(1)

WELL 34/10-3

GEOLOGICAL PROGNOSIS AND

DRILLING PROGRAM

DATE: JANUARY 1979

Den norske stats oljeselskap a.s

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S T A T O I L

W E L L P R O G N O S I S

WELL NO. 34/10-3

PROSPECT Delta

General Data:

LOCATION

Country Norway
Area North Sea
Licence No. 050
Block No. 34/10
Coordinates 61°12'49,70" N , 02°11'53,65" E

Seismic: Shotpoint No. 405 Line No. 708/709-404

4,05 Km S of 34/7 Boundary

10,6 Km E of 33/12 Boundary

135 Km from Norwegian coast

21 Km from N/UK median Line

3,8 Km NNW of nearest well 34/10-1

20 Km E of nearest field Statfjord

WATER DEPTH 173 Meters

K.B.E! 25 Meters

PROJECTED TOTAL DEPTH 2800 Meters

CONTRACTORS

Drilling Platform	"Ross Rig"
Drilling Contractor	Ross Drilling Co. A/S
Mudlogging Contractor	Baroid
Type Logging Unit	ADT
Electric Logging Contractor	Schlumberger
Rig Positioning Contractor	Geoteam or Decca
Bottom Survey Contractor	Geoteam
Helicopter Service	Helikopter Service A/S
Supply Boats	m/v "Ibis I" and m/v "Karmøy Boy"

GEOLOGICAL PROGRAM, WELL 34/10-1

PURPOSE OF TEST

34/10-3 is a wildcat well designed to test possible hydrocarbons on a separate fault block on the Delta closure. The Delta closure is situated in the north-eastern part of Block 34/10. The well will be drilled into Triassic to an estimated total depth of 2800 m KB.

OBJECTIVES

The primary objective of well 34/10-3 is sandstones of Middle Jurassic age. Secondary objectives are sandstones of Lower Jurassic and Upper Triassic age.

DRILLING HAZARDS

Based on data from nearby wells, no extreme drilling hazards are anticipated in this well. Hva med 34/10-1 ?

However, the preliminary site survey results indicate that gas might be encountered at ± 900 meters.

From the site survey boulders could be encountered while drilling the hole for the 30" casing.

SURVEY AND POSITIONING

The rig will be navigated by Pulse 8 and finally positioned by Satnav. Rig location accuracy is requested within a 100 m radius off the proposed location at sp. 405 on seismic line 708/709-404. Favoured direction for error is to the west.

STRATIGRAPHIC PROGNOSIS

UNIT	DEPTH (meters KB)
Top Oligocene	900 ± 50
Top Paleocene	1580 ± 50
Top Cretaceous	1755 ± 50
Top Jurassic	1915 ± 50
Top BRENT	1915 ± 50
Top DUNLIN	2145 ± 50
Top STATFJORD	2465 ± 50
Top Triassic	2715 ± 50
T.D.	2800

The above structural depths have been derived from seismic line 708/709-404, and from correlations with 34/10 wells.

GEOLOGICAL WELL LOGGING AND SAMPLING PROCEDURES

Mud logging Contractor: Baroid
A Baroid Drilling Technology (ADT) Unit will be employed to log the well for hydrocarbon shows, collect samples, prepare sample log and conduct certain other services throughout drilling operations.

Sampling interval

Samples will be collected at 10 meter intervals down to 1700 meters. Thereafter 3 meters intervals will be collected. Sampling intervals might be changed on the well site geologist's discretion.

2 sets of washed and dried samples will be collected at each interval.

5 sets of unwashed samples (½ kg) will be collected at each interval.

One composite sample of unwashed cuttings will be canned at 30 m intervals down to 1500 m. Below this depth 15 m sampling interval will be used.

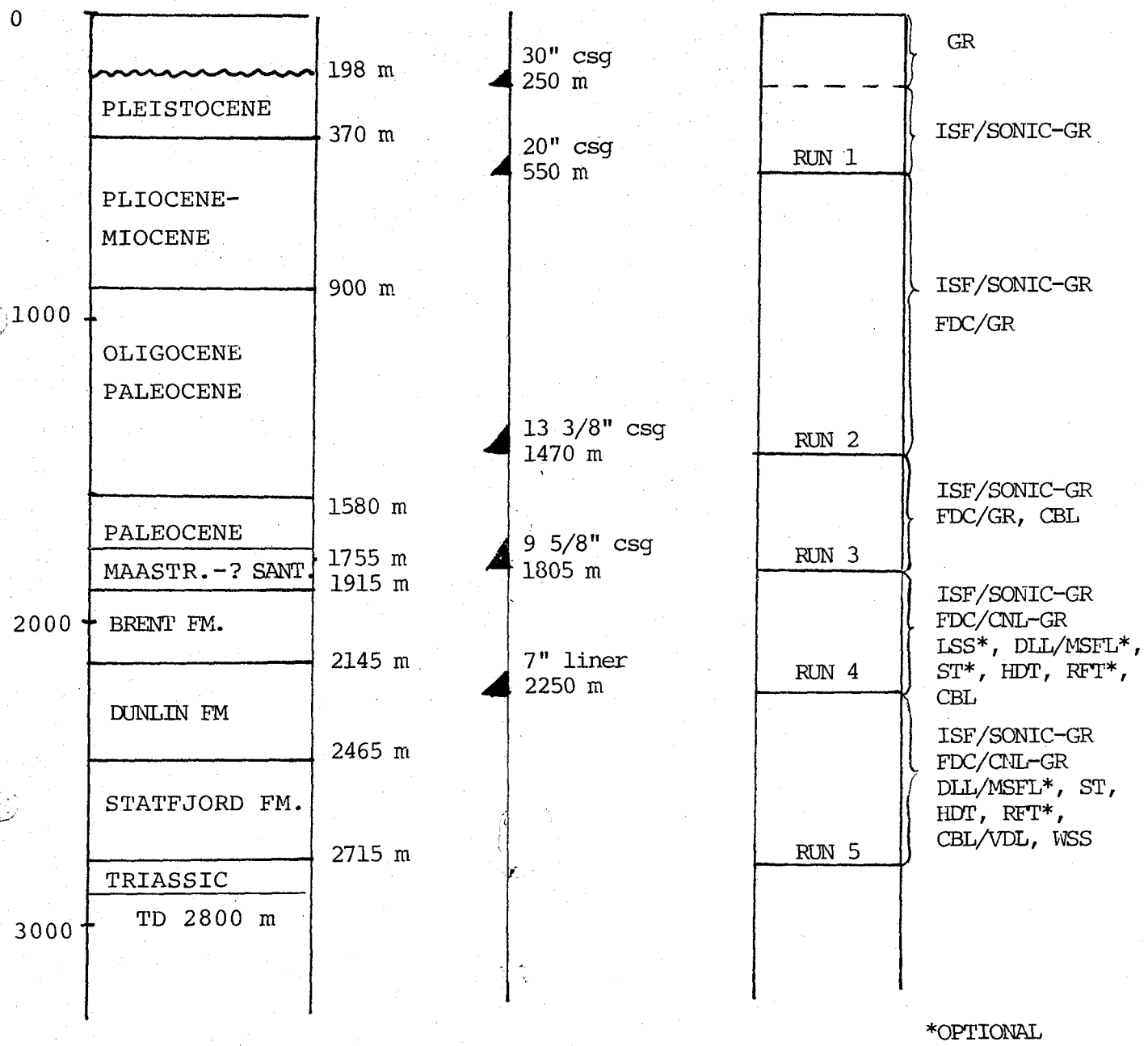
One set of washed and dried samples will be retained on the rig until the well is finished. The remaining samples will be sent to GECO, Stavanger periodically during drilling. Storage, washing and distribution will be handled by GECO as per instructions.

LOGGING PROGRAM

RUN	HOLE SIZE	TYPE LOGS
1	17½"	ISF/SONIC-GR, (GR to sea bed)
2	17½"	ISF/SONIC-GR, FDC/GR
3	12½"	ISF/SONIC-GR, FDC/GR, CBL (in 13 3/8" csg)
4	8½"	ISF/SONIC-GR, FDC/CNL-GR, LSS*, DLL/MSFL*, ST*, HDT, RFT* CBL (in 9 5/8" csg)
5	6"	ISF/SONIC-GR, FDC/CNL-GR, DLL/MSFL*, ST, HDT, RFT*, CBL/VDL (in 7" liner), WSS

*Optional

WELL LOGGING PROGRAM 34/10-3



CORING PROGRAM

A minimum of one core will be taken in middle Jurassic sandstone for reservoir analysis. Additional cores may be requested if significant hydrocarbon shows are encountered during drilling. This will be at the discretion of the wellsite geologist. All cores will be sent to GECO, Stavanger for analysis, distribution and storage.

TESTING PROGRAM

Med 7" liner vil dette bli vanskelig for Statfjord! Hva med Stat.?

If hydrocarbon accumulations are present, testing will be requested. These tests may be RFT's or production tests through casing depending on analysis of well potential at the time.

A supplementary work program will be issued if necessary.

COMMUNICATION PROCEDURE

Confidentiality

All data are considered confidential and will be released to third parties only by decision of Statoil.

Delivery to participants

A daily well report will be sent by the operator (Statoil) to all partners and to the Norwegian Petroleum Directorate. All other wellsite data, including field prints of logs, will be sent by post or messenger.

A final well report will be prepared for distribution to partners and to the appropriate Norwegian Government agencies no later than six months after completion of the well.

STAFF

Staff of the Exploration Department, Statoil, who are involved in the planning and drilling of well 34/10-3.

Name	Title	Office	Home	Mobile
J. Bleie	Exploration Manager	33180	32630	47461
D.I. Milton	Chief Geologist	"	51264	62513
S. Nedland	Area Geologist	"	-	36309
S.G. Larsen	Head Exploitation Geol.	"	25374	36340
Erik Lie	Supr. Wellsite Geol.	"	-	57916
Wellsite geologist on duty		"	-	57905

COMMUNICATION PERSONELL DURING THE DRILLING OF 34/10-3

Norsk Hydro A/S:

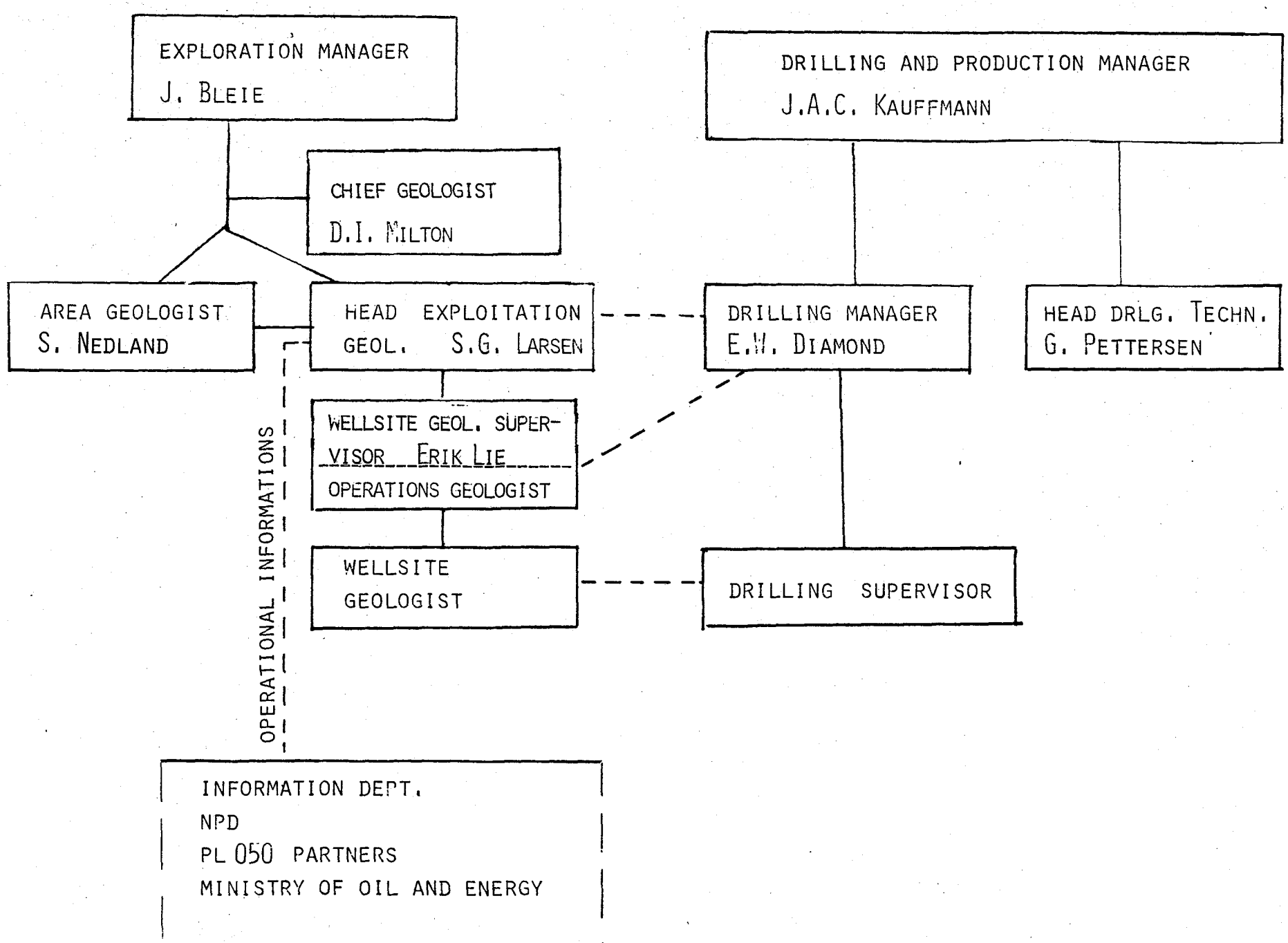
Name	Title		Office	Home	Mobile
J. Small	Expl. Manager	(02)	543920	149280	-
K.A. Oppebøen	Area Coordinator		"	170206	-
S.I. Leivestad	Operations Geologist		"	601956	57568

Saga Petroleum A/S & Co.:

Kjell G. Finstad	Expl. Manager	(02)	543952	225643	
Rolf Myrland	Chief Geol.		"	-	
S. Johansen	Chief Geof.		"	170044	

ORGANIZATION CHART

DRILLING OF WELL 34/10-3



STATOIL

DRILLING PROGRAM

WELL 34/10-3

NOTE: This program is designed to supplement Statoil's DRILLING OPERATION MANUAL AND FLOATING DRILLING BLOWOUT PREVENTION MANUAL.

The procedures as presented in this program will be followed in cases where differences exist between this program and the abovementioned procedures.

DRILLING PROGRAM.

Well Designation	: 34/10-3
Vessel	: "Ross Rig" (TF 103)
Drilling Draft	: 21.3 m (70 ft)
KBE to MSL	: 25 m
Water depth	: 173 m
Depths	: Referred to KBE except where specified otherwise.

I LOCATION:

See Geological Program.

II MOORING:

As per general Procedure. The seabed is sloping towards NE. Slopeangle inside the anchoring area is limited to approx. 6^{o}.

III GEOLOGICAL PROGNOSIS:

See Geological Program.

IV GENERAL DRILLING:

Estimated total depth: 2800 m

Operation phase:

Drill 36" hole with 26" x 36" H.O. to $\pm$ 250 m. Stab 30" casing blind. (4 joints) Do not use a temporary guide base.

Drill out 30" casing with 17½" bit to 560 m. Log and open with 26" H.O. Set 20" casing.

Drill 17½" hole to 1485 m, log and set 13 3/8" casing.

Drill 12 1/4" hole ± 50 m into the Cretaceons formation. This depth will be ± 1820 m. Log and set 9 5/8" casing. Drill 8½" hole below the shoe, through the Brent formation and ± 100 m into the Dunlin formation (to ± 2260 m). Cores will be cut according to the geological program.

The decision wheather or not to commit 7" liner in the Dunlin formation will be based upon an evaluation of the reservoir rock quality of the Brent formation such as core and log analysis (height of hydrocarbon bearing section, porosity, permeability, pressure development etc.)

If 7" liner is not set in the Dunlin formation, the 8" hole will be drilled to T.D. The hole will be logged. 7" liner will be run if required.

Drilling Considerations.

Control wells.
The drilling program for this well is to a large degree based upon the experience gained from 34/10-1 which was the first well drilled on this structure. Correlations have also been made with 34/10-2 and the wells drilled in the Statfjord area.

Seabed Conditions.

The water depth at the location is 173 m. The seabed is sloping towards NE and the slope angle at the location is approximately 6^{o}. This is not considered to be a severe problem. Utmost care must be taken when drilling the hole for the 30" casing and the casing with guide base must be landed in a horizontal position. Regan Bull's Eye must be checked before and after cementing.

Shallow Gas.

There are indications that gas might be encountered at ± 900 m. If drilling break occurs, check for flow and circulate bottoms up according to the procedure laid down in the operations manual.

Directional Survey.

The necessity for adhering to the directional survey procedure is emphasized. The geological objective is relatively shallow making any relief well drilling operation more difficult to plan. Accurate survey data is therefore essential.

Single shot directional surveys will be run every bit run below the 20" casing shoe, and every 90 m after setting the 13 3/8" casing if hole conditions permit.

H_2S - checks.

H_2S - checks shall be performed on mud filtrate at 100 m intervals below the 9 5/8" casing shoe.

V MUD PROGRAM

Interval m RKB	Hole size	Mud type	Weight (g/cm^3)	PV	YP	HTHP w.l.	pH
198 - 250	26" x 36"	Seawater w/gel slugs	-				
250 - 560	17½"	Seawater w/gel slugs	-				
250 - 560	26"	Seawater w/gel slugs	-				
560 - 1485	17½"	Seawater, lignosulfonate	1.06 - 1.4	low	15 - 20	25 or less	9.5 - 10.5
1485 - 1820	12 1/4"	Sea-/freshwater, chromelignosulfonate	1.5 - 1.75	low	10 - 15	15 or less	10.0 - 11.0
1820 - 2800	8½"	Sea-/freshwater, chromelignosulfonate	1.8	low	10 - 15	15 or less	10.0 - 11.0
2250 - 2800	6"	Sea-/freshwater, chromelignosulfonate	1.8	low	10 - 15	15 or less	10.0 - 11.0

Remarks:
- Rheology properties will be tested and reported at 50°C. Reported mud weight is to be measured using a Pressurized Mud Balance.
- Maintain drill solids content at minimum by means of the desander, desilters/mud cleaners (150 - 120 mesh screens).
- Utilize the centrifuge for viscosity control and for barite salvage.
- See separate Mud Program for details.

VI HYDRAULICS/BITS

Interval m RKB	Hole size	Bit type	Nozzles (32 nds)	WOB (tons)	RPM	Circ. (cum/min)	Pump press (bar)
198 - 250	26"x36"	26" + H.O.	3 x 20	0 - 5	60	-	-
250 - 560	17½"	DSJ	4 x 18	0 - 10	125 - 150	3.4	-
250 - 560	17½"x26"	DSJ + H.O.	4 x 18	0 - 7	120	3.6	-
560 - 1485	17½"	DSJ/OSJ-3J	4 x 18/3 x 18	5 - 15	125 - 150	3.3 - 3.5	200
1485 - 1820	12 1/4"	X1G, XV	3 x 15/3 x 14	10 - 20	80 - 130	2.0 - 2.5	200
-	8 15/32"	C18, CB 303 core	-	5 - 10	80 - 100	1.0	-
1820 - 2800	8½"	X1G, M44N, SDGH	3 x 14	10 - 25	60 - 100	2.0	200
2250 - 2800	6"	J22, FP52, FZ	3 x 11	10 - 20	60 - 100	1.0	200

Remarks: - Hydraulics and Drilling Parameters will be optimized on the rig according to actual mud properties and hole conditions. Surface pressure is to be recorded at different Circulating rates before the bit is pulled.

- Bit type does not necessarily indicate actual make of bit. Equivalent bit types may be used.

VII WELL LOGGING PROGRAM

See Geological Program

VIII CASING

Set casing as per general procedures

Casing program:

Size (inch)	Depth (m)	Weight (lbs/ft)	Grade	Thread
30	4 joints	1" wall	B	Vetco ATD/RB
20	550- 198(RKB)	94	J55	Vetco L
13 3/8	1470-1050(RKB)	68	K55	Buttress
	1050- 198(RKB)	72	N80	Buttress
9 5/8	1805-1400(RKB)	43.5	N80	Buttress
	1400- 198(RKB)	47	N80	Buttress

See "Casing calculations".

IX CEMENTING

As per general procedure. See "Cement Calculations" for slurry compositions and slurry amounts. A cement bond log will be run to check the top and quality of the cement for the 13 3/8" and 9 5/8" casings.

X BOP TESTING

As per general procedures.

XI PRESSURE INTEGRITY TESTS.

The pressure integrity tests will be performed according to normal procedures.

XII DRILLS.

As per general procedures.

XIII ABNORMAL PRESSURE DETECTION.

The most effective abnormal pressure detection operation will be the result of team effort involving the Drilling Supervisor, Drilling Engineer, Wellsite Geologist, and Mud Logging Engineer. Pressure indicators will be monitored continuously and any deviation investigated immediately. The reliability of each abnormal pressure indicator will have to be established during the course of operation.

A Mud Logging Unit will be utilized below the 30 inch casing shoe to collect and monitor abnormal pressure parameters. This unit will be programmed to record and plot the following parameters relating to abnormal pressure:

a) On a depth scale:
   1. Drillability
   2. ROP
   3. "d" exponent

b) On a time scale:
   1. Rotary torque
   2. Mud temperature in
   3. Mud temperature out

4. Lagged differential temperature
5. Mud flow in
6. Mud flow out
7. Mud weight in
8. Mud weight out
9. Pit volume
10. Pit volume total change
11. Mud gas

In addition, below the 20" casing shoe, manual plots will be recorded and reviewed continuously by the Drilling Engineer and Drilling Supervisor. These plots will include ROP, "d"-exp., Gas Units, and Shale Density.

Abnormal pressure detection data will be forwarded into the Stavanger Operations Office twice daily on a routine basis and more frequently if drilling a suspect transition zone. Any change in abnormal pressure detection parameters will be immediately reported by the rig to the Stavanger Operations Office.

XIV PRODUCTION TESTS.

As per production test manual. A detailed testing program will be issued prior to each production test.

XV PLUG AND ABANDONMENT.

As per general procudures.

Approved:

Expl. Manager
Statoil

Drilling and
Production Manager
Statoil

Maximum kick size (BHA 180 m):

1805 - 1925 m: casing limitation (15 m^3+)
1925 - 1985 m: 120 • 0.0152 m^3 = 1.8 m^3
1985 - 2105 m: 1.8 - 2.8 m^3
2105 - 2250 m: 120 • 0.0239 m^3 = 2.8 m^3

7" liner.

Setting depth 2250 m. Formation integrity equal to 0.199 bar/m

Annular capacity (6" - 3½") = 0.012 m^3/m
Annular capacity (6" - 4 3/4") = 0.007 m^3/m

From fig. 3 it can be seen that max equivalent influx height at 7" shoe, using 1.70 g/cm^3 mud + 0.05 g/cm^3 increase is appr. 350 m.

Maximum kick size (BHA 240 m):

2250 - 2600 m: Casing limitation (15 m^3+)
2600 : 240 • 0.007 m^3 + 110 • 0.012 m^3 = 3 m^3
2600 - 2800 m: 3 - 4 m^3
2800 m: 40 • 0.007 m^3 + 310 • 0.012 m^3 = 4 m^3

All depths measured from RKB.

Wd = Well depth, (m)
Y = Depth to fluid column, (m)
x = Casing seat depth, (m)
Z = Liner top depth
G p' = Pore pressure. Normal gradient, (bar/m)
Gp" = Pore pressure, Actual gradient (bar/m)
G = Mud pressure gradient at casing setting depth, (bar/m)
Gpf = Fracture mud gradient (bar/m)
Gi = Mud pressure gradient at Well depth (bar/m)
G i' = Maximum mud pressure gradient (bar/m)
Ggas = Gas gravity gradient (bar/m)
Sfc = Safety factor, collapse
Sfb = Safety factor, burst
Sft = Safety factor, tension
RESc = Collapse resistance (bar)
RESb = Burst resistance, (bar)
KESt = Tension resistance, (bar)
Pp = Pore pressure, (bar)
A = Cross-sectional area of casing, (cm^2)
Pc = Collapse pressure (bar)
Pb = Burst pressure (bar)
Sd = Sea bed depth

<u>13 3/8" casing</u>

Wd = 1805 m
X = 1470 m
Gp' = 0.1 bar/m
G = 0.137 bar/m
Gi' = 0.171 bar/m
Gpf = 0.181 bar/m

Kick calculations. See fig. 3

20" Casing. Setting depth.: 550 m. The normal procedure of not shutting in the well will be used.

13 3/8" casing. Setting depth 1470 m. Formation integrity equal to 0.182 bar/m.

Annular capacity (12 1/4" - 8") = 0.0436 m^3/m
Annular capacity (12 1/4" - 5") = 0.0627 m^3/m

From fig. 3 it can be seen that when using mud weight 1.75 g/cm^3 while drilling below 13 3/8" casing shoe, and the required weight increase is 0.05 g/cm^3, the equivalent influx height at the 13 3/8" casing shoe may be appr. 40 m before the formation is factured.

Maximum kick size (BHA 180 m):

1470 - 1510 m: casing limitation (15 m^3+)
1510 - 1650 m: 40 • 0.0436 m^3 = 1.75 m^3
1650 - 1690 m: 1.75 - 2.5 m^3
1690 - 1805 m: 40 • 0.0627 m^3 = 2.5 m^3

9 5/8" shoe: Setting depth 1805 m. Formation integrity equal to 0.194 bar/m.

Annular capacity (8½" - 6½") = 0.0152 m^3/m
Annular capacity (8½" - 5") = 0.0239 m^3/m

From fig. 3 it can be seen that when drilling below the 9 5/8" shoe, using mud weight 1.80 g/cm^3 and 0.05 g/cm^3 weight increase, appr. 120 m equivalent influx height can be tolerated at the 9 5/8" shoe before the formation is fractured.

Collapse.

Mud level if mud is lost to a normal pressure formation at 1805 m:

$$Y = (Wd - \frac{Wd \cdot Gp'}{Gi'}) = (1805 - \frac{1805 \cdot 0.1}{0.171})\ m = \underline{750\ m}$$

Max collapse pressure $= Y \cdot G = 750 \cdot 0.137$ bar $= \underline{103\ bar}$

Select:

198 - 1050 m: N80, 72 lb/ft, Buttress
RESc = 184 bar
RESb = 371 bar
RESt = $738 \cdot 10^3$ daN
A = 134 cm^3

1050 - 1470 m: K55, 68 lb/ft, Buttress
RESc = 134 bar
RESb = 238 bar
RESt = $475 \cdot 10^3$ daN
A = 125.5 cm^3

See fig. 1

Collapse pressure at 1050 m depth:

$Pc = 1050 \cdot G - (1050 - Y) \cdot Gi' =$
$1050 \cdot 0.137$ bar $- (1050 - 750) \cdot 0.171$ bar $= 92.5$ bar

K55, 68 lb/ft, buttress, RESc = 134 bar
A = 125,5 cm^2
Yield strength = 55000 psi = 3866 kg/cm^2

Weight load = 101,2 kg$\cdot$(1470 - 1050) = 42504 kg

$$\text{Stress load} = \frac{42504\ kg}{A} = 338{,}7\ kg/cm^2$$

$$\frac{\text{Stress load}}{\text{Yield strength}} = \frac{338,7}{3866} = 0.087 \Rightarrow \text{Collapse resistance}$$

reduced by 5% (Fig. 7.4.2, casing manual)
Reduced collapse resistance = 127.3 bar

$$Sfc = \frac{127.3}{Pc} = \frac{127.3}{92.5} = \underline{1.37 > 1.3}$$

Burst

Kick volume 15 m^3, mud density increase necessary to balance formation pore pressure 0.010 bar/m.

Length of BHA appr. 180 m
Annular capacity 12 1/4" - 8" = 0.0436 m^3
Annular capacity 12 1/4" - 5" = 0.0627 m^3

$$\text{Height of influx: } L = \frac{15\ m^3 - 180 \cdot 0.0436\ m^3}{0.0627\ m^3/m} + 180\ m = \underline{294\ m}$$

Bottom hole pressure before kick at 1805 m:

$$Pp = Gi' \cdot Wd = 0.171 \cdot 1805 \text{ bar} = 309 \text{ bar}$$

Bottom hole pressure after kick:

$$Pp = (Gi' + 0.01) \cdot Wd = (0.171 + 0.01) \cdot 1805 \text{ bar} = \underline{327 \text{ bar}}$$

$$Pg = ((Wd - Sd) - Hg) \cdot Gi' = Pp \qquad \text{Eq (1)}$$

$$\frac{Pp \cdot Vi}{T_1 \cdot Z_1} = \frac{Pg \cdot Vg}{T_2 \cdot Z_2} \qquad \text{Eq (2)}$$

where
- Pg = Pressure of gas at wellhead
- V_1 = Volume of influx = 15 m^3
- T_1 = Bottom hole temperature = 74°C (347°K)
- Z_1 = Gas comp. factor at bottom = 0.99 (γ = 0.6)
- T_2 = Wellh. temp. of gas 25°C (298°K)
- Z_2 = Gas comp. factor at wellh. = 0.82 (γ=0.6)
- Hg = Height of gas bubble at wellhead

Annular capasity 5" drill pipe - 13 3/8", 72 lb/ft = 0.0646 m^3/m

Equation 2

$$\frac{327 \cdot 15}{347 \cdot 0.99} = \frac{Pg \cdot Vg}{298 \cdot 0.82}$$

$$Vg = Hg \quad 0.0646$$

$$Hg = \frac{Vg}{0.0646} = \frac{327 \cdot 15 \cdot 298 \cdot 0.82}{327 \cdot 0.99 \cdot 0.0646} \; Pg = \frac{54009}{Pg}$$

SubstituteHg in Equation (1)

$$Pg + (1607 - \frac{54009}{Pg}) \cdot 0.171 = 327$$

Pg 126 bar

$$Hg = \frac{54009}{126} = 428 \text{ m}$$

Max burst pressure at 13 3/8" shoe depth (1470 m):

$$Pb = Pg + \frac{(Pp - Pg)(x - Sd)}{(Wd - L - Sd)} - X \cdot Gp' =$$

$$126 \text{ bar} + \frac{(327 - 126)(1470 - 198)}{1805 - 294 - 198)} \text{ bar} - 1470 \cdot 0.1 \text{ bar} = \underline{174 \text{ bar}}$$

K55, 68 lb/ft, Buttress, RESb = 238 bar

$$Sfb = \frac{RESb}{Pb} = \frac{238}{174} = \underline{1.36 > 1.1}$$

Tension

Load on top of casing: (1050 - 198)·107,1 kg + (X-1050) 101.2 kg = 133750 kg ⇒ 131.10 daN

N80, 72 lb/ft, buttress, RESt = $738 \cdot 10^3$ daN

$$SfT = \frac{738}{131} = \underline{5.63 > 1.5}$$

Load at 1050 m depth: (x - 1050 m) · 101.2 kg/m =

42500 kg ⇒ $41.6 \cdot 10^3$ daN

K55, 68 lb/ft, Buttress, RESt = $475 \cdot 10^3$ daN

$$Sft = \frac{475}{41.6} = \underline{11.4 > 1.5}$$

9 5/8" casing.

Wd = 2800 m
x = 1805 m
Gp' = 0.1 bar/m
G = 0.171 bar/m
Gi = 0.171 bar/m
Gi' = 0.176 bar/m
Gpf = 0.195 bar/m

Formation pressure (Statfjord) = Gp = 0.157 bar/m
Ggas ($\bar{p}$ = 410 bar, $\bar{T}$ = 158°F, γ = 0.6) = 0.023 bar/m

Collapse

Mud level if mud is lost to a normal pressure formation at 2800 m: $Y = (Wd - \frac{Wd \cdot Gp'}{Gi}) =$

$(2800 - \frac{2800 \cdot 0.1}{0.171})m = \underline{1162\ m}$

Maximum collapse pressure: $Y \cdot G = 1162 \cdot 0.171$ bar = 199 bar

Select: 198 - 1400: N80, 47 lb/ft, Buttress
RESc = 328 bar
RESb = 474 bar
RESt = $482 \cdot 10^3$ daN
A = 87.5 cm^2

1400 - 1805: N80, 43.5 lb/ft, Buttress
RESc = 263 bar
RESb = 436 bar
RESt = 445 bar
A = 81 cm^3

See fig. 2

Max collapse pressure at 1400 m depth:

$Pc = 1400 \cdot G - (1400 - 1162) \cdot Gi = \underline{199 \text{ bar}}$

N80, 43.5lb/ft, buttress, RESc = 263 bar
$A = 81 \text{ cm}^2$

Yield strength = 80000 psi = 5624 kgf/cm^2

Weight load = 64.7 (x - 1400 m)kg/m = 26200 kg

$\text{Stress load} = \frac{26200}{81} \text{ kg/cm}^2 = 323 \text{ kg/cm}^2$

$\frac{\text{Stress load}}{\text{Yield strength}} = \frac{323}{5624} = 0.057 \Rightarrow$ Collapse resistance

reduced by 3% (fig. 7.4.2, casing manual)

Reduced collapse resistance = $263 \cdot 0.97$ bar = 255 bar

$Sfc = \frac{255}{Pc} = \frac{255}{199} = \underline{1.28 > 1.25}$

Burst

Kick volume 15 m^3, mud density increase necessary to balance formation pore pressure 0.01 bar/m.
Length of BHA appr. 180 m.

Annular capacity 8½" - 6½" = 0.0152 m^3/m
Annular capacity 8½" - 5" = 0.0239 m^3/m

Height of influx: $L = \frac{15 \text{ m} - 180 \text{ m} \cdot 0.0152}{0.0239} + 180 \text{ m} = \underline{693 \text{ m}}$

Bottom hole pressure before kick at 2800 m:

$Pp' = Gi \cdot Wd = 0.171 \cdot 2800 \text{ bar} = 479 \text{ bar}$

Bottom hole pressure after kick at 2800 m

$Pp' = (Gi \cdot 0.01) \cdot Wd = (0.171 + 0.01) \cdot 2800 \text{ bar} = 507 \text{ bar}$

$Pg = ((Wd - Sd) - Hg) \cdot Gi = Pp$ Eq (1)

$\frac{Pp \cdot Vi}{T_1 \cdot Z_1} \quad \frac{Pp \cdot Vg}{T_2 \cdot Z_2}$ Eq (2)

Where
- Pg = Pressure of gas at wellhead
- V_1 = Volume of influx = 15 m^3
- T_1 = Bottom hole temperature = 90°C (363°K)
- Z_1 = Gas compr. factor at bottom = 1.2 ($\gamma = 0.6$)
- T_2 = Wellhead temp. of gas = 25°C (298°K)
- Z_2 = Gas compr. factor of wellhead = 0.82 ($\gamma = 0.6$)
- Hg = Height of gas bubble at wellhead

Annular capacity 5" drill pipe - 9 5/8", 47 lb/ft = 0.0255 m^3/m

Equation 2

$$\frac{507 \cdot 15}{363 \cdot 1.2} = \frac{Pg \cdot Vg}{298 \cdot 0.82}$$

$Vg = Hg \cdot 0.0255 \text{ } m^3/m$

$$Hg = \frac{Vg}{0.0255} = \frac{507 \cdot 15 \cdot 298 \cdot 0.82}{363 \cdot 1.2 \cdot 0.0255 \cdot Pg} = \frac{167302}{Pg}$$

Substitute Hg in Equation (1):

$$Pg + (2602 - \frac{167302}{Pg}) \cdot 0.171 = 507$$

$$\underline{Pg = 203 \text{ bar}}$$

$$Hg = \frac{167302}{203} \text{ m} = 824 \text{ m}$$

Max burst pressure at 9 5/8" shoe depth (1805 m):

$$Pb = Pg + \frac{(Pp - Pg)(x - Sd)}{(Wd-L-Sd)} - X \quad Gp' =$$

$$203 \text{ bar} + \frac{(507 - 203)(1805 - 198)}{(2800 - 693 - 198)} \text{ bar} - 1805 \cdot 0.1 \text{ bar} =$$

$$\underline{278 \text{ bar}}$$

N80, 43.5 lb/ft, buttress, RESb = 436 bar

$$Sfb = \frac{RESb}{Pb} = \frac{436}{278} = \underline{1.57 > 1.1}$$

Burst pressure at wellhead in case of a tubing leak while testing at 2600 m:

$$Pb = 2600 \cdot Gp - Ggas\ (2600 - Sd) - Sd \quad Gp' =$$

$$2600 \quad 0.157 \text{ bar} - 0.023 \cdot 2402 \text{ bar} - 198 \cdot 0.1 \text{ bar} = \underline{333 \text{ bar}}$$

N80, 47 lb/ft, buttress, RESb = 474 bar

$$Sfb = \frac{474}{333} = \underline{1.42 > 1.1}$$

Tension:

Load on top of casing: (1400 - 198) 70 kg + (1805 - 1400) G4,7 kg = 110343 kg • 108 • 10^3 daN

N80, 47 lb/ft, Buttress, RESt = 482 10^3 daN

$$Sft = \frac{482}{108} = \underline{4.46 > 1.5}$$

7" Liner.

Alternative A) Well depth 2800 m, liner shoe depth 2250 m.

Alternative B) Well depth 2800 m, liner shoe depth 2800 m.

A)

Wd	=	2800 m
x	=	2250 m
z	=	1705 m
Gp'	=	0.1 bar/m
G	=	0.176 bar/m
Gi	=	0.166 bar/m
Ggas	=	($\bar{P}$ = 335 bar, $\bar{T}$ = 160°F, γ = 0.6) = 0.020 bar/m
G_2gas	=	($\bar{p}$ = 486 bar, $\bar{T}$ = 180°F, γ = 0.6) = 0.024 bar/m

Formation pressure (Brent) gradient=Gp=0.164 bar/m
Formation pressure (Lower Brent) gradient = Gp" = 0.162 bar/m

Burst

Burst pressure at top of liner if there is a tubing leak while testing Brent formation at 2100 m:

$$Pb = 2100 \cdot Gp'' - Ggas\ (2100 - Z) - Z \cdot Gp' =$$

$$2100 \cdot 0.162 - 0.020 \cdot (2100 - 1705) - 1705 \cdot 0.1 = \underline{162 \text{ bar}}$$

Burst pressure while circulating gas which has entered the well at 2800 m (Influx = 15 m^3, mud weight increase = 0.01 bar/m):

Annular capacity 4 3/4" - 6" = 0.0068 m^3/m

Annular capacity 3½" - 6" = 0.012 m^3/m

Heigh of influx : $L = \frac{15\ m - 180\ m \cdot 0.0068}{0.012} + 180\ m = \underline{1328\ m}$

Max burst pressure at shoe (2250 m):

$Pb_2 = Wd \cdot (0.166 + 0.01)bar/m - (Wd - 2250\ m)\, G_2 gas -$

$2250\ m \cdot Gp' =$

$2800 \cdot 0.176\ bar - (2800 - 2250) \cdot 0.024\ bar - 2250 \cdot 0.1\ bar =$

$\underline{255\ bar}$

Select 1705 - 2250 m: N80, 29 lb/ft, buttress
RESc = 484 bar
RESb = 563 bar
$RESt = 300 \cdot 10^3$ daN

$Sfb = \frac{RESb}{Pb_2} = \frac{563}{255} = \underline{2.2 > 1.1}$

Collapse

Mud level if mud is lost to a normal - pressure formation at 2800 m:

$Y = (Wd - \frac{Wd \cdot Gp'}{Gi'}) = (2800 - \frac{2800 \cdot 0.1}{0.166})m = 1113\ m$

Collapse pressure at 1705 m:

$Pc = Z \cdot G - (Z - 1113) \cdot Gi =$

$1705 \cdot 0.176\ bar - (1705 - 1113) \cdot 0.16\ bar = 202\ bar$

N80, 29 lb/ft, buttress, RESc = 484 bar

Reduction in RESc caused by longtudinal tension stress = 3%

$$Sfc = \frac{RESc \cdot 0.97}{Pc} = \frac{470}{202} = \underline{2.33 > 1.25}$$

Minimum allowable flowing bottomhole pressure while testing at 2100 m:

$$Pwf\ min, = 2100 \cdot Gp'' - \frac{RESc}{1.25} \Rightarrow \underline{0\ bar}$$

Tension

Weight load = $43.15 \cdot (2250 - 1705)kg = 23516\ kg \Rightarrow 23 \cdot 10^3$ daN

N80, 29 lb/ft, buttress, RESt = $300 \cdot 10^3$ daN

$$Sft = \frac{RESt}{23 \cdot 10^3\ daN} = \frac{300}{23} = \underline{13 > 1.5}$$

B)

Wd	=	2800 m
X	=	2800 m
Z	=	1705 m
Gp'	=	0.1 bar/m
G	=	0.171 bar/m
Ggas	($\bar{p}$ = 395 bar, $\bar{T}$ = 175°F, γ = 0.6) =	0.023 bar/m

Formation pressure - Statfjord = 0.157 bar/m

Burst

Burst pressure at top of liner in case of a tubing leak while testing at 2600 m:

$Pb = 2600 \cdot 0.157\ bar - Ggas\ (2600 - Z) - Z \cdot Gp'$ =

$2600 \cdot 0.157\ bar - 0.023\ (2600 - 1705)bar - 1705 \cdot 0.1\ bar$ = <u>217 bar</u>

Select N80, 29 lb/ft, Buttress

RESc = 484 bar

RESb = 563 bar

RESt = 300 10^3 daN

$$Sfb = \frac{RESb}{Pb} = \frac{563}{217} = \underline{2.59 > 1.1}$$

Minimum allowable flowing bottomhole pressure while testing at 2600 m:

$$Pwf\ min = 2600 \cdot 0.157\ bar - \frac{484}{1.25}\ bar = \underline{21\ bar}$$

Tension

Weight load = $43.15 \cdot (X - Z)$ kg/m = $43.15 \cdot (2800 - 1705)$ kg = 47250 kg $\Rightarrow$ $46 \cdot 10^3$ daN

N80, 29 lb/ft, Buttress, RESt = $300 \cdot 10^3$ daN

$$Sft = \frac{RESt}{46 \cdot 10^3\ daN} = \frac{300}{46} = \underline{6.5 > 1.5}$$

Weight load on top of 9 5/8" casing:

$(1400 - 198) \cdot 70$ kg + $(1805 - 1400) \cdot 64.7$ kg

+ $(2800 - 1705) \cdot 45.15$ kg = 110343 kg + 47250 kg =

157593 kg $\cdot$ $155 \cdot 10^3$ daN

9 5/8", N80, 47 lb/ft, buttress, RESt = $482 \cdot 10^3$ daN

$$Sft = \frac{482}{155} = \underline{3.1 > 1.5}$$

CASING CEMENT DATA AND CALCULATIONS, 30" CASING.

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

WELL DATA:

Depth kb-sea bed	197	m
Depth kb-last shoe	-	m
Depth kb-casing set point	250	m
Open hole dia	36	"
Annulus capacity, cased hole	-	l/m
Annulus capacity, open hole	200	l/m
Internal capacity, " casing	397	l/m
Mud weight	1.1	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:

CEMENT SLURRY COMPOSITION		SLURRY CLASS G + 3.2 l/100 kg D-75	SLURRY CLASS G + 1 kg/100 kg $CaCl_2$
Mix water	l/100 kg	93 sea	93 sea
Total liquid	l/100 kg	96.2	44.6
Slurry weight	g/cm^3	1.56	1.91
Slurry yield	l/100 kg	128	76
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		6:00+	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	-	9.7
	N/mm^2, 24 hr	9.7	21.2
SPECIAL TESTS:			

Volume calculations: (30" casing)

Annular volume :	0.200 $m^3/m \cdot 54$ m	= 10.6 m^3
3 m plug at shoe:	0.397 $m^3/m \cdot 3$ m	= 1.3 m^3
Total :		11.8 m^3
Volume + 150% excess in open hole:		27.7 m^3

USE:

Lead: Class G cement + 3.2 l/100 kg D-75
14000 kg (328 sacks) cement
equal to 17.92 m^3 slurry.

Tail in: Class G cement + 1 kg/100 kg $CaCl_2$
12800 kg (300 sacks) cement
equal to 9.73 m^3 slurry

Job preparation:

Total liquid lead slurry: 14000 kg cmt (93+3.2) l/100 kg
= 13468 liter (= 13.47 m^3 or 85 bbls)

Volume of D-75 needed in each 10 bbls (1.59 m^3)

displacement tank: 1590 liter $\frac{3.2}{93 + 3.2}$ = 53 liter

Total volume D-75: 53 liter $\cdot \frac{85}{10}$ = 450 liter

Total liquid tail in: 12800 kg cmt. $\cdot$ 44.6 l/100 kg = 5709 liter
(= 5.71 m^3 or 36 bbls)

Amount of $CaCl_2$ needed = 12800 kg $\cdot$ 1 kg/100 kg = 128 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 the sea bed with 100% excess on the open hole volume.

WELL DATA:

Depth kb-sea bed	197	m
Depth kb-last shoe	250	m
Depth kb-casing set point	550	m
Open hole dia	26	"
Annulus capacity, cased hole	195	l/m
Annulus capacity, open hole	140	l/m
Internal capacity, 20" casing	178	l/m
Mud weight	1.1	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	59	bar
Est. bottom hole static temp. (BHST)	96	^oC
Est. bottom hole circulating temp. (BHCT)	31	^oC
Est. formation integrity	0.149	bar/m

CEMENT SLURRY DATA, STAGE:

CEMENT SLURRY COMPOSITION		SLURRY CLASS G + 3.2 l/100 kg D-75	SLURRY CLASS G neat
Mix water	l/100 kg	93 sea	44 sea
Total liquid	l/100 kg	96.2	44
Slurry weight	g/cm^3	1.56	1.92
Slurry yield	l/100 kg	128	76
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		5:00+	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@27°C	-	6.7
	N/mm^2, 24 hr@27°C	9.7	20.6
SPECIAL TESTS:			

Volume calculations: (20" casing)

Annular volume: 0.140 $m^3/m \cdot (550 - 250)$ m	=	42.00 m^3
Volume between the casings: 0.195 $m^3/m \cdot (250-197)$m	=	10.34 m^3
10 m plug at shoe: 0.187 $m^3/m \cdot 10$ m	=	1.78 m^3
Total theoretical volume:		54.12 m^3
100% excess in open hole:		42.00 m^3
Total cement slurry volume:		96.12 m^3

USE:

Lead slurry: Class G cement + 3.2 l/100 kg D-75
67400 kg (1580 sacks) cement
equal to 86.27 m^3 slurry

Tail in slurry: Class G cement neat with seawater
13000 kg (305 sacks) cement
equal to 9.88 m^3 slurry

Job preparation:

Total liquid lead slurry: 67400 kg $\cdot$ 96.2 l/100 kg =
64840 liter (=64.84 m^3 or 408 bbls)

Volume of D-75 needed in each 10 bbls
displacement tank : 1590 liter $\frac{3.2}{96.2}$ = 53 liter

Total volume of D-75 needed: 53 liter $\frac{408}{10}$ = 2160 liter

Total liquid tail in slurry: 13000 kg $\cdot$ 44 l/100 kg =
5720 liter (= 5.72 m^3 or 36 bbls)

Time estimate for cement job :

Mix cement: 92.12 $m^3/0.8$ m^3/min	=	120 min
Displacement: 54 $m^3/1.0$ m^3/min	=	54 min
Total pumping time:		174 min

or 2 hours 54 min

Hydrostatic pressure at the casing shoe (550 m):

Height of tail in slurry: $(9.88 - 1.78)m^3/0.140\ m^3/m$ = 58 m

Hydrostatic head lead slurry: 0.153 bar/m · (550-197-58)m	=	45.1 bar
Hydrostatic head tail in slurry: 0.188 bar/m · 58 m	=	10.9 bar
Hydrostatic head seawater: 0.100 bar/m · (197 - 25)m	=	17.2 bar
Total hydrostatic pressure:		73.2 bar

Equivalent gradient: 73.2 bar/550 m = 0.133 bar/m

Estimated formation integrity: 0.149 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 the 20" casing with 25% excess on open hole volume.

WELL DATA:

Depth kb-sea bed	197	m
Depth kb-last shoe	550	m
Depth kb-casing set point	1470	m
Open hole dia	17½	"
Annulus capacity, cased hole	94.7	l/m
Annulus capacity, open hole	64.5	l/m
Internal capacity 13 3/8" casing, 72 lb/ft	77.3	l/m
Mud weight	1.4	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	202	bar
Est. bottom hole static temp. (BHST)	51	°C
Est. bottom hole circulating temp. (BHCT)	40	°C
Est. formation integrity	0.181	bar/m

CEMENT SLURRY DATA, STAGE:

CEMENT SLURRY COMPOSITION		SLURRY CLASS G + 3.2 l/100 kg D-75	SLURRY CLASS G neat
Mix water	l/100 kg	93 sea	44 fresh
Total liquid	l/100 kg	96.2	44
Slurry weight	g/cm^3	1.56	1.90
Slurry yield	l/100 kg	128	76
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		4:30	3:00
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 @ 27°C		-	4.8
N/mm^2, 24 hr @ 27°C		9.7	12.8
N/mm^2, 24 hr @ 51°C		-	31.7
SPECIAL TESTS:			

Hydrostatic pressure at the casing shoe (1470m):

Height of tail in slurry : (9.88 - 1.86)m^3/0.0645 m^3/m	=	124 m
Maximum height lead cement:		
Volume to 20" shoe : 0.0645 m^3/m · (1470-124-550)m	=	51.3 m^3
Volume above 20" shoe: 75.65 m^3 - 51.3 m^3	=	24.35 m^3
Height above 20" shoe: 24.35 m^3/0.0947 m^3/m	=	257 m
Maximum height lead cement: (1470-550-124+257)m	=	1053 m
Hydrostatic head lead slurry: 153 bar/m · 1053 m	=	161.1 bar
Hydrostatic head tail in slurry: 0.186 bar/m · 124 m	=	23.1 bar
Hydrostatic head mud: 0.137 bar/m · 293 m	=	40.1 bar
Total hydrostatic pressure	=	224.3 bar
Equivalent gradient: 224.3 bar/1470 m	=	0.153 bar/m
Estimated formation integrity:	=	0.181 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 volume.

WELL DATA:

Depth kb-sea bed	197	m
Depth kb-last shoe	1470	m
Depth kb-casing set point	1805	m
Open hole dia	12 1/4	"
Annulus capacity, cased hole	30.3	l/m
Annulus capacity, open hole	29.1	l/m
Internal capacity, 9"5/8"casing 43.5 and 47 lb/ft	38.8/38.2	l/m
Mud weight	1.75	g/cm^3
Bottom hole hydrostatic pres. (BHHP)	310	bar
Est. bottom hole static temp. (BHST)	69	^oC
Est. bottom hole circulating temp. (BHCT)	46	^oC
Est. formation integrity	0.193	bar/m

CEMENT SLURRY DATA, STAGE:

CEMENT SLURRY COMPOSITION		SLURRY CLASS G + 1.8 1/100 kg D-73 + 1.3 1/100 kg D-80	SLURRY CLASS
Mix water	1/100 kg	41 fresh	
Total liquid	1/100 kg	44.1	
Slurry weight	g/cm^3	1.90	
Slurry yield	1/100 kg	76	
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		3:30	
Crit. Turb.Flow rate: m/s (l/min)			
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength, N/mm^2,	hr		
	N/mm^2, 24 hr	17	

SPECIAL TESTS:

Note: Pump 20 bbls preflush spacer 1000 ahead of the cement.
The spacer to be 9.82 g/cm^3 (15.2 ppg)

Volume calculations: (9 5/8" casing)

Annular volume (12 1/4-9 5/8")	:0.0291 m^3/m · (1805-1470)m	=	9.75 m^3
Volume between casings	:0.0303 m^3/m · 100 m	=	3.03 "
24 m plug at shoe	:0.0388 m^3/m · 24 m	=	0.93 "
Total theoretical volume	:	=	13.71 m^3
25% excess in open hole	:9.75 m^3 · 0.25	=	2.44 "
Total slurry volume	:	=	16.15 m^3

USE:

Class G cement +
21250 kg (500 sacks) cement
equal to 16.15 m^3 slurry

Job preparation:

Total liquid needed; 21250 kg · 44.1 l/100 kg = 9370 ltr.
(= 9.37 m^3 or 59 bbls)

Volume of D-73 needed in each 10 bbls displacement tank	1590 ltr · $\frac{1.8}{44.1}$	=	65 ltr.
Volume of D-80 needed in each 10 bbls displacement tank	: 1590 ltr · $\frac{1.3}{44.1}$	=	47 ltr.
Total volume of D-73 needed	: 65 liter . $\frac{59}{10}$	=	384 ltr.
Total volume of D-80 needed	: 47 liter . $\frac{59}{10}$	=	277 ltr.

20 bbls spacer to used at 1.82 kg/liter.

Time estimate for the job:

Mixing cement: 16.15 m^3/0.8m^3/min.	=	20 min.
Displacement : 71 m^3/1.0 m^3/min	=	71 min.
Total pumping time:	=	91 min.
	or 1 hour 31 min.	

Volume calculations:

Annular volume (17½"-13 3/8")	: 0.0645 $m^3/m \cdot (1470-550)m$	=	59.34 m^3
Volume between the casings:	0.0947 $m^3/m \cdot 100$ m	=	9.47 "
24 m plug at shoe	: 0.0773 $m^3/m \cdot 24$ m	=	1.86 "
Total theoretical volume	:	=	70.67 m^3
25% excess in open hole	: 59.34 $m^3 \cdot 0.25$	=	14.84 "
Total slurry volume	:	=	85.51 m^3

USE:

Lead slurry: Class G cement + 3.2 l/100 kg D·75
59100 kg (1386 sacks) cement
equal to 75.65 m^3 slurry

Tail in slurry: Class G cement neat with fresh water
1300 kg (305 sacks) cement
equal to 9.88 m^3 slurry

Job preparation:

Total liquid lead slurry: 59100 kg · 96.2 l/100 kg = 56854 ltr.
(= 5.69 m^3 or 358 bbls)

Volume of D.75 needed in each 10 bbls displacement tanks : 1590 liter . $\frac{3.2}{96.2}$ = 53 liter

Total volume of D.75 needed: 53 liter . $\frac{358}{10}$ = 1900 liter

Total liquid tail in slurry: 13000 kg · 44 l/100 kg = 5720 liter
(= 5.72 m^3 or 36 bbls)

Time estimate for the job:

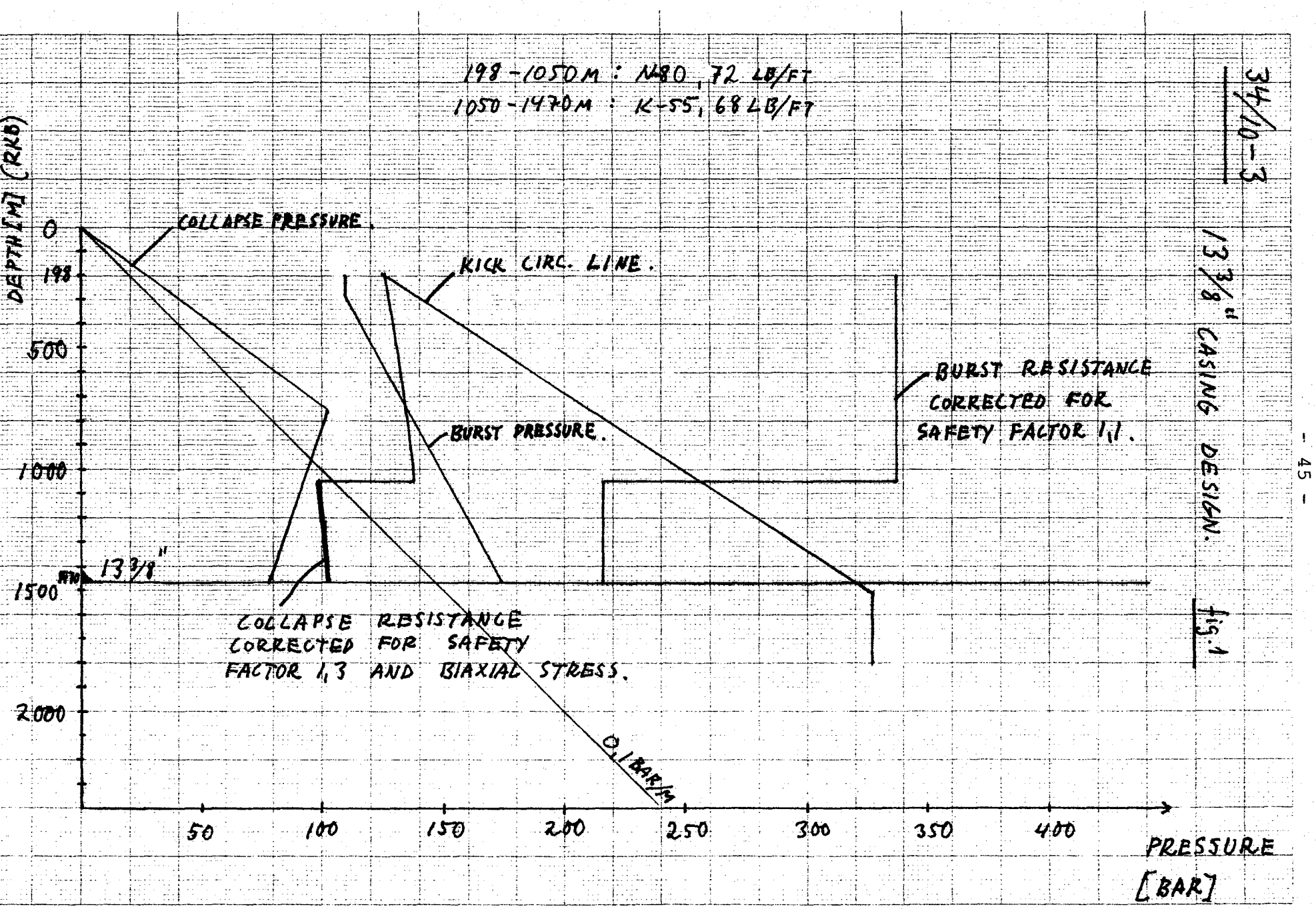
Mixing cement: 85.51 $m^3/0.8$ m^3/min	=	107 min
Displacement : 101 $m^3/1.0$ m^3/min	=	101 min
Total pumping time:	=	208 min

or 3 hours 28 min.

Hydrostatic pressure at the casing shoe (1805 m):

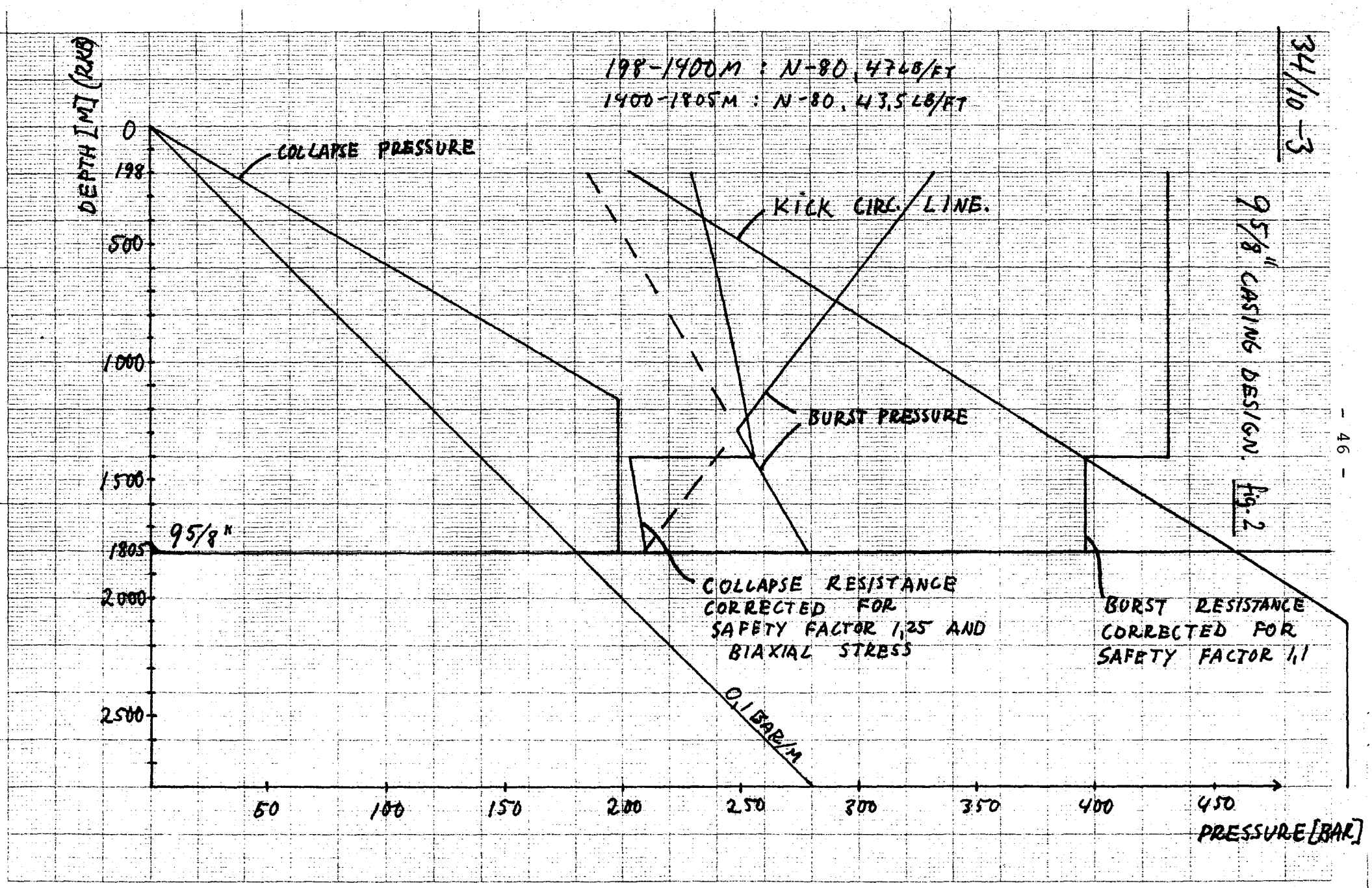
Height of 20 bbls spacer in annulus 13 3/8"-9 5/8":			
	20 bbls/0.0581 bbl/ft = 344 ft	=	105 m
Cement volume in annulus 13 3/8"-9 5/8" : 16.15 m^3-10.68 m^3		=	5.47 m^3
Height of cement in annulus 13 3/8"-9 5/8":5.47m^3/0.0303m^3/m		=	181 m
Hydrostatic head cement slurry: 0.186 bar/m · 516 m		=	96.0 bar
Hydrostatic head spacer : 0.178 bar/m · 105 m		=	18.7 bar
Hydrostatic head mud : 0.172 abr/m ·1184 m		=	203.6 bar
Total hydrostatic pressure :		=	318.3 bar
Equivalent gradient: 318 bar/1805 m		=	0.176 bar/m
Estimated formation integrity:		=	0.193 bar/m

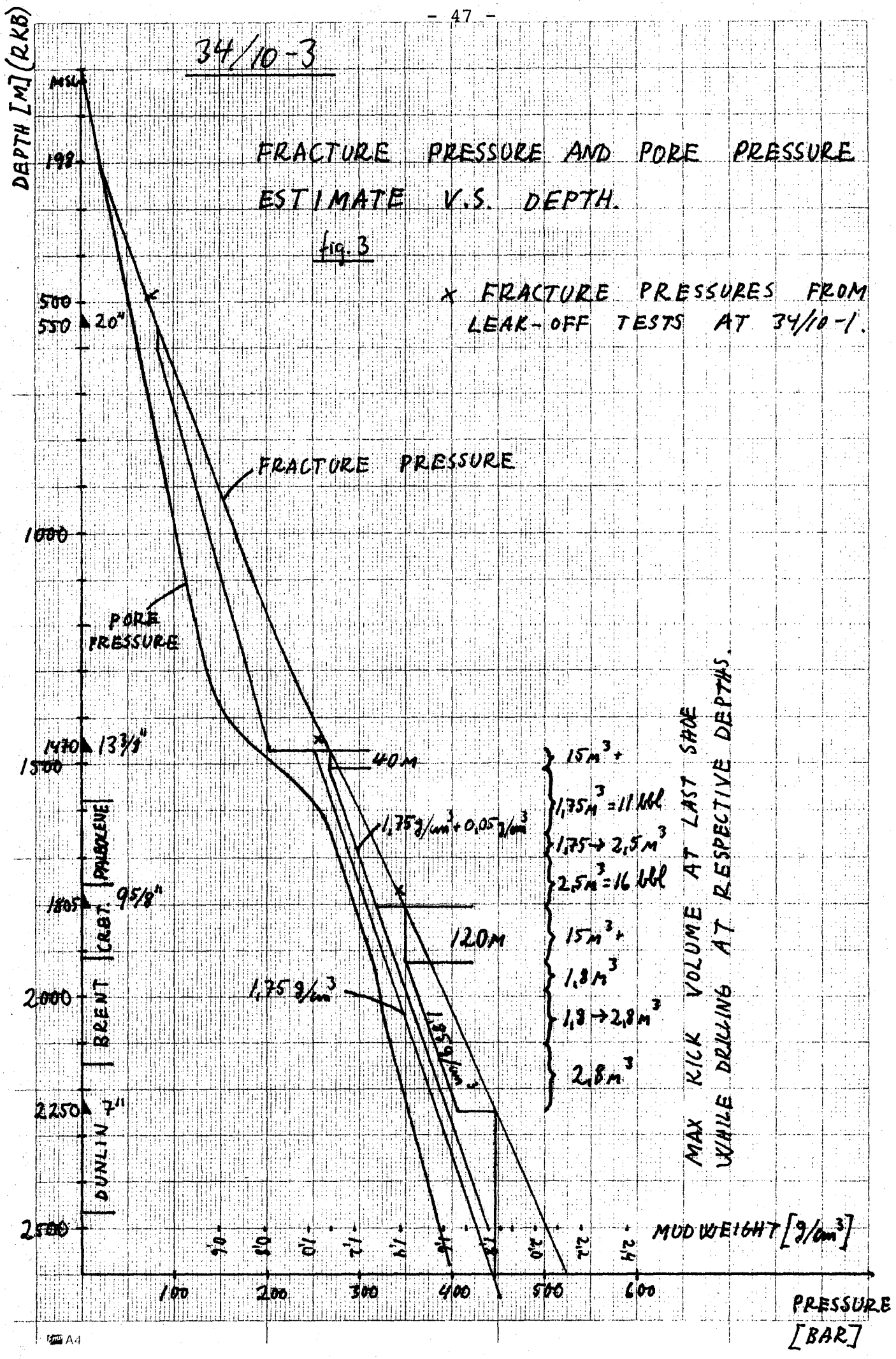
198 - 1050 M : N80, 72 LB/FT
1050 - 1470 M : K-55, 68 LB/FT

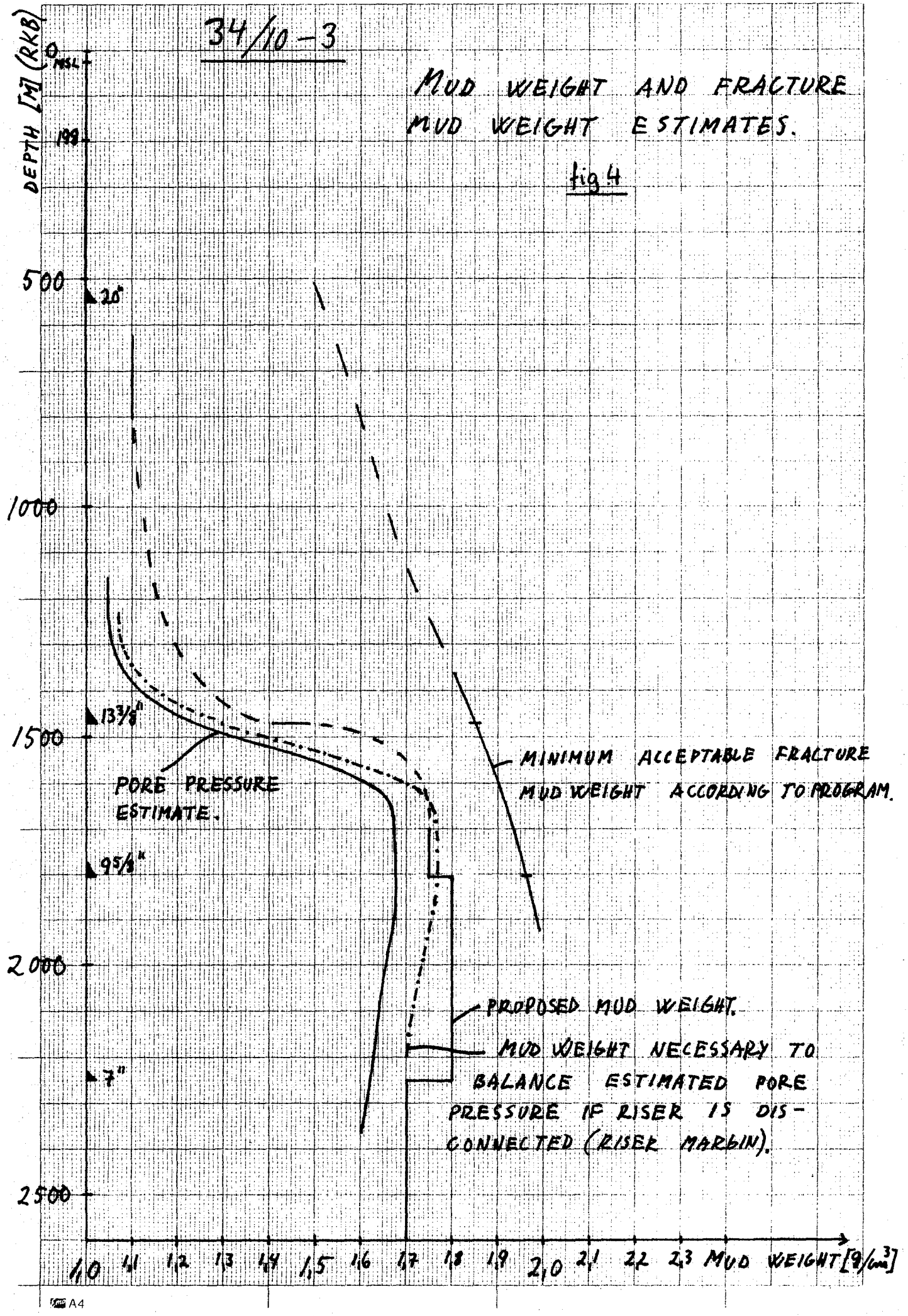


13 3/8" CASING DESIGN.

fig. 1


34/10 -3
198-1400M : N-80, 47LB/FT
1400-1805M : N-80, 43,5 LB/FT
9 5/8" CASING DESIGN. Fig. 2
DEPTH [M] (RKB)
0
198
500
1000
1500
1805
2000
2500
95/8"
COLLAPSE PRESSURE
KICK CIRC. LINE.
BURST PRESSURE
COLLAPSE RESISTANCE CORRECTED FOR SAFETY FACTOR 1,25 AND BIAXIAL STRESS
BURST RESISTANCE CORRECTED FOR SAFETY FACTOR 1,1
0,1 BAR/M
50
100
150
200
250
300
350
400
450
PRESSURE [BAR]


34/10-3
FRACTURE PRESSURE AND PORE PRESSURE ESTIMATE V.S. DEPTH.
fig. 3
× FRACTURE PRESSURES FROM LEAK-OFF TESTS AT 34/10-1.
DEPTH [M] (RKB)
MSL
198
500
550
20"
FRACTURE PRESSURE
PORE PRESSURE
1000
1470
13 3/8"
1500
40M
1,75 g/cm3 + 0,05 g/cm3
1805
9 5/8"
120M
1,75 g/cm3
2000
2250
7"
2500
PALEOCENE
KRBT.
BRENT
DUNLIN
15m3+
1,175m3 = 11 bbl
1,175 → 2,5m3
2,5m3 = 16 bbl
15m3+
1,8m3
1,8 → 2,8m3
2,8m3
MAX KICK VOLUME AT LAST SHOE WHILE DRILLING AT RESPECTIVE DEPTHS.
MUDWEIGHT [g/cm3]
1,0
1,1
1,2
1,3
1,4
1,5
1,6
1,7
1,8
1,9
2,0
2,2
100
200
300
400
500
600
PRESSURE [BAR]
A4


34/10-3
MUD WEIGHT AND FRACTURE MUD WEIGHT ESTIMATES.
fig 4
DEPTH [M] (RKB)
0 MSL
199
500
1000
1500
2000
2500
20"
13 3/8"
9 5/8"
7"
PORE PRESSURE ESTIMATE.
MINIMUM ACCEPTABLE FRACTURE MUD WEIGHT ACCORDING TO PROGRAM.
PROPOSED MUD WEIGHT.
MUD WEIGHT NECESSARY TO BALANCE ESTIMATED PORE PRESSURE IF RISER IS DISCONNECTED (RISER MARGIN).
1,0 1,1 1,2 1,3 1,4 1,5 1,6 1,7 1,8 1,9 2,0 2,1 2,2 2,3 MUD WEIGHT [g/cm3]
A4

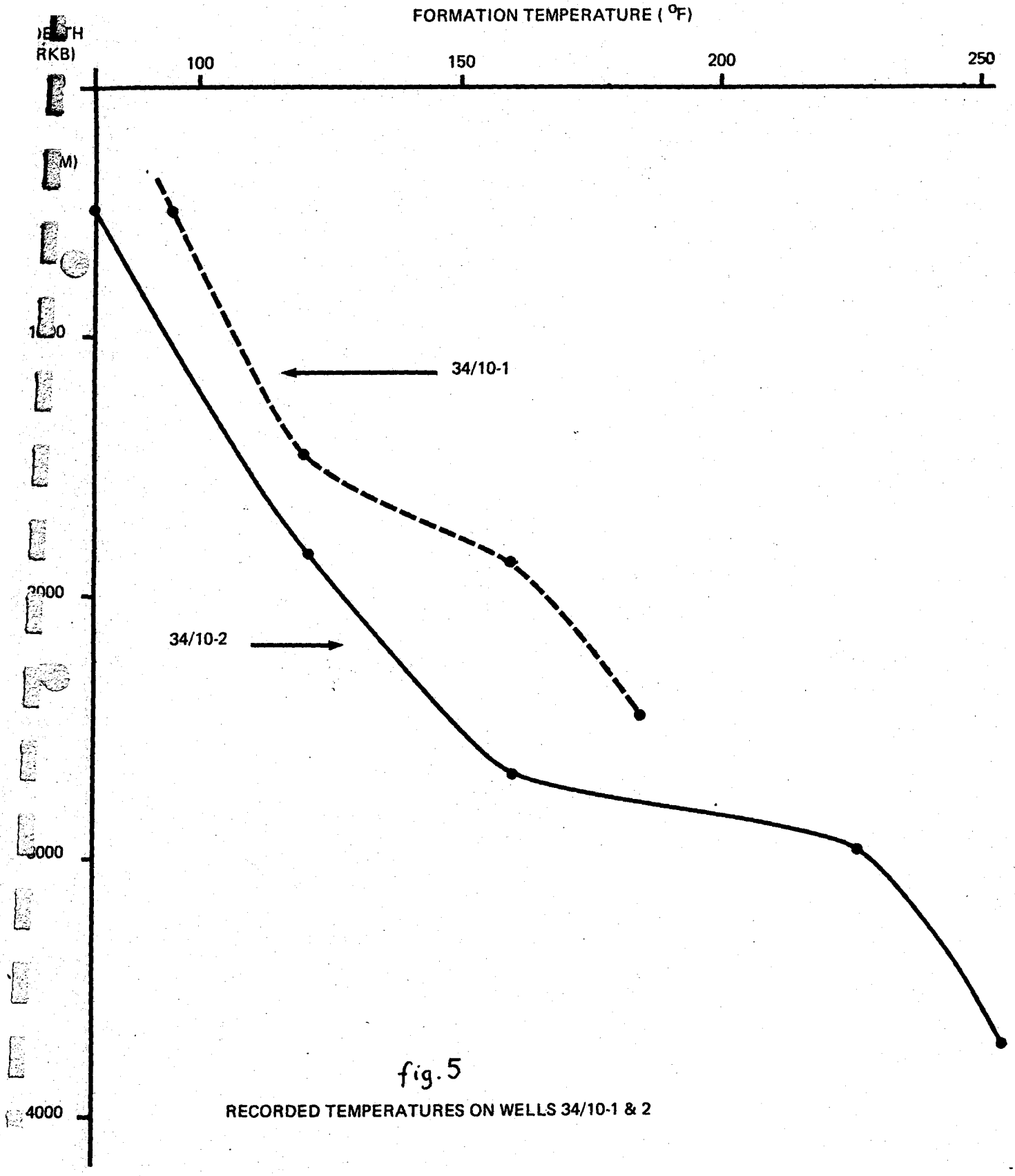


fig. 5

RECORDED TEMPERATURES ON WELLS 34/10-1 & 2

34-10-3 PREDICTED PORE-AND FRACTURE PRESSURE GRADIENTS

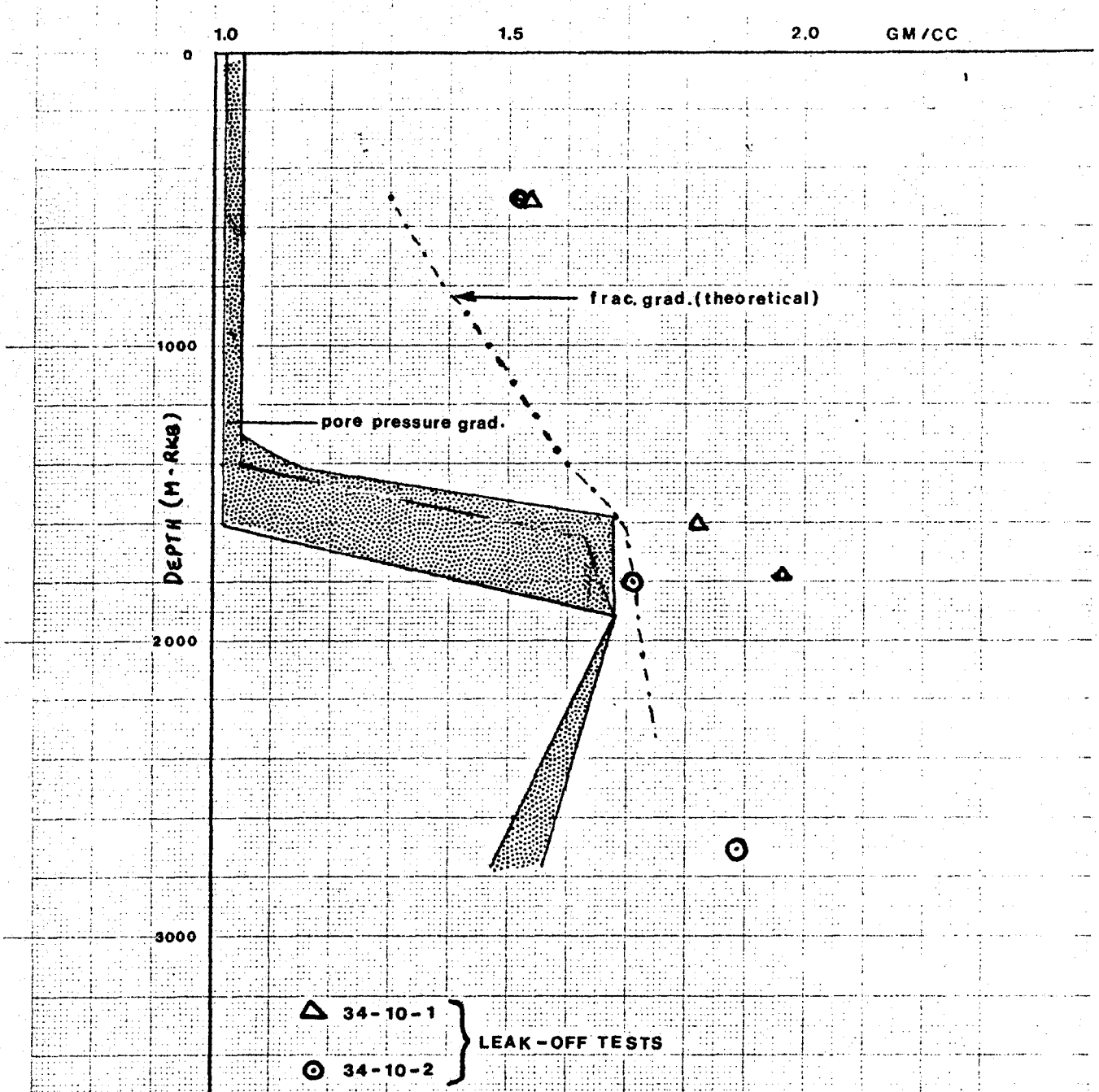
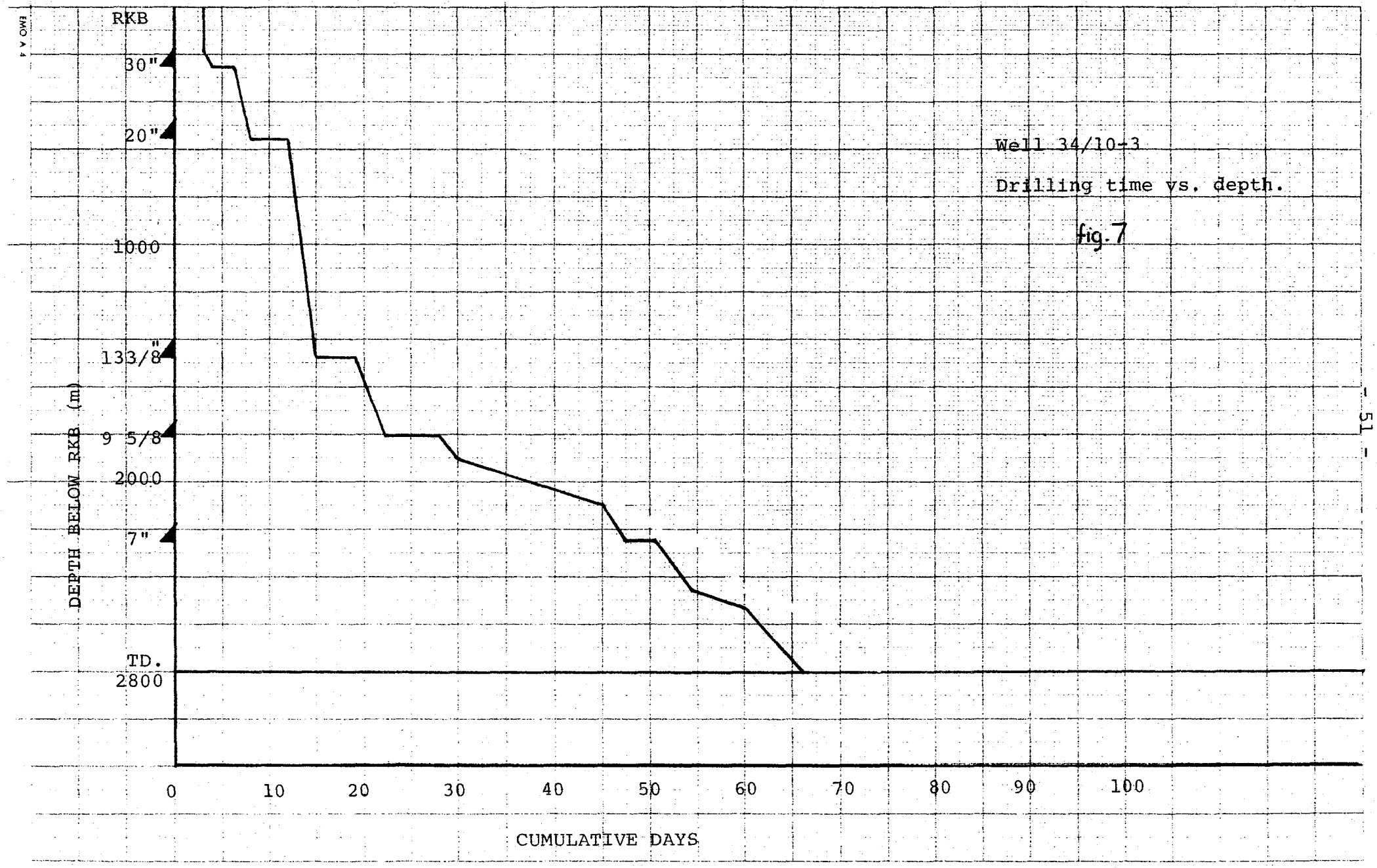
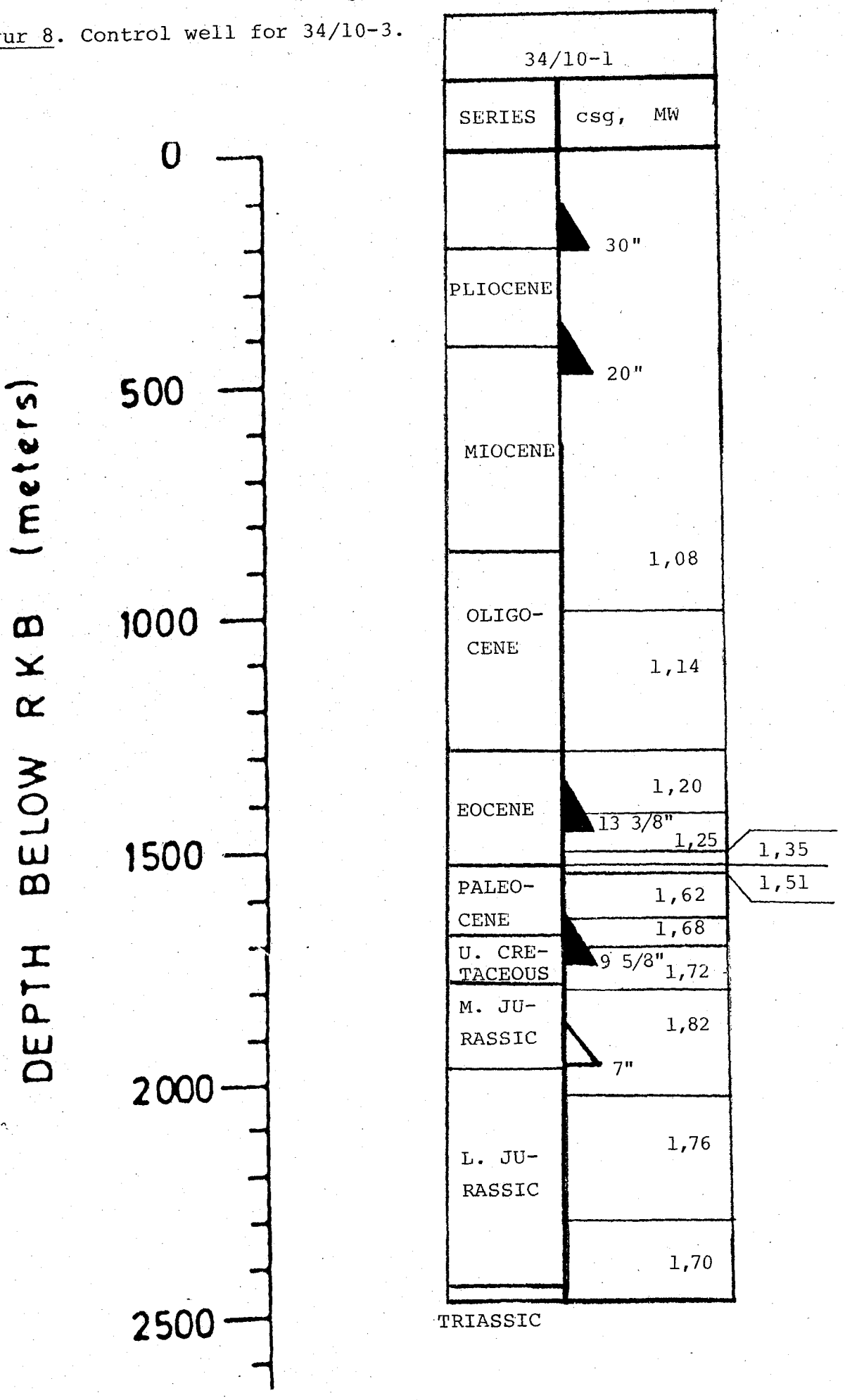


fig. 6


RKB
30"
20"
1000
13 3/8"
9 5/8"
2000
7"
TD.
2800
DEPTH BELOW RKB (m)
0
10
20
30
40
50
60
70
80
90
100
CUMULATIVE DAYS
Well 34/10-3
Drilling time vs. depth.
fig. 7

Figur 8. Control well for 34/10-3.



statoil
Den norske stats oljeselskap a.s

WELL NO. 34/10-3

NOT TO SCALE

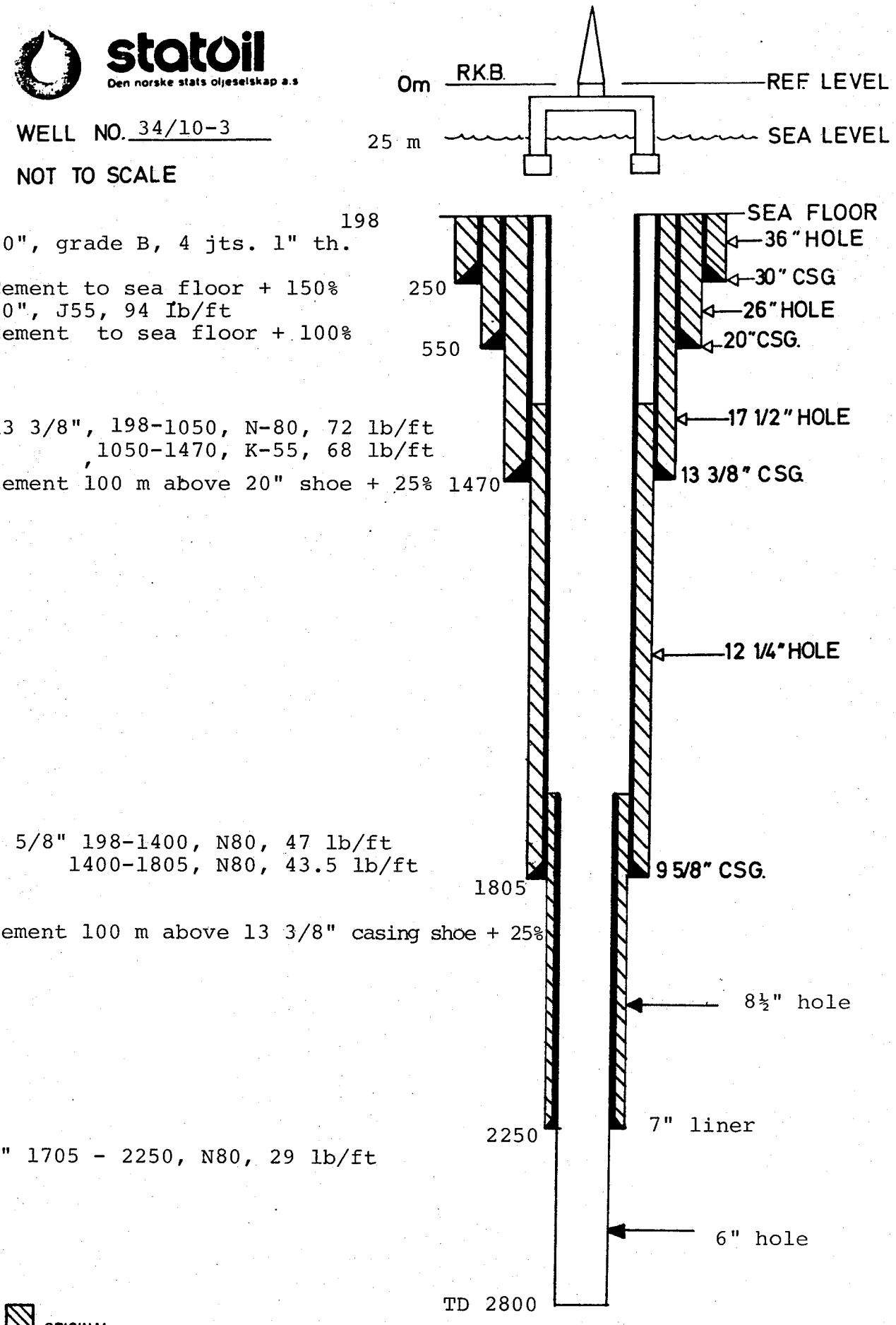


Fig. 9. Well Schematic.

statoil

WELL PROGNOSIS SHEET

LOCATION PLAT

COMPANY:

WELL PROGNOSIS

34/10 - 3

AUTHOR:	DATE: 8.1.79
CO-ORDINATES:	61° 12' 49.7" N 02° 11' 53.65" E
R.K.B.: 25 m	COUNTRY: NORWAY
WATER DEPTH: 173 m	AREA: NORTH SEA
TOTAL DEPTH: 2800 m	SEISMIC LINE: 708/709 - 404
MUD LOGGING CO: BAROID	SEISMIC SHOT POINT: 405

OBJECTIVE HORIZONS Primary: Middle Jurassic sandst.
Secondary: Lower Jurassic sandst. and Upper Triassic sandst.

ELECTRIC LOGS Run 1: ISF/SONIC-GR (GR to sea bed)
Run 2: ISF/SONIC-GR, FDC/GR
Run 3: ISF/SONIC-GR, FDC/GR, CBL (in 13 3/8" csg)
Run 4: ISF SONIC-GR FDC/CNL-GR, LSS*, DLL/MSFL*, ST*, HDT, RFT*, CBL (in 9 5/8" csg)
Run 5: ISF/SONIC-GR, FDC/CNL-GR, DLL/MSFL*, ST, HDT, RFT*, CBL/VDL (in 7" liner), WSS
*Optional

CORES A minimum of one core from top of Middle Jurassic sandst.

FORMATION TESTS If significant shows are encountered

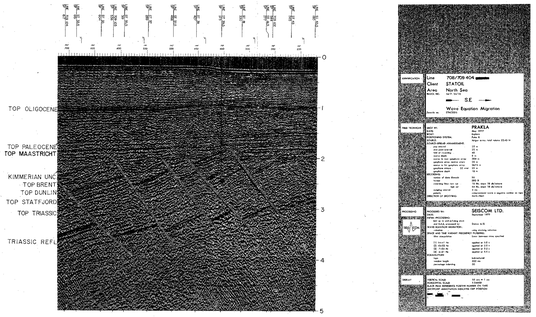
SIDEWALL CORES Over zones of interest

STRATIGRAPHY	CASING CORES	DRILL DEPTH (metres)	LITHOLOGY	DESCRIPTION
		0	KB	25 m MSL
		100		
		198		198 m SF
Quaternary Pleistocene	30"	200		clay, lt gy, sft, stky, sl calc, silty, tr shell fragments, lign
		300		sand, clr qtz, med - crs
370		400		tr limestone, wh, hd
Pliocene - Miocene	20"	500		
		600		
		700		
		800		
900		900		sand, a/a, micaceous, tr of gl
		1000		claystone, med gy - brn, firm non calc, tr gl, pyr, lz
		1100		
Oligocene - Paleocene		1200		
		1300		claystone a/a
	13⅜"	1400		
		1500		
1580		1600		tr tuff, lt gy - bluish gy sft, non calc, mottled claystone, lt gy, grn gy, silty, else a/a
Paleocene		1700		
1755	9 5/8"	1800		marl, lt gy - lt brn, interbedded w/ls and claystone
Cretac. Maastrichtian - ? Santonian		1900		
1915		2000		sandstone, vf - crs, fair srt, subrnd, lse - friable, micaceous, coal, beds of shale, med dk gy, mod hd
Middle Jurassic Brent Fm		2100		
2145		2200		claystone, med gy, firm, occ calc, grading into siltst and sandst
Jurassic Dunlin Fm	7" liner	2300		
		2400		
2465		2500		sandstone, f - v crs, occ granules, kaolinitic, interb w/sh, med gy - lt brn
Lower Statfjord Fm		2600		tr of pyr, lign, gl
2715		2700		
Triassic		2800		T.D. 2800
		2900		
		3000		
		3100		
		3200		
		3300		
		3400		
		3500		
		3600		
		3700		
		3800		
		3900		
		4000		

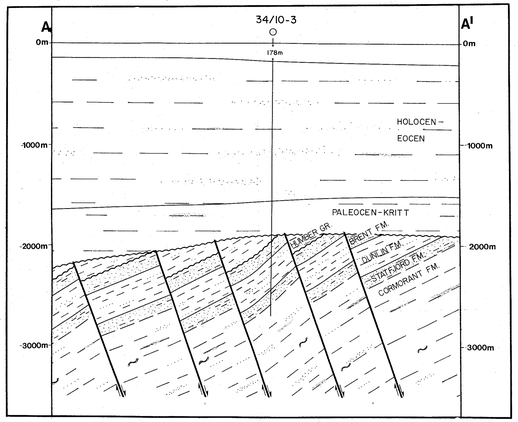
VERTICAL SCALE 1:5000

PL 050 ,34/10-3 DELTA EXPLORATION WELL

SEISMIC LINE 708/709-404



34/10-3 STRUCTURAL CROSS SECTION



34/10-3- FORMATION TOPS

FORMATION	SEISMIC T.W.T. TIME (SEC)	AVERAGE VELOCITY (m/s)	INTERVAL VELOCITY (m/s)	DEPTH M.S. LEVEL (m)
SEABOTTOM	0.234	1980		173
OLIGOCENE	0.930	1882	2017	875
PALEOCENE	1.570	1981	2125	1555
JURASSIC	1.880	2011	2161	1890
BRENT	1.898	2013	2600	1900
DUNLIN	2.050	2068	2706	2120
STATFJORD	2.265	2155	2977	2424
TRIASSIC	2.435	2209	2941	2690
T.D.				2800

34/10-3 GEOLOGICAL PROGRAM

PURPOSE OF TEST

34/10-3 IS A WILDCAT WELL DESIGNED TO TEST POSSIBLE HYDROCARBON ACCUMULATIONS IN A SEISMIC CLOSURE (DELTA-CLOSURE) LOCATED TO THE WEST OF A NORTH-EAST RUNNING FAULT. THE DELTA CLOSURE IS SITUATED IN THE NORTH-EASTERN PART OF BLOCK 34/10.
THE WELL WILL BE DRILLED INTO TRIASSIC TO AN ESTIMATED TOTAL DEPTH OF 2800 M (KB).

OBJECTIVES

THE PRIMARY OBJECTIVE OF WELL 34/10-3 IS SANDSTONES OF MIDDLE JURASSIC AGE. SECONDARY OBJECTIVES ARE SANDSTONES OF LOWER JURASSIC AND UPPER TRIASSIC AGE.

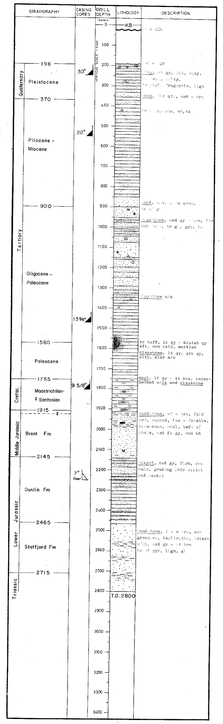
DRILLING HAZARDS

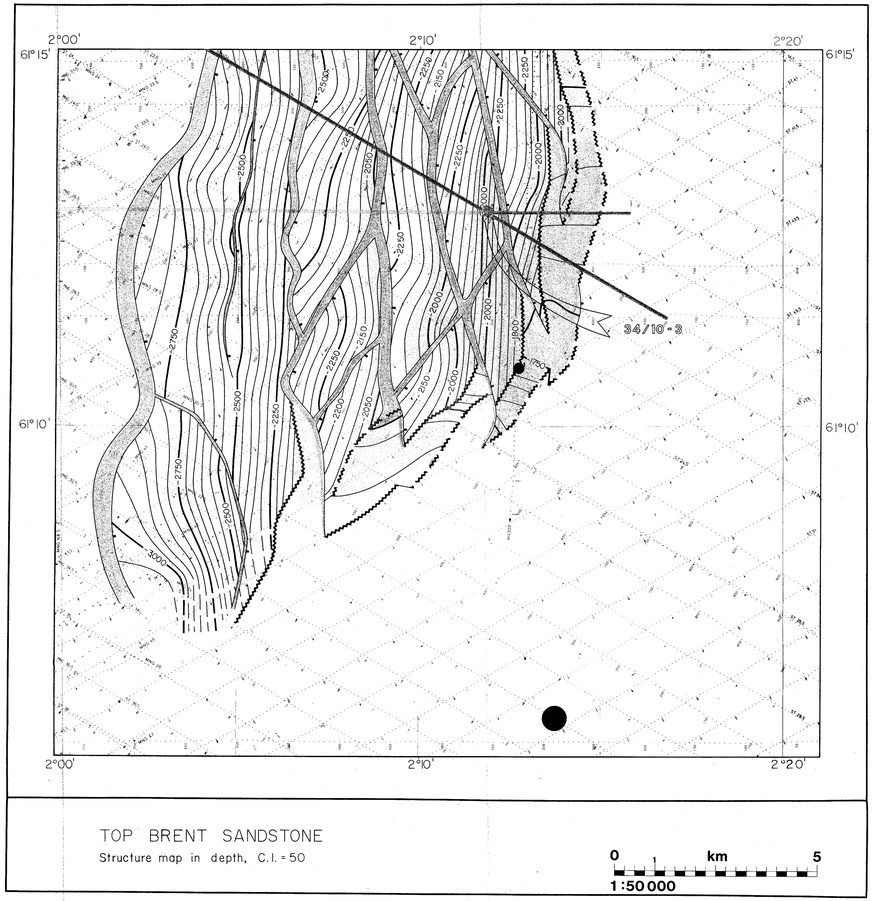
BASED ON DATA FROM NEARBY WELLS, NO EXTREME DRILLING HAZARDS ARE ANTICIPATED IN THIS WELL. NO SHALLOW GAS CAN BE SEEN ON THE SEISMIC.

SURVEY AND POSITIONING

THE RIG WILL BE NAVIGATED BY PULSE 8 AND FINAL POSITION WILL BE DONE BY SATNAV. RIG LOCATION ACCURACY IS REQUESTED WITHIN A 100 M RADIUS OFF THE PROPOSED LOCATION AT SP. 405 ON LINE 708/709-404. FAVOURED DIRECTION FOR EVENTUAL TIE TO THE WEST.

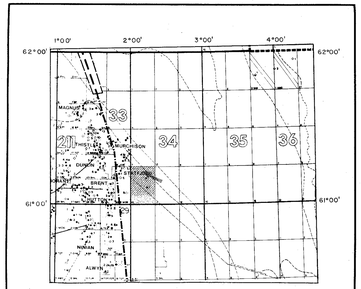
34/10-3 GEOLOGICAL PROGNOSIS





TOP BRENT SANDSTONE
Structure map in depth, C.I. = 50

0 1 km 5
1:50 000



INDEX MAP: NORTHERN NORTH SEA 1:500 000

LICENCE INFORMATION

AREA	Norwegian North Sea	
BLOCK	34/10	
LICENCE NO	PL 050	
LICENCEES	Statoil	85 %
	Norsk Hydro	9 %
	Saga	6 %
OPERATOR	Statoil	

34/10-3 INFORMATION

CLASSIFICATION	Exploration well
COORDINATES	61° 12' 49,70" N 02° 11' 53,65" E
SEISMIC LOCATION	Line 708/709-404 Shot point 405
DRILLING RIG	Ross Rig
WATER DEPTH	173 m
KBE	25 m
PROJECTED T.D.	-2800 m
SURVEY AND POSITION	Pulse 8 and Satnav

statoil
Den norske stats oljeselskap a.s

DISPLAY PANEL for
34/10-3, DELTA
PL 050

G.T.SÆLAND