UIC - I - 5

EPA FALL-OFF TEST PLAN

Chavez, Carl J, EMNRD

From: VonGonten, Glenn, EMNRD
Sent: Wednesday, June 15, 2011 8:35 AM
To: Chavez, Carl J, EMNRD; Sanchez, Daniel J., EMNRD
Subject: FW: New Mexico UIC Class I (non-hazardous) Well MIT & Annual Fall-Off Test Scheduling with Completion by September 30, 2011

Carl,

FYI,

Do not respond. Jami will handle. Daniel spoke with EPA who told us that it was mandatory.

Glenn

From: wayne price [mailto:wayneprice77@earthlink.net]
Sent: Tuesday, June 14, 2011 4:22 PM
To: Jami Bailey; VonGonten, Glenn, EMNRD
Cc: Dan Gibson; lmolleur@keyenergy.com
Subject: Fwd: New Mexico UIC Class I (non-hazardous) Well MIT & Annual Fall-Off Test Scheduling with Completion by September 30, 2011

Dear Director Bailey,

Key Energy respectfully request that we may waive this very expensive test as has been discussed. Please advise.

Begin forwarded message:

From: "Gibson, Dan" <dgibson@keyenergy.com>
Date: June 14, 2011 4:11:00 PM MDT
To: wayne price <wayneprice77@earthlink.net>, "Molleur, Loren" <lmolleur@keyenergy.com>, "Luckianow, Brian" <bluckianow@keyenergy.com>
Subject: FW: New Mexico UIC Class I (non-hazardous) Well MIT & Annual Fall-Off Test Scheduling with Completion by September 30, 2011

See below..from our good friend, Carl...

Daniel K. Gibson, P.G. | **Key Energy Services, Inc.** | Corporate Environmental Director
6 Desta Drive, Suite 4300, Midland, TX 79705| **o:** 432.571.7536 | **c:** 432.638-6134 | **e: dgibson@keyenergy.com**

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Tuesday, June 14, 2011 11:53 AM
To: Patterson, Bob; Gibson, Dan; Moore, Darrell; Lackey, Johnny; Schmaltz, Randy
Cc: Dade, Randy, EMNRD; Perrin, Charlie, EMNRD; VonGonten, Glenn, EMNRD
Subject: New Mexico UIC Class I (non-hazardous) Well MIT & Annual Fall-Off Test Scheduling with Completion by September 30, 2011

Gentlemen:

Re:

Key Energy Services: UICI-005
Navajo Refining Company: UICI-008; UICI-008-0 & UICI-008-1
Western Refining Southwest, Inc.: UICI-009

Good morning. It is that time of year again to remind operators that their annual MITs and Fall-Off Tests (FOT) for this season must be completed by 9/30/2011. The list of operator names w/ associated UIC Class I (non-hazardous) Wells are provided above.

Operators are aware of the MIT (30 min @ 300 psig or more w/ Bradenhead) requirement(s) that are typically run concurrently (usually before the FOT) with the FOT and more frequent where required.

The FOTs span several days with a couple of important notes to operators from past testing, please install your bottom hole gauge(s) with recorder(s) at least 48-hours in advance of the pump shut-off during the steady-state injection period. Also, you are accountable for your OCD approved FOT Test Plan and the requirements in the UIC Test Guidance at http://www.emnrd.state.nm.us/ocd/documents/UICGuidance.pdf.

You may access your well information on OCD Online either by API# and/or Permit Number at http://ocdimage.emnrd.state.nm.us/imaging/AEOrderCriteria.aspx andhttp://www.emnrd.state.nm.us/OCD/OCDPermitting/Data/Wells.aspx. For information on New Mexico's UIC Program and training information, please go to:http://www.emnrd.state.nm.us/ocd/Publications.htm.

Please contact me at (505) 476-3490 on or before June 30, 2011 to schedule your preferred MIT and FOT date and time. I will work to finalize the witness schedule with each of you. Thank you in advance for your cooperation.

File: Class I (non-hazardous) Well Files UICI- 5, 8, 8-0, 8-1 & 9

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
"Why not Prevent Pollution; Minimize Waste; Reduce the Cost of Operations; & Move Forward with the Rest of the Nation?" To see how, go to "Pollution Prevention & Waste Minimization" at:http://www.emnrd.state.nm.us/ocd/environmental.htm#environmental)

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Tuesday, June 14, 2011 10:53 AM
To: 'Patterson, Bob'; 'Dan Gibson'; 'Moore, Darrell'; 'Lackey, Johnny'; 'Schmaltz, Randy'
Cc: Dade, Randy, EMNRD; Perrin, Charlie, EMNRD; VonGonten, Glenn, EMNRD
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http://www.emnrd.state.nm.us/ocd/environmental.htm#environmental)

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, July 03, 2008 8:36 AM
To: 'EverQuest@nts-online.net'
Cc: Mark Philliber; Price, Wayne, EMNRD; Jones, William V., EMNRD; Perrin, Charlie, EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: Sunco Fall-Off Test Plan & OCD Approval
Attachments: Pre-FOT - Proposed Test Procedure dtd 6-23-2008.doc; Sunco FOT Test Plan 6-2008 - Attachments.pdf

Mr. Duffey:

The Fall-Off Test Plan is hereby approved. Please confirm your schedule below with exact date and time for installing pressure gauges, etc. in preparation of the test. The OCD may be present to witness the work.

Proposed Test Schedule

Date	Event	Remarks
Thursday, July 10, 2008	Check TD	Ensure perforations are open
Friday, July 11, 2008	Injection pre-conditioning	Begin 4000 Bpd constant injection period
Tuesday, July 15, 2008	Begin FOT	RU Tefteller, run pressure bombs to mid-perfs, Shut-in
Friday, July 18, 2008	End FOT	

Thank you.

