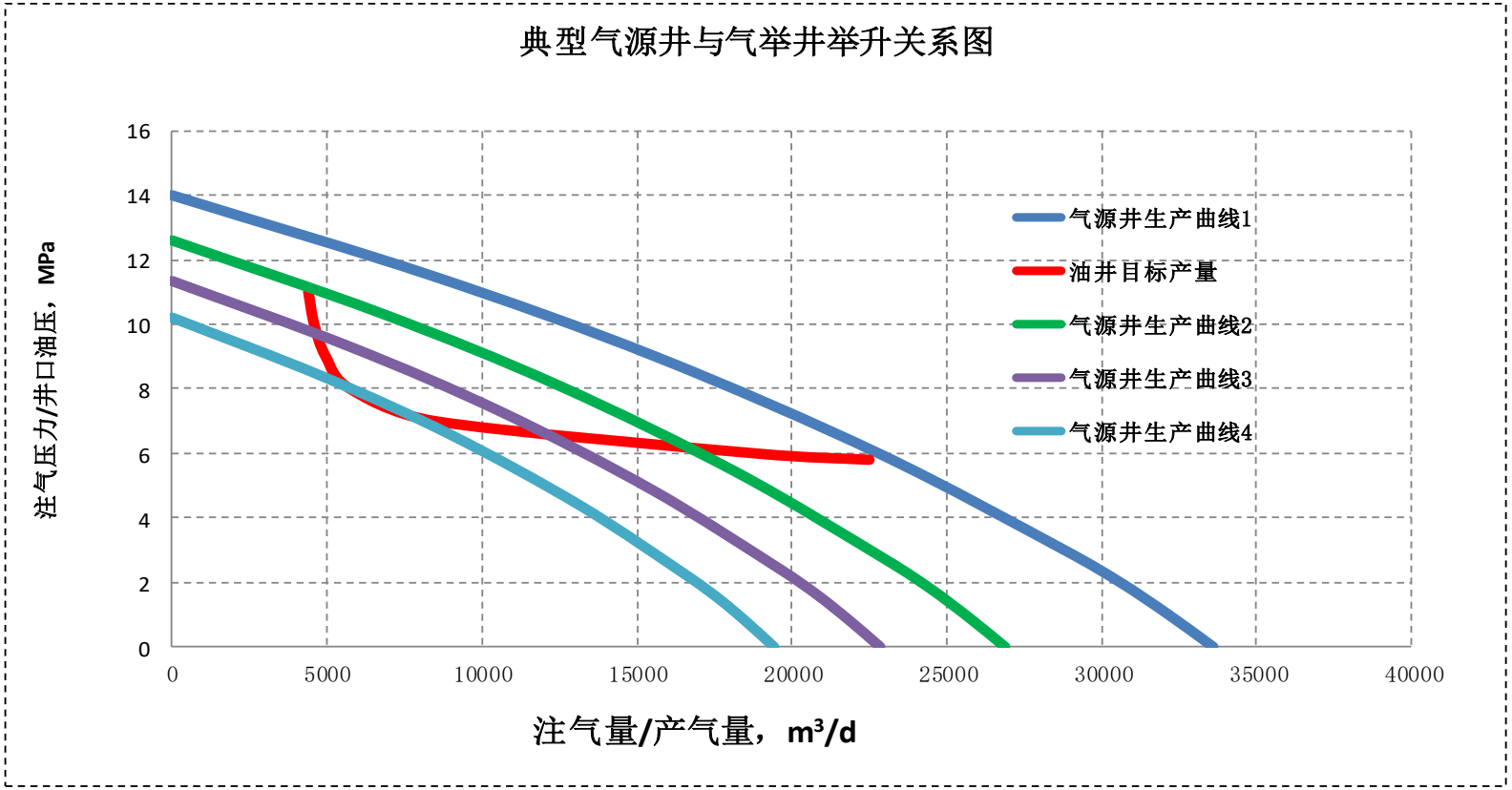
2. Analysis on lift with gas from offset well

- By using the plot of gas well and oil well, the max. oil rate of oil well can be obtained to guide the oil well production allocation.



