Central Petroleum
EP-93-004-1 Well
Purni Formation
Perdika Basin
December 2009
Water Injection-Falloff Test Analysis Summary

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Summary

Weatherford Laboratories (WFT Labs) conducted one water injection-falloff test between December 24th, 2009 and December 25th, 2009, of Purni Formation penetrated by Central Petroleum's EP-93-004-1 well. Table 1 summarizes the pressure and temperature conditions of tested interval. Table 2 summarizes the test analysis results.

This well is a core hole that was not produced before testing and the coal natural fracture (cleat) systems were water filled during each test. Therefore, estimates of permeability to water were equivalent to the absolute permeability.

Table 1. EP-93-004-1 Pressure and Temperature Conditions

Test Interval	Coal Top Depth	Coal Bottom Depth	Static Pressure	Pressure Depth	Pressure Gradient*	Temperature	Temperature Gradient**
	m	m	kPaa	m	kPa/m	°C	°C/m
Purni Formation	759.6	772.1	7,247	758.5	9.421	66.8	0.055

* Pressure gradient computed with a surface pressure of 101.325 kPaa.
** Temperature gradient computed with a mean annual surface temperature of 25 °C.

Table 2. EP-93-004-1 Reservoir Property Summary

Test Interval	Coal Thickness	Effective Conductivity to Water	Effective Permeability to Water	Skin Factor	Radius of Investigation
	m	md-m	md	-	m
Purni Formation	13.5	10.53	0.78	0.46	38.3

The test was evaluated with a single porosity model with infinite boundary condition. The permeability estimate of 0.78 md was moderate. The estimated skin factor of 0.46 suggests that a slightly damaged near-well area with lower permeability than the reservoir. The static pressure estimate indicated that the tested interval was slightly under pressured relative to the hydrostatic head of water to surface.

The estimated radius of investigation during the test was 38.3 m due to the extended falloff test.

The remainder of this report discusses the test data and the analysis thereof.

Test Analysis Details

The water injection-falloff test was performed between December 24th, 2009 and December 25th, 2009. The test interval was Purni Formation at depths between 759.6 and 772.1 m. The upper and lower packer were placed at depths of 757.9 and 772.1 m, respectively. This section discusses the analysis of the data collected during this test.

Figure 1 illustrates pressure and temperature measured by a transducer at a depth of 758.5 m. The test consisted of an 8.5-hour injection period at an average rate of 2.28 liters per minute that started approximately 7 hours after the transducers were initialized followed by a 16-hour falloff period with no injection.

