statoil

GRAVEL PACK OPERATION
OF
WELL 31/3-1 ON THE TROLL FIELD

BRØNNTEKNIKK OG UNDERVANNSKOMPLETTERING

ROY RUSÅ OG VIDAR FJELLSTAD

1. 1984

Den norske stats oljeselskap a.s

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Gradering

Oppdragsgiver

LET, ROALD RIISE

Undertittel

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Tittel

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JAN. 1984

Utarbeidet		Kontrollert		Godkjent	
Dato		Dato	Gruppeleder	Dato	Seksjonsleder
1/84	Vidar Fjellstad Roy Rusa	12/1-84	Roy Rusa		

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Dato		Dato	Gruppeleder	Dato	Seksjonsleder

9.03.21

This report points primarily on highlights from the gravelpack completion of the two zones in well 31/3-1: 1519.0 to 1529.0 m and 1373.0 to 1383.0 m.

A brief review of the gravelpack operation is given in "Sequence Of Events" followed by Dowells 4 pump chart used in the actual operation.

Detailed drawings of the two gravelpack assemblies used, sieve analysis and volume calculation of the slurries follow next.

The report ends off with gas flow data from the two zones after having gravelpacked.

WELL31/3-1 GRAVEL PACK OPERATION (151 .0-1529.0,)

SEQUENCE OF EVENTS

13 SEPTEMBER 1983

Operation: Perforating and testing the well.

11.25 Dropped the bar

11.28 Guns detonated. Perforated the test interval and commenced to back-surge

11.29 Recovered 1.6 m^3 .Reduced choke to 28/64"

11.40 Gas to surface

12.05 Shut in. Leak in chiksan

12.34 Reopened on 28/64" choke

13.26 Shut in. Leak in chiksan

13.56 Reopened well using heater chokes

14.00 Flowed through separator, Adjusted choke sizes to obtain 28000 m^3/D

15.32 Adjusted choke to obtain 42000 m^3/D

16.00 Shut in at PCT and choke manifold

18.00 Filled the string with 1.16 SG brine . Opened the PCT valve and bull headed the well back to the formation. Opened the SSARV valve and reversed out.

22.00 Unseated the packer. Bull headed the gas below the packer back to the formation. Observed the well for 10 min. OK.

23.00 Circultated the long way until the brine was cleaned and the gas circulated out.

05.00 Spotted 0.35 m^3 $CaCO_3$ pill outside the SSARV and observed the well. The brine dropped 1.6 m^3 in the riser and it became static.

06.00 Pulled out of the hole with the test string.

12.00 Laid down the test tool.

14 SEPTEMBER. 1983

14.30 Started to pick up "bottom hole assembly" as per program. See fig 1.

18.00 Completed to make up the "bottom hole assembly".
Started to run into the hole with 8 stands 4 3/4 drill collar and 3 1/2 drill pipe, 1.32 SG brine diluted to 1.16 SG.
Mixed 11.4 m^3 15% HCL
Made up 2 x 4.0 m^3 gel pills.
Picked up 77 sacks 20-40 mesh gravel.

21.30 Picked up circulating head assembly.

21.47 Tested Dowell lines to low torque valve on circulating head to 207 BARG. for 10 min. OK!

22.02 Tested upper and lower closed kelly cock to 207 barg. for 10 min. OK.

22.12 Start to run into the hole, test two stands.
Down weight: 88000 DaN
Up weight : 88000 DaN

22.50 Located the F-1 packer at 1533.0 m. 1000 DaN to push through the collet. 4000 DaN to pull out.
Landed in the F-1 packer and spaced out the drill pipe to ca. 4 m above drillfloor.

23.05 Broke the circulation by pumping down drill pipe, taking returns through the crossover tool. Circulated 6.4 m^3 at 0.28 m^3/min. 14 BARG pump pressure. OK.

23.25 Opened upper kelly cock and dropped packer setting ball (1 7/16" OD.).

15 SEPTEMBER 1983

00.05 Pressured drill pipe in 35 BARG increments. Hydraulic setting tool sheared at 62 barg. The seat sheared at 124 BARG.

00.11 Pulled with 11000 DaN to check packer setting.

00.25 Closed lower annular valve. Opened Dowell connection at the rig floor. Pressureized to 34 BARG, negative. Opened annular valve. Pumped 1.6 m^3 down choke line to flush lines. Closed lower annular valve. Pressured to 34 BARG. for 6 min. OK. Started to mix 77 sacks of gravel into paddle mixer tank.

01.00 Desconnected flexihose at circulating head. Rotated 12 turns to the right. Released crossover tool from the packer.
Sat down with 15000 DaN to locate position 1, squeeze position.
Picked up 1.5 m from neutral point.
Came down and located position 2, circulating position, 0.9 m above squeeze position.
Pushed the collet through at 11500 DaN. Picked up 3.5 m.
Came down and located position 3, reverse postion, 2.7 m above position 2.
Pushed collet through at 7000 DaN and relocated position 2, circulating position.
Made up flexihose to circulating head.
Tested surface lines to kelly cock valves 207 BARG for 5 min. OK.
Started circulating slowly and stabilized at 0.16 m^3 per min. at 14 BARG. Total 3.5 min. Attempted to increase rate to 0.24 m^3 per min. but the pressure rose to 32 BARG. See pump chart nr. 1.
Stopped pumping. The pressure dropped slowly. Total 0.32 m^3 pumped. Decided to reestablish the gravel pack

positions. Bled the pressure and relocated postion 1., Squeeze. The pressure increased to ca. 34 BARG when lowering the string. Picked up into position 3, reverse position to check for open work string. (pumping down the drill pipe, out the crossover tool and up the annulus).
Pumped 1.4 m^3. The returns taken over shaker. Lines found OK. Moved into position 1, squeeze to achieve injection and remove eventual plugging of the lower screen. Increased the pressure slowly to 71 BARG. Negative, and bled back immediately in order not to fracture the formation. The valve was closed at the pump outlet and the pressure dropped slowly. Picked up 3 m (past position 3, reverse) and moved down into position 2, circulating in order to assure that the closing sleeve was open. (closing sleeve closes when moving up from position 2 to 3 and opens when moving in the opposite direction. Broke circulation at low rate and maintained 0.13 m^3 per min circulating rate at ca. 9 BARG. Circulated totally for ca. 10 min. Attempted slowly to incrase the rate, but pressure immediately built to 46 BARG. Total volume pumped 0.4 m^3. Pressure bled off. Picked up into position 3, reverse and pumped 1.6 m^3 per min. (pumped down drill pipe, out crossover tool and up annulus).

03.15 Pumped 0.8 m^3 1.25 SG pill in the drill pipe. Prepared to pull out of the hole. Spotted new pill since the well was unbalanced.

RIH w bit and scraper, condition brine.

16. SEPTEMBER 1983

20.30 Started to run into the hole with the "bottom hole assembly".

22.40 Spaced out the wash pipe, made up bottom hole assembly and ran into the hole with 8 stands 4 3/4 drill collars and 3 1/2 drill pipe.

17. SEPTEMER 1983

01.45 Picked up circulating head and landed in the F-1 packer. Pushed thrcugh at ca. 1000 DaN. pulled through at ca 5000 DaN.

01.55 Flushed surface lines. Tested kelly cocks to 207 BARG for 10 min. OK.

02.10 Pressure tested the low torque valve on the flowhead to 207 BARG for 10 min OK. Stabbed into the F-1 packer and landed with 2000 DaN.

02.27 Broke criculation
0.16 m^3 per min (1 BPM), 12 BARG (170 PSIG)
0.24 " " " (1.5 BPM), 15 BARG (220 PSIG)
Stabilized at:
0.25 m^3 per min (1.6 BPM), 14 BARG (200 PSIG)
Total volume pumped 6.4 m^3 (40 BBl)

03.25 Opened upper cock and dropped the ball.

03.55 Pressureized the drill pipe slowly with brine in 34 BARG (500 PSIG) increments holding each increment for 1 min. The seat sheared at 203 BARG (2950 PSIG).
Pulled 11000 DaN on packer to check setting. OK.

04.33 Closed lower annular valve and opened for observation point at rig floor. Pressurized annulus and tested packer element sealing for 34 BARG (500 PSIG) for 10 min. Opened annular valve. Rotated 10 turns to the right and released the crossover tool form the pakcer. Sat back down and located squeeze position 1. Picked up ca 1.5 m from neutral and located circulating position 2. Picked up further ca. 3.0 m and located reverse postion 3 ca. 3000 and 4000 DaN squeezed to push through collets. Relocated circulating position 2.

05.00 Established criculation rates versus pump pressure

6.08 m^3/min (0.5 BPM) -	3.45 BARG	(50 PSI)	4 BBL
0.16 m^3/min (1.0 BPM) -	7.5 BARG	(100 PSI)	6 BBL
0.32 m^3/min (2.0 BPM) -	17 BARG	(250 PSI)	8 BBL
0.48 m^3/min (3.0 BPM) -	31 BARG	(450 PSI)	11 BBL
0.56 m^3/min (3.5 BPM) -	37 BARG	(540 PSI)	21 BBL

Started cutting sand. See pump chart nr. 2. Pumped 15% HCL at 0.56 m^3/min. (3.5 BPM) at 36 BARG (520 PSIG). The pressure increased to 50 BARG (720 PSIG) after having pumped 6.5 m^3 (41 BBL). Stopped circulating and closed lower annular valve. Closed the choke. Started to inject 15% HCL at 0.16 m^3/min. (1 BPM). The pressure stabilized at 9.3 BARG (135 PSIG) after having pumped 7.0 m^3 (44 BBL) at 0.16 m^3/min. The pressure increased to 40 BARG (580 PSIG) after having pumped 8.43 m^3 (53 BBL). Stopped pumping and located position 1, squeeze. The pressure immediately bled off to the formation. Soaked 15% HCL for 10 min. Pumped additional 0.32 m^3 (2 BBL) and the pressure increased. Soaked for 10 min, and the pressure immediately bled off. Pumped additional 1.0 m^3(6 BBL), totally 9.7 m^3 (61 BBL) at 0.35 m^3/min (2.2 BPM). Shut-in and soaked for 5 min. Maximum pressure of 65 BARG (950 PSIG) before shut in. The pressure immediately bled off. Pumped to total of 11.0 m^3 (69 BBL). Maximum pressure of 69 BARG (1000 PSIG).

06.20 Started to displace with 1.16 brine. Decided to pump 3.2 m^3 (20 BBL) brine, but found that the formation damage increased after only 0.8 m^3 (5 BBL) pumped. Discussed to start pumping the pre-pad, but pumped the drill pipe volume, 4.8 m^3 (30 BBL), 1,16 SG in order to avoid U-tube effect and possible underbalance when going from position 1, squeeze to position 2, circulating. Pumped totally 4.8 m^3 (30 BBLS). Maximum pressure was 52 BARG (750 PSIG) and the flowrate was kept relatively stable, 1 BPM.
Pumped 2.4 m^3 (15 BBL) pre-pad. The flowrate dropped from 0.22 m^3/min. (1.4 BPM) at 55 BARG (800 PSIG) to 0.13 m^3/min (0.8 BPM) at 69 BARG (1000 PSIG), indicating further formation damage.

06.55 Shut down.

07.15 Repositioned valves. Closed annular and repressurized annulus to 38 BARG (550 PSIG). Picked up into reverse position, but unable to break circulation. Increased to 52 BARG (750 PSIG) and broke circulation at 0.14 m^3 (0.9 BPM). Increased to 62 BARG (900 PSIG) and reversed at 0.41 m^3/min. (2.6 BPM). Stabilized the flowrate at 0.57m^3/min (3.60 BPM). Reversed a total of 17.0 m^3 (107 BBLS). During the reversing operation, the packer setting ball released and plugged the tubing. Pumped down the drill pipe and reversed again. OK.
Started to pull out of the hole.

Pulled out the bottom hole assembly. Removed the packer setting ball. Replaced the G-22 locator seal assembly with 2 7/8 pup joint (ca 3 m). See fig. 4. Checked the crossover tool seals. OK. Ran into the hole with the bottom hole assembly. Made up 2.3 m^3 (15 BBL) high vis. pad in one of the paddle mixer tanks and 2.07 m^3 (13 BBL) slurry base.

17.50 Tested the circulating head kelly cock to 207 BARG (3000 PSIG) for 10 min. OK. Made up the circulating head and stabbed into the Baker SC-1 packer with both the kelly valves open.

18.05 Located positions 1,2 and the with the crossover tool. Relocated position 3.

18.05 Pumped 14.3 m^3 (90 BBL) 1.16 SG brine down the drill pipe. Average 0.72 m^3/min (4.5 BPM) at 52 BARG (750 PSIG). See pump chart nr. 3.