Please be advised that NMOCD approval of this Fall-Off Test Plan does not relieve Key Energy Services, LLC of responsibility should their operations fail to meet NMOCD Fall-Off Test Guidelines. In addition, NMOCD approval does not relieve Key Energy Services, LLC of responsibility for compliance with any other federal, state, or local laws and/or regulations throughout the Fall-Off Test.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Terry M. Duffey [mailto:EverQuest@nts-online.net]
Sent: Friday, June 27, 2008 4:15 PM
To: Chavez, Carl J, EMNRD
Cc: Mark Philliber
Subject: Sunco FOT

The revised **Test Plan** is attached.
I followed the *Guidance Document* very closely this time around.
It should make it much easier for next year's submittal.
The cited attachments from the Test Plan are also attached.
Have a great weekend.
Wish we had had more time to visit at the Pit Rule seminar in Artesia. Too much data to have any free time left over.

Terry M. Duffey
EverQuest Energy Corporation – Dominating World Oil - One Well at a Time.
PO Box 10079
Midland, Texas 79702
432-686-9790
432-682-3821 Fax
EverQuest@nts-online.net

Chavez, Carl J, EMNRD

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Sent: Friday, June 27, 2008 4:15 PM
To: Chavez, Carl J, EMNRD
Cc: Mark Phillibe
Subject: Sunco FOT
Attachments: Sunco FOT Test Plan - Attachments.pdf; Pre-FOT - Proposed Test Procedure dtd 6-23-2008.doc

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Terry M. Duffey
EverQuest Energy Corporation – Dominating World Oil - One Well at a Time.
PO Box 10079
Midland, Texas 79702
432-686-9790
432-682-3821 Fax
EverQuest@nts-online.net

Key Energy Services, LLC
Sunco SWD – Class I Disposal Well
San Juan County, NM
Test Plan for a Pressure Fall-off Test (FOT)

Proposed Test Schedule

Date	Event	Remarks
Thursday, July 10, 2008	Check TD	Ensure perforations are open
Friday, July 11, 2008	Injection pre-conditioning	Begin 4000 Bpd constant injection period
Tuesday, July 15, 2008	Begin FOT	RU Tefteller, run pressure bombs to mid-perfs, Shut-in
Friday, July 18, 2008	End FOT	

All of the following references are relative to the NMOCD UIC Class I Well Fall-Off Test Guidance document dated 12/3/2007

Section V – General Test Operational Considerations

V.1 Operationally, a constant injection rate can be maintained during the injection-conditioning portion of the test.

V.2 The 4000 bpd injection rate is sufficient to produce a measurable bottomhole pressure buildup to give valid test data during the fall-off portion of the test. We expect this injection rate will allow for a pressure decrease of over 400 psi during the fall-off test period.

V.3 The normal and typical waste liquid accepted for disposal at this facility will be used during the injection portion of the test.

V.4 The total volume of waste liquid need for the test is calculated to be 16,000 bbls.

V.4.a 20,000 bbls of liquid will be available in storage, as a contingency, if operational conditions warrant additional fluid.

V.4.b Consideration will be given to a lower pre-test injection rate if conditions dictate. We believe the probability of the need to reduce the injection rate below 4000 bpd is very low.

V.5 The pressure gauges will be run into the well at the conclusion of the 4-day injection conditioning period. The bottomhole pressure will be allowed to stabilize for minimum of 2-hours after they are positioned at the top perf. A surface gauge will be monitored to ensure pressure stabilization prior to shut-in.

V.6 The storage volume is more than adequate to hold the incoming waste volume that will continue to be trucked into the facility during the 3-day fall-off test.

V.7 The closest well completed in the same Point Lookout disposal formation is over 1-mile to the north. That well (also disposal; but Class II) is operated by ConocoPhillips – McGrath #4. This well is actively disposing produced water from various ConocoPhillips leases in the Farmington area. This well was NOT shut-in during the fall-off and step-rate testing done during 2007. There was no evidence of any pressure interference from this active well during that testing. As a result, we see no reason to interfere in their operation at this time and recommend they be allowed to continue injection during our planned test.

V.8 A crown valve is already in-place on the wellhead. This will allow us to rig-up the wireline lubricator and run the pressure gauges into the well without interrupting injection.

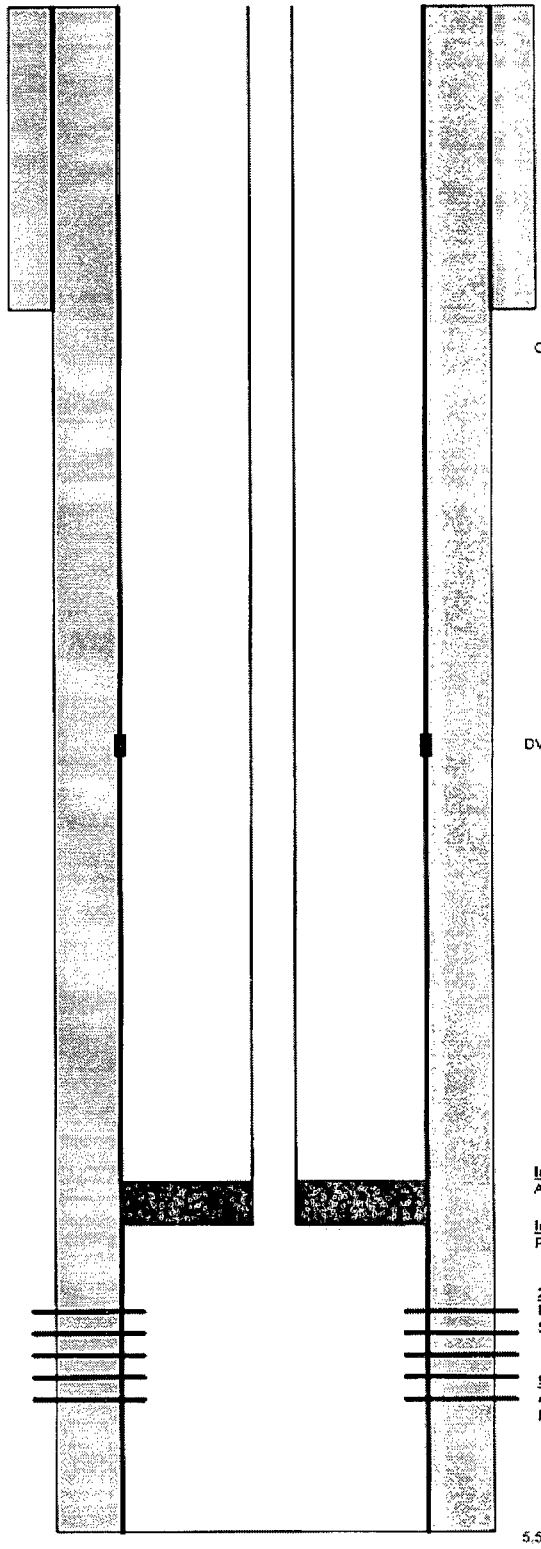
V.9 A shut-in valve is located on the injection line riser approximately 3-feet upstream of the wellhead. The valve can be quickly closed.