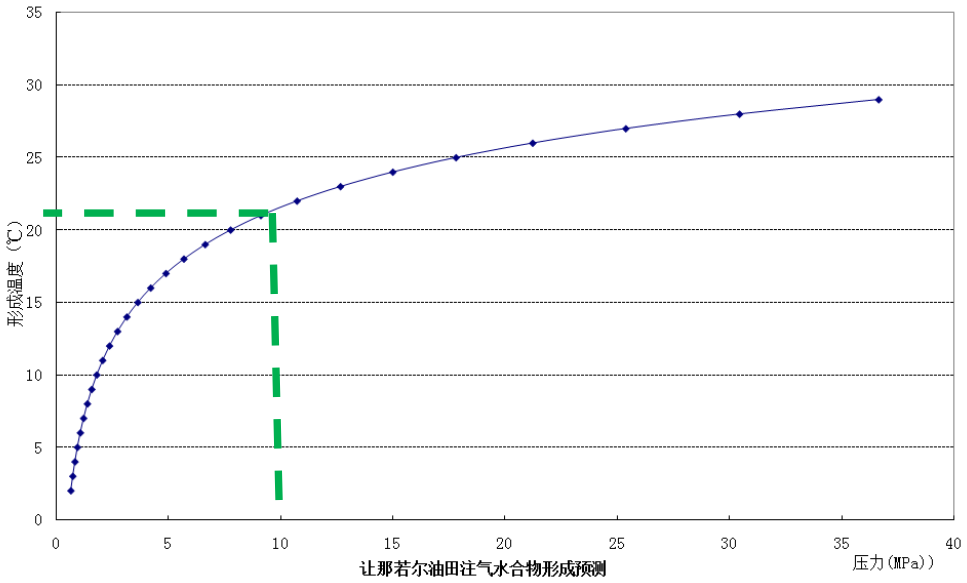
2. Analysis on lift with gas from offset well

- With the decrease of formation pressure of gas well, the gas well production characteristics plot moves downward till there is only one intersection. At this point, the corresponding formation pressure is the lowest pressure that gas well satisfies oil well production. Based on the prediction of the variation of formation pressure of gas well, the production cycle of lift with gas from offset well can be obtained.

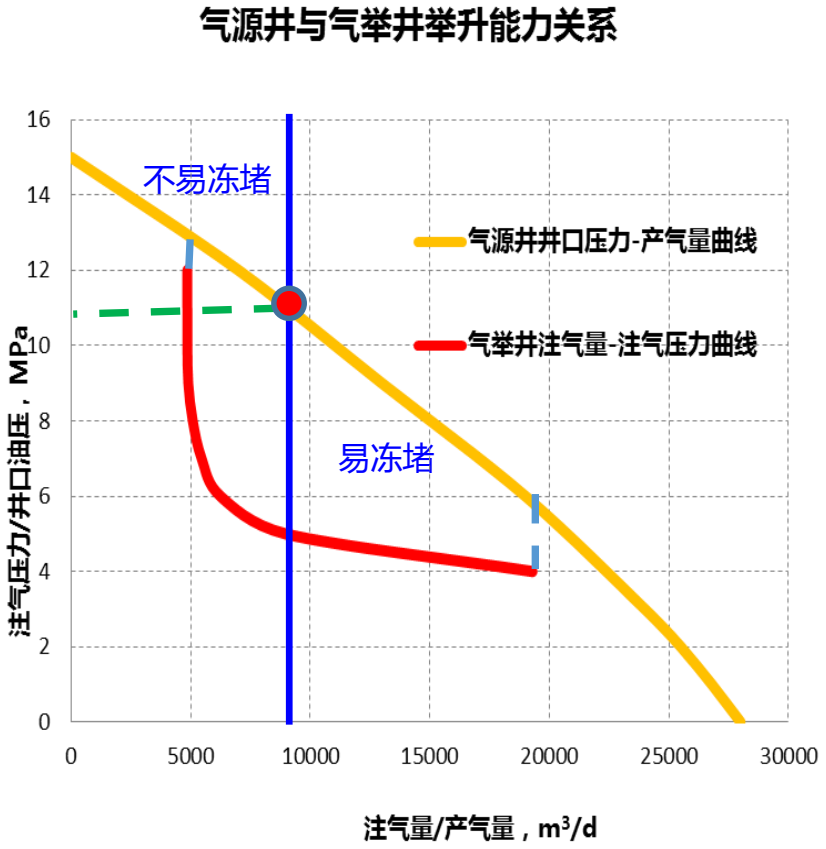


2. Analysis on lift with gas from offset well

- The freeze blockage can be analyzed by using the relationship plot of gas source well and oil well. The oil well gas injection pressure under the optimally selected oil rate could guarantee under such pressure condition, the hydrate formation temperature is lower than the environment temperature so as to avoid the freeze blockage of surface gas supply pipeline.



