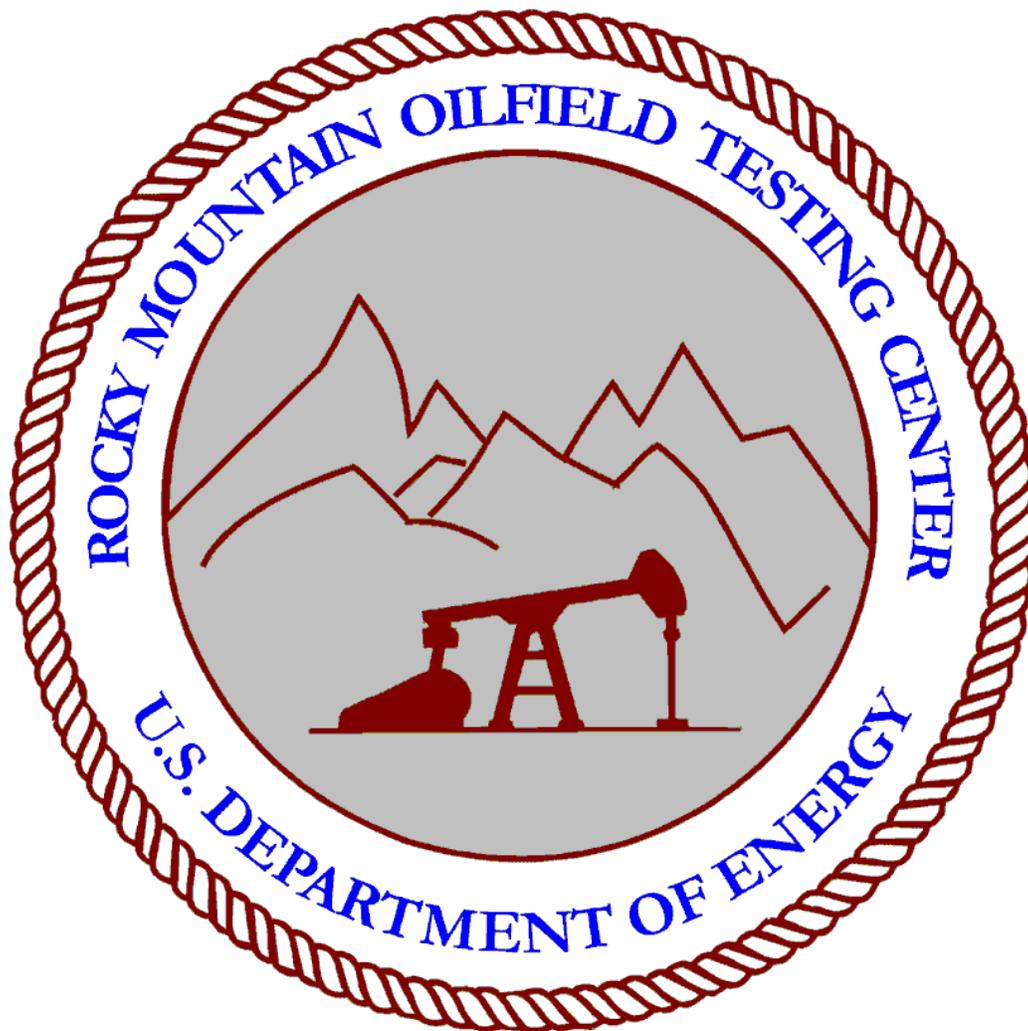


ROCKY MOUNTAIN OILFIELD TESTING CENTER

PROJECT TEST RESULTS

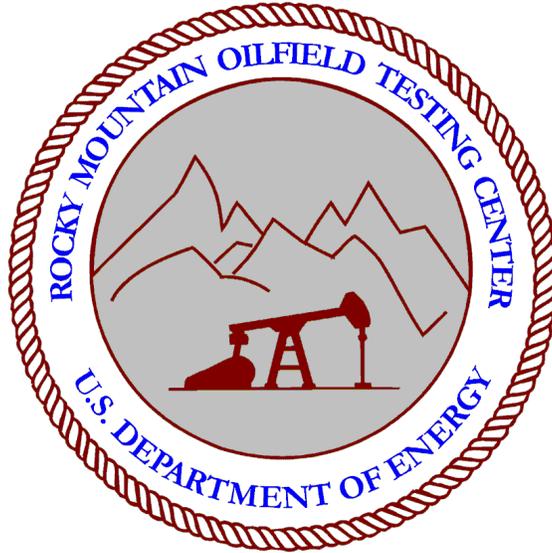


PETRO-PLUG BENTONITE PLUGGING

JANUARY 27, 1998

Report No. RMOTC/97PT22

ROCKY MOUNTAIN OILFIELD TESTING CENTER



PROJECT TEST RESULTS

PETRO-PLUG
BENTONITE PLUGGING

Prepared for:

INDUSTRY PUBLICATION

Prepared by:

Michael R. Tyler
RMOTC Project Manager

January 27, 1998

Report No. RMOTC/96ET4

CONTENTS

	Page
Technical Description	1
Problem	1
Solution	2
Operation.....	3
Test Wells.....	4
Test Results	4
Well 13-A-10 Pressure Test Results	6
Well 13-A-10 Bentonite Test Results	6-A
Well 13-A10 Gravel Test Results	6-B
Well 65-AX-15 Pressure Test Results	7
Well 65-AX-15 Bentonite Test Results	7-A
Well 65-AX-15 Gravel Test Results	7-B
Technical Observations	8
Summary	9
Acknowledgements	10
Manufacturer	11

ROCKY MOUNTAIN OILFIELD TESTING CENTER
PETRO-PLUG
PROJECT TEST RESULTS
January 27, 1998

Michael R. Tyler
Project Manager

Abstract

The Petro-Plug process using bentonite and gravel to plug oil and gas wells was field tested by the Rocky Mountain Oilfield Testing Center (RMOTC). The process was used on two wells (1 13-A-10 and 65-AX-1 5) at the Naval -Petroleum Reserve 3 (NPR-3) in Natrona County, Wyoming. The selected wells were inactive water injection wells and had been perforated in the Second Wall Creek formation at depths below 3200'. The production casings were filled with bentonite from Plug Back Total Depth (PBSD) to a minimum of 100' above the perforations. They were pressure tested to the Wyoming Oil and Gas Conservation Commission (WOGCC) requirements and passed. The wells were then filled with alternating intervals of peagravel and bentonite to the surface. The production casing was not removed from either well bore, nor were they cemented back to surface, so the annular space from surface to a minimum depth of 25' was filled with bentonite. The production and surface casings were then pressure tested and met the WOGCC requirements. A schematic diagram of each well is attached illustrating what was accomplished.

