

Wellbore Plugging Using Hydrated Bentonite

Joel Dill, Adam Badura, Mitch Heimer, Tanner
Messer, James Ringler

Agenda

- Objective
- Past Research
- Lab Construction
- Experiment Design
- Results
- Summary

Objective

- To test the effects of salinity and residual oil on the dislodgement pressure of hydrated Bentonite plugs
- To alleviate industry concerns of using Bentonite as an effective plugging material (vs. cement)

History of Bentonite Plugging

- Bentonite first introduced to plug seismic drill holes penetrating ground water supplies in Wyoming in 1984
- Field trials ran in California and Texas on oil & gas wells. Similar tests conducted in Australia
- This project is a continuation from 2009 Senior Capstone project

P&A Cost Comparison

- In field trials, Bentonite found to be up to 40% cheaper than plugging using neat cement
- Plugging with Bentonite requires far less equipment on location and less labor

Australian P&A Cost Comparison

	Cement		Zonite	
	Time (hrs)	Cost (\$000)	Time (hrs)	Cost (\$000)
MIRU, well control	12	2.5	12	2.5
Running bridge plug	6	2.5	6	2.5
Deep cement plug	6	7.5	/	
Waiting on cement	6	2.5	/	
Pour Zonite	/		4	1
Shallow Zonite retainer	/		1	1
Shallow cement plug	6	7.5	/	
Waiting on cement	6	2.5	/	
Pour Zonite	/		4	1
Surface casing cement	6	5	6	2.5
Wellhead removal	6	2.5	6	2.5
Contingency	6	2.5	4	1
SUB TOTAL	60	35	44	14
Supervision	48	2.5	12	2.5
GRAND TOTAL	60	37.5	39	16.5

Source: Clark and Salsbury (2003)

Last Year's Group Results

Apparatus	Plug Height (in)	Failure Pressure (psi)	Hydrating Time (days)	Conditions
1	76	66	26	Normal
	76	80	28	Normal
	76	90	42	Normal
2	75	70	26	Normal
	75	100	31	Normal
	75	125	42	Normal
3	50.5	56	28	Normal
	50.5	57	35	Normal
	50.5	70	44	Normal
4	50	59	28	Normal
	50	60	35	Normal
	50	125	44	Normal
1	100.75	124	50	Additional Bentonite
	100.75	250	71	Additional Bentonite
2	99	272	50	Cored then added bentonite
	99	310	71	Cored then added bentonite
3	43	27	10	New bentonite with center holes
	43	69	31	New bentonite with center holes
4	53.5	120	10	New bentonite hydrated under pressure

Salinity Tests -- 2009



These tests are completed in approximately 50,000 ppm saline solution.
The solution was made up of NaCl and CaCl.

Effects of Residual Oil

- Most wells that will be plugged will have residual crude oil left in wellbore.
 - Complete effects of this oil unknown
 - In one SPE paper (Englehardt) it is suggested that hydrocarbons will not effect the hydration of bentonite.

Lab Set-up

- The Lab was set-up for experiments in the following way:
 - Four 10 ft sections of 4” casing were hung suspended in the room
 - Flanges were attached to both top and bottom
 - Incoming fresh water supply from University water well
 - Supply of Nitrogen (used to pressure test plugs) tied into bottom

Lab Fabrication



Lab Fabrication



Safety Considerations

- Hard hat, gloves, eye protection, boots worn while working in lab
- Fall harness used when working on upper open levels
- MSDS sheets in lab for oil

Experiment Design (Salinity)

- Filled four, 10 foot casing segments with bentonite & water
 - Used varying concentrations of Sodium Chloride in water to see effects of salinity
 - Fresh; 5,000 PPM; 10,000 PPM; 20,000 PPM
- Hydrated for 38 days, then for additional 21 days
 - Ruptured plugs after 7 days then for an additional 14 days to test healing of bentonite

Experiment Design (Residual Oil)

- Filled one, 10 foot segment of casing with bentonite, fresh water, and oil
 - Used fresh water, Dakota oil from 15 Mile field (light, waxy)
 - Dropped bentonite through 2ft oil column
- Hydrated for 21 days, then additional 4 days to test healing of bentonite

Results

Apparatus	Plug Height (in)	Failure Pressure (psi)	Hydrating Time (days)	Friction Factor	Conditions
1	66	70	38	0.24	Normal (Fresh)
	66	75	45	0.26	Normal (Fresh)
	66	98	59	0.34	Normal (Fresh)
2	66	15	38	0.03	Normal (5,000 PPM)
	66	15	45	0.03	Normal (5,000 PPM)
	66	10	59	0.02	Normal (5,000 PPM)
3	66	115	38	0.41	Normal (10,000 PPM)
	66	90	45	0.31	Normal (10,000 PPM)
	66	104	59	0.37	Normal (10,000 PPM)
4	66	190	38	0.69	Normal (20,000 PPM)
	66	180	45	0.65	Normal (20,000 PPM)
	66	220	59	0.8	Normal (20,000 PPM)
1	66	50	21	--	2 ft Oil column, granulated bentonite
	66	54	25	--	2 ft Oil column, granulated bentonite

Conclusions

Tests have shown that Hydrated Bentonite does not seem affected in salinity up to 20,000 PPM.

Hydrated Bentonite also is not affected by residual oil in well.

Thank you!

Questions?

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Denbury Resources

References

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