Prediction of hydrate formation



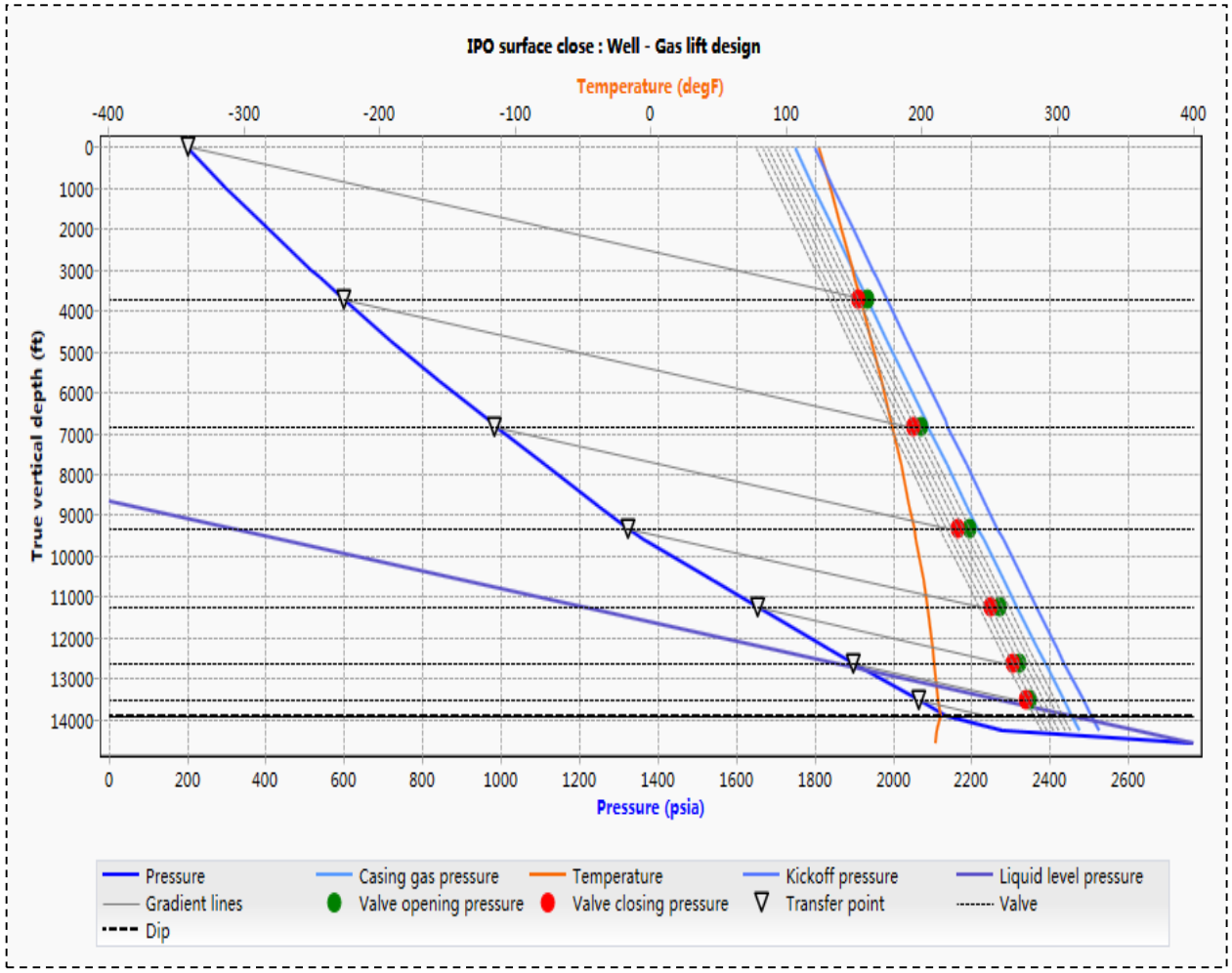
3. Supporting processes

1. Oil well design

◆ GLV deployment

The design of process parameters for gas lift valve deployment for the lift with gas from offset well is the same as boosting continuous gas lift production.

The calculation method or professional gas lift software can be used.



Design of process parameters for GLV

3. Supporting processes

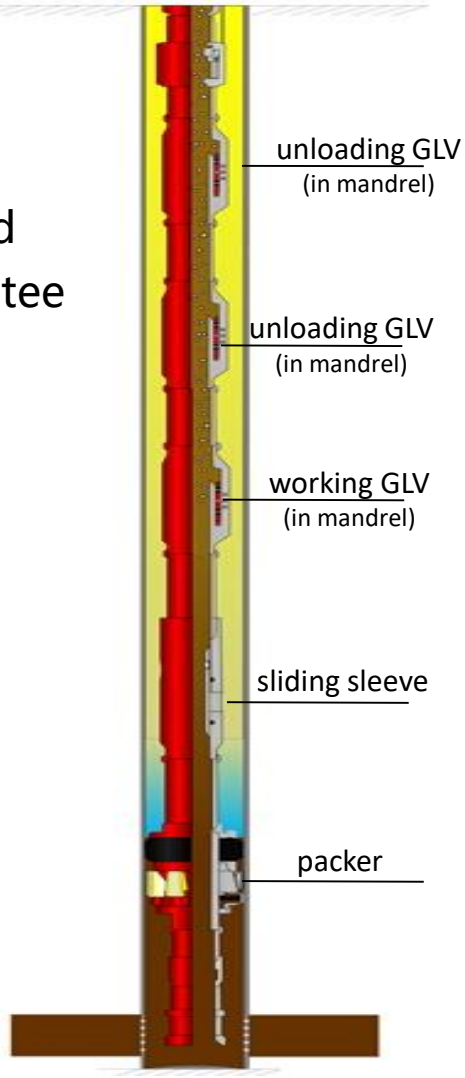
1. Oil well design

◆ Design of completion string

Usually semi-closed completion string is used, which could avoid the gas injection pressure being applied to formation, to guarantee well perform of the oil well capacity.

