S T A T O I L

GEOLOGICAL PROGNOSIS & DRILLING PROGRAM

WELL 15/12-3

MARCH 1980

Den norske stats oljeselskap a.s

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CONTENT

FIGURES

S T A T O I L

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

WELL NO. 15/12-3
PROSPECT (field) 15/12-Delta

General Data:

LOCATION

Countrh	Norway
Area	North Sea
Licence No.	038
Block No.	15/12
Coordinates	58° 14' 35,1" N, 01° 52' 45,8"E
Devation	6° W

Seismic: Shotpoint No. 1720 Line No. 511-324

0,8 Km south of north Block Boundary
4,6 Km west of east Block Boundary
220 Km from Norwegian coast, "Jærens Rev"
11,8 Km northeast of nearest well 15/12-1
20 Km northeast of nearest field "Maureen"
WATER DEPTH 86 Meters (MSL)
K.B.E. 25 Meters
PROJECTED TOTAL DEPTH 4900 Meters (RKB)

CONTRACTORS

Drilling Platform	Nordraug
Drilling Contractor	Ross Drilling Co. A/S
Mudlogging Contractor	Baroid
Type Logging unit	S-1000
Electric Logging Contractor	Schlumberger
Rig Positioning Contractor	Decca/Geoteam
Bottom Survey Contractor	Geoteam
Helicopter Service	Helikopter Service
Supply Boats	
Core analysis	GECO

GEOLOGICAL PROGRAM 15/12-3

Purpose of test

15/12-3 is an exploration well, designed to test possible hydrocarbons on the northern flank of the 15/12-delta structure. The well will be drilled 100 m into Rotliegendes or to a total depth of 4900 m.

Objectives

Sandstones of Upper Jurassic age are the primary objective in this well. This sand is proved in the 15/12-2 well.

Secondary objectives are Rotliegendes sandstone of Lower Permian age and Danian sandstone. Minor sandbeds of Danian age are proved in the 15/12-1 well. Further west, on UK side, oil is produced from Paleocene sand in the Maureen field.

Drilling Hazards

Based on data from the site survey and the 15/12-1 and 2 wells, no extreme drilling hazards are anticipated down to Triassic.

The drilling of the Zechstein salt require special precautions to be taken. The dip of the salt layers may cause extra borehole deviation.

The uncertanties in the estimate of top salt are high, and top Zechstein salt may come in 200 m above the prognosed depth. (See Stratigraphic prognosis, mudprogram, drilling program and appendix A).

Rig 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 on sp. 1720 on seismic line 511 - 324.

STRATIGRAPHIC PROGNOSIS

UNIT	DEPTH m.	THICKNESS
Top Pliocene	675 +-40	525
Top Utsira Fm.	845 +-30	220
Top Oligocene	1200 +-40	590
Top Eocene	1790 +-40	440
Top Paleocene	2230 +-30	360
Top Danian Sand	2450 +-40	30
Top Ekofisk Fm.	2480 +-40	110
Top Cretaceous	2590 +-50	305
Top Plenus Marl Fm	2750 +-60	25
Top Lower Cretaceous	2820 +-50	75
Top Jurassic	2895 +-50	150
Top Upper Jurassic sand	2920 +-50	30
Top Middle Jurassic	2955 +-60	90
Top Sleipner Fm	2990 +-60	
Top Triassic	3045 +-80	530
Top Permian	3575 +-200	1325+
Top Zechstein	3575 +-200	1100
Top Rotliegendes	4675 +-150	225+
T.D.	4900*	

* 100 m into Rotliegendes or 4900 m.

GEOLOGICAL WELL LOGGING AND SAMPLING PROCEDURES

Mud logging contractor: Baroid
A Baroid computerized mudlogging unit, type S - 1000, will be employed to log the well for hydrocarbon shows, collect samples, prepare sample log and conduct certain other services throughout drilling operations.

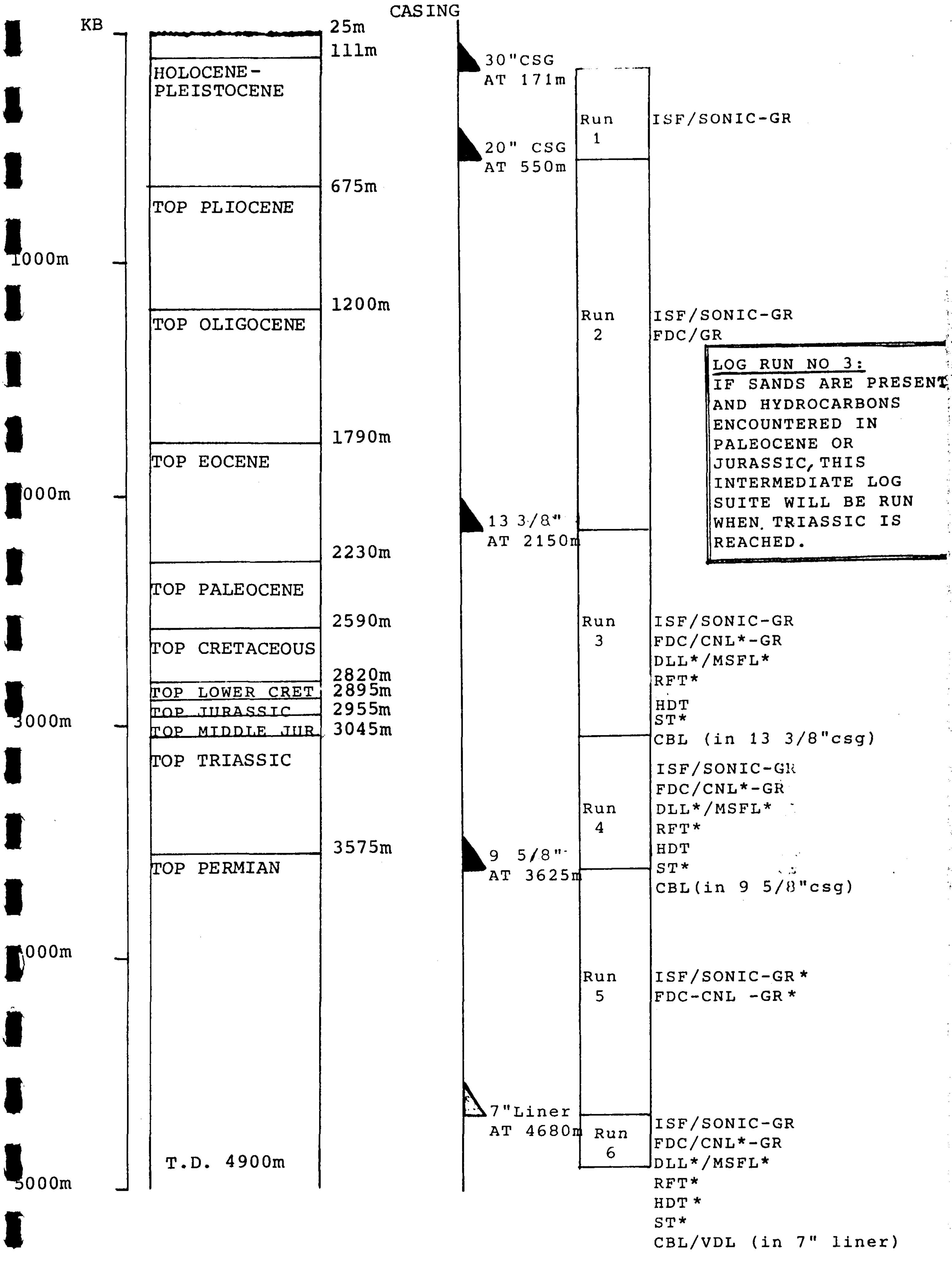
Sampling interval

5 sets of unwashed samples (½ kg) will be collected at 10 meter intervals down to 2150 meters. Thereafter 3 or 5 meters intervals will be collected, down to 2400 meters. From this depth 3 meter samples will be collected until setting depth for 9 5/8" csg is reached. 5 meters sampling intervals will be used throughout Zechstein salt, to 4400 m. From this depth and to TD, samples will be collected at 3 meter intervals. Over zones of interest, 2 meter sampling intervals might be requested by the wellsite geologist.

2 sets of washed and dried samples will be collected at the same intervals. One composite sample will be canned at 30 meters intervals from 30" casing to TD.

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 and distribution to partners and government agencies will be handled by GECO as per instructions.

WELL LOGGING PROGRAM- WELL 15/12-3



*Optional

CORING PROGRAM

If hydrocarbon shows are found in the Danian sand, this section will be cored. Minimum one core will be cut in Jurassic sandstone - additional cores if significant hydrocarbon shows are encountered.

Also in Rotliegendes sandstone a minimum of one core will be cut.

The coring points and the number of cores to be cut, will be at the discretion of the Wellsite Geologist, subject to review by Head Exploitation Geologist.

All cores will be sent to GECO, Stavanger for analysis, distribution and storage.

TESTING PROGRAM

If hydrocarbon accumulations are present, testing will be requested. These tests may be RFT's and/or production tests through casing depending on analysis of well potential at the time. A supplementary work program will be issued if necessary.

BASE AND OPERATION

The operation will be run from Statoil's base at Dusavik, Stavanger.

Statoils warehouse at Dusavik will support the rig, on order from the operation office.

RESPONSIBILITY: See organization chart, page 10.

a) Drilling Supervisor

The Statoil designated Drilling Supervisor will be immediately responsible for all operations on the rig in accordance with this program and drilling contracts. He will be adviced by a Drilling Engineer and a Wellsite Geologist. The Drilling Supervisor will report to the Statoil Drilling Superintendent.

b) Drilling Engineer

The Wellsite Drilling Engineer will provide technical assistance to the Drilling Supervisor. He will have special responsibility for pore pressure prediction and will work closely with the Baroid Engineer.

c) Wellsite Geologist

The Wellsite Geologist will advise the Drilling Supervisor of any changes in the geological prognosis and of any shows of oil or gas as soon as encountered. He will supervise the mud loggers during sampling and coring operations and together with the logging/testing engineer ensure that the Schlumberger logs are run properly and are of acceptable standard. He will recommend coring intervals. The Wellsite Geologist will report to the Statoil Operations Geologist.

d) Logging and Testing Engineer

The Wellsite Logging/Testing Engineer will assist the Drilling Supervisor/Wellsite Geologist in supervising the logging/testing operations. He will perform the necessary quality control of logging/testing/sampling data and ensure optimal data gathering during logging and testing operations.