Figure 1. Pressure and Temperature Data

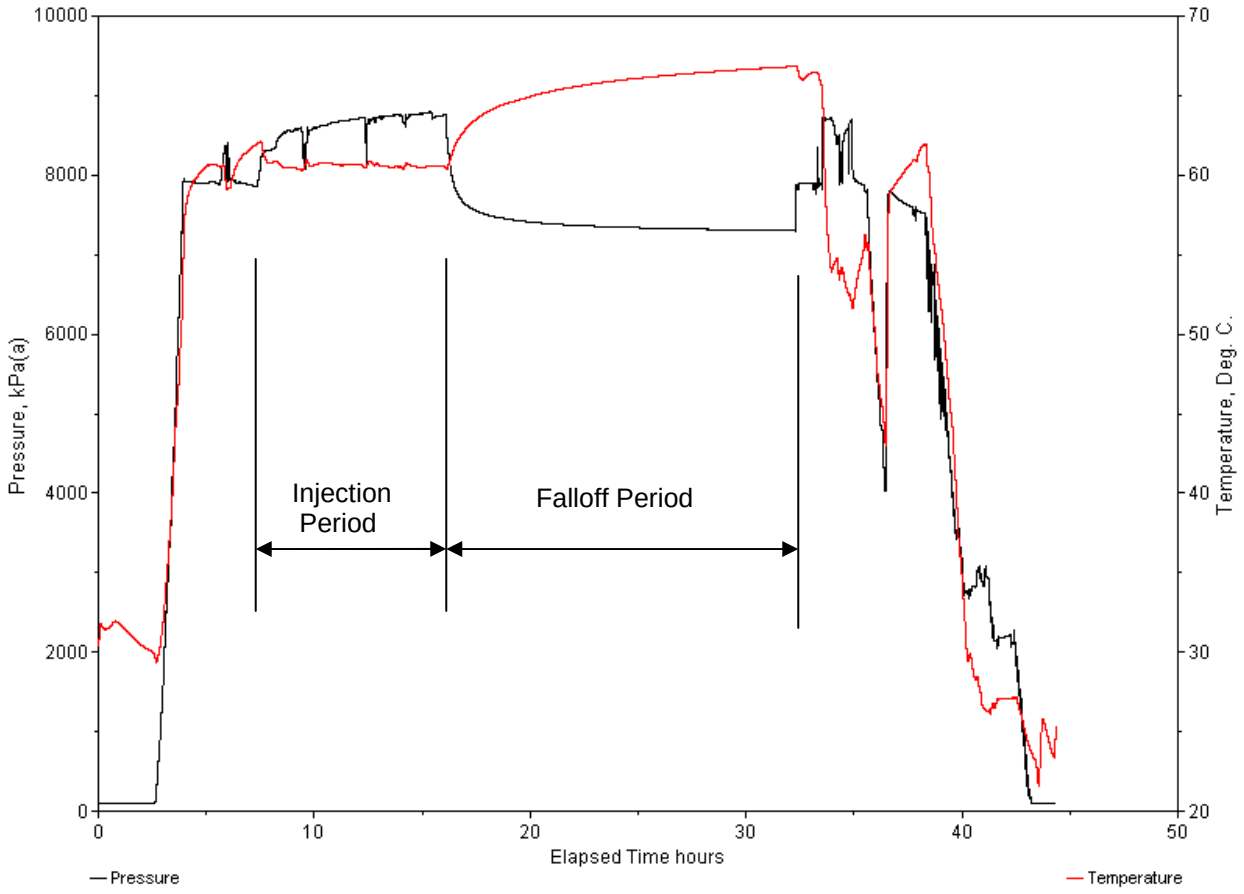


Figure 3 illustrates the surface water injection rate data. The injection rate data were simplified to the test history summarized in Table 3 for analysis.

