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CRITERIA FOR THE MOST RELIABLE RESERVOIR FLUID SAMPLES FOR PVT STUDIES; A CASE STUDY

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Abstract

The purpose of performing PVT studies on the reservoir fluid samples is the analysis of the reservoir fluid properties with using the experimental data and equation of states (EOS's). Results of tuned EOS's should be in accordance with the results of experimental data.

All computations and results of them are directly depended on the chosen representative reservoir fluid samples. If we do our studies based on some samples, which are not truly the representative reservoir fluids, the wrong sample selection will influence all the results. So it is vital to screen available reservoir fluid samples based some reasonable criteria and select some of them as the representative reservoir fluid samples.

In this study, in order to investigating the fluid properties and evaluating of data of 23 given samples from 7 exploratory wells in South Pars gas field, PVT experiments have been performed and the attained results from them have been compared with the results of tuned EOS's to evaluate the accordance of them with each other.

Basically, in this paper after a comprehensive describing of available data, we summarized all important criteria for screening samples and arranged them into a four step and in each step, some parameters of all available samples, include well head and bottom-hole samples, have been investigated. With removal of some samples in each step, finally just 3 samples have been selected as representative fluid samples that have been used for simulating reservoir fluid behavior. By the way, the obtained results from analysis of formation water samples have been evaluated in this study. Stiff diagrams have been plotted for all 17 available formation water samples which depict the scattering of salinity in different regions. So, with consideration of calculated gradient for formation water and available data from analysis of static reservoir pressure, the representative formation water samples have been selected.

Keywords: Reservoir Fluid Samples; PVT; CCE; CVD; Formation Water; Gas Condensate.

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1. Introduction

Characterization of and understanding reservoir fluid properties are essential throughout the life of a field for effective reservoir evaluation and management. Studies can range from simple tests for the type of fluid in the reservoir to full compositional and PVT analyses including conventional depletion tests such as differential liberation or constant volume depletion studies, fluid viscosity measurements, and multi-stage separator tests to obtain gas-oil ratios or condensate gas ratios as well as EOR studies such as multi-contact experiments or swelling tests. Successfully obtaining accurate results from all of these tests hinges on obtaining representative reservoir fluid samples. The objective of reservoir fluid sampling is to collect a sample that represents the fluid in the reservoir at the time of sampling. Incentives for collecting representative fluid samples include [3]:

1. proper sizing of wells and design of surface facilities [1-2],
2. ensuring compatibility of materials in contact with the fluids such as corrosion resistant materials for acid gases,

3. accurate calculation of in-place volumes and recoverable reserves [4],
4. appropriate input to software ranging from pipe flow modeling to complex reservoir simulation,
5. developing accurate equation of state models,
6. planning reservoir depletion strategies.

Ensuring that the sample is representative of the reservoir fluids at actual reservoir conditions may be a difficult goal to achieve. Fluid properties can be position, structure, or time-dependent, requiring collection of multiple samples at different locations at different times in the reservoir [4].

Whether or not a sample is representative is also affected by how the sample is collected, transferred and transported from the reservoir to the laboratory for analysis. Every step of this process involved in taking a sample could change the pressure, temperature, or composition of the small volume of reservoir fluid that is obtained. The changes result from a myriad of factors including [3]:

1. tool and hardware used in sample capture
2. method by which the sample gets from the reservoir into the sample chamber
3. location where the sample is taken
4. experience and knowledge of the sample taker
5. heat transfer or loss to the environment
6. phase behavior resulting from differences in pressure and temperature

There are two locations that fluid samples can be taken: down-hole and at the surface. Each location has its advantages and disadvantages. Down-hole or bottom-hole samples can represent fluid at their true reservoir state but are sometimes spoiled by contamination from drilling fluids or drawdown. Surface sampling can be completed later, after the drilling fluids have been produced from the wellbore, but the fluids are no longer at native reservoir conditions and will require recombination at the producing gas oil ratio for further testing. During sampling operations in saturated gas-condensate reservoirs, some loss of C_{7+} components is likely to occur due to liquid dropout in the reservoir. Similarly, part of the H_2S may be lost through absorption in the drilling mud if adequate near-wellbore cleanup is not achieved [3].

PVT analysis has been routinely used by reservoir engineers to characterize the physical properties of a reservoir fluid as well as the change in volume and phase state occurring during the production [5]. This characterization is generally performed using software packages which calculate PVT and phase behavior based on fluid composition, as determined in specialized laboratories on reservoir fluid samples at reservoir pressure and temperature, using equations of state (EOS). These EOS provide a mathematical description of the fluid behavior for reservoir simulation and reserve stimulation. It is very important in compositional reservoir simulation to get satisfactory agreement between EOS results and the measured laboratory PVT data, and this must be relevance to the fluid in the reservoir and its recovery process [6-8].

There are two basic methods of sample collection; sub surface (bottom-hole) and surface (separator).the suitability of the particular sampling technique will depend on a large number of factors which may include economic consideration such as the cost of sampling and associated loss of production, the type of surface facilities that are available, the fluid volumes that will be required and the type of reservoir and fluid to be sampled [9].

Obtaining representative samples of saturated oil and gas-condensate reservoirs where the possibility of entertainment of disassociated phase's decreases is more difficult than for a conventional black-oil reservoir. Surface sampling is the method which recommended for these types of reservoir [9-10].

Constant Composition Expansion (CCE) and Constant Volume Depletion (CVD) are tests that usually employ for gas condensate reservoirs. The CCE test is designed to provide the dew-point pressure at reservoir temperature and the total relative volume of the reservoir fluid (relative to the dew-point volume) as a function of pressure. Constant-volume depletion (CVD) experiments are performed on gas condensates and volatile oils to simulate reservoir depletion performance and compositional variation. The test provides a variety of useful and important information that is used in reservoir engineering calculations. To consider the obtained liquids are the same which produce in the reservoir we need to screen the samples [11-12]. This accrues along comparing condensate liquid percentage with curve of RLD diagram.

At first, the quality control has been performed on the available data. In this step, some of the samples were removed because of the sample invalidity, improper condition of sampling or insufficient laboratory data. In the next step, data were controlled in respect of consistency and compatibility and some of samples were removed because of inconsistency an income-patibility of them with others. Finally, three samples have been selected as valid samples.

2. Available data

There are 7 exploratory well in the area we talking about and their names are SP-3, SP-7, SP-9, SP-10, SP-12, SP-15, SPD10-08. PVT tests have been performed on the 17 wellhead samples and 6 bottom-hole samples which obtained from these 7 exploratory wells. As mentioned earlier, in this study, samples have been divided in two different categories, the wellhead samples and the bottom-hole samples and their quality have been investigated separately. By the way, the number of samples and laboratory tests which performed on them, have been divided in two categories, single layer and multi layer, and are shown in table 1. Also the number of samples from each layer (single layer and multi layer) and the number of bottom-hole samples and wellhead samples are shown in table 2.

Table 1 Number of samples in each experiment

The total number of samples : 23											
Bottom hole : 6						Well head :17					
6 CVD		7 CCE		6 Fluid composition analysis		13 CVD		15 CCE		17 Fluid composition analysis	
Multi layer	Single layer	Multi-layer	Single layer	Multi layer	Single layer	Multi layer	Single layer	Multi layer	Single layer	Multi-layer	Single layer

Table 2 Number of samples in each layer

Bottom hole samples	Wellhead samples	Number of samples	Layer
1	5	6	K1
1	1	2	K2
1	1	2	K3
0	5	5	K4
1	4	5	K2+K3
1	0	1	K3+K4
1	0	1	K2+K3+K4
0	1	1	K1+K2+K3+K4

2.1. Description of existing data

2.1.1. Well SP-03

A wellhead sample was obtained from the layer “K1” in “DST-1” during the productive interval of 2825-2777 driller meters. It analyzed on the April 4th of 1992. Dew point pressure and temperature reported regularly in 4895 Psia, 199.8^{o}F. In this report the results of CCE test, and CVD test were mentioned. Also, the reservoir fluid composition that obtained from Re-composition of condensation samples and separator gas with the Ratio of 43/5 STB/MMSCF have been presented.

