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Interpretation of Parameters for Monitoring Wells during the Discharge Test of NWS-9D

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ABSTRACT

The Sabalan geothermal field is a high-temperature area under development. Geothermal exploration was started in 1975 by the Ministry of Energy of Iran. After revolution in 1979 in Iran, it was stopped, and it was started again in 1998 by SUNA – the Renewable Energy Organization of Iran. Three deep exploration wells and two shallow reinjection wells were drilled in 2002-2004 in three sites A, B and C by SUNA, as well as the preparation of two sites D and E for new drilling. This area is about 16 km southeast of the town of Meshkin shahr. There is an overall potential for the generation of about 200 MWe over the greater prospect area. S.K.M was the main consultant from 1998 to 2006. SUNA is planning to drill thirteen new wells and build a 50 MWe power plant when these wells will be drilled. As the first part of project, SUNA will build a pilot power plant in order to confirm that a geothermal power plant can be operated in Iran. Moshanir was the consultant for civil work 1998-2006; since 2006 the consortium of Moshanir, EDC and Lahmeyer was selected as main consultant for the geothermal field. New drilling was commenced from 2008 till 2011. In this stage, 5 deep wells were drilled and one previous well was deepened (table.1).

Well NWS-9D is the ninth drilled well in Sabalan geothermal project, and part of drilling operation was done at the second stage of exploration at 2010. These wells were discharge tested in 2012.

During the NWS-9D discharge test, when any well head pressure changed, all the physical and chemical parameters of NWS-9D were recorded; these parameters were also determined for NWS-8D, NWS-4D, NWS-5D & NWS-11RD.

In this paper we discuss the interpretation of output data that was received by the running memory in NWS-8D, NWS-4D, NWS-5D & NWS-11RD while in discharge and shut down of NWS-9D.

1. INTRODUCTION

The Northwest Sabalan (NW Sabalan) geothermal project is located in the province of Ardabil in northwest Iran. The project lies along the slopes of the 4,811 meters high Mt. Sabalan volcano, which is the most northwestern of the many different geothermal prospects associated with the Mt. Sabalan volcano. The geothermal potential of the area has been recognized based on the results of the exploration activities since 1979. Exploration drilling in Northwest Sabalan started in 2002 with the drilling of well NWS1. Eleven wells have already been drilled (Table 1) in the area to date. Exploration drilling yielded more geo-scientific information supporting the existence of a geothermal resource that is viable for development.

A reserve estimate was conducted by SKM in 2005 to evaluate the initial potential of the field for electrical power generation. During that time, only wells NWS1, NWS3 and NWS4 had been drilled and tested (SKM, 2005). The power potential of the geothermal reserve, covering an area ranging from 7 to 30 km^2 and having temperatures ranging from 180°C to 280°C, was estimated using the probabilistic Monte Carlo approach. The probabilistic Monte Carlo approach allows uncertainty in reservoir parameters to be factored in the estimate, which is not possible in the deterministic stored heat method. A power output of 206 MWe for 25 years was estimated using the Monte Carlo method.

As exploration activities in NW Sabalan continued, four new wells were successfully drilled and additional Magneto telluric (MT) geophysical surveys were conducted to cover the greater Sabalan area. Latest available downhole measurements of all the wells shows the hottest portion of the field to be located near NWS1, with a maximum measured temperature of about 240°C. Geochemistry analysis of fluid samples collected during discharge testing of wells NWS1 and NWS4 in 2004 also suggests reservoir temperatures reaching as high as 260°C to 280°C, based on cation geo thermometry (SKM, 2005).

Interpretation of the latest MT geophysical data delineated a postulated resource area of 25 km^2 west of Mt. Sabalan and extending towards Alvares, which is south of Mt. Sabalan (EDC, 2010). The MT interpretation also implied that another resource area, approximately 10 km^2 in size, may exist in Shabil area located on north of Mt. Sabalan. The geothermal reserve estimate was then updated with the additional data acquired from the newly drilled wells and MT geophysical surveys.

1.2 LOGGING EQUIPMENT AND LOGGING PARAMETERS

1.2.1 Mechanical thermometers are mainly used in high temperature wells.

The data is not transmitted to the surface, but recorded inside the temperature sensor on a clock-driven black faced the chart as a curve. Many measuring points can be recorded during one run based on the operational program, and the method of recording temperature is similar to pressure records by AMARADA.

Table1. Drilling histories of Sabalan geothermal wells

Liner	Production Casing		Total Depth	End of Drilling	Drilling Spud Date	Site Name	Well Name
Size (inches)	Depth (m)	Size (inches)					
7"	1586	9-5/8”	3197	Jun-01-2003	Nov-22-2002	A	NWS-1
9-5/8”	1589	13-3/8"	3166	Jun-25-2003	Jun-07-2003	C	NWS-3
7"	1166	9-5/8”	2255	Nov-27-2003	Jul-02-2003	B	NWS-4
9-5/8”	360	13-3/8"	638	Mar-27-2004	Dec-17-2003	A	NWS-2R
9-5/8”	139	20"	538	May-02-2004	Apr-07-2004	B	NWS-5R
7"	745	9-5/8”	1901	Aug-31-2008	May-30-2008	B	NWS-5D
7"	1250	9-5/8”	2377	Feb-19-2009	Oct-16-2008	D	NWS-6D
7"	1313	9-5/8”	2705	Aug-17-2009	Mar-26-2009	D	NWS-7D
7"	1438	9-5/8”	2640	Jan-21-2010	Aug-21-2009	E	NWS-8D
7"	-	9-5/8”	500	Mar-19-2010	Feb-08-2010	E	NWS-9D
7"	977	9-5/8”	2300	Sep-o5-2010	Apr-10-2010	D	NWS-10D
7"	1101	9-5/8”	2703	Dec-16-2010	Sep-16-2010	E	Re-Entry NWS-9D
7"	1286	9-5/8”	2813	May-10-2010	Dec-25-2010	C	NWS-11RD

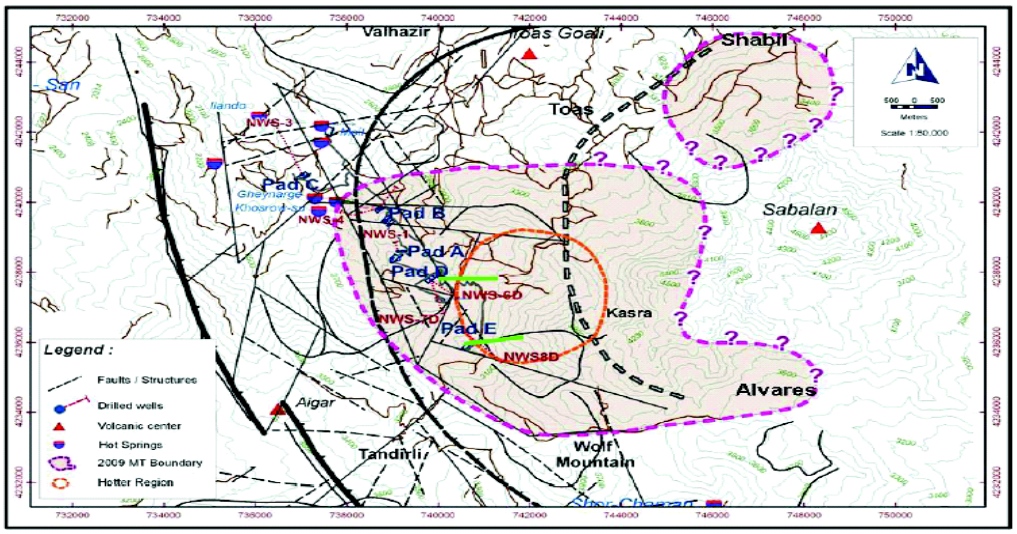

Figure1. Well Nws-9d Well Location

1.2.2 Temperature:

The fundamental parameter in geothermal investigation is temperature.

