Advanced Stripper Gas Produced Water Remediation

Quarterly Technical Report for the Period Ending 12/31/2000

Western SynCoal, LLC

Ray W. Sheldon, P.E.

September 2001

Grant DE-FG26-00NT40965

Western SynCoal, LLC
P.O. Box 7137
Billings, MT 59103-7137

TABLE OF CONTENTS

Disclaimer	1
Abstract	1
Executive Summary	2
Experimental	2
Results and Discussion	6
Conclusions	6
References	6

LIST OF TABLES AND FIGURES

Initial Column Test Notes & Results	3
Preliminary Column Test	4
Preliminary Laboratory Results	5
Project Photographs	7

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Abstract

Natural gas and oil production from stripper wells also produces water contaminated with hydrocarbons, and in most locations, salts and trace elements. The hydrocarbons are not generally present in concentrations that allow the operator to economically recover these liquids. Produced liquids, (stripper gas water) which are predominately water, present the operator with two options; purify the water to acceptable levels of contaminants, or pay for the disposal of the water.

The project scope involves testing SynCoal as a sorbent to reduce the levels of contamination in stripper gas well produced water to a level that the water can be put to a productive use. Produced water is to be filtered with SynCoal, a processed sub-bituminous coal. It is expected that the surface area of and in the SynCoal would sorb the hydrocarbons and other contaminants and the effluent would be usable for agricultural purposes.

Test plan anticipates using two well locations described as being disparate in the level and type of contaminants present. The loading capacity and the rate of loading for the sorbent should be quantified in field testing situations which include unregulated and widely varying liquid flow rates. This will require significant flexibility in the initial stages of the investigation.

The scope of work outlined below serves as the guidelines for the testing of SynCoal carbon product as a sorbent to remove hydrocarbons and other contaminants from the produced waters of natural gas wells. A maximum ratio of 1 lb carbon to 100 lbs water treated is the initial basis for economic design. While the levels of contaminants directly impact this ratio, the ultimate economics will be dictated by the filter servicing requirements. This experimental program is intended to identify those treatment parameters that yield the best technological practice for a given set of operating conditions. The goal of this research is to determine appropriate guidelines for field trials by accurately characterizing the performance of SynCoal over a full range of operating conditions.

Executive Summary

Work completed in this reporting period included construction of test columns and support facilities to conduct the preliminary scoping trials to process produced water with SynCoal. The construction, installation, column packing and acquisition of water to be treated required three weeks of effort. The actual test runs ran two consecutive days of constant flow at a rate of approximately three gallons per minute. Three gallons per minute is similar to the rate of water production from the majority of wells in the Denver-Julesberg (D-J) basin. A single SynCoal column with 104 lbs of media was employed for this preliminary test. The column pressure remained constant throughout the test period. Analysis indicated good hydrocarbon retention on the SynCoal averaging 90% or better removal from the produced water. Water clarity was observed to be greatly improved at the column discharge. Major ions and trace metals were largely unaffected by exposure to SynCoal.

Experimental

08/31/2000 through 12/31/2000

After a prototype “filter canister” was designed and fabricated from steel pipe, the project team decided to construct the test units from six inch PVC pipe and fittings and mount them on portable angle iron skid mounted stands to simplify construction, modification and installation. NARCo’s Wattenberg shop and lab buildings were cleaned out to provide work space near the production field. In October 2000, fabrication of a two stage filter unit constructed of

schedule 40 PVC pipe and related fittings was completed (see photographs). Initially, some difficulty was encountered in preventing the migration of coal particles from the canister but after trying several screen / packing materials the filter retained the coal without losing particles with the water flow. The filter unit is mounted in an angle iron frame which can be easily be modified to provide an insulated shed around the filter unit with an access door in front. With the filter unit housed in an insulated structure coupled with a small catalytic heater, this unit should prove to be functional in winter as well as summer.

The filter unit was installed into a single state separator at the Lone #11 production battery in an effort to evaluate the functionality of the unit under field conditions. While the unit was determined to be of the correct design for generic connection to a separator unit, the surge discharge pressure of the single stage unit at the Lone battery was greater than anticipated (+ 200 psig). In order to use the PVC filter unit on locations with pressures in excess of 50 psig, a surge tank is needed to control the impact force of the water discharged to the filter unit.

The filter unit was moved back to the Wattenberg location where it was installed with a surge feed tank, a pump to supply a steady flow to the filter and a “clean” water tank to characterize the filter. The initial testing was conducted on November 1 and 2, 2000 with water flowing through the filter for approximately 12 hours at a 3.0 to 3.5 gpm rate. Pre-treatment and post-treatment water samples were collected

and analyzed. It appeared from visual observation of the pre-treatment and post-treatment water samples that the filter unit is removing insoluble and colloidal particulates in the produced water being treated. The analyses indicated that the oil and grease content was reduced from an average of 36.8 mg/l to under 2.4 mg/l, approximately 93

percent reduction. Total suspended solids were reduced from 59 mg/l in the initial sample to under 20 mg/l on average. Copper and silver concentrations appeared to be reduced as well. Unfortunately, the sodium, calcium, magnesium and potassium concentrations did not appear to be affected.

