RECOMMEND MUD PROGRAM

COMPANY: STATOIL
RIG: Deep Sea Bergen
WELL NAME: 15/9-18

NORSK PETROLEUM SERVICES A/S

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OPERATING AREA Statoil
Deep Sea Bergen
15/9-18

INDEX

OIL COMPANY	: STATOIL
CONTRACTOR	: ODCC
RIG	: DEEP SEA BERGEN
WELL NAME/No.	: 15/9-18
LOCATION/BLOCK No.	: 15/9
ENGINEERS	:
T.D.	: 3700 m
TOTAL DEVIATION	:

NORSK PETROLEUM SERVICES A/S.

RECOMMENDED MUD PROGRAM

Company STATOIL — Date Nov 1983

Well Name & Number 15/9-18 — Proposed Depth 3700 m

Location North Sea Norway

Casing: Surf 30" at 188 m — Inter. — Prod.

RECOMMENDED MUD PROPERTIES				TREATMENT
DEPTH FEET m	WEIGHT LB/GAL SG	VISCOSITY SEC.	FILTRATE ML	I 36" Hole
123 to 188	ALAP	100+	NC	SPUD MUD Prehydrated Bentonite Sea Water

Remarks Prehydrate Bentonite in fresh water. Mix in sea water to the required viscosity. Pump high viscosity pills as requested to clean the hole.

Estimated cost for mud materials: $ 8,211.55

Recommended Program Based Upon 15/9-18 prognosis

15/9-1, 2, 3, 4, 12, 14, 16

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Deep Sea BErgen
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INTERVAL DISCUSSION

I. 36" Hole 123 to 188 meters 65 meters to drill
30" Casing at 188 meters

This section will be drilled with seawater. Returns will be to the sea bed. Periodically clean the hole with high viscosity pills (40-50 barrels). The high viscosity mud is built by adding pre-hydrated Bentonite to sea water to the required viscosity.

When TD is reached, circulate the hole clean and displace the hole with high viscosity spud mud (150 % of the estimated hole volume). If no drag or fill is encountered on the wiper trip, displace the hole with high viscosity spud mud and run 30" casing. If drag of fill is encountered, displace the hole with a weighted ($\pm$ 1.25 SG) high viscosity spud mud and run 30" casing.

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MATERIALS USED PER CASING INTERVAL

I. 36" Hole 123 to 188 meters 65 meters to drill
30" Casing at 188 meters

A. Volumes

1)	High Viscosity Pills	64 m^3	400 bbls
2)	Displacements (2 x 150% Hole Volume)	127 m^3	800 bbls
	Volume required	191 m^3	1200 bbls

B. Materials Required

MATERIAL	UNIT	UNIT COST $	QTY	COST $
BARGAIN	M/T	119.47	33	3,942.51
BENTONITE	M/T	265.00	16	4,240.00
Soda Ash	50 kg	14.52	2	29.04
Total Cost				8,211.55
Cost per m^3			191	42.99
Cost per barrel			1200	6.84
Cost per meter			65	126.33

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RECOMMENDED MUD PROGRAM

Company STATOIL Date Nov 1983

Well Name & Number 15/9-18 Proposed Depth 3700 m

Location North Sea Norway

Casing: Surf 30" at 188 m Inter. 20" at 500 m Prod.

RECOMMENDED MUD PROPERTIES				TREATMENT
DEPTH FEET m	WEIGHT LB/GAL SG	VISCOSITY SEC.	FILTRATE ML	II 26" Hole
188 to 515	ALAP	As req'd	NC	SPUD MUD Prehydrated Bentonite Sea Water

Remarks Prehydrate Bentonite in fresh water. Add to seawater to the required viscosity. Utilize the solids control equipment and dilution to maintain the density as low as possible. Utilize prehydrated Bentonite to maintain the viscosity required to clean the hole.