The process will provide an effective alternative to well abandonment using cement.

ROCKY MOUNTAIN OILFIELD TESTING CENTER
PETRO-PLUG
PROJECT TEST RESULTS
January 27, 1998

Michael R. Tyler
Project Manager

TECHNICAL DESCRIPTION:

This process uses bentonite to plug and abandon cased oil and gas wells. The bentonite is placed in the well casing from Plug Back Total Depth (PBTD) to a minimum of 100' above the top perforations. Gravel is then placed on top of the bentonite. Alternating intervals of bentonite and peagravel are placed to the surface. The annulus between the production and surface casings is filled from the surface to a minimum depth of 25' with bentonite.

PROBLEM:

When a well bore is drilled, a conduit is formed that may allow hydrocarbons to migrate into fresh water formations. Casing is placed in the well bore and cement is pumped down the casing and up the outside to form a seal to prevent the migration of fluids between formations. The casing is then perforated in hydrocarbon bearing zones to allow gas & oil to be produced. When the producing zones are depleted, the well is shut in. If no further commercial hydrocarbon production can be found, the well must be abandoned and the casing and perforations are plugged.

The currently approved method to abandon oil and gas wells is to pump a cement slurry, through tubing, setting cement to cover the perforations and isolate other formations from migrating through the casing should it fail later. Pump trucks are required to transport, mix and pump the cement into the casing. A rig is required to run the tubing in to the well to place the cement. This process is successful but is expensive due to the equipment required.