Initial Column Test Notes & Results

Wattenburg Location

SynCoal Water Treatment Test Series 1

Nov. 1, 00

Sample Log

ID	Interval	Time	R Malmquist			Notes
			pH	Cond, ms/cm		
NA-001A	0.00	11:30	6.5	2.84		Flow adjusted to 3.3gpm, inlet = 11psi
NA-001B	0.00		6.5			Outlet = <3psi
NA-001C	0.00		6.5			
NA-002A	0.25	11:45	6.5	2.08		
NA-002B	0.25		6.5			
NA-002C	0.25		6.5			
NA-003A	0.50	12:00	6.5	2.30		Flow 3.3gpm
NA-003B	0.50		6.5			
NA-003C	0.50		6.5			
NA-004A	0.75	12:18	6.5	2.27		
NA-004B	0.75		6.5			
NA-004C	0.75		6.5			
NA-005A	1.00	12:32	6.5	2.26	Inlet = 12.5psi	Flow = 3.5gpm
NA-005B	1.00		6.5		Outlet = <3psi	
NA-005C	1.00		6.5			
NA-006A	1.50	13:00	6.5	2.27		
NA-006B	1.50		6.5			
NA-006C	1.50		6.5			
NA-007A	2.00	13:35	6.5	2.25		
NA-007B	2.00		6.5			
NA-007C	2.00		6.5			
NA-008A	2.50	14:00	6.5	2.30	Inlet = 15 psi	
NA-008B	2.50		6.5		Outlet = <3psi	
NA-008C	2.50		6.5			
NA-009A	3.00	14:30	6.5	2.30		
NA-009B	3.00		6.5		inlet = 16psi	
NA-009C	3.00		6.5		Flow = 2.1gpm	
NA-010A	3.50	15:00	6.5	2.39	SAMPLES:	
NA-010B	3.50		6.5			
NA-010C	3.50		6.5		A: Preserved w/5ml HCl for Oil & Grease,	
NA-011A	4.00	15:30	6.5	2.32	1 liter sample	
NA-011B	4.00		6.5		B: Preserved w/1ml HNO3, filtered through	

NA-011C	4.00		6.5		0.45 micron filter for trace metal		
NA-012A	4.50	16:00	6.5	2.39	analysis. 250ml sample		
NA-012B	4.50		6.5		C: Unpreserved sample for TSS, cation		
NA-012C	4.50		6.5		anion balance, pH, Cond. 500ml		
NA-013A	5.00	16:30	6.5	2.39			
NA-013B	5.00		6.5		Estimated gallons treated	=	925
NA-013C	5.00		6.5				
Wattensburg Location		SynCoal Water Treatment Test Series 1			Nov. 2, 00		
NA-014A	0.00	10:00	6.5	2.42	NA-014A,B,C IS INFEED SAMPLE		
NA-014B	0.00						
NA-014C	0.00				flow 3.0gpm		
NA-015A	1.00	11:00	6.5	2.35	inlet 17psi		
NA-015B	1.00						
NA-015C	1.00						
NA-016A	2.00	12:00	6.5	2.30	flow 3.3gpm		
NA-016B	2.00						
NA-016C	2.00						
NA-017A	3.00	13:02	6.5	2.33	inlet 17psi		
NA-017B	3.00						
NA-017C	3.00						
NA-018A	4.00	14:00	6.5	2.34			
NA-018B	4.00						
NA-018C	4.00				inlet 17psi		
NA-019A	5.00	15:00	6.5	2.36	flow 3.3gpm		
NA-019B	5.00						
NA-019C	5.00						
NA-020A	6.00	16:00			Gallons Treated	=	1152
NA-020B	6.00				Previous day		925
NA-020C	6.00				Total for single column to date =		2077

Preliminary Column Test

Preliminary Laboratory Results

Lab Results
Weld Laboratories, Inc.
Lab No: 4287

	Oil/Grease ppm	Ca	Na	Mg	K	SO ₄	Cl
NA-001 FEED	44.0	231	5480	38.6	38.0	<1.0	4550
NA-002	9.6	241	5380	30.0	36.0	<1.0	4550
NA-003	5.3	239	5460	28.8	42.0	<1.0	4640
NA-004	5.1	242	5610	112.6	40.8	<1.0	4290
NA-005	6.4	223	5360	38.6	41.8	<1.0	4730
NA-006	2.8	239	5570	29.0	47.8	<1.0	4640
NA-007	3.5	238	5540	43.7	49.3	<1.0	4550
NA-008	3.8	241	5330	31.1	45.3	<1.0	4550
NA-009	1.8	246	5570	41.0	47.3	<1.0	4460
NA-010	<0.1	238	5310	32.3	51.3	<1.0	4640
NA-011	1.1	243	5230	35.1	48.5	<1.0	4640
NA-012	0.7	250	5230	27.7	48.3	<1.0	4550
NA-013	<0.1	245	5000	27.9	46.0	<1.0	4550
NA-014 FEED	30.8	245	5040	25.8	48.5	<1.0	4460
NA-015	1.1	245	5040	47.3	44.8	<1.0	4640
NA-016	2.9	246	5120	89.3	51.0	<1.0	4460
NA-017	1.2	242	5100	49.6	46.3	<1.0	4550
NA-018	1.1	240	5020	36.5	48.5	<1.0	4550
NA-019	2.8	245	5100	48.7	51.0	<1.0	4640
NA-020	4.2	237	5120	59.2	48.0	<1.0	4550