2.1.2. Well SP-07

Three wellhead samples were obtained from the layers “K4” in “DST-1," “K3” in “DST-2” and “K2” in “DST-3” respectively during the productive intervals of 3015-2963, 20-2846 and 2834-2805 driller meters. They analyzed on the November 1st, 7th and 12th of 2001. Fluid composition of all samples and the results of CCE and CVD on the sample of K2 are available. Dew point and the ratio of oil per gas in these layers reported respectively as follows:

K2: 5236 Psia at 204.4^{o}F. the portion of Re-combination condensate, and separator gas is 62/1 STB/MMSCF.

K3: Dew point not reported.

K4: 5165 Psia at 213.6 ^{o}F. The portion of Re-combination condensate and separator gas is 60/4 STB/MMSCF

2.1.3. Well SP-09

Two bottom-hole samples were obtained from the layers "K2-K3" in "DST-2," "K3-K4" in "DST-2" respectively during the productive intervals of 2940-3125, 3080-3150 driller meters. They analyzed on the November 2nd and 22nd of 2001. Fluid composition and the results of CCE and CVD on the both samples have been reported. Dew point and the ratio in these layers reported regularly as follows:

K2+K3: 4913 Psia at 212°F. The oil-gas ratio in the recombination of condensate and gas is 41/7 STB/MMSCF.

K3+K4:4515 Psia at 217°F. The oil-gas ratio did not report.

2.1.4. Well SP-10

A bottom hole sample was obtained from the layers "K2+K3+K4" in "DST-1'" during the productive intervals of 2885-3203 driller meters. They analyzed on the January 24th of 2002. Dew point and oil-gas ratio in the recombination of condensate and gas reported in 4618 Psia at 215°F is 35/1 STB/MMSCF. Fluid composition and the results of CCE and CVD presented as well.

2.1.5. Well SP-12

Ten wellhead samples of this were obtained as follows:

One of them took from "K4" in "DST-1," six of them belonged to "K4" in "DST-2" and "K2+K3" in "DST-3" with reel sizes of 32/64, 42/64 and 48/64 inches for each layer. The last three samples were of "K1" in "DST-4" with reel sizes of 32/64, 44/64 and 54/64 inches. They acquired respectively during the productive intervals of 3155-3170, 3115-3145, 2954-3006 and 2857-2911.5 driller meters, and analyzed on the January 23rd, February 4th, 11th and 19th of 2003. The results of CCE and CVD are available for all samples. Dew point and the oil-gas ratio in these layers are reported regularly respectively from small size of Reel to large one as follows:

K1: 5180 Psia, 5100 Psia, 5100 Psia at 205°F and the portions of condensate to gas are38/2, 33/2 and 33/8 STB/MMSCF.

K2+K3: 5250 Psia, 5270 Psia, 5280 Psia at 212°F and the portions of condensate to gas are 38/4, 39/5 and 40/2 STB/MMSCF.

K4: 5300 Psia, 5250 Psia, 5250 Psia at 216°F and 5150 Psia at 219°F .The portions of condensate to gas are38/4, 39/5 and 40/2 STB/MMSCF.

2.1.6. Well SP-15

Three bottom hole samples were obtained from the layers "K1","K2" and "K3"in "MDT" respectively during the productive intervals of 2964-3056, 3088 driller meters. They analyzed on the March 27th of 2007. Fluid composition and the results of CCE and CVD on the three samples are reported. Dew point and the oil-gas ratio in these layers reported regularly as follows:

K1: 4976 Psia at 212.6°F. The portion of condensate to gas was 30 STB/MMSCF.

K1: 5330 Psia at 215.9°F. The portion of condensate to gas was 48 STB/MMSCF.

K1: 5154 Psia at 217°F. The portion of condensate to gas was 45 STB/MMSCF.

Two wellhead samples obtained from the layers "K1" in "DST-3", "K3+K4" in "DST-2" respectively during the productive intervals of 2952-3023, 3023-3041 driller meters. They analyzed on the May 4th, and April 20th of 2007. Fluid composition and the results of CCE and CVD on the both samples are reported. Dew point pressure and the oil-gas ratio in these layers reported regularly as follows:

K1: 4948 Psia at 213.4°F. The portion of condensate to gas was 28/4 STB/MMSCF.

K2+K3: 5313 Psia at 216.6°F. The portion of condensate to gas was 51/7 STB/MMSCF.

2.1.7. Well SPD 10-08

A wellhead sample was obtained from the layers of "K1+K2+K3+K4" in "DST-1" during the productive interval of 2795-3075 driller meters. It analyzed on the March 4th of 2006. Fluid composition of this sample and the results of CCE test and CVD test are available in the report. Dew point pressure and the ratio of oil to gas of these layers have been reported as follows:

K1+K2+K3+K4: 5091 Psia at 212°F and 55.8 STB/MMSCF.

3. The first step of screening

As mentioned before, if reservoir pressure (P_r) drops below dew point pressure (P_d) due to production from reservoir, liquid phase will be produce in the reservoir. If at this condition, a sample of reservoir fluid has been taken from the reservoir, these two phases sample are not real representative of reservoir fluid. So in the first step of screening, dew point pressure and initial reservoir pressure (P_i) and flowing bottom-hole pressure (P_{wf}) was compared and some samples which had been obtained when P_d was greater than Pi and P_{wf}, have been removed. These samples are:

1. SP-07, Wellhead samples from layers K2 and K3
2. SP-15, Bottom-hole samples from layer K2
3. SP-15, Wellhead samples from layers K1 and K2+K3
4. SP-12, All samples

Pressure data of these wells are presented in table 3 for comparison.

By the way, because of insufficient laboratory data for wellhead samples from layer K4, these samples removed from this study.

Table 3 Comparison of dew point pressure with initial reservoir pressure and bottom-hole flow pressure

Well No.	Type of Sample	Formation	FBHP (psia)	Reservoir Pressure (psia)	Reservoir Temp (F)	Choke Size /64	Dew Point Pressure psia	P_d<Pr	P_d<P_{BHF}
SP # 7	Separator	K2	5119	5236.1	204.4	32	5236.1	Not OK	Not OK
	Separator	K3	5185	5255	207.1	32	-	Not OK	Not OK
SP#12	Separator	K4	5213.5	5321	216.0	32	5300	OK	Not OK
	Separator	K4	5165.5	5321	216.0	42	5250	OK	Not OK
	Separator	K4	5152	5321	216.0	48	5250	OK	Not OK
	Separator	K2 & K3	5194	5285	212.0	32	5250	OK	Not OK
	Separator	K2 & K3	5173	5285	212.0	42	5270	OK	Not OK
	Separator	K2 & K3	5169	5285	212.0	48	5280	OK	Not OK
	Separator	K1	4270	5206	205.0	32	5180	OK	Not OK
	Separator	K1	4507	5206	205.0	44	5100	OK	Not OK
	Separator	K1	4230	5206	205.0	54	5100	OK	Not OK
SP#15	Separator	K2&K3	4830	5313	216.6	28	5313	Not OK	Not OK
	Separator	K1	4620.4	5261.5	213.4	24	4948	Not OK	OK
	Bottom hole	K2	5327	5327	215.93	-	5330	Not OK	Not OK

4. The second step of screening

For sampling on surface, if there is two phase flow, it should be getting a sample from each phase according to their fractional flow, to achieve a sample which represents the reservoir fluid caused by recombination of them. Wellhead sampling needs high precision, which usually gathers by Test Separator that gases and liquids samples are taken in single phase.

Producing rate of each phase should be surveyed in a given period of time to ensure that the fluid flow is steady state. Separator temperature (T) and pressure and gas-liquid ratio are some other important parameters for recombination of these phases.

These samples will be investigated in laboratory. The first parameter is sample vessel pressure. Decrease in this pressure may caused by leakage of vessel or decrease in its temperature.

Hence this vessel pressure, increased to sampling condition's pressure by increase in temperature. So, sometimes, because of imprecision in sampling especially in wellhead sampling, PVT tests' results haven't an accurate and acceptable trend. Therefore, in the second step of screening, laboratory result surveyed. In this part of study, schematic of some curves had not explicit and accurate trend.