SOLUTION:

Bentonite is used to provide an effective seal in the casing and across the perforations. The bentonite must be placed in the casing dry and allowed to hydrate. Based on a test conducted by the Montana College of Mineral Science and Technology in 1994, when bentonite hydrates, it will increase in volume by 50% over the dry state creating an effective seal. The aim of this testing program was to find a reliable method to place the bentonite in the well casing at the proper depth.

The problem of placing the bentonite in the casing was solved by selecting the proper size and form for the bentonite, and dropping the product from the surface into the production and surface casings.

When the bentonite is placed in the casing across the perforations and allowed to hydrate, a plug or seal is formed. The plug is then pressure tested to prove its integrity. The Wyoming Oil and Gas Conservation Commission (WOGCC) requires that a well plug be pressure tested to a minimum of 300 psi and hold for 15 minutes.

OPERATION:

The casing is first filled with water. The bentonite plugs (1.250" X 1.250") are dropped from the surface at the minimum rate of one box (40 lbs.) every five (5) minutes and fall to the bottom where they hydrate. The bentonite is placed from PBTD to a minimum of 100' above the top perforation. Peagravel is placed above the bentonite at the minimum rate of one barrel (55 gal.) every eight minutes. Then intervals of approximately 50' of bentonite and 1400' to 1700' of peagravel are placed in the casing up to the surface. The peagravel is used to provide structural support to the casing wall and to provide a porous medium filled with water to ensure that the bentonite stays hydrated.

Next, the casing head is removed and the annular space is opened. The annulus is filled with water and bentonite plugs (.375" X .375") are dropped in at the minimum rate of one sack (50 lbs.) every 3 minutes where it hydrates and seals. The annulus is filled with bentonite to within 25' from surface.

Both the production and surface casings are pressure tested to ensure the minimum requirements of the WOGCC are met. The well head is then sealed with a dry hole marker to complete the abandonment requirements.

BENEFITS:

1. The bentonite will not crack or break.
2. The bentonite will seal casing leaks.
3. The bentonite continues to seal when ground motion occurs.
4. The bentonite will expand to fill breaches.
5. The bentonite and gravel can be removed by circulation.

TEST WELLS:

The test was conducted by RMOTC on Department of Energy (DOE) wells 13-A-10 0 and 65-AX-1 5 at the Naval Petroleum Reserve 3 (NPR-3) in Natrona County, Wyoming.

Well 13-A-10 was drilled to Total Depth (TD) of 3540'. The surface casing (10.7511 x 32.75#) was run to 843' Kelly Bushing (KB). The production casing (5.5" X 14#) was run to 3508' and the well was cemented to Plug Back Total Depth (PBSD) of 3474'. The well was perforated from 3379'-3439' with two shots per foot.

Well 66-AX-16 was drilled to TD of 3476'. The surface casing (8.625" X 24#) was run to 190' (KB). The production casing (5.5" X 15.5#) was run to 3460' and the well was cemented to PBSD of 3372'. The well was perforated from 3276'-3339' with two shots per foot.

Both wells were inactive water injection wells used in the Second Wall Creek waterflood project.

TEST RESULTS:

Well 13-A-10 was plugged on 16-Oct-97. The bentonite was placed from PBTD 3408' to 3208', 171' above the top perforation at 3379'. Then 47' of peagravel was placed on top of bentonite, bringing TD to 3161'.

On 20-Oct-97 TD was 3165' as gravel and bentonite had settled to bottom. The casing threads were burred, so a pressure test with a water truck could not be done. The casing was filled with water to surface and observed. No water loss occurred during a 15 minute interval. The pressure exerted on the bentonite was calculated at 1370 psi. This production casing test met the WOGCC requirements. (See Chart 1).

The production casing was plugged to surface with alternating intervals of peagravel and bentonite. The casing head was removed and the annular space was filled with water and bentonite. Fifty (50) ft. of bentonite was placed from TD @ 843' to 793'. A cement basket was installed at 43' and sacrete was poured in, to form a bridge. Water and bentonite were poured into annular space to the surface. The casings were sealed and pressure tested on 11-Dec-97 and met the WOGCC requirements. (See Well Diagram 13-A-10).