Throughout the history of logging, many types of thermometers have been used.

Two types of temperature sensors are used for mechanical thermometers.

These are the probe sensor (AMARADA type) and bimetal (KUSTER-gauge), where the temperature expansion of the bimetal indicates the temperature.

Higher accuracy than +,- (1) C^o should not be expected for commercial mechanical thermometers, but at high temperatures they are superior to other thermometers and can be operated up to (350) C^o, which is close to the highest temperature measured in a geothermal well to date.

Picture1. Well NWS-9D during discharge test

1.2.3 Pressure:

It is common in geothermal investigation to use the fluid level, or the pressure of different depths on the wells if the well is artesian, to indicate the pressure potential of the geothermal system at the well site. This is a rather good way of determining the pressure if the temperature is uniform from the water level/wellhead down to the main aquifer of the well, and no water flow or boiling is present inside the well.

In other cases, especially at high temperature when the density of water depends strongly on the temperature, water level or WHP can give quite erroneous results. In such cases the pressure can either be determined by actual pressure logging of the well head down to the main aquifer.

Pressure logging of geothermal wells is widely used in high temperature wells (T> 150^{o}C). The use of electrical logging sensors (like PIEZO-electrical crystals) is not possible at such temperatures, and mechanical pressure gauges expect in the pressure gauge (AMARADA) the bourdon tube that is not sealed from the well fluid, but the gauge senses the pressure among a port on the burden tube housing in the well and records the pressure on a clock driven black faced the chart as curve, recorded based on the operational program.

1.2.4 Flow meters

Flow meters measure different flow rate depending on flow type and their position in the borehole. In production logging for rate calculation we need average velocity. So we need to relate the velocity that spinner measure to average velocity.

1.2.5 K10 Geothermal PTS:

The K10 Geothermal tool has been designed to record Pressure, Temperature data Spinner in a high temperature geothermal well. Our K10 Geothermal tool is available in a memory or surface readout (SRO) configuration. The K10 Geothermal PTS can operate down hole for up to 6 hours at 300^{o}C. The electronic and battery section is encased in a pressure housing, which thermally protects it from high temperature geothermal temperatures. The pressure transducers senses wellbore pressure through a capillary tube, while the external fast response platinum-resistive temperature device (RTD) sensor remains exposed to the wellbore for accurate and fast response temperature sensing and recording. The K10 Geothermal tool utilizes a proprietary electronic memory recording system that allows for redundant memory. This design allows the data to be recorded onto 4 Flash memory components to increase data reliability. The low power design allows you to operate this tool using only 1 “AA” lithium battery.

Table2. Specification of KUSTER-gauge,K10

K10 High temperature geothermal tools		
Pressure	Range up to 5,000 psi	
	Accuracy 0.024% F.S.	
	Resolution 0.0003% F.S.	
Temperature	Down hole Time	4 hours at 350°C

		6 hours at 300°C
	Accuracy ± 0.25°C	
	Resolution 0.001°C	
	Response Time 1.5 sec./10°C	
Physical	Outside Diameter 1.75”	
	Length (approx.) 60”	
	Outer Housing Collapse Pressure 5,000 psi	
	Transducer Type Piezoresistive	
Miscellaneous	Number of Data Points 1,400,000 sets	
	Minimum Sample Rate 1 sec.	
	Interface USB	

2. NWS-9D

Well NWS-9D has been drilled in 2 periods. At the first period (Feb 07, 2010 to Mar 19, 2010), the well was drilled to 500 mMD then NIDC Run 9 5/8 to this point; the last period was drilled to 2703 mMD, and 7" perforated liner was run to TD(Total Depth). NWS-9D is collared at pad E, Cellar 1, Inclination is 40 deg and target azimuth is 45˚, NWS-9D was drilled by NIDC Rig 41 FATH.

Well NWS9-D was discharged by airlift stimulation in Sep 2012 for a period of 77 days with reinjection of waste brine into well NWS-2D.

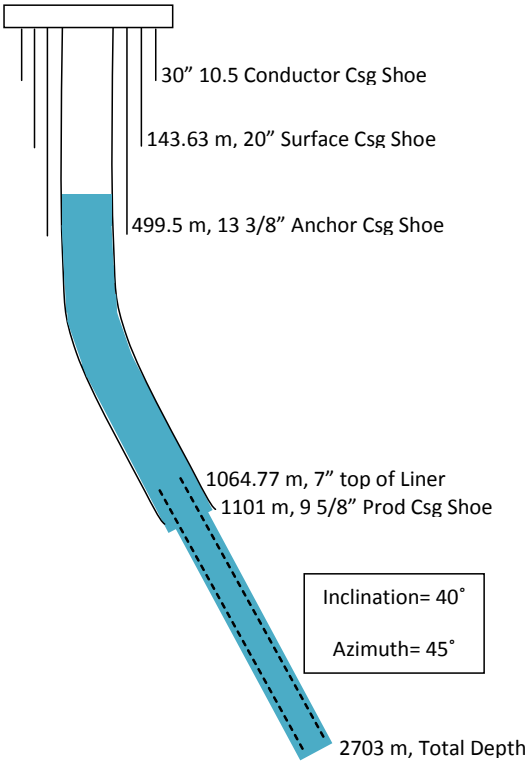

Figure2. Schematic of Well NWS-9D

2.1 Summary of Discharge Test Report for NWS-9D

NWS-9D was programmed to the discharge test for 47 days, but actually Discharge test operation was took about 77 days.

After discharge by air-lifting on Sep, 25, 2012 flow was discharge direct to silencer as full open condition. The highest wellhead pressure attained on discharge direct to the silencer was 7.7 barg at Sep, 25, 2012 (91/07/04) In This condition (F.D).The mass flow was about 42 kg/s and the discharge enthalpy was about 1110 kJ/kg.

2.1.1 On Oct, 01, 2012

Flow was throttled to 4 3/4 inches. The highest wellhead pressure attained on discharge direct to the silencer was 7.95 barg. The mass flow was about 42 kg/s and the discharge enthalpy was about 1076 kJ/kg.

2.1.2 On Oct, 11, 2012

Flow was throttled to 3 3/4 inches. The highest wellhead pressure attained on discharge direct to the silencer was 8.25 barg. The mass flow was about 40kg/s and the discharge enthalpy was about 1125 kJ/kg.

2.1.3 On Oct, 21, 2012

Flow was throttled to 3 inches. The highest wellhead pressure attained on discharge direct to the silencer was 8.79 barg. The mass flow was about 34kg/s and the discharge enthalpy was about 1114 kJ/kg.

2.1.4 On Oct, 31, 2012

Flow was throttled to 2 3/4 inches. The highest wellhead pressure attained on discharge direct to the silencer was 8.82 barg. The mass flow was about 32kg/s and the discharge enthalpy was about 1150 kJ/kg.

