statoil

STATOIL

GEOLOGICAL PROGNOSIS, PRESSURE PREDICTION & DRILLING PROGRAM

WELL 15/9-18

SIGMA, WILDCAT

Den norske stats oljeselskap a.s

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& DRILLING PROGRAM

WELL 15/9-18

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WELL 15/9-18
CONTENT

Program Responsibility:
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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.	15/9-18, Wildcat
PROSPECT (field)	Sigma

General Data:

LOCATION

Country	Norway
Area	North Sea
Licence No.	046
Block No.	15/9

Coordinates 58° 21' 01.6" N, 01° 48' 11.8" E.

Seismic: Shotpoint No. 636 Row No. ST 8215-122

16.5	Km	south	of	north Block Boundary
12	Km	west	of	east Block Boundary
223	Km	from Norwegian coast, "Jærens Rev"		
15	km	from N/UK median line		
3	Km	NNE	of nearest well 15/9-10	
4	km	S	of well 15/9-8	

WATER DEPTH 100 Meters (MSL)

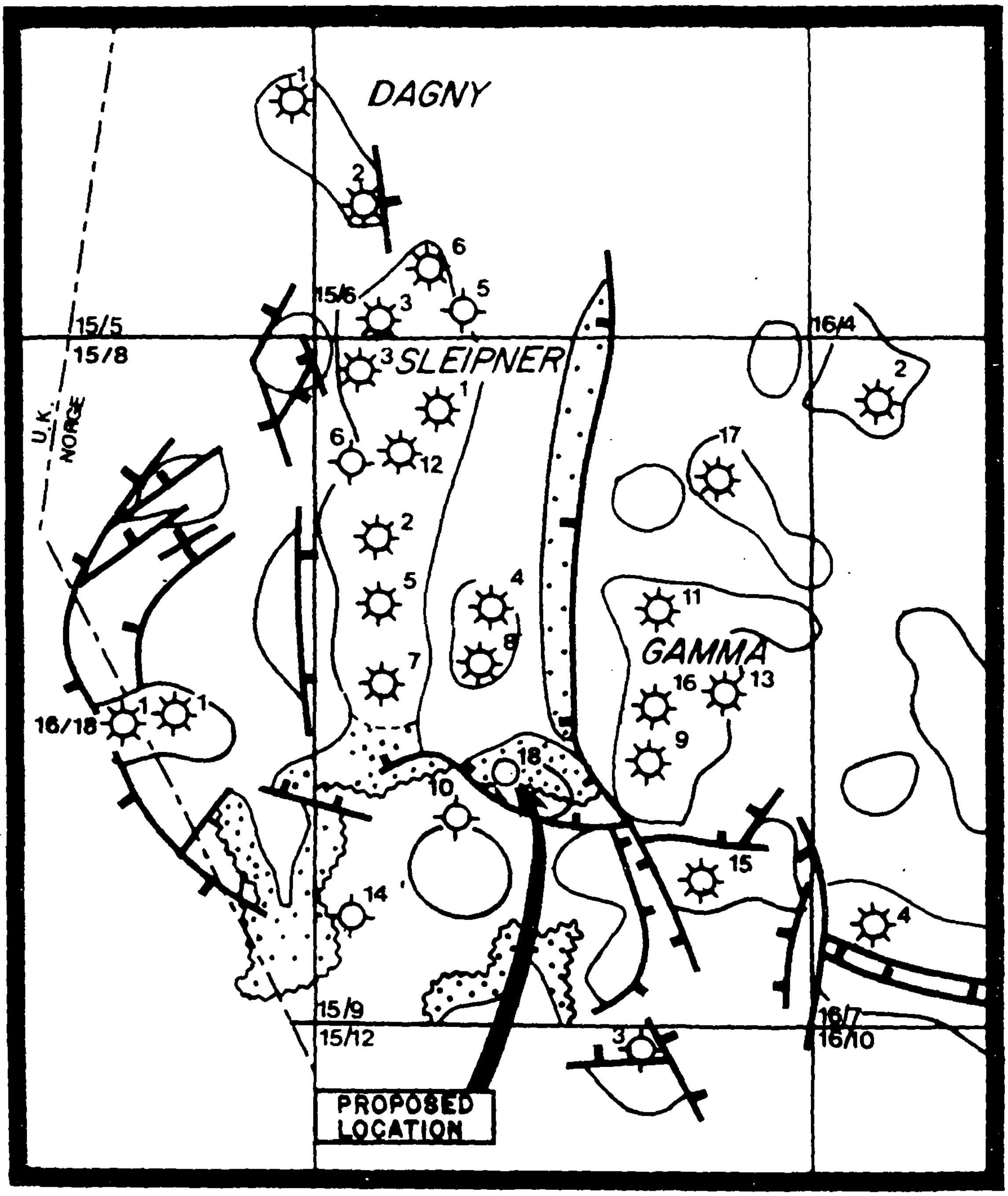
K.B.E. 23 Meters

PROJECTED TOTAL DEPTH 3700 Meters (RKB)

CONTRACTORS

Drilling platform	"Deepsea Bergen"
Drilling Contractor	Odfjell Drilling and cons. Co.
Mudlogging Contractor	Exploration Logging
Type Logging unit	Exlog unit (Gemdas)
Electric Logging Contractor	Dresser Atlas
Mud Contractor	NPS
Cement Contractor	Halliburton
Rig positioning Contractor	Decca / Geoteam
Bottom Survey Contractor	Odin Survey
Helicopter Service	Helikopter Service
Supply Boats	From Statoil "Supply boat pool"
Standby Boat	Geo Boy
Core analysis	GECO (& Corelab)

SLEIPNER AREA



INTRODUCTION

The 15/9-18 well is located on the Sigma prospect. Sigma is a combined stratigraphical and structural prospect which is located to the south of the Sleipner Field. This well proposal is based upon the interpretation of the 1982 3-D data in the block.