TEST RESULTS:

Well 65-AX-15 was plugged in December of 1995. The bentonite was placed from PBTD 3372' to 3148', which was 128' above the top perforation at 3276'. The well was pressure tested to WOGCC requirements. (See Chart 2).

In October of 1997 the well was plugged to surface with alternating intervals of peagravel and bentonite. The casing head was removed and the annular space was filled with water and then bentonite. (See Well Diagram 65-AX-15).

The well was pressure tested to WOGCC requirements. (See Chart 2).

Pressure Test Results 13-A-10

DATE	TIME	PRODUCTION CASING SURFACE PRESSURE*	SURFACE CASING SURFACE PRESSURE*	COMMENTS
20-Oct-97	10:40	475		Pressured with truck. Leak on Casing collar
	10:45	410		Leak on Casing collar
	10:55	290		Leak on Casing collar
	11:00	0		Water still at surface. 3165' water x .4331 = 1370 psi
12-Nov-97	2:12	500		Pressured with truck
	2:15	250		
	2:18	210		
	2:19	580		Pressured with truck
	2:34	580		
	2:43	565	350	Pressure SC to 350# with Water Truck. Psi bled off instantly
24-Nov-97	11:05	500	210	Pressured with 30 bbls hot water pumped into SC
	11:25	600	200	
	12:45	500	178	
	1:05	0	178	
25-Nov-97	8:07		110	Pressured with cold water
	8:17		225	
	8:32		250	Pumped 50 barrels
	8:42		250	Pumped 75 barrels
	8:57		238	Held for 15 min
11-Dec-97	10:22	320	320	Both casings pressured to 320
	10:37	320	320	Pressure held.