18.40 Stopped pumping and located postion 2, circulation. Closed lower annular preventor and opened the choke fully.

18.55 Established circulation through the main screen 0.16 m^3/min. (1 BPM) at ca 10 BARG (150 PSIG). The total of 0.64 m^3 (4 BBL). 0.32 m^3/min (2 BPM) at ca 20.7 BARG (300 PSIG). A total of 1.6 m^3 (10 BBL).

19.05 Mixed the gravel slurry, 1438 KG gravel per m^3 carrying fluid, totally 65 sack added.

19.35 Opened lower annular preventor and relocated position 3, reverse. Closed lower annular prevetor.

19.40 Pumped 1.6 m^3 (10 BBL) pre-pad.

19.45 Stopped pumping and located position 2, circulating

19.55 Continued pumping 2.7 m^3 (17 BBL) of 1.16 SG gravel slurry followed by 5 BBL of post pad and displaced by 1.16 SG brine (15 BBL)

20.20 Pumped with 0.16 m^3/min. (1 BPM) at 17.2 - 20.7 BARG (250 - 300 PSIG). The pressure increased after 7.8 m^3 (49 BBL) pumped (total volume). The pressure built up to 65.5 BARG (950 PSIG) two times.

20.35 Bled off the pump pressure and repositioned the valves at the surface. Maintained 34.5 BARG (500 PSIG) in the annulus and picked up into reverse position 3.

20.45 Ca. 1.0 m^3 (6.3 BBL) slurry reversed out.

21.15 A total of 16 m^3 (100 BBL) was reversed out.

22.00 Started to circulate the long way.

18 SEPTEMBER 1983

02.00 Relocated position 2, circulating. Checked the gravel pack by pumping 0.5 BBL (0.08 m^3) at (500 PSIG) 35 BARG. The pressure built up rapidly between 0.4 - 0.5 BBL pumped. The pressure bled off to (200 PSIG) 14 BARG. Bled of 200 PSIG at the Dowell unit.

02.15 Pulled out of the hole.

WELL 31/3-1 GRAVEL PACK OPERATION (1373 - 1383 m)

SEQUENCE OF EVENTS

24 SEPTEMBER 1983

07.00 Ran into the hole with stinger on 3 1/2 in drill pipe.

09.30 Squeeze cemented the test zone 1519 - 1529 m with 2 m^3 slurry. Left 1 m^3 above and below the packer. Pulled out to 1437 m.

11.30 Reverse circulated.

12.00 Circulated the long way.

14.00 Pressure tested the casing to 100 BAR.

14.30 Displaced the hole with 1.3 SG brine.

25 SEPTEMBER 1983

17.30 Circulated and conditioned the brine.

00.30 Pulled out of the hole and laid down the stinger.

02.00 Dresser Atlas ran gauge ring and junk basket.

03.00 Dresser Atlas ran and sat Baker F-1 sump packer at 1388.5 m. (top packer)

25 - 28 SEPTEMBER 1983

Picked up and ran test string bottom hole assembly with Geovann conveyed perforation gun. Landed the string in the sump packer at 1385.5 m.

Perforated casing for DST no.2 1373-1383 m. Flowed the well and shut it in for build up. Opened PCT-valve and bullheaded 3,5 m^3 brine into the formation. Opened SSARV. Released the packer. Attempted to bullhead down the annulus. Picked up the string. Landed string in the wellhead. Started to loose fluid to annulus, a total of 2.8 m^3. Bullheaded 1,5 m^3 $CaCO_3$ - pill and 1.1 m^3 brine. Squeezed 4.1 m^3 brine and observed the well OK.

Pulled out of the hole and laid down the test tools and the packer. Lost approxemately a total of 25 m^3 to the formation from time annulus was open until LCM-pill was in place.

Packer condition:
Packer collapsed position ok.
Upper packer element: OD: 8 3/64"
Middle packer element: Missing
Lower packer element: OD: 8 9/64"

Lower packer element almost splitted all around. Upper spacer ring partly bent. Lower spacer ring (below M.P.-element) found to be in a moved up position close to U.P element. Partly bent.
Lowe slips collapsed OK.
Bypass points OK.

28 SEPTEMBER 1983

01.30 Ran into the hole with 8 1/2 in bit and scraper. Tagged the sump packer at 1388.5 m. Picked up the kelly cock and the circulating nose.

06.00 Circulated through the choke line. Filtered the brine and dumped the $CaCO_3$ pill.

09.00 Opened annular preventer and circulated up the riser and filtered the brine.

18.30 Pulled out of the hole.

20.35 Started to pick up the gravel pack bottom hole assembly. See fig. 5
Broke out the short Tell tale screen and replaced it by 3.12 m screen. Ran 2 1/8" tubing through 3.25 sealbore receptacle. (The G-22 seal assembly was not used.) See fig. 8

29 SEPTEMBER 1983

01.05 Ran into the hole with 8 stands 4 3/4" drill collar and 3 1/2" drill pipe. Spaced out the tool joint. The circulating head approximately 5 m above the rig floor. The F-1 packer was located and 2500 DaN was applied to push through the collet. 5000 DaN required to pull off. Landed in the packer with approx. 3000 DaN.

06.35 Made up the circulating head. Tested the kelly cocks Valves to 210 BARG (3050 PSIG) for 10 min. OK. Pumped 6.3 m^3 (40 BBL) at 0.24 m^3/min (1.5 BPM) at 17.2 BARG (250 PSIG).

07.20 Dropped the 1 7/16" packer setting ball.

07.50 Pressurised in 34 BARG (500 PSIG) increments to set the packer. The seat sheared at 131 BARG (1900 PSIG)

Tested the packer slips setting by 11.000 DaN overpull. OK. Flushed the choke line with 1.6 m^3 (10 BBL). Tested the packer element sealing with 34 BARG (500 PSIG) for 10 min. down the annulus. Opened the kelly cocks. OK.

08.30 Rotated 12 turns to the right to come free from the packer.
Located position 1, squeeze by 15000 DaN weight set on the SC-1L packer. Picked up approx. 1.5 m above neutral and located position 2, circulating.
Picked up further approx. 3 m and located position 3, reverse. 8000 DaN was required to push through the collet in the reverse position. Relocated position 2, circulating and closed the annulus preventer.

08.50 Broke the circulation and established following circulating rates.

Started to mix gravel into the slurry basis. Pumped 15 % HCL at 0.37 m^3/min (2.3 BPM). See pump chart no. 4. Initial pressure was 29.3 BARG (425 PSIG). The pressure increased steadily to 56.9 BARG (825 PSIG) when having pumped 4.4 m^3 (27.5 BBL). The return was lost at 5.6 m^3 (35 BBL) pumped. Started to choke back on the surface. Both chokes were closed at 6.5 m^3 (41 BBL) pumped. Injected at 0.37 m^3/min. (2.3 BPM) at 50 BARG (725 PSIG). Started to open the chokes after 0.56 m^3 (3.5 BBL) squeezed. Both chokes were open when the total of 7.5 m^3 (47 BBL) 15% HCL was pumped. Started immediately to pump 0.8 m^3 1.3 SG brine.

09.30 Started to pump 2.4 m^3 (15 BBL) pre-pad at 0.16 m^3/min (1.0 BBM) and 31.0 BARG (450 PSIG). The pressure increased steadily and levelled off at approx. 51.7 BARG (750 PSIG) and 2.4 m^3 (15 BBL) pumped. Started to pump 1.61 SG gravel slurry (1437.8 KG gravel/m^3 1.05 SG base fluid). The pressure increased slowly after 3.5 m^3 (22 BBL) slurry pumped (all slurry) to approx. 58.6 BARG (850 PSIG). Started to pump 0.8 m^3 (5 BBL) post-pad.

The pressure increased rapidly to 62.0 BARG (900 PSIG) after 0.5 m^3 (3 BBL) postpad pumped. Regained return. Stopped pumping and located position 1, squeeze. Squeezed 0.16 m^3 (1.0 BBL). The pressure remained constant at 31.0 BARG (450 PSIG). Relocated position 2, circulation, and pumped at 0.02 m^3/min (0.1 BPM) at approx. 38 BARG (550 PSIG). Displaced the postpad with 1.2 m^3 (7.5 BBL) 1.30 SG brine. Stopped pumping and relocated position 1, squeeze. Pressurised slowly. The pressure was stable at 38 BARG (550 PSIG) and increased to 52 BARG. Stopped pumping and observed the pressure drop. Pressurised the pack twice. The total of 1.4 m^3 (9.0 BBL) 1.3 SG brine was pumped.

11.30 Repositioned valving and picked up into position 3, reverse with 41 BARG (600 PSIG) on the annulus. Gained the return at 127 BARG (1850 PSIG). Reversed at approx. 1.24 m^3/min (1.5 BPM) at 22 BARG (325 PSIG). Reversed the total of 3580 KG was pumped. Approx 1100 KG was reversed out. (Measured in desander pit). No HCL detected. Repositioned the valving and circulated the long way through the choke line. The total of 52 m^3 (326 BBL) was circulated.

30 SEPTEMBER 1983

13.30 Relocated position 2, circulating. Checked the packing and pressurised the pack to 38 BARG (550 PSIG) - OK.

13.45 Displaced 1.6 m^3 (10 BBL) what size $CaCO_3$ pad and 1.6 m^3 (10 BBL) high-vis pad with 4.6 m^3 (29 BBL). Pulled out of the hole with 3 stands very slowly.

GRAVELPACK OPERATION OF WELL 31/3-1

COMMENTS AND CORRECTION OF THE ORIGINAL TEST PROGRAM

INTERVAL: 1515.0 - 1529.0 m

6. b Pumped 10 bbls prepad 1.16 SG

c Pumped 17 bbls of slurry, the prepad arrived at the crossover tool.
(See Sequence of Events!)

INTERVAL: 1373.0 - 1383.0 m

3. a The G-22 seal assembly was not used! It was replaced with a 2 1/8" pup joint in order to be able to circulate through the main screen in case of plugging of the Tell tale screen.

4. c 7" tubing instead of 7 5/8"

d 7 x 5 1/2" crossover sub instead of 6 5/8". The points l and m were not included.

5. The outer blank pipe was connected to the lower indicating coupling.

1.4.2

a) Mix 0.41 m^3 (2,5 bbl) 1.30 SG brine and 2.03 m^3 (12.8 bbl) 1.00 SG filtered drillwater to give 2.03 m^3 (15.3 bbl) 1.05 SG brine.

c) Added 23.3 kg (53 lbs) 1-164 (HEC) to the brine.

2. Closed the annualar preventer and opened the choke fully. With the work string in position 2, circulation was established with brine through the Tell-tale screen and the 2 7/8" washpipe to a maximum of 400 psig.

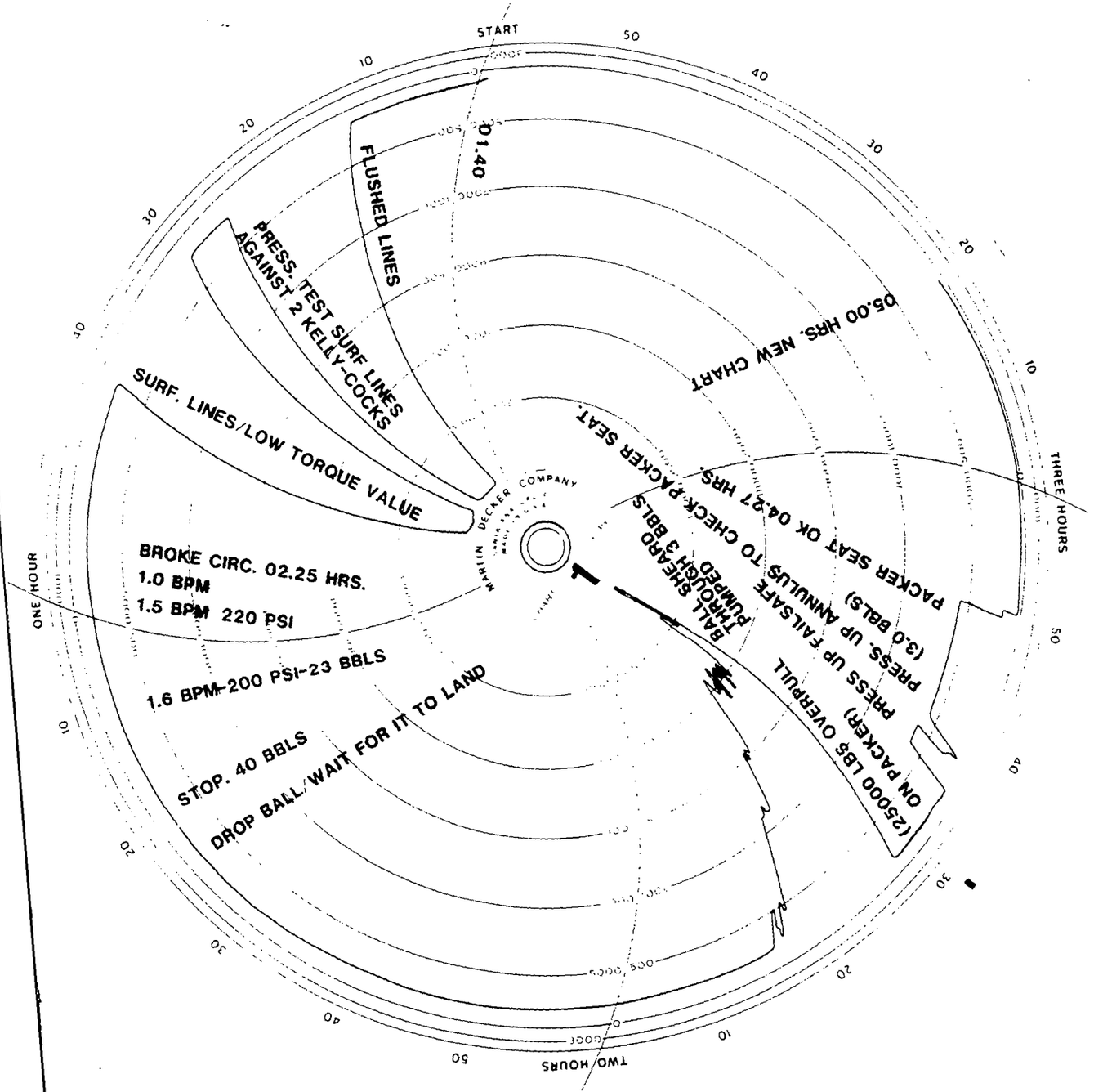
3. Mixed 12 lbs/gal gravel into the gravel slurry basis. Totally 79 sacks to give 3.78 m^3 (23.8 bbl) of 1.58 SG gravel slurry density.