V.10 Prior to injection conditioning a gauge ring will be run into the tubing to ensure there are no tubing restrictions and entire perforated interval 4350-4460' is open to flow. Any fill over the perforations will be cleaned out before the FOT is run.
V.11 Due to cost considerations and our experience with recent pressure testing of this well, surface readout gauges will not be utilized for this testing. Tefteller, Inc. will run tandem electronic pressure gauges on slickline and leave them hanging on their wire during the duration of the test. The gauge range is 0-5000 psi. The maximum anticipated bottomhole pressure will be over 1000 psi below the upper limit of the gauges. The accuracy of the gauges satisfies the resolution level of 0.0002 percent, or 0.01 psi, of the full gauge range.
V.12 A test operations log will be maintained during the FOT. The key test events will be reflected on the final reports submitted to the OCD.
V.13 A circular recorder will be installed at the surface to monitor the shut-in tubing pressure throughout the test. Any aberrations will be factored into any decisions to abort the test.
V.14 The pressure gauges will be memory-type. The memory size would allow for a measurement frequency much higher than we actually need for this 3-day test. The gauges will be programmed to gather and store data every 15-seconds for the duration of the test. This frequency proved to be acceptable during the 2007 FOT.
V.15 The injection triplex pump typically used to pressurize the waste fluid for disposal at this facility will be used for the test. The pump is capable of maintaining a constant rate as it is a positive displacement type pump running at a constant RPM. We expect the pressure differential at the bottomhole to be more than 100 psig between the final injection and shut-in pressure.

Section VI - Background Information
VI.1. (refer to attached wellbore diagram)
VI.1.a 2.875" 6.5# J55 EUE 8Rd plastic coated
VI.1.b Arrow XL-W retrievable w/ seal bore set at 4282'
VI.1.c Tubing set at 4282', w/ Arrow T-2 on/off tool and two (2) F-type profile nipples. Tubing string was run in July 1994.
VI.1.d Surface casing: 8.625" 24# K55 at 209', Cmtd 150 sx-circ to surf
Production casing: 5.50" 15.5# K55 4760', Cmtd 745 sx w/ 2 stages of cement... DV tool at 2244', Stg1: 230 sx-circ to surf, Stg2: 515 sx-circ to surf
VI.1.e See VI.1.d above
VI.1.f Perforated Feb 1992 4350-4460' 2 spf, EHD unknown
VI.1.g TD 4760', PBTD 4706', no fill found across perforations during July 2007 testing
VI.1.h The bottom of the tandem gauges will be positioned at 4350'; at the top of the perforated interval.
VI.2 Copy of electric log encompassing disposal interval in the Point Lookout formation is attached.
VI.3 Copy of Density porosity log encompassing disposal interval is attached
VI.4.a-c Formation fluid is water only-not productive of oil or gas. Analytical data not available
VI.5.a Waste fluids that are approved for Class I and Class II disposal
VI.5.b-d See attached fluid analysis
VI.6 See attached Daily Injection Reports for April-May 2008
VI.7 Cumulative Injection:
Sunco 12.9 million bbls thru 4/08
McGrath 14.3 million bbls thru 2/08
VI.8.a Micro-Smart Systems, Model SP2000, Downhole gauges
VI.8.b 0-5000 psi range
VI.8.c gauges will have been calibrated within 6-months of test date, the date will be shown on the final pressure report

Key Energy Services, LLC
Sunco Disposal #1
Class I SWD
Current Configuration Jun'08

API# 30-045-28653
Sect 2, T29N, R12W
Drilled 1/92



12-1/4" Hole
8-5/8" 24# K55 csg at 209'
Cmt w/ 150 sx
Circ to surf w/ 100 sx thru 1" OD tbg

DV Tool at 2244'

Injection Packer:
Arrow XL-W retrievable seal bore at 4282'