Another important parameter which is measured in both Constant Composition Expansion (CCE) and Constant Volume Depletion (CVD) is produced liquid percentage caused by pressure drop. Therefore, tests' reliability and proportion of maximum produced liquid percentage investigated in these two tests. Usually the amount of this parameter in CCE test is greater than CVD test.

Whereas produced liquid percentage curve caused by pressure drop (RLD) is an important parameter in samples' credibility and signify that the sample represent the reservoir fluid or not, therefore, in this part of screening, the samples which their produced liquid percentage curves in CVD and CCE tests hadn't precision and acceptable curvature , removed from this study.

Note that, all samples achieved from well SP-12 had not precision and acceptable curvature which presented in figure 1.

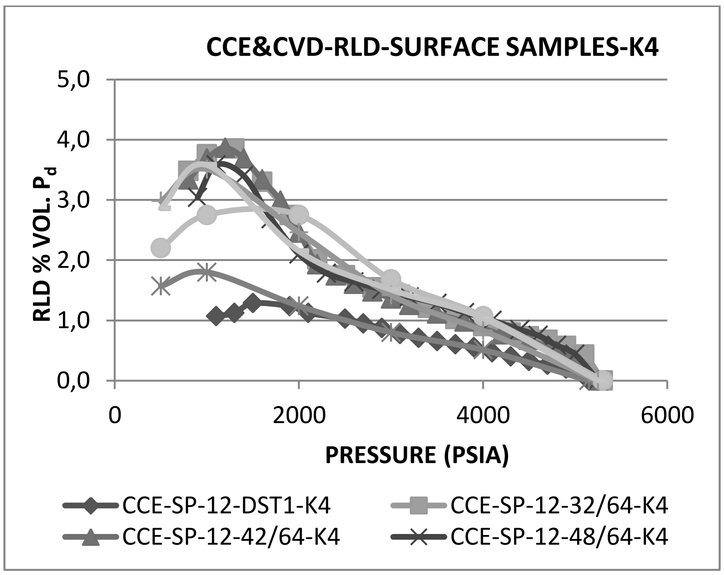

Figure 1 The percentage of condensate liquid versus pressure during the CCE and CVD in well sp-12, layer K4

5. The third step of Screening

In the third step of screening, with surveying the production history of this field and available production data, amount of average CGR from output of this fields refineries measured between 40 STB/MMSCF to 46 STB/MMSCF, with considering the changes in temperature in various seasons, which in warm seasons is greater than cold seasons.

Therefore in this step, with considering that the amount of measured CGR from output of South Pars' refineries could be assumed as reliable field fluid CGR, this amount investigated for the samples of this field. Hence, some other samples removed that mentioned below:

- SP-15, wellhead samples from layers K2+K3 with CGR=51 and MAX RLD=5.62(CCE)
- SPD10-08, wellhead samples from layers K1+K2+K3+K4 with CGR=55.8 and MAX RLD=5.62 (CCE) and MAX RLD=4.80 (CVD)

The considerable point in this part of study is that after investigating the removed samples in this step, we concluded that maximum produced liquid percentage in CVD and CCE tests, reported much great that isn't reliable for this field.

6. The forth step of screening

Whereas as condensate producing begins around the wellbore, where maximum pressure drop occurs and by producing it penetrate far from the wellbore, as much as spool's size be little, producing rate will be lesser and advancing velocity of two-phase region will be slower. So, if assume that under this condition fluid flow is pseudo-steady state, then the composition of producing fluid is the same as near wellbore fluid's composition and there will not be gas condensate aggregation around the wellbore. Hence the sample achieved under this condition can be representative of real reservoir fluid.

According to experience in South Pars gas field, the samples achieved from spools which greater than 36/64 inches, can't be reliable samples from reservoir fluid. Therefore all samples achieved from greater than 36/64 inches spools, removed from this study. Most of well SP-12 samples were in this category.

It is obvious that in each screening step, validity of samples surveyed in several point of view. For example, well SP-12 samples rejected after comparison of P_d with P_i and P_{wf} and after evaluation of the laboratory data quality and also spools sizes.

Rest samples are:

Well SP-09, two bottom-hole samples from layers K2+K3 and K3+K4

Well SP-10, one bottom-hole sample from layer K2+K3+K4

These samples achieved from different depths and their sampling's temperatures are not equals. Therefore, dew point pressures were calculated at a basis temperature.

Hence, a fluid model by using an Equation of States (EOS) was built and after tuning these EOSs, P_d for each samples were calculated at constant temperature of 216°F. In table 4, calculated amounts of P_d (Psia) and in figure 2, dew point pressures (P_d) versus depth (ft) have been shown. It's obvious that there is not any slope which imply that there are some changes in fluid properties along the reservoir.

Table 4 Dew point pressures

Well Name	Formation Test	Temp.(°F)	Dew point pressure (psia)
SP-09	K2+K3	216	4871
SP-09	K3+K4	216	4477
SP-10	K2+K3+K4	216	4611

The components of the fluid of these selected samples which will use in simulations are tabulated in table 5. RLD, Relative Volume, Gas Z-Factor, Gas Compressibility (C_g), Cumulative Produced Gas for all samples and for both CCE and CVD test have been shown through Figure 3 to Figure 15 (supplement).

Table 5 The percentage of selected compositions of samples

Component	SP-09-K2K3	SP-09-K3K4	SP-10	Component	SP-09-K2K3	SP-09-K3K4	SP-10
N_2	3.32	3.36	3.28	C_{10}	0.22	0.19	0.23
CO_2	1.93	1.9	1.92	C_{11}	0.18	0.15	0.19
H_2S	0.24	0.11	0.15	C12	0.14	0.12	0.15
C_1	82.78	83.09	82.81	C_{13}	0.12	0.1	0.12
C_2	5.24	5.41	5.23	C_{14}	0.09	0.07	0.09
C_3	1.96	1.98	1.95	C_{15}	0.07	0.05	0.08
iC_4	0.43	0.42	0.42	C_{16}	0.05	0.04	0.05
nC_4	0.72	0.71	0.72	C_{17}	0.04	0.03	0.04
iC_5	0.31	0.31	0.32	C_{18}	0.03	0.02	0.04
nC_5	0.29	0.28	0.29	C_{19}	0.03	0.02	0.03
C_6	0.54	0.51	0.56	C_{20+}	0.07	0.03	0.08
C_7	0.56	0.51	0.58	MW-C_{20+}	302	288.7	300.6
C_8	0.4	0.37	0.42	SG-C_{20+}	0.8767	0.8711	0.876
C_9	0.24	0.22	0.25				

7. Formation water samples analysis

There are some samples of formation water which obtained from different layers of wells located in the study region. They have been analyzed in the laboratory as show in table 6 and summary data for these samples are shown in table 7. 17 water samples obtained from the layers k1, K2, k3 and k4 of wells sp-12, sp-09 and sp-15 during the years 2001 and 2007. Based on the data there is a distribution in amount of Total Dissolved Sediments (TDS) because of anions and cations scattering. The data of water samples are drawn in water hardness diagram. To select a representative sample of formation water, formation water gradient was calculated. In this case, the obtained data compromise with exiting data of reservoir static pressure and disparate samples was removed. The samples of Southern Pars field's formation water are shown as follows:

SP-09 (TDS=215496 mg/L, gradient =0.50 psi/ft)

SP-15 (TDS=258550 mg/L, gradient =0.51 psi/ft)

Table 6 Available formation water samples

Well Name	Test	Date	Formation	Well Name	Test	Date	Formation
SP-09	DST 1	2001/10/22	K3 & K4	SP-15	Dead Water	2007/04/09	-
SP-09	DST 2	2001/11/02	K2 & K3	SP-15	Dead Water	2007/04/10	-
SP-09	MDT	-	-	SP-15	Dead Water	2007/04/10	-
SP-12	DST 1	2003/01/26	K4	SP-15	Dead Water	2007/04/16	-
SP-12	DST 2	2003/02/04	K4	SP-15	Dead Water	2007/04/20	-
SP-12	DST 3	2003/02/11	K2 & K3	SP-15	Dead Water	2007/04/20	-
SP-12	DST 4	2003/02/19	K1	SP-15	Dead Water	2007/04/20	-
SP-15	Bottom hole	2007/03/27	K3	SP-15	Dead Water	2007/05/04	-
SP-15	Bottom hole	2007/03/27	K4				