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 telex from the Statoil operation office to Esso and to the Norwegian Petroleum Directorate. All other wellsite data, including field prints of logs, will be sent by post or messenger from Statoil.

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 Statoil Exploration and Drilling Department, who are involved in the planning and drilling of well 15/12-3:

NAME	TITLE	TELEPHONE		
		OFFICE	HOME	MOBILE
Aga. O.J.	Operations Geologist	33180	57717	36341
Bleie. J.	Exploration Manager	33180	32630	47461
Diamond, W.E.	Drilling Manager	41099	56131	36407
Frøyland, B.	Head Drlg.Techn.Section	77245	21919	44752
Hauge, T.	Drilling Eng.	77212		
Larsen, S.G.	Head Exploit.Geol.Sect.	33180	25374	36340
Lie, E.	Oper. Geol. Supervisor	33180		64911
Lorentsen, O.	Area Supervisor	33180	18770	
Milton, D.I.	Chief Geologist	33180	51264	
Pettersen, G.	Ass.Drlg.Manager	41099	91145	48567

COMMUNICATION PERSONNEL; 15/12-3

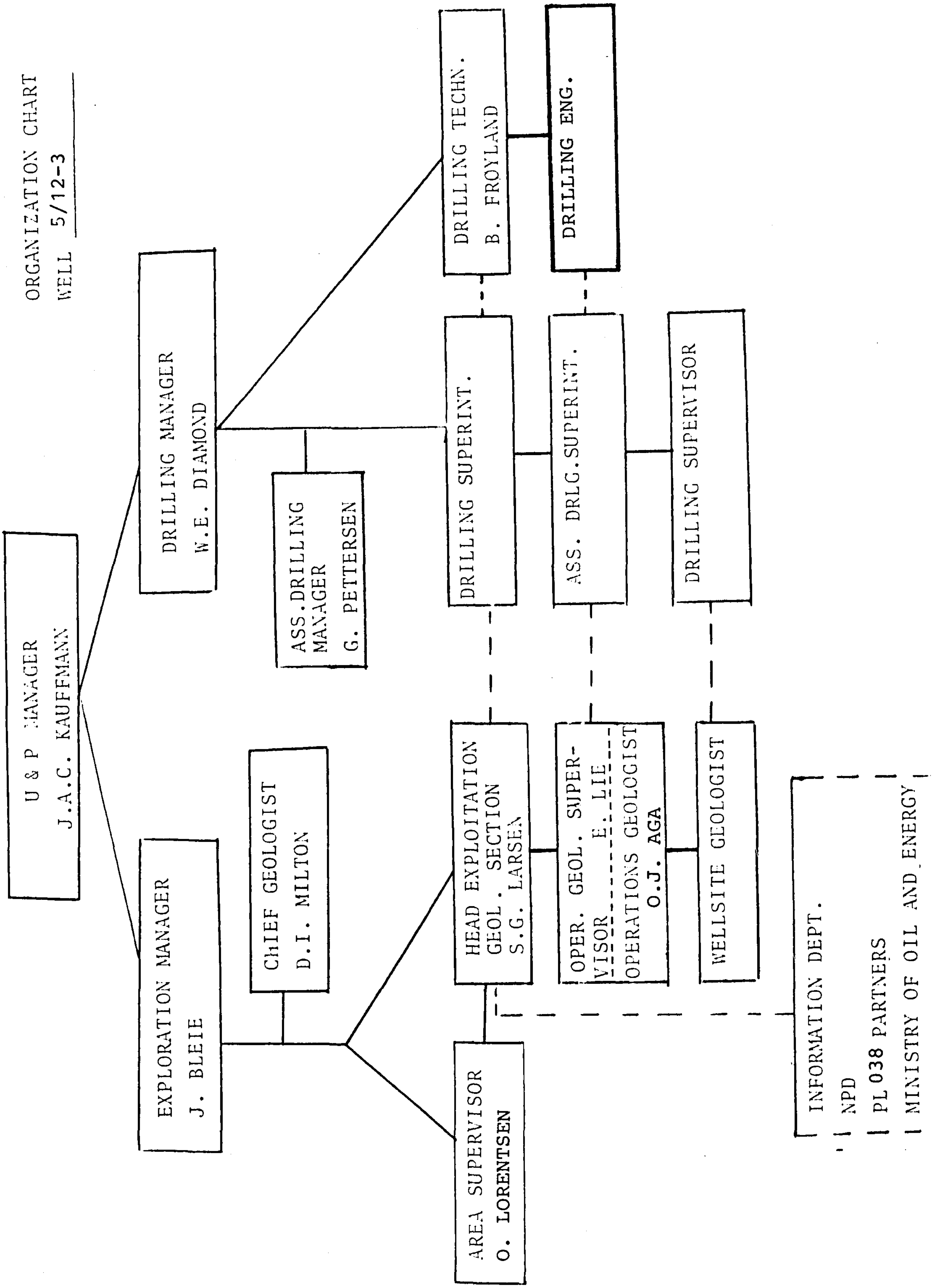
Esso Exploration and Production Norway Inc.:

NAME	TITLE	TELEPHONE OFFICE	NIGHT	HOME
Barrier, J.	Chief Geologist	28540	28546	22355
Diebel, K.L.	Exploration Manager	28540	28549	56074
Holmefjord, T.	Geologist	28540	(Mobile:	61685)
McRaynolds P.S.	Oper. Manager	28540	28542	89145
Phillips, S.I.	Geol. Supervisor	28540		51518

Contact in Norwegian Petroleum Directorate:

Aamodt. F. 33160

ORGANIZATION CHART
WELL 5/12-3



DRILLING PROGRAM.

Well designation:	15/12-3
Vessel:	"Nordraug"
Drilling draft:	20.3 m (70 ft)
KBE to MSL:	25 m
Water depth:	86 m
Depths:	Referred to KBE except where other wise specified.

LOCATION.

See geological program.

MOORING.

As per general procedure.

GENERAL DRILLING.

Estimated total depth: 4 900 m

General procedures.

- Drill 36" hole with 36" hole opener and 26" pilotbit to ± 171 m. Stab 30" casing blind. Do not use temporary guide base.

Drill 17½" hole to 565 m log and open hole to 26". Run 20" casing.

- Drill 17½" hole to 2165 m. Log and run 13 3/8" casing.

- Drill 12 1/4" hole until the main objective is penetrated. If hydrocarbons present, carry out intermediate log run. Drill 12 1/4" hole until 75 m or more of Zechstein salt i exposed. Sufficient casing seat is obtained in Zechstein. Log and run 9 5/8" casing.

- Convert to oil base mud. Drill 8½" hole until 5 m of Rotliegende is exposed. Log and run 7" liner.

- Drill to TD and log as programmed.

DRILLING CONSIDERATIONS.

26" hole.

Pore pressure is expected to be normal. The high resolution seismic carried out over the location has no indication of shallow gas in this interval.

17½" hole.

The pore pressure is expected to be normal down to 2000 m where a slight pressure increase is expected. Possible gas at 585 m and 725 m.

Some of the Tertiary clays have tendency to swell and cause tight hole.

12 1/4" hole.

The remaining part Eocene and the upper part of Paleocene will probably be overpressured. When approaching Cretaceous the formation pressure is expected to fall back to normal and stay through upper Cretaceous.

A pressure transition zone is expected towards base of Cretaceous. The maximum pressure of 1.37 EMW is likely to occur at the late Kimmerian unconformity. Below the depth a slight pressure regression is expected.

When approaching the Zechstein the mud will be 50% salt saturated. To minimize the problems with the conversion, the solids content in the mud has to be at a minimum. That means the mudwight has to be kept as low as possible and the solids control equipment has to be run optimal.

The objective for the 9 5/8" casing seat is to penetrate any possible anhydrite caprock and get adequate penetration into massive Zechstein salt (minimum of 75 m) to obtain cement seal sufficient to withstand pressure integrity test of 2,3. S.G. To be able to log and run pipe in this section of the salt a rather high mud weight is required. The required mudweight depends on the depth the salt is encountered and on the formation temperature, but will be within range of 1.55 to 1.75 gm/cc. This high mudweight means we will be very overbalanced to the formation above. Fluid losses and differential sticking have to be regarded as potential problems and action has to be taken to avoid them. Again the solids control is of importance and of course also the fluid loss properties.

8½" hole.

In the 8½" hole we will mainly deal with Zechstein Evaporites. See appendix for more detailed information and discussion of salt related drilling problems.

6" hole.

The purpose of the 7" liner is to seal off the salt and enable us to cut mudweight before Rotliegende sandstone are drilled.

Disposal of the oil mud.

Before plugging the well the oil mud will be pumped into the formation. Dependent on conditions in the well either a Rotliegende or Jurassic sandstone will be used for this purpose.

Directional survey.

A single shot directional survey will be run every bit run below 20" casing shoe, and every 90 m after setting the 13 3/8" casing.

H_2S-detection.

The hole will be checked for H_2S in 100 m intervals, starting at 2900 m by means of Garret's Gas Train.

MUD PROGRAM 15/12-3

Interval (m)	Høle size	Mud type	Mud weight g/cm^3	PV	YP	HTHP	pH
111 - 171	20" x 36"	Sea water, Prehyd. bent Slugs	-				
171 - 565	17½"	" " " "	-				
171 - 565	26"	" " " "	-				
565 - 2165	17½"	Prehyd. bent/lignosul-fonate	1.06 - 1.10	low	15-20		9.5-10.5
2165 - 3665	12 1/4"	See mud program	1.10 - 1.40	low	See Mud	Program	
3665 - 4695	8½"	Oil based	1.80 - ~~1.95~~ 2.15		" "	"	
4695 - TD	6"	Oil based	1.60		" "	"	

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, desiltres/mud cleaners (150-120 mesh screens)

- Utilize the centrifuge for viscosity control and for barite salvage.