Injection Tubing:
Plastic coated 2.875" 6.5# J55 EUE 8RD

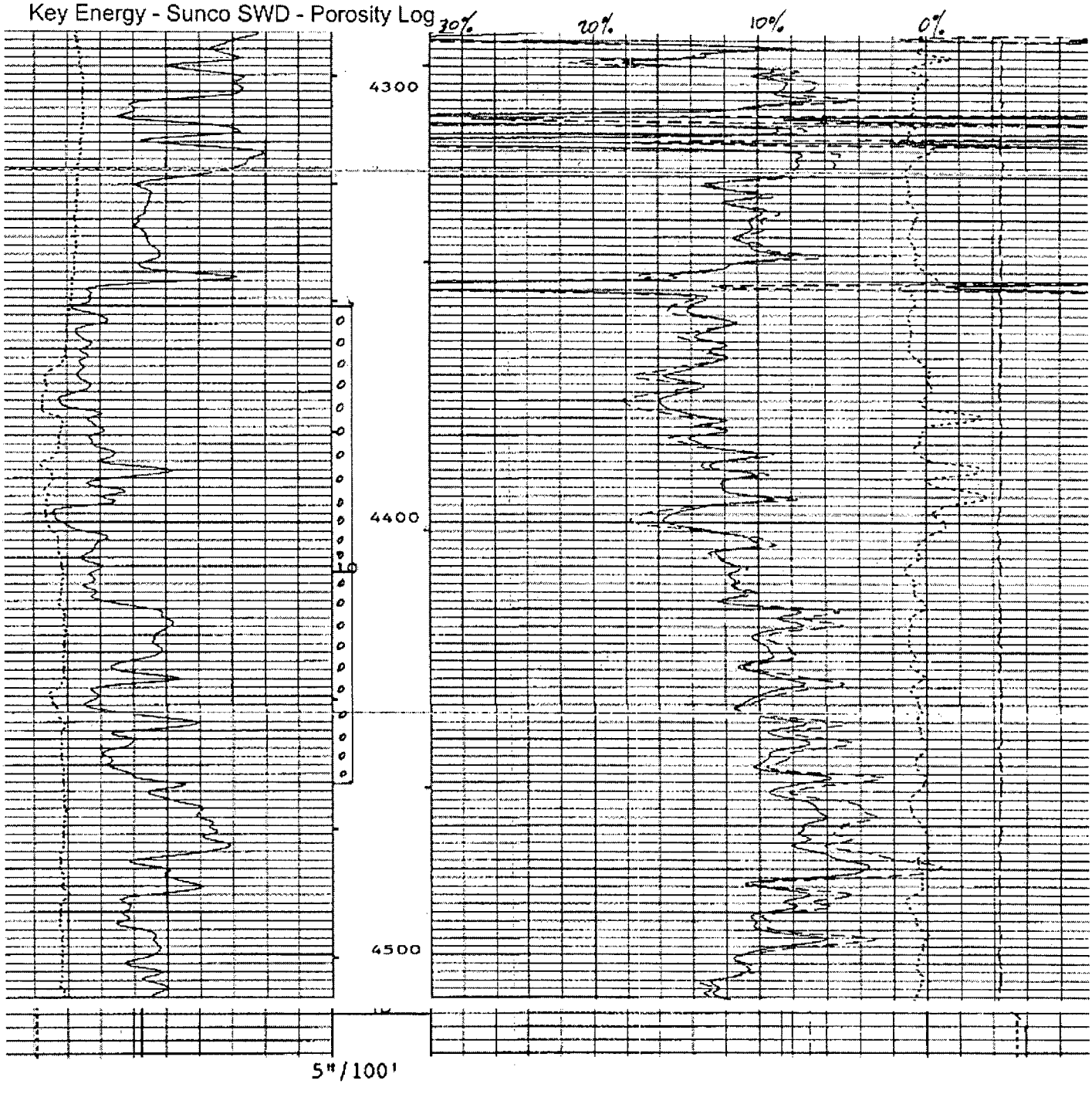
2/92:
Perfs: 4350-4460', 2 spf
SRT: BHFP 2707 psi (WHFP 1044 psi)

9/93:
Acdz w/ 2000 gal 15% HCl
Frac w/ 100,000# 20/40 sand

TD 4760'
PBTD 4706'

7-7/8" Hole
5.50" 15.5# K55 csg at 4760'
DV Tool at 2244'
Stage 1: 230 sx
Stage 2: 515 sx
Circ 25 sx to surf

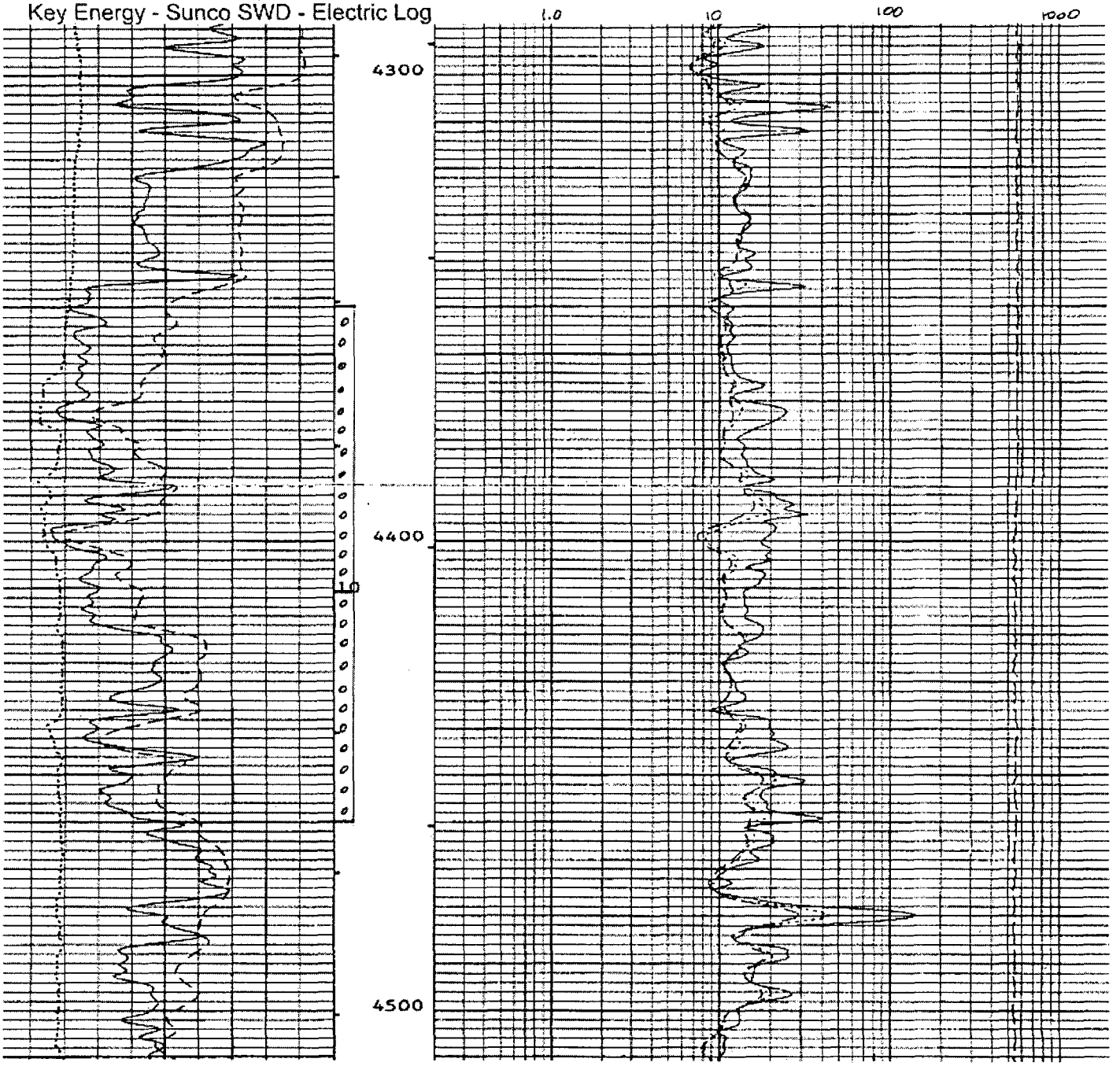
Key Energy - Sunco SWD - Porosity Log



CP 32.6 FILE 6 01-FEB-1992 20:21 (UP)