Table 7 Summary of formation water data

Well Name	Date	Formation	TDS (mg/l)	Specific Gravity	pH	Cations mg/L				Anions (mg/L)			
						(Na^+) (K^+)	(Ca^{2+})	(Mg^{2+})	(Fe)	(Cl^-)	(HCO^{3-})	$(SO4^{2-})$	$(CO_3)^{2-}$
SP-09	2001/10/22	K3 & K4	48190	1.034	7.89	17650	580	95	61	25400	1720	2740	NIL
SP-09	2001/11/02	K2 & K3	37940	1.028	7.82	13945	710	135	21	19040	2110	2000	NIL
SP-09	-	-	215496	1.148	6.5	70400	15952	729	-	129935	635	2309	0.0
SP-12	2003/01/26	K4	140000	-	6.5	43600	8400	1400	3	83000	1200	590	
SP-12	2003/02/04	K4	300	-	5.2	6.6	8	3	40	20	180	20	
SP-12	2003/02/11	K2 & K3	69000	-	3.8	3850	12400	5800	500	43000	2500	230	
SP-12	2003/02/19	K1	170000	-	4.9	26900	22700	10400	58	105000	4000	600	
SP-15	2007/03/27	K3	258550	1.168	7.1	99849	2967	369	11	151371	402	3272	0
SP-15	2007/03/27	K4	305900	1.201	6.1	84504	30636	2558	<0.1	185741	144	780	0
SP-15	2007/04/09	-	299222	1.198	5.7	81654	30219	2902	<0.1	182084	150	506	0
SP-15	2007/04/10	-	302672	1.202	5.8	82932	30316	2889	<0.1	184278	134	416	
SP-15	2007/04/10	-	303788	1.2	5.8	82419	31198	2872	<0.1	182084	150	506	0
SP-15	2007/04/16	-	290337	1.192	5.9	79557	29133	2769	0.7	176600	165	488	0
SP-15	2007/04/20	-	290819	1.193	5.9	79908	29032	2713	<0.1	176966	155	422	0
SP-15	2007/04/20	-	289029	1.194	5.9	75974	32000	2726	<0.1	176234	139	317	0
SP-15	2007/04/20	-	294982	1.193	5.8	80731	29594	2902	0.6	179525	134	354	0
SP-15	2007/05/04	-	119109	1.087	6.8	33929	11549	628	0.4	71664	186	792	0

Conclusions

Many factors can affect the representative quality and integrity of the samples. These must be identified and mitigated. With consideration of experiences of sampling in this field, samples which obtained from some spools with a diameter more than 36/64 inches, cannot be a reliable sample of reservoir fluid.

The amount of CGR from output of this field's refineries can be a reliable CGR of this reservoir fluid. The effect of temperature change during the different seasons should be considered that this amount in hot seasons is lesser and during cold seasons is the most.

The samples which removed in the CGR checking step, shown a really great maximum produced liquid percentage in CVD and CCE tests.

Reservoir fluid samples should at least evaluate from some aspect like Pd, Pi, PBHF, the size of spools as well as the quality of laboratory experiments and figures.

According to three remained samples, bottom-hole samples are more reliable than well head samples as well as multi-layer samples are more reliable than single layer samples.

According to plotted stiffness diagrams, there is a considerable diversity in formation water salinity throughout the field

