15/12-3

APPENDIX DRILLING PROGRAM

CASING CEMENT DATA AND CALCULATIONS

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CASING CEMENT DATA AND CALCULATIONS, 30" CASING.

GENERAL: The volume is calculated on the basis of the theoretical hole volume, and the casing to be cemented to sea bed with 150% excess volume on open hole.

WELL DATA:

Depth kb-sea bed	111	m
Depth kb-last shoe	-	m
Depth kb-casing set point	171	m
Open hole dia	36"	
Annulus capacity, cased hole	-	l/m
Annulus capacity, open hole	200.6	l/m
Internal capacity, 30" casing..1".grade	397.2	l/m
Mud weight	1.06	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	-	bar
Est. bottom hole static temp. (BHST)	27	^oC
Est. bottom hole circulating temp. (BHCT)	27	^oC
Est. formation integrity	-	bar/m

CEMENT SLURRY DATA, STAGE:

		FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION		CLASS G + 3.2 l/100 kg A3-L	CLASS G + 1 kg/100 kg $CaCl_2$
Mix water	l/100 kg	93.9 sea	44.7 sea
Total liquid	l/100 kg	97.1	
Slurry weight	g/cm^3	1.56	1.91
Slurry yield	l/100 kg	129	77
TEST DATA @ BHCT			
Thickening time @ BHHP, hr: min		6:30	4:00
Crit. Turb. Flow rate: m/s (l/min)			
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength,	N/mm^2, 12 hr	30	
	N/mm^2, 24 hr	70	
REMARKS			
Max rate plug flow:		4.2 m^3/min	
Fann VG readings: 600/300/200/100		42/33/29/25	

Volume calculations:

Annular volume: 0.2006 m^3/m x (171-111)m	=	12.0 m^3
3 m plug at shoe: 0.3972 m^3/m x 3 m	=	1.2 m^3
150% excess in open hole:	=	18.0 m^3
Total slurry volume:		31.2 m^3

Lead/filler slurry: Class G cement + 3.2 l/100 kg A-3L mixed with seawater at 1.56 kg/l.

16500 kg cement equivalent to 21.2 m^3 slurry.

Tail in slurry: Class G cement + 1 kg/100 kg $CaCl_2$ mixed with seawater at 1.91 kg/l.

13000 kg cement equivalent to 10 m^3 slurry.

Job preparation.

Total liquid lead slurry: 16500 kg x 97.1 l/100 kg	= 16.022 l
Volume av A-3L in each displ.tank: 1590 x $\frac{3.2}{97.1}$	= 52.4 l
Total volume of A-3L needed: 16500 kg x 3.2 l/100 kg	= 528 l
Total liquid tail in slurry: 13000 kg x 44.7 l/100 kg	= 5811 l
Amound $CaCl_2$ needed: 13000 kg x 1 kg/100 kg	= 130 kg

CASING CEMENT DATA AND CALCULATIONS, 20" CASING.

GENERAL: The cement volume is calculated on the basis of the theoretical annulus volume, and the casing to be cemented to sea bed with 100% excess on open hole volume.

WELL DATA:

Depth kb-sea bed	111	m
Depth kb-last shoe	171	m
Depth kb-casing set point	550	m
Open hole dia	26"	
Annulus capacity, cased hole	194.5	l/m
Annulus capacity, open hole	139.4	l/m
Internal capacity, 20" casing (94 lb/ft)	185.3	l/m
Mud weight	1.06	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	77.8	bar
Est. bottom hole static temp. (BHST)	36	°C
Est. bottom hole circulating temp. (BHCT)	31	°C
Est. formation integrity	0.147	bar/m

CEMENT SLURRY DATA, STAGE:

	FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION	CLASS G + 3.2 l/100 kg A-3L	CLASS G neat
Mix water l/100 kg	93.9 sea	44.0 sea
Total liquid l/100 kg	97.1	44.0
Slurry weight g/cm^3	1.56	1.91
Slurry yield l/100 kg	129	76
TEST DATA @ BHCT		
Thickening time @ BHHP, hr: min	6:00	4:35
Crit. Turb. Flow rate: m/s (l/min)		
Fluid loss, ml/30 min, 70 bar		
TEST DATA @ BHST, BHHP		
Compr. strength, N/mm^2, 12 hr	30	170
N/mm^2, 24 hr	67	310
REMARKS		
Max. rate plug flow	3.8 m^3/min	4.3 m^3/min
Fann VG readings: 600/300/200/100	52/42/37/32	129/90/76/62