		DRHO(G/C3)	
		-.2500	.25000
		TENS(LBF)	
		10000.	0.0
CALI(IN.)		RHOB(G/C3)	
6.0000	16.000	2.0000	3.0000
GR(GAPI)		DPHI(V/V)	
0.0	200.00	.30000	-.1000

Key Energy - Sunco SWD - Electric Log



		TENS(LBF)	
		10000.	0.0
CALI(IN)		SFLU(OHMM)	
3.0000	16.000	.20000	2000.0
GR(GAPI)		ILD(OHMM)	
0.0	200.00	.20000	2000.0
SP(MV)		ILM(OHMM)	
80.00	20.000	.20000	2000.0

APRIL 08

220,318

DATE	BBLS/HR	BBLS/DAY	BBLS/MONTH	CUMULATIVE
01	80	1916	1916	222,234
02	81	1945	3861	224,179
03	68	1571	5432	225,750
04	81	1963	7395	227,713
05	80	1,928	9323	229,641
06	80	1,698	11,021	231,339
07	74	1,374	12,395	232,711
08	74	1,792	14,187	234,503
09	119	2,447	16,634	236,950
10	167	4018	20,652	240,968
11	123	3913	24,565	244,881
12	171	4121	28,686	249,002
13	~~158~~ 172	3795	32,481	252,797
14	173	3471	35,952	256,268
15	172	4125	40,077	260,393
16	172	4129	44,206	264,522
17	172	4119	48,325	268,641
18	172	4125	52,450	272,766
19	172	4,119	56,569	276,885
20	173	3,625	60,194	280,510
21	175	2,724	62,918	283,234
22	175	3938	66,856	287,172
23	172	4134	70,990	291,306
24	172	3960	74,950	295,266
25	172	4141	79,091	299,407
26	172	4,138	83,229	303,545
27	172 21	3,608	~~86,837~~	307,153
28	—	—	—	—
29	—	—	—	—
30	—	—	—	—
31				

86837

86835

MAY-08

307,153

DATE	BBLS/HR	BBLS/DAY	BBLS/MONTH	CUMULATIVE
01	—	—	—	307,153
02	—	—	—	
03	—	—	—	307,153
04	—	—	—	307,153
05	—	—	—	307,153
06	—	—	—	307,153
07	65	973	973	308,126
08	63	946	1919	309,072
09	57	854	2773	309,926
10	54	815	3588	310,741
11	56	838	4,426	311,579
12	54	814	5,240	312,393
13	55	834	6,074	313,227
14	61	655	6,629	313,782
15	52	774	7,403	314,556
16	57	850	8,253	35,406
17	55	818	9,071	316,224
18	53	851	9,922	317,075
19	52	825	10,747	317,900
20	54	703	11,450	318,603
21	51	823	12,273	319,426
22	48	722	12,995	320,148
23	48	774	13,769	320,922
24	50	796	14,565	321,718
25	—	—	—	4
26	—	—	—	321,718
27	46	738	15,394	322,456
28	53	849	16,243	323,305
29	51	815	17,058	324,120
30	—	—	—	324,120
31	—	—	—	324,120
		16,967		16,967

ANALYSIS NO. S1-76-9

FIELD RECEIPT NO. ____

API FORM 45-1

API WATER ANALYSIS REPORT FORM

Company: Coleman Oil & Gas			Sample No.: 2	Date Sampled: 02-25-92
Field:	Legal Description: Sec 2 T29N R9W		County or Parish: San Juan	State: NM
Lease or Unit: Sunco Disposal	Well: #1	Depth: 4	Formation: M.V. (Pt. Lookout)	Water, B/D:
Type of Water (Produced, Supply, etc.): Produced	Sampling Point: Pit			Sampled By:

DISSOLVED SOLIDS

CATIONS	mg/l	me/l
Sodium, Na (calc.)	7451	323.94
Calcium, Ca	168	8.40
Magnesium, Mg	39	3.20
Barium, Ba	—	—
Potassium, K	720	18.41

ANIONS		
Chloride, Cl	11879	335.10
Sulfate, SO_4	185	3.85
Carbonate, CO_x	0	0
Bicarbonate, HCO_x	915	15.00
Hydroxide, OH	0	0

Total Dissolved Solids (calc.) 21357

Iron, Fe (total) 25 ppm

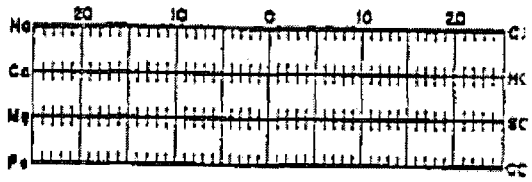
Sulfide, as H_2S Neg

OTHER PROPERTIES

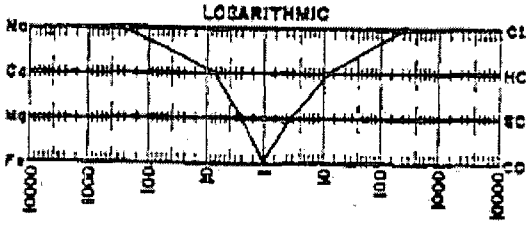
pH	7.01
Specific Gravity, 60/60 F.	1.013
Resistivity (ohm-meters) 78 F.	.35
Total Hardness	580

WATER PATTERNS — me/l

STANDARD



LOGARITHMIC



REMARKS & RECOMMENDATIONS:

ANALYST: Lee

PLEASE REFER ANY QUESTIONS TO:

THE WESTERN CO. OF NORTH AMERICA
FARMINGTON, N.M.
BRIAN AULT-District Engineer
1(505) 327-6222

New Mexico Oil Conservation Division
UIC Class I Well Fall-Off Test Guidance

(December 3, 2007)

New Mexico Oil Conservation Division
UIC Class I Well Fall-Off Test Guidance

Why does a fall-off test need to be performed?

