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S T A T O I L

GEOLOGICAL PROGNOSIS & DRILLING PROGRAM

WELL 34/10-4

28. JUNI 1979

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FIGURES

ATTACHMENTS

STATOIL

WELL PROGNOSIS

WELL NO. 34/10-4

PROSPECT (field) Delta

General Data:

LOCATION

Country	Norway
Area	North Sea
Licence No.	050
Block No.	34/10
Coordinates	61°12'15,9 N , 02°13' 55,7 E

Seismic: Shotpoint No. 322 Line No. 708/709-404

5 Km S of 34/7 Boundary

5,7 Km W of 34/11 Boundary

133 Km from Norwegian coast

22 Km from N/UK median Line

1,9 Km NW of nearest well 34/10-3

20 Km E-SE of nearest field Statfjord

WATER DEPTH 197 Meters

K.B.E. 25 Meters

PROJECTED TOTAL DEPTH 2600 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 Services A/S
Supply Boats	M/V "Ibis I" and M/V "Karmøy Boy"

GEOLOGICAL PROGRAM, WELL 34/10-1

PURPOSE OF TEST

34/10-4 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 2600 m KB.

OBJECTIVES

The primary objective of well 34/10-4 is sandstones of Middle Jurassic age. Secondary objectives are sandstones of Lower Jurassic age.

DRILLING HAZARDS

Based on data from nearby wells, no extreme drilling hazards are anticipated in this well.

From the shallow sparker, boulders will probably not be encountered while drilling the hole for the 30" casing. The results from the deep sparker will be enclosed later on.

SURVEY AND POSITIONING

The rig will be navigated by Pulse 8 and finally positioned by Satnav. Rig location accuracy is requested within a loo m radius off the proposed location at sp. 322 on seismic line 708/709-404.

STRATIGRAPHIC PROGNOSIS

UNIT	DEPTH (meters KB)
Top Oligocene	900 ± 50
Top Paleocene	1530 ± 50
Top Cretaceous	1710 ± 50
Top Jurassic	1815 ± 50
Top BRENT	1815 ± 50
Top DUNLIN	1990 ± 50
Top STATFJORD	2310 ± 50
Top Cormorant	2530 ± 50
T.D.	2600

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 1500 meter. 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. Through Dunlin Formation 10 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	12¼"	ISF/SONIC-GR, FDC/GR, RFT*, CBL
4	8½"	ISF/SONIC-GR, FDC/CNL, DLL/MSFL, CST*, HDT, NGS*, RFT*, CBL
5	6"	ISF/SONIC-GR, FDC/CNL, DLL/MSFL*, HDT, CST*, RFT*, CBL/VDL, WSS

*Optional

LOGGING PROGRAM WELL 34/10-4

	STRATIGRAPHY	DEPTH m	CASING	RUN	LOGS
0					
		197	30" 274 m		GR to sea floor
	PLEISTOCENE - MIOCENE		20" 615 m	1	ISF/SONIC-GR
		900		2	ISF/SONIC-GR, FDC/GR
1000	OLIGOCENE - EOCENE		13 3/8" 1420		
		1530			
	PALEOCENE		9 5/8" 1730	3	ISF/SONIC-GR, FDC/GR RFT*, CBL
		1710			
	CRETACEOUS	1815			
	BRENT	1990		4	ISF/SONIC-GR, FDC/CNL, DLL/MSFL, CST*, HDT, NGS*, SFT*, CBL
2000	DUNLIN		7" liner 2200		
		2310			
	STATFJORD	2530		5	ISF/SONIC-GR, FDC/CNL, DLL/MSFL*, HDT, CST*, RFT*, CBL/VDL, WSS
	CORMORANT				
		TD 2600			
3000					

*Optional

CORING PROGRAM

A minimum of one core will be taken in the middle Jurassic Upper sand (Tarbert?) for reservoir analysis. On request from the reservoir engineer one core will be taken both from Etive Fm and Rannoch Fm if the sand is consolidated.
If the hole conditions permit, another core will be taken in Statfjord Fm for reservoir analysis.

TESTING PROGRAM

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 34/10-4.

Name	Title	Office	Home	Mobile
J. Bleie	Expl. Manager	33180	32630	47461
D.I. Milton	Chief Geologist	"	51264	
S. Nedland	Area Supervisor	"	-	36309
S.G. Larsen	Head Exploitation Geologist	"	25374	36340
Erik Lie	Supervisor Wellsite Geol.	"	-	57916
B. Rasmussen	Operations Geol.	"	-	57905

COMMUNICATION PERSONELL DURING THE DRILLING OF WELL 34/10-4

Norsk Hydro A/S:

Name	Title	Office	Home	Mobile
J. Small	Expl. Manager	02-543920	159280	-
K.A. Oppebøen	Area Coordinator	"	170206	-
S.I. Leivestad	Operations Geol.	"	601956	57568

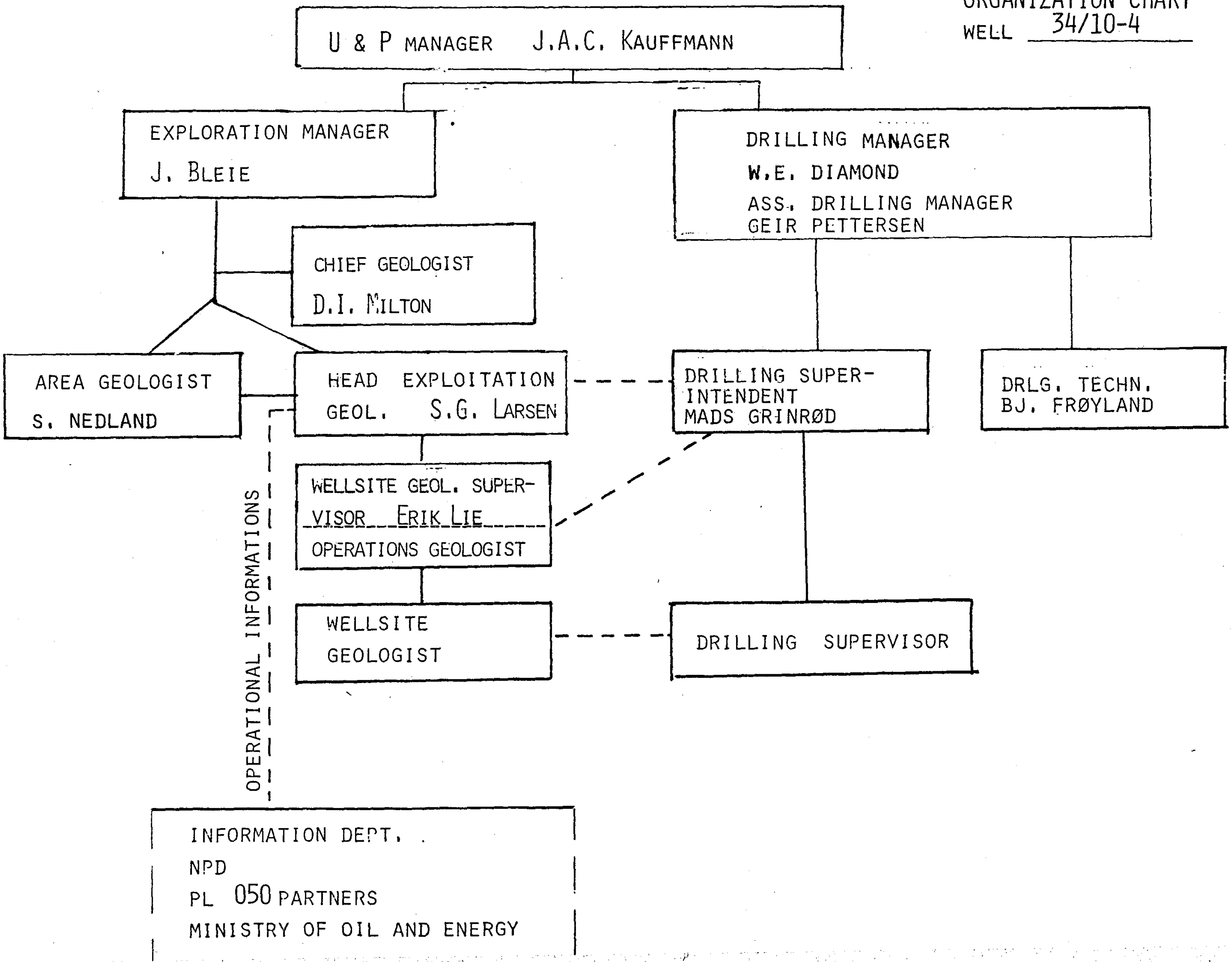
Saga Petroleum A/S & Co.: (Night number: 02 543954)

Kjell G. Finstad	Expl. Manager	02-543950	225643
Rolf Myrland	Chief Geol.	"	788396
S. Johansen	Chief Geoph.	"	170044

Esso Expl. & Prod. Norway Inc. Office tel. 28540

		NIGHT	HOME
K.L. Diebel	Expl. Manager	28549	56074
J. Barrier	Chief Geol.	28545	Esso Motor Hotel (tlf. 26500)

ORGANIZATION CHART
WELL 34/10-4



Drilling Program.

Well Designation:	34/10-4
Vessel:	"Ross Rig" (TF 103)
Drilling Draft:	21.3 (70 ft)
KBE to MSL:	25 m
Water depth:	197 m
Depths:	Referred to KBE except where specified otherwise.

I Location

See Geological Program

II Mooring.

As per general Procedure

III Geological prognosis.

See Geological Program

IV General Drilling

Estimated total depth: 2600 m

Operation phase.

Drill 36" hole with 26" x 36" H.O. to ± 274 m. Stab 30" casing blind. (4 joints) Do not use a temporary guide base.

Drill out 30" casing with 17½" bit to 625 m. Log and open with 26" H.O. Set 20" casing.

Drill 17½" hole to 1435 m, log and set 13 3/8" casing.

Drill 12 1/4" hole to 1745 m. Log and set 9 5/8" casing.

Drill 8½" hole to ± 2210 m. Cores will be cut according to the geological program. Log and set 7" liner.

Drill 6" hole to 2600 m. If the Statfjord formation is going to be tested, a 5" liner will be run.