Estimated cost for mud materials: $ 15,092.99

Recommended Program Based Upon 15/9-18 prognosis
15/9-1, 2, 3, 4, 12, 14, 16

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INTERVAL DISCUSSION

II. 26" Hole 188 to 515 meters 327 meters to drill
20" Casing at 500 meters

This section will be drilled with a seawater, prehydrated Bentonite Spud Mud. Returns will be to the rig shakers. A 12 1/4" pilot hole will be drilled to 520 meters. The hole will then be opened up to 26" as per the drilling program.

The spud mud is to be made by adding prehydrated Bentonite to sea water pretreated with Caustic and Soda Ash to remove the Calcium and Magnesium to the required viscosity to clean the hole. Utilize the solids control equipment and pretreated seawater to keep the mud density and drilled solids to a minimum.

Displace the hole with high viscosity mud after running the 26" bit to make sure the hole is opened to 26". If no drag of fill is encountered on the short trip, displace the hole with high viscosity spud mud and run 20" Casing. If drag of fill is encountered on the short trip, displace the hole with a weighted ($\pm$ 1.25 SG) high viscosity spud mud and run 20" Casing.

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MATERIALS USED PER CASING INTERVAL

II. 26" Hole 188 to 515 meters 327 meters to drill
20" Casing at 500 meters

A. Volumes

1) Surface Volume	95 m^3	600 bbl
2) Riser Volume	27 m^3	170 bbl
3) 30" Casing Volume	25 m^3	165 bbl
4) 12 1/4" Open Hole Volume	25 m^3	155 bbl
5) 26" Open Hole Volume	115 m^3	725 bbl
6) Dilution Volume	403 m^3	2535 bbl
Total Volume Required	692 m^3	4350 bbl

B. Materials Required

MATERIAL	UNIT	UNIT COST $	QTY	COST $
BARGAIN	M/T	119.47	37	4,420.39
Bentonite	M/T	265.00	40	10,600.00
Soda Ash	50 kg	14.52	5	72.60
Total Cost				15,092.99
Cost per m^3			692	21.81
Cost per barrel			4350	3.47
Cost per meter			327	46.16

C. Contigency Materials

Caustic Soda	80
Lignosulfonate	120
Mica F/C	150/150
Wallnut F/C	150/150
Kwik Seal	100

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RECOMMENDED MUD PROGRAM

Company Statoil — Date November 1983

Well Name & Number 15/9-18 — Proposed Depth 3700 m

Location North Sea Norway

Casing: Surf 20" at 500 m — Inter. 13 3/8" at 1150 m — Prod.

RECOMMENDED MUD PROPERTIES				TREATMENT
DEPTH FEET	WEIGHT LB/GAL	VISCOSITY SEC.	FILTRATE ML	
515-1165	1.10	40-50	10-15	III. 17 1/2" Hole Gyp/Lignosulfonate Make up mud as follows: Seawater Caustic 3/4 ppb Q-Mix 1:3 ratio Gypsum 10 ppb Dextrid 2-3 ppb CMC LV 1-2 ppb as required XCD Polymer 1-2 ppb as required

Remarks

Make up Q-Mix as follows:

Drillwater
Soda Ash - 1/2 ppb
Caustic - 1/2 ppb
Aquagel - 45 ppb
Q-Broxin - 2 ppb

Maintain properties:
PV - ALAP
YP - 20-25
pH - 9.5-10.5
Excess Gyp - 3-5 ppb
MBT - 10-15

Estimated cost for mud materials: $ 50,057.62

Recommended Program Based Upon 15/9-18 prognosis

15/9-1, 2, 3, 4, 12, 14, 16

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INTERVAL DISCUSSION

III. 17 1/2" Hole 515 to 1165 meters 650 meters to drill
13 3/8" Casing at 1150 meters

Drill cement and 20" Casing shoe with seawater. Displace the hole with Gyp/Lignosulfonate mud made up in following order:

Seawater - pretreated with 1/2 ppb Soda Ash
Caustic Soda - 1 ppb
Q-Mix - 1/3 bbl for each 2/3 bbl seawater
Gypsum - 8 ppb
Dextrid - 2 1/2 ppb
CMC LV - 1-1 1/2 ppb
XCD Polymer - .5-1 ppb
Bargain - if required

Since the mud weight is to be kept at 1.10 SG or below, large amounts of dilution will be necessary. It is recommended that the dilution be made with new mud. This will help maintain the mud properties much better than adding chemicals directly to the active system.