Figure 2. Surface Water Injection Rate Data

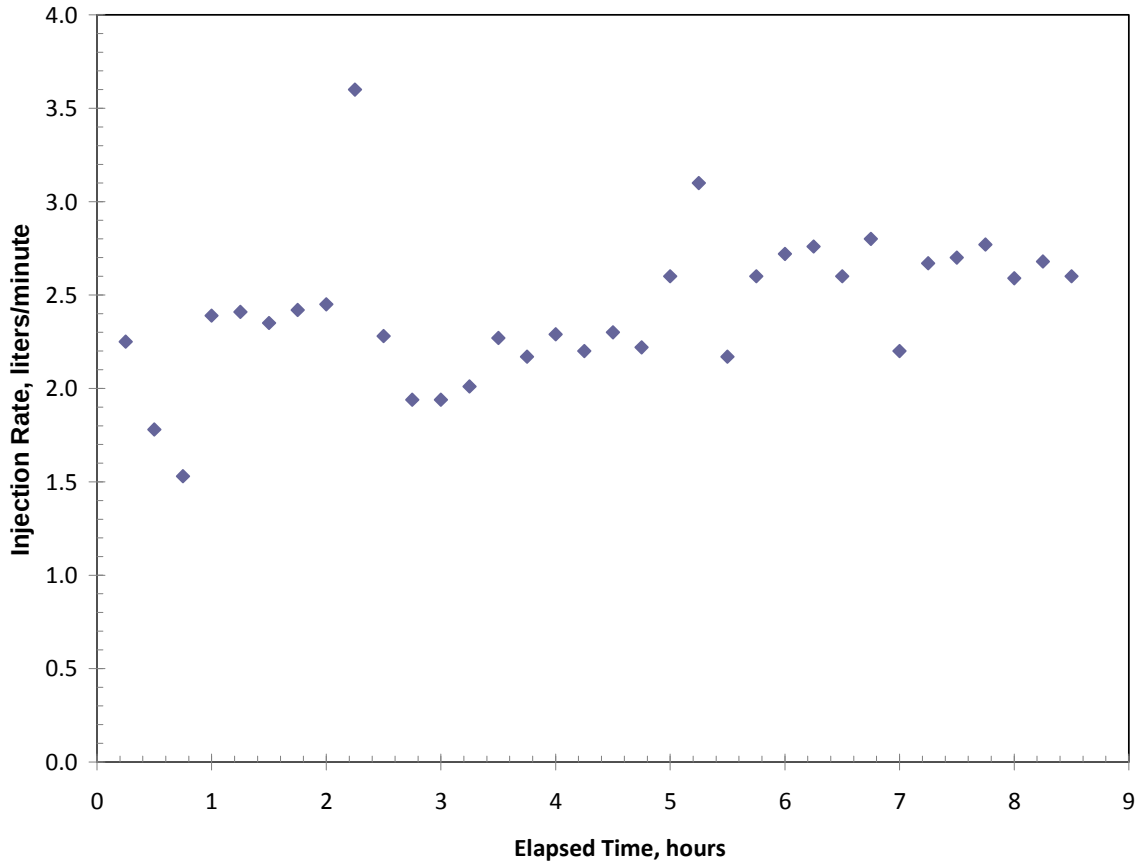


Table 3. Injection-Falloff Test Times

Test Period	Elapsed Time at Period Start	Elapsed Time at Period End	Surface Water Injection Rate	Pressure at Period Start	Pressure at Period End
	hours	hours	liters/min	kPaa	kPaa
Injection	0.000	8.783	2.28	7,858.8	8,761.9
Falloff	8.783	24.972	0.00	8,761.9	7,298.5

Table 4 summarizes the test analysis parameters. The coal thickness was determined by visual observation during drilling and coring. The values for Young's Modulus, Poisson's Ratio, and the natural fracture porosity were typical values for coal and were used to compute the pore volume compressibility. These values affect the radius of investigation and skin factor estimates but do not affect the conductivity or permeability estimates. Water properties were estimated from correlations[1] for fresh water at the reservoir temperature.

Figure 3 illustrates a diagnostic graph of the falloff period data. A diagnostic graph presents the log of the pressure change and the log of the derivative of the pressure change versus the log of the elapsed time during the period.

Table 4. Analysis Parameter

Parameter	Units	Value
Geometry		
Top Depth	m	759.6
Bottom Depth	m	772.1
Coal Thickness	m	13.5
Wellbore Radius	m	0.089
Coal Matrix Properties		
Temperature	°C	66.8
Young's Modulus	kPaa	$3.65(10^6)$
Poisson's Ratio	-	0.25
Natural Fracture Properties		
Porosity	vol. fraction	0.001
Total Compressibility	kPa^{-1}	$2.3\ (10^{-4})$
Water Properties		
Viscosity	cp	0.425
Formation Volume Factor	res. vol./surface vol.	1.018

The data were evaluated with a wellbore storage and skin reservoir model[2]. Table 5 summarizes the analysis results that resulted from matching the infinite model to the observed test behavior. The model matched the falloff period well as illustrated in Figure 3 and Figure 4, which is a semilog graph of the falloff period data. Figure 5 illustrates the match with the entire test history. The computed behavior generally matched the measured data throughout the test.

Table 5. Test Analysis Results

Property	Unit	Value
Model	-	variable permeability composite model with wellbore storage and skin effects
Static Pressure	kPaa	7,247
Temperature	°C	66.8
Pressure and Temperature Depth	m	758.5
Pressure Gradient to Surface	kPa/m	9.421
Temperature Gradient to Surface	°C/m	0.055
Effective Conductivity to Water	md-m	10.53
Effective Permeability to Water	md	0.78
Dimensionless Wellbore Storage Coefficient	-	160
Skin Factor	-	0.46
Flow Efficiency	%	92.8
Radius of Investigation	m	38.3