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Supplement: figures 2 - 14

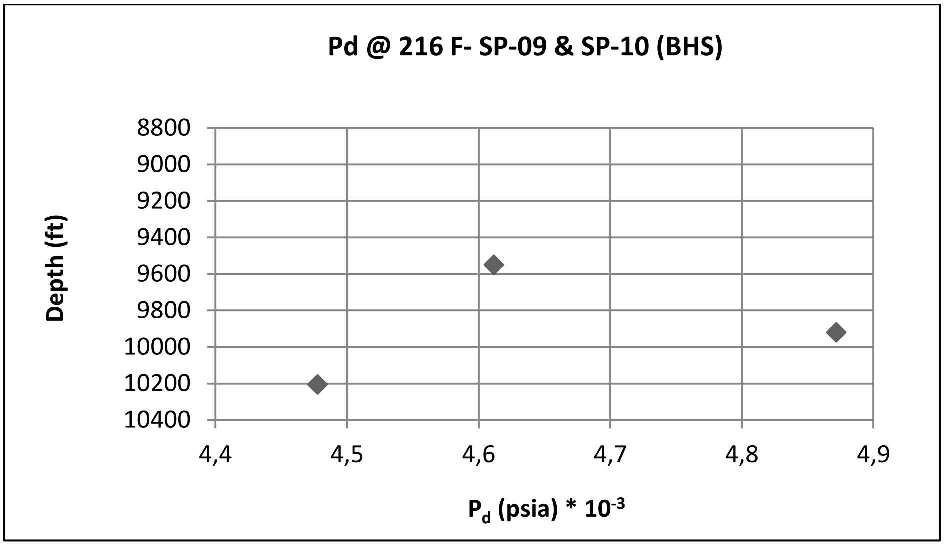

Figure 2 Isothermal dew point pressure changes vs depth

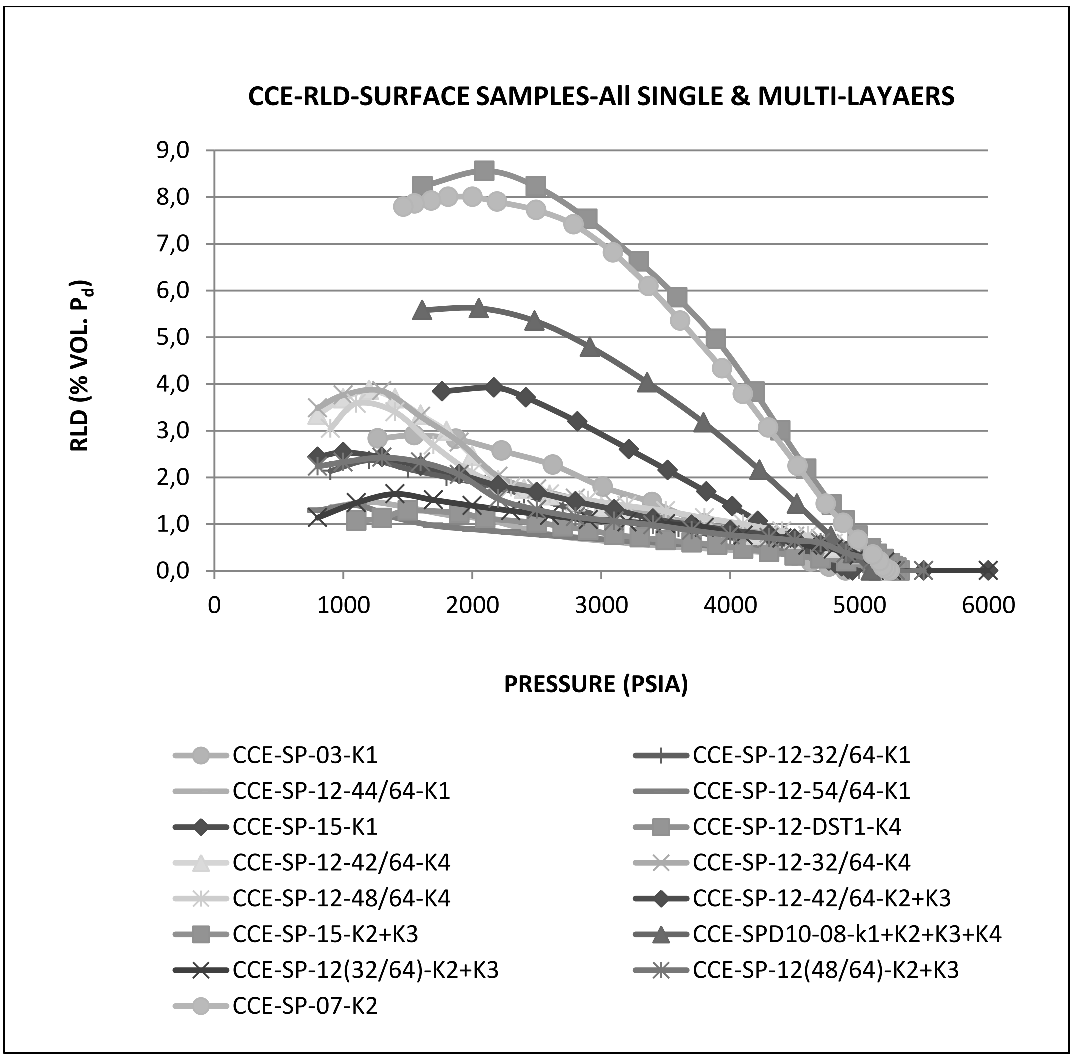

Fig 3 RLD of wellhead samples in CCE testing

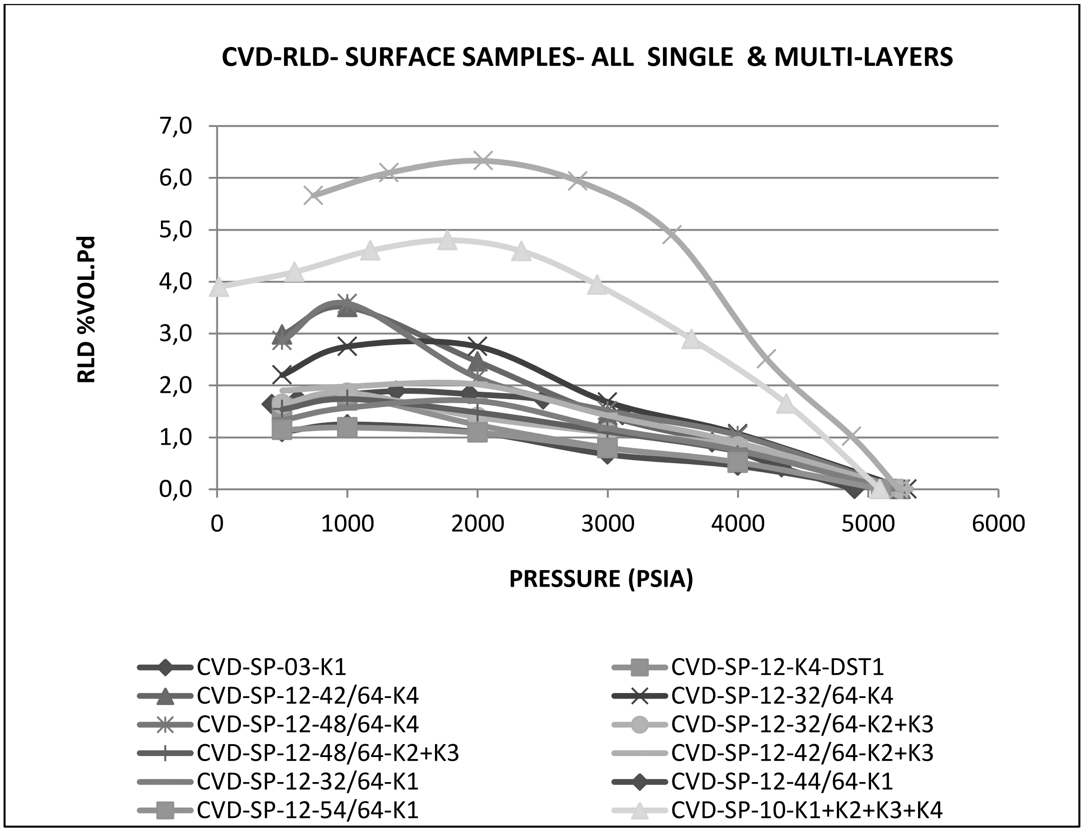

Fig 4 Diagram of relative volume in CVD testing of bottom-hole samples