Drilling Considerations.

Control wells.

The drilling program for this well is mainly based on data from the wells 34/10-1 and 34/10-3.

Shallow Gas.

There are no indications of shallow gas from the seismic.

Directional Survey.

The geological objective is relatively shallow making any relief well drilling operations more difficult to plan. It is therefore essential to have accurate survey data. Single shot directional surveys will be run every bit run below 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
222- 274	26" x 36"	Seawater w/gel slugs	-				
274- 625	17½"	Seawater w/gel slugs	-				
274- 625	26"	Seawater w/gel slugs	-				
625-1435	17½"	Seawater, lignosulfonate	1.06 - 1.5	low	15 - 20	25 or less	9.5 - 10.5
1435-1745	12 1/4"	Sea-/freshwater, chromelignosulfonate	1.75	low	10-15	15 or less	10.0 - 11.0
1745-2210	8½"	Sea-/fresh water, chromelignosulfonate	1.85	low	10-15	15 or less	10.0 - 11.0
2210-2600	6"	Sea-/fresh water, chromelignosulfonate	1.72	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	NOZZELS (32 nds)	WOB (tons)	RPM	CIRC. (cum/min)	Pump press (bar)
222 - 274	26" x 36"	26" + H.O.	3 x 20	0 - 5	60	-	-
274 - 625	17½"	DSJ	4 x 18	0 - 10	125 - 150	3.4	-
274 - 625	17½" x 26"	DSJ + H.O.	4 x 18	0 - 7	120	3.6	-
625 - 1435	17½"	DSJ/OSJ-3J	4 x 18/3 x 18	5 - 15	125 - 150	3.3 - 3.5	200
1435 - 1745	12 1/4"	X1G, XV	3 x 15/3 X 14	10 - 20	80 - 130	2.0 - 2.5	200
1745 - 2210	8 15/32"	C18, CB 303 core	-	5 - 10	80 - 100	1.0	-
	8½"	X1G, M44N, SDGH	3 x 14	10 - 25	60 - 100	2.0	200
2210 - 2600	6"	J22, FP52, F2	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 Gological Program.

VIII CASING.

Set casing as per general procedures.

CASING PROGRAM

SIZE (inch)	DEPTH (m)	WEIGHT (lbs/ft)	GRADE	THREAD
30	1 joint	1½" WALL	B	Vetco ATD/RB
	3 joints	1" WALL	B	Vetco ATD/RB
20	615 - 222 (RKB)	94	J-55	Vetco L
13 3/8"	1420 - 222 (RKB)	68	K-55	Buttress
9 5/8"	1730 - 222 (RKB)	43.5	N-80	Buttress
7"	2200 -1580 (RKB)	29	N-80	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 procedures.

Approved:

29/6-79 Jakob Bleie

Expl. Manager, Statoil

Drilling Manager, Statoil

U & P Manager, Statoil

CALCULATIONS.

Kick control.

Drilling below 20" casing shoe:

20" casing setting depth: 615 m. The normal procedure of not shutting in the well will be used.

Drilling below 13 3/8".

13 3/8" casing setting depth: 1420 m.
Estimated fracture gradient at 1420 m: 1.81 g/cm^3 eq.
Maximum pore pressure gradient while drilling below 13 3/8" shoe is expected to be 1.71 g/cm^3 eq. at 1730 m.
Annular capacity (12 1/4" - 8") = 0.0436 m^3/m.
From fig. 1, it can be seen that when drilling at 1730 m a kick height of approx. 40 m can be taken before the formation is fractured on shut in. (Mud weight 1.75 g/cm^3, pore pressure 1.75 g/cm^3 eq., gas influx). This equals a kick volume:
$0.0436 \text{ m}^3/\text{m} \cdot 40 \text{ m} = 1.7 \text{ m}^3 = 11$ bbl.

Drilling below 9 5/8" shoe:

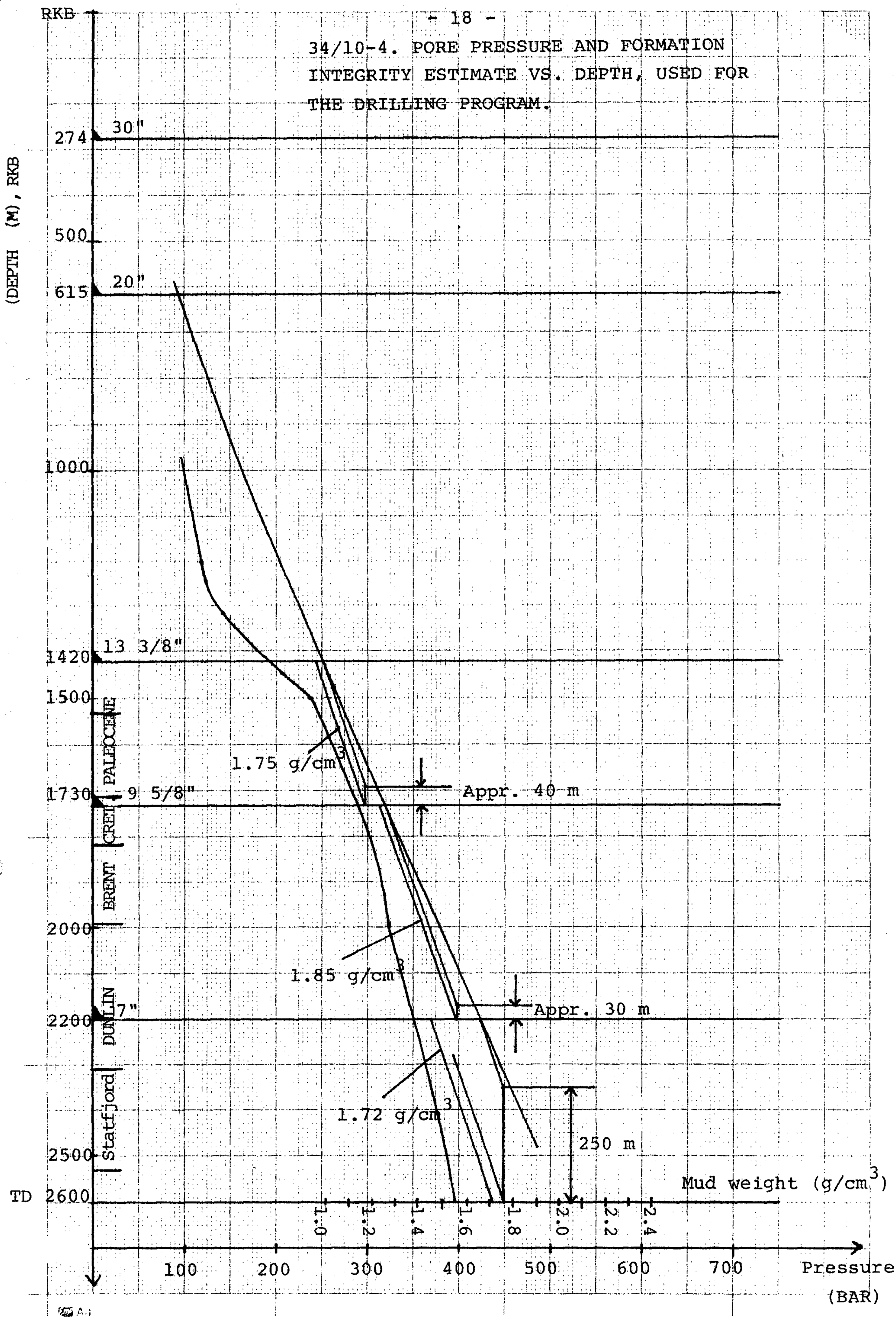
9 5/8" casing setting depth: 1730 m.
Estimated fracture gradient at 1730 m: 1.89 g/cm^3 eq.
Maximum pore pressure gradient while drilling below 9 5/8" shoe is expected to be 1.73 g/cm^3 eq. at 1815 m. Necessary riser margin at this depth is 0.11 g/cm^3. From fig. 1, it can be seen that the maximum kick height that can be taken, using the proposed mud weight 1.85 g/cm^3 is quite small, approx. 30 m, corresponding to a kick volume close to zero (Pore pressure 1.85 g/cm^3 eq., gas influx). However, the proposed mud weight 1.85 g/cm^3 will reduce the possibility of taking a kick to a minimum.

Drilling below 7" shoe.

7" liner setting depth: 2200 m.

Estimated fracture gradient at 2200 m: 1.97 g/cm^3.
Maximum pore pressure gradient while drilling below 7" shoe is expected to be 1.64 g/cm^3 eq. at 2200 m. Annular capacity (6" - 4 3/4") = 0.007 m^3/m. From fig. 1, it can be seen that a maximum kick height of approx. 250 m can be taken before the formation is fractured on shut in (Mud weight 1.72 g/cm^3, pore pressure 1.77 g/cm^3 eq., gas influx). This equals a kick volume: 0.007 $m^3/m \cdot 250$ m = 1.75 m^3 = 11 bbl.

34/10-4. PORE PRESSURE AND FORMATION INTEGRITY ESTIMATE VS. DEPTH, USED FOR THE DRILLING PROGRAM.



CASING CALCULATIONS.

All depths measured from RKB.

W_D = Well depth (m)

X = Casing setting depth (m)

Y = Depth (m) to top of fluid column if mud is lost to a low-pressure formation.

Z = Depth (m) from RKB to wellhead.

G_F = Fracture gradient (bar/m)

Ggas = Gas gradient (bar/m)

$Ggas_1$ = Gas gradient (bar/m)

Gi = Mud gradient at casing setting depth (bar/m)

G'i = Mud gradient below shoe (bar/m)

G"i = Mud gradient below shoe (bar/m)

Gp = Normal pore pressure gradient = 0.1 bar/m

G'p = Actual pore pressure gradient

G"p = Actual pore pressure gradient

Mc = Casing mass- gradient (kg/m)

YSm = Min. yield strength (N/mm^2)

x-area = Casing cross-sectional area (cm^2)

RES_C = Collapse resistance (bar)

RES_B = Burst resistance (bar)

RES_T = Tensile resistance (10^3 daN)

$S.F._C$ = Safety factor, collapse = 1.25 (1.3 for 13 3/8" and larger)

$S.F._B$ = Safety factor, burst = 1.10

$S.F._T$ = Safety factor, tension = 1.5

34/10-4 CASING DESIGN.