2.1.5 On Nov, 30, 2011

Flow was throttled to F.D. The Average wellhead pressure attained on discharge direct to the silencer was 7.4 barg. The mass flow was about 40 kg/s and the discharge enthalpy was about 1135 kJ/kg.

2.1.6 On Dec, 01, 2011

Flow was throttled to 2 3/4". The Average wellhead pressure attained on discharge direct to the silencer was 8.75 barg. The mass flow was about 32 kg/s and the discharge enthalpy was about 1163 kJ/kg.

2.1.7 On Dec, 08, 2011

Flow was throttled to F.D. The Average wellhead pressure attained on discharge direct to the silencer was 8.75 barg. The mass flow was about 32 kg/s and the discharge enthalpy was about 1163 kJ/kg.

Table3. Summary of Discharge Test Report for NWS-9D According to side valve condition

DAYS NO.	DATE	LOGGING OPERATION		NWS-9D VALVE COND	DAILY REPORT NO.
		PT	PTS		
	2012,08,22		NWS-5D	Base line survey	
	2012,08,23		NWS-4D		
	2012,08,26		NWS-8D		
	2012,08,28		NWS-1D		
	2012,09,11		NWS-11RD		
	2012,09,23		NWS-9D		
7	2012.09.25		NWS-9D	Discharge by CTU ,FD	16
	2012.09.27		NWS-9D	FD	18
	2012.09.28		NWS-5D	FD	19
	2012.09.29		NWS-9D	FD	20
	2012.09.30		NWS-8D	FD	21
	2012.10.01		NWS-1D	FD to Vertical Discharge then Throttle to 4,3/4"	22
	2012.10.02		NWS-4D		
10	2012.10.08	NWS-5D		4,3/4"	29
	2012.10.09	NWS-4D		4,3/4"	30
	2012.10.10		NWS-11RD	4,3/4"	31
	2012.10.11		NWS-9D	4,3/4" to Vertical Discharge then Throttle to 3,3/4"	32
10	2012.10.12		NWS-8D	3,3/4"	33
	2012.10.21			3,3/4" to Vertical Discharge then Throttle to 3 "	42
10	2012.10.28	NWS-4D		3 "	49
	2012.10.29	NWS-5D		3 "	50
	2012.10.30	NWS-8D		3 "	51
	2012.10.31	NWS-9D		3 " to Vertical Discharge then Throttle to 2,3/4"	52
30	2012.11.15	NWS-5D		2 3/4 "	67
	2012.11.16	NWS-4D		2 3/4 "	68
	2012.11.30			2 3/4 " to Vertical Discharge then Throttle to F.D"	82
1	2012.12.01			F.D to Vertical Discharge then Throttle to 2 3/4"	83
7	2012.12.06		NWS-9D	2,3/4"	88
	2012.12.08			2,3/4" to Vertical Discharge then Throttle to F.D	90
2	2012.12.12			F.D and SHUT IN NWS-9D @15:00, **AFTER VERTICAL DISCHARGE**	92

2.2 Survey Data

2.2.1 NWS-9D Wire-Line Shut-in Base Line Survey Data Sep, 23, 2012:

Maximum surveyed depth was 2657.17mMD.

Maximum temperature: 230.5 °C

Maximum Pressure: 164.074 bar

Temperature gradient is going up with High slope to 1056.48 mMD

Temperature is increasing from 1065.48 with low slope (~1.5 °C/100m) to ~1130mMD; temperature at this depth is 135 °C,

Temperature gradient is going up with Extremely high slope from 1161.05 mMd (with 141.35 deg) to 1199.82 mMD, temperature at this depth is 160 °C, it is due to a hot zone .

Temperature gradient is going up with High slope (~9.5 °C/100m) from 1199.82. mMd with 160 °C to 1900 mMD, temperature at this depth is 224.36 °C, it is due to a Feed zone.

Temperature is Increasing from 1900 with low slope to 2657.17mMD temperature at this depth is 228.77 °C.

Pressure curve shows that water level is 530mMD and hydraulic pressure of water column is rise up from this depth. Maximum Pressure Is 164.074 bar at 2645.65 mMD

2.2.2 NWS-9D Wire-Line Flowing Survey Data Sep, 29, 2012

The maximum surveyed depth was 2657.08 mMD.

On this day side valve of well NWS-9D is in F.D condition, and well was in stable condition for 5 days. Interconnection between boiling temperature curve and temperature curve shows that steam cap is top of this depth (~570 mMD) and top of this depth is two-phase. Flash point is 570 mMd.

The steam cap could be detected from the considerable changes in spinner response and pressure curve changes.

Considerable changes at ~750mMD until 1065 mMD is because of turbulent flow due to liner lap point.

There is a permeable zone at ~1250 mMD until ~1400mMD. This permeable zone is evident from the increase in spinner response for each line speed and is considered to be an inflow of hot brine.

A permeable zone is located somewhere 1650mMD to 1800 mMD. This is likewise evident in the increase in spinner response.

The next zone could be found at the vicinity. This zone is a loss zone from ~1900mMD to 1980mMD. This is inferred from the decrease in magnitude of the spinner in different intervals.

The depth from ~2000 to 2100 is a weak permeable zone due to low rate spinner response.

The depth from ~2300 to 2310 is a weak bit cold zone due to change temp curve

Loss zones are observed from the PTS:

- 1250 to 1400mMD (Positive)
- 1650 to 1800mMD (positive)
- 1900 t0 1980mMD (Negative)
- 2000 to 2100mMD (positive)
- 2300 to 2310mMD (Semi negative)

Positive is feed zone and Negative is Loss zone.

2.2.3 NWS-9D Wire-Line Flowing Survey Data Oct, 10, 2012:

The maximum surveyed depth was 2657.17 mMD.

On this day side valve of well NWS-9D is in 4 ¾" condition, and well was in stable condition for 10 days. Interconnection between boiling temperature curve and temperature curve shows that steam cap is about 850 mMD and top of this depth is two-phase. Flash point is 850 mMd.

The steam cap could be detected from the considerable changes in spinner response and pressure curve changes.

Considerable changes at ~1065mMD until 1110 mMD is because of turbulent flow due to liner lap point.

There is a permeable zone at ~1850 mMD until ~1870mMD. This permeable zone is evident from the increase in spinner response for each line speed and is considered to be an inflow of hot brine.

The next zone could be found at the vicinity. This zone is a loss zone from ~2010mMD to 2090mMD. This is inferred from the decrease in magnitude of the spinner in different intervals.

The depth from ~2250 to maximum surveyed depth (MSD) the failure of spinner was observed

Loss zone and permeable zone are observed from the PTS:

- 1850 to 1870mMD (Positive)
- 2250 to MSD (Negative)

Positive is feed zone and Negative is Loss zone.

2.2.4 NWS-9D Wire-Line Flowing Survey Data Dec, 12, 2012:

The maximum surveyed depth was 2657.17 mMD.

On this day side valve of well NWS-9D is in 2 ¾" condition.changing of flowing diagram was same as last flowing survey data (Oct,11,2012) and Interconnection between boiling temperature curve and temperature curve shows that steam cap is about 840 mMD and top of this depth is two-phase. Flash point is 840 mMd.

The steam cap could be detected from the considerable changes in spinner response and pressure curve changes.

Considerable Changes at ~1065mMD until 1110 mMD is because of turbulent flow due to liner lap point.