Utilization of all solids control equipment to reduce solids build up is very important. However, the centrifuge will not be effective and probably should not be used in the Barite recovery mode.

Maintain the bentonite at 10-15 ppb by controlling amount of pre-mix added. Maintain the excess gypsum at 3 to 5 ppb at all times. (See attached test for determing excess Gypsum). Maintain the PV as low as possible with dilution and solids control equipment. Maintain the YP at 20-25 with XCD Polymer and Q-Mix. Maintain the density at 1.10 SG with Bargain or dilution and solids control equipment.

Maintain the pH at 9.5 to 10.5 with Caustic and Lime.

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III. 17 1/2" Hole 515 to 1165 meters 650 meters to drill
13 3/8" Casing at 1150 meters Cont'd.

The Calcium content of the seawater/Gypsum/Lignosulfonate mud will be +- 2000 ppm.

In previous wells drilled in this area, problems encountered were tight hole, plugged flow lines and loss circulation from packing off from balled up BHA. The higher YP point should increase hole cleaning. If severe balling occurs, Con Det can be added in concentration of 4-6 ppb to help reduce it. This addition will be made only with the Statoil drilling supervisor's approval.

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MATERIALS USED PER CASING INTERVAL

III. 17 1/2" Hole 515 to 1165 meters 650 meters to drill
13 3/8" Casing at 1150 meters

A. Volumes

1)	Surface Volume	79.5 m^3	500 bbl
2)	Riser Volume	27 m^3	170 bbl
3)	20" Casing Volume	73 m^3	460 bbl
4)	17 1/2" Hole Volume ±25%	126 m^3	795 bbl
5)	Dilution Volume 150%	459 m^3	2885 bbl
	Total Volume Required	765 m^3	4810 bbl

B. Materials Required

Material	Unit	Unit Cost $	Qty	COST $
Bargain	M/T	119.47	25	2,986.75
Bentonite	M/T	265.00	33	8,745.00
Caustic Soda	25 kg	11.55	170	1,963.50
CMC LV	25 kg	39.90	140	5,620.00
Dextrid	50 lb	41.65	240	9,996.00
Gypsum	25 kg	4.65	700	3,255.00
Lignosulfonate	25 kg	16.35	175	2,861.25
Soda Ash	50 kg	14.52	11	159.72
XCD Polymer	50 lb	258.40	56	14,470.40
Total Cost				50,057.62
Cost per m^3			765	65.43
Cost per bbl			4810	10.41
Cost per meter			650	77.01

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III. 17 1/2" Hole Cont'd.

C. Contingency Materials

Sodium Bicarbonate	- 48
Con Det	- 18
Torq Trim	- 12
Mica F/C	- 150/150
Wallnut F/C	- 150/150
Kwik Seal	- 100

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RECOMMENDED MUD PROGRAM

Company	Statoil	**Date**	November, 1983
Well Name & Number	15/9-18	**Proposed Depth**	3700 m
Location	North Sea Norway		
Casing: Surf	13 3/8" at 1150 m	**Inter.** 9 5/8" at 2770 m	**Prod.**

RECOMMENDED MUD PROPERTIES

DEPTH FEET	WEIGHT LB/GAL	VISCOSITY SEC.	FILTRATE ML	TREATMENT
1165 to 2785	1.10 to 1.20	45 to 55	5 to 10	Gypsum/Lignosulfonate Utilize mud from the previous section

PV - ALAP
YP - 15-20
pH - 9.5-10.3
Excess Gyp - 3-5 ppb
MBT - 10-15

Remarks Maintain mud as previous section. Treat out cement contamination with Sodium Bicarbonate, should not have any problems drilling cement. Control mud weight with Bargain. Reduce API filtrate with Dextrid and CMC LV. Continue using all solids control equipment to reduce drill solids. Dilute with new mud as much as possible.