- See separate Mud Program for detalils.

BITS AND HYDRAULICS

Intervall RKB	Hole size	Bit type	Nozzles 32nds	Wob tons	RPM	Circ. (cum/min)	Pump press (bar
111 - 171	26" x 36"	OSC3A + H.O.	3 x 20	0-5	60	3,9 - 4,2	140 - 160
171 - 565	17½"	OSC3AJ	3 x 18	0-10	140 - 160		
171 - 565	17½" x 26"		3 x 18	0-7	120		
565 - 2165	17½"	OSC3AJ, DSJ	3 x 18	10-14	130 - 150	3,9 - 4,2	160 - 200
2165-2490	12 1/4"	X3A	3 x 14	10-12	120 - 140	2,6 - 2,8	200
2490-2900	12 1/4"	Turbo drilling L x 13					
2900- 3650	12 1/4"	XV, SVH	3 x 14	18-20	110 - 120	2,4 - 2,6	210
	12 1/4"	X44, X77	3 x 14	18-23	60 - 70	2,2 - 2,5	210
3650-4695	8½"	X3, X1G J3	3 x 12	2-8	150	0,8 - 0,95	250
4695 - TD	6"	Rotary diamond drilling MD 311					
	6"	M44N, S21G	3 x 12	7-10	70 - 90	0,5 - 0,68	270

REMARKS:

- Hydraulics and Drilling will be optimized on the rig according to actual mud properties and hole conditions. Surface pressure is to be 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.

CASING.

Set casing as per general procedures.

Casing Program

Size (inch)	Depth (m)	Weight (lbs/ft)	Grade	Thread
30"	1 joint 4 joints	1 ½" wall 1" wall	B B	Vetco ATD/RB Vetco ATB/RB
20"	111 - 550	94	X-56	LS
13 3/8"	111 - 2150	72	N-80	Buttress
9 5/8"	111 - 3450 3450 - 3650	53,5 53,5	P-110 MW-125	Buttress
7" liner	3475 - 4680	32	P-110	Buttress

See "Casing calculations".

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", 9 5/8" and 7" casings.

C BOP TESTING

As per general procedures.

PRESSURE INTEGRITY TESTS.

As per general procedures. See also remarks under GENERAL DRILLING.

DRILLS

As per general procedures.

ABNORMAL PRESSURE DETECTION.

The most effective abnormal pressure detection operation will be the result of team effort involving the Drilling Supervisor, Drilling Engineer, Wellsite Geologest, 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.

PRODUCTION TESTS.

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

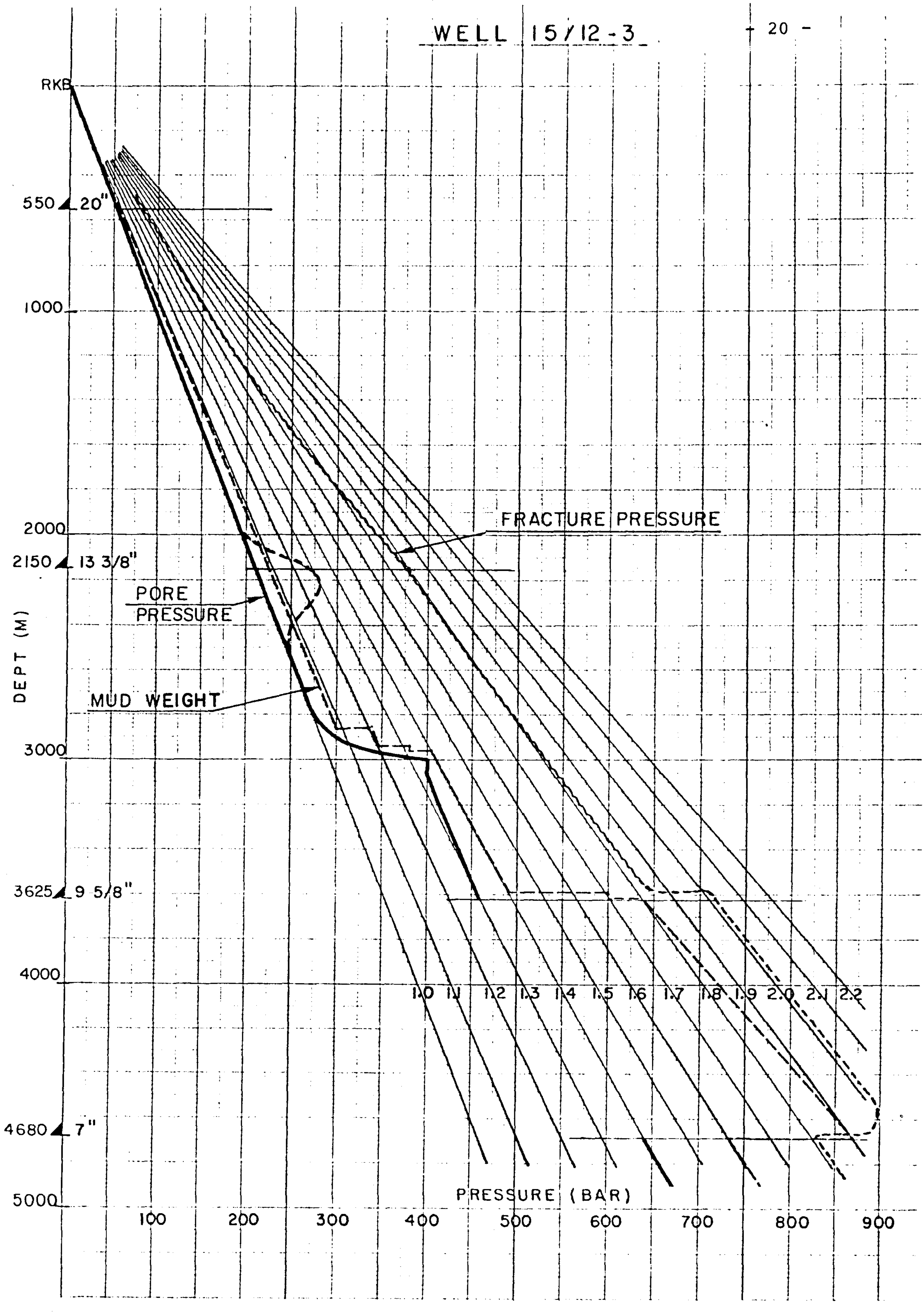
PLUG AND ABANDONMENT.

As per general procedures.

Approved:

Expl. Manager, Statoil

Drilling Manager, Statoil


WELL 15/12-3
RKB
550 20"
1000
2000
2150 13 3/8"
3000
3625 9 5/8"
4000
4680 7"
5000
DEPT (M)
FRACTURE PRESSURE
PORE PRESSURE
MUD WEIGHT
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
100 200 300 400 500 600 700 800 900
PRESSURE (BAR)

KICK CALCULATIONS.

Drilling below 13 3/8" shoe:

Annular capacity (8" - 12 1/4") = 0.0436 m^3/m
Annular capacity (5" - 12 1/4") = 0.0627 m^3/m
13 3/8" setting depth 2150 m
9 5/8" setting depth 3650 m
BHA ≈ 180 m

Estimated minimum fracture gradient below 13 3/8" shoe:
1.78 gm/cc at 2150 m.

The suggested mudweight in 12 1/4" hole (1.4 gm/cc) is believed to be sufficient to controle the formation pressure in this section. However, if this fails, and the well kicks (gas influx) from a zone with pore pressure 1.4 gm/cc EMW (at 2900 m), a kick height of approx. 700 m can be taken before the formation at the shoe is fractured. The equivalent kick volume:

$180 \times 0.0436 + 520 \times 0.0627 = 40\ m^3 \sim 250$ bbls

Drilling below 9 5/8" shoe:

9 5/8" setting depth 3650 m. Formation integrity: greater than 2.0 EMW. With the suggested mudweight and the estimated pore pressure kicks of any size can be shut in without breaking the formation at the shoe.

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.

X-area = Cross-sectional area (cm^2)

Z = Depth (m) from RKB to wellhead.

G_f = Fracture gradient (bar/m)

G_{gas} = Gas gardient (bar)m)

G_i = Mud gradient at casing setting depth (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

L = Liner lenght

Mc = Casing mass-gradient (kg/m)

RESc = Collapse resistance (bar)

RESb = Burst resistance (bar)

RESt = Tention resistance (10^3daN)

S.F.c = Safety factor, collapse = 1.25 (1.3 for 13 3/8" casing)

S.F.b = Safety factor, burst = 1.10

S.F.t = Safety factor, tension = 1.5

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

15/12-3 CASING DESIGN.

20" casing:

W_D = 2165 m

X = 550 m

G_F = 0.147 bar/m

Gi = 0.108

G_{gas} = 0.01 bar/m ($\bar{P}$ = 112 bar, $\bar{T}$ = 20^oC, γ = 0.6)

Z = 111 m

Gp = 0.1 bar/m

G_{cem1} = 0.184 bar/m

G_{cem2} = 0.153 bar/m

BURST.

Max burst load at wellhead if the casing is filled with gas:

$P_B = X \times G_F - (X - Z)\ G_{gas} - (Z - 25)\ Gp =$

$550 \times 0.147 - (550 - 111)\ 0.01 - (111 - 25)\ 0.1 =$

$= 68$ bar

COLLAPSE.

Max collapse load during cementing (assume the cement is displaced with 1.1 SG mud).