The 3-D interpretation of the Sleipner Field does not show any obvious structural closure of the field (ε-structure) to the south. Additionally all the GWC's in the wells on the Sleipner Field favour a migration route from the South Viking Graben, through the block 15/8 (well 15/8-1) into the 15/9 block northwards through the ε-structure (fig. 2). These facts together with the dry 15/9-10 well have led to the conclusion that a stratigraphical closure is possible in the area immediately south of the Sleipner Field.

The intentions behind the Sigma well are:

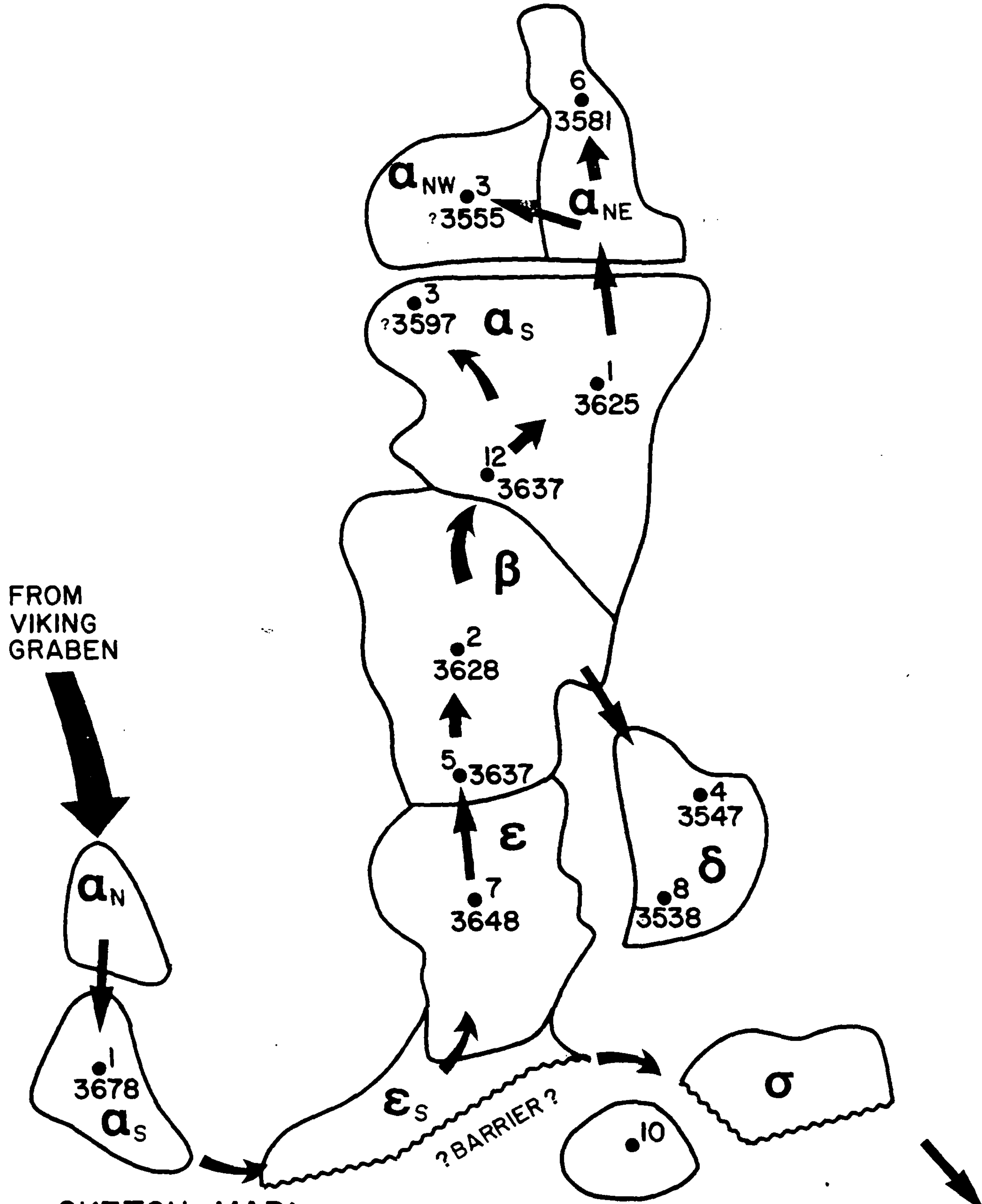
- To drill a stratigraphical prospect overlying a small structural closure, to test the validity of stratigraphical traps in the southern part of the Sleipner Terrace.

- To fulfil the work program of the licence.

Additionally information will be:

- To test a possible migration route.

- To penetrate sediments giving rise to a previously undrilled doublet reflector on the seismic sections which will be of importance for further interpretation and correlation in the southern part of the 15/9-block.



SKETCH MAP:
SLEIPNER TERRACE; POSTULATED MIGRATION ROUTE.
GWC in meter MSL depth.

FIG. 2

PURPOSE OF TEST AND OBJECTIVES

The well is designed to test possible hydrocarbon accumulation in potential sandstones of Paleocene, Middle Jurassic, (Callovian) and Triassic age.

The primary objective of the 15/9-Sigma well is Callovian sandstone of the Hugin Formation. Secondary objectives are Paleocene sandstone of the Heimdal Formation and Sleipner Formation/Triassic sandstones.

The well will be drilled to an estimated depth of 3700 m (RKB).

DRILLING HAZARDS

According to the preliminary results of the site survey the water-depth at the drilling location is approximately 100 m.

The side scan sonar show a typical North Sea sandy seafloor free from man made debris.

The sparker records show that at the proposed location there is 7 m of medium dense recent sand and/or silty and clayed sand. At 200 m RKB the records show a prominent glacial surface. Between the upper sand layer and this glacial surface, there is a sequence of poorly stratified glaciomarine clay, sand and silt. At, or immediately above the glacial surface, it is possible to find sand and glacial till.