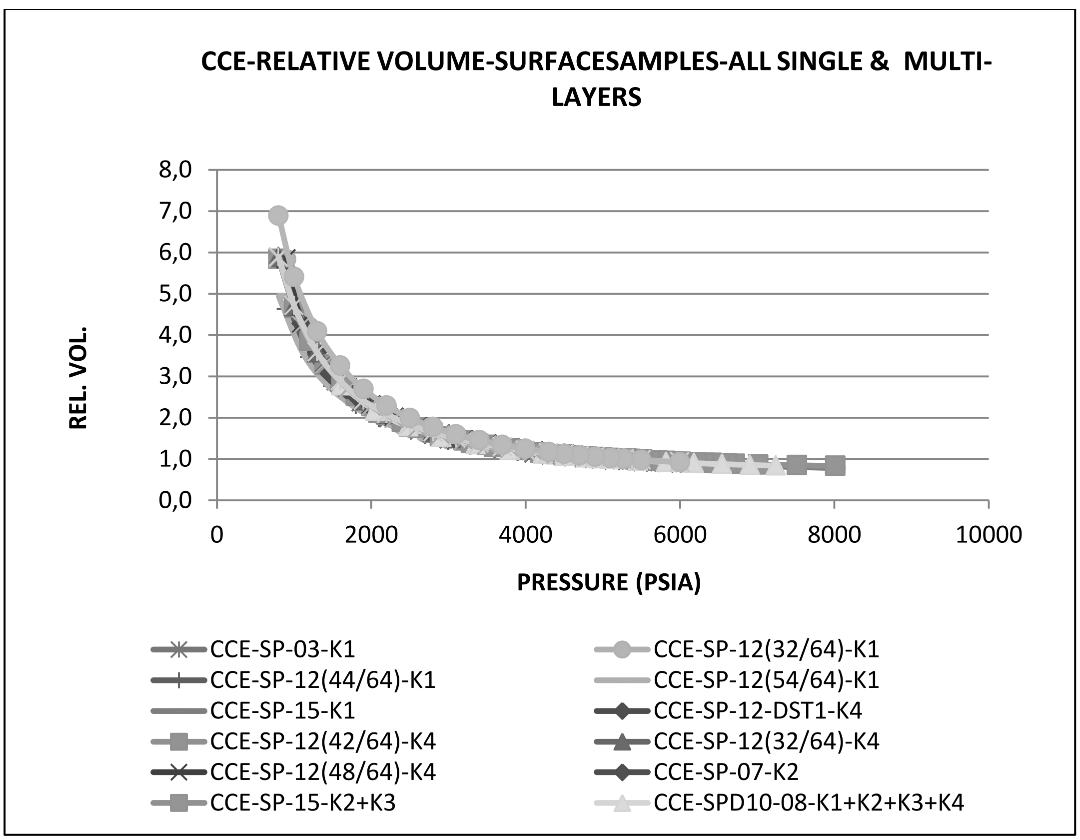

Fig 5 Diagram of relative volume in CCE testing of wellhead samples

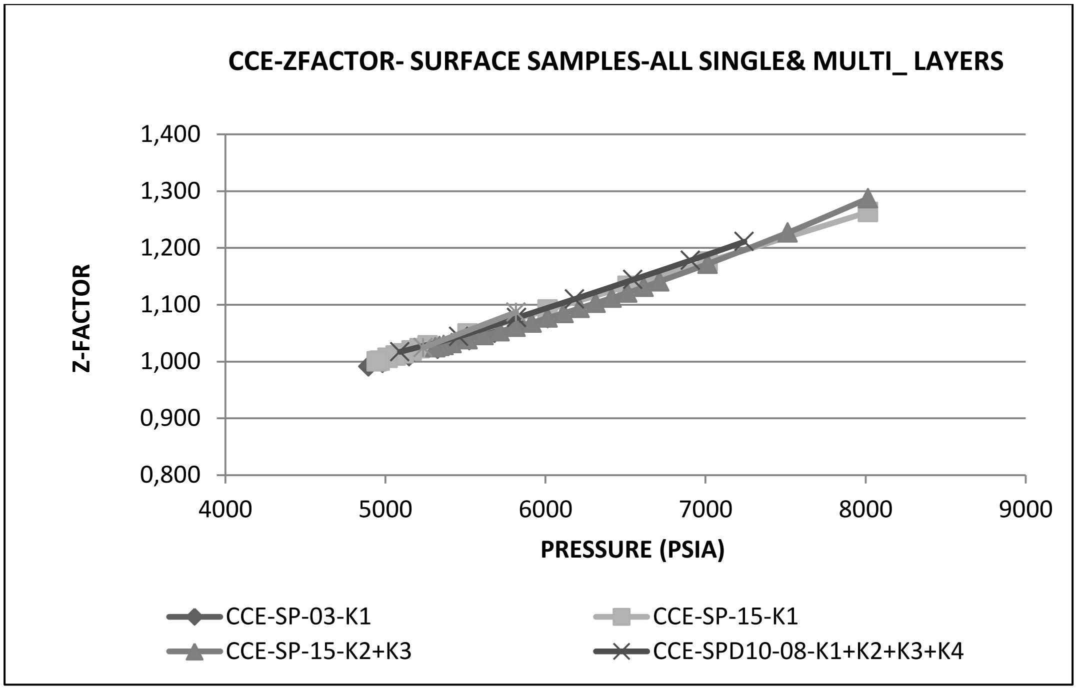

Fig 6 Diagram of gas Z – Factor in CCE testing of wellhead samples

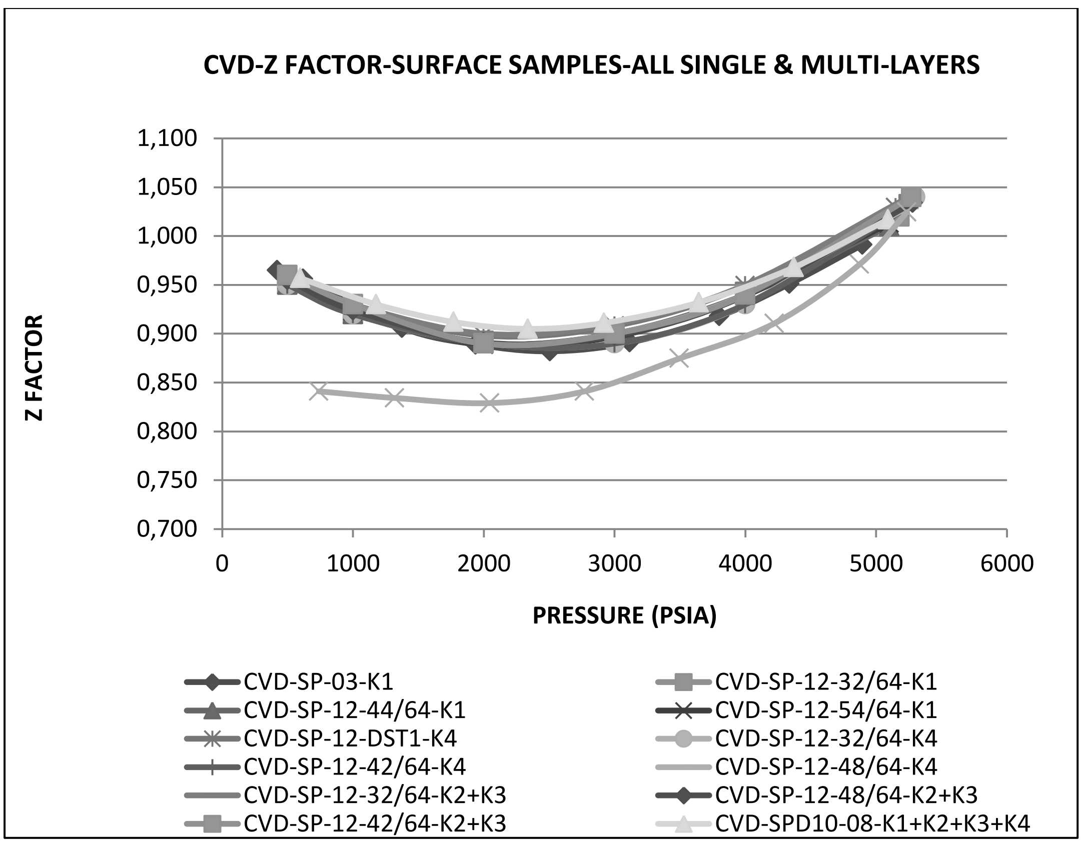

Fig 7 Diagram of gas Z – Factor in CVD testing of wellhead samples

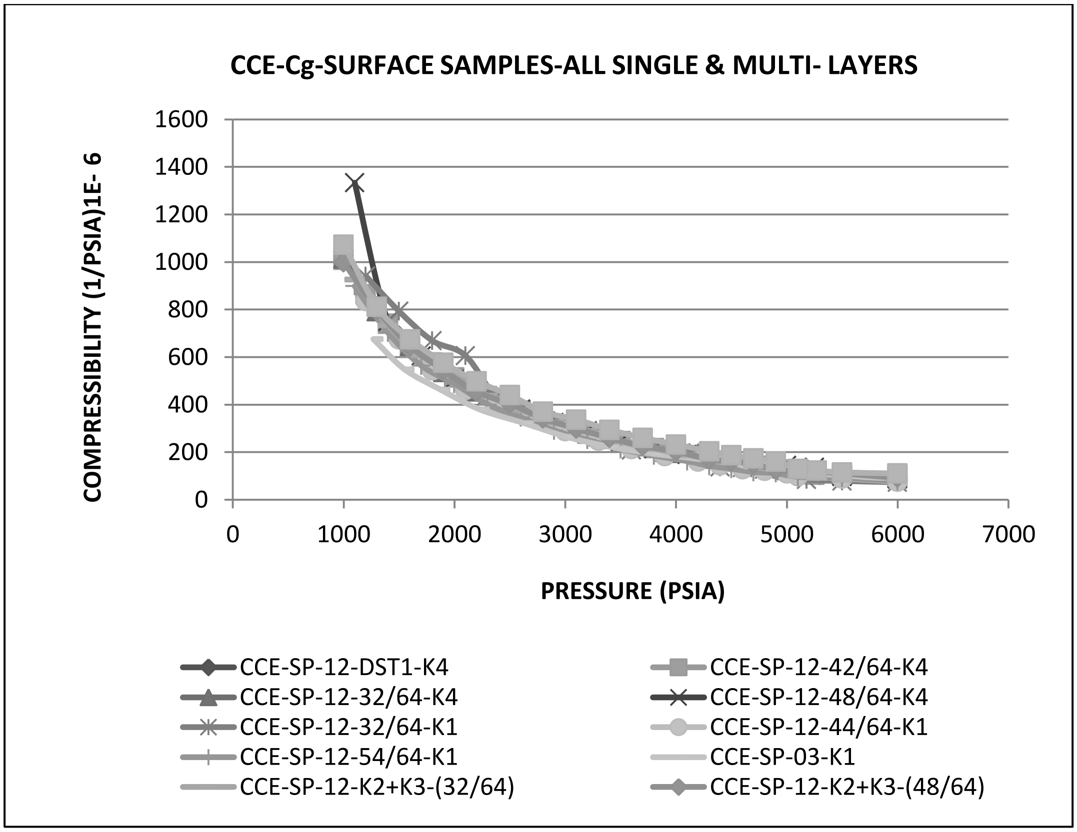