Figure 3. **Falloff Period Diagnostic Graph**

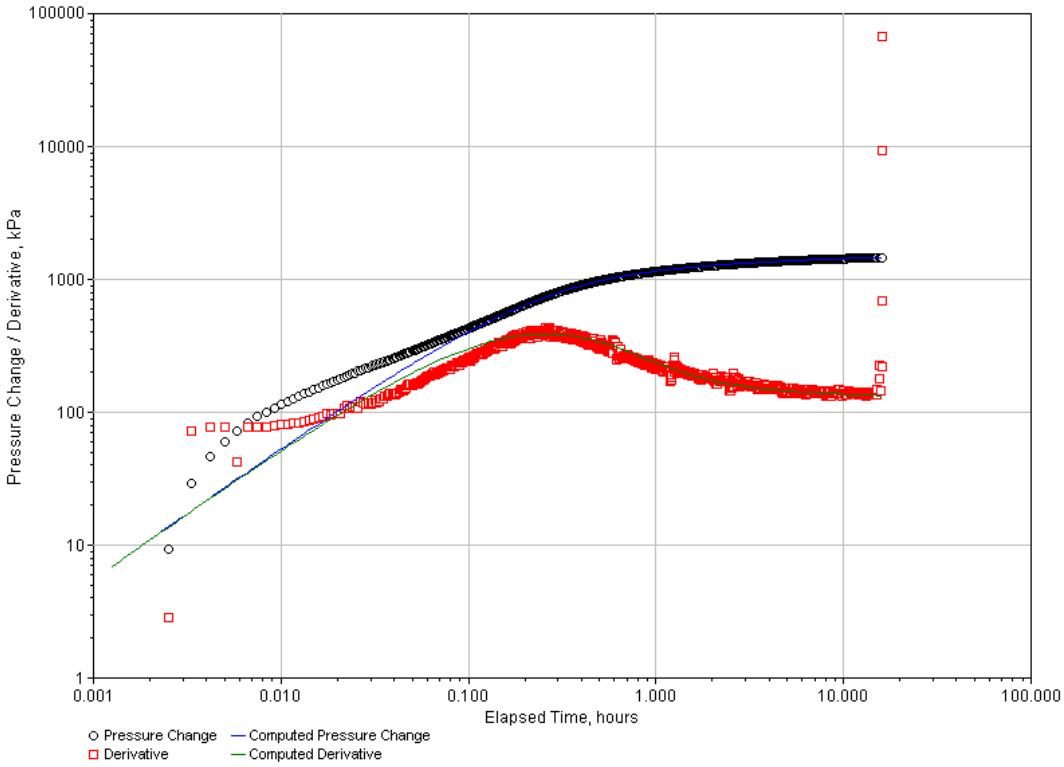


Figure 4. **Falloff Period Semilog Graph**

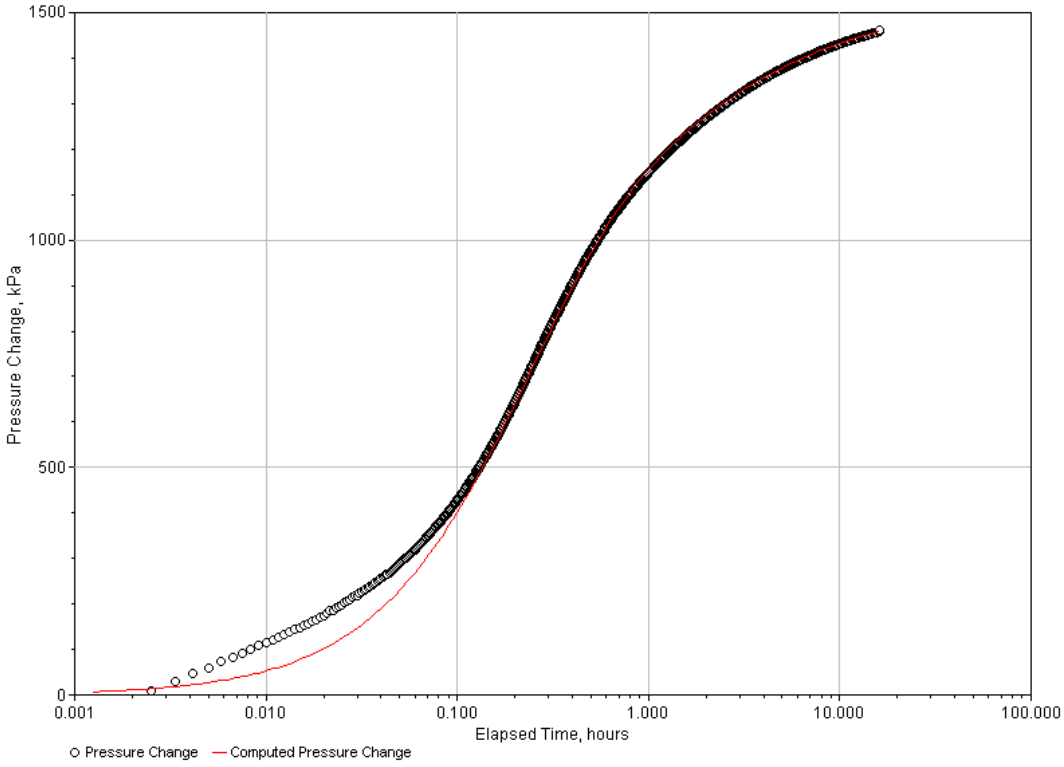
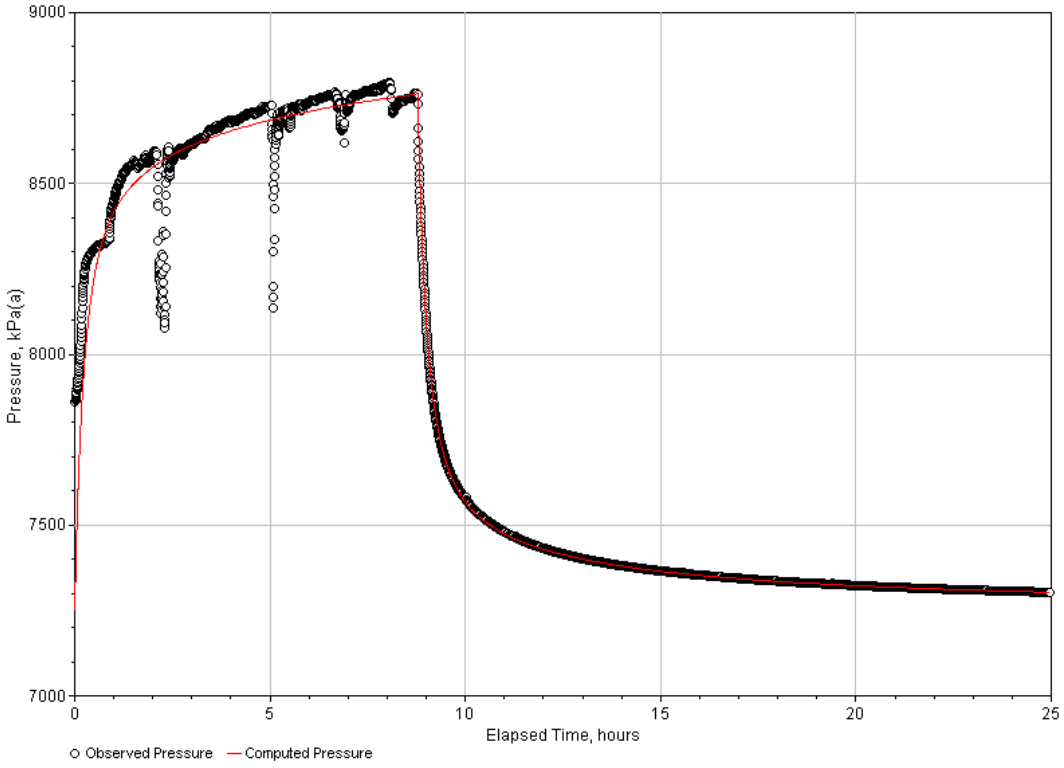


Figure 5. **History Match**



References

1. Whitson, C.H., and Brule, M.R.: *Phase Behavior*, Monograph Volume 20, Henry L. Doherty Series, Society of Petroleum Engineers, Richardson, Texas (2000).

2. Agarwal, R.G., Al-Hussainy, R., and Ramey, H.J., Jr.: "An Investigation of Wellbore Storage and Skin Effect in Transient Liquid Flow – I. Analytical Treatment," *Society of Petroleum Engineers Journal* (September, 1970) pp. 279-290.