At approximately 620 - 645 m RKB there is a strong reflector, probably associated with heavily overconsolidated clay, immediately below this strong reflector there are high amplitude reflections that might be associated with gas. It is recommended to take precautions when drilling this section.

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 of the proposed location on s.p. 636 of 3-D seismic Row ST8215-122.

STRATIGRAPHIC PROGNOSIS

UNIT	DEPTH (m RKB)
Top Pliocene	640 ± 20
Top Utsira Fm	870 + 30
Top Frigg Fm	2070 ± 40
Top Balder Fm	2325 + 30
Top Sele Fm	2375 ± 30
Topp Heimdal Fm	2630 ± 30
Top Ekofisk Fm	2730 ± 20
Top Plenus Marl Fm	2950 + 30
Top Sola Fm	3050 ± 30
Top Draupne Fm	3160 ± 30
Top Hugin Fm	3230 ± 40
Top Sleipner Fm	3360 ± 40
Top Triassic	3415 ± 40
T.D.	3700

GENERAL LITHOLOGY

Tertiary

The sediments of the Nordland Group is dominated by medium grey, soft clay with the exception of the Utsira Formation which consists of loose, fine to very fine sand interbedded with thin layers of clay/claystone. Some fine to coarse sand occures in the Quaternary section in the upper part of the group.

The Hordaland Group consists mainly of medium to brownish grey claystone interbedded with some siltstone, limestone and sandstone. The sandstone occures mainly in the Marstein Formation and the Frigg Formation. At the base of the group the limestone content increases.

The Rogaland Group is dominated by both sandstone and shale.

The Balder Formation consists of varicoloured tuffaceous shale interbedded with some limestone streaks. The Sele and Lista Formations are dominated by medium to dark grey shale. Both the Heimdal Formation and Maureen Formation consist of fine to medium occasionally coarse sandstone interbedded with layers of shale and some limestone streaks.

Cretaceous

The Upper Cretaceous section consists of chalk and limestone with an increasing amount of marl at the base of the section.

The Lower Cretaceous is dominated by marl interbedded with some limestone and shale.

Jurassic

The Draupne Formation is dominated by dark grey to brown to black carbonaceous claystone/shale. The Heather Formation consists of dark grey shale interbedded with streaks of limestone. The Hugin Formation is expected to be represented by very fine to medium sandstone interbedded by some shale and minor amounts of coal. The shale content is expected to increase downwards.

The Sleipner Formation is mainly composed of coal interbedded with shale and minor amounts of siltstone/sandstone.

Triassic

The Triassic is expected to be sandstone (Skagerrak Formation) in the upper part with the possibility of red shale in the lowermost part of the section (Smith Bank Formation).

GEOLOGICAL WELL LOGGING AND SAMPLING PROSEDURES

Mud logging contractor is Exploration Logging.
A Gemdas-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 meters intervals down to 2000 meters. Thereafter at 3 meters intervals. Sampling intervals might be changed on request by the wellsite geologist.

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

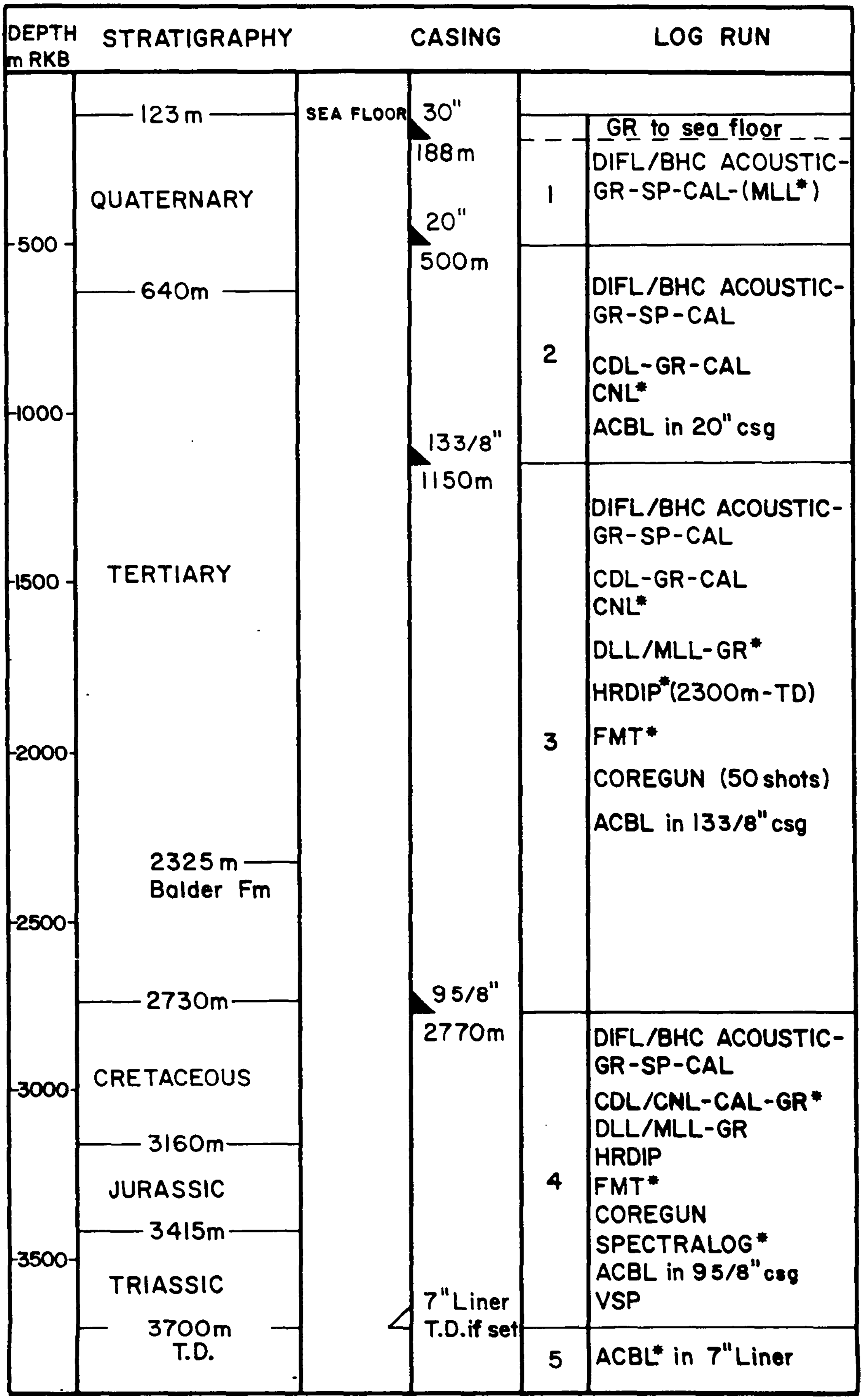
Five sets of unwashed samples (½ kg) will be collected at each interval.