Estimated cost for mud materials: $ 70,080.53

Recommended Program Based Upon 15/9-18 prognosis

15/9-1, 2, 3, 4, 12, 14, 16

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OPERATING AREA
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INTERVAL DISCUSSION

IV. 12 1/4" Hole 1165 to 2785 meters 1620 meters to drill
9 5/8" Casing at 2770 meters

The 12 1/4" hole will be drilled using the same seawater/Gypsum/ Lignosulfonate system used in the 17 1/2" section.

In order to maintain mud properties large amounts of dilution will be necessary in upper clay sections. Drilled solids should not be allowed to build up. Mud weight will be raised with Bargain when needed. All dilution should be made with new mud as in previous section. Since the filtrate must be reduced some additions of Dextrid and CMC LV will need to be made in the active system. Also, in order to maintain YP above 20 it may be necessary to add XCD Polymer to active system. However, seawater should not be added directly to active system in order to insure good mud properties.

Previous wells have had to use Con det and Soltex to reduce tight hole. So these materials should be stocked as contingency items.

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MATERIALS USED PER CASING INTERVAL

IV. 12 1/4" Hole 1165 to 2785 meters 1620 meters to drill
9 5/8" Casing at 2770 meters

A. Volumes

1) Surface	79.5 m^3	600 bbl
2) Riser Volume	27 m	170 bbl
3) 13 3/8" Casing	80 m^3	505 bbl
4) 12 1/4" Hole + 25 %	154 m^3	970 bbl
5) Dilution 150 %	511 m^3	3211 bbl
Volume required	851.5 m^3	5360 bbl
Volumes saved from 17 1/2" Section	(186.5 m^3)	(1175 bbl)
New volume Required	665 m^3	4185 bbl

B. Materials Required

Material	Unit	Unit Cost $	Qty	Cost $
Bargain	MT	119.47	125	14,933.75
Bentonite	MT	265.00	28	7,420.00
Caustic	25 kg	11.55	228	2,633.40
CMC LV	25 kg	39.90	152	6,064.80
Dextrid	50 lb	41.65	335	13,952.25
Gypsum	25 kg	4.65	760	3,534.00
Lignosulfonate	25 kg	16.35	305	4,986.75
Soda Ash	50 kg	14.52	19	275.88
XCD Polymer	50 lb	258.40	63	16,279.20
Total Cost				70,080.53
Cost per m^3			665	105.38
Cost bbl			4185	16.75
Cost per meter			1620	43.20

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IV. 12 1/4" Hole Cont'd.

C. Contingency Materials

Sodium Bicarbonate	- 48
Con Det	- 24
Torq Trim	- 12
Mica F/C	- 150/150
Wallnut F/C	- 150/150
Kwik Seal	- 100

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RECOMMENDED MUD PROGRAM

Company	Statoil	**Date**	November 1983
Well Name & Number	15/9-18	**Proposed Depth**	3700 m
Location	North Sea Norway		

Casing: Surf 13 3/8" at 1150 m Inter. 9 5/8" at 2770 m Prod. 7" liner at 3700 m if required

RECOMMENDED MUD PROPERTIES

DEPTH FEET	WEIGHT LB/GAL	VISCOSITY SEC.	FILTRATE ML
2785 to 3700	1.20 to 1.42	45 to 55	5 to 10

TREATMENT

V. 8 1/2" Hole

GEL/LIGNOSULFONATE

Sea Water	
Caustic Soda	1- 2 ppb
Soda Ash	.25- 1 ppb
Prehydrated Bentonite	10-15 ppb
Lignosulfonate	4- 6 ppb
CC-16	2- 4 ppb
CMC LV	1- 2 ppb
BARGAIN	as required

PV - ALAP
YP - 12-15
HPHT - < 15
pH - 9.5-11
MBT - 10-30

Remarks Utilize the mud from the previous section. Treat out any cement contamination with Sodium Bicarbonate. Disperse the mud system as required. Utilize the solids control equipment and sea water dilution to maintain the PV as low as possible. Use prehydrated Bentonite and Lignosulfonate to maintain the YP at 12-15. Utilize CC-16 to maintain the HTHP Filtrate below 15 ml. Maintain the pH at 9.5 - 11 with Caustic Soda. Treat out hardness with Soda Ash.