$Pc = 27 \times G_{cem1} + (X - Z - 27)\ G_{cem2} - (X - Z - 26)\ 1.03 \times 0.098 =$

$27 \times G_{cem1}$

$= 27 \times 0.184 + (550 - 111 - 27)\ 0.153 - (550 - Z - 27)\ 1.03 \times 0.098 - 27 \times 0.184 = 21$ bar

Select: 111 - 550 m: X-56, 94 lbs/ft, LS

$RES_c = 36$ bar

$RES_B = 145$ bar

$RES_T = 658 \times 10^3$ daN

Safety factor burst:

$$SF_B = \frac{RES_B}{P_B} = \frac{145}{68} = 2.1 > 1.1$$

Safety factor, collapse:

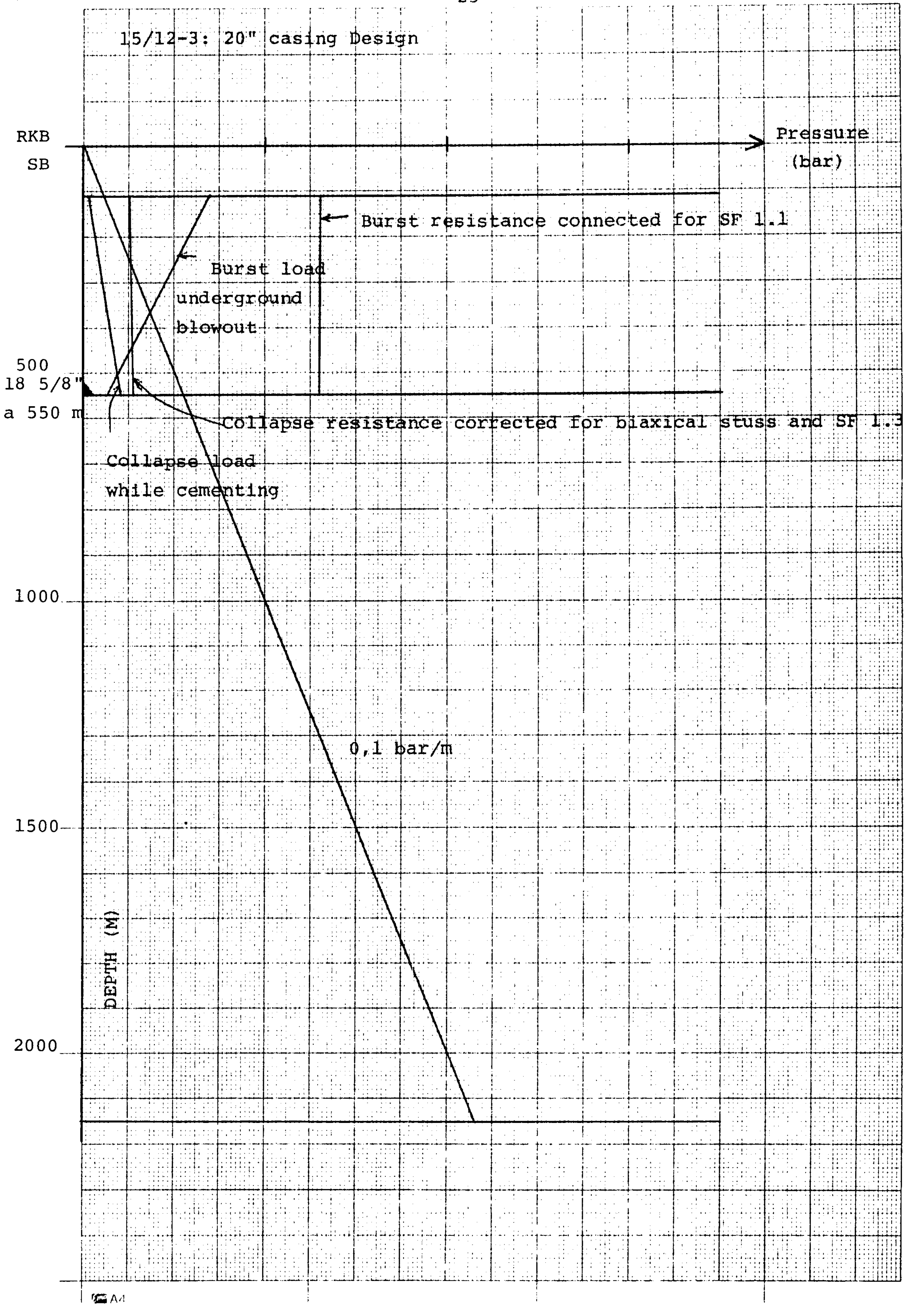
$$SF_c = \frac{RES_c}{Pc} = \frac{36}{21} = 1.7 > 1.3$$

Tension:

Weight load: (X - Z) 136 x 0.98 daN

$= (550 - 111)\ 136 \times 0.98 \text{ daN} = \underline{58 \times 10^3 \text{daN}}$

$$SF_T = \frac{RES_T}{58 \times 10^3} = \frac{658}{58} = 11 > 1.5$$


15/12-3: 20" casing Design
RKB
SB
Pressure
(bar)
Burst resistance connected for SF 1.1
Burst load
underground
blowout
500
18 5/8"
a 550 m
Collapse resistance corrected for biaxical stuss and SF 1.3
Collapse load
while cementing
1000
0,1 bar/m
1500
DEPTH (M)
2000

13 3/8" CASING.

W_D = 3750 m (Deepest possible 9 5/8" csg.)

X = 2150 m

Gi = 0.115 bar/m

G_F = 0.176 bar/m

G_p = 0.1 bar/m

G'p = 0.133 bar/m

G_{gas} = 0.023 bar/m

Z = 111 m

Gi = 0.137 bar/m

BURST.

Maximum burst load if there is an underground blowout (from Upper Jurassic sand, PP = 1.37 EMW).

$$P_B = 2920 \times 1.37 \times 0.098 - G_{gas} (2920 - Z) - (Z - 25)\ G_p$$

$$= 392 - 0.023\ (2920 - 11) - (111 - 25)\ \ 0.1 = \underline{318\ \text{bar}}$$

Possible burst load while testing casing to 2500 psi:

$$\frac{2500}{14.5} + X\ (Gi - G_p) = \frac{2500}{14.5} + 2500\ (0.115 - 0.1) = \underline{210\ \text{bar}}$$

COLLAPSE.

Mud level if mud is lost to a low pressure formation at 2700 m:

$$X = 2700 - \frac{2700 \times 1.1}{1.4} = \underline{578\ \text{m}}$$

Collapse load at 578 m:

$P_{c1} = Y \times Gi = 578 \times 0.115 = \underline{66\ bar}$

Collapse load while cementing:
(assume 1000 m cement SG 1.6)

$P_{c2} = 1000\ (1.6 - 1.2)\ \ 0.098 = \underline{39\ bar}$

Select: 111 - 2150 m: 72 lbs/ft, N-80

$RES_C = 184$ bar

$RES_B = 371$ bar

$RES_T = 738 \times 10^3$ daN

Safety factor, burst:

$SF_B = \frac{371}{318} = 1.17 > 1.1$

Safety factor, collapse:

Weight load at 578 m:
$(2150 - 578)\ 106 \times 0.98 = 163 \times 10^3$ daN

⇒ Corrected RES_C: 160 bar

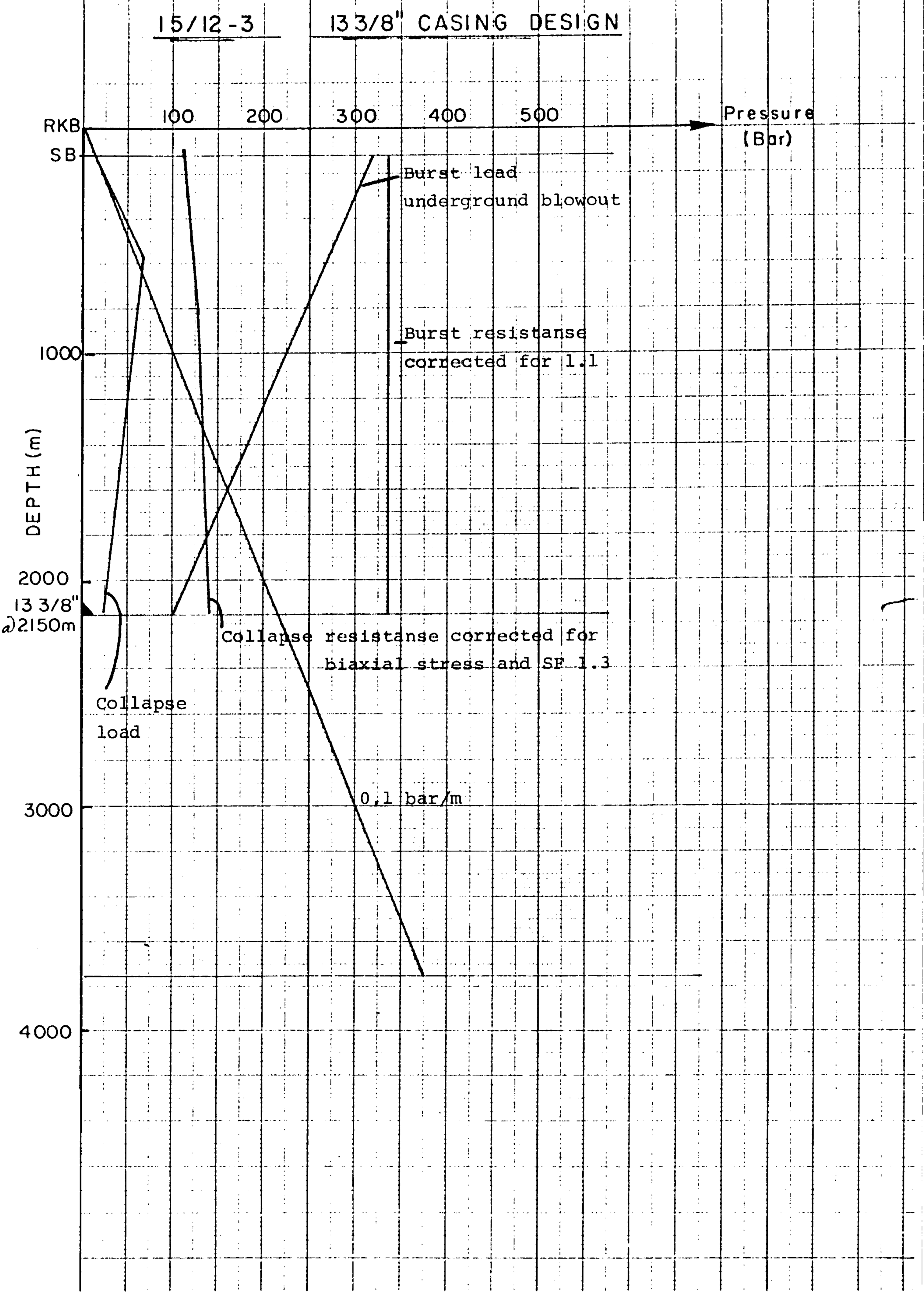
$SF_C = \frac{160}{66} = 2.4 > 1.3$

Safety factor, tension:

Weight load at wellhead:

$(2150 - 111)\ 106 \times 0.98 = 250 \times 10^3$ daN

$$SF_T = \frac{RES_T}{250 \times 10^3 daN} = \frac{738}{250} = 3.0$$


15/12-3
13 3/8" CASING DESIGN
100
200
300
400
500
Pressure
(Bar)
RKB
SB
1000
2000
13 3/8"
@2150m
3000
4000
DEPTH (m)
Burst load
underground blowout
Burst resistanse
corrected for 1.1
Collapse resistanse corrected for
biaxial stress and SF 1.3
Collapse
load
0,1 bar/m

9 5/8" CASING

W_D	=	4 900 m
Z	=	111 m
X	=	3 750 m
Gi	=	0,176 bar/m (Mw when running 9 5/8 csg)
Gf	=	0,215 bar/m (Frac. grad at 9 5/8 shoe)
Gp	=	0,1 bar/m (Normal pore pressure)
G'p	=	0,137 bar/m (Pore pressure grad in Rotliegende
G'i	=	0,186 bar/m (Mw requiud to overcome saltcreep)
G_{gas}	=	0,023 bar/m
G_{salt}	=	0,216 bar/m overburden in the Zechstein

Note: The 9 5/8" casing is designed for what is regarded as the deepest possible setting depth.

BURST

Burst load if there is an underground blow out and the entire casing is filled with gas:

$$P_B = W_D \times G'_p - (W_D - Z) \times G_{gas} - (Z - 25)\ G_p =$$

$$= 4\ 900 \times 0{,}137 - (4\ 900 - 111)\ 0{,}023 - (111 - 25) \times 0{,}1 = 554 \text{ bar}$$

COLLAPSE

Collapse load if circulation is lost when drilling at 4900 m. (Resistance to mud flow into formation: 0,137 bar/m)

$$Y = W - \frac{W_D \times 0{,}137 \text{ bar/m}}{G'i}$$

$$= 4\ 900 - \frac{4\ 900 \times 0{,}137}{0{,}187} = 1310 \text{ m}$$

Collapse load at 1310 m

Pc_1 = Y x Gi = 1310 x 0,176 = 230 bar

Collapse load in the salt if circulation is lost at 4 900 m.

Pc_2 = X x G salt - (X - Y) x G'i =
= 3750 x 0,216 - (3750 - 1310) x o,187=
= 353 bar

Select:	111 - 3550 m:	53,5 lbs/ft	P-110
		RES_C	547 bar
		RES_B	752 bar
		RES_T	759 bar
	3550 - 3 750 m:	53,5 lbs/ft	MW 125
		RES_C	582 bar
		RES_B	854 bar
		RES_T	864 bar

SAFETY FACTORS

$$SF_B = \frac{RES_B}{P_B} = \frac{752}{554} = \underline{1,36} > 1,1$$

Satety factor, collapse

Weight load at 1310 m

$$(3750 - 1310)\ 78 \times 72 \times 0,98 \text{ da N} = 188 \times 10^3 \text{ da N}$$

RESc corrected: 360 bar

$$SF_{c1} = \frac{RES_{C\ cor}}{P_{c1}} = \frac{375}{230} = \underline{1,63} > 1,25$$

Safety factor, collapse, in the salt.

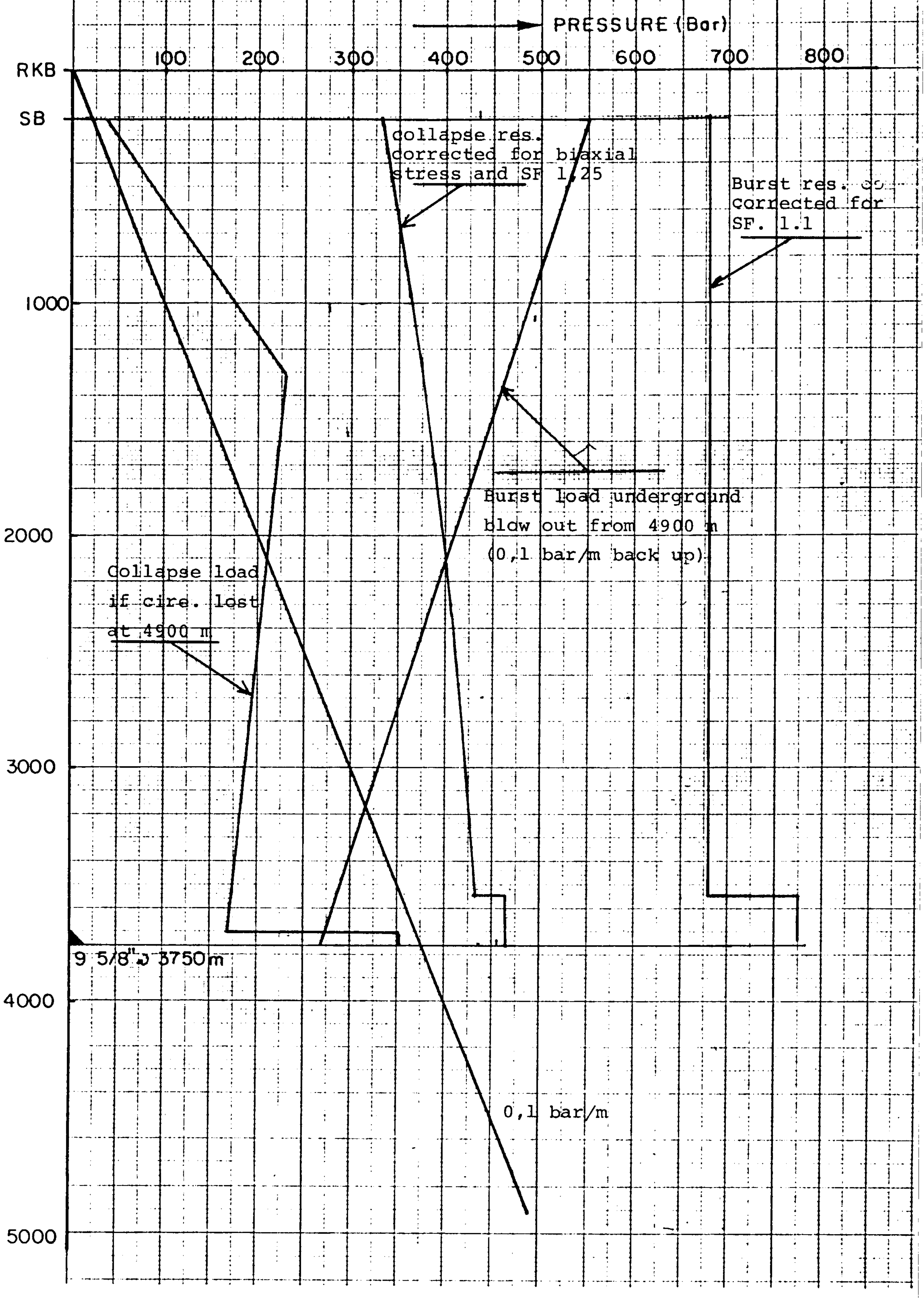
$$SF_{c2} = \frac{RES_C}{P_{c_2}} = \frac{582}{353} = 1,65 > 1,25$$

Weight load at wellhead.

$$(3750 - 111)\ 78 \times 72 \times 0,98 = 281 \times 10^3 \text{da N}$$

$$SF_T = \frac{RES_T}{281 \times 10^3} = \frac{759}{281} = 2,7 > 1,5$$

15/12-3 9 5/8" CASING DESIGN



7" LINER.

W_D = 4900 m

X = 4680 m

G_{gas} = 0.03 bar/m ($\bar{P}$ = 780, $\bar{T}$ = 85°C, γ = 0.6) Testing at 4700 m.

Z = 111 m

G_p = 0.186 bar/m

Gi = 0.186 bar/m

G'p = 0.186 bar/m

G"p = 0.137 bar/m (Pressure grad. in Rotliegende)

Collapse:

Lost circ. at 4900 m

$$Y = 4900 - \frac{4900 \times 1.02}{1.90} = 2269 \text{ m}$$

Collapse load at base salt:

$$P_{c1} = (4650 \times 2.2 - (4650 - 2269)\ 1.9)\ 0.098 = \underline{559 \text{ bar}}$$

Collapse load at top salt:

$$P_{c2} = (3600 \times 2.2 - (3600 - 2269)\ 1.9)\ 0.098 = \underline{528 \text{ bar}}$$

Select: 3615 - 4900 m: P-110, 32 lbs/ft, Buttr.