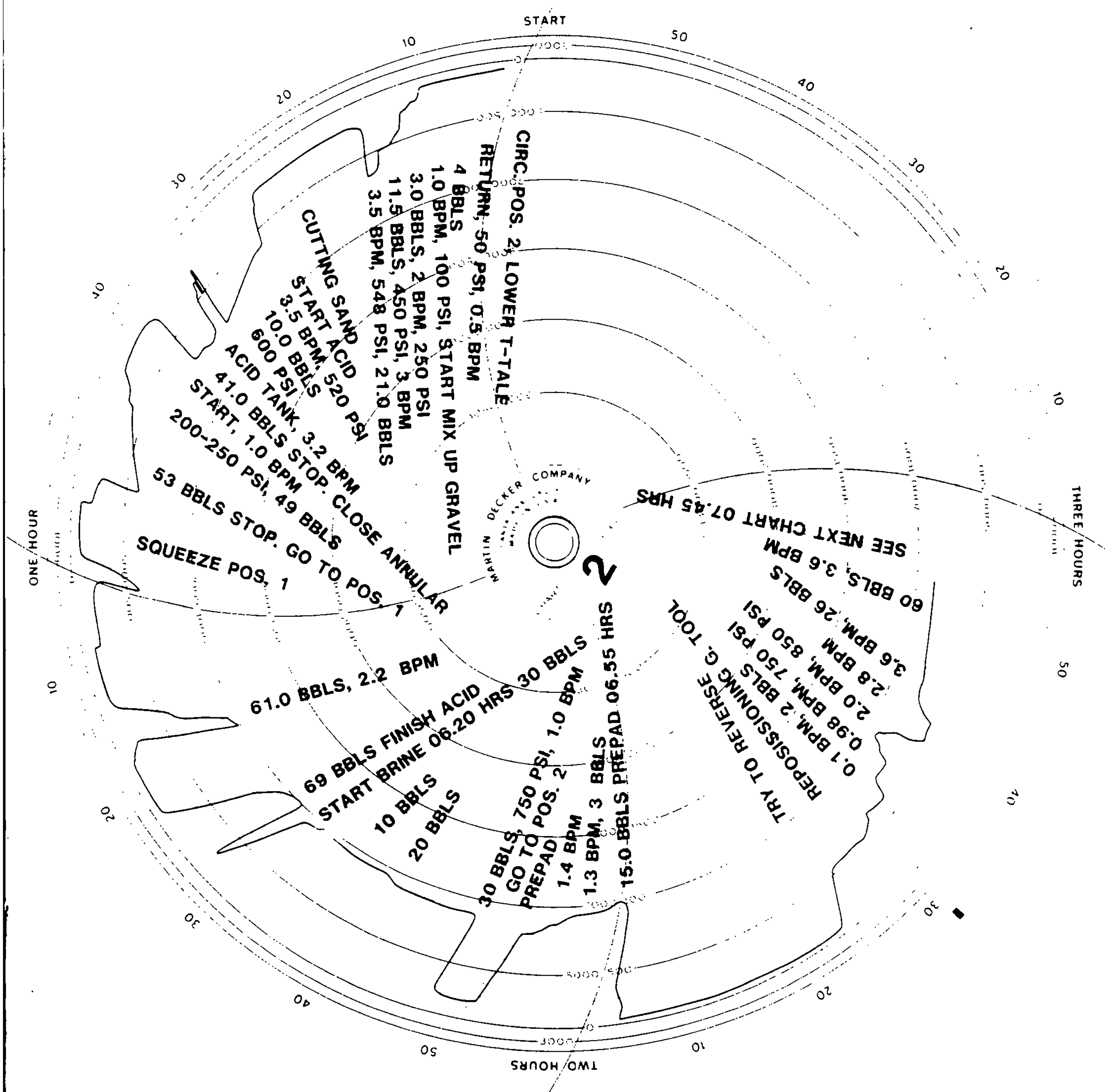
Note: Max pressure with slurry in the string is equivalent to 1.56 SG.

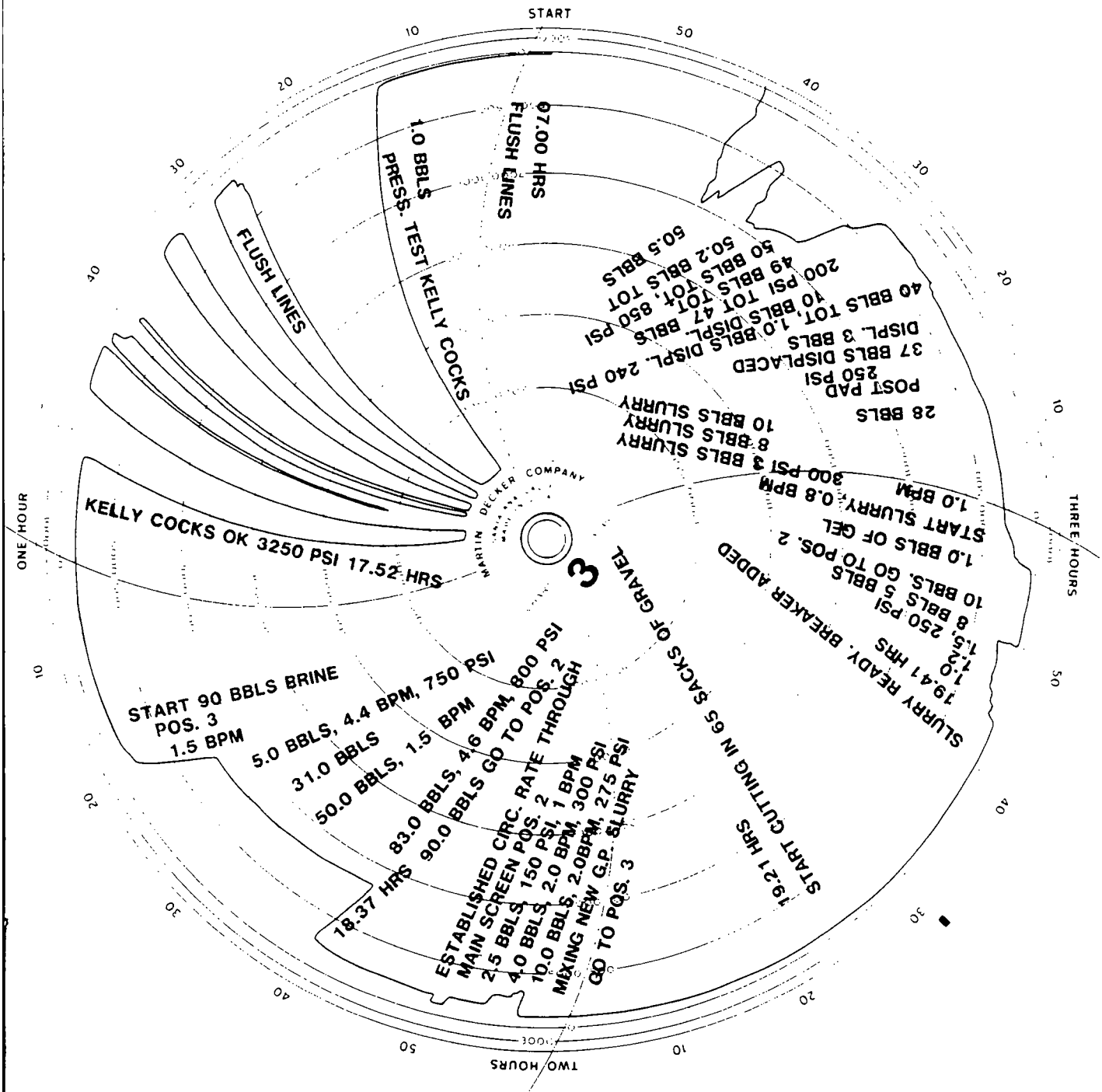
4. a Pumped 7.2 m^3 (45 bbl) of the acid at high rate max 400 psig/3BPMwith the string in the circulating position (2).

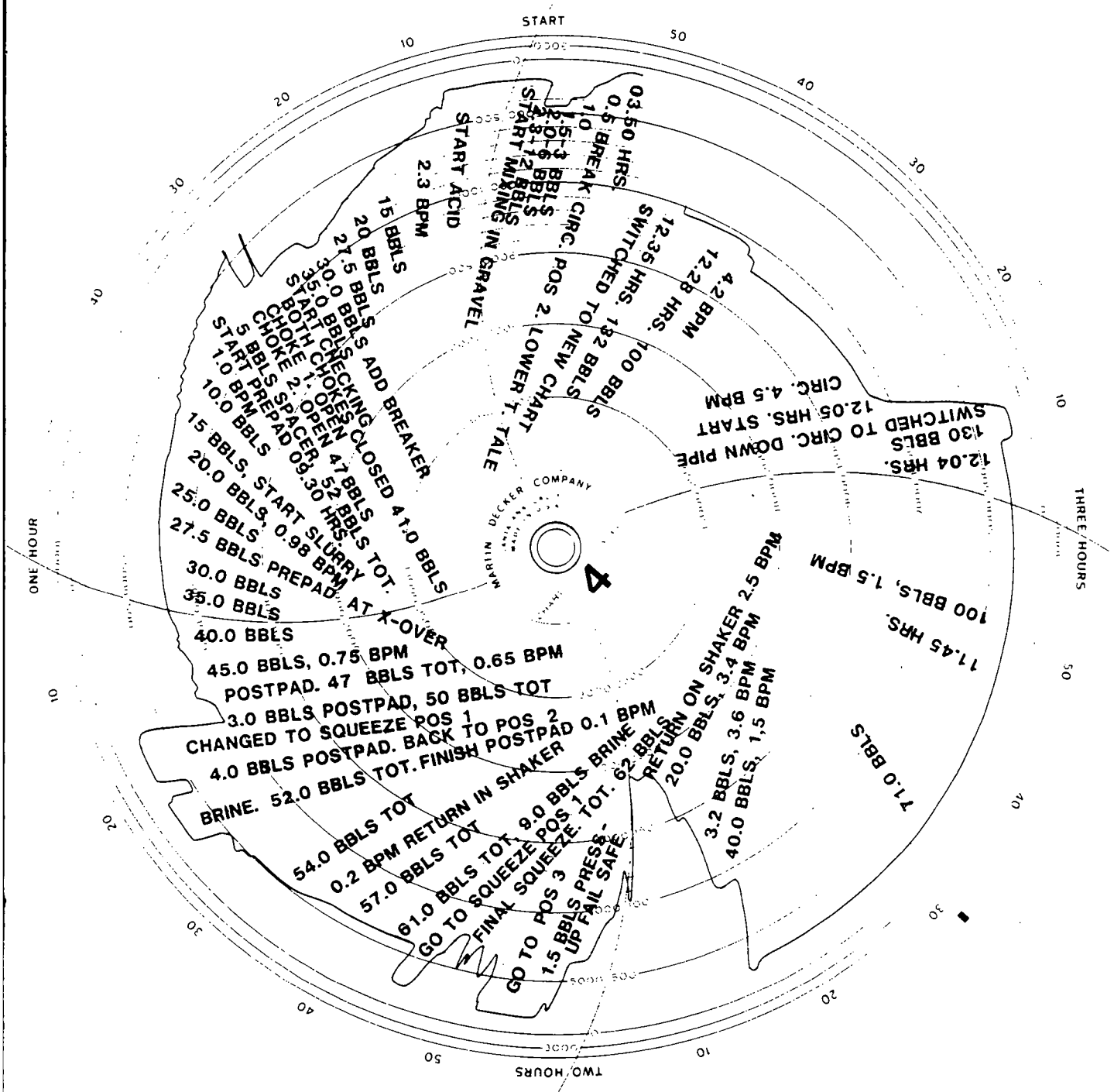
b Stopped pumping. Choke return. Pumped additionaly 0.8 m^3 (5bbl) of acid.