Estimated cost for mud materials: $ 35,458.07

Recommended Program Based Upon 15/9-18 prognosis

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Deep Sea Bergen
15/9-18

INTERVAL DISCUSSION

V. 8 1/2" Hole 2785 to 3700 meters 915 meters to drill
7" Casing if required at 3700 meters

Drill out with the mud from the previous section. Treat out any cement contamination with Sodium Bicarbonate. Disperse the system as required to a sea water/Gel/Lignosulfonate system. Pilot test for material requirements prior to dispersing the system.

Maintain the PV as low as possible with the solids control equipment and sea water dilution.

Maintain the YP at 12-15 with pregydrated Bentonite and Lignosulfonate.

Maintain the HPHT Filtrate below 15 with CC-16.

Maintain the pH at 9.5 to 10.3 with Caustic Soda.

Treat out magnesium with Soda Ash.

Maintain the density at 1.20 - 1.42 as the hole dictates with BARGAIN and the centrifuge.

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MATERIALS USED PER CASING INTERVAL

V. 8 1/2" Hole 2785 to 3700 meters 915 meters to drill
7" Casing at 3700 meters if required

A. Volumes

1)	Surface Volume	95 m^3	600 bbl
2)	Riser Volume	27 m^3	170 bbl
3)	9 5/8" Casing Volume	101 m^3	635 bbl
4)	8 1/2" Open Hole	33 m^3	210 bbl
5)	Dilution Volume	237 m^3	1485 bbl
	Total Volume Required	493 m^3	3100 bbl
	Volume from 12 1/4" Section	(223 m^3)	(1405 bbl)
	New Volume Required	270 m^3	1695 bbl

B. Materials Required

MATERIAL	UNIT	UNIT COST $	QTY	COST $
BARGAIN	M/T	119.47	151	18,039.97
BENTONITE	M/T	265.00	18	4 770.00
Caustic Soda	25 kg	11.55	113	1,305.15
CC-16	50 lb	17.00	186	3,162.00
CMC LV	25 kg	39.90	56	2,234.40
Lignosulfonate	25 kg	16.35	338	5,526.30
Sod. Bicarb.	50 kg	16.69	13	216.97
Soda Ash	50 kg	14.52	14	203.28
Total Cost				35,458.07
Cost per m^3			270	131.33
Cost per barrel			1695	20.92
Cost per meter			915	38.75

C. Contingency Materials

Lime	80
Con Det	12
Torq Trim	12
Mica F/C	150/150
Mica F/C	150/150
Kwik Seal	100

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TOTAL MATERIAL CONSUMPTION

MATERIAL	PACKAGING	QUANTITY
BARGAIN	M/T	371
Bentonite	M/T	135
Caustic Soda	25 kg	511
CC-16	50 lb	186
CMC LV	25 kg	348
Dextrid	50 lb	575
Gypsum	25 kg	1460
Lignosulfonate	25 kg	818
Sodium Bicarbonate	50 kg	13
Soda Ash	50 kg	51
XCD Polymer	50 lb	119

Section Costs:

I.	30" Casing	$ 8,211.55
II.	20" Casing	$ 15,092.99
III.	13 3/8" Casing	$ 50,057.62
IV.	9 5/8" Casing	$ 70,080.53
V.	8 1/2" Hole	$ 35,458.07
Total Cost		$ 178,900.76
Cost per m^3		$ 69.26
Cost per bbl		$ 11.02
Cost per m		$ 50.01

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OPERATING AREA

RECOMMENDED RIG INVENTORY OF MATERIALS PER CASING INTERVAL

I. 36" Hole 123 to 188 meters 65 meters to drill
30" Casing at 188 meters

MATERIAL	PACKAGE	QUANTITY
Bargain	M/T	150
Bentonite	M/T	40
Soda Ash	50 kg	48

II. 26" Hole 188 to 515 meters 327 meters to drill
20" Casing at 500 meters

MATERIAL	PACKAGE	QUANTITY
Bargain	M/T	150
Bentonite	M/T	80
Soda Ash	50 kg	48
Caustic Soda	25 kg	80
Lignosulfonate	25 kg	120
Mica F/C	25 kg	150/150
Wallnut F/C	25 kg	150/150
Kwik Seal	40 lb	100