20" casing:
Volume calculations:

Annular volume: 0.1394 m^3/m x (550-171)m	=	52.8 m^3
Volume between casings: 0.1945 m^3/m x (171-111)m	=	11.7 m^3
10 m plug at shoe: 0.1853 m^3/m x 10 m	=	1.9 m^3
100% excess in open hole	=	52.8 m^3
Total cement slurry volume:		119.2 m^3

Lead slurry: Class G cement + 3.2 l/100 kg A-3L mixed with seawater at 1.56 kg/l.

85000 kg cement equivalent to 109.3 m^3 slurry.

Tail in slurry: Class G cement mixed with seawater at 1.91 kg/l.

13000 kg cement equivalent to 9.9 m^3 slurry.

Height of tail in slurry: (9.9-1.9)m^3/0.1394 m^3/m = 57 m

Hydrostatic head lead slurry: 0.153 bar/m (550-111-57)m	= 58.4 bar
Hydrostatic head tail in slurry: 0.188 bar/m x 57 m	= 10.7 bar
Hydrostatic head sea water: 0.101 bar/m x (111-25)m	= 8.7 bar
Total hydrostatic pressure at 20" csg shoe:	77.8 bar

Equivalent pressure gradient: 77.8 bar/550 m = 0.142 bar/m

Estimated formation integrity: 0.147 bar/m

CASING CEMENT DATA AND CALCULATIONS, 13 3/8" CASING.

GENERAL: The cement volume is calculated on the basis of the theoretical annulus volume, and the casing to be cemented 100 m into 20" casing with 25% excess on open hole volume.

WELL DATA:

Depth kb-sea bed	111	m
Depth kb-last shoe	550	m
Depth kb-casing set point	2150	m
Open hole dia	17½"	
Annulus capacity, cased hole	94.5	l/m
Annulus capacity, open hole	64.4	l/m
Internal capacity,13 3/8"casing	77.2	l/m
Mud weight	1.10	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	232	bar
Est. bottom hole static temp. (BHST)	78	^{o}C
Est. bottom hole circulating temp. (BHCT)	52	^{o}C
Est. formation integrity	0.177	bar/m

CEMENT SLURRY DATA, STAGE:

		FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION		CLASS G + 3.55 l/100 kg A-3L + 0.27 l/100 kg R-14L	CLASS G + 0.89 l/100 kg R-12L
Mix water	l/100 kg	92.6 sea	43.3 fresh
Total liquid	l/100 kg	96.4	44.2
Slurry weight	g/cm^3	1.56	1.90
Slurry yield	l/100 kg	128	76
TEST DATA @ BHCT			
Thickening time @ BHHP, hr: min		6:22	5:32
Crit. Turb. Flow rate: m/s (l/min)			
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength, N/mm^2, 12 hr			18
N/mm^2, 24 hr		30	323
REMARKS:			
Max. rate plug flow		2.1 m^3/min	4.8 m^3/min
Fann VG readings: 600/300/200/100		55/47/42/37	97/63/51/39

13 3/8" casing, volume calculations:

Annular volume: 0.0644 m^3/m x (2150-550)m	=	103.0 m^3
Volume between casings: 0.0945 m^3/m x 100 m	=	9.5 m^3
24 m plug at shoe: 0.0772 m^3/m x 24 m	=	1.9 m^3
25% excess in open hole:	=	25.8 m^3
Total cement slurry volume:		140.2 m^3

Lead slurry: Class G cement + 3.55 l/100 kg A-3L + 0.27 l/100 kg R-14L mixed with sea water at 1.56 kg/l.

101800 kg cement equivalent to 130.2 m^3 slurry.

Tail in slurry: Class G cement + 0.89 l/100 kg R-12L mixed with fresh water at 1.90 kg/l.