Fall-off testing is a pressure transient test conducted on injection well formations to assess individual well conditions. The test provides the state regulatory agency with the necessary information to assess the validity of requested or existing injection well permit conditions and satisfy the permitting objective of protecting underground sources of drinking water (USDW). The test may also provide information about reservoir and completion characteristics such as transmissibility, skin factor, bottomhole injection pressure, reservoir static pressure, and geologic boundaries.

In addition to the state UIC regulatory requirements, Federal UIC regulations in 40 CFR Part 146 have monitoring requirements applying to both Class I hazardous and nonhazardous injection wells that include annual fall-off testing. Specifically, Part 146 regulations state "the Director shall require monitoring of the pressure buildup in the injection zone annually, including at a minimum, a shutdown of the well for a time sufficient to conduct a valid observation of the pressure fall-off curve" (§146.13 (Non-hazardous)/§146.68 (Hazardous)). In the case of Class II wells, the regulations may not directly require that a fall-off test be conducted, but under 40 CFR 146.8(f), EPA or the state agency delegated UIC Class II program primacy can require additional testing such as a fall-off test on individual injection wells to ensure protection of USDWs.

Essentials of Fall-off Testing

A fall-off test is a pressure transient test involving shutting in an injection well and measuring the wellbore pressure decline versus time after radial flow conditions are achieved and well established in the preceding injection period. It is analyzed using the same pressure transient techniques for oil and gas well pressure buildup and drawdown tests. The fall-off period is a replay of the preceding injection period, but is typically less noisy since no injection occurs while the well's pressure change is measured, similar to the pressure buildup period in a production well.

Fall-off test data analysis can provide valuable information about both the condition of the wellbore itself and the nature of the reservoir the well injects into. For example, the skin factor parameter obtained from a fall-off test analysis can indicate whether completion damage exists and provide justification for a well stimulation or remedial treatment. The signature of the derivative may also provide insight into the well's completion, for example a negative half slope indicating spherical flow may be caused from wellbore fill or the well's completion. A properly designed fall-off may also provide information about natural fractures or geologic boundaries in the reservoir. The test analysis provides a determination of reservoir transmissibility which can be utilized to predict the relationship between reservoir pressure and injection rate, critical to designing appropriate UIC permit conditions. Recommended published technical references on fall-off testing methodology include Society of Petroleum Engineers (SPE) Monographs Volumes 1 and 5 as well as SPE Textbook Series Volumes 1 and 9.

For more detailed information about the basis, recommended calculations, and procedures for fall-off tests, the reader is referred to the US EPA internet URLs provided below:

USEPA Fall-Off Test Course
http://www.epa.gov/safewater/dwa/electronic/presentations/uic/2003nutsbolts-notebook.pdf

EPA Region 6 Fall-off Guidelines
http://www.epa.gov/region6/water/swp/uic/guideline.pdf

OCD UIC FALL-OFF TEST GUIDANCE

SECTION I. Purpose

The purpose of a fall-off test is to identify injection interval or wellbore problems and injection interval characteristics. The permittee is responsible for developing a testing procedure which will generate adequate data for a meaningful analysis.

SECTION II. Regulatory Citation

Pursuant to all applicable parts of the Water Quality Control Commission (WQCC) Regulations 20.6.2 NMAC and more specifically 20.6.2.3104 - 20.6.2.3999 discharge permit, and 20.6.2.5000-.5299 Underground Injection Control, the Oil Conservation Division (OCD), the OCD UIC Permit requires monitoring of the pressure buildup in the injection zone at least annually, including at a minimum, shut down of the well for a time sufficient to conduct a valid observation of the pressure fall-off. This test is known as the formation pressure fall-off test.

SECTION III. Developing a Test Plan

A plan for conducting the test shall be submitted to OCD for review and approval prior to conducting the test. Plan approval shall be obtained from OCD prior to commencing the test. The plan shall include a proposed schedule. The test plan must address all items listed in the Sections V through IX of this document.

SECTION IV. Scheduling of Test and Report

The schedule for the test must be mutually agreed upon between OCD and the permittee so that OCD has the opportunity to witness the test. The operator should submit a summary report to OCD within 30 days of test completion.

SECTION V. General Test Operational Considerations

A successful fall-off test involves consideration of numerous factors of which most are under the control of the permittee. These include but are not limited to the following:

1. Confirmation a constant injection rate can be maintained into the test well during the injectivity portion of the test.
2. The injection rate is sufficient to produce a measurable pressure buildup that will result in valid test data.
3. Consideration for using the normal waste liquid during the injectivity portion of the test unless the waste will be corrosive to the downhole pressure gauge.
4. Calculating the total volume of injection fluid needed for the injectivity portion of the test.

a. Arrange for additional fluids and storage of such fluid
b. Reduce the injection rate to reduce the total fluid requirement

5. Sustaining a constant injection rate after installing the pressure gauges to allow stabilization of the gauges prior to initiating the fall-off test. A three day period is recommended, but adjustments may be made because rates have previously been stabilized or historical test results indicate a lesser time is adequate.
6. Ensuring adequate waste storage is available for the duration of the fall-off test.
7. Shutting in offset wells completed in the same formation as the test well prior to the test. If impractical, then maintaining stable measured injection rates into the offset injection wells prior to and during the fall-off test.
8. Installing a crown valve on the well prior to starting the injectivity portion of the test so the well does not have to be shut-in to install the pressure gauges. Running both memory gauges in the hole through a lubricator installed into the crown valve for safety.
9. Locating the shut-in valve ceasing flow to the well at or near the wellhead to minimize the wellbore storage in the well. Shut-in must be accomplished as instantaneously as possible to prevent erratic pressure behavior during the shut-in caused by the rate fluctuations.
10. Evaluating the condition of the well, including wellbore fill, junk in the hole or wellbore damage, which may increase the length of shut-in time needed for the well to obtain a valid fall-off test and therefore also necessitate a longer injectivity period.
11. Using a surface readout downhole pressure gauge. Utilizing tandem downhole memory electronic pressure gauges, one of which is surface readout capable, with a pressure resolution level of 0.0002% of the gauge's full pressure range. Gauge pressure range should exceed the maximum pressure expected during the testing with the larger the percentage of the gauge pressure range utilized, the better.
12. Maintaining a test operations log throughout the fall-off test and submitting the log as part of the test report. The log should list all key test events, dates, and times. For example, the time the gauges were activated, run in the well and placed on bottom as well their setting depths. Synchronization of times and events is especially important in tests involving multiple wells.
13. If available, monitoring test progress with appropriate plots at the wellsite to insure valid test data is obtained and problematic tests can be identified and aborted.
14. Configuring the test gauges to obtain pressure data more frequently in the early portion of the test when the rate of pressure decline is greater if the memory capacity of the gauge is limited. Memory capacity of the gauge should allow for a 10-day total recording time interval unless a shorter test time is sufficient based on prior testing or appropriate test design calculations. Larger time increments may be used to obtain data later in the test when the rate of pressure decline is less. The recording frequency of the gauges and overall length of test should be set based on results of previous tests or test design calculations.
15. Using the injection facility pump if capable of maintaining a constant injection rate at the desired pre-fall-off test rate. If an alternate pump is needed, design the pump to operate as smoothly as possible at the desired constant rate. If feasible, design the test for a constant injection rate to cause a minimum of 100 psi differential pressure between the final injection and shut-in pressures.