Commonly used downhole tools:

SN	Name	Function
1	Gas lift valve	to realize oil well unloading and gas injection production
2	Mandrel	to install gas lift valve
3	Sliding sleeve	Provide circulating channel for tubing and annulus to realize well flushing and kill operation
4	Packer	Separate oil zone and upper casing and tubing annulus, avoid high pressure gas contacting reservoir directly and decrease impact on oil well production



Schematic of semi-closed completion string

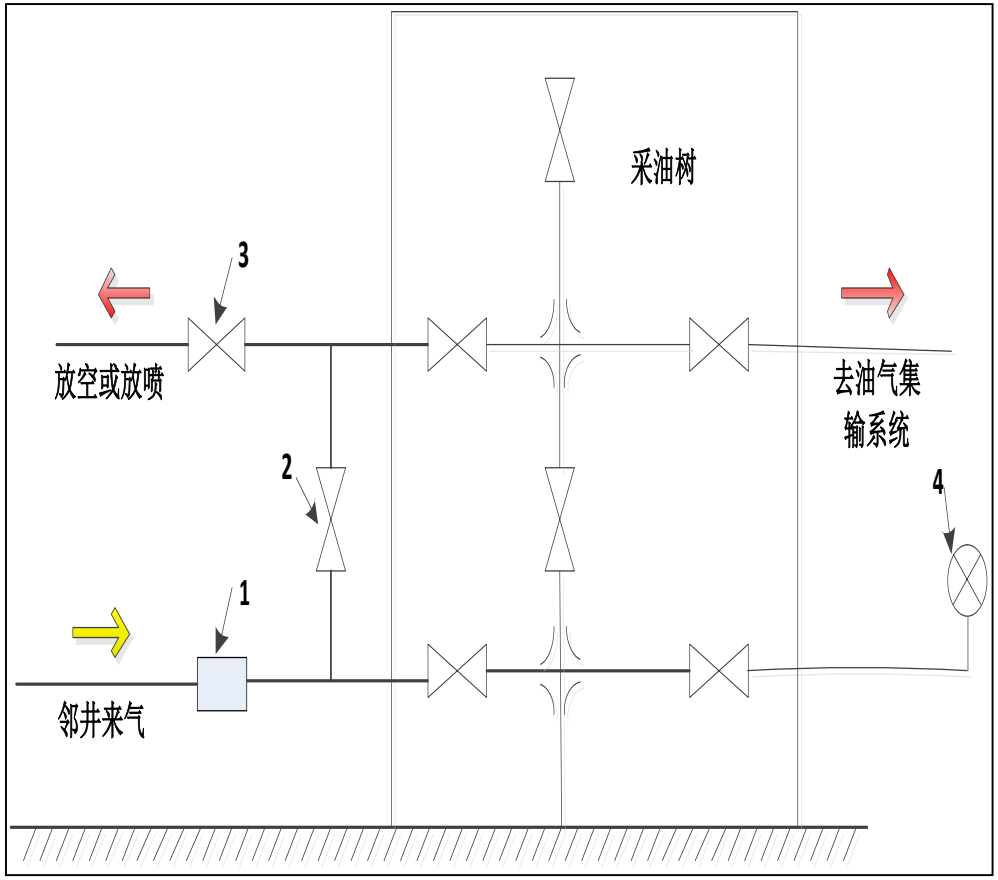
3. Supporting processes

1. Oil well design

◆ Surface process design

For lift with gas from offset well, usually reconstruction of oil well surface flow is needed to adapt to gas lift production

- 1--gas metering & adjustment devices
- 2,3--gate valve, used for change and control direction of gas supply
- 4--pressure gauge to record wellhead casing pressure during lift operation



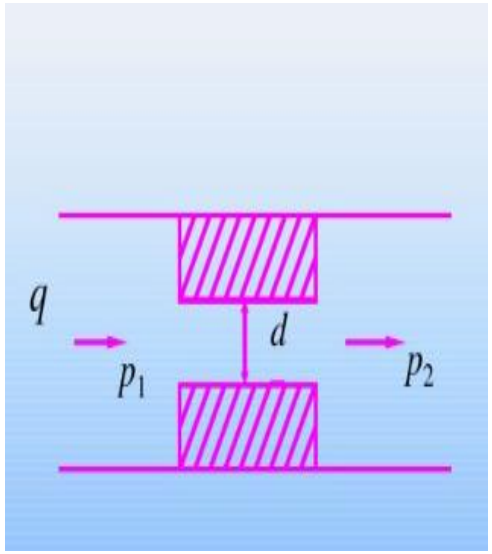
Schematic of surface flow for lift with gas from offset well