$RES_C = 742$

$RES_B = 859$

$RES_T = 455 \times 10^3$ daN

x-area = 60.11 cm^2

Minimum flowing bottom hole pressure while testing at 4700 m:

$$P_{WFmin} = 4700 \text{ m} \times G"p - \frac{RES_C}{1.25} =$$

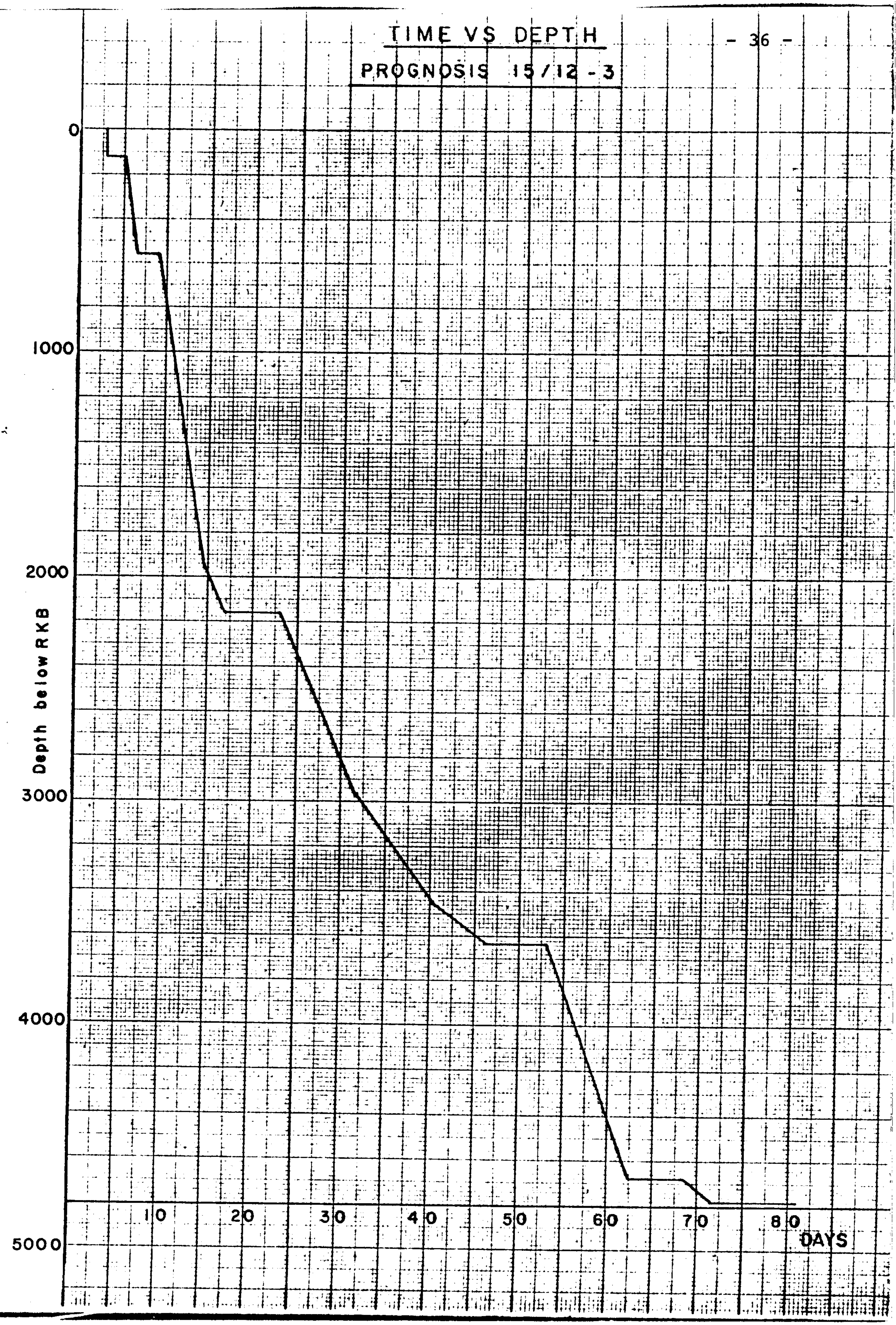
$$4700 \times 0.137 - \frac{742}{1.25} = \underline{50 \text{ bar}}$$

TENSION.

Weight load (4900 - 3615) 47.6 = 61×10^3 kg = $\underline{60 \times 10^3 \text{daN}}$

Safety factor tension:

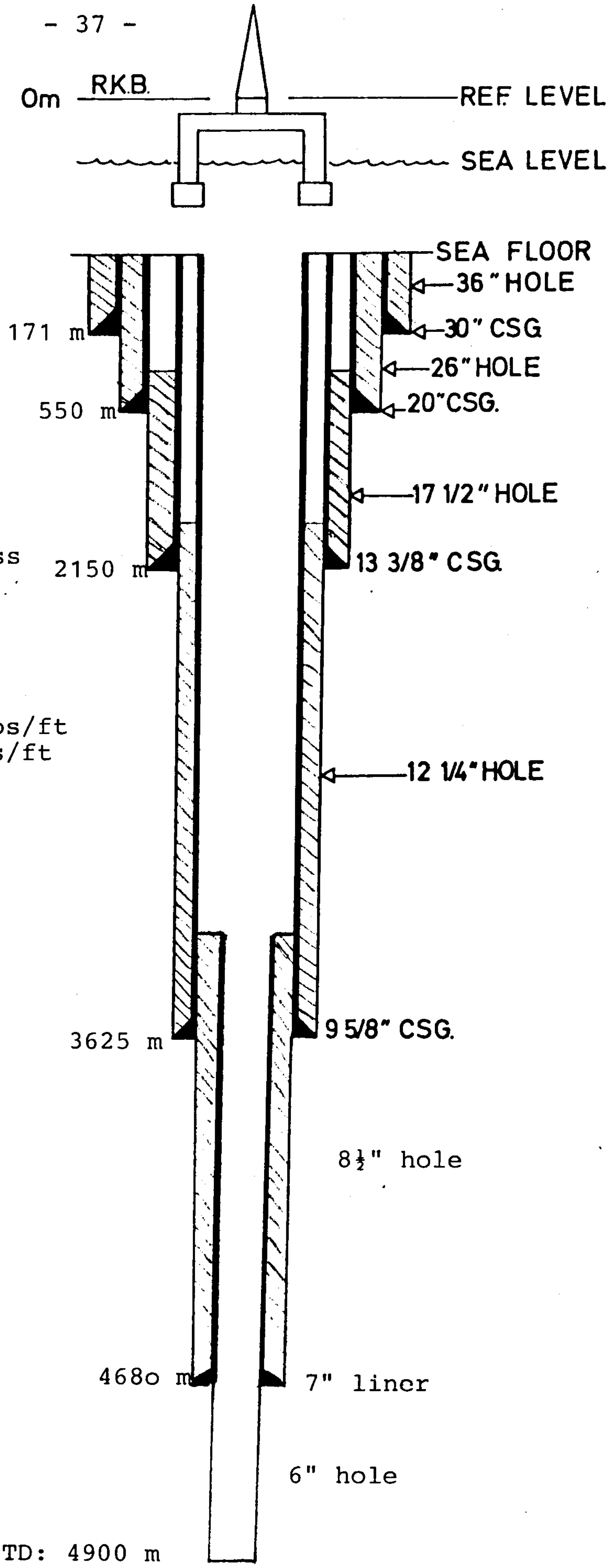
$$SF_T = \frac{RES_T}{60 \times 10^3} = \frac{455}{60} = 7.6 > 1.5$$


TIME VS DEPTH
PROGNOSIS 15/12-3
0
1000
2000
3000
4000
5000
Depth below RKB
10
20
30
40
50
60
70
80
DAYS

statoil
Den norske stats oljeselskap a.s

WELL NO. 15/12-3

NOT TO SCALE



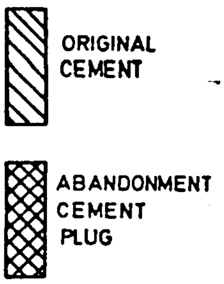
30" grade B, 1 jt. 1.5" th.
3 jts. 1" th.

Cement to sea floor + 150%
20" X-56, 94 lbs/ft LS
Cement to sea floor + 100%

13 3/8" N-80, 72 lbs/ft
Cement
100 m into 20" casing + 25% excess
volume on open hole.

9 5/8" 111-3450 m: P-110, 53.5 lbs/ft
3450-5650 m: MW 125, 53.5 lbs/ft
Cement 100 m into 13 3/8" casing
+ 25% excess volume on open hole

7" liner, P-110, 32 lbs/ft
Cement 150 m into 9 5/8" casing
? 25% excess volume on open hole.



APPENDIX A

MARINE EVAPORITE MINERALS

Marine evaporite minerals are formed by evaporation of sea water. A basin with restricted connection to the ocean, exposed to a hot, arid climate, will eventually generate evaporite deposits through continued evaporation of sea water. Such evaporation of sea water will increase the salinity of water in the basin. This high salinity water, called a brine, will through continued evaporation reach a point of saturation, whereafter the precipitation of minerals starts. The very first mineral to precipitate is calcite. The next minerals will be hydrated and/or non hydrated calsium sulfates followed by halite. K-Mg salts are formed when most of the potensial halite has precipitated from the brine.

This sequencial precipitation will result in layered deposits on the bottom of the basin. The layers in the deposits are stacked according to the order of precipitation, and is called a cycle. Flucrtuation in the climate, minor transgressions and regressions, and successive infilling of the basin, alter the ideal regular pattern of deposition within an evaporite cycle. Major transgressions mark the boundary between cycles. At the location of 15/12-3 correlations indicate the existence of three major evaporite cycles of Zechstein age, Z1 - Z3. Z1 and Z3 are incompletely developed, and Z2 is the only cycle that contain halite and K-Mg layers at this location.

Nature exhibits a large number of different evaporite minerals. Most of them are very rare. The important ones are given in table 1.

When K-Mg systems are buried within the crust they experience changes in the physical conditions. This will cause mineral reactions; but for all conditions the depositions do always consist of minerals given in table 1.