	Cr	Mo	Ni	Pb	Ag	Hg	Ba	Cd
NA-001 FEED	<0.01	<0.05	<0.01	<0.01	0.183	<0.0002	<1.0	0.080
NA-002	<0.01	<0.05	<0.01	<0.01	0.000	<0.0002	<1.0	0.065
NA-003	<0.01	<0.05	<0.01	<0.01	0.013	<0.0002	<1.0	0.065
NA-004	<0.01	<0.05	<0.01	<0.01	0.034	<0.0002	<1.0	0.063
NA-005	<0.01	<0.05	<0.01	<0.01	0.020	<0.0002	<1.0	0.065
NA-006	<0.01	<0.05	<0.01	<0.01	0.028	<0.0002	<1.0	0.065
NA-007	<0.01	<0.05	<0.01	<0.01	0.030	<0.0002	<1.0	0.065
NA-008	<0.01	<0.05	<0.01	<0.01	0.033	<0.0002	<1.0	0.070
NA-009	<0.01	<0.05	<0.01	<0.01	0.035	<0.0002	<1.0	0.065
NA-010	<0.01	<0.05	<0.01	<0.01	0.043	<0.0002	<1.0	0.068
NA-011	<0.01	<0.05	<0.01	<0.01	0.045	<0.0002	<1.0	0.068
NA-012	<0.01	<0.05	<0.01	<0.01	0.050	<0.0002	<1.0	0.068
NA-013	<0.01	<0.05	<0.01	<0.01	0.050	<0.0002	<1.0	0.068
NA-014 FEED	<0.01	<0.05	<0.01	<0.01	0.053	<0.0002	<1.0	0.068
NA-015	<0.01	<0.05	<0.01	<0.01	0.058	<0.0002	<1.0	0.075
NA-016	<0.01	<0.05	<0.01	<0.01	0.058	<0.0002	<1.0	0.068
NA-017	<0.01	<0.05	<0.01	<0.01	0.050	<0.0002	<1.0	0.070
NA-018	<0.01	<0.05	<0.01	<0.01	0.060	<0.0002	<1.0	0.068
NA-019	<0.01	<0.05	<0.01	<0.01	0.065	<0.0002	<1.0	0.068
NA-020	<0.01	<0.05	<0.01	<0.01	0.065	<0.0002	<1.0	0.068

Preliminary Laboratory Results (cont)

	CO3	TSS	Zn	Fe	Mn	Cu	Al
NA-001 FEED	119	59	0.40	69.1	0.92	0.265	<0.1
NA-002	108	19	0.55	77.9	0.93	0.050	<0.1
NA-003	118	22	0.55	76.4	0.89	0.028	<0.1
NA-004	119	15	0.44	75.3	0.88	0.033	<0.1
NA-005	114	21	0.93	72.6	0.87	0.030	<0.1
NA-006	114	14	0.94	73.9	0.87	0.035	<0.1
NA-007	114	18	1.28	73.9	1.00	0.033	<0.1
NA-008	119	13	1.10	72.5	0.96	0.043	<0.1
NA-009	108	15	1.07	72.5	0.97	0.033	<0.1
NA-010	114	25	0.90	71.4	1.00	0.033	<0.1
NA-011	102	17	0.63	68.8	0.96	0.028	<0.1
NA-012	102	19	0.90	71.0	0.90	0.023	<0.1
NA-013	102	23	1.00	69.9	0.90	0.023	<0.1
NA-014 FEED	108	20	1.16	69.9	0.95	0.043	<0.1
NA-015	119	24	1.11	69.4	0.88	0.045	<0.1
NA-016	114	19	1.28	69.8	0.89	0.035	<0.1
NA-017	102	17	1.28	72.6	0.91	0.038	<0.1
NA-018	91	25	1.10	72.6	0.89	0.043	<0.1
NA-019	97	30	1.18	72.8	0.89	0.033	<0.1
NA-020	97	18	1.19	72.6	0.90	0.035	<0.1

Results and Discussion

The analyses indicated that the oil and grease content was reduced from an average of over 37 mg/l to under 3 mg/l, approximately 92 percent reduction. Total suspended solids were reduced from 59 mg/l in the initial sample to under 20 mg/l on average. Copper and silver concentrations appeared to be reduced as well. Unfortunately, the sodium, calcium, magnesium and potassium concentrations did not appear to be affected. Further work is necessary to repeat these results and try to enhance the metal capture as well as enhance the oil and grease removal.

Conclusions

The initial testing indicates that the use of Syncoal as a filter/adsorption media works well for removing oils and grease from the produced water but is not demonstrating much effect on the metal (salt) contents.

References

None.

Prototype "Filter Canister"
From Steel Pipe

Filter Unit Installed
at Field Site

Portable Skid Mounted PVC
Filters