* Pressured by water truck

Chart 1

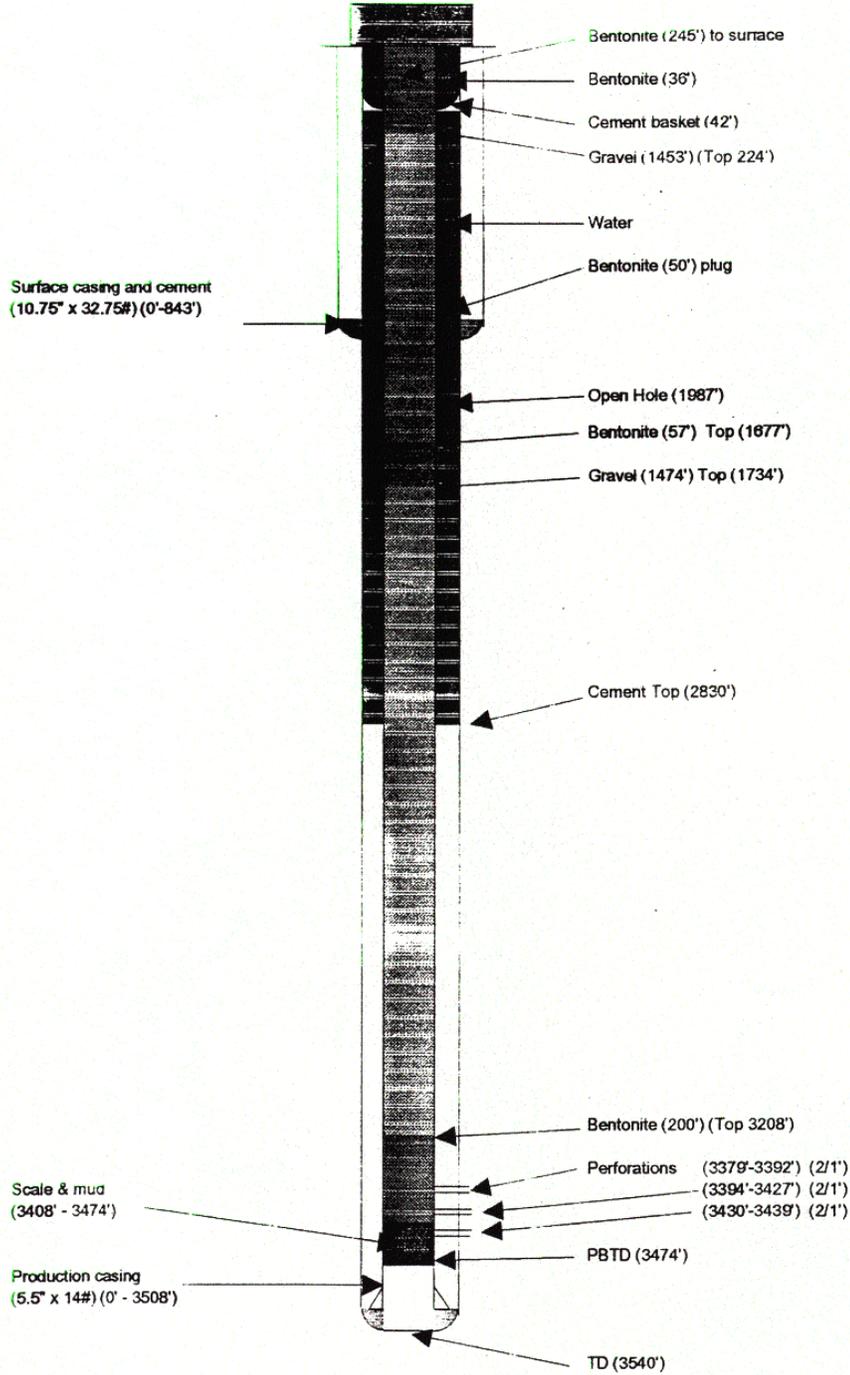
Michael R. Tyler
Project Manager

RMOTC Test
Petro-Plug

Well 13-A-10
Second Wall Creek
Sec. 10, 38N. R. 78 W.
1650 FNL 330' FWL
Natrona County, WY.

Well 13-A-10

Elevations: KB: 5305'
GL: 5295'



Bentonite

Date	Time Wireline (WL) Run	Avg. Time to Pour (Min.)	Total Depth (ft.)	Total Linear Fill (Ft.)	Total Boxes (40#)	Boxes (40#)	Total Sacks (50#)	Sacks (50#)	Avg. Linear Ft. Fill	Comments
14-Oct-97	3:38 AM	7	3392		1	1				
	5:19 PM	11	3372	20	6	5				
15-Oct-97	7:31 AM		3372	0					4	
	8:32 AM	8.4	3351	21	11	5			4.2	
	9:30 AM	5.6	3335	16	16	5			3.2	
	10:27 AM	5.4	3323	12	21	5			2.4	
	12:01 PM	3.4	3301	22	26	5			4.4	
	1:21 PM	4	3285	16	31	5			3.2	
	2:15 PM	7.4	3264	21	36	5			4.2	
	3:27 PM	4.6	3237	27	43	7			3.8	
	4:35 PM	4.7	3208	29	50	7			4.1	
21-Oct-97	3:07 PM		1734							
22-Oct-97	8:25 AM	4.3	1703	31	56	6			5.1	
	9:20 AM	3.8	1677	26	62	6			4.3	
23-Oct-97	9:15 AM		224							
	9:45 AM	3.8	195	29	67	5			5.8	
	10:05 AM	3.4	172	23	72	5			4.6	
	10:25 AM	3.4	150	22	77	5			4.4	
	10:55 AM	3.5	124	26	83	6			5.2	
Total / Average		5.23		341.00		83.00			4.11	
	11:16 AM	3.3	97	27			6		4.5	
	11:30 AM	1.4	70	27			10		6.9	
	11:52 AM	3.8	41	29			15		5.6	
	12:10 PM	3.3	8	33			21		5.4	
	12:18 PM	3.2	5	3			22		3.1	Partial Sack
Total / Average		3.00		119.00			22.00		5.41	