3. Supporting processes

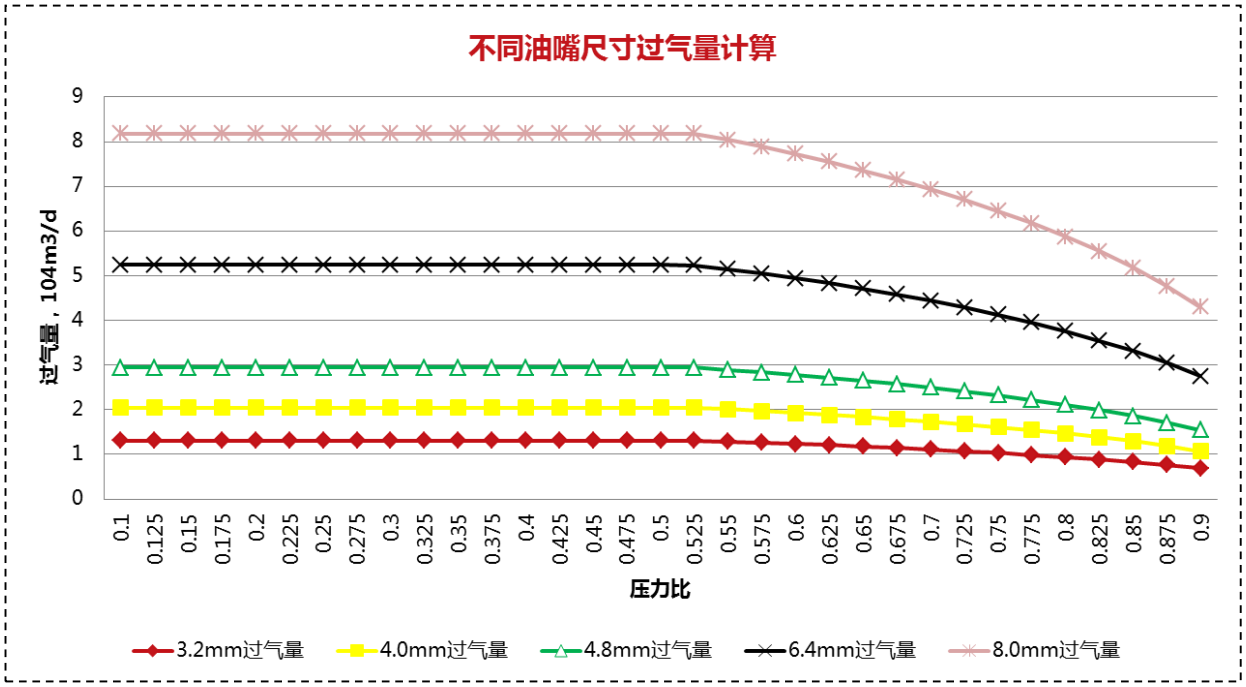
2. Gas well design

◆ Design of surface choke

Usually, for lift with gas from offset well, throttling devices such as choke or needle valve shall be installed at wellhead of gas well to achieve the gas injection pressure and volume demanded by oil well gas lift production. The diameter of choke can be calculated or based on professional software result.