5 Note:
The pre-pad, gravelslurry and post pad will lead to maximum imbalance between the heavy drillpipe fluid and light annulus fluid of +/- 35 barg (500 psig) while the fluids are in the drillpipe.
(See Sequence of Events!)


START
01.40
FLUSHED LINES
PRESS. TEST SURF LINES AGAINST 2 KELLY-COCKS
SURF. LINES/LOW TORQUE VALUE
BROKE CIRC. 02.25 HRS.
1.0 BPM
1.5 BPM 220 PSI
1.6 BPM-200 PSI-23 BBLS
STOP. 40 BBLS
DROP BALL/WAIT FOR IT TO LAND
BALL SHEARD THROUGH PUMPED 3 BBLS
PRESS UP FAILSAFE TO CHECK PACKER SEAT.
(3.0 BBLS)
PACKER SEAT OK 04.27 HRS.
05.00 HRS. NEW CHART
(25000 LBS OVERPULL ON PACKER)
ONE HOUR
TWO HOURS
THREE HOURS
MARTIN DECKER COMPANY

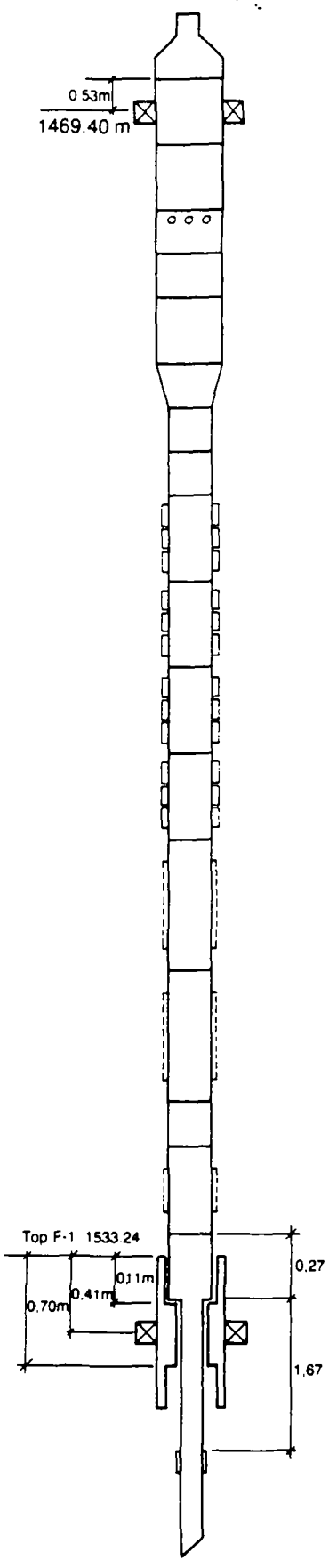

START
ONE HOUR
TWO HOURS
THREE HOURS
MARTIN DECKER COMPANY
2
CIRC. POS. 2, LOWER T-TALE
RETURN, 50 PSI, 0.5 BPM
4 BBLS
1.0 BPM, 100 PSI, START MIX UP GRAVEL
3.0 BBLS, 2 BPM, 250 PSI
11.5 BBLS, 450 PSI, 3 BPM
3.5 BPM, 548 PSI, 21.0 BBLS
CUTTING SAND
START ACID
3.5 BPM, 520 PSI
10.0 BBLS
600 PSI
ACID TANK, 3.2 BPM
41.0 BBLS STOP. CLOSE ANNULAR
START, 1.0 BPM
200-250 PSI, 49 BBLS
53 BBLS STOP. GO TO POS. 1
SQUEEZE POS. 1
61.0 BBLS, 2.2 BPM
69 BBLS FINISH ACID
START BRINE 06.20 HRS 30 BBLS
10 BBLS
20 BBLS
30 BBLS, 750 PSI, 1.0 BPM
GO TO POS. 2
PREPAD
1.4 BPM
1.3 BPM, 3 BBLS
15.0 BBLS PREPAD 06.55 HRS
TRY TO REVERSE
REPOSISSIONING G. TOOL
0.1 BPM, 2 BBLS
0.98 BPM, 750 PSI
2.0 BPM, 850 PSI
2.8 BPM, 26 BBLS
3.6 BPM
60 BBLS, 3.6 BPM
SEE NEXT CHART 07.45 HRS


START
ONE HOUR
TWO HOURS
THREE HOURS
MARTIN DECKER COMPANY
3
KELLY COCKS OK 3250 PSI 17.52 HRS
START 90 BBLS BRINE
POS. 3
1.5 BPM
5.0 BBLS, 4.4 BPM, 750 PSI
31.0 BBLS
50.0 BBLS, 1.5 BPM
83.0 BBLS, 4.6 BPM, 800 PSI
90.0 BBLS GO TO POS. 2
18.37 HRS
ESTABLISHED CIRC. RATE THROUGH
MAIN SCREEN POS. 2
2.5 BBLS, 150 PSI, 1 BPM
4.0 BBLS, 2.0 BPM, 300 PSI
10.0 BBLS, 2.0BPM, 275 PSI
MIXING NEW G.P. SLURRY
GO TO POS. 3
19.21 HRS
START CUTTING IN 65 SACKS OF GRAVEL
SLURRY READY. BREAKER ADDED
19.41 HRS
1.0
1.2
1.5, 250 PSI
8 BBLS 5 BBLS
10 BBLS. GO TO POS. 2
1.0 BBLS OF GEL
START SLURRY 0.8 BPM
1.0 BPM
300 PSI 3 BBLS SLURRY
8 BBLS SLURRY
10 BBLS SLURRY
28 BBLS
POST PAD
250 PSI
37 BBLS DISPLACED
DISPL. 3 BBLS
40 BBLS TOT, 1.0 BBLS DISPL.
10 BBLS DISPL. 47 BBLS
200 PSI TOT, 850 PSI
49 BBLS TOT
50 BBLS TOT
50.2 BBLS TOT
50.5 BBLS
07.00 HRS
FLUSH LINES
1.0 BBLS
PRESS. TEST KELLY COCKS
FLUSH LINES


START
ONE HOUR
TWO HOURS
THREE HOURS
MARTIN DECKER COMPANY
4
START ACID
2.3 BPM
15 BBLS
20 BBLS
27.5 BBLS
30.0 BBLS
35.0 BBLS ADD BREAKER
START CHECKING CLOSED 41.0 BBLS
BOTH CHOKES OPEN
CHOKE 1 - OPEN 47 BBLS TOT.
CHOKE 2 - SPACER 09.30 HRS. 52 BBLS TOT.
5 BBLS PREPAD
START PREPAD
1.0 BPM BBLS
10.0 BBLS
15 BBLS, START SLURRY
20.0 BBLS, 0.98 BPM
25.0 BBLS
27.5 BBLS PREPAD AT X-OVER
30.0 BBLS
35.0 BBLS
40.0 BBLS
45.0 BBLS, 0.75 BPM
POSTPAD. 47 BBLS TOT, 0.65 BPM
3.0 BBLS POSTPAD, 50 BBLS TOT
CHANGED TO SQUEEZE POS 1
4.0 BBLS POSTPAD. BACK TO POS 2
BRINE. 52.0 BBLS TOT. FINISH POSTPAD 0.1 BPM
54.0 BBLS TOT
0.2 BPM RETURN IN SHAKER
57.0 BBLS TOT, 9.0 BBLS BRINE
61.0 BBLS TOT. 62 BBLS
GO TO SQUEEZE POS 1
FINAL SQUEEZE. TOT.
GO TO POS 3
1.5 BBLS PRESS -
UP FAIL SAFE
RETURN ON SHAKER 2.5 BPM
20.0 BBLS, 3.4 BPM
3.2 BBLS, 3.6 BPM
40.0 BBLS, 1.5 BPM
71.0 BBLS
11.45 HRS.
100 BBLS, 1.5 BPM
12.04 HRS.
130 BBLS
SWITCHED TO CIRC. DOWN PIPE
12.05 HRS. START
CIRC. 4.5 BPM
4.2 BPM
12.28 HRS. 100 BBLS
12.35 HRS. 132 BBLS
SWITCHED TO NEW CHART
POS 2. LOWER T. TALE
CIRC. BREAK
1.0
2.5
3.0
6 BBLS
12 BBLS
START MIXING IN GRAVEL
03.50 HRS.
0.5

STATOIL GRAVEL PACK ASSEMBLY, 31/3-1

DST no. 1 (1519,0 – 1529,0 m RKB), Run no. 2, Run no. 3

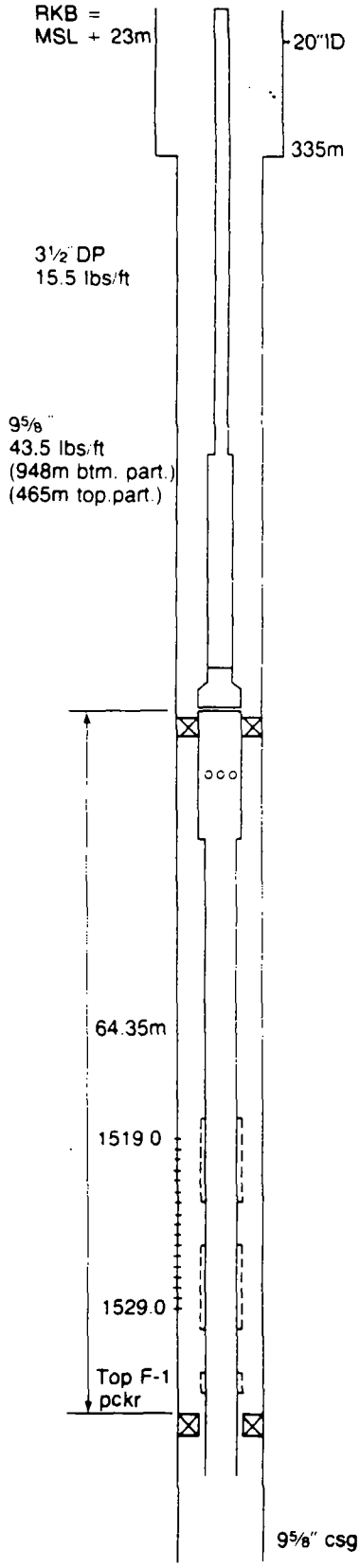


	Item lgth. (m)	Depth (m RKB)	OD (in)	ID (in)
SC-IL setting tool	0.82	1468.05	8.15	
SC-IL packer (96–60) w/7⅝" 8RD box down	1.27	1468.87	8.44	6.00
7⅝" GP extension w/7⅝" 8RD pin x pin	1.43	1470.14	8.44	
Closing sleeve w/7⅝" 8RD box up x 7 165 8 stub ACME pin	0.65	1471.57	8.18	
Lower seal bore sub w/7.165 8 stub ACME box x 7" 8RD box	0.52	1472.22	8.27	6.00
7" Lower extension w/7" 8RD pin x pin	5.93	1472.74	7.00	
7" x 5½" crossover sub w/7" 8RD box up x 5½" 8RD pin down	0.23	1478.67	8.33	4.95
Size 4.5 model «A» ind sub w/5½" 8RD box x pin	0.23	1478.90	6.05	4.50
Size 5½" shear out safety jt. w/rot.lock w/5½" 8RD box x pin (43000 lbs shear)	0.32	1479.13	6.05	4.95
Size 5½" 15 lbs/ft, J-55 casing. w/5½" 8RD box x pin w/3x0.030m centr.welded lugs at center and 0 16 m from pin and box	9.20	1479.45	6.05	4.95
Size 5½", 15 lbs/ft, J-55 casing w/5½" 8RD box x pin w/3x0.030m centr. welded lugs at center and 0.16m from pin and box	9.20	1488.65	6.05 + lugs	4.95
Size 5½", 15 lbs/ft, J-55 casing w/5½" 8RD box x pin w/3 x 0.030m centr welded lugs at center and 0.16m from pin and box.	9.20	1497.85	6.05 + lugs	4.95
Size 5½, 15 lbs/ft, J-55 casing w/5½" 8RD box x pin w/3 x 0.030m centr. welded lugs at center and 0.16m from pin and box	9.20	1507.05	6.05 + lugs	4.95
Size 5½" x 0.012 gauge screen w/5½" 8 RD box x pin	7.08	1516.25	6.10	4.95
Pipe base: 5½", 15 lbs/ft, J-55				
Size 5½" x 0.012 gauge screen w/5½" 8RD box x pin	7.08	1523.33	6.10	4.95
Pipe base: 5½", 15 lbs/ft, J-55				
Size 5½" x 3.25" sealbore sub w/5½" 8RD box x pin	0.78	1530.41	6.05	3.25
Size 5½" x 0.012 gauge screen w/5½" 8RD box x pin	1.89	1531.19	6.10	4.95
Pipe base: 5½", 15 lbs/ft, J-55				
Size 190–60 Model «B» ind. seal assy. w/5½" 8 RD box up x muleshoe w/kickover lug.		1533.08	6.50	4.88
		1536.40		