There is a permeable zone at ~1850 mMD until ~1870mMD. This permeable zone is evident from the increase in spinner response for each line speed and is considered to be an inflow of hot brine.

The next zone could be found at the vicinity. This zone is a loss zone from ~2010mMD to 2090mMD. This is inferred from the decrease in magnitude of the spinner in different intervals.

The depth from ~2250 to maximum surveyed depth (MSD) the failure of spinner was observed

Loss zone and permeable zone are observed from the PTS:

- 1850 to 1870mMD (Positive)
- 2250 to MSD (Negative)

Positive is feed zone and Negative is Loss zone.

Following diagram shows feed zone (Red area) and loss zones (Blue area) in terms of depths, it is clear that feed zones at state 2 ¾", 4 ¾" is weak and at Full open state is strong.

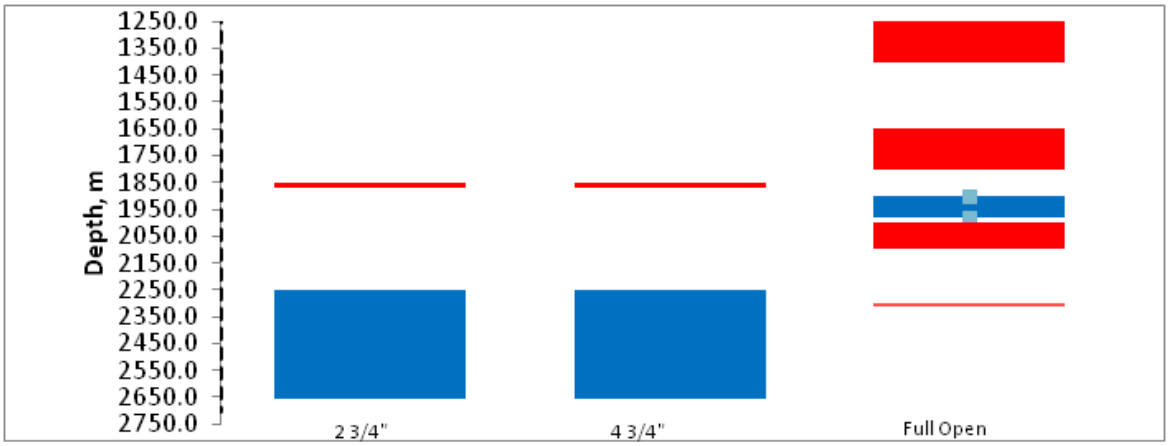

Figure 3: Feed zones and Loss Zones

Table4. NWS-9D Flowing Information

ITEM	Unit	NWS-9D	NWS-9D	NWS-9D	NWS-9D
DATE	D	2012,09,23	2012,09,29	2012,10,11	2012,12,06
SIDE VALVE COND (THROTTLE)	In	B.L	F.D	4 3/4"	2 3/4"
Max pressure	bar	164.074	160.589	160.418	159.288
Max Pressure Depth	bar	2645.65	2640.06	2651.08	2651.08
Max Temperature Depth	bar	2359.6	1966.49	2115.57	2115.57
Max Temperature	c^0	230.05	231.02	231.29	231.29

MCD	m	2657.17	2657.08	2657.17	2657.17
Feed Zone Depth (1)			1250-1400	1850-1870	1850-1870
Feed Zone Depth (2)	m		1650-1800	2010-2090	2010-2090
Feed Zone Depth (3)	m		1900-1980		