20" casing.

W_D = 1420 m

X = 615 m

G_F = 0.152 bar/m (1.55 g/cm^3) at 615 m

G_i = 0.108 bar/m (1.10 g/cm^3)

Ggas = 0.008 bar/m ($\bar{P}$ = 92 bar, $\bar{T}$ = 30°C, γ = 0.6)

Z = 222 m

Gp = 0.1 bar/m (1.02 g/cm^3)

Burst.

If the well is filled with gas (well closed in or flow diverted) the maximum internal casing pressure will be limited by formation fracture pressure at the casing shoe. Maximum burst load at wellhead:

$$P_B = X \cdot G_F - (X - Z) \cdot Ggas - (Z - 25\ m) \cdot Gp =$$

$$615 \cdot 0.152\ bar - (615 - 222) \cdot 0.008\ bar - (222 - 25) \cdot 0.1\ bar =$$

<u>71 bar</u>

Collapse.

Max collapse load during cementing:

$$(G_F - G_i) \cdot (X - 24\ m) = (0.152 - 0.108) \cdot (615 - 24)\ bar = 26\ bar$$

Select: 222 - 615 m: 94 lb/ft, J-55, Vetco L

RES_C = 36 bar

RES_B = 145 bar

RES_T = 658 · 10^3 daN

Safety factor, burst:

$$S.F._B = \frac{RES_B}{P_B} = \frac{145}{71} = 2.04 > 1.1$$

Safety factor, collapse:

$$S.F._C = \frac{RES_C}{P_B} = \frac{36}{26} = 1.38 > 1.3$$

Safety factor, tension:

Weight load: $(615-222)\cdot 140\ \text{kg} = 55 \cdot 10^3\ \text{kg} \Rightarrow 54 \cdot 10^3\ \text{daN}$

$$S.F._T = \frac{RES_T}{54\cdot 10^3\ \text{daN}} = \frac{658}{54} = 12.2 > 1.5$$

13 3/8" casing.

W_D = 1730 m

X = 1420 m

G_i = 0.147 bar/m (1.5 g/cm^3)

G'i = 0.172 bar/m (1.75 g/cm^3)

G_p = 0.1 bar/m (1.02 g/cm^3)

G_F = 0.177 bar/m (1.8 g/cm^3)

Z = 222 m

Ggas = 0.018 bar/m ($\bar{P}$ = 240 bar, $\bar{T}$ = 40°C, γ = 0.6)

Burst.

Kick considerations:
BHA-length approx. 180 m
Annular capacity 8" - 12 1/4" = 0.0436 m^3/m
Annular capacity 5" - 12 1/4" = 0.0627 m^3/m
Kick volume = 15 m^3

Height of kick = $\left(\frac{15-180\cdot 0.0436}{0.0627} + 180\right)$m = 294 m

BHP after kick at 1730 m: 1730 m · (G'i +0.01 bar/m) =

1730 · 0.182 bar = 315 bar

$$Pg + (W_D - Z - Hg) \cdot G'i = Pp \qquad 1)$$

$$\frac{P_p \cdot V_1}{T_1 \cdot Z_1} = \frac{P_g \cdot V_g}{T_2 \cdot Z_2} \qquad 2)$$

P_g = Pressure of gas at wellhead

V_1 = Volume of influx = 15 m^3

T_1 = Bottom hole temperature = 70 °C (343 °K)

Z_1 = Gas compr. factor at bottom = 0.96 (γ = 0.6)

T_2 = Wellhead temp. of gas = 25 °C (298 °K)

Z_2 = Gas compr. factor at wellhead = 0.79 (γ = 0.6)

Hg = Height of gas bubble at wellhead

P_p = Pore pressure at 1730 m

Equation 2.

$$\frac{315 \cdot 15}{343 \cdot 0.96} = \frac{P_g \cdot V_g}{298 \cdot 0.79}$$

Capacity 5" DP - 13 3/8", 68 lb/ft = 0.065 m^3/m ⇒

$Vg = Hg \cdot 0.065\ m^3/m$ ⇒

$$Hg = \frac{315 \cdot 15 \cdot 298 \cdot 0.79}{343 \cdot 0.96 \cdot 0.065 \cdot Pg} = \frac{51970}{Pg}$$

Subst. in eq. 1):

$$Pg + (1730 - 222 - Hg) \cdot 0.172 = 315$$

$$Pg + (1508 - \frac{51970}{Pg}) \cdot 0.172 = 315$$

Pg = 127 bar

Max burst load while circulating kick:

$$P_{Bmax} = Pg + \frac{(Pp-Pg)\cdot(x-z)}{(W_D - Hg - Z)} - X \cdot Gp =$$

$$(127 + \frac{(315 - 127)\cdot(1420 - 222)}{(1730 - 294 - 222)} - 1420 \cdot 0.1)\text{bar} = 171 \text{ bar}$$

The maximum burst load is based on 313 bar internal pressure at 13 3/8" shoe. The formation at this depth is expected to fracture at 250 bar (see fig. 1).

Burst load at wellhead if there is underground blowout, and the entire casing is filled with gas:

$$P_{BW} = X \cdot G_F - (X - Z) \cdot Ggas - (Z - 25 \text{ m}) \cdot Gp =$$

$$(1420 \cdot 0.177 - (1420 - 222) \cdot 0.018 - (222 - 25)\cdot 0.1)\text{bar} = 210 \text{ bar}$$

Collapse.

Max collapse load during cementing (Mud weight 1.3 g/cm^3):

$$P_{cl} = (G_F - 0.127 \text{ bar/m})\cdot(X - 24 \text{ m}) = (0.177-0.127)\cdot(1420 - 24)\text{bar} =$$

70 bar

Mud level if mud is lost to a low-pressure formation at 1420 m:

$$Y = 1420 \text{ m} - \frac{1420 \text{ m} \cdot Gp}{G'i} = (1420 - \frac{1420 \cdot 0.1}{0.172})\text{m} = 595 \text{ m}$$

Collapse load: $P_c = G_i \cdot Y = 0.147 \cdot 595$ bar = 88 bar

Select: 222 - 1420 m: 13 3/8", 68 lb/ft, K-55, Buttress

$RES_c = 134$ bar

$RES_B = 238$ bar

$RES_T = 475 \cdot 10^3$ daN

Safety factor, burst:

$$S.F._B = \frac{RES_B}{P_{BW}} = \frac{238}{210} = 1.13 > 1.1$$

Safety factor, collapse:

$$\text{Buoyancy factor} = \frac{7.8 - 1.3}{7.8} = 0.83$$

Weight load at 595 m: $(X - 595 \text{ m}) \cdot Mc \cdot 0.83 \Rightarrow$

$(1420 - 595) \cdot 101 \cdot 0.98 \cdot 0.83$ daN $= 67.7 \cdot 10^3$ daN

$$\frac{\text{Weight load}}{\text{Tensile strength}} = \frac{67.7}{475} = 0.14 \Rightarrow RES_c \text{ red. by } 8\%$$

$$S.F._c = \frac{RES_c \cdot 0.92}{P_c} = \frac{134 \cdot 0.92}{88} = 1.4 > 1.3$$

Safety factor, tension:

Weight load at wellhead: $(X - Z) \cdot Mc =$

$(1420 - 222) \cdot 101$ kg $= 121 \cdot 10^3$ kg $\Rightarrow 118.6 \cdot 10^3$ daN

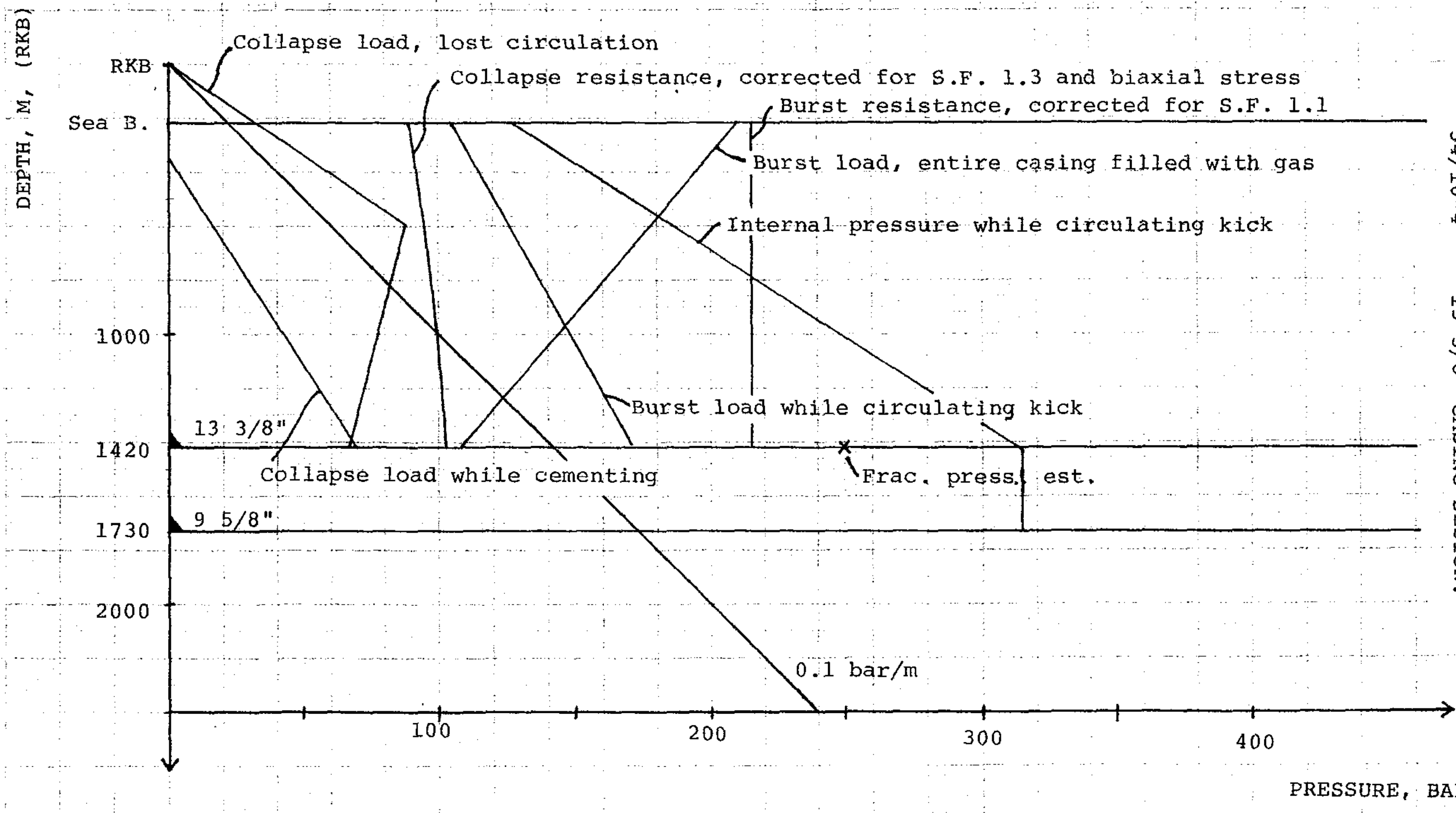
$$S.F._T = \frac{RES_T}{118.6 \cdot 10^3 \text{ daN}} = \frac{475}{118.6} = 4 > 1.5$$