NOTE: Top SC-IL packer: 1468,87m
Top F-1 packer: 1533,24m

FIG 1

1519.0 – 1529.0

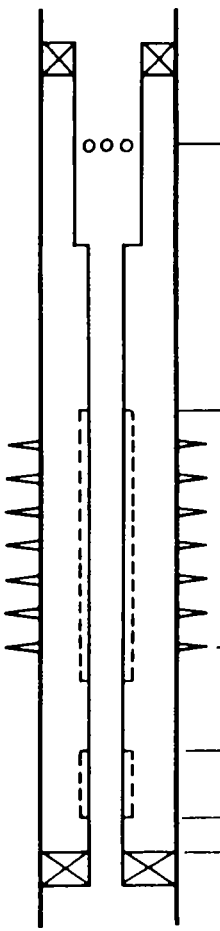


Section length (m)	Depth (m RKB)	Work stg.ID (in)	Work stg.cap. (x 10^{-3} m^3/m)	Sect. ID vol. (x $10^{-3}m^3$)	Workstg OD (in)	Ann. cap. (x$10^{-3}m^3$/m)	Sect OD vol. (x$10^{-3}m^3$)
1241.20	0	2.60	3.43	4257.32	3.50		72559.44
	(358)				3.50	32.63	28818.82
226.87	1241.20	2.25	2.57	583.06	4.75	27.41	6218.51
0.82	1468.07	~ 2.60	3.43	2.81	~ 8.00	6.41	5.26
2.84	1468.89	~ 2.60	3.43	9.74		–	–
6.95	1471.73		–	–	7.0	14.01	97.37
38.03	1478.68		–	–	5.5	23.51	894.09
11.89	1516.71		–	–	6.1	19.98	237.56
2.92	1528.60		–	–	5.5	23.51	68.65
1.22	1531.52		–	–	6.1	19.98	24.38
0.50	1532.74		–	–	5.5	23.51	11.76
	1533.24		–	–			

9⅝" csg, 43.5 lbs/ft: 8.755" ID, 38.85 · 10^{-3} m^3/m

FIG. 2

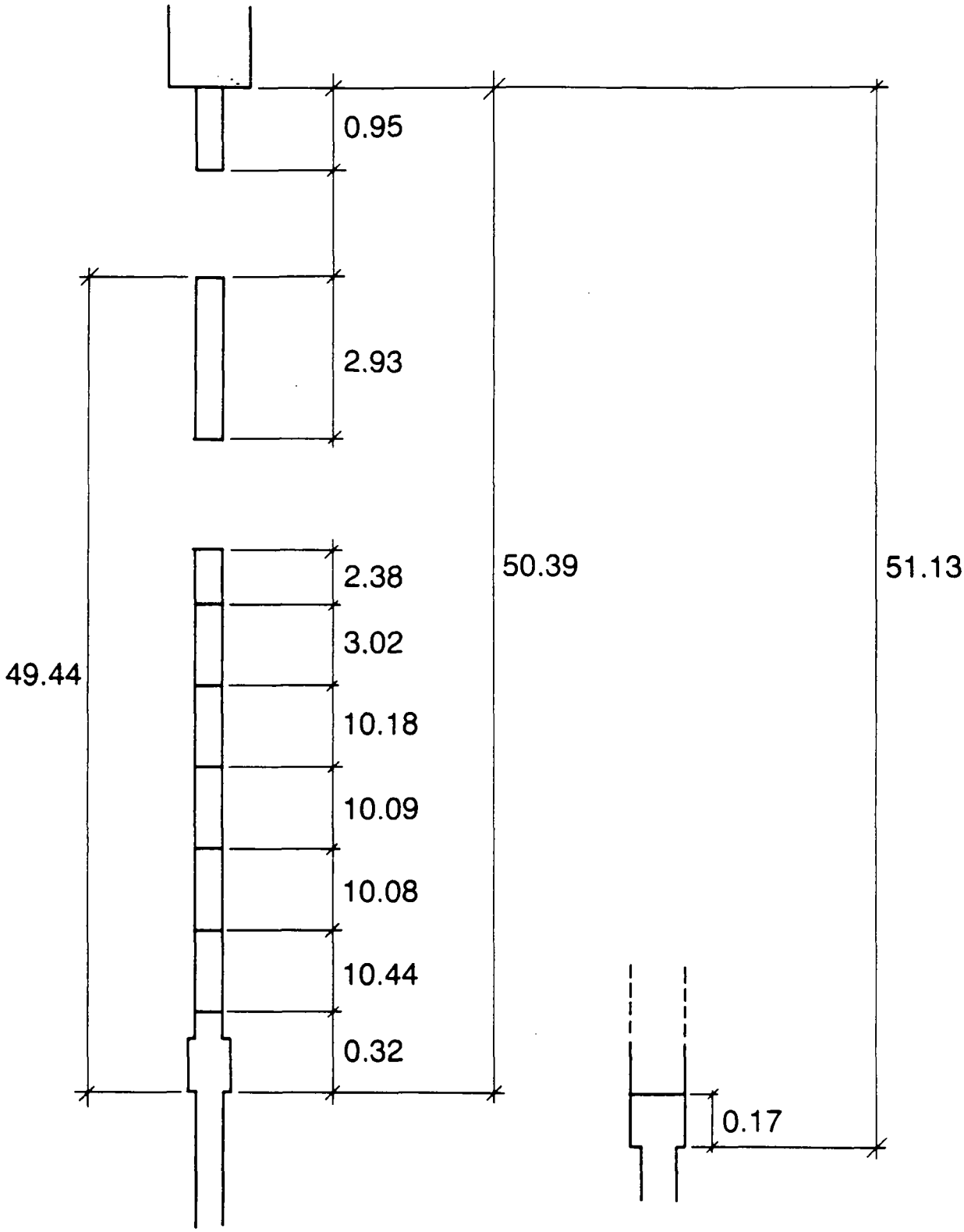
Volumes of slurry pumped during the squeeze high density GP.



	Bulk volume associated with each section ($x10^{-3}m^3$)
section 5	991.46
section 4	237.56 (ann.) +464.52 (perf.) 702.08
section 3	68.65
section 2	24.38
section 1	11.76

FIG. 3

Wash pipe requirements

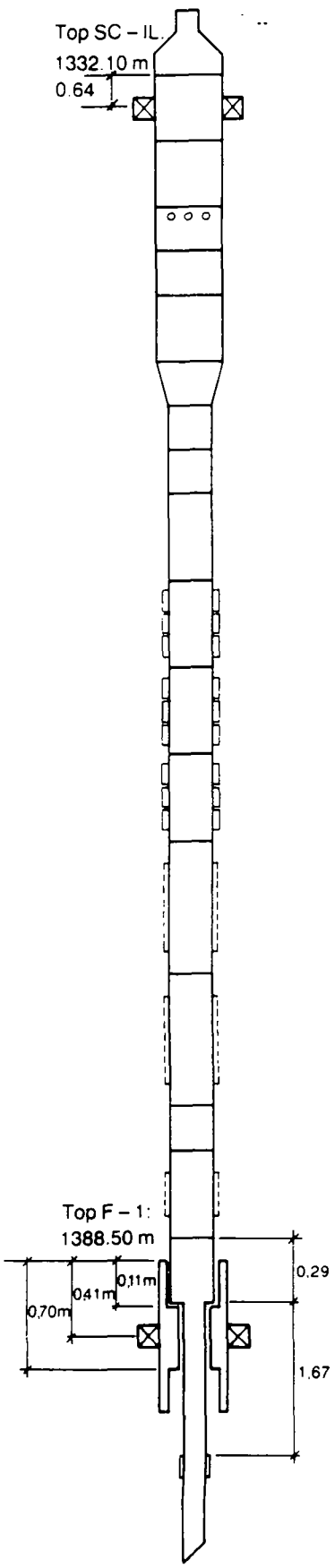


△ seal: 51.13 – 50.39 = 0.74

FIG 4

STATOIL GRAVEL PACK ASSY, INTERVAL 1373,0 – 1383,0 m RKB DST#2

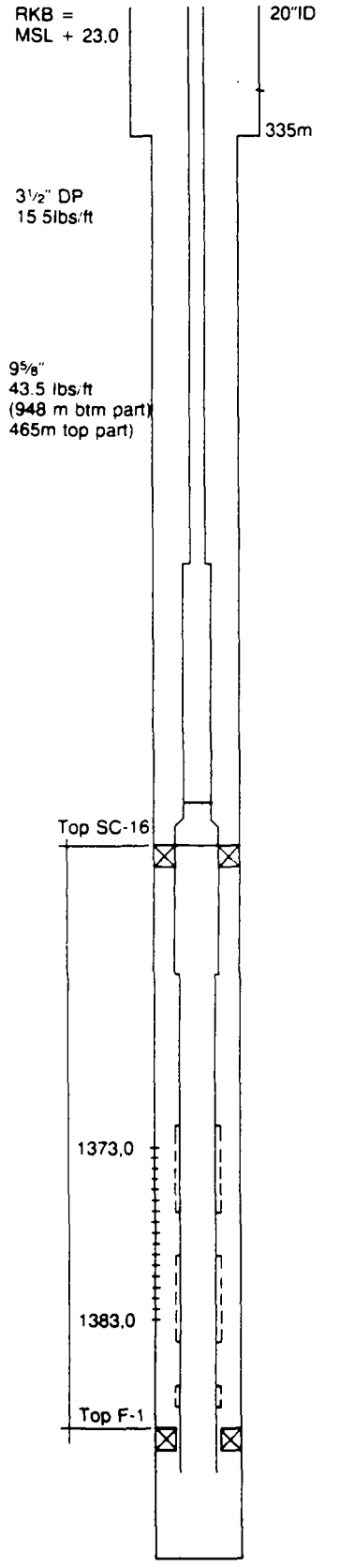
31/3–1



Item	lgth. (m)	Depth (m RKB)	OD (in)	ID (in)
SC-IL setting tool	0.82	1331.28	8.15	
SC-IL packer (96–60) w/ 7⅝" 8RD box down	1.27	1332.10	8.44	6.00
7⅝" GP extension w/ 7⅝" 8RD pin x pin	1.43	1333.37	8.44	
Closing sleeve w/ 7⅝" 8RD box up x 7.165 8 stub ACME pin	0.64	1334.80	8.18	
Lower seal bore sub w/ 7 165 8 stub ACME box x 7" 8RD box	0.52	1335.44	8.27	6.00
7" Lower extension w/ 7" 8RD pin x pin	5.97	1335.96	7.00	
7" x 5½" crossover sub w/ 7" 8RD box up x 5½" 8RD pin down	0.24	1341.93	8.33	4.95
Size 4.5 model «A» ind sub w/ 5½" 8RD box x pin	0.24	1342.17	6.05	4.50
Size 5½" shear out safety jt w rot.lock w 5½"8 RD box x pin (43000 lbs shear)	0.32	1342.41	6.05	4.95
Size 5½", 15 lbs/ft J-55 casing w/ 5½" 8RD box x pin w/ 3 x 0,030m welded centr lugs at center and 0.16 m from pin and box	9.21	1342.73	6.05 + lugs	4.95
Size 5½", 15 lbs/ft.. J-55 casing w/ 5½", 8RD box x pin w/ 3 x 0.030m welded centr.lugs at center and 0.16m from pin and box	9.20	1351.94	6.05 + lugs	4.95
Size 5½", 15 lbs/ft J-55 casing w/ 5½ 8RD box x pin w/ 3 x 0.030 m welded centr lugs at center and 0.16 m from pin and box	9.13	1361.14	6.05 lugs	4.95
Size 5½" x 0.012 gauge screen w/ 5½" 8 RD box x pin	7.07	1370.27	6.10	4.95
Pipe base: 5½", 15 lbs/ft, J-55				
Size 5½" x 0.012 gauge screen w/ 5½" 8RD box x pin	7.08	1377.34	6.10	4.95
Pipe base: 5½", 15 lbs ft. J-55				
Size 5½" x 3.25" sealbore sub w/ 5½" 8RD box x pin	0.78	1384.42	6.05	3.25
Size 5½" x 0.012 gauge screen w/ 5½" 8RD box x pin	3.12	1385.20	6.10	4.95
Pipe base: 5½", 15 lbs/ft, J-55				
Size 190–60 Model «B» ind. seal assy w/ 5½" 8 RD box up x muleshoe w/kickover lug.	3.32	1388.32	6.50	4.88
Top F-1: 1388,5 m RKB Top SC-IL: 1332,10 m RKB		1391.64		