Table 1

SELECTED EVAPORITE MINERALS

Anhydrous minerals		Hydrous minerals	
Halite	$NaCl$	Polyhalite	$K_2Ca_2Mg(SO_4)_4\ 2H_2O$
Sylvite	KCl	Kainite	$KMg(SO_4)Cl\ 3H_2O$
Anhydrite	$CaSO_4$	Gypsum	$CaSO_4\ 2H_2O$
Langbeinite	$K_2Mg_2(SO_4)_3$	Kieserite	$MgSO_4\ H_2O$
Calcite	$CaCO_3$	Carnallite	$KMgCl_3\ 6H_2O$
Magnesite	$MgCO_3$	Bischofite	$MgCl_2\ 6H_2O$
Dolomite	$CaMg(CO_3)_2$		

These are the most common constituents of the K-Mg rich layers of evaporite deposits (except Bischofite).

A complete salt cycle consists of the following layers from bottom and upwards: Carbonates. Sulfates (Anhydrite $CaSO_4$ or Gypsum $CaSO_4 \cdot 2H_2O$), Halite (NaCl) and K-Mg salts. A salt section may consist of several cycles stacked on top of each other.

The problematic zone from a drillling point of view appears to be the K-Mg salts for the following reasons:

1. The K-Mg minerals are highly dissolvable in water.

2. The lattice strength of the K-Mg minerals is low, and any change in conditions could cause recrystallization and reactions.

3. The K-Mg deposits may have relatively high content of geopressured pore water.

During diapirism the natural bedding of the salt is destroyed and K-Mg salts may loose water to the surrounding rocks and thus become more stable. It is not possible to predict the posistion of K-Mg salts in the diapir, and hence impossible to predict where they may occur in the 15/12-3 salt section.

Mechanical Properties of Salt.

Because of the viscoplastic behaviour of salt, once the salt is penetrated the wellbore will start to close. The closure rate depend on mudweight, temperature and depth. Other factors such as tectonic stresses and impurities in the salt also affect the creep rate.

Below are two figures showing theoretical creep rates in pure halite. The graphs shows the time required to reduce borehole diameter by 5 and 10%. The presence K - and Mg-salts will probably cause higher creep rates. But the graphs give a clue to the minimum mudweight required in the salt.

Drilling problems related to salt.

General.

In the past most of the drilling problems have occured in the presence of K- and Mg-salts. These salts are the last minerals that crytalize in an evaporite cycle and are therefore likely to occure near the interface between two cycles. Drilling breaks (negative or positive) might indicate such an interface. If drilling break occure followed by K-and Mg-salts in the cuttings the well should be monitored very carefully. These zones might give trouble such as salt water flows, stuck pipe and even lost circulation.

K - and Mg-salt are also very easy to erode. If they are present it is of importance that the annulus flow is kept laminar.

Influxes of formation fluids:

Several kicks have been reported from previous wells. Nothing but salt water has been found.

The K- and Mg-salt might under certain conditions dehydrate and thereby form pockets of dehydrated crystals and water. These zones might have sufficient permeability to cause a kick. Mud-weight as high as 1.92 gm/cc was in one well (16/11-1x) required to controle such a zone.

Stuck pipe:

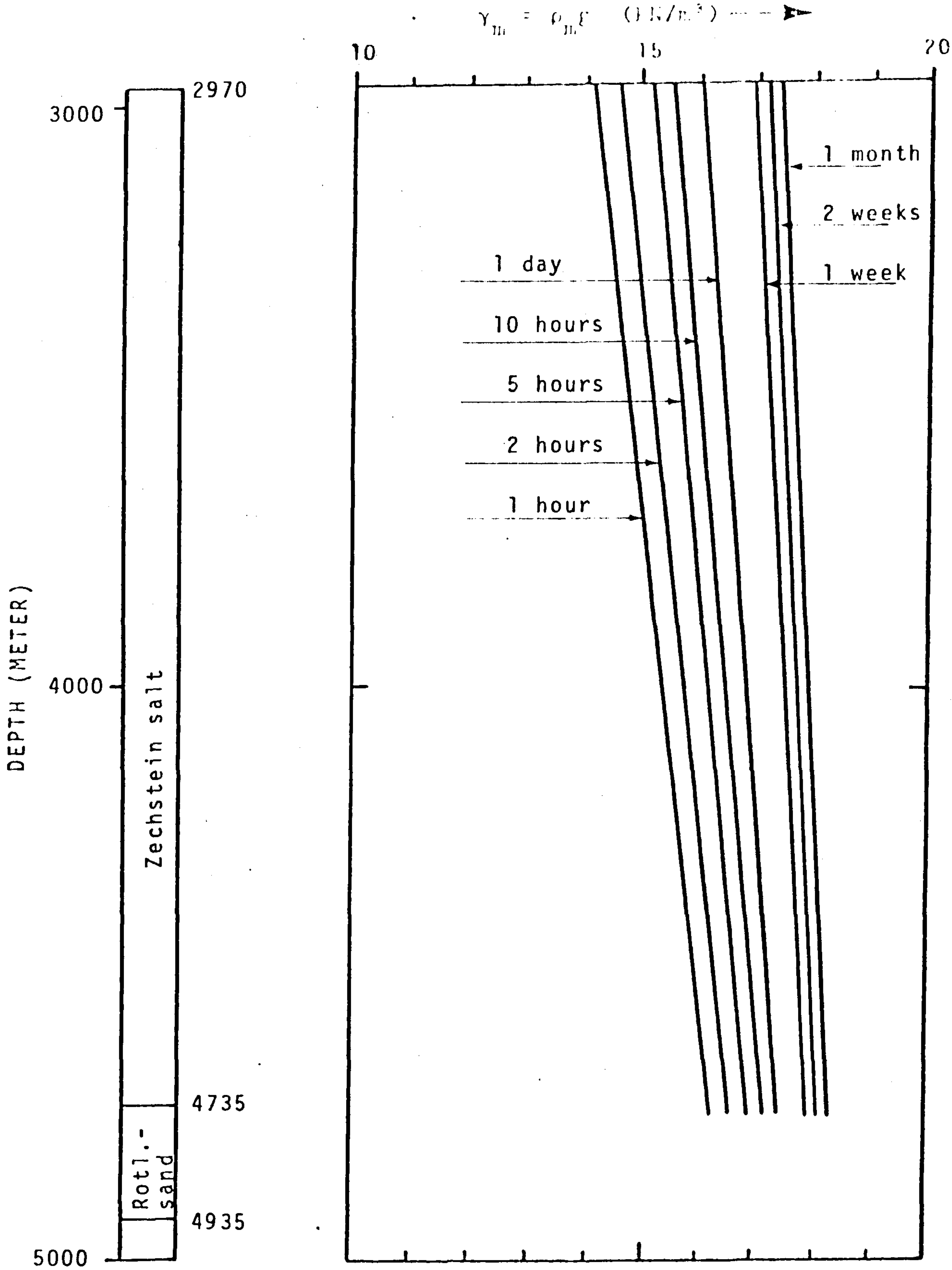
Stuck pipe has been a frequent problem in the salt. The reasons have been insufficient mudweight to control creep and the impredictable behaviour of k- and Mg-salts.

Stuck pipe has in most cases been freed by pumping pills of fresh water.

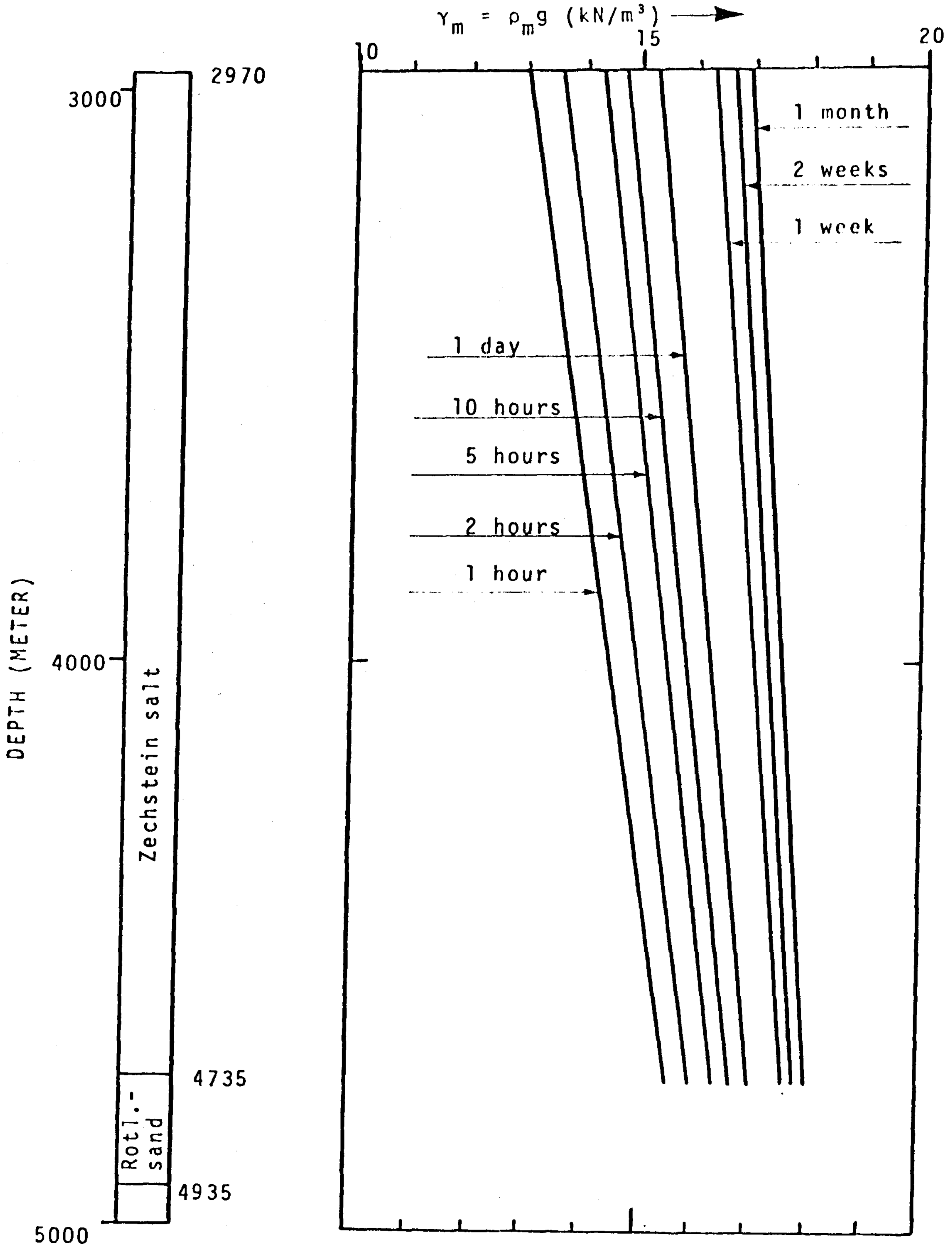
Deviation:

Another frequent problem has been deviation. The origin of the problem has been steeply dipping anhydrite bands and stringers, which are likely to occur in a salt dome. In one particular well (29/23-1 UK) it was impossible to reduce the trend with packed hole drilling assemblies or by using different combinations of stabilizers. To contain the deviation within acceptable limits the drilling weight was restricted to less than 10.000 lbs in combination with various bottom hole assemblies.