222 - 1420 m: K-55, 68 lb/ft, Buttress

RES_C = 134 bar

RES_B = 238 bar

RES_T = 475 · 10^3 daN



34/10-4

13 3/8" CASING DESIGN.

9 5/8" casing.

W_D = 2600 m

X = 1730 m

G_i = 0.172 bar/m (1.75 g/cm^3)

G'i = 0.181 bar/m (1.85 g/cm^3) from 1730 - 2200 m

G"i = 0.168 bar/m (1.72 g/cm^3) (drilling below 2200 m)

Gp = 0.1 bar/m (1.02 g/cm^3)

G'p = 0.17 bar/m (1.73 g/cm^3) (Testing at 1850 m)

G"p = 0.157 bar/m (1.6 g/cm^3) (Testing at 2400 m)

G_F = 0.185 bar/m (1.89 g/cm^3) at 1730 m

Z = 222 m

G_{gas1} = 0.021 bar/m ($\bar{p}$ = 297 bar, $\bar{T}$ = 45°C, γ = 0.6) (Testing at 1850 m)

G_{gas} = 0.023 bar/m ($\bar{P}$ = 352 bar, $\bar{T}$ = 50°C, γ = 0.6) (Testing at 2400 m)

Burst.

Burst load at wellhead if there is a tubing leak just below the wellhead while testing at 2400 m:

$$P_B = G''p \cdot 2400\ m - G_{gas} \cdot (2400\ m - Z) - (Z - 25\ m) \cdot Gp =$$

$$0.157 \cdot 2400\ bar - 0.023 \cdot (2400 - 222)bar - 197 \cdot 0.1\ bar = 307\ bar$$

Mud weight inside casing while testing at 2400 m is estimated to be 1.7 g/cm^3.
As 9 5/8" casing is set in 1.75 g/cm^3 mud, and pore pressure in the 9 5/8" cemented interval is estimated to be high (mainly around 1.7 g/cm^3), the external gradient for burst calculation while testing is estimated equal to internal gradient.

Burst load at wellhead if there is a tubing leak just below the wellhead while testing at 1850 m:

$$P_{B1} = G'p \cdot 1850\ m - G_{gas1} \cdot (1850\ m - Z) - (Z - 25\ m) \cdot Gp =$$

$0.17 \cdot 1850$ bar $- 0.021 \cdot (1850 - 222)$bar $- 197 \cdot 0.1$ bar $=$
261 bar

Mud weight inside casing while testing at 1850 m is estimated to be 1.8 g/cm^3.

Max burst pressure at 1630 m (100 m liner overlap):

$$P_{B2} = G'p \cdot 1850 \text{ m} - G_{gas1} \cdot (1850 \text{ m} - Z) + (1850 \text{ m} - Z) \cdot 1.8 \cdot$$

$$0.098 \text{ bar/m} - 1850 \cdot 1.7 \cdot 0.098 \text{ bar} =$$

$$(0.17 \cdot 1850 - 0.021 \cdot (1850 - 222) + (1850 - 222) \cdot 0.176 - 1850 \cdot$$

$$0.167) \text{bar} = 258 \text{ bar}$$

<u>Collapse.</u>

Mud level if mud is lost to a low - press. formation
(0.1 bar/m) at 2600 m:

$$Y = W_D - \frac{W_D \cdot Gp}{G"i} = (2600 - \frac{2600 \cdot 0.1}{0.168}) \text{m} = 1052 \text{ m}$$

$$P_c = Y \cdot Gi = 1052 \text{ m} \cdot 0.172 \text{ bar/m} = 181 \text{ bar}$$

Select: 222 - 1730 m: 9 5/8", 43.5 lb/ft, N-80, Buttress

$RES_C = 263$ bar

$RES_B = 436$ bar

$RES_T = 445 \cdot 10^3$ daN

Safety factor, burst:

$$S.F._B = \frac{RES_B}{P_B} = \frac{436}{307} = 1.42 > 1.1$$

Safety factor, collapse:

$$\text{Buoyancy factor} = \frac{7.8 - 1.7}{7.8} = 0.78$$

Weight load at 1052 m: $(X - 1052\ m) \cdot M_c \cdot 0.78 \Rightarrow$

$(1730 - 1052) \cdot 65 \cdot 0.98 \cdot 0.78\ daN = 33.6 \cdot 10^3\ daN$

$$\frac{\text{Weight load}}{\text{Tensile strength}} = \frac{33.6}{445} = 0.076 \Rightarrow RES_c \text{ red. by } 4\%$$

$$SF_c = \frac{RES_c \cdot 0.96}{Pc} = \frac{263 \cdot 0.96}{181} = 1.4 > 1.25$$

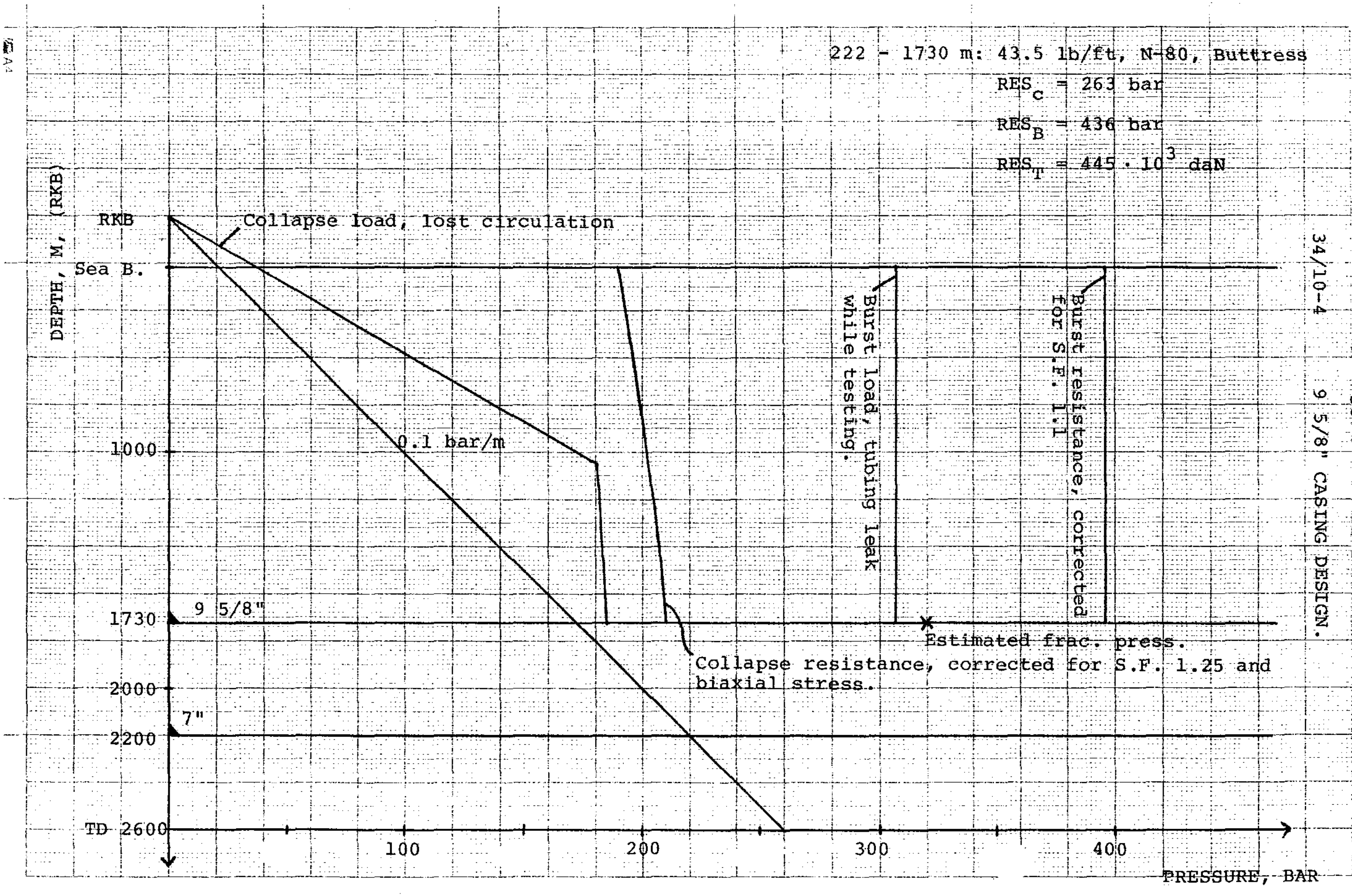
Safety factor, tension:

Weight load at wellhead: $(X - Z) \cdot Mc =$

$(1730 - 222) \cdot 65\ kg = 98 \cdot 10^3\ kg \Rightarrow 96 \cdot 10^3\ daN$

$$S.F._T = \frac{RES_T}{96 \cdot 10^3\ daN} = \frac{445}{96} = 4.6 > 1.5$$

34/10-4 9 5/8" CASING DESIGN.