FIG 5

1373,0 – 1383,0

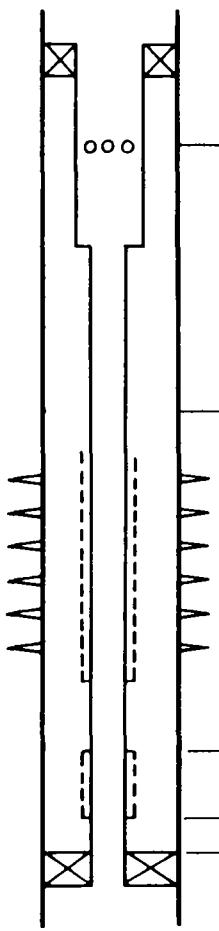


Section length (m)	Depth (m RKB)	Work stg.ID (in)	Work stg.cap. (x 10^{-3} m^3/m)	Sect. ID vol. (x $10^{-3}m^3$)	Workstg OD (in)	Ann. cap. (x$10^{-3}m^3$/m)	Sect.OD vol. (x$10^{-3}m^3$)
1101.18	0	2,60	3,43	3777,05	3,5	196,47	70337,27
	(358,0)				3,50	32,63	24249,96
226,87	1101,18	2,25	2,57	583,06	4,75	27,41	6218,51
0,82	1328,05	~ 2,60	3,43	2,81	~ 8,00	6,41	5,26
2,84	1328,87	~ 2,60	3,43	9,74		–	–
6,95	1331,71		–	–	7,00	14,01	97,37
29,13	1338,66		–	–	5,5	23,51	684,85
11,89	1367,79		–	–	6,1	19,98	237,56
2,92	1379,68		–	–	5,5	23,51	68,65
2,40	1382,60		–	–	6,1	19,98	47,95
0,50	1385,00		–	–			
	1385,50		–	–	5,5	23,51	11,76

9⅝" csg, 43.5 lbs/ft: 8.755" ID, 38.85 · 10^{-3} m^3/m

FIG 6

Volumes of slurry pumped during the squeeze high density GP.



	Bulk volume associated with each section ($x10^{-3}m^3$)
section 5	782.22
section 4	237.56 (ann.) +464.52 (perf.) 702.08
section 3	68.65
section 2	47.95
section 1	11.76

FIG. 7

Washpipe requirements

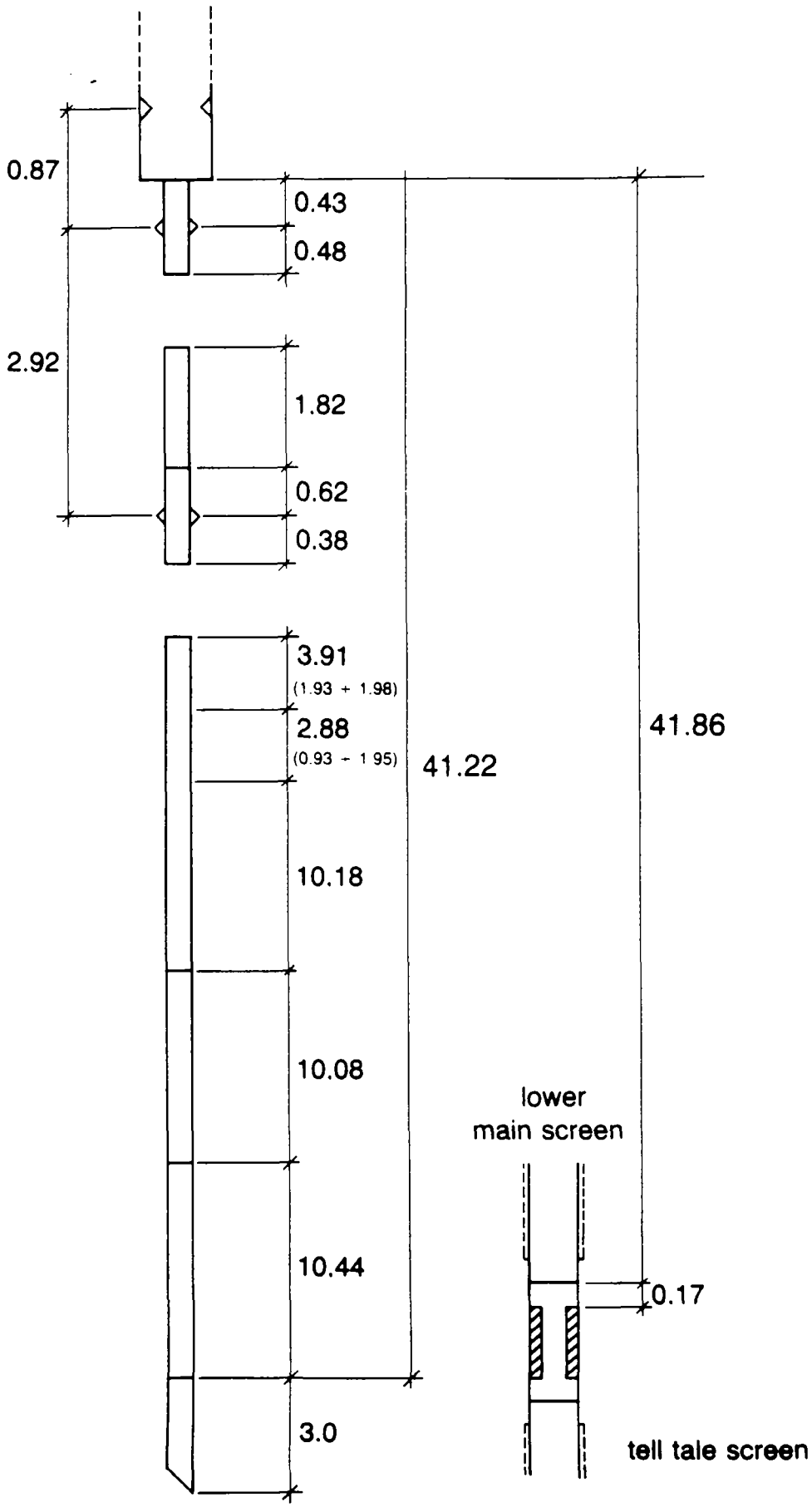
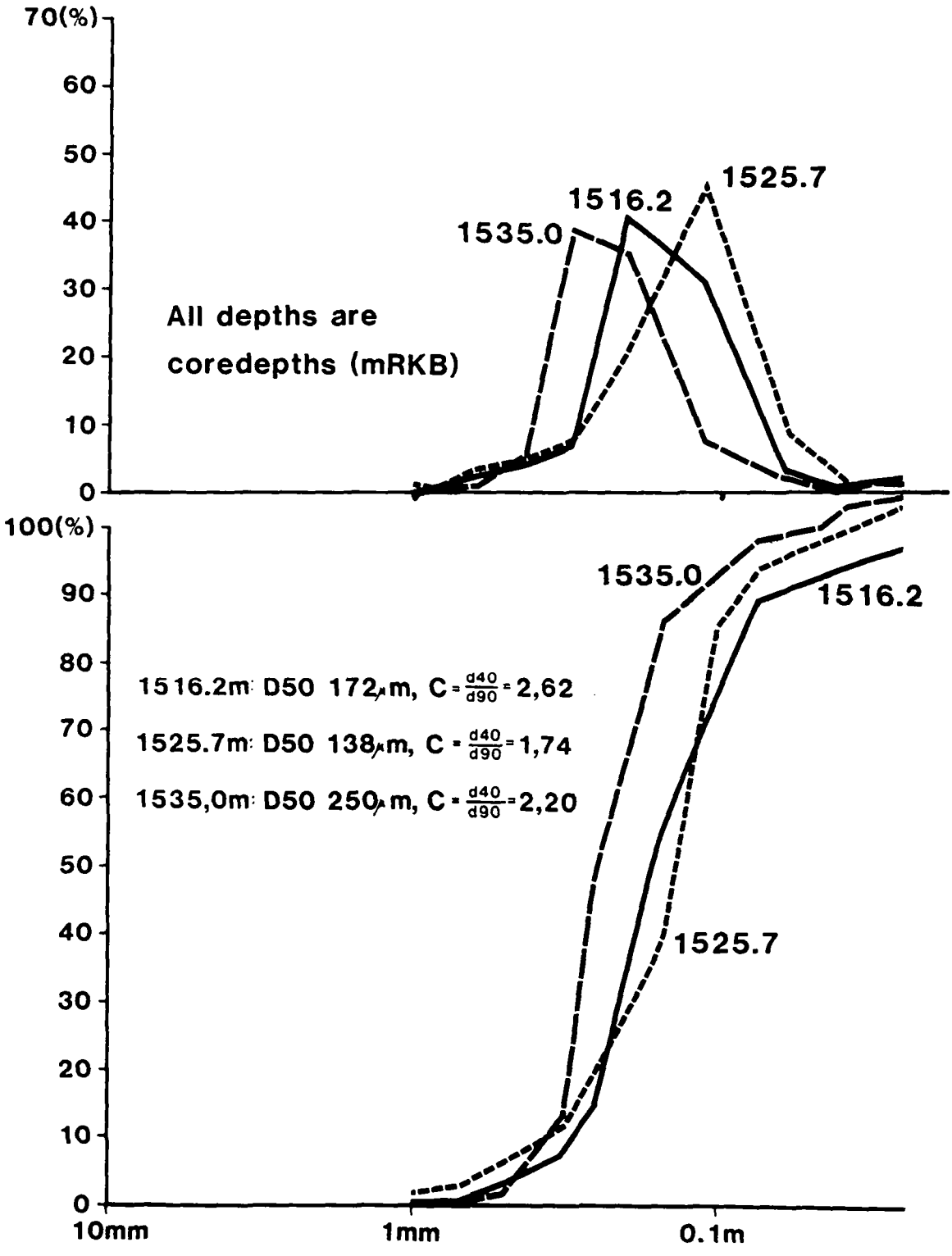