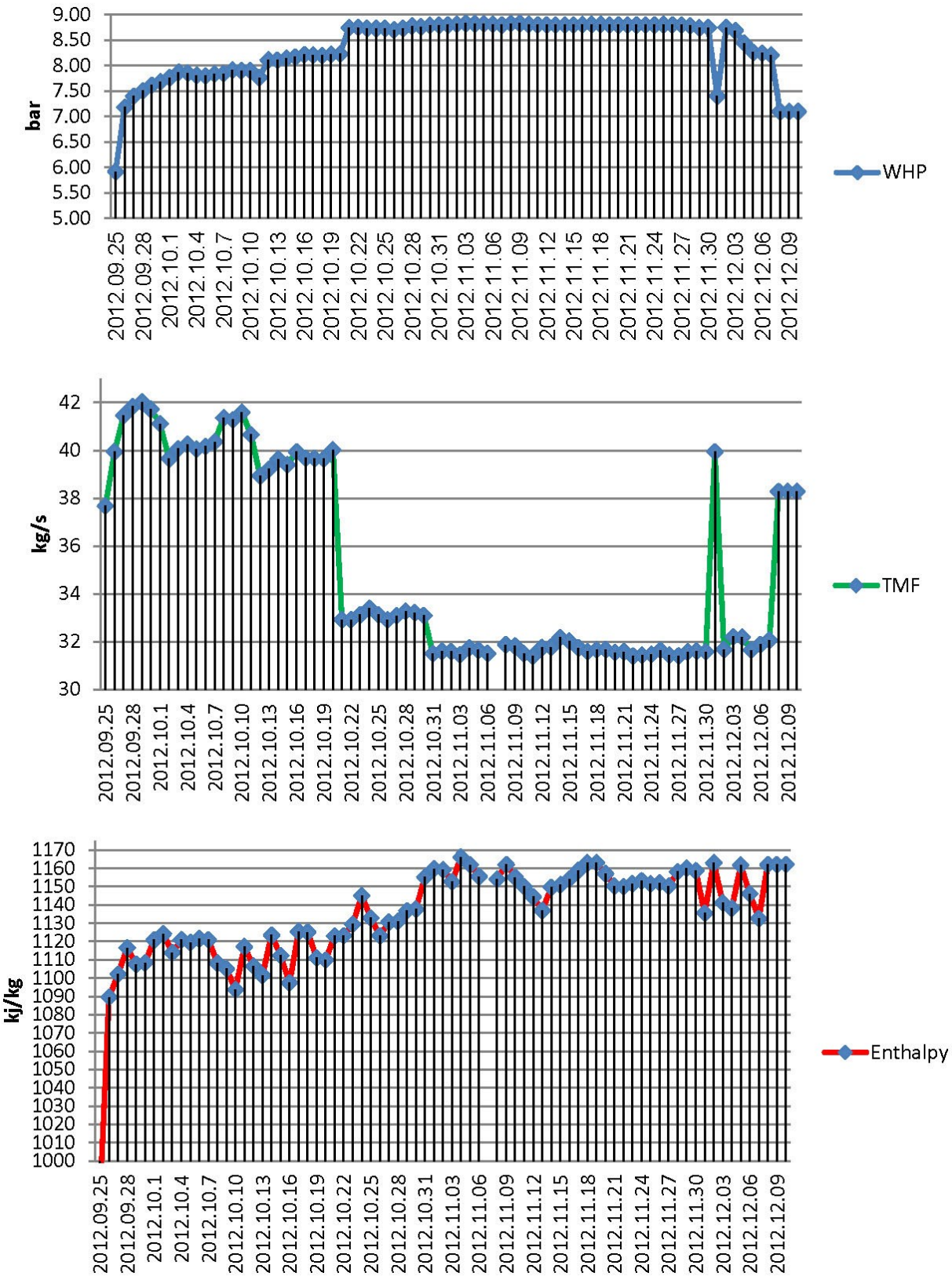

Figure 4: Physical Parameters of Well NWS-9D

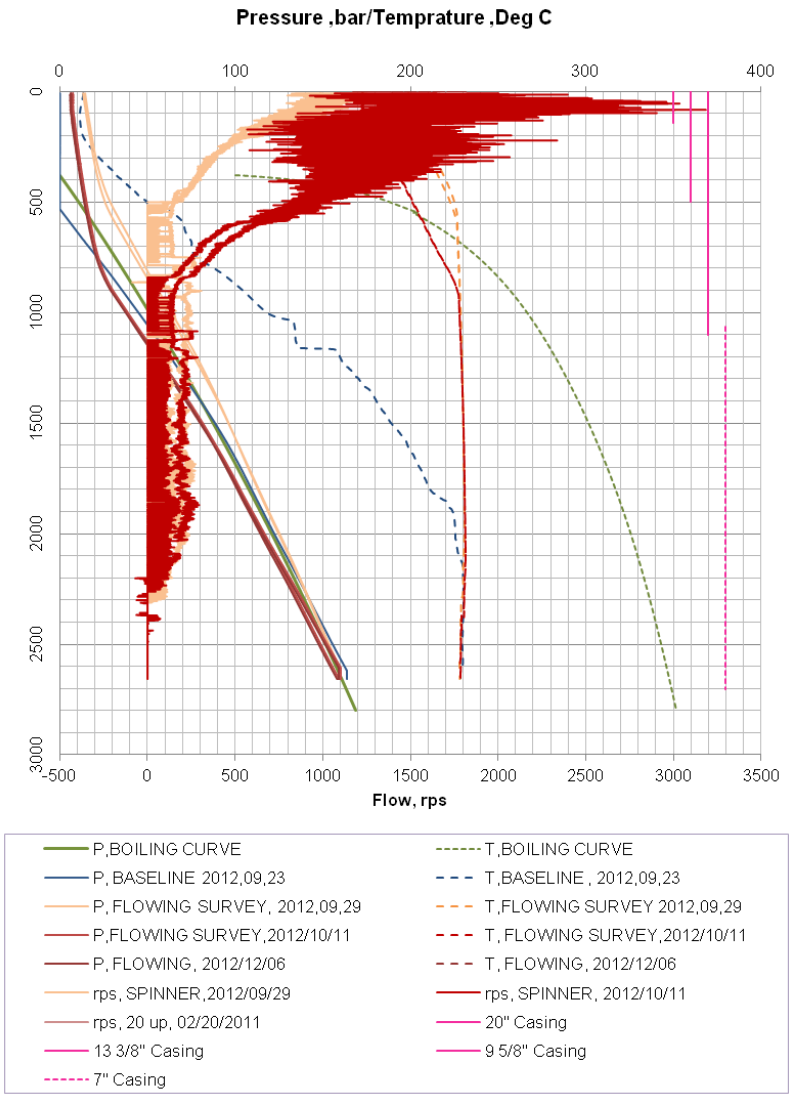

Figure 5: Comparison Curves of Well NWS-9D Surveys

2.2.5 NWS-5D Wire Line Shut-in Base line Data Aug, 22, 2012:

A PTS Base Line log was done at Aug, 22, 2012 on NWS-5D shut well. The maximum surveyed depth was 1811.14mMD. The results of the PTS log shows that temperature gradient is going up with high slope to ~753mMD and then it increases with low slope (~ 9 °C /100m) to ~1180mMD, temperature at this depth is 208 °C, and it was raised up due to a bit feed zone at this point (~1180 mMd) and temperature gradient was going up with low slope to ~229 °C at 1500 but it is behind 9 5/8" production casing. Temperature is going up again with low slope to 238.22 ° °C at maximum surveyed depth 1811.14 mMD. Pressure curve shows that water level is ~101mMD and hydraulic pressure of water column is rise up from this depth. Maximum pressure is 129.787 bar at depth 1810.22 mMD.

2.2.6 NWS-5D Wire Line Monitoring Data Sep, 28, 2012:

A PTS Monitoring log was done at Sep, 28, 2012 on NWS-5D while NWS-9D is flowing. The maximum surveyed depth was 1811.19mMD.

Side valve of well NWS-9D is in F.D condition, and this well has been stable after 3 days.

2.2.7 NWS-5D Slick line Monitoring Data Oct, 08, 2012:

A PT Monitoring log was done at Oct, 08, 2012 on NWS-5D while NWS-9D is flowing. The maximum surveyed depth was 1800 mMD.

Side valve of well NWS-9D is in 4 ¾" condition, and this well has been stable after 7 days.

2.2.8NWS-5D Slick line Monitoring Data Oct, 29, 2012:

A PT Monitoring log was done at Oct, 29, 2012 on NWS-5D while NWS-9D is flowing. The maximum surveyed depth was 1800 mMD.

Side valve of well NWS-9D is in 3" condition, and this well has been stable after 8 days.

Table5. NWS-5D Monitoring Information during NWS-9D Discharge test

	Unit	NWS-5D	NWS-5D	NWS-5D	NWS-5D
DATE	D	2012,08,22	2012,09,28	2012,10.08	2012,10,29
SIDE VALVE COND (THROTTLE) OF FLOWING WELL NWS-9D	In	B.L	F.D	4 3/4"	3"
Max pressure	bar	129.787	129.743	128.68	136.06
Max Pressure Depth	bar	1810.22	1771.82	1800	1800
Max Temperature Depth	bar	1639.91	1606.66	1800	1800
Max Temperature	c^0	240.45	240.38	223.9	221.32
MCD	m	1811.14	1811.19	1800	1800
Bottom hole Temperature	c^0	238.22	238.11	239.91	221.32
Feed Zone Depth (1)		1180	1180		
Static Water Level Inside Well	m	101	100	98	100-105

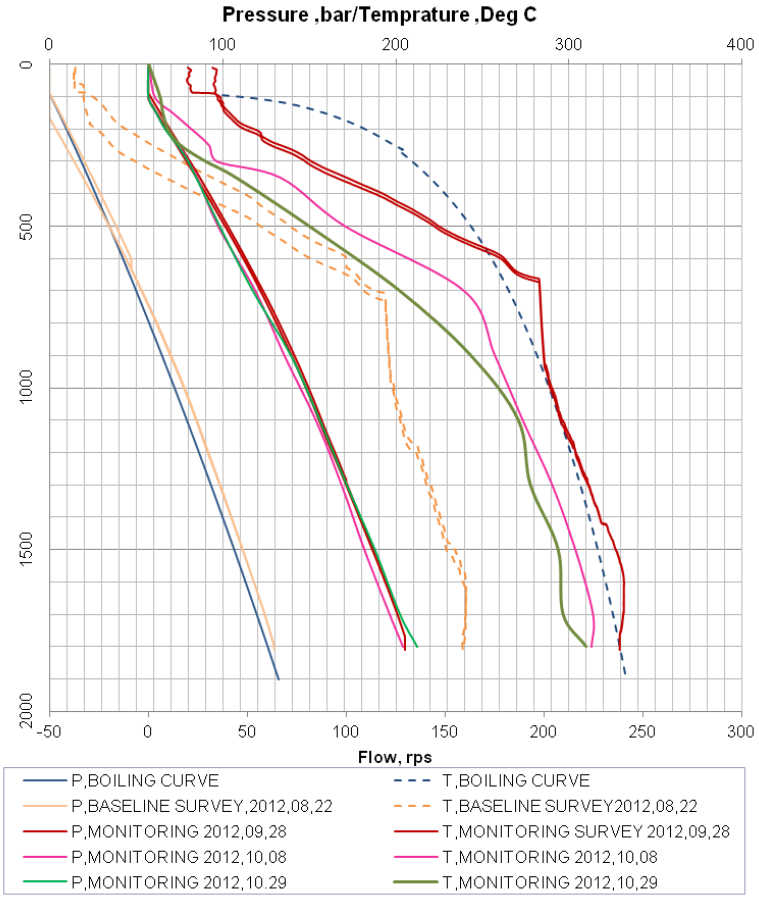

Figure 6: Comparison Curves of Well NWS-5D Surveys

2.2.10 NWS-8D Wire line Shut-in Base Line Data Aug, 26, 2012:

A PTS Wire line Shut-in Base Line log was done at Aug, 26, 2012 on NWS-8D. The maximum surveyed depth was 2128mMD. NWS-9D was shut and this well will be stimulated one month later.