One composite sample of unwashed cuttings will be canned at 30 meters intervals down to 3000 m. Thereafter at 15 meters intervals. Each can should be 3/4 filled and covered with water and a full dropper of bactericide, leaving a 2 - 3 cm air space. The cans should be stored inverted.

One or more mudsamples of 3 litres will be collected from the active pits when drilling through any hydrocarbon bearing interval. The number of samples will be at the discretion of the wellsite geologist. The sample should be properly marked with depth and sent to Statoil Laboratories, Forus.

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.

WELL LOGGING PROGRAM 15/9-18



COMPANY: DRESSER ATLAS *OPTIONAL

CORING PROGRAM

A minimum of one core will be cut both in Paleocene and Middle Jurassic/Triassic sandstones, additional cores will be cut if significant hydrocarbon shows are encountered. Attempts to core the Upper Jurassic shale - Middle Jurassic sand transition will be made. The coring points, and the number of cores to be cut, will be at the discretion of the wellsite geologist, subject to review by the operation geologist.

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

TESTING PROGRAM

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

BASE

Statoil operations base at Dusavik will be utilized for the drilling of this well.

RESPONSIBILITY

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 advised by a Drilling Engineer and a Wellsite Geologist. The Drilling Supervisor will report to the Statoil Drilling Superintendent.

b) 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 be responsible for that the electrical logs are run properly and are of acceptable standard. He will recommend coring intervals. The Wellsite Geologist will report to the Statoil Operations Geologist.

c) Logging and Testing Engineer

The Wellsite Logging/Testing Engineer will assist the Drilling Supervisor 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 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.

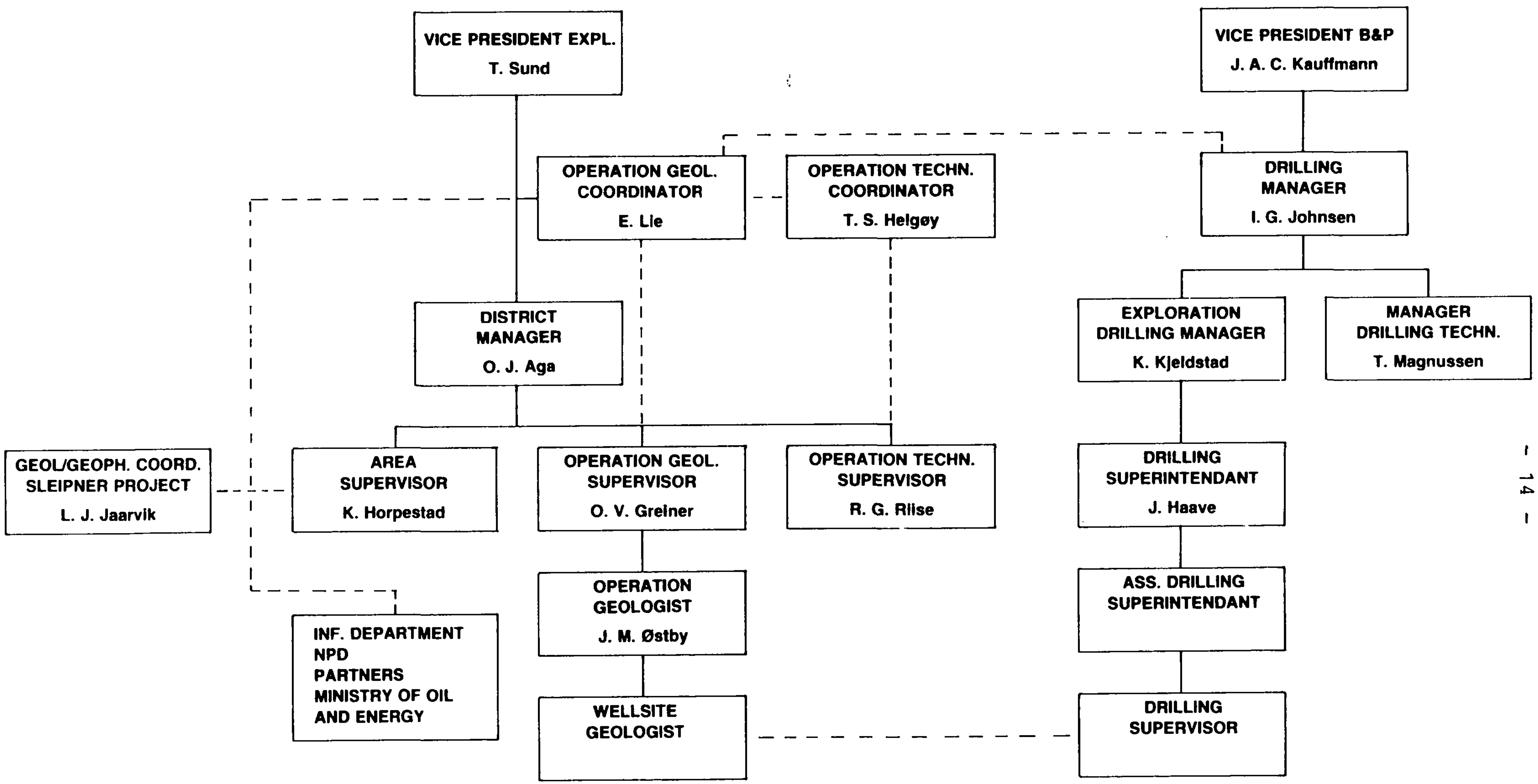
A final well report will be prepared for distribution to partners and to the appropriate Norwegian Government agencies not later than six months after completion of the well.