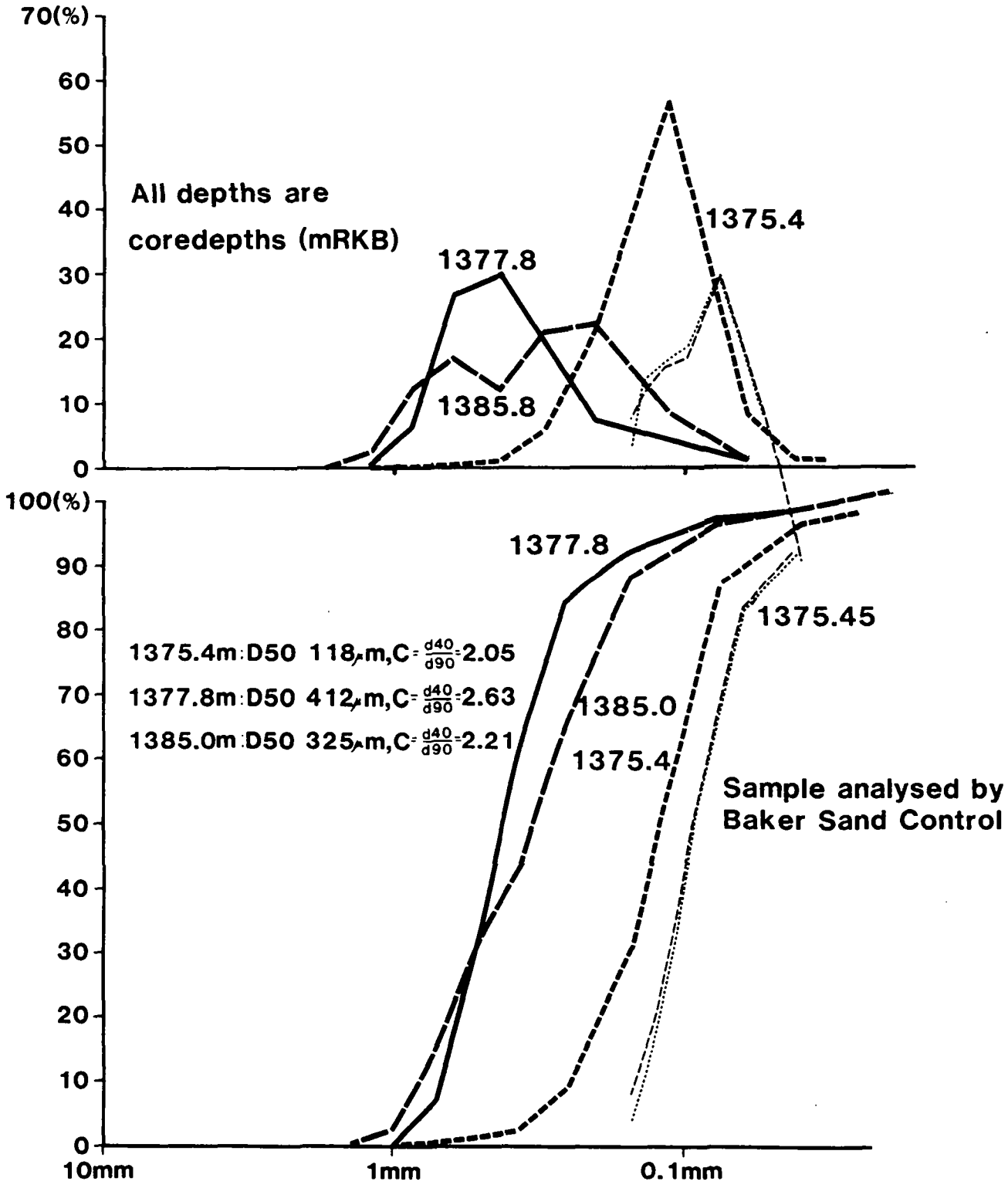
FIG 8

Sieve Analysis, 31/3-1
DST#1.,interval 1519.0 - 1529.0 mRKB



Sieve Analysis, 31/3-1

DST#2, interval 1373.0 - 1383.0 mRKB



Volumes

Hole Volume, surf. - top F-1 packer, no pipe: 112.39544 m^3 = 708.15 bbl

Hole Volume, surf. - top SC-1L packer, no pipe: 110.39536 m^3 = 694.31 bbl

Hole Volume, surf. - top SC-1L packer, 3 1/2" DP + 4 3/4" DC 105.17392 m^3 bbl = 661.47 bbl

Ann. vol., surf. - top SC-1L packer, 3 1/2" DP + 4 3/4" DC: 100.81100 m^3 = 634.03 bbl

DP/DC vol, surf. - top SC-1L packer 4.36292 m^3 = 27.44 bbl

DP/DC vol, surf. - X-O ports 4.37266 m^3 = 27.50 bbl

Ann. vol, X-O ports - top F-1 packer (not incl. perfs.): 1.14814 m^3 = 7.22 bbl

+ 0.5 ft^3/ft perfs. 0.46452 m^3 = 2.92 bbl

1.61266 m^3 = 10.14 bbl

+ 40% 0.64506 m^3 =

2.25772 m^3

20-40 mesh gravel: 79.73 ft^3 → 80 sacks

Remarks:

11 $\frac{lbs}{gal}$ slurry conc. = 1317.98 kg gravel/m^3 base fluid

= 880.21 kg gravel/m^3 slurry

= 1.58 SG slurry dens. (1.05 SG base fluid)

Dowell paddle mixer tank: 1000 gal = 23.8 bbl = 3.79 m^3

Amount of gravel in 3.79 m^3 (23.8 bbl) tank when 11 lbs/gal slurry:

880,21 kg/m^3 x 3.79 m^3 = 3332.22 kg ≙

3332.22 kg gravel is equivalent to:

$$\frac{3332.22 \text{ kg}}{2650 \text{ kg/m}^3 \times 0.6 \ (0.3048 \text{ m}^3)} \text{ ft}^3 = 74.01 \text{ ft}^3 \triangleq \underline{74 \text{ sacks}}$$

Total slurry: 3.78 m^3 (23.8 bbl)

Amount of 1.05 base fluid, using 74 sacks: $23.8 \times 0.159 - \frac{74 \times 100 \times 0.453592}{2650} = 2.52 \text{ m}^3$ (15.8 bbl)

Mix ratio 1.30 SG brine and 1.00 SG filtered drillwater: to give 1.05 SG base fluid 2

x 1.30 + (2.52 - x) x 1.0 = 2.52 x 1.05 = 0.42 m^3 (2.6 bbl) 1.30 SG brine

2.10 m^3 (13.2 bbl) 1.00 SG filt.drillw. } 1.05 SG/2.52 m^3

12 $\frac{\text{lbs}}{\text{gal}}$ slurry conc. = 1437.8 kg gravel/m^3 base fluid

= 932.08 kg gravel/m^3 slurry

= 1.61 SG slurry dens. (1.05 SG base fluid)

Dowell paddle mixer tank: 1000 gal = 23.8 bbl = 3.79 m^3

Amount of gravel in 3.79 m^3 (23.8 bbl) tank when 12 lbs/gal slurry:

932.08 kg/m^3 x 3.79 m^3 = 3532.60 kg

3532.60 kg gravel is equivalent to:

$$\frac{3532.60 \text{ kg}}{2650 \text{ kg/m}^3 \times 0.6 \times (0.3048 \text{ m}^3)} \times \text{ft}^3 = 78.46 \text{ ft}^3 \hat{=} 79 \text{ sacks}$$

This corresponds to (see calc. for 11 lbs/gal conc.): 2.43 m^3 (15.3 bbl) 1.05 SG base fluid made up of 0.41 m^3 (2.5 bbl) 1.30 SG brine and 2.03 m^3 (12.8 bbl) 1.0 SG filtered drillwater.

Note: Due to the viscous nature of the slurry, only ca. 3.34 m^3 - 3.50 m^3 (21 - 22 bbl) may be "sucked" out of the paddle mixer before air is "sucked". A slurry concentration before of 11 lbs/gal gives the optimum slurry density. However, the amount of gravel is in the lower range. If a smaller slurry volume is used (less than the paddle mixer capacity of 3.79 m^3 (23.8 bbl) due to air being sucked a somewhat higher slurry concentration is recommended. Consequently, 12 lbs/gal is recommended.

Assuming 12 lbs/gal and 3.79 m^3 (23.8 bbl) slurry volume (100% tank cap.), the max pressure equivalent is

DC: 226.87 m = 0.58306 m^3

DP: $\frac{(3.79 - 0.58306) \text{ m}^3}{3.43 \times 10^{-3} \text{m}^3/\text{m}}$ = 935.0 m

$$\frac{(227.0 + 935.0) \times 1.61 + (1373.0 - 227.0 - 935.0) \times 1.30}{1373.0} = 1.56 \text{ SG}$$

Thus, the max pressure is equivalent to 1.56 SG. If less than 3.79 m^3 (23.8 bbl) is sucked, the equivalent pressure will be less also.

Volumes of slurry pumped during the squeeze high density GP.

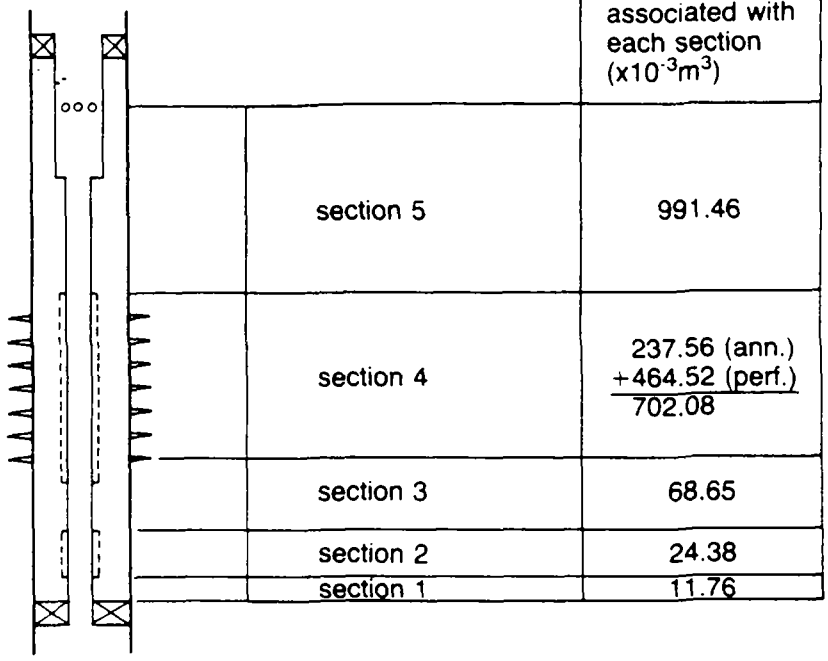


FIG. 3

Section 1: Slurry conc./not packed

Slurry volume: $11.76 \times 10^{-3} m^3$ (0.07 bbl)

Section 2: Packed

$47.95 \times 10^{-3} m^3 \times 0.6 \times 2650\ kg/m^3 = 76.24$ kg gravel

$\frac{76.24\ kg}{932.08\ kg/m^3} = 0.08\ m^3$

Slurry volume: $81.8 \times 10^{-3} m^3$ (0.51 bbl)

Section 3: Slurry conc./ not packed

Slurry volume: $68.65 \times 10^{-3} m^3$ (0.43 bbl)

Section 4: Packed

Not incl. perfs.: $237.56 \times 10^{-3} \times 0.6 \times \frac{2650}{932.08} = 405.24 \times 10^{-3} m^3$ (2.55 bbl) slurr

Incl. perfs.: $702.08 \times 10^{-3} \times 0.6 \times \frac{2650}{932.08} = 1197.65 \times 10^{-3} m^3$ (7.53 bbl) slurr

Section 5: Slurry conc./not packed

Slurry volume: $782.22 \times 10^{-3} m^3$ (4.92 bbl)

Amount of gravel required to pack the volume below top of the main screen section to the F-1 packer: (See fig. 3.)

	Section no.	Slurry vol. ($x10^{-3}m^3$)	Gravel cont. (kg)	Total slurry ($x10^{-3}m^3$(bbl))	Total Gravel (kg)
Incl. perfs.	1	11.76	10.96		
	2	81.80	76.24	1359.86	1267.50
	3	68.65	63.99	(8.55)	
	4	1197.65	1116.31		
Not incl. perfs.	1	11.76	10.96	567.45	528.91
	2	81.80	76.24	(3.57)	
	3	68.65	63.99		
	4	405.24	377.72		

79 sacks $\hat{=}$

Gravel Pack Operation, Summary

Pump in sequence:

2.39 m^3 (15 bbl) 1.30 SG prepad
3.78 m^3 (23.8 bbl) 1.61 SG slurry containing 79 sacks gravel
0.80 m^3 (5 bbl) 1.30 SG postpad
x m^3 (as necessary) 1.30 SG brine

Individual Fluid Volumes m^3 (bbl)		Cummulative Volume, calculated, m^3 (bbl)		Remarks
2.39 m^3 (15 bbl) prepad		2.39 m^3 (15 bbl)		All prepad pumped
1.99 m^3 (12.5 bbl) slurry		4.38 m^3 (27.5 bbl)		Prepad at X-O ports
3.13 m^3 (19.7 bbl) slurry		5.52 m^3 (34.7 bbl)		Prepad at tell tale screen
3.78 m^3 (23.8 bbl) slurry		6.17 m^3 (38.8 bbl)		All slurry pumped
0.59 m^3 (3.7 bbl) postpad		6.67 m^3 (42.5 bbl)		Slurry at X-O ports
0.80 m^3 (5.0 bbl) postpad		6.97 m^3 (43.8 bbl)		All post pad pumped
0.94 m^3 (5.9 bbl) brine		5.77 m^3 (44.7 bbl)		Slurry at tell tale screen, sand out
Packed perfs.:	Not packed perfs:	Packed perfs.:	Not packed p.	
1.11m^3(7.0bbl)br.	1.90m^3(11.9bbl)br.	7.28m^3(45.8bbl)	8.07m^3(50.9bbl)	Final sand out
Reversing out:				
1.11m^3(7.0bbl)br.	1.90m^3(11.9bbl)br.	1.11m^3(7.0bbl)	1.11m^3(7.0bbl)	Postpad to surface
1.91m^3(12.0bbl)br.	2.69m^3(16.9bbl)br.	1.91m^3(12.0bbl)	2.69m^3(16.9bbl)	Excess slurry to surface
4.37m^3(27.5bbl)br.	4.37m^3(27.5bbl)br.	4.37m^3(27.5bbl)	4.37m^3(27.5bbl)	Prepad to surface
6.76m^3(42.5bbl)br.	6.76m^3(42.5bbl)br.	6.76m^3(42.5bbl)	6.76m^3(42.5bbl)	Excess acid to surface

Volumes:

Hole volume, surf. - top F-1 packer, no pipe: 118.22713 m^3 = 743.6 bbl
Hole volume, surf. - top SC-1L packer, no pipe: 115.72713 m^3 = 728.1 bbl

Hole volume, surf. - top SC-1L packer, 3 1/2" DP + 4 3/4" DC: 112.44533 m^3 = 707.20 bbl

Ann. volume, surf. - top SC-1L packer, 3 1/2" DP + 4 3/4" DC: 107.60203 m^3 = 676.74 bbl
DP/DC volume, surf. - top SC-1L packer, : 4.84319 m^3 = 30.5 bbl
DP/DC volume, surf. - X-O ports: 4.85293 m^3 = 30.5 bbl

Ann. volume, X-O ports - top F-1 packer (not incl. perfs.): 1.333.81 m^3 = 8.39 bbl
+ 0.5 ft^3/ft perfs. 0.46452 m^3 = 2.92 bbl

1.79833 m^3 = 11.31 bbl
+ 40% 0.71933 m^3

2.51766 m^3

20-40 mesh gravel: 88.91 ft^3 = 89 sacks

Volumes of slurry pumped during the squeeze high density GP.