Gravel

Date	Time Wireline (WL) Run	Avg. Pour Time (Min.) (55 Gal. Bbl.)	Total Depth (ft.)	Total Linear Fill (ft.)	Total Bbl.	Bbl Gravel / Interval	Avg. Linear Ft. Fill	Comments
15-Oct-97	4:35 PM		3208					
	4:43 PM	15						
16-Oct-97	7:15 AM		3161		1	1	47	
20-Oct-97	10:03 AM		3165		1	0	51	Gravel Settled
	10:59 AM		3166	42	1	0	50	Casing Pressured & Plug settled
	12:39 PM	4	3114	52	2	1	52	
	2:32 PM	9.4	2887	227	7	5	45.4	
21-Oct-97	8:20 AM	9.4	2656	231	12	5	46.2	
	9:42 AM	8.8	2418	238	17	5	47.6	
	12:00 PM	9.8	2184	234	22	5	46.8	
	1:38 PM	8.6	1958	226	27	5	45.2	
	3:07 PM	8.2	1734	224	32	5	44.8	
22-Oct-97	9:20 AM		1677					
	11:38 AM	5.8	1444	233	37	5	46.6	
	1:55 PM	5.8	1000	444	47	10	44.4	
	3:30 PM	7.8	554	446	57	10	44.6	
23-Oct-97	8:05 AM		554	0				
	9:15 AM	7.1	224	330	64	7	47.1	
Total/ Average		8.31		2927.00		64.00	45.73	

Pressure Test Results 65-AX-15

DATE	TIME	PRODUCTION CASING PRESSURE*	SURFACE CASING PRESSURE*	COMMENTS
12-Dec-95	10:00	500		Pressured by truck
	10:15	470		
	13:15	390		
	15:15	375		
13-Dec-95	8:00	320		
4-Dec-96	8:30	510		
	8:45	510		
	9:00	510		
	10:00	510		
	11:00	510		
	12:15	490		
	15:00	490		
5-Dec-96	8:30	490		
14-Aug-97	8:15	503		
	8:30	503		
20-Oct-97	8:11	520		
	8:12	500		
	8:15	490		
	8:19	480		
	8:22	475		
	8:26	460		
	8:28		520	
	8:37		510	
	8:40		510	
	8:45		505	
	8:48		500	
	8:49		500	
	12:15		450	
	16:00		420	
3-Nov-97	8:13	500		
	8:30	500	500	
	8:45	500	500	