SECTION VI. Background Information

Acquisition of the following information is recommended for the planning, design, and analysis of the fall-off test.

1. Current wellbore schematic
    a. Size and type of injection tubing (include type of internal coating, if applicable)
    b. Packer depth
    c. Tubing length including the depth of any seating or profile nipples, and the last date tubing was run
    d. Size, type, and depth of casings
    e. Cement tops with method of determining the top of cement
    f. Top and bottom perforation/completion depths including the size of perforation holes and date perforated
    g. Total depth, plug back depth, and the most recent depth to wellbore fill and date measured
    h. Location of the pressure measuring tool during the test
2. Copy of an electric log encompassing the completed interval
3. Copy of relevant portions of any porosity log used to estimate formation porosity
4. PVT data
    a. Estimation of formation fluid and reservoir rock compressibilities
    b. Formation fluid viscosity with reference temperature
    c. Formation fluid specific gravity/density with reference temperature
5. Injection fluids
    a. Description of fluids injected
    b. Injection fluid specific gravity/density with reference temperature
    c. Injection fluid compressibility
    d. Injection fluid viscosity with reference temperature
6. Daily rate history data for a minimum of one month preceding the fall-off test
7. Cumulative injection into the formation from test well and offset wells
8. Pressure gauges
    a. Description of the downhole surface pressure readout or memory gauge
    b. List the full range, accuracy and resolution of the gauges
    c. A calibration certificate showing date the gauges were last calibrated
9. One mile Area of Review (AOR)
    a. Identification of wells located within the one mile AOR
    b. Ascertaining the status of wells within the one mile AOR
    c. Providing details on any offset producers and injectors completed in the same injection interval
10. Geology
    a. Description of the geologic environment of the injection interval
    b. Discussion on the presence of pinchouts, channels, and faults, if applicable
    c. Providing a portion of a relevant structure map, if necessary

SECTION VII. Conducting the Fall-off Test

The following are recommended procedures for conducting the fall-off test. Alternative procedures that will produce valid test results and satisfy the requirements of OCD and the regulations will be considered by the OCD.

1. Install a digital surface recorder, connected to a rate meter and a digital surface transducer, capable of adequately measuring surface injection rates and wellhead injection pressures during the test.
2. Confirm the constant pre-fall-off test injection rate is maintained prior to the fall-off.
3. Confirm pressure gauges have stabilized prior to shutting in the well for the fall-off test.
4. Following installation of the bottom hole pressure gauges and surface recorders, regulate injection to the stabilized designated pre-fall-off test injection rate that will result in a sufficiently sized pressure increase (above shut-in pressure) on the wellhead. If the injection rate was stabilized prior to running the downhole gauges and the gauge installation did not disrupt the injection rate, monitoring the gauge for a minimum of one hour may be sufficient for verifying that the bottom hole pressure is stabilized prior to initiating the fall-off test.
5. The injection rate shall be high enough and continuous for a period of time sufficient to produce a pressure buildup that will result in valid test data. The injection rate shall result in a pressure buildup such that a semi-log straight line can be determined from the Horner plot or other appropriate semi-log plot. The injection rate shall be the maximum injection rate that can be feasibly maintained constant in order to maximize pressure changes in the formation and provide valid test results, but not exceeding the daily injection pressure and volume limit of the UIC Permit.
6. Confirm the liquid injection density is held relatively constant during the injectivity portion of the test by periodically measuring one or more of the following:
    a. Density
    b. Chloride concentration
    c. Total dissolved solids concentration
    d. Conductivity
    e. pH
7. The surface readout downhole pressure gauge must be located at or near the top of the injection interval unless previous testing indicates a more appropriate location.
8. ***If the stabilization injection period is interrupted, for any reason and for any length of time, the stabilization injection period must be restarted unless superposition analysis can be applied and valid test results obtained.***
9. The well must be shut-in at the wellhead or as near as feasible to the wellhead to minimize wellbore storage and after flow.
10. The well shut-in must be accomplished as instantaneously as possible to prevent erratic pressure behavior during the test.
11. Following shut-in at the well, shut-in relevant tubing valves to ensure complete shut-in of the well. Bottom-hole shut-in is preferred to surface shut-in, but not required. Shut-in the well with no disturbances for at least seven days or other approved time period as determined from previous tests results or the test design.
12. Upon completion of the test, tag fill depth with gauges, pull out bottom hole gauges making stops every 1000 feet for 5 minutes to obtain gradient data, rig down, and resume normal injection into the well as needed.
13. The fall-off portion of the test must be conducted for a length of time sufficient to reach radial flow, i.e., the pressure is no longer influenced by wellbore storage or skin effects and enough data points lie within the infinite acting period that the semi-log straight line

is well developed. A log-log with derivative plot should be prepared during the fall-off to verify that radial flow is occurring.