7" liner.

W_D = 2600 m

X = 2200 m (setting interval 1580 - 2200 m, 150 m overlap)

Gi = 0.181 bar/m (1.85 g/cm^3)

G'i = 0.167 bar/m (1.7 g/cm^3) (Testing at 2400 m)

G"i = 0.168 bar/m (1.72 g/cm^3) (Drilling below 2200 m)

Gp = 0.1 bar/m (1.02 g/cm^3)

G'p = 0.17 bar/m (1.73 g/cm^3) (Testing at 1850 m)

G"p = 0.157 bar/m (1.60 g/cm^3) (Testing at 2400 m)

Z = 222 m

Ggas = 0.023 bar/m ($\bar{P}$ = 352 bar, $\bar{T}$ = 50°C, γ = 0.6) (Testing at 2400 m)

Burst.

Max burst load while testing: P_B = 307 bar (See 9 5/8" casing calculations).

Collapse.

Mud level if mud is lost to a low - press. formation (0.1 bar/m) at 2600 m:

$$Y = W_D - \frac{W_D \cdot Gp}{G''i} = (2600 - \frac{2600 \cdot 0.1}{0.168})\text{m} = 1052\text{ m}$$

Max collapse load (at 2200 m):

$$P_C = X \cdot Gi - (X - Y) \cdot G''i = (2200 \cdot 0.181 - (2200 - 1052) \cdot 0.168)\text{bar} = 205\text{ bar}$$

Select: 1580 - 2200 m: 7", 29 lb/ft, N-80, Buttress

RES_C = 484 bar
RES_B = 563 bar
RES_T = 300 · 10^3 daN

Safety factor, burst:

$$S.F._B = \frac{RES_B}{P_B} = \frac{563}{307} = 1.83 > 1.1$$

Safety factor, collapse:

$$S.F._C = \frac{RES_C}{P_C} = \frac{484}{205} = 2.36 > 1.25$$

Minimum flowing bottomhole pressure while testing at 1850 m:

$$P_{WFmin.} = G"p \cdot 1850\ m - \frac{RES_C}{1.25} = 0.157 \cdot 1850\ bar - \frac{484}{1.25}\ bar \Rightarrow 0\ bar$$

Safety factor, tension:

Weight load = (X − 1580 m) · Mc =

$(2200 - 1580) \cdot 43\ kg = 26.6 \cdot 10^3\ kg \Rightarrow 26 \cdot 10^3\ daN$

$$S.F._T = \frac{RES_T}{26 \cdot 10^3\ daN} = \frac{300}{26} = 11.5 > 1.5$$

5" liner.

W_D = 2600 m

X = 2600 m (setting interval 2100 - 2600 m, 100 m overlap)

Gi = 0.168 bar/m (1.72 g/cm^3)

G_{i2} = 0.167 bar/m (1.70 g/cm^3) (Testing at 2400 m)

Gp = 0.1 bar/m (1.02 g/cm^3)

G'p = 0.157 bar/m (1.60 g/cm^3) (Testing at 2400 m)

Z = 222 m

Ggas = 0.023 bar/m ($\bar{P}$ = 352 bar, $\bar{T}$ = 50^0C, γ=0.6) (Testing at 2400 m)

Burst.

Possible burst load at 2400 m if there is a tubing leak just below the wellhead while testing at 2400 m:

$$P_B = G'p \cdot 2400\ m - Ggas \cdot (2400\ m - Z) + (2400\ m - Z) \cdot G_{i2} - 2400\ m \cdot G'p =$$

$$(0.157 \cdot 2400 - 0.023 \cdot (2400 - 222) + (2400 - 222) \cdot 0.167 - 2400 \cdot 0.157)\,bar = 314\ bar$$

Select: 2100 - 2600 m: 5", 15 lb/ft, N-80, Buttress

RES_C = 500 bar

RES_B = 572 bar

RES_T = $156 \cdot 10^3$ daN

Safety factor, burst:

$$S.F._B = \frac{RES_B}{P_B} = \frac{572}{314} = 1.82 > 1.1$$

Minimum flowing bottomhole pressure while testing at 2400 m:

$$G'p \cdot 2400 \text{ m} - \frac{RES_c}{1.25} = (0.157 \cdot 2400 - \frac{500}{1.25})\text{bar} \Rightarrow 0 \text{ bar}$$

Safety factor, tension:

Weight load on top of 5" liner:

$$(X - 2100 \text{ m}) \cdot M_c = (2600 - 2100) \cdot 22 \text{ kg} = 11 \cdot 10^3 \text{kg} \Rightarrow$$

$$10.8 \cdot 10^3 \text{ daN}$$

$$S.F._T = \frac{RES_T}{10.8 \cdot 10^3 \text{ daN}} = \frac{156}{10.8} = 14.4 > 1.5$$

Weight load on top of 7" liner:

$$(2200 - 1580) \cdot M_c + (X - 2100 \text{ m}) \cdot M_c =$$

$$(2200 - 1580) \cdot 43 \text{ kg} + (2600 - 2100) \cdot 22 \text{ kg} =$$

$$(26 + 11) \cdot 10^3 \text{ kg} \Rightarrow 36 \cdot 10^3 \text{ daN}$$

$$S.F._T = \frac{RES_T}{36 \cdot 10^3 \text{ daN}} = \frac{300}{36} = 8.3 > 1.5$$

Weight load on top of 9 5/8" casing: $(1730 \text{ m} - Z) \cdot M_c +$

$$(2200 - 1580)\text{m} \cdot M_c + (X - 2100 \text{ m}) \cdot M_c = (1730 - 222) \cdot 65 \text{ kg} +$$

$$620 \cdot 43 \text{ kg} + (2600 - 2100) \cdot 22 \text{ kg} \Rightarrow 132 \cdot 10^3 \text{ daN}$$

$$S.F._T = \frac{RES_T}{132 \cdot 10^3 \text{ daN}} = \frac{445}{132} = 3.37 > 1.5$$

CASING CEMENT DATA AND CALCULATIONS, 30 " CASING.

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

WELL DATA:

Depth kb-sea bed...........................:	222	m
Depth kb-last shoe.........................:	-	m
Depth kb-casing set point..................:	274	m
Open hole dia..............................:	36	"
Annulus capacity, cased hole...............:	-	l/m
Annulus capacity, open hole................:	200	l/m
Internal capacity, 30 " casing. 1" grade........:	426	l/m
Mud weight.................................:	1.05	g/cm^3
Bottom hole hydrostatic pres. (BHHP).......:	-	bar
Est. bottom hole static temp. (BHST).......:	27	°C
Est. bottom hole circulating temp. (BHCT)...:	27	°C
Est. formation integrity...................:	-	bar/m

	FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION	CLASS G +3,2 l/100 kg D-75	CLASS +1 kg/loo kg $CaCl_2$
Mix water 1/100 kg	93 sea	44 sea
Total liquid 1/100 kg	96,2	44.6
Slurry weight g/cm^3	1.56	1.91
Slurry yield 1/100 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, bar 12 hr	10	80
bar 24 hr	30	160
REMARKS:		

Volume calculations (30" casing)

Annular volume: 0.200 $m^3/m \cdot 52$ m	= 10.4 m^3
3 m plug at shoe: 0.426 $m^3/m \cdot 3$m	= 1.3 m^3
Total volume:	= 11.7 m^3
150% excess in open hole:	15.6 m^3
Total slurry volume:	27.3 m^3

Lead / filler slurry: Class G cement + 3.2 ℓ/100 kg D-75 mixed with seawater at 1.56 kg/l.
13750 kg cement equivalent to 17.6 m^3 slurry.

Tail in slurry: Class G cement + 1 kg/100 kg $CaCl_2$ mixed with seawater at 1.91 kg/l.
12800 kg cement equivalent to 9.7 m^3 slurry.

Job preparation:

Total liquid lead slurry: 13750kg · 96.2 l/100kg	= 13228 liter
Volume fo D-75 meeded in each 10 bbls (1.59m^3) displacement tank: 1590 l $\cdot \frac{3.2}{96.2}$	= 52.9 liter
Total volume of A-3L: 13757 kg · 3.2 l/100 kg	= 440 liter
Total liguid tail in slurry: 12800kg · 44.6 l/100 kg	= 5709 liter
Amount of$CaCl_2$ needed: 12800 kg · 1.0 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 open hole volume.

WELL DATA:

Depth kb-sea bed.............................:	222	m
Depth kb-last shoe...........................:	274	m
Depth kb-casing set point....................:	615	m
Open hole dia................................:	26	"
Annulus capacity, cased hole.................:	223	l/m
Annulus capacity, open hole..................:	140	l/m
Internal capacity, 20 " casing...94 lbs/ft.......:	186	l/m
Mud weight...................................:	1.05	g/cm^3
Bottom hole hydrostatic pres. (BHHP)........:	63	bar
Est. bottom hole static temp. (BHST)........:	37	°C
Est. bottom hole circulating temp. (BHCT)...:	32	°C
Est. formation integrity.....................:	0,152	bar/m

		FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION		CLASS G +3,2 ℓ/100 kg D - 75	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	1.91
Slurry yield	l/100 kg	128	
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		5:oo+	4:00
Crit. Turb. Flow rate: m/s (l/min)			
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength,	bar 12 hr	10	150
	bar 24 hr	30	260
REMARKS:			
Compr. strength, bar 12hrs 27°C			200

Volume calculations (20" casing):

Annular volume: 0.140 $m^3/m \cdot (615 - 274) m$ = 47.7 m^3
Volume between casings: 0.223 $m^3/m \cdot (274 - 222) m$ = 11.6 m^3
10 m plug at shoe: 0.185 $m^3/m \cdot 10 m$ = 1.9 m^3
100% excess in open hole: 47.7 m^3
Total cement slurry volume: = 108.9 m^3

Lead slurry: Class G cement + 3,2 ℓ/100kg D-75 mixed with seawater at 1.56 kg/ℓ.
77350 kg cement equivalent to 99.0 m^3 slurry.

Tail in slurry: Class G cement neat mixed with seawater at 1.91 kg/ℓ.
13000 kg cement equivalent to 9.9 m^3 slurry.