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RECOMMENDED RIG INVENTORY OF MATERIALS PER CASING INTERVAL

III. 17 1/2" Hole 515 to 1165 meters 650 meters to drill
13 3/8" Casing at 1150 meters

MATERIAL	PACKAGE	QUANTITY
Bargain	M/T	150
Bentonite	M/T	80
Caustic Soda	25 kg	240
CMC LV	25 kg	200
Dextrid	50 lb	336
Lignosulfonate	25 kg	240
Soda Ash	50 kg	48
XCD Polymer	50 lb	80
Sodium Bicarbonate	50 kg	48
Con Det	55 gal	18
Torq Trim	55 gal	12
Mica F/C	25 kg	150/150
Wallnut F/C	25 kg	150/150
Kwik Seal	40 lb	100

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RECOMMENDED RIG INVENTORY OF
MATERIALS PER CASING INTERVAL

IV. 12 1/4" Hole 1165 to 2785 meters 1620 meters to drill
9 5/8" Casing at 2770 meters

MATERIAL	PACKAGE	QUANTITY
Bargain	M/T	375
Bentonite	M/T	60
Caustic Soda	25 kg	320
CMC LV	25 kg	200
Dextrid	50 lb	420
Lignosulfonate	25 kg	360
Soda Ash	50 kg	48
XCD Polymer	50 lb	40
Sodium Bicarbonate	50 kg	48
Con Det	55 gal	24
Torq Trim	55 gal	12
Mica F/C	25 kg	150/150
Wallnut F/C	25 kg	150/150
Kwik Seal	40 lb	100

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RECOMMENDED RIG INVENTORY OF
MATERIALS PER CASING INTERVAL

V. 8 1/2" Hole 2785 to 3700 meters 915 meters to drill
7" Casing at 3700 meters if required

MATERIAL	PACKAGE	QUANTITY
Bargain	M/T	375
Bentontie	M/T	40
Caustic Soda	25 kg	160
CC-16	50 lb	240
CMC LV	25 kg	80
Lignosulfonate	25 kg	440
Sodium Bicarbonate	50 kg	48
Soda Ash	50 kg	48
Lime	25 kg	80
Con Det	55 gal	12
Torq Trim	55 gal	12
Mica F/C	25 kg	150/150
Wallnut F/C	25 kg	150/150
Kwik Seal	40 lb	100

Procedure for pH of the filtrate

9.27 Use the pH paper strips to measure the pH of the undiluted filtrate, or use a glass-electrode pH meter if suitable electrodes for the small quantities are available.

Interpretation — Basic Relationships

9.28 The interpretation of the filtrate alkalinities involves differences between certain alkalinity values. It is for this reason that special attention to accurate measurement of the various reagents is important in all steps of the procedure.

9.29 The composition of mud filtrates is often so complex that the interpretation of alkalinities in terms of assumed ionic components may be misleading. Any particular alkalinity value represents all of the anions which will react with the acid in the pH range over which that particular value is determined. Inorganic ions which may contribute to the alkalinity are: hydroxyl, carbonate, bicarbonate, borate, silicate, sulfide, and phosphate. Perhaps more serious in drilling fluids, the anionic organic thinners, fluid loss additives, and their degradation products may contribute a large portion of the alkalinity value. The organic materials make a particularly large contribution to the M_f alkalinity in *highly treated* muds. The application of the simple water analysis type of calculations using P_f and M_f is likely to be misleading in all except the simplest mud systems; it is therefore not recommended as general practice.

9.30 The procedure detailed in previous paragraphs is intended to reduce the major interferences, both inorganic and organic, and thus provide a better estimate of hydroxyl, carbonate, and bicarbonate alkalinities. Calculating the concentrations of these particular constituents does not make them true values; the composition is assumed. The calculations reflect the effects of those interfering components which may be present.