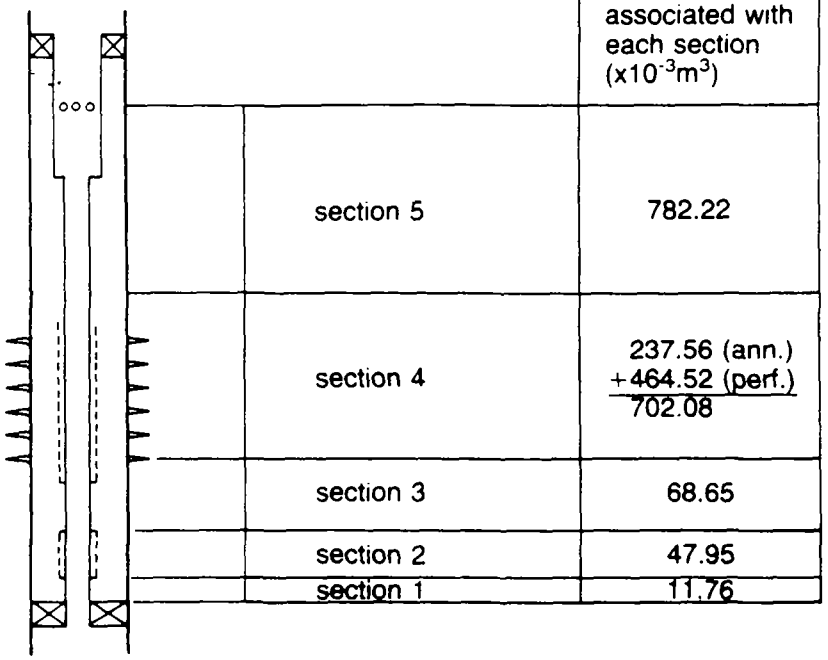


FIG. 7

Section 1: Tool position: 2, circulation

The gravel in section 1 will remain in the slurry concentration (no dehydration)

Slurry volume required for section 1: $11.76 \times 10^{-3} m^3$ (0.07 bbl)

Section 2: Tool position: 2, circulation

The gravel in section 2 will be dehydrated/packed.

$24.38 \times 10^{-3} m^3$ is conseq. the bulk volume of packed gravel:

$$24.38 \times 10^{-3} m^3 \times 0.6 \times 2650 \text{ kg/m}^3 = 38.76 \text{ kg gravel}$$

where $\varphi_{gravel} \sim 40\%$

Slurry volume required to pack section 2, assuming 1437.8 kg/m³ (12 lbs/gal) gravel conc.:

$$\frac{38.76 \text{ kg}}{2650 \text{ kg/m}^3} + \frac{38.76 \text{ kg}}{1437.8 \text{ kg/m}^3} = 41.58 \times 10^{-3} m^3 \text{ (0.26 bbl)}$$

Section 3: Tool position: 2, circulation

Theoretically, at sand out for the tell tale screen, the volume in section 3 will be filled with gravel still in the slurry concentration. Thus, section 3 will not be packed/dehydrated. (In practice, however, part or all of section 3 will probably be packed/dehydrated.) Assuming no pack:

Slurry volume required for section 3: $68.65 \times 10^{-3} m^3$ (0.43 bbl)

Following the reasoning for section 2: $117.1 \times 10^{-3} m^3$ (0.74 bbl) is required if section 3 packs off

Section 4: Tool position: 1, squeeze

Section 4 is considered to pack off/dehydrate completely from the lower perf. and until top of the main screen.

Bulk volume to be packed: $702.08 \times 10^{-3} m^3$

The amount of gravel in this volume is:

$$702.08 \times 10^{-3} m^3 \times 0.6 \times 2650 \text{ kg/m}^3 = 1116.31 \text{ kg}$$

where $\phi_{gravel} \sim 40\%$

Slurry volume required to pack section 4, assuming 1437.8 kg/m^3 (12 lbs/gal) slurry conc.:

$$\frac{116.31 \text{ kg}}{2650 \text{ kg/m}^3} + \frac{1116.31 \text{ kg}}{1437.8 \text{ kg/m}^3} = \underline{1197.65 \times 10^{-3} m^3 \text{ (7.5 bbl)}}$$

If the perforations are not packed off, the following slurry volumes is required:

$$\frac{237.56 \times 10^{-3} \times 0.6 \times 2650}{2650} + \frac{237.56 \times 10^{-3} \times 0.6 \times 2650}{1437.8} = \underline{405.24 \times 10^{-3} m^3 \text{ (2.55 bbl)}}$$

Section 5: Tool position: 1, squeeze

At the moment of sand out of the main screen (section 4) the volume in section 5 will be filled with gravel still in the slurry concentration.

Slurry volume required for section 5: $\underline{991.46 \times 10^{-3} m^3 \text{ (6.2 bbl)}}$

The amount of gravel per unit volume slurry is:

$$\frac{1437.8 \ \frac{\text{kg gravel}}{\text{m}^3 \text{ base fluid}}}{\frac{1437.8}{2650} \text{ m}^3 \text{ gravel matrix} + 1 \text{ m}^3 \text{ base fluid}} = 932.08 \ \frac{\text{kg gravel}}{\text{m}^3 \text{ slurry}}$$

Consequently, the amount of gravel associated with $991.46 \times 10^{-3} m^3$ slurry is:

$$932.08 \ \frac{\text{kg gravel}}{\text{m}^3 \text{ slurry}} \times 991.46 \times 10^{-3} m^3 \text{ slurry} = \underline{924.12 \text{ kg}}$$

Thus, after the breaker activates, this amount of gravel will give the following height of reserve above the top screen

$$\frac{924.12 \text{ kg}}{2650 \text{ kg/m}^3 \times 0.6 \times 23.51 \times 10^{-3} m^3/m} = \underline{24.7 \text{ m}}$$

Note: 24.7 m is theoretical. Due to the roping effect when the slurry passes through the X-O ports, only the following slurry volume may be trapped across the blank pipe at the moment of sand out:

Assuming a) 0.04 (1.6 in) "rope", b) blank pip length plus 30%

$$\frac{\Pi}{4} (0.04\ m)^2 \times (9.20 \times 4 \times 1.3) = 61.93 \times 10^{-3} m^3$$

This gives the following height of reserve gravel:

$$\frac{61.93 \times 10^{-3} \times 932.08}{2650 \times 0.6 \times 23.51 \times 10^{-3}} = 1.54\ m$$

The final amount of reserve gravel will be in between 1.5 m and 24.7 m

Amount of gravel required to pack the volume below top of the main screen sectio

F-1 packer: (See fig. 7.)

	Section no.	Slurry vol. ($\times 10^{-3} m^3$)	Gravel cont. (kg)	Total Slurry ($\times 10^{-3} m^3$/bb
Inlcud perfs.	1	11.76	10.96	
	2	41.58	38.76	
	3	68.65	63.99	1319.64 (8.
	4	1197.65	1116.31	
Not incl. perfs.	1	11.76	10.96	
	2	41.58	38.76	
	3	68.65	63.99	527.73 (3.3.
	4	405.24	377.72	

Gravel Pack Operation

As planned:

Pump in sequence:

0.8 m^3 (5 bbl) 1.16 SG Spacer

2.39 m^3 (15 bbl) 1.16 SG prepad

3.8 m^3 (23.8 bbl) 1.61 SG slurry containing 77 sacks 20-40 mesh gravel

0.8 m^3 (5 bbl) 1.16 SG Spacer

X m^3 (as necessary) 1.16 SG brine

Volume pumped: (0.8 m^3 (5 bbl) spacer assumed taken on acid "flowmeter")

Individual fluid volumes m^3 (bbl)	Cummulative m^3 (bbl)	Remarks
2.39 m^3 (15 bbl) prepad	2.39 m^3 (15 bbl)	All prepad pumped
2.46 m^3 (15.5 bbl) slurry	4.85 m^3 (30.5 bbl)	Prepad at X-over tool
3.78 m^3 (23.8 bbl) slurry	6.17 m^3 (38.8 bbl)	All slurry pumped
0.02 m^3 (0.1 bbl) postpad	6.19 m^3 (38.9 bbl)	Prepad at tell tale screen
0.80 m^3 (5.0 bbl) postpad	6.99 m^3 (44.0 bbl)	All postpad pumped
0.27 m^3 (1.7 bbl) brine	7.26 m^3 (45.7 bbl)	Slurry at X-O ports
1.61 m^3 (10.1 bbl) brine	8.60 m^3 (54.1 bbl)	Slurry at tell tale screen
1.63 m^3 (10.3 bbl) brine	8.62 m^3 (54.2 bbl)	Tell tale screen packed. (Sand Out I)
2.13 m^3 (13.4 bbl) brine	9.12 m^3 (57.4 bbl)	Main screen packed (Sand Out II) assuming perf. packed.
Reversing out:		
2.13 m^3 (13.4 bbl) brine	2.13 m^3 (13.4 bbl)	Postpad to surface
2.93 m^3 (18.4 bbl) brine	2.93 m^3 (18.4 bbl)	Slurry to surface
4.86 m^3 (30.6 bbl) brine	4.86 m^3 (30.6 bbl)	Prepad to surface
7.25 m^3 (45.6 bbl) brine	7.25 m^3 (45.6 bbl)	Brine to surface

Gravel Pack Operation, Summary

Pump in sequenc:

1.75 m^3 (11 bbl) 1.16 SG prepad

2.70 m^3 (17 bbl) 1.61 SG slurry containing 65 sacks 20-40 mesh gravel

0.80 m^3 (5 bbl) 1.16 SG postpad

X m^3 (as necessary) 1.16 SG brine

Volume pumped:

Individual Fluid Volumes m^3 (bbl)	Cummulative Volume, calculated, m^3 (bbl)	Remarks	Cumul.vol. obser m^3 (bbl)
1.75 m^3 (11 bbl) prepad	1.75 m^3 (11.0 bbl)	All prepad pumped	
2.70 m^3 (17 bbl) slurry	4.45 m^3 (28.0 bbl)	All slurry pumped	
0.40 m^3 (2.4 bbl) postpad	4.85 m^3 (30.5 bbl)	Prepad at X-O tool	
0.80 m^3 (5.0 bbl) postpad	5.25 m^3 (33.0 bbl)	All postpad pumped	
0.94 m^3 (5.9 bbl) brine	6.19 m^3 (38.9 bbl)	Prepad at tell tale screen	
2.68 m^3 (16.9 bbl) brine	7.93 m^3 (49.9 bbl)	Slurry at tell tale screen	7.79 m^3 (49 bbl)
2.86 m^3 (18.0 bbl) brine	8.11 m^3 (51.0 bbl)	Pack completed (Sand Out)	8.03 m^3 (50.56
Reversing out:			
2.86 m^3 (18.0 bbl) brine	2.86 m^3 (18.0 bbl)	Postpad to surface	
3.66 m^3 (23.0 bbl) brine	3.66 m^3 (23.0 bbl)	Excess slurry to surface	
4.85 m^3 (30.5 bbl) brine	4.85 m^3 (30.5 bbl)	Prepad to surface	
6.44 m^3 (40.5 bbl) brine	6.44 m^3 (40.5 bbl)	Brine to surface	

The amount of gravel required to pack the volume below top of the main screen to the F-1 packer is 491.4 kg when neglecting the perforations were packed.

The amount of slurry reversed out was 1.11 m^3 (7.0 bbl) (measured), After settlement, it was measured a ca. 5 cm layer in a 4.15 x 2.0 m pit, indicating ca. 400 kg reversed out. However, 1.11 m^3 (7.0 bbl) is mixed to contain 1035 kg gravel. Gravel was also observed in the reversed out prepad and the brine used during the reversing process. The measured 400 kg is thus to small, but the amount to small is unknown. Consequently, the minimum of gravel left in the hole is ca. 1485 kg, since the 2.70 m^3 (17 bbl) slurry contained 2520 kg.