Choke



Performance of choke flow for different sizes

3. Supporting processes

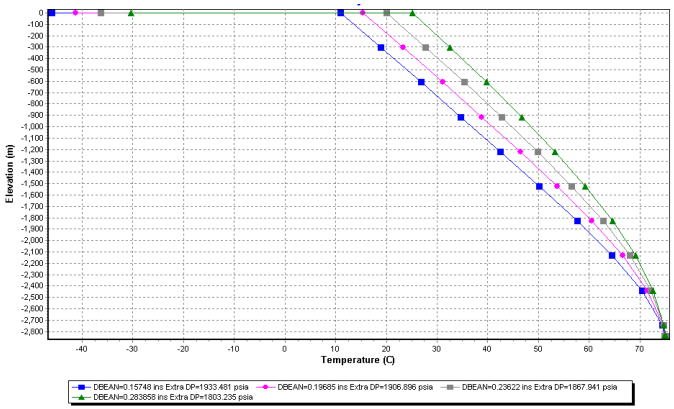
2. Gas well design

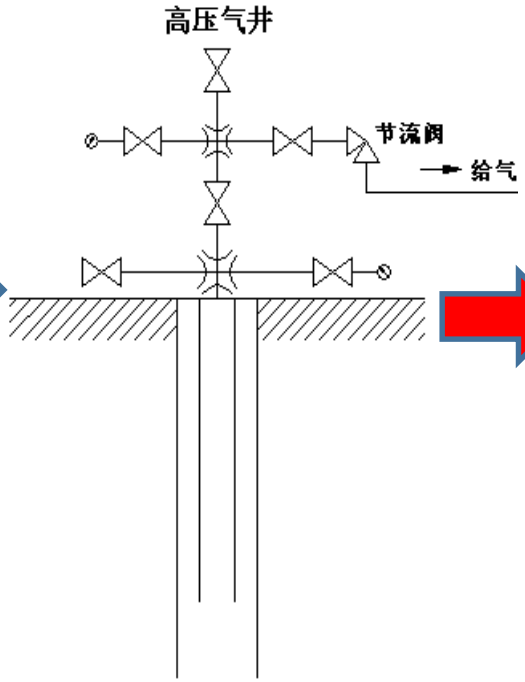
◆ Design of bottomhole choke

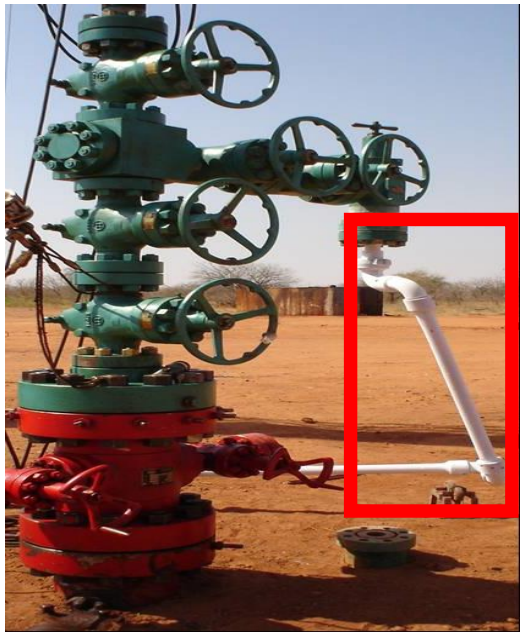
The source gas of lift with gas from offset well is untreated gas and it is prone for the formation of hydrate after surface throttling, leading to the freeze of gas supply pipeline.

Example of wellhead temperature drop

choke size (mm)	4	5	6	7.2
T before choke (℃)	11	15	19	25
T after choke (℃)	-46	-41	-36	-30
T difference before and after choke(℃)	-57	-56	-55	-55





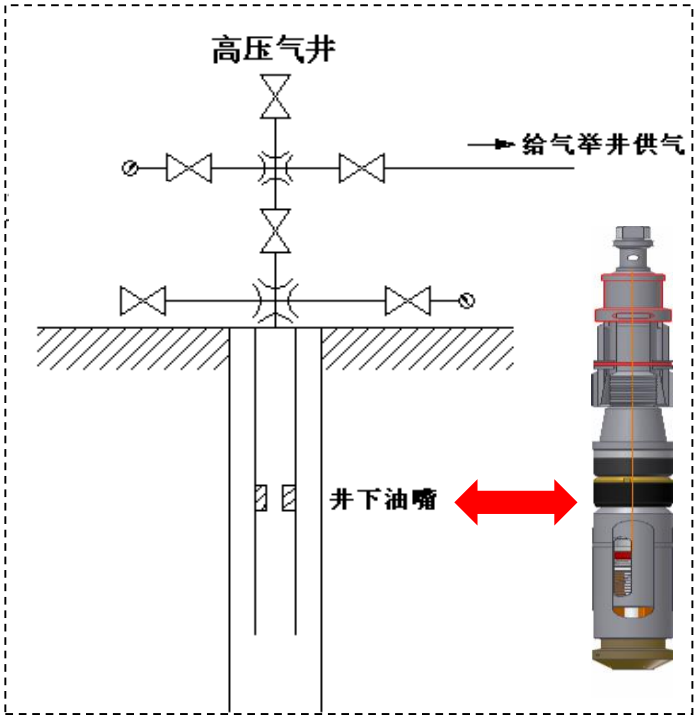


3. Supporting processes

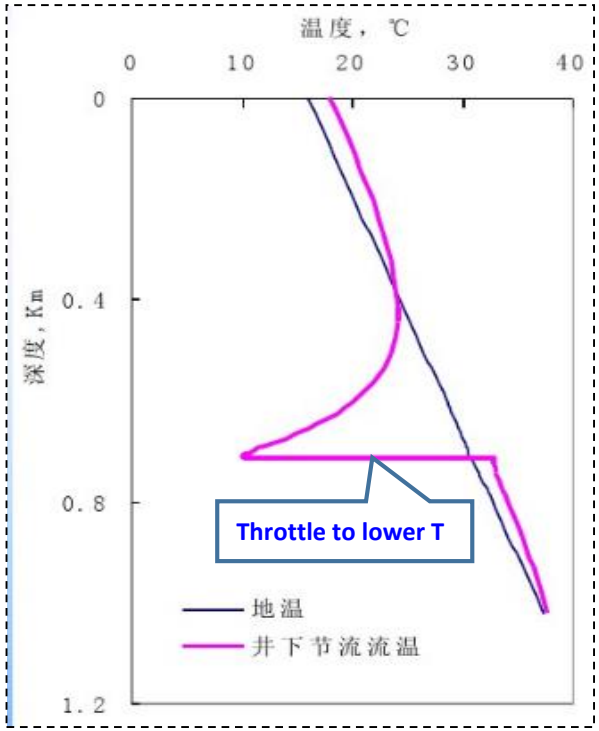
2. Gas well design

◆ Design of downhole choke

Downhole choke throttling technology is adopted. Downhole choke is installed at appropriate point of tubing. Throttling is transferred from surface to wellbore to increase wellhead gas temperature and the surface freezing problem is effectively solved.