To avoid a possible deviation problem to get too far it is re-commended to run directional surveys more frequent than the regulations calls for in the upper part of the salt.



TIME-DEPENDENT BOREHOLE STABILITY	Proj. no.: 0.79.27
Time required to reduce borehole radius by 5 %	Date: Jan.-80
GEOTEKNIKK NTH Trondheim	6.3



TIME-DEPENDENT BOREHOLE STABILITY	Proj. no.: 0.79.27	
Time required to reduce borehole radius by 10 %	Date: Jan.-80	6.4
GEOTEKNIKK NTH Trondheim		

Sentral arkiv

statoil
UND-RKr/THd
24.10.80

TO: Receivers of Geological Prognosis & Drilling Program, 15/12-3 well.

Please find enclosed 6 pages with corrections of the Geological Prognosis & Drilling Program of the 15/12-3 well.

Regards,

Roar Kræmer

Sentral arkiv

statoil
UND-RKr/THd
24.10.80

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Please find enclosed 6 pages with corrections of the Geological Prognosis & Drilling Program of the 15/12-3 well.

Regards,

Roar Kræmer

Revision of drilling program, well 15/12-3

During drilling of the well, the salt has been encountered higher up than orginally expected. Because of this, the setting depth of the 9 5/8" casing will have to be altered. The new 9 5/8" casing program will be as follows:

Setting depth:		3 350m (RKB)
111-3150m	:	9 5/8", 53,5 Lb/ft, P-110, buttress
3150-3350m	:	9 5/8", 53,5 Lb/ft, mw-125, buttress
Float shoe	:	53,5 Lb/ft, P-110, buttress. Min. Collapse resistance 8250 psi (569bar)

Float collar, placed 2_jts above shoe: 53,5 Lb/ft, P-110, buttress.
Min.Collapse resistance 8250 psi (569 bar).

9 5/8" CASING CEMENT DATA AND CALCULATIONS, WELL 15/12-3

GENERAL: The cement volume is calculated on the basis of the theoretical annulus volume. The placement of DV collar is dependent on hole condition. Replace DV collar if severe washouts is indicated by the caliper log.

WELL DATA:

Depth kb-sea bed..............................:	111	m
Depth kb-last shoe............................:	2150	m
Depth kb-casing set point.....................:	3350	m
Open hole dia.................................:	12 1/4	"
Annulus capacity, cased hole..................:	30.1	l/m
Annulus capacity, open hole...................:	28.9	l/m
Internal capacity, 9 5/8" casing 53.5 lbs/ft..:	36.9	l/m
Mud weight....................................:	1.5	g/cm^3
Bottom hole hydrostatic pres. (BHHP)..........:	493	bar
Est. bottom hole static temp. (BHST)..........:	113	°C
Est. bottom hole circulating temp. (BHCT).....:	84	°C
Est. formation integrity......................:	0.196	bar/m

CEMENT SLURRY DATA, STAGE:

Two stage cementing

DV tool at 2350 m

		STAGE I	STAGE II
CEMENT SLURRY COMPOSITION		CLASS G cement + 22% A-5 by wt of seawater + 2.7 l D-19 lN/100 kg cem. + 1.0 l R-12 l/100 kg cem.	CLASS G cement + 0.9 l R-12 l/100 kg ce
Mix water	l/100 kg	43.0 seawater (without salt); 47.5 seawater + salt	43.3 fresh water
Total liquid	l/100 kg	51.2	44.2
Slurry weight	g/cm^3	1.90	1.90
Slurry yield	l/100 kg	83.0	75.7
TEST DATA @ BHCT			
Thickening time @ BHHP, hr: min		5:40 (3280 m)	3:50 (2350 m)
Crit. Turb. Flow rate: m/s (l/min)		0.41 (720)	(1.55) (2740)
Fluid loss, ml/30 min, 70 bar		330	
Crit. Plug, Flow rate: m/s (l/min)			(0.14) (242)
TEST DATA @ BHST, BHHP			
Compr. strength, bar 12 hr		253	
bar 24 hr		282	
SPECIAL TESTS			
Fann VG readings θ600, θ300, θ200, θ100		46/20/13/7	77/44/35/26
N_{RE} turb/plug		3000/100	3000/100
K/N		$2.962 \cdot 10^{-4}$/1.053	$1.136 \cdot 10^{-2}$/0.598

VOLUME CALCULATIONS (STAGE I TO 2350 m)

Annular volume: 0.0289 m^3/m x (3350-2350)m	= 28,9 m^3
24 m plug at shoe: 24 m x 0.0369 m^3/m	= 0.89 m^3
Total volume of stage I slurry	= 29,8 m^3

VOLUME CALCULATIONS (STAGE II FROM 2350 TO 2000 m)

Annular volume open hole: 0.0289 m^3/m x (2350-2150) m	= 5.78 m^3
Annular volume cased hole: 0.0301 m^3/m x (2150-2000) m	= 4.52 m^3
Total volume of stage II slurry	= 10.30 m^3

Cement slurry stage I: Class G-cement + 22% A-5 (NACL) by weight of sea water + 2.7 D-19 LN/100 kg cement + 1.0 l R-121/100 kg cement mixed with sea water at 1.90 kg/l.

35903 kg cement equivalent to 29,8 m^3 slurry.

Pump 8 m^3 fresh water bentonite mud as preflush ahead of cement. The preflush mud should have same weight as the mud in the hole. (1.50 g/cm^3)

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

Cement slurry stage II: Class G cement + 0.9 l R-12 l/100 kg cement mixed with fresh water at 1.90 kg/l
13600 kg cement equivalnet to 10.30 m^3 slurry.

Pump 8 m^3 fresh water bentonite mud as pre-flush ahead of cement. The preflush mud should have same weight as the mud in the hole.(1.5g/cm^3)

NOTE: The excess volume must be calculated from the caliper log and corrections must be done to give:

Volume of stage I slurry from 3350 m to 2350 m
Volume of stage II slurry from 2350 m to 2000 m

Jop preparation stage I

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

Required amount of seawater per 100 kg cement: = 43 l

Required amount of salt per m^3 seawater:
1.0 m^3 x 1.025 kg /l x 0.22 x 1000 l/m^3 = 225.5 kg

Total amount of seawater: 43 l/100 kg x 35903 kg = 15438 l

Amount of salt needed: $\frac{225.5 \text{ kg} \times 15{,}438 \text{ m}^3}{1.0 \text{ m}^3}$ = 3481 kg

Volume of salt: 3481 kg/2.16 kg/l = 1611 l

Volume of salt + seawater: 1611 l + 15438 l = 17049 l

Number of displacement tanks needed:

$$\frac{35903 \text{ kg} \times 51.2 \text{ l/100 kg}}{1590 \text{ l pr. tank}} = \underline{11,6}$$

Volume of premixed saltwater needed in each tank:

$$\frac{17049 \text{ l}}{11,6} = \underline{1472 \text{ l}}$$

Volume of D-19 LN needed in each displ.tank:

$$1590 \text{ l} \times \frac{2.7 \text{ l/100 kg}}{51.2 \text{ l/100 kg}} = \underline{83.8 \text{ l}}$$

Volume of R-12 l needed in each displ.tank:

$$1590 \text{ l} \times \frac{1.0 \text{ l/100 kg}}{51.2 \text{ l/100 kg}} = \underline{31.0 \text{ l}}$$

<u>Jop preparation stage II</u>

Total liquid stage II slurry: 13600 kg x 44.2 l/100 kg = <u>6011 l</u>

Volume of R-12L needed in each displ.tank:

$$1590 \text{ l} \times \frac{0.9 \text{ l/100 kg}}{44.2 \text{ l/100 kg}} = \underline{32.4 \text{ l}}$$

Total volume of of R-12L needed: (stage 1 and 2).
35903 kg x 1.0 l/100 kg + 13600 kg x 0.9 l/100 kg = <u>481 l</u>

Total volume of D-19LN needed: (Stage 1 and 2)
35903 kg/ x 2.7 l/100 kg = <u>969 l</u>

Hydrostatic pressure calculations

Hydrostatic head from cement slurrys: 0.186 bar/m x (3358-2000) m	=	251	bar
Hydrostatic head from mud: 0.147 bar/m x 2000 m	=	294	bar
Total hydrostatic pressure at 9 5/8" shoe	=	545	bar
Equivalent pressure gradient at 9 5/8" shoe: 545 bar/ 3350 m	=	0.162	bar/
Estimated formation integrity at 9 5/8" shoe:	=	0.196	bar/
Equivalent pressure gradient at 13 3/8" shoe: 322 bar/2150 m	=	0.149	bar/
" " " 2490m : 385 bar/2490m	=	0.154	bar/m