13000 kg cement equivalent to 10 m^3 slurry.

Job preparation:

Total liquid lead slurry: 101800 kg x 96.4 l/100 kg	= 98135 l
Volume of A-3L in each displ.tank: 1590 l x $\frac{3.55}{96.4}$	= 58.6 l
Total volume A-3L needed: 101800 kg x 3.55 l/100 kg	= 3614 l
Volume of R-14L in each displ.tank: 1590 l x $\frac{0.27}{96.4}$	= 4.5 l
Volume of R-14L needed: 101800 kg x 0.27 l/100 kg	= 275 l
Total liquid tail in slurry: 13000 kg x 44.2 l/100 kg	= 5746 l
Volume of R-12L in each displ.tank: 1590 x $\frac{0.89}{44.2}$	= 32.0 l
Volume of R-12L needed: 13000 kg x 0.89 l/100 kg	= 115.7 l

Max height tail in slurry: (10-1.9) m^3/0.0644 m^3/m = 126 m

Volume of lead slurry to 20" shoe: 0.0644 m^3/m
0.0644 m^3/m x (2150 - 550 - 126)m = 94.9 m^3

Max volume above 20" csg. shoe: 130.2 m^3 - 94.9 m^3 = 35.3 m^3

Max height above 20" csg shoe: 35.3 m^3/0.0945 m^3/m = 374 m

Max height lead slurry: (2150-550-126+374)m = 1848 m

Hydrostatic head slurry: 0.153 bar/m x 1848 m = 282.7 bar
Hydrostatic head tail in slurry: 0.186 bar/m x 126 m = 23.4 bar
Hydrostatic head mud: 0.108 bar/m x (2150-1848-126)m = 19.0 bar

Total hydrostatic pressure at 13 3/8" csg. shoe 325.1 bar

Equivalent pressure gradient: 321.5 bar/2150 m = 0.151 bar/m

Estimated formation integrity: 0.177 bar/m

Hydrostatic head at 20" csg. shoe:
0.153 bar/m x 374 m + 0.108 bar/m (550 - 374)m = 76.2 bar/m

Equivalent pressure gradient at 20" csg shoe:
76.2 bar/550 m = 0.139 bar/m

Estimated formation integrity: 0.147 bar/m

CASING CEMENT DATA AND CALCULATIONS, 9 5/8" CASING.

GENERAL: The cement volume is calculated on the basis of the theoretical annulus volume, and the casing to be cemented 100 m into the 13 3/8" casing with 25% excess on open hole.

WELL DATA:

Depth kb-sea bed	111	m
Depth kb-last shoe	2150	m
Depth kb-casing set point	3625	m
Open hole dia	12 1/4"	
Annulus capacity, cased hole	30.1	l/m
Annulus capacity, open hole	28.9	l/m
Internal capacity, casing 53.5 lbs/ft	36.9	l/m
Mud weight	1.40	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	498	bar
Est. bottom hole static temp. (BHST)	113	°C
Est. bottom hole circulating temp. (BHCT)	84	°C
Est. formation integrity	0.196	bar/m

CEMENT SLURRY DATA, STAGE:

		CEMENT SLURRY
CEMENT SLURRY COMPOSITION		CLASS G CEMENT +22% A-5(NaCl) by weight of seawater +2.66 l D-19L per 100 kg cement +1.07 l R-12L per 100 kg cement
Mix water	l/100 kg	43.0 seawater (without salt) 47.5 seawater + salt
Total liquid	l/100 kg	51.2 (seawater + salt + additives)
Slurry weight	g/cm^3	1.90
Slurry yield	l/100 kg	82.9
TEST DATA @ BHCT		
Thickening time @ BHHP, hr: min		5:40
Crit. Turb. Flow rate: m/s (l/min)		0.41 (720)
Fluid loss, ml/30 min, 70 bar		330
TEST DATA @ BHST, BHHP		
Compr. strength, bar, 12 hr		253
bar, 24 hr		282
REMARKS:		
Max rate plug flow, m/s (l/min)		0.04 (60)
Fann VG readings: 600/300/200/100		46/20/13/7
Pump 20 bbls of mixing water ahead of cement slurry as a preflush		