Fig 8 Diagram of gas compressibility in CCE testing of well head samples

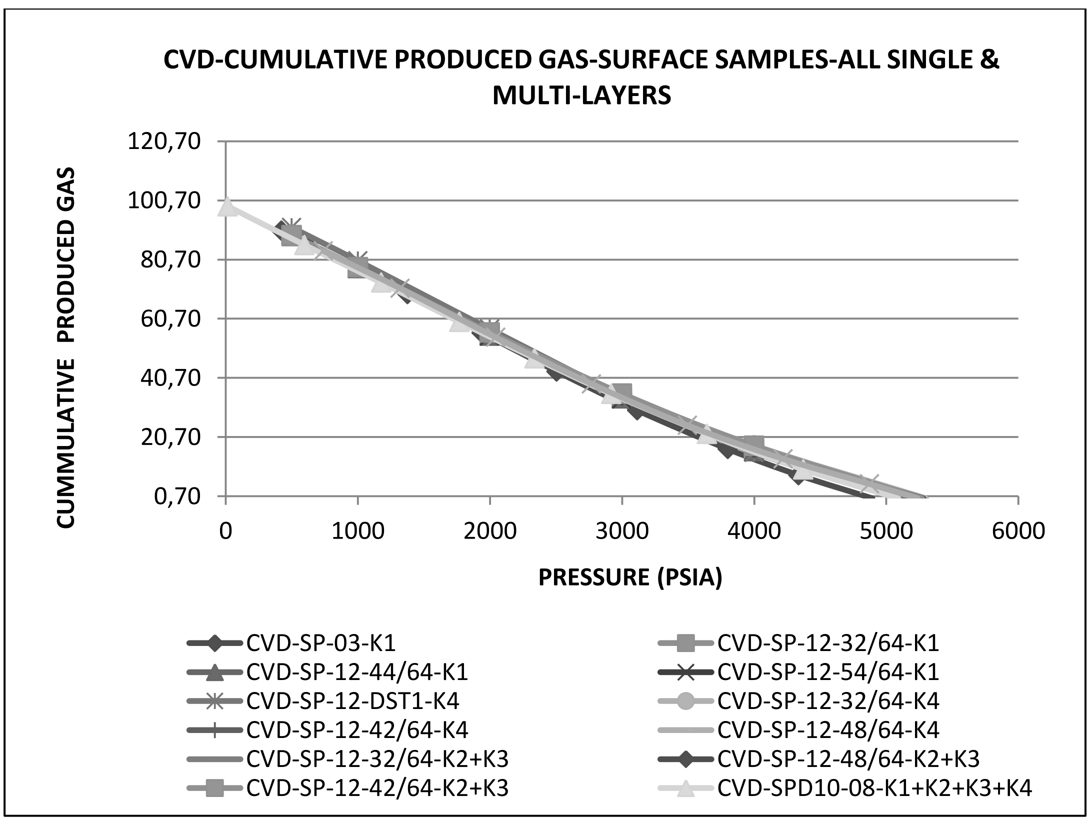

Fig 9 Diagram of cumulative produced gas in CVD testing of wellhead samples

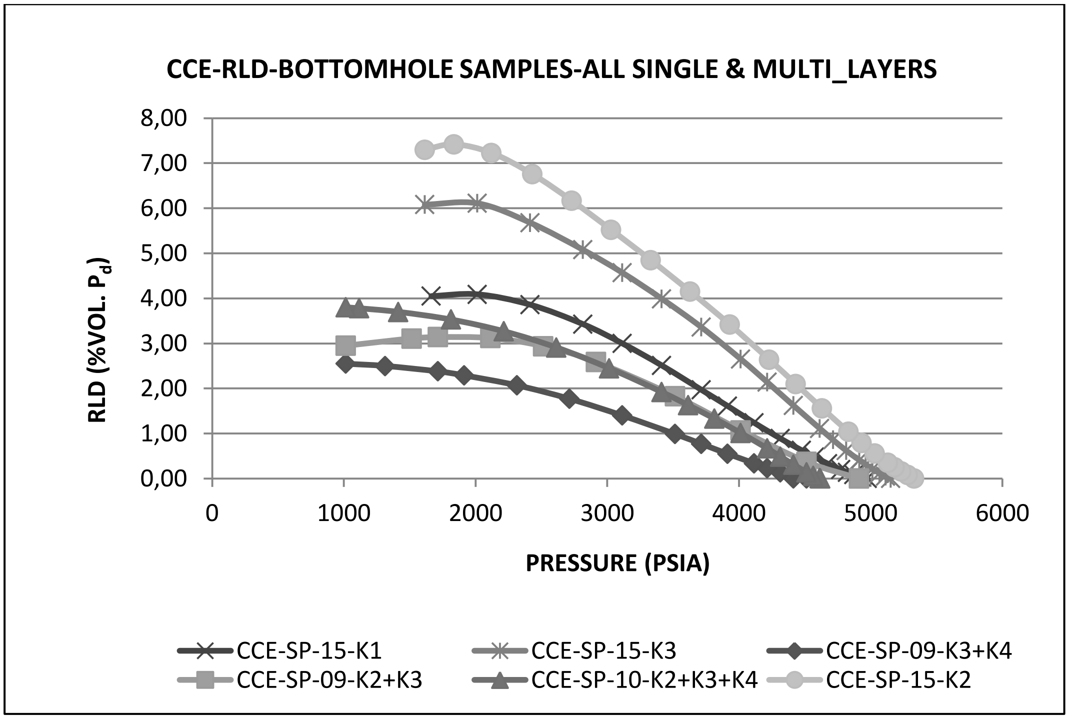

Fig 10 Diagram of RLD in CCE testing of bottomhole samples

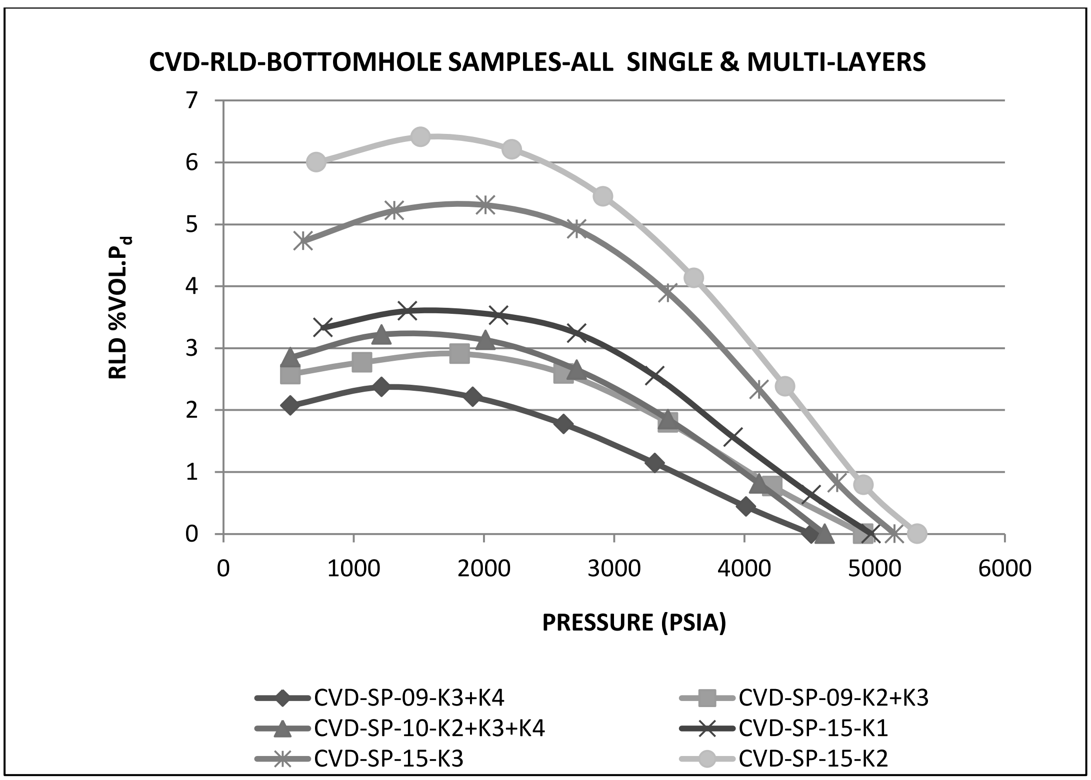