Job preparation:

Total liquid lead slurry: 77350 kg·96.2 l/100 kg = 74410 l
Volume of D-75 needed in each displ. tank: 1590 l·3.2/96.2 = 52.9 l
Total volume of D-75 needed: 77350 kg·3.2 ℓ/100 kg = 2475 l
Total liquid (sea water) tail in slurry: 13000kg·44 ℓ/100 kg = 5720 l

Hydrostatic pressure at 20"casing shoe:

Height of tail in slurry: $(9.9 - 1.9) m^3 / 0.14 m^3/m$ = 57 m
Hydrostatic head lead slurry: 0.153 bar/m·(615-222-57)m = 51.4 bar
Hydrostatic head tail in slurry: 0.187 bar/m·57 m = 10.7 bar
Hydrostatic head mud: 0.103 bar/m·(222-25) m = 20.3 bar
Total hydrostatic pressure: = 82.4 bar

Equivalent pressure gradient: 82.4 bar/615 m = 0.134 bar/m

Estimated formation integrity: 0.152 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..............................:	222 m
Depth kb-last shoe............................:	615 m
Depth kb-casing set point.....................:	1420 m
Open hole dia.................................:	17 1/2"
Annulus capacity, cased hole..................:	94.7 l/m
Annulus capacity, open hole...................:	64.5 l/m
Internal capacity, 13 3/8" casing 68. lbs/ft.......:	78.1 l/m
Mud weight....................................:	1.5 g/cm³
Bottom hole hydrostatic pres. (BHHP).........:	209 bar
Est. bottom hole static temp. (BHST).........:	50 °C
Est. bottom hole circulating temp. (BHCT)...:	40 °C
Est. formation integrity......................:	0.177 bar/m

		FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION		CLASS G +3.2 ℓ/100 kg D - 75	CLASS G neat
Mix water	l/100 kg	93 sea	44 fresh
Total liquid	l/100 kg	96.2	44
Slurry weight	g/cm³	1.56	1.90
Slurry yield	l/100 kg	128	76
TEST DATA @ BHCT			
Thickening time @ BHHP, hr:min		4:00	3:00
Crit. Turb. Flow rate: m/s (l/min)			
Fluid loss, ml/30 min, 70 bar			
TEST DATA @ BHST, BHHP			
Compr. strength,	bar 12 hr @ 27 °C	10	50
	bar 24 hr @ 27 °C	30	130
REMARKS:	bar 12 hr @ 50 °C		85
	bar 24 hr @ 50 °C		140

Volume calculations (13 3/8" casing):

Annular volume: $0.0645\ m^3/m \cdot (1420-615)\,m$	=	$51.9\ m^3$
Volume between casings: $0.0947\ m^3/m \cdot 100\ m$	=	$9.5\ m^3$
24 m plug at shoe: $0.0781\ m^3/m \cdot 24\ m$	=	$1.9\ m^3$
25% excess in open hole:		$13.0\ m^3$
Total cement slurry volume:		$76.3\ m^3$

Lead slurry: Class G cement + 3.2 ℓ/100 kg D-75 mixed with seawater at 1.56 kg/l.
51900 kg cement equivalent to $66.4\ m^3$ slurry.

Tail in slurry: Class G cement neat mixed with fresh water at 1.90 kg/ℓ.
13000 kg cement equivalent to $9.9\ m^3$ slurry.

Job preparation:

Total liquid lead slurry: 51900 kg·96.2 ℓ/100kg	= 49928 l
Volume of D-75 in each tank: $1590 \cdot \frac{3.2}{96.2}$	= 51.9 l
Total volume of D-75 needed: 51900 kg·3.2 ℓ/100kg	= 1661 l
Total liquid (fresh water) tail in slurry: 13000 kg·44 ℓ/100 kg	= 5720 l

Time estimate for the job:

Mixing cement: $76.3\ m^3/0.8\ m^3/min$	= 95 min
Displacement: $110\ m^3/1.0\ m^3/min$	= 110 min
Total pumping time:	= 205 min
	or 3 hrs 25 min.

Max. height tail in slurry: $(9.9-1.9)m^3/0.0645m^3/m$	= 124 m
Volume to 20"shoe: $0.0645m^3/m \cdot (1420-615-124)m$	= $43.9\ m^3$
Volume above 20"shoe: $66.4m^3-43.9m^3$	= $22.5\ m^3$
Height above 20"shoe: $22.5m^3/0.0947m^3/m$	= $238\ m^3$
Maximum height lead slurry: (1420-615-124+238)m	= 919 m

Hydrostatic head lead slurry: 0.153 bar/m · 919 m = 140.6 bar

Hydrostatic head tail in slurry: 0.186 bar/m·124 m = 23.1 bar

Hydrostatic head mud: 0.147 bar/m · (1420-919-124)m = <u>55.5 bar</u>

Total hydrostatic pressure at 13 3/8" csg. shoe: = <u>219.1 bar</u>

Equivalent pressure gradient: 219.1 bar/140 m = <u>0.154 bar/m</u>

Estimated formation integrity: = <u>0.177 bar/m</u>

Hydrostatic head at 20" casing shoe:

0.153 bar/m · 238 m + 0.147 bar/m · 377 m = <u>91.8 bar</u>

Equivalent pressure gradient at 20" casing shoe:
91.8 bar/615 m = <u>0.149 bar/m</u>

Estimated formation integrity: = <u>0.152 bar/m</u>

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

GENERAL: The cement volume is calculated on the basis of the theoretical hole volume and the casing to be cemented to 1480 m with 25% excess in open hole.

WELL DATA:

Depth kb-sea bed.............................:	222	m
Depth kb-last shoe...........................:	1420	m
Depth kb-casing set point....................:	1730	m
Open hole dia................................:	12 1/4	"
Annulus capacity, cased hole.................:	31.2	l/m
Annulus capacity, open hole..................:	29.1	l/m
Internal capacity, 9 5/8"casing..............:	38.8	l/m
Mud weight...................................:	1.75	g/cm^3
Bottom hole hydrostatic pres. (BHHP)........:	297	bar
Est. bottom hole static temp. (BHST)........:	68	°C
Est. bottom hole circulating temp. (BHCT)...:	45	°C
Est. formation integrity.....................:	0.185	bar/m

	FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION	CLASS G + 0.89 l/100 kg DS 80 + 0.27 l/100 kg D-73	CLASS
Mix water l/100 kg	43.0 fresh	
Total liquid l/100 kg	44.2	
Slurry weight g/cm^3	1.90	
Slurry yield l/100 kg	76	
TEST DATA @ BHCT		
Thickening time @ BHHP, hr:min	4:19	
Crit. Turb. Flow rate: m/s (l/min)		
Fluid loss, ml/30 min, 70 bar		
TEST DATA @ BHST, BHHP		
Compr. strength, bar hr		
bar 24 hr	260	
REMARKS: Pump 15 bbls Spacer 1000 preflush ahead of the cement slurry. The spacer to be pumped ahead of the bottom plug.		

Volume calculations (9 5/8" casing):

Annular volume: 0.0291 $m^3/m \cdot (1730 - 1480)$ m	=	7.3 m^3
24 m plug at shoe: 0.0388 $m^3/m \cdot 24$ m	=	0.9 m^3
25% excess in open hole	=	1.8 m^3
Total slurry volume	=	10.0 m^3

Cement slurry: Class G cement + 0.89 l/100 kg DS-80 + 0.27 l/100 kg D-73 mixed with fresh water at 1.90 kg/l.

13200 kg cement equivalent to 10.0 m^3 cement slurry.

Pump 15 bbls Spacer 1000 ahead of the cement. The preflush to be pumped ahead of the bottom plug. The specific gravity of the spacer should be 1.80.

Time estimate for the job:

Mixing cement: 10.0 m^3/0.8 m^3/min	=	13 min
Displacement: 68 m^3/1.0 m^3/min	=	68 min
		81 min
		or 1 hour 21 min

Job preparation:

Total liquid lead slurry: 13200 kg $\cdot$ 44.2 l/100 kg	=	5834 liter
Volume of DS-80 needed in each displ. tank:	=	32 l
Total volume of DS-80 needed: 13200 kg $\cdot$ 0.89 l/100 kg	=	117 l
Volume of D-73 needed in each displ. tank:	=	9.7 l
Total volume of D-73 needed: 13200 kg $\cdot$ 0.27 l/100 kg	=	36 l

Hydrostatic head:

Height of cement in annulus: $(10-0.9)m^3/0.0291\ m^3/m$	=	313 m
Hydrostatic head cement slurry: 0.186 bar/m • 313 m	=	58.2 bar
Hydrostatic head mud: 0.172 bar/m • 1341 m	=	230.7 bar
Hydrostatic head spacer: 0.176 bar/m • 76 m	=	13.4 bar
Total hydrostatic pressure:	=	302.3 bar

Equivalent pressure gradient at 9 5/8" csg. shoe: $\frac{302.3\ \text{bar}}{1730\ \text{m}}$

= 0.175 bar/m

Estimated formation integrity:	=	0.185 bar/m
Equivalent pressure gradient at 13 3/8" csg. shoe	=	0.172 bar/m
Estimated pressure gradient:	=	0.177 bar/m

Minimum hydrostatic head at 1730 m: (9 5/8" csg. shoe)

Hydrostatic head **spacer**: $\frac{1.59\ m^3 \cdot 1.5}{0.0291\ m^3/m} \cdot 0.176$ bar/m	= 14.4 bar
Hydrostatic head mud: 1648 m • 0.172 bar/m	= 283.5 bar
Minimum hydrostatic head	= 297.9 bar
Equivalent pressure gradient: $\frac{297.9\ \text{bar}}{1730\ \text{m}}$	= 0.172 bar
Estimated pore pressure:	= 0.168 bar/m

CASING CEMENT DATA AND CALCULATIONS, 7 " LINER

GENERAL: The volume is calculated on the basis of the theoretical hole volume and the liner to be cemented 150 m into the 9 5/8" casing with 20% excess volume in open hole.