STAFF

Staff of the Exploration and Drilling Department, Statoil, who are involved in the planning and drilling of the well:

NAME	TITLE	TELEPHONE OFFICE (area code 04)	TELEPHONE HOME (area code 04)	MOBIL 097
Sund, T.	Exploration Manager	578178	560235	
Johnsen, I.	Drilling Manager	541099	576125	
Kjeldstad, K.	Exploration Drlg. Mngr.	541099	591437	
Haave, J.	Drlg. Superintendent	541099	558139	
Helgøy, T.S.	Oper. Coord. Op.Techn.	577297	661757	
Lie, E.	Oper. Coord. Geol.	578162	620918	57916
Aga, O.J.	District Manager	533180	534739	
Horpestad, K.	Area Supervisor	533180	591400	
Riise, R.G.	Oper.Techn.Supervisor	533180	591401	
Greiner, O.V.	Oper.Geol.Supervisor	533180	677816	57910
Østby, J.M.	Oper. Geologist	533180	575767	64911
Jaarvik, L.J.	Geol/Geoph Coord Sleipner	578157	665206	

ORGANIZATION CHART WELL 15/9-18



COMMUNICATION PERSONNEL, 15/9-18

Esso Exploration and Production Norway Inc.

NAME	TITLE	TELEPHONE OFFICE	HOME	NIGHT
Hedberg, J.D.	Expl. Manager	04-606060	04-556074	04-528549
Gist, A.N.	Operation Manager	04-606060	04-587084	04-528553
Thomas, J.	Chief Geologist	04-606060	04-560729	
MacduffDuncan,C.R.	Oper.Geol.Manager	04-606060	04-550100	

Norsk Hydro Produksjon A/S:

NAME	TITLE	TELEPHONE OFFICE	HOME	MOBIL
Oppebøen, K.A.	Exploration Manager	02-543920	02-170206	16274
Sæbøe, A.	Area Coordinator	02-543920	02-543805	
Leivestad, S.I.	Oper.Geol. Manager	02-543920	02-121546	

Contact in Norwegian Petroleum Directorate:

NAME	TITLE	TELEPHONE OFFICE	HOME	MOBIL
Lysholm, S.		04-533160		

PORE PRESSURE AND OVERBURDEN/FRACTURE GRADIENT PREDICTION

Overburden gradient

The overburden gradient is based on bulk densities taken from well 15/9-8, (see figure).