Schematic of downhole choke



Downhole throttling temperature plot

4. Application performance

1. X Oilfield in Africa

◻ Production status of oil well before gas lift

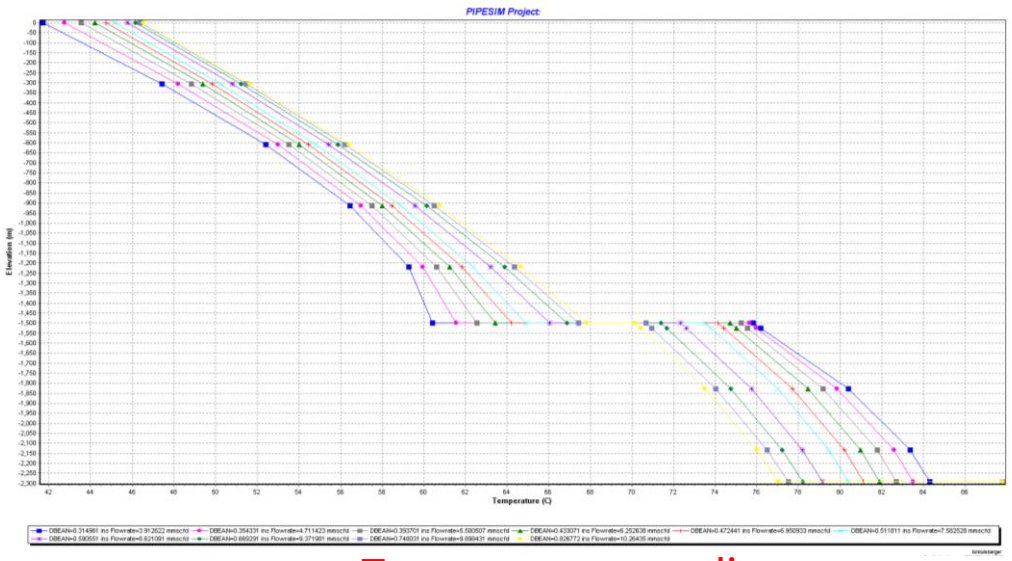
Well no.	Oil zone mid-depth (m)	Formation pressure (Mpa)	FBHP before experiment (MPa)	Oil rate before experiment (bbl/d)	Production status
XX-17	1880	15.67	15	151	flow ends
XX-59	2012	17.94	17	319	weak flow

◻ Production status of gas source well

Well no.	Oil zone mid-depth (m)	Formation pressure(Mpa)	Formation temperature (℃)	Gas rate (m^3/d)	Oil rate (m^3/d)	Water cut	Wellhead tubing pressure (MPa)	Remarks
XX-27	2292	21.23	87.8	234,764	13.04	0	17(shut in)	frequent freezing