* Pressured by water truck

Chart 2

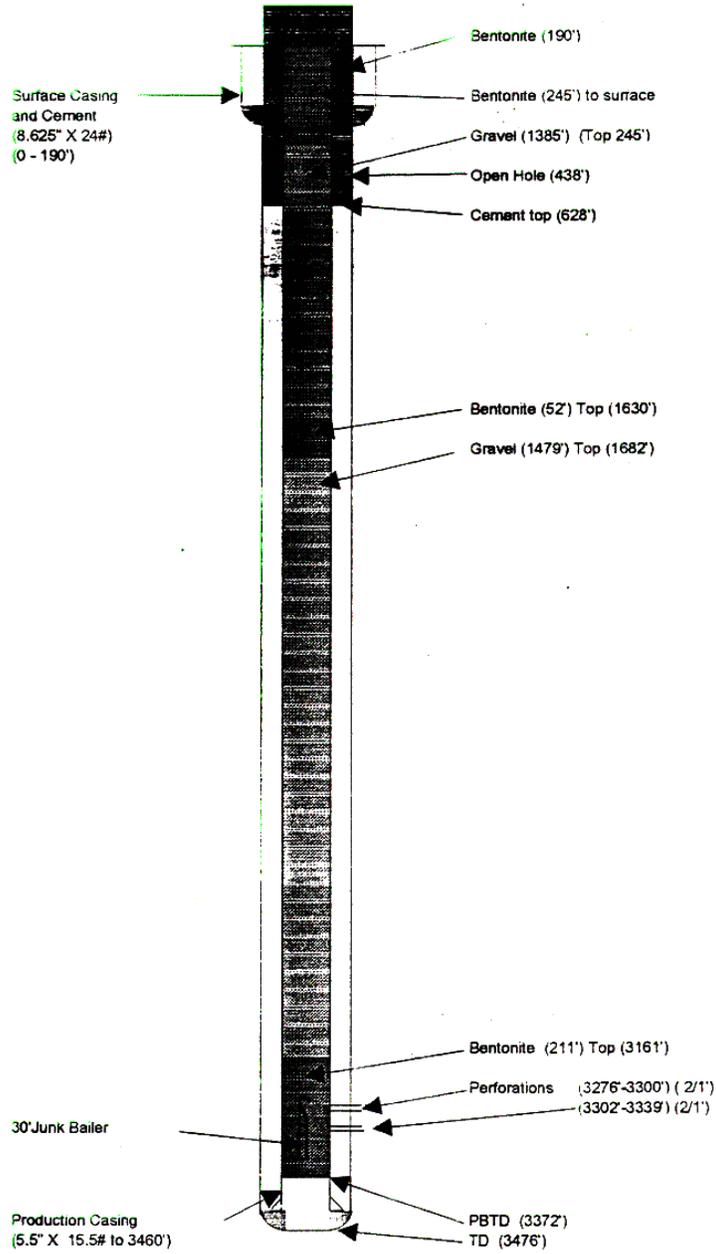
Michael R. Tyler
Project Manager

RMOTC Test
Petro-Plug

Well 65-AX-15
Second Wall Creek
Sec. 15, T. 38N, R. 78 W.
1945' FSL 1161' FEL
Natrona County, WY.

Well 65-AX-15

Elevations: 4B 5287'
3L 5277'



Bentonite

Date	Time Wireline (WL) Run	Avg. Time to Pour (Min.)	Total Depth (ft.)	Total Linear Fill (Ft.)	Total Boxes (40#)	Boxes (40#)	Total Sacks (50#)	Sacks (50#)	Avg. Linear Ft. Fill	Comments
10/5/97	3:12 PM		245							
	3:49 PM	4	241	4	1	1				
	4:05 PM	3	237	4	2	1		4.00		
10/7/97	9:18 AM		225	12	6	4			3.00	Bentonite and gravel settled to TD
	9:44 AM	7	202	23						
	10:11 AM	5	179	23	11	5			4.60	
	10:28 AM	4	157	22	16	5			4.40	
	10:48 AM	4	135	22	21	5			4.40	
	11:31 AM	4	88	47	31	10			4.70	
	1:04 PM	4	40	48	42	11			4.36	
1:25 PM	5	21	19	46	4			4.75		
1:33 PM	2	20	1	46.25	0.25			0.25		
Total/Average		4.2		225.00	46.25	46.25			4.86	
	1:37 PM	4	14	6			1	1	6.00	
	1:42 PM	5	8	6			2	1	6.00	
Total/Average		4.5		12.00			2	2	6.00	

Date	Time Wireline (WL) Run	Avg. Pour Time (Min.) (55 Gal. Bbl.)	Total Depth (ft.)	Total Linear Fill (ft.)	Total Bbl.	Bbl. Gravel / Interval	Avg. Linear Ft. Fill	Comments
30-Sep-97	2:30 PM		3162					
	4:06 PM		3124		1	1		
1-Oct-97	7:45 AM		3100	62	1	0	62.00	Gravel settled overnight
	9:20 AM	37.00*	3070	30	2	1	30.00	* Not used in average calculation
	10:27 AM	20.00*	3035	35	3	1	35.00	* Not used in average calculation
	11:11 AM	16.00			4			
	11:40 AM	16.00	2989		4			
	12:02 PM		2964		4			
	12:25 PM		2961		4			
	12:44 PM		2960	75	4	1	75.00	Gravel floats & settles slowly
	2:48 PM	21.00	2814	146	7	3	48.67	
	5:00 PM	17.00	2671	143	10	3	47.67	
2-Oct-97	7:41 AM		2671					
	11:07 AM	12.00	2433	238	15	5	47.60	
	1:32 PM	15.00	2193	240	20	5	48.00	
	4:30 PM	16.00	1947	246	25	5	49.20	
3-Oct-97	7:41 AM		1945	2	25			2' fill overnight
	10:49 AM	15.00	1682	263	31	6	43.83	
4-Oct-97	11:45 AM		1630	52				
	12:37 PM		1625	5		0.5		
	3:00 PM	14.00	1387	238	36	5	47.60	5 gallons gravel poured in
	4:30 PM	15.00	1296	91	39	3	30.33	Bbl. not full
5-Oct-97	7:36 AM		1291	5	39	0		Gravel settled overnight
	9:36 AM	13.00	1060	231	44	5	46.20	
	11:24 AM	11.00	815	245	49	5	49.00	
	12:58 PM	9.00	593	222	54	5	44.40	
	2:18 PM	7.00	362	231	59	5	46.20	
	3:12 PM	7.00	245	117	62	2.5	46.80	
Total/Average		12.00		2917		62.00	47.05	