Volume calculations:

Annular volume: 0.0289 m^3/m x (3625 - 2150)m	=	42.6 m^3
24 m plug at shoe: 0.0369 m^3/m x 24 m	=	0.9 m^3
Volume between casings: 0.0301 m^3/m x 100 m	=	3.0 m^3
25% excess in open hole:	=	10.7 m^3
Total cement slurry volume:		57.2 m^3

Cement slurry: Class G cement + 22% A.5 (NaCl) by weight of seawater + 2.66 l D-19L per 100 kg cement + 1.07 l R-12L per 100 kg cement mixed with seawater at 1.90 kg/l.

69000 kg cement equivalent to 57.2 m^3 slurry.

Pump 20 bbls of the mixing water ahead of the cement slurry (ahead of bottom plug as a preflush.

NOTE: The A-5 (NaCl-salt) should be premixed in seawater using a mud pit. The fluid loss additive and retarder to be added continuously during the cement job.

Job preparation:

Premix the A-5 (NaCl-salt) in a mud pit:

Required amount of seawater per 100 kg cement: 43 l

Required amount of salt per m^3 seawater:
1.0 m^3 x 1.025 kg/l x 0.22 = 225.5 kg

Total amount of seawater: 43 l/100 kg x 69000 kg = 29670 l

Amount of salt needed: $\frac{225.5 \text{ kg} \times 29.67 \text{ m}^3}{1.0 \text{ m}^3}$ = 6690 l

Volume of salt: 6690 kg/2.16 kg/l = 3097 l

Volume of salt + seawater: 29670 l + 3097 l = 32767 l

Number of displacement tanks needed:

$$\frac{69000 \text{ kg} \times 51.2 \text{ l}}{100 \text{ kg} \times 1590 \text{ l per tank}} = 22.2$$

Volume of premixed saltwater in each tank: $\frac{32767 \text{ l}}{22.2}$ = 1476 l

Volume of D-19L in each tank: $\frac{69000 \text{ kg} \times 2.66 \text{ l}}{100 \text{ kg} \times 22.2}$ = 82.7 l

Volume of R-12L in each tank: $\frac{69000 \text{ kg} \times 1.07 \text{ l}}{100 \text{ kg} \times 22.2}$ = 33.3 l

Max height of cement above 13 3/8" casing shoe:

$100 + 10.7 \text{ m}^3/0.0301 \text{ m}^3/\text{m}$ = 455 m

Hydrostatic head cement: 0.186 bar/m x (3625-2150+455)m = 359.0 bar

Hydrostatic head mud: 9.137 bar/m x (3625 - 1930)m = 232.2 bar

Hydrostatic pressure at 9 5/8" csg shoe 591.2 bar

Equivalent pressure gradient: 591.2 bar/3625 m = 0.163 bar/m

Estimated formation integrity = 0.196 bar/m

Hydrostatic pressure at 13 3/8" csg. shoe:

0.186 bar/m x 455 m + 0.137 bar/m (2150 - 455)m = 316.8 bar

Equivalent pressure gradient: 316.8 bar/2150 m = 0.147 bar/m

Estimated formation integrity: 0.177 bar/m

CASING CEMENT DATA AND CALCULATIONS, 7" LINER.

GENERAL: The cement volume is calculated on the basis of the theoretical annulus volume, and the liner to be cemented 150 m into the 9 5/8" casing with 25% excess on open hole.

WELL DATA:

Depth kb-sea bed	111	m
Depth kb-last shoe	3625	m
Depth kb-casing set point	4680	m
Open hole dia	8½"	
Annulus capacity, cased hole	12.04	l/m
Annulus capacity, open hole	11.73	l/m
Internal capacity, 7" casing.32.1lbs/ft	18.82	l/m
Mud weight	1.90	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	892.2	bar
Est. bottom hole static temp. (BHST)	138	°C
Est. bottom hole circulating temp. (BHCT)	113	°C
Est. formation integrity	0.199	bar/m

CEMENT SLURRY DATA, STAGE:

		CEMENT SLURRY	
CEMENT SLURRY COMPOSITION		CLASS G +22.7% A-5 by weight of sea water +35% D-8C by weight of cement +0.62% R-14L per 100 kg cement	
Mix water	l/100 kg	43.0 seawater	
Total liquid	l/100 kg	43.6	
Slurry weight	g/cm^3	2.03	
Slurry yield	l/100 kg	93.3	
TEST DATA @ BHCT			
Thickening time @ BHHP, hr: min		5:35	
Crit. Turb. Flow rate: m/s (l/min)		1.32 (940)	
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength,	bar , 24 hr	790	
	bar , 72 hr	752	
	12 hr	110°C 344	
REMARKS:			
Max rate plug flow , m/s (l/min)		0.19 (130)	
Fann VG readings: 600/300/200/100		62/31/24/13	
Pump 20 bbls RSB spacer ahead of cement slurry			

Volume calculations:

Annular volume: 0.01173 m^3/m x (4680-3625)m	=	12.4 m^3
24 m plug at shoe: 0.01882 m^3/m x 24 m	=	0.5 m^3
Annular volume cased hole: 0.01204 m^3/m x 150 m	=	1.8 m^3
25% excess volume in open hole	=	3.1 m^3
Total cement slurry volume	=	17.8 m^3

Cement slurry: Class G cement + 22.7% A-5 (NaCl) by weight of seawater + 35% D-8C (sand) by weight of cement + 0.62 l R-14L (retarder) per 100 kg cement mixed with seawater at 2.03 kg/l.

19100 kg cement equivalent to 17.8 m^3 slurry.

The A-5 and D-8C will be dryblended into the cement onshore.

Pump 20 bbls of RSB spacer ahead of the cement. Specific gravity of spacer to be 1.98. (see attached mixing procedure)

Dryblended cement:

Cement:		19100 kg
D-8C (sand):	$\frac{19000 \text{ kg} \times 0.35}{100}$	= 6685 kg
A-5 (salt):	$\frac{43.0 \times 1.025 \times 0.227 \times 19100}{100}$	= 1911 kg
Total weight dryblended cement:		27696 kg

Seawater needed: 19100 kg x 43.0 l/100 kg	=	8213 l
R-14L retarder needed: 19100 kg x 0.62 l/100 kg	=	118.4 l
Total amound of liquid:		8331 l

Number of displacement tanks: $\frac{8331\ l}{1590\ l/tank}$ = 5.2

Volume of R-14L in each displacement tank: 22.8 l

Max height of cement above 9 5/8" shoe:

150 m + 3.1 m^3/0.0236 m^3/m = 281 m

Max height of spacer: 3.2 m^3/0.0236 m^3/m = 136 m

Hydrostatic head of cement:

0.119 bar/m x (4680 - 3625 + 281) m = 265.9 bar

Hydrostatic head of spacer: 0.194 bar/m x 136 m = 26.4 bar

Hydrostatic head of mud:

0.187 bar/m x (3625 - 282 - 136)m = 599.9 bar

Max hydrostatic head at 7" liner shoe: 892.2 bar

Equivalent pressure gradient: 892.2 bar/4680 m = 0.191 bar/m

Estimated formation integrity: 0.199 bar/m

Max. hydrostatic head at 9 5/8" csg. shoe:

0.199 bar/m x 281 m + 26.4 bar + 0.187 bar/m x (3625 - 136 - 281)m = 682.2 bar

Equivalent pressure gradient: 682.2 bar/3625 m = 0.188 bar/m

Estimated formation integrity: 0.196 bar/m

SPACER PROPERTIES:

Weight of spacer	:	1.98 g/cm^3
Diesel/water ratio	:	60/40
Concentration of RSB	:	5.7 liter per bbl of spacer
Density at RSB	:	0.94 g/cm^3

MATERIALS REQUIRED FOR 20 BBLS OF SPACER:

Fresh water	:	757 liter
RSB	:	114 liter
Diesel	:	1305 liter
Barite	:	4349 kg

MIXING PROCEDURE:

1. Fill the tank with the proper amount of water.
2. Add the required amount of RSB while circulating.
3. Add the diesel required.
4. Then add the required amount of barite as weighting material.