Condition: P_1 greater than P_2

9.31 The relationship between P_1 and P_2 is the key to interpretation. If P_1 is greater than P_2, then it is highly probable that there is free hydroxyl in the filtrate in addition to that which was added for the P_1 titration. When the filtrate contains sulfide, it is usually in the form of the hydrosulfide ion HS between pH 9 and 13. This procedure would include the HS as part of the calculated hydroxyl concentration in such systems. If the filtrate contains free hydroxyl then it cannot contain bicarbonate.

9.32 The purpose of the barium chloride is to remove carbonate, as insoluble barium carbonate, so that it will not react in the back titration for P_1. It is assumed that the barium removes only carbonate. It would also remove phosphate, silicate, and aluminate if they were present, and it could remove organic materials, such as quebracho, lignite, etc. that form insoluble barium salts at that pH. These materials contribute to the calculated value of the carbonate concentration.

9.33 If it is assumed that the phenolphthalein alkalinity P_f is made up of the free hydroxyl plus the carbonate alkalinities then the carbonate alkalinity can be calculated from P_f and $(P_1 - P_2)$.

Condition: P_2 greater than P_1

9.34 When P_2 is greater than P_1, there is no free hydroxyl in the filtrate and it is possible for bicarbonate to be present. The difference between P_2 and P_1 represents the *hydroxyl demand* of the filtrate. Part of the demand can be for the conversion of bicarbonate to carbonate and its removal by the barium. Another part could be for the reaction with other components removed by the barium. Still another part could be for the reaction with organic components to make a net raise in pH to 8.3. If it is assumed that the total hydroxyl demand is for reaction with bicarbonate, then the bicarbonate concentration can be estimated from $P_2 - P_1$. The P_f consists entirely of carbonate alkalinity in this case.

Calculations

9.35 Within the limitations outlined previously, and noting that the composition is assumed and not proven by other tests, the various ionic alkalinities can be calculated as follows:

When $P_1 > P_2$,

Hydroxyl Alkalinity $= P_1 - P_2$

Carbonate Alkalinity $= 2[P_f - (P_1 - P_2)]$

When $P_2 > P_1$,

Bicarbonate Alkalinity $= P_2 - P_1$

Carbonate Alkalinity $= 2P_f$

Confirmation

9.36 More extensive tests on the filtrate would be necessary to confirm the composition suggested by this interpretation of the filtrate alkalinities.

HARDNESS

Equipment

9.37 The following materials are required to determine the hardness of mud filtrates or make-up waters as calcium carbonate by the versenate method:

a. Versenate solution: 0.01 molar EDTA ($C_{10}H_{14}N_2O_8Na_2 2H_2O$); standardized, 1 cm³ = 1 mg $CaCO_3$.

b. Buffer solution: 7.0 g ammonium chloride and 970 cm³ ammonium hydroxide (15 N) made up to 1000 cm³ with distilled water.

c. Hardness indicator solution: "Calmagite" 1-HO-4-CH_3-C_6H_3—N:N-$C_{10}H_5$-2-OH-4-SO_3H) 1 g per 1000 cm³ distilled water.

d. Titration vessels: 100-150 cm³, preferably white.

e. Two graduated pipettes: one 5-cm³ and one 10-cm³.

f. Graduated cylinder: 50 cm³.

g. Distilled water.

h. Stirring rod.

Procedure

9.38 To approximately 50 cm³ of distilled water in a titration vessel, add about 2 cm³ of hardness buffer solution and sufficient hardness indicator solution to give a strong color (2 to 6 drops). If a red color develops, indicating hardness in the distilled water, add versenate solution dropwise until the water first turns to blue. Do not include this volume of versenate solution in calculating hardness of the sample.

9.39 Measure one or more cm³ of sample into the titrating vessel. A wine color will develop if calcium or magnesium is present. Add versenate solution, stirring continuously, until the sample first turns to blue. In filtrates colored reddish-brown by chemical thinners, the masking effect of the thinner tint may cause the color change to be from brownish-purple to slate gray.