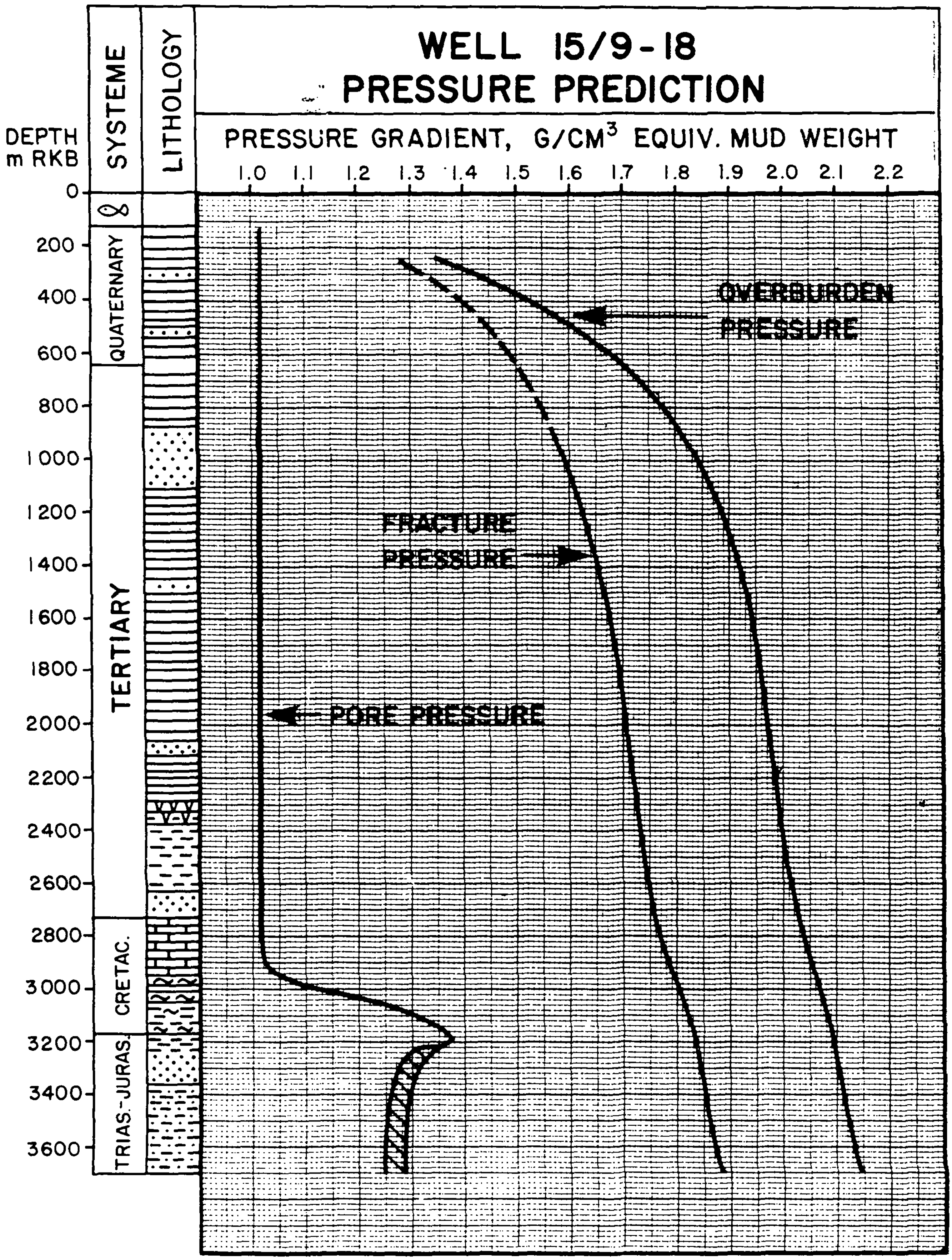
Pore pressure

The Quaternary and Tertiary Sections are expected to be normally pressured. Based on RFT data from well 15/9-10, the pore pressure is assumed to be 1.02 g/cc at 2630 m RKB (top Heimdal Fm.).

A pore pressure increase is expected through the lower Cretaceous shales. The pressure will reach its maximum at the top of Upper Jurassic, and it will probably be equivalent to 1.35 - 1.40 g/cc. By assuming pressure communication with 15/9-7, the pore pressure is estimated to be between 1.30 g/cc and 1.34 g/cc at the top of the reservoir at 3230 m RKB depending on the height of the gas column.

Fracture gradient

A theoretical fracture gradient has been calculated for this well. This gradient has been adjusted in the Quaternary and Upper Tertiary to match the leak off tests from 15/9-7 and 15/9-8 better. Otherwise the theoretical calculations fit well with the leak-offs reported for the correlation wells.


WELL 15/9-18
PRESSURE PREDICTION
PRESSURE GRADIENT, G/CM3 EQUIV. 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
DEPTH m RKB
SYSTEME
LITHOLOGY
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
QUATERNARY
TERTIARY
CRETAC.
TRIAS.-JURAS.
OVERBURDEN PRESSURE
FRACTURE PRESSURE
PORE PRESSURE

DRILLING PROGRAM

Well designation	:	15/9-18
Vessel	:	Deep Sea Bergen
Type drilling rig	:	Aker H-3.2
Drilling draft	:	22 m maximum
RKB to MSL	:	23 m
Air gap	:	15.2 m
Water depth	:	100 m
BOP system	:	NL-Schaffer 18-3/4", 690 bar W.P, (10 000 psi) stack
Wellhead system	:	Vetco 18-3/4", 690 bar W.P, (10 000 psi), 3 hanger torque set system

Depths are referred to RKB except were otherwise specified. The first following pages refers to Statoil's "Floating Drilling Operations Manual" and should be used as additional information.

2.0 General procedure

2.1.1. Location survey

The sparker records from 200 m RKB shows a prominent glacial surface. At, or immediately above this surface, it is possible to find sand and glacial till.

At approximately 620 - 645 m RKB there is a strong reflector, probably associated with heavily overconsolidated clay, that might be associated with gas. It is recommended to take precautions when drilling this section.

Further details; see page 5 in Geological prognosis.

2.2.1. Mooring

As per general procedure. Rig heading 315 DEG.

3.0 General drilling

- Drill 36" hole with 26" x 36" H.O. to ± 188 m. Space out so that top of 30" housing will be positioned approx. 1.5 m above the sea bed. Do not use temporary guide base, stab 30" casing blind.

- Drill out cmt + shoe w/26" bit. Run riser w/pin connector and attach diverter. Drill 12 1/4" pilothole to 520 m and log. The hole will be opened to 26" using underreamer or holeopener after having evaluated the possibility of the presence of gasbearing sands (see drilling considerations). 20" casing will be set at 500 m.

- Run BOP and test according to chapter 4.4.1. Drill 17½" hole to 1165 m, log and set 13 3/8" casing at 1150 m. This depth should be adjusted to be approx. 40 m below Utsira Sand.

- Drill 12 1/4" hole with rockbit to approximately 50 m into Ekofisk Chalk Formation. Core as required. Log as programmed. Set 9 5/8" casing with 15 m rathole.

- Drill 8½" hole to T.D. at 3700 m. Core as required. Log as programmed. The limestone/chalk will be drilled using a turbine.

- If it is decided to test the Jurassic sandstone, a 7" liner will be run through the test interval w/150 m overlap in 9 5/8" casing.

Drilling considerations

3.1.1. 36" hole

After cementing casing, check bulls eye indicator on PGB. If angle is more than 1½° off, consult with operations office before proceeding.

3.2.1. Drilling pilot hole and logging

Prior to drilling out 30" shoe, there should always be 50 m^3 1.23 S.G. mud in reserve pit.

In order to obtain the desired formation integrity, the 20" casing should be set at approx 500 m.

Check regularly the density of return mud to prevent the annulus from overloading and breaking down the formation.

While drilling the 12 1/4" pilot hole, all the drilling data should be carefully observed and interpreted. Indication of shallow gas sands may dictate intermediate logging.

Before deciding how to enlarge the 12 1/4" pilot hole, all the drilling data and logs should be carfully reviewed and discussed with the operations office.

If the presence of gas bearing sands cannot be excluded, the hole should be underreamed.