4. Application performance

☐ Technical measures for anti-freeze for downhole choke of Well XX-27



Temperature gradient

Design depth:1500m

Downhole nozzle:13mm

Gas rate: $20\times10^4 m^3/d$

Wellhead tubing pressure:12MPa

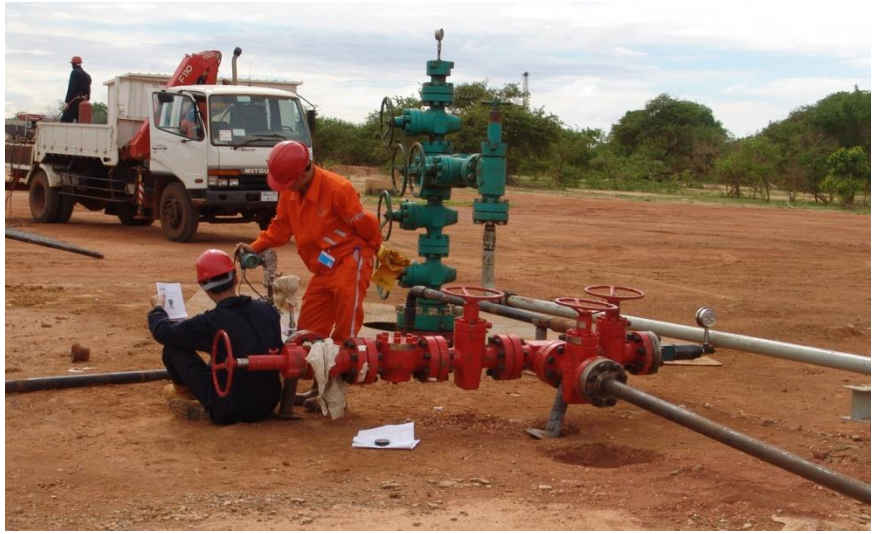
Wellhead temperature: 35℃, no freeze

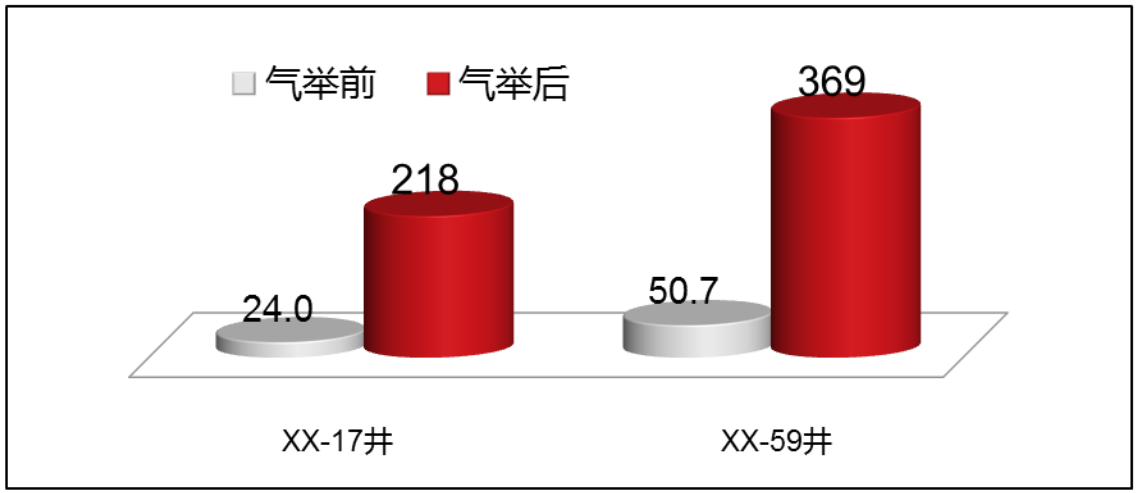
Downhole choke construction for Well XX-27

4. Application performance

1. X Oilfield in Africa

After the implementation of lift with gas from offset well in 2011 for Well XX-17 and Well XX-59, the oil rates increased from 24.0m^3/d and 50.7m^3/d to 218m^3/d and 369m^3/d respectively, an increase of 8 and 6 folds.





4. Application performance

2. X Oilfield in Mid-Asia

2015-2016, applied totally for 42 well times. Average single well oil incremental 21.25t/d and cumulatively surface investment was saved by USD 17 million.

SN	Well no.	Before gas lift				After gas lift				Comparison	
		Liquid rate (t/d)	Oil rate (t/d)	Water cut (%)	GOR (m^3/t)	Liquid rate (t/d)	Oil rate (t/d)	Water cut (%)	GOR (m^3/t)	Liquid incremental (t/d)	Oil incremental (t/d)
1	7639		0	1		32	32	0.3	890	32	32
2	5578		0	0.7		20	20	0.0	977	20	20
3	7570		0	55		31	15	52.5	902	31	15
4	7545		0	0.5		36	36	0.2	547	36	36
5	7669		0	3		21	15	27.9	1074	21	15
6	7871		0	0		14	14	1.3	1090	14	14
7	7546	15	12	21	358	33	25	23.0	1294	18	13
8	CT-45		0	0		24	24	0.0	364	24	24
9	601	0	0	54.3		31	15	51.8	249	31	15
10	566	15	6	58	781	31	21	31.0	441	16	15
11	7675	20	20	0.2	232	41	41	0	314	21	21
12	7640	0	0	0.0	526	31	31	0	696	31	31
13	498	17	17	0.1	188	34	34	0.4	459	17	17
14	719	3	1	62.2	1254	29.6	17.26	41.72	1245	26.6	16.26
:											
40	H519	30	15	49.8	677	35	18	48	369	5	3
41	7548	0	0	0.0	0	11	8.32	24.4	1258	11	8.32
42	7865	9	6	35.8	984	17	12	30.3	1242	8	6
Average											**21.25**

5. Conclusions

- Lift with gas from offset well could realize gas lift production when gas boosting system is not available. The field construction can be accelerated and the surface system investment can be lowered.
- The method for lift with gas from offset well is formed. The feasibility of lift with gas from offset well can be judged. The core process parameters including oil rate, gas injection pressure and injection rate of oil well can be determined.
- The maximum oil well rate, gas lift service life and surface freezing etc. can be effectively predicted.
- The main constraint of lift with gas from offset well is the wellhead tubing pressure and gas production rate of gas well, therefore, it is of great importance to predict the gas rate and pressure variation of gas source well.

CNPC

THANKS!