TECHNICAL OBSERVATIONS:

1. Several methods of application of the bentonite into the well casing were tried. The size of the bentonite plugs requires careful consideration for each application.
2. The extruded bentonite plugs (1.250" x 1.250"), when placed in the casing, fell to bottom without bridging. This product was used to cover the perforations in the deepest intervals, and no problems were experienced in application or sealing.
3. The minimum time to pour a (40#) box of the bentonite plugs was five (5) minutes. The average linear fill was four (4') per box. The depth to top of bentonite should be verified frequently by wireline measurement to assure the bentonite has reached bottom.
4. The peagravel is buoyant and will bridge off if poured into the well too rapidly. The minimum time to pour a (55 gal.) barrel was 8 minutes. The average linear fill per barrel was 46'. The depth should be verified frequently by wireline measurement.
5. On well 13-A-10, the seal in the annular space failed on the pressure test. The bentonite was placed from surface to 43' and allowed to hydrate. When pressure tested the bentonite washed out. A cement basket was installed at 43' and four 80# sacks of sacrete were poured into the annular space to form a bridge. Bentonite was used to fill the annular space (36') to the surface. The surface and production casing were pressured to 320 psi and held for 15 minutes.
6. On well 65-AX-15, the bentonite plug fell 44' from the original PBTD of 3148' to 3192'. This drop occurred during the sand pumping of the well to remove a bridge formed by gravel. Additional bentonite was added to the well to meet the WOGCC requirements.
7. Candidate wells must be evaluated on an individual basis. The criteria should include, but not be limited to, the following:
 - Total depth
 - Deviations of well bore
 - Casing size
 - Casing ID (caliper tool should be run)
 - Bottom hole pressure
 - Fluid depth

SUMMARY

The Petro-Plug bentonite plugging process for cased oil and gas well abandonment was successful. Several methods of application and different sizes of bentonite products were used in this test. The extruded bentonite plugs (1.250" x 1.250") provided the most reliable results when poured into the well at a minimum rate of 5 minutes per 40# box. The peagravel should be poured in at a minimum rate of 8 minutes per (55 gal.) barrel. Frequent measurement by wireline should be conducted to verify bridging has not occurred. Pressure testing of the seal should be done after the perforations have been covered and before further bentonite or gravel is placed in the well. Cost analysis are not included in this report.

ACKNOWLEDGEMENTS

This research was funded by the Department of Energy with work conducted by the Rocky Mountain Oilfield Testing Center (RMOTC). Work was directed by Michael R. Tyler, RMOTC Project Manager, and supported by Vickie Stamp, RMOTC Engineer, Dick Webb, RMOTC Field Technician and Dan Kelly, RMOTC Field Technician. RMOTC is operated by Fluor Daniel (NPOSR), Inc., the Management and Operating Contractor for the Department of Energy Naval Petroleum Oil Shale Reserves in Colorado, Utah, and Wyoming (NPOSR-CUM.

MANUFACTURER:

Petro-Plug, USA. LLC of Casper, Wyoming, holds the patent application No. 08/532,420 for "Drill Hole Plugging Method Utilizing Layered Sodium Bentonite and Liquid Retaining Particles."

TITLE: Petro-Plug Bentonite Plugging

INVENTOR: Maurice James
Petro-Plug, USA, LLC.
106 Big Horn RD.
Casper, Wyoming 82601

PHONE: (307) 473-8696