If it is decided to enlarge the hole with a holeopener, the procedure will be as follows:

- Displace the hole with sea water in three steps.

- Check for flow after each step.

- Displace the hole from TD to wellhead with mud.

- Pull the riser.

When pulling the riser, the hydrostatic pressure in the hole should exceed the minimum pressure the hole earlier has been exposed to with sufficient safety margin over any possible gas bearing sand.

<u>3.2.5. Running 20" casing and cementing:</u>

Fill 20" casing every joint after shoe has reached sealevel. After 1st stand of landing string has been run, attach circulation head and fill 20" casing and landing string. Make sure not to exceed the pressure necessary to release sub sea plug. The landing string shall be filled every second stand using the mudhose. 20" casing shoe will be set at 500 m.

<u>3.4.1. Drilling 17 1/2", 12 1/4" and 8 1/2" hole:</u>

<u>17½" hole: 515-1165 m</u>

The pore pressure is expected to be normal.

<u>Remarks</u>

- For information on well control see "KICK PROCEDURE".
- When drilling this section, there should always be $70m^3$ 1.25 S.G. mud in reserve.

12 1/4" hole: 1165-2785 m

The pore pressure is expected to be normal through this section. The 9 5/8"casing will be set after drilling 50m into Ekofisk fm, approximately at 2770 m. Secondary objective is sandstone of Paleocene age. On previous wells on the 15/9 block, tight hole has been experienced down to 2300 - 2400 m. These problems seem to be caused by swelling clays and possibly differential sticking. To reduce the problems, mud weight should be kept at a minimum and a thin filter cake maintained. The hole is expected to stabilize after a few wiper trips.

8½" hole: 2785-3700 m

A pore pressure increase is expected through the lower Cretaceous shales. The porepressure is expected to increase to 1.35-1.4 S.G. at the top of upper Jurassic. (approx. 3180 m). The porepressure at the top of the reservoir is expected to be equivalent to 1.3-1.34 S.G. The GWC is estimated to be at 3345 m with a pore pressure of approx, 1.26-1.3 S.G. At T.D. the pressure declines to approx. 1.25-1.3 S.G.

For information on maximum kick sizes that can be taken before breaking down formation, see "kick limitations".

The predicted pore pressure of 15/9-18 structure is based on the result from 15/9-7, 8 and 10.

Directional survey program

Directional surveys will be run every 100 m after setting the 20" casing.

4.0 MUD PROGRAM 15/9-18

Interval M RKB	Hole size	Mud type	Weight (g/cm^3)	PV	YP	HTHP w.1	pH
123-188	36"	Spud mud					
188-515	26"	Spud mud					
515-1165	17½"	* Gyp/Ligno	1.1	As low	20-25	API: 10-15	9.5-10.3
1165-2785	12 1/4"	* Gyp/ligno	1.1-1.2	as possible	15-20	API: 5-10	9.5-10.3
2785-3700	8½"	Gel/ligno	1.2-1.42		12-15	HTHP below 15	9.5-10.5

REMARKS:
- Rheology properties will be tested and reported at 50^0. 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 cleaner (150-120 mesh screens).
- Utilize the centrifuge for viscosity control and for barite salvage.
- See separate Mud program for details

* optional Gyp/Polymer

4.4.1. BOP TESTING

BOP test pressures:	Pipe rams	Bags	Choke and kill valves
1. On surface	690bar	241bar	690 bar
2a Initial and subsequent installation on wellhead	380bar	241bar	380bar
Close shear ram with the accoustic system and test shear ram against casing.			
2b Weekly test with 20" casing set	60bar	60bar	60bar
3a After 13 3/8" seal assembly is tested with no leak	172bar	172bar	172bar
3b Weekly test with 13 3/8" casing set	172bar	172bar	172bar
4a After 9 5/8" seal assembly is tested	380bar	241bar	380bar
4b Weekly test with 9 5/8" casing set	380bar	241bar	380bar
5. Weekly test with 7" liner set	330bar	241bar	330bar

Shear ram will be tested to 690 bar on surface. After BOP is mounted on wellhead, it will only be tested when testing casings.

NOTE: - If the BOP stack must be pulled after initial installation:

a) Pressure test on surface acc. to pt. 1. above.
b) Pressure test after reinstallation acc. to pt. 2a above. During this test, if 13 3/8" csg is set, observe pressure and volume pumped carefully to ensure that the seal assembly is not leaking.

- For more information on BOP testing, refer to general procedures in Statoils Floating Drilling Operation Manual.

Casing and seal assembly test pressure (see note below)

20" casing	-	60 bar
13 3/8" casing	-	172 bar
9 5/8" casing	-	380 bar
7" liner	-	330 bar

The given test pressure should be the pressure measured at surface.

NOTE: - When testing casing: If cement has been brought up inside the previous casing shoe, observe pressure and volume pumped carefully to ensure that the seal assembly is not leaking.

Safety factors:	Collapse:	Burst:	Tension:
20"	1.30	1.18	1.5
13 3/8"	1.30	1.18	1.5
9 5/8"	1.25	1.18	1.5
7"	1.25	1.18	1.5

CASING PROGRAM

SIZE	DEPTH	WEIGHT	GRADE	CONNECTION
30".	123 - 188	1jnt 1.5"wt.	B	Vetco ATD/RB
		4jnt 1" wt	B	" " "
20"	123 - 500	94	X-56	Vetco LS
13 3/8"	123 - 1150	68	K-55	Buttress
9 5/8"	123 - 2300	47	N-80	Buttress
	2300- 2770	47	P-110	"
7"+	2620 - 3700	29	N-80	Buttress

See "Casing Design"
+ optional.

4.8.1. 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" casing shoe to collect and monitor abnormal pressure parameters. This unit will be programmed to record the following parameters relating to abnormal pressure:

1. Mud weight
2. Drilling rate
3. Weight on bit
4. RPM
5. Torque
6. "d" exponent
7. Mud gas
   a) Background gas
   b) Connection gas
   c) Trip gas
8. Mud temperature at flowline
9. Mud flow
10. Pit volume

In addition, shale density and chloride content in the mud will be measured manually.