2.2.11 NWS-8D Wire line Monitoring Data Oct, 12, 2012:

A PTS Monitoring log was done at Oct, 12, 2012 on NWS-8D while NWS-9D is flowing. The maximum surveyed depth was 2108mMD.

Side valve of well NWS-9D is in 4 ¾" condition, and this well has been stable after 10 days.

2.2.12 NWS-8D Wire line Monitoring Data Sep, 30, 2012:

A PTS Monitoring log was done at Sep, 30, 2012 on NWS-8D while NWS-9D is flowing. The maximum surveyed depth was 2008.04mMD.

Side valve of well NWS-9D is in F.D condition, and this well has been stable after 5 days.

2.2.12 NWS-8D Wire line Monitoring Data Dec, 20, 2012:

A PTS Monitoring log was done at Oct, 12, 2012 on NWS-8D while NWS-9D is flowing. The maximum surveyed depth was 2108mMD.

Side valve of well NWS-9D is in 4 ¾" condition, and this well has been stable after 10 days.

2.2.13 NWS-8D Wire line Monitoring Data Oct, 30, 2012:

A PT Monitoring log was done at Oct, 30, 2012 on NWS-8D while NWS-9D is flowing. The maximum surveyed depth was 2100 mMD.

Side valve of well NWS-9D is in 3" condition, and this well has been stable after 9 days.

Table 6. NWS-8D Monitoring Information during NWS-9D Discharge test

TEM	Unit	NWS-8D	NWS-8D	NWS-8D	NWS-8D
DATE	D	2012,08,26	2012,10,12	2012,10,30	2012,12,20
SIDE VALVE COND (THROTTLE) OF FLOWING WELL NWS-9D	In	B.L	F.D	4 3/4"	3"
Max pressure	bar	130.064	128.683	130.12	121.633
Max Pressure Depth	bar	1985.6578	2078.75	21100	1977.74
Max Temperature Depth	bar	2011.5	1968.5	2100	2100
Max Temperature	c^0	199.77	193.68	197.39	191.54
MCD	m	2128	2008.04	2108	2100
Static Water Level Inside Well	m	240	220	303	400

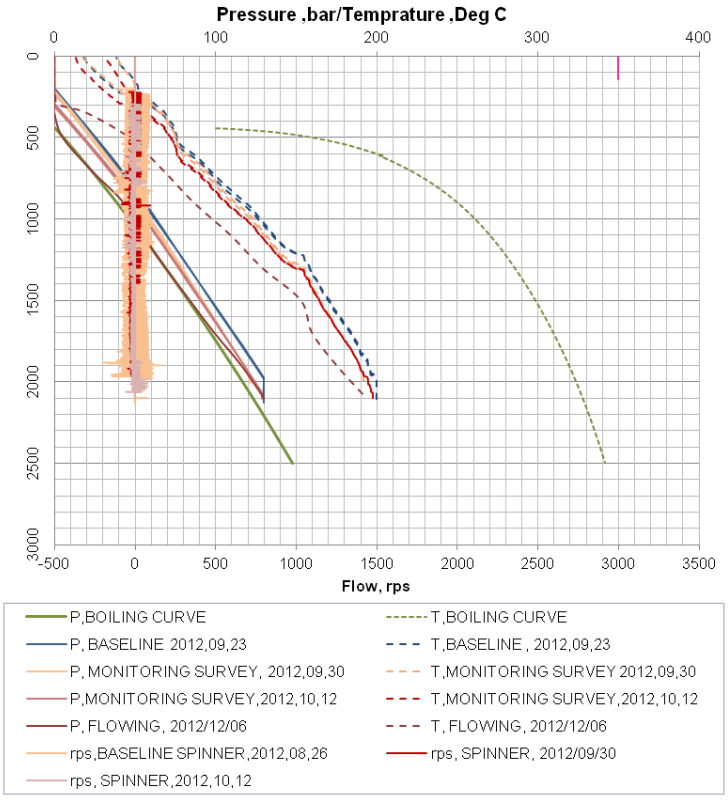

Figure 7: Comparison Curves of Well NWS-8D Surveys

2.2.14 NWS-4D Wire line Shut-in Base Line Data Aug 23, 2012:

A PTS Base Line log was done on Aug. 23, 2012 on NWS-4D shut well. The maximum surveyed depth was 2210mMD.

The results of the PTS log shows that temperature gradient is going up with high slope (34.5 °C /100m) to ~658.67mMD and then it increases with low slope (~ 13.33 °C /100m) to ~1024.5mMD, temperature at this depth is 233.31 °C, then it was stable to ~1600 mMd and then temperature gradient was going down with low slope to maximum surveyed depth. Temperature is going up again with low slope to 215.93 °C at maximum surveyed depth 2210 mMD.

Pressure curve shows that water level is ~154mMD and hydraulic pressure of water column is rising up from this depth.

2.2.15 NWS-4D Wire line Monitoring Data Oct 03, 2012:

A PTS Monitoring log was done on Oct. 03, 2012 on NWS-4D while NWS-9D is flowing. The maximum surveyed depth was 2210 mMD.

Side valve of well NWS-9D is in F.D condition, and this well has been stable after 7 days.

The results of the PTS log show that temperature of production liner intervals is the same as the base line survey.

2.2.16NWS-4D slick line Monitoring Data Oct, 09, 2012:

A PT Monitoring log was done on Oct, 09, 2012 on NWS-4D while NWS-9D is flowing. The maximum surveyed depth was 2200 mMD.

Side valve of well NWS-9D is in 4 3/4" inch condition, and this well has been stable after 7 days.

The results of the PT log show that temperature of production liner intervals has decreased from the base line survey.

2.2.17 NWS-4D slick line Monitoring Data Oct, 28, 2012:

A PT Monitoring log was done on Oct, 28, 2012 on NWS-4D while NWS-9D is flowing. The maximum surveyed depth was 2200 mMD.

Side valve of well NWS-9D is in 3 " inch condition.

The results of the PT log show that temperature of production liner intervals has increased from the base line survey.

2.2.18 NWS-4D slick line Monitoring Data Nov, 16, 2012:

A PT Monitoring log was done on Nov, 16, 2012 on NWS-4D while NWS-9D is flowing. The maximum surveyed depth was 2250 mMD.

Side valve of well NWS-9D is in 2 3/4" inch condition, and this well has been stable after 15 days.