SECTION VIII. Evaluation of the Test Results

A licensed professional who is knowledgeable in the methods of pressure transient test analysis, must evaluate and summarize the test results. The following information and evaluations shall be provided in the test report:

1. A log-log plot with a derivative diagnostic plot shall be used to identify flow regimes.
2. The wellbore storage portion and infinite acting portion of the test shall be identified on the plot. Type curves shall be used to verify results.
3. A Horner plot or other appropriate semi-log plot must be used to calculate the kh/μ product and to determine P*. The wellbore storage and infinite acting portions of the test should be identified on the plot. An expanded semi-log plot containing the entire infinite acting portion must be reproduced to permit a closer inspection of the semi-log slope and any data fluctuations. The slope used to calculate the transmissibility (kh/μ) and to determine P* must be drawn on both semi-log plots.
4. The "h" value (injection interval thickness) used in the analysis must be agreed upon between OCD and the permittee. For formations with characteristics such as fracture-controlled karst reservoirs with porosity and permeability influenced by basement structural patterns and subaerial exposure, the entire thickness of the injection interval should be considered. A reliable literature value can be used if site specific data is not available.
5. The viscosity used in analyzing the test shall be that of the liquid through which the pressure transient was propagating during the infinite acting portion of the test. The information used to determine the viscosity shall be provided. Distance estimates to the waste front may also be needed.
6. Any test that was not shut-in long enough to develop an infinite acting period, or cannot be properly analyzed for transmissibility (kh/μ) from the semi-log plot, should be rerun using a procedure that will result in valid test results, unless other arrangements have been made with OCD.
7. All equations and assumptions used in the analysis shall be provided with the appropriate parameters substituted into the equations.
8. A plot of the temperature data shall be provided for review. Any temperature anomalies shall be noted to determine if they correspond to pressure anomalies since the temperature compensation mechanism of the pressure gauge may be influenced by temperature fluctuations.
9. Explain any anomalous pressure data responses. Investigate any potential physical causes for the anomaly in addition to potential reservoir response characteristics.

SECTION IX. Report Components

Include the following information in the report to the OCD in Santa Fe - Attention Environmental Bureau of the Division (see address under OCD contacts listed in the Contacts Section). The information in the report includes general information, an overview of the test, analysis of the test data, summary of the results and a comparison of the results with previous test results and UIC permit parameters. Submit the report to OCD within 30 days of test completion.

1. Facility information
    a. Name
    b. Location
    c. Operator's OGRD number
2. Well information:
    a. OCD UIC Permit number authorizing injection
    b. Well classification
    c. Well name and number
    d. API number
    e. Legal location
3. Current wellbore schematic as described in Section VI
4. Copy of an electric log encompassing the completed interval
5. Copy of relevant portions of any porosity log used to estimate formation porosity
6. PVT data of the formation and injection fluid as described in Section VI
7. Daily rate history data for a minimum of one month preceding the fall-off test
8. Cumulative injection into the formation from test well and offset wells
9. Pressure gauges
    a. Describe the type of downhole surface pressure readout gauge used including manufacturer and type
    b. List the full range, accuracy and resolution of the gauge
    c. Provide the manufacturer's recommended frequency of calibration and a calibration certificate showing date the gauge was last calibrated
10. One mile Area of Review (AOR)
    a. Identify wells located within the one mile AOR
    b. Ascertain the status of wells within the one-mile AOR
    c. Provide details on any offset producers and injectors completed in the same injection interval
11. Geology
    a. Describe geologic environment of the injection interval
    b. Discuss the presence of geologic features, i.e., pinchouts, channels, and faults, if applicable
    c. Provide a portion of a relevant structure map, if necessary
12. Offset wells
    a. Identify the distance between the test well and any offset wells completed in the same injection interval
    b. Report the status of the offset wells during both the injection and shut-in portions of the test
    c. Describe the impact, if any, the offset wells had on the test
13. Chronological listing of the daily testing activities (operations log)
    a. Date of the test
    b. Time of the injection period
    c. Type of injection fluid
    d. Final injection pressure and temperature prior to shutting in the well
    e. Total shut-in time
    f. Final static pressure and temperature at the end of the fall-off portion of the test

14. Describe the location of the shut-in valve used to cease flow to the well for the shut-in portion of the test.
15. Provide each of the following; including the equations used to calculate each, the equations with the appropriate parameters substituted in them, description of parameters used in calculations with references as to how the values were derived:
    a. Radius of test investigation
    b. Time to beginning of the infinite acting portion of the test
    c. Slope or slopes determined from the semi-log plot
    d. The value for transmissibility (kh/μ)
    e. Permeability (k)
    f. Skin factor (s)
    g. Pressure drop due to skin (ΔP_{skin})
    h. Flow efficiency ($(Pwf-\Delta P_{skin}-Pstatic)/(Pwf-Pstatic)$)
    i. Flow capacity (kh)
    j. P_{1hr} (extrapolated pressure at one hour)
16. Explain any pressure or temperature anomaly
17. Describe the test results
    a. Discuss if the test reached radial flow or if it was dominated by wellbore storage or another type of flow regime.
    b. Describe the reservoir results as homogeneous or heterogeneous explaining how this was determined.
18. Provide the following graphs:
    a. Cartesian plot of pressure and temperature versus time
    b. Cartesian plot of injection rate versus time
    c. Log-log and derivative plots with the flow regions identified
        i. Identify the wellbore storage period
        ii. Identify the radial flow period
        iii. Identify any other relevant flow regimes
    d. Semi-log plot and expanded semi-log plot (typically Horner plots)
        i. Identify the flow regions on each
        ii. Draw the semi-log straight line
        iii. Identify the P* (false extrapolated pressure)
        iv. Calculate P_{1hr} (extrapolated pressure at one hour)
    e. Plot of the digital surface rates and pressures from the surface pressure gauge
    f. Plot of digital pressures and times from the bottom hole gauges
    g. Complete injection rate history plot (injection rate and wellhead pressure vs. calendar time)
    h. Current Hall plot with explanation for any changes to the slope of this plot
19. Comparison of permeability (k), transmissibility (kh/μ), skin (s), false extrapolated pressure (P*), and depth to fill with the same values determined from fall-off tests previously conducted in the well.
20. A statement that the raw test data generated by the test will be kept on file by the permittee for a period of not less than 3 years and will be made available to OCD upon request during this time period. The raw test data need not be submitted to OCD unless requested.

SECTION X. Contacts

OCD Contacts:

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