Manual plots will be recorded and reviewed continuously by the Drilling Engineer and Drilling Supervisor. These plots will include drilling rate, lithology, mud weight, weight on bit, "d" exp., gas units, mud temperature and shale density, together with bit and hydraulics data.

Input parameters (weight on bit,RPM,hydraulics) should be held fairly constant. This is especially important in the pressure transition zone. Abnormal pressure detection data will be forwarded to the Stavanger Operation Office twice daily on 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 Operation Office.

4.9.1. Formation evaluation:

The mud returns will be monitiored continuously to detect H_2S. Also check the hole for H_2S-content in 100 m intervals below 2100m (or when background gas exceeds 1%) by means of Garret Gas Train (use fresh filtrate from the filter press only).

A detailed testing program will be issued prior to test.

4.11.1 Plug and Abandonment:

A detailed P and A program will be issued prior to P and A.

Approved

Vice President Expl.
Statoil

Drilling Manager Statoil

KICK LIMITATION

Drilling below 20" casing:

The general procedure is: Not to shut in a well with only 20" casing set. Consult with the operations office on permission to close the BOP after the leak off test is finished. Maximum porepressure is expected to be 1.02 S.G. in this interval. Formation integrity below 20" casing shoe is expected to be 1.45 S.G. A mud weight of 1.10 S.G. should be sufficient to control the well. If the well kicks at 1165m (p.p. = 1.10 S.G.) a kick height of approx 160 m can be controlled by closing the BOP. (See fig. 1). This is equal to a volume of 19 m^3 influx.

Drilling below 13 3/8" casing:

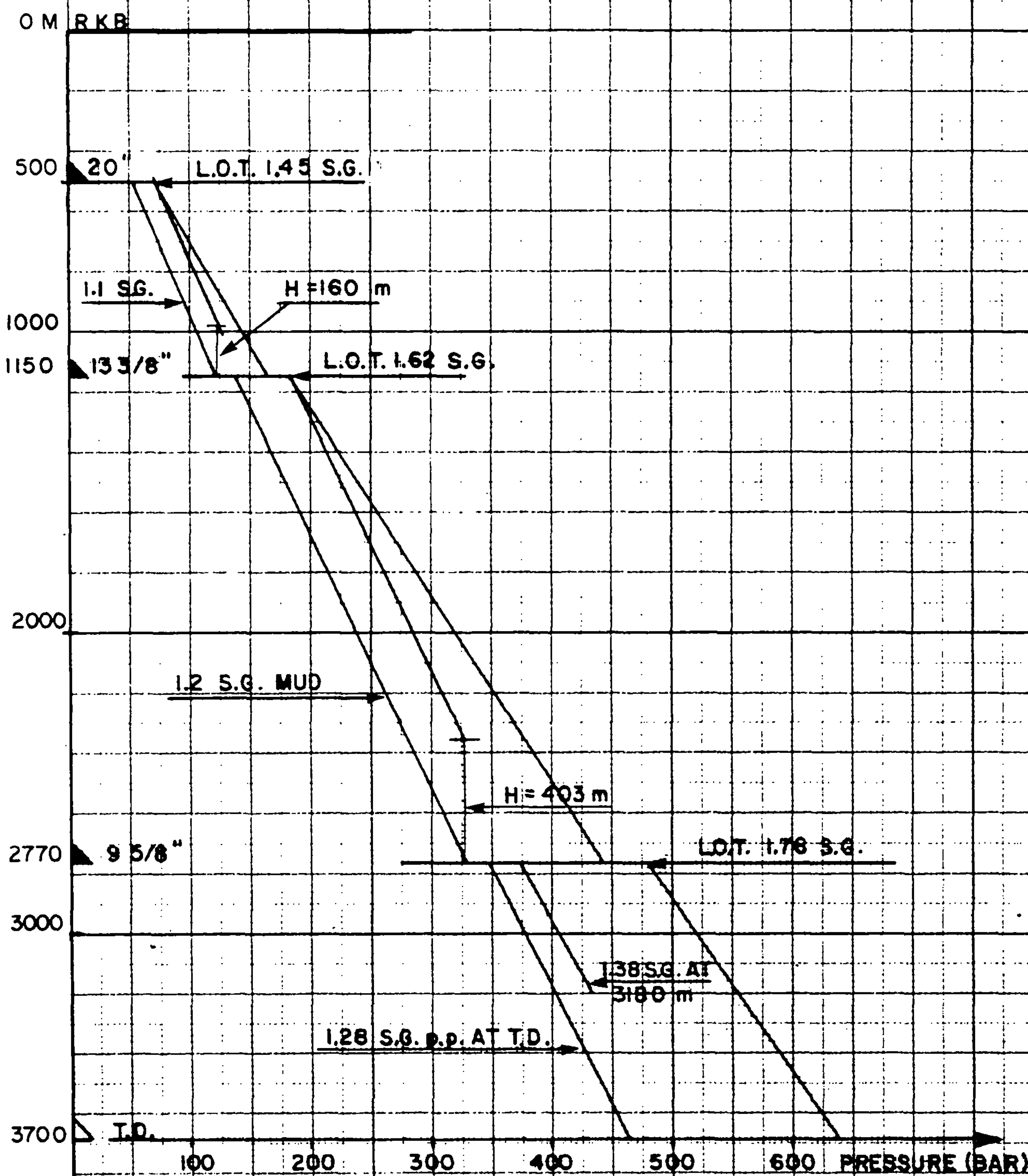
Formation integrity below the 13 3/8" casing shoe is expected to be 1.62 S.G. The maximum considered porepressure is 1.02 S.G