Pressure curve shows that water level is ~120 mMD

Table7. NWS-4D Monitoring Information during NWS-9D Discharge test

ITEM	Unit	NWS-4D	NWS-4D	NWS-4D	NWS-4D	NWS-4D
DATE	D	2012,08,23	2012,10,02	2012,10,09	2012,10,28	2012,11,16
SIDE VALVE COND (THROTTLE) OF FLOWING WELL NWS-9D	In	B.L	F.D	4 3/4"	3"	2 3/4"
Max pressure	bar	156.621	156.675	157.43	149.25	163.19
Max Pressure Depth	bar	2204.4	2208	2200	2200	2250
Max Temperature Depth	bar	1024.5	1553-1559	1500	1500	1500
Max Temperature	c^0	233.31	230.32	218.58	224.51	237.68
MCD	m	2210	2210	2200	2200	2250
Static Water Level Inside Well	m	154	104	110	110-120	120

2.2.19 NWS-1D Wire line Shut-in Base Line Data Aug 28, 2012:

A PTS Base Line log was done on Aug 28, 2012 on NWS-1D shut well. The maximum surveyed depth was 3160mMD.

The results of the PTS log shows that temperature gradient is going up with a high slope from 247.93 to 551 mMD, and then it decreases with a high slope to ~628mMD, temperature at this depth is 114 °C. It was raised up again with a high slope to ~702mMD with 159.7, and the temperature gradient was going down with low slope to ~156.26 °C at 758.12. Temperature is going up again with a high slope to 243.09 °C, with maximum temperature at 874.4 mMD then going down with a low slope at MCD °C with 236.28 °C

Pressure curve shows that water level was ~250mMD. Maximum pressure was 241.887 bar at depth 3151.71 mMD.

The pressure of maximum surveyed depth was 241.87.

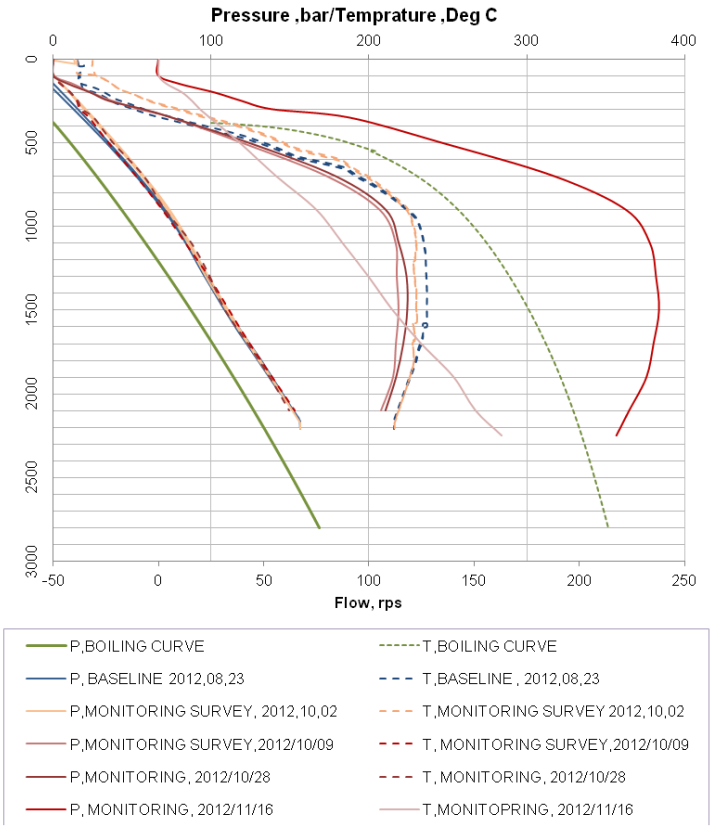

Figure 8: Comparison Curves of Well NWS-4D Surveys

2.2.20 NWS-1D Wire line Monitoring Data Oct, 01, 2012:

A PTS Monitoring log was done on Oct 01, 2012 on NWS-1D while NWS-9D is flowing. The maximum surveyed depth was 3160mMD.

Side valve of well NWS-9D is in F.D condition, and this well has been stable after 6 days.

The results of the PTS log show that the temperature of production liner intervals in comparison with base line survey is the same. Maximum temperature is 243.08°C from 822.37 to 823.14 mMD and temperature of maximum surveyed depth is 236.38°C

Pressure curve shows that water level is ~215 mMD due to flowing NWS-9D, and hydraulic pressure of water column is raised up from this depth in comparison with base line survey. Maximum pressure is 241.963 bar from 3113.07 to 3113.44 mMD

2.2.21 NWS-11D Wire line Shut-in Base Line Data Sep 11, 2012:

A PTS Base Line log was done on Sep 11, 2012 on NWS-11D shut well. The maximum surveyed depth was 2758mMD.

The results of the PTS log shows that temperature gradient is going up with a high slope to 864.50 mMD and then it decreases with a low slope to 2100 mMD, temperature at this depth is 161.15 °C, and it was raised up again with low slope to MCD with 174.51°C.

Pressure curve shows that water level was ~35mMD. Maximum pressure was 214.094 bar at depth 2730.15 mMD. The pressure of maximum surveyed depth was 214.08.

2.2.22 NWS-11D Wire Line Monitoring Data Oct 10, 2012:

A PTS Monitoring log was done on Oct 10, 2012 on NWS-11D while NWS-9D is flowing. The maximum surveyed depth was 2754.694mMD.

Side valve of well NWS-9D is in 4 ¾" condition, and this well has been stable after 9 days.

The results of the PTS log show that temperature of production liner intervals in comparison with base line survey is the same. Maximum temperature is 174.54 °C from 2731.3 to 2734.24; also, this temperature was continued from 2741.84 to 2743.5 mMD and temperature of maximum surveyed depth is 174.51 °C

Pressure curve shows that water level is ~35 mMD, and compared to the base line survey it is the same. Maximum pressure is 214.085 bar at 2730.151 mMD, and the temperature of the bottom hole is 214.085 mMD.