Fig 11 Diagram of RLD in CVD testing of bottom-hole samples

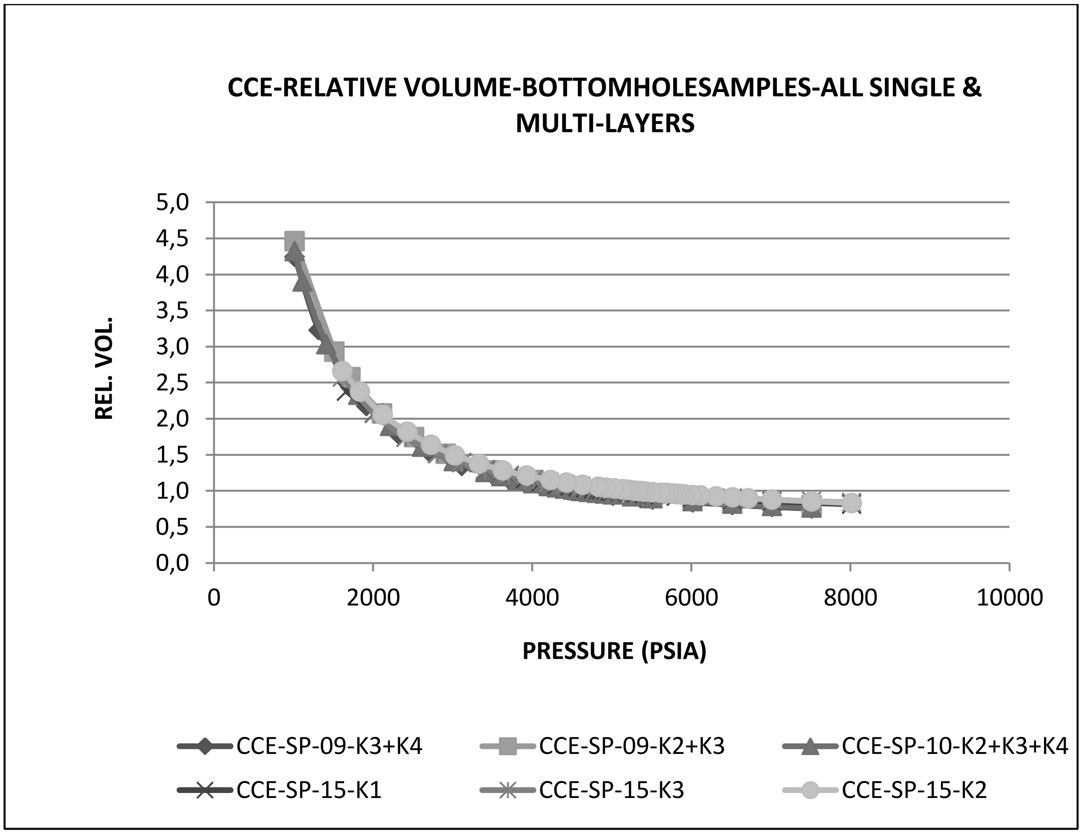

Fig 12 Diagram of relative volume in CCE testing of bottom-hole samples

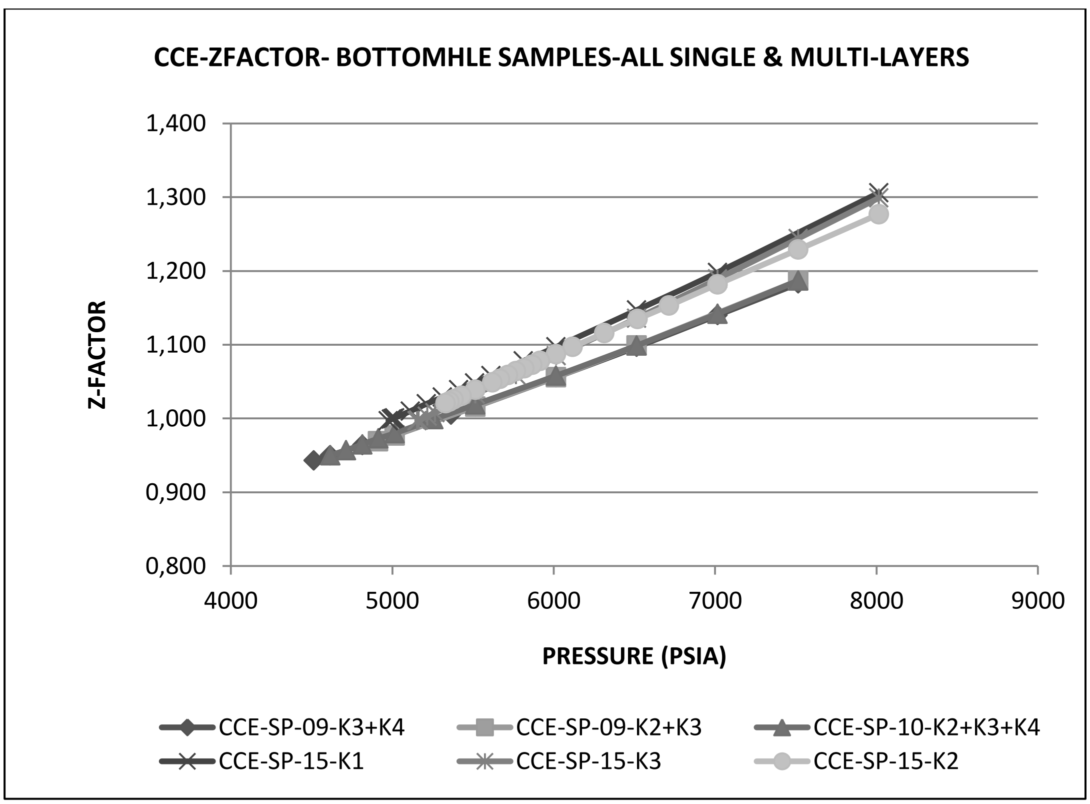

Fig 13 Diagram of gas Z-Factor in CCE testing of bottom-hole samples

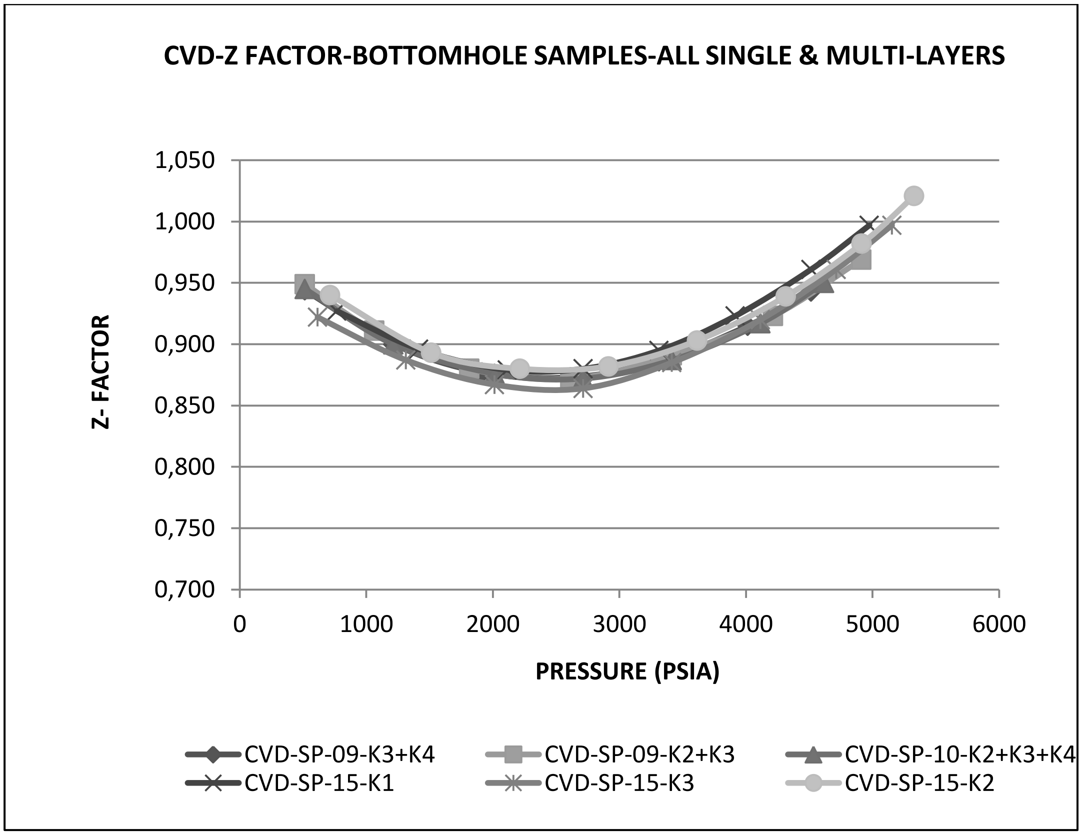

Fig 14 Diagram of gas Z-Factor in CVD testing of bottom-hole samples