Calculations

9.40 Calculate hardness of the sample by Equation 9.6, 9.7, and 9.8.

$$\frac{CaCO_3,\ mg/1000\ cm^3}{} = \frac{(cm^3\ standard\ versenate)\ (1{,}000)}{cm^3\ sample} \quad (9.6)$$

$$\text{Calcium, mg/1000 mc}^3 = (0.4)\ (\text{calcium carbonate, mg/1000 cm}^3) \quad (9.7)$$

$$\text{Grains per gallon} = (0.0583)\ (\text{ppm}) \quad (9.8)$$

NOTE: *To convert to ppm, divide the value in mg per 1000 cm³ by the specific gravity of the solution.*

CALCIUM SULFATE

Equipment

9.41 The following materials are required to determine the calcium sulfate content of mud by the versenate method.

a. Versenate solution: 0.01 molar EDTA ($C_{10}H_{14}N_2O_8Na_2 \cdot H_2O$); standardized, 1 cm³ = 1 mg $CaCO_3$.
b. Buffer solution: 7.0 g ammonium chloride and 970 cm³ ammonium hydroxide (15 N) made up to 1000 cm³ with distilled water.
c. Hardness indicator solution: "Calmagite" (1-HO-4-CH_3-C_6H_3—N:N-$C_{10}H_5$-2-OH-4-SO_3H) 1 g per 1000 cm³ distilled water.
d. Titration vessel: 100-150 cm³, preferably white.
e. Two graduated pipettes: one 5-cm³ and one 10-cm³.
f. Graduated cylinder: 50 cm³.
g. Distilled water.
h. Stirring rod.

Procedure

9.42 Add 5 cm³ of mud to 245 cm³ of distilled water. Stir the mixture for 15 minutes and then filter through hardened filter paper (Par. 3.3). Discard the cloudy portion of filtrate.

9.43 Titrate 10 cm³ of the clear filtrate (Par. 9.42) to the versenate end point, as described in Par. 9.38, 9.39, and 9.40.

9.44 Titrate 1 cm³ of filtrate of the original mud (obtained as described in Par. 3.1-3.10) to the versenate end point.

9.45 Report the calcium sulfate content in lb per bbl*, calculated as follows:

$$\text{Total calcium sulfate, lb per bbl*} = 2.38\ V_t \quad (9.9)$$

$$\text{Undissolved calcium sulfate, lb per bbl*} = 2.38\ V_t - 0.48\ V_f F_w \quad (9.10)$$

Where: V_t = cm³ of versenate solution to titrate 10 cm³ of the filtrate of the diluted mud, obtained in Par. 9.42.

V_f = cm³ of versenate solution to titrate 1 cm³ of filtrate of the original mud.

F_w = volume fraction of water in the mud (Par. 9.13).

CALCIUM: QUALITATIVE METHOD

Equipment

9.46 The following materials are required to determine qualitatively the presence of calcium:

a. Test tube.
b. Dropper bottle of saturated solution of ammonium oxalate.

Procedure

9.47 Place 1 to 3 cm³ of filtrate in test tube. Add a few drops of saturated ammonium oxalate. The formation of a white precipitate indicates the presence of calcium. Record as light, medium, or heavy.

**kg per m³ may be obtained by multiplying lb per bbl by 2.85.*

CALCIUM: QUANTITATIVE METHOD (TENTATIVE)

Principle

9.48 When EDTA (ethylenediaminetetraacetic acid or its salt) is added to water containing both calcium and magnesium, it combines first with calcium. Calcium can be determined with EDTA when the pH of the sample is sufficiently high, so that magnesium is precipitated as the hydroxide, and an indicator specific for calcium is used. Several indicators will give color changes when all of the calcium has been complexed by EDTA at a pH of 12 to 13. An end point obscured by dark organic components can be remedied by oxidizing with a reagent such as a hypochlorite.

Reagents and Equipment

9.49 The following materials are required to determine calcium content of mud by the versenate method.

a. EDTA Solution (Versenate): 0.01 molar, EDTA ($C_{10}H_{14}N_2O_8Na_2 \cdot 2H_2O$); standardized, 1 cm³ = 1 mg $CaCO_3$, 1 cm³ = 400 mg/1000 cm³ calcium.