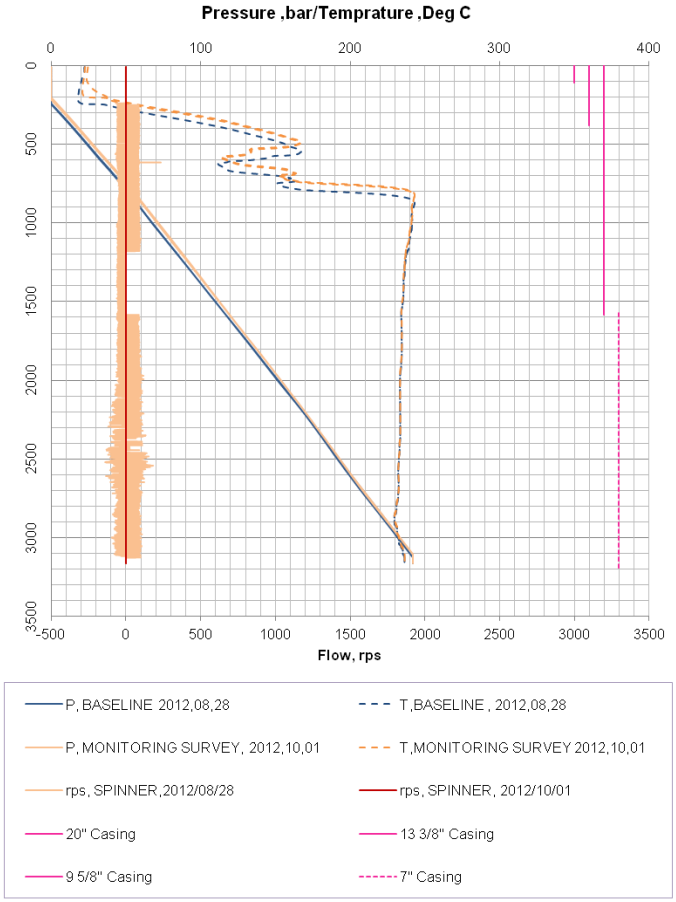

Figure 9: Comparison Curves of Well NWS-1D Surveys

Table8. NWS-1D and NWS-11RD Monitoring Information during NWS-9D Discharge test

ITEM	Unit	NWS-1D	NWS-1D	NWS-11D	NWS-11D
DATE	D	2012,10,28	2012,10,01	2012,09,11	2012,10,10
SIDE VALVE COND (THROTTLE) OF FLOWING WELL NWS-9D	In	B.L	F.D	B.L	4 3/4"
Max pressure	bar	241.887	241.963	214.9	214.08
Max Pressure Depth	bar	3151.71	3113	2730	273.015
Max Temperature Depth	bar	874.4	822	2758	2731-2734.24
Max Temperature	c^0	243.09	243.08	174.5	1745.51
final depth for set as bottom	m	3160	3160	2758	2754.69
Bottom hole pressure	bar	241.87		214.08	214.08
Bottom hole Temperature	c^0	236.28	236.38	174.5	174.51
Static Water Level Inside Well	m	250	215	35	35
Site Elevation:	m			2264.15	
Inclination:	Deg	0	0	38	
Azimuth:	Deg	0	0	63	
B.L: Base Line Logging operation			F.D: Full Discharge		

3. CONCLUSION

Based on table 4, behavior of NWS-9D has shown that the bottom hole pressure was decreased 4 bar from 164.074 to 160.589 bar. This is when the side valve of NWS-9 D was full open and pressure parameters were the same as the previous condition (160bar), the side valve changed to 4 3/4", and in 2 3/4" side valve condition pressure was dropped to 159.286. The temperature parameters in all conditions were the same at about 230 degrees centigrade.

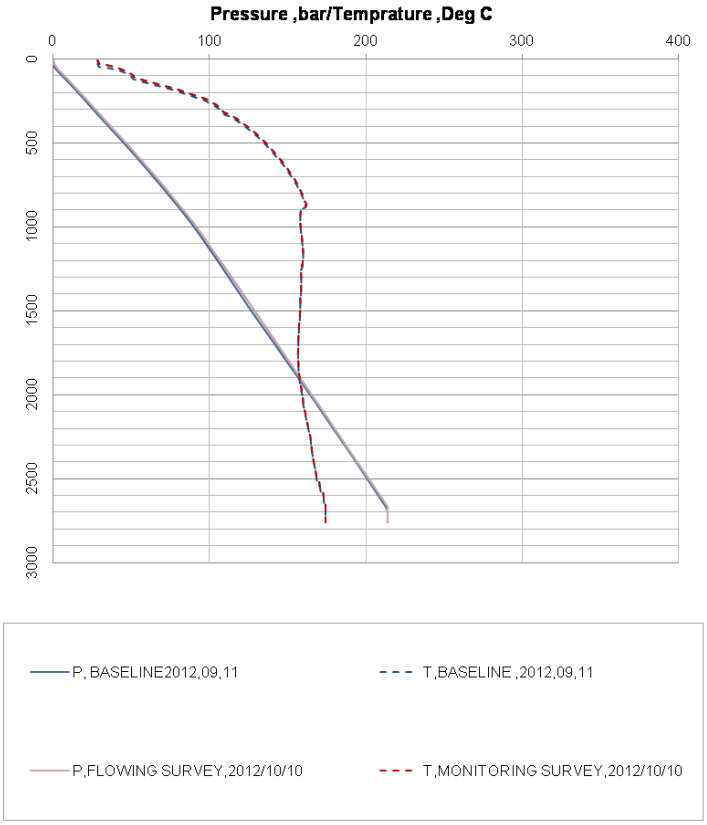

Figure 10: Comparison Curves of Well NWS-11RD Surveys

According to analysis of monitoring wells during NWS-9D discharge test, these results were accrued:

- According to table 5, behavior of NWS-5D as monitoring well was shown that the water level was raised up and the temperature of bottom hole was increased as 1 meter when the valve of NWS-9D Was switch from baseline to Full Discharge condition and also was raised up again as 2 meters when valve of NWS-9 D Was 4 ¾".
- According to table 5, behavior of NWS-5D as monitoring well was shown that the pressure was the same as baseline in full condition of NWS-9D condition and the pressure was dropped from F.D to 4 3/4" condition of NWS-9D Discharge as 1 bar and pressure was raised up again as 8 bar from 4 3/4" to 3" side valve condition.
- According to table 5, behavior of NWS-5D as monitoring well was shown that the temperature was the same as previous condition(baseline) as 240 centigrade degree and the temperature of bottom hole was decreased as 7 deg C when the valve of NWS-9D Was 4 3/4".
- According to table 6, behavior of NWS-8D as monitoring well was shown that the water level was raised 20 meters up from Baseline(240 to 220 mMd) to Full Discharge of NWS-9D, and going down from F.D to 4 3/4" as 83 meter (water level was 303 mMd) and going down again from 4 3/4" to 3" as 100 meter (water level was 400 mMd)
- According to table 6, behavior of NWS-8D as monitoring well was shown that the pressure was increased from baseline in full condition of NWS-9D condition to full condition as 2 bar (130 to 128) and the pressure was increased from F.D to 4 3/4" condition of NWS-9D Discharge as 2 bar (128 to 130) and pressure was dropped again as 9 bar from 4 3/4" to 3" side valve condition (130 to 121bar).
- According to table 6, behavior of NWS-8D as monitoring well was shown that the temperature was decreased from 199 to 193 degrees centigrade from first condition (baseline) to F.D condition and the temperature was decreased as 6 deg C when the valve of NWS-9D was switched from 4 3/4 to 3" (197 to 191 degrees centigrade).
- According to table 7, behavior of NWS-4D as monitoring well was shown that the water level was raised up and the temperature of bottom hole was decreased when valve of NWS-9 D Was full open,
- According to table 7, behavior of NWS-4D as monitoring well was shown that the water level was going down and the temperature of bottom hole was increased when valve of NWS-9 D Was 4 ¾".
- According to table 7, behavior of NWS-4D as monitoring well was shown that the water level was raised up and the temperature of bottom hole was increased when valve of NWS-9D Was 3".
- According to table 7, behavior of NWS-4D as monitoring well was shown that the water level going down and the temperature of bottom hole was increased when valve of NWS-9D Was 2 3/4".
- According to table 8, behavior of NWS-1D as monitoring well was shown that the water level was raised up and the temperature of bottom hole was increased when valve of NWS-9 D Was full open,
- According to table 8, behavior of NWS-11RD as monitoring well was shown that the water level was the same and also the temperature of bottom hole was the same when valve of NWS-9 D Was 4 ¾".

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