WELL DATA:

Depth kb-sea bed.............................:	222	m
Depth kb-last shoe...........................:	1730	m
Depth kb-casing set point....................:	2200	m
Open hole dia................................:	8½	"
Annulus capacity, cased hole.................:	14.0	l/m
Annulus capacity, open hole..................:	11.8	l/m
Internal capacity, 7" liner, 29 lb/ft........:	19.4	l/m
Mud weight...................................:	1.85	g/cm^3
Bottom hole hydrostatic pres. (BHHP).........:	399	bar
Est. bottom hole static temp. (BHST).........:	79	°C
Est. bottom hole circulating temp. (BHCT)....:	53	°C
Est. formation integrity.....................:	0.193	bar/m

	FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION	CLASS G + 0.89 l/100 kg DS-80 + 1.78 l/100 kg D-73 + 0.18 l/100 kg D-81	CLASS
Mix water l/100 kg	38.0 fresh	
Total liquid l/100 kg	40.85	
Slurry weight g/cm^3	1.94	
Slurry yield l/100 kg	73	
TEST DATA @ BHCT		
Thickening time @ BHHP, hr:min	4:14	
Crit. Turb. Flow rate: m/s (l/min)		
Fluid loss, ml/30 min, 70 bar		
TEST DATA @ BHST, BHHP		
Compr. strength, bar hr		
bar 24 hr	290	
REMARKS: Pump 10 bbls fresh water ahead of the cement. The fresh water to be pumped ahead of the bottom plug.		

Volume calculations, 7" liner:

Volume between 8½" hole - 7" liner: $0.0118\ m^3/m \cdot (2200-1730)m$	=	
	=	$5.5\ m^3$
24 m plug at shoe: $0.0194\ m^3/m \cdot 24\ m$	=	$0.5\ m^3$
150 m overlap: $0.0140\ m^3/m \cdot 150\ m$	=	$2.1\ m^3$
20% excess in open hole:	=	$1.1\ m^3$
Total slurry volume:		$9.2\ m^3$

Cement slurry: Class G cement + 0.89 l/100 kg DS-80 + 1.78 l/100 kg D-73 + 0.18 l/100 kg D-81 mixed with fresh water at 1.94 kg/l.

12600 kg cement equivalent to $9.2\ m^3$ slurry. Pump 10 bbls fresh water ahead of the cement slurry. The water should be pumped ahead of the bottom plug.

Job preparation:

Total liquid needed: 12600 kg · 40.85 l/100 kg	=	5147 liter
Volume of DS-80 needed in each displ. tank:	=	34.6 liter
Total volume of DS-80 needed:	=	112 liter
Volume of D-73 needed in each displ. tank	=	69.3 liter
Total volume of D-73 needed:	=	224 liter
Volume of D-81 needed in each displ. tank:	=	7.0 liter
Total volume of D-81 needed:	=	22.7 liter

Hydrostatic heads:

Minimum hydrostatic head during the job (at liner shoe):

Hydrostatic head preflush: $\frac{1590\ l}{11.8\ l/m} \cdot 0.098$ bar/m	=	13.2 bar
Hydrostatic head mud: 0.181 bar/m · 2065 m	=	373.8 bar
Minimum hydrostatic head:	=	387.0 bar

Equivalent pressure gradient at 2200 m: 0.176 bar/m

Estimated pore pressure at 2200 m: 0.161 bar/m

Minimum hydrostatic head at maximum pore pressure (1820):

Hydrostatic head preflush:

$$(1820\text{-}1730\ m)\quad 0.098\ bar/m + \frac{1.59\ m^3 - (90 \cdot 0.0118\ m^3/m)}{0.0140\ m^3/m} \cdot 0.098\ bar/m = 12.5\ bar$$

Hydrostatic head mud: 0.181 bar/m · 1692 m	=	306.3 bar
Minimum hydrostatic head at 1820 m	=	318.8 bar
Equivalent pressure gradient: $\frac{318.8\ bar}{1820\ m}$	=	0.175 bar/m
Estimated pore pressure at 1820 m:	=	0.170 bar/m

Maximum hydrostatic head during the job: (at liner shoe)

Hydrostatic head cement: 0.190 bar/m · 470 m	=	89.3 bar
Hydrostatic head spacer: 0.098 bar/m $\frac{1.59\ m^3}{0.0326\ m^3/m}$	=	4.8 bar
Hydrostatic head mud: 0.181 bar/m · 1681 m	=	304.3 bar
Max. hydrostatic head:		398.4 bar

Equivalent pressure gradient: $\frac{398.4 \text{ bar}}{2200 \text{ m}}$ = 0.181 bar/m

Estimated formation integrity: = 0.193 bar/m

CASING CEMENT DATA AND CALCULATIONS, 5" LINER

GENERAL: The cement volume is calculated on the basis of the theoretical hole volume, and the liner to be cemented 100 m into the 7" liner with 20% excess volume in open hole.

WELL DATA:

Depth kb-sea bed......:	222	m
Depth kb-last shoe......:	2200	m
Depth kb-casing set point......:	2600	m
Open hole dia......:	6	"
Annulus capacity, cased hole......:	6.7	1/m
Annulus capacity, open hole......:	5.6	1/m
Internal capacity, 5" liner, 15.lbs/ft......:	9.8	1/m
Mud weight......:	1.72	g/cm^3
Bottom hole hydrostatic pres. (BHHP)......:	438	bar
Est. bottom hole static temp. (BHST)......:	88	^oC
Est. bottom hole circulating temp. (BHCT)...:	61	^oC
Est. formation integrity......:	0.198	bar/m

	FILLER/LEAD SLURRY	TAIL IN SLURRY
CEMENT SLURRY COMPOSITION	CLASS G + 0.89 1/100 kg DS-80 + 1.79 1/100 kg D-73 + 0.18 1/100 kg D-81	CLASS
Mix water 1/100 kg	41.4	
Total liquid 1/100 kg	44.25	
Slurry weight g/cm^3	1.90	
Slurry yield 1/100 kg	76	
TEST DATA @ BHCT		
Thickening time @ BHHP, hr:min	3:58	
Crit. Turb. Flow rate: m/s (1/min)		
Fluid loss, ml/30 min, 70 bar		
TEST DATA @ BHST, BHHP		
Compr. strength, bar hr		
bar 24 hr	260	
REMARKS: Pump 10 bbls fresh water ahead of the cement.		

Volume calculations, 5" liner:

Volume between 6" hole-5" liner: 0.0056 $m^3/m \cdot 400$ m	= 2.2 m^3
24 m plug at shoe: 0.0098 $m^3/m \cdot 24$ m	= 0.2 m^3
100 m overlap: 0.0067 $m^3/m \cdot 100$ m	= 0.7 m^3
20% excess in open hole:	= 0.4 m^3
Total cement slurry volume:	= 3.5 m^3

Cement slurry: Class G cement + 0.89 l/100 kg DS-80 + 1.78 l/100 kg D-73 + 0.18 l/100 kg D-81 mixed with fresh water at 1.90 kg/l.

Pump 10 bbls fresh water ahead of the cement slurry. The water should be pumped ahead of the bottom plug.

4600 kg cement equivalent to 3.5 m^3 slurry.

Hydrostatic heads:

Minimum hydrostatic head during the job (at liner shoe):

Hydrostatic head preflush: $\frac{1590\ l}{5.6\ l/m} \cdot 0.098$ bar/m	= 27.8 bar
Hydrostatic head mud: 0.169 bar/m $\cdot$ 2316 m	= 391.4 bar
Minimum hydrostatic head:	= 419.2 bar

Equivalent pressure gradient at 2600 m:	0.161 bar/m
Estimated pore pressure at 2600 m:	0.154 bar/m

Minimum hydrostatic head at maximum pore pressure (2200 m):

Hydrostatic head preflush:

$$(2200-2100)\text{m} \;\; 0.098\ \text{bar/m} + \frac{1.59\ \text{m}^3-(100\ \text{m}\cdot 0.067\ \text{m}^3/\text{m})}{0.0132\ \text{m}^3/\text{m}} \cdot 0.098\ \text{bar/m} = 16.6\ \text{bar}$$

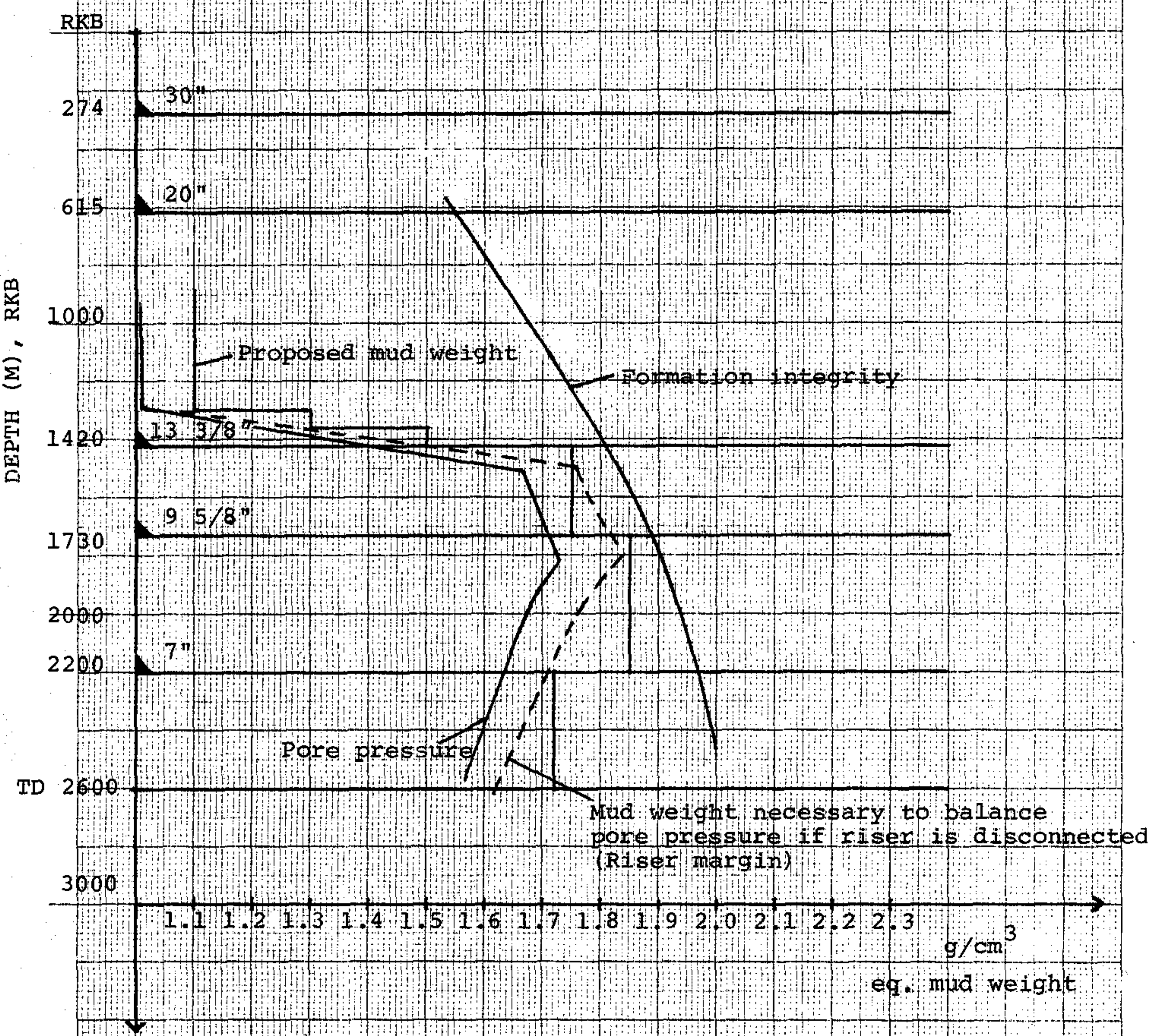
Hydrostatic head mud: 0.169 bar/m • 2030 m = 341.1 bar

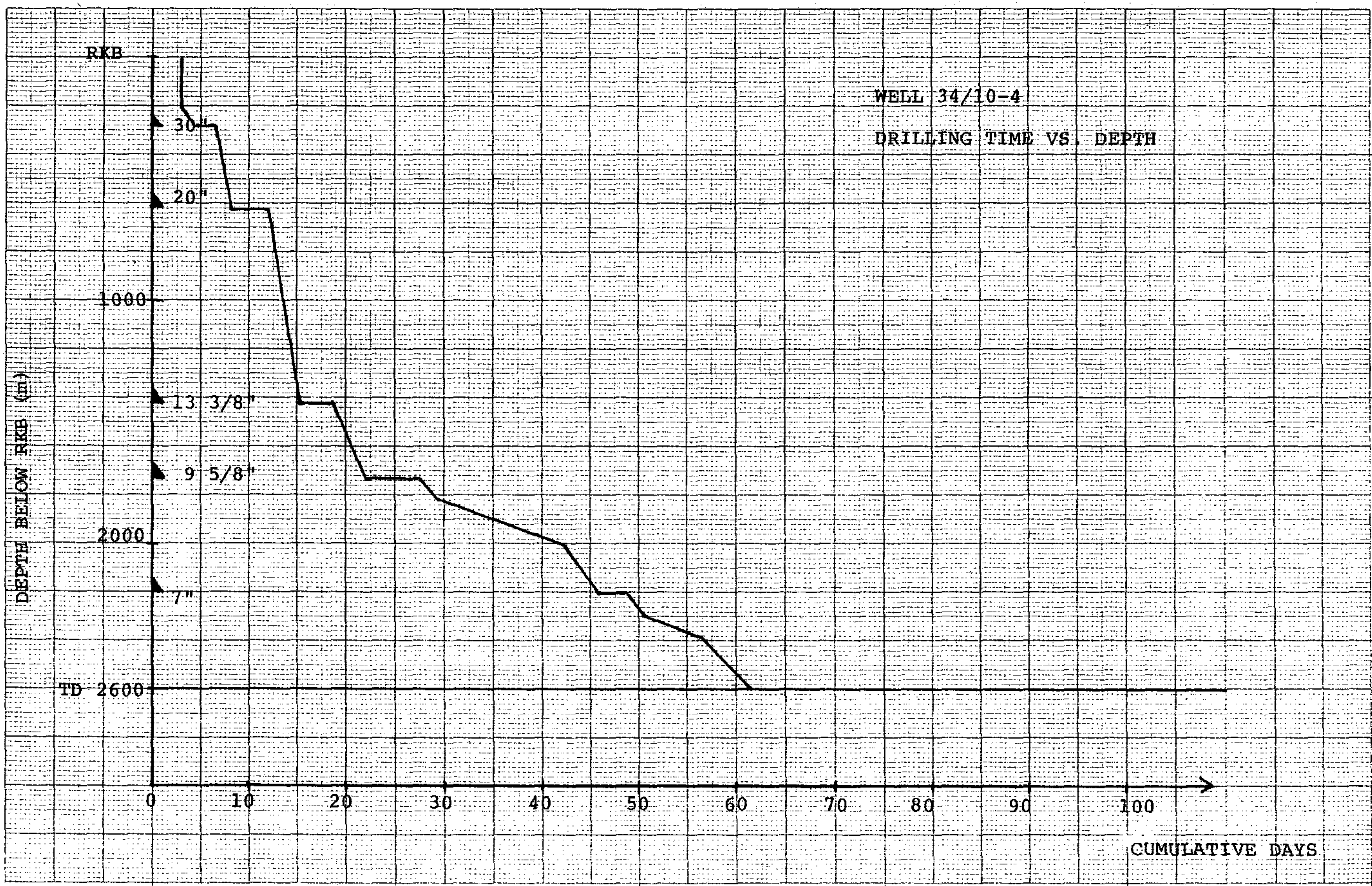
Minimum hydrostatic head at 2200 m = 359.7 bar

Equivalent pressure gradient: $\frac{359.7\ \text{bar}}{2200\ \text{m}}$ = 0.164 bar/m

Estimated pore pressure: = 0.160 bar/m

34/10-4. PORE PRESSURE AND FORMATION INTEGRITY ESTIMATE VS. DEPTH, USED FOR THE DRILLING PROGRAM.



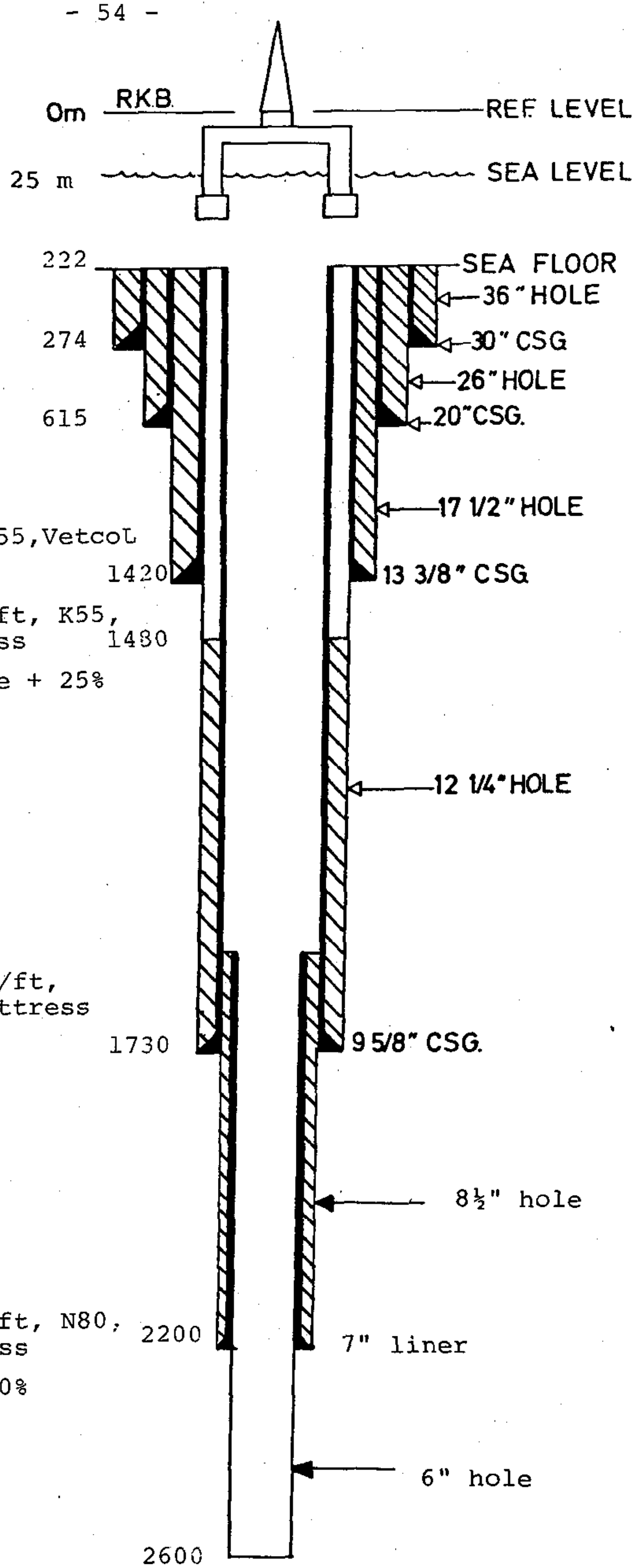


WELL 34/10-4
DRILLING TIME VS. DEPTH
RKB
30"
20"
13 3/8"
9 5/8"
7"
1000
2000
TD 2600
DEPTH BELOW RKB (m)
0
10
20
30
40
50
60
70
80
90
100
CUMULATIVE DAYS

statoil
Den norske stats oljeselskap a.s

WELL NO. 34/10- 4

NOT TO SCALE



30" grade B, 1 jt 1½" th
3 jts 1" th

Cement to sea floor + 150%

20",222-615 m: 94 lb/ft, J55,VetcoL

Cement to sea floor + 100%

13 3/8",222-1420 m: 68 lb/ft, K55, Buttress

Cement 100 m above 20" shoe + 25%

9 5/8",222-1730 m: 43.5 lb/ft, N80, Buttress

Cement to 1480 m + 25%

7", 1580 - 2200 m: 29 lb/ft, N80, Buttress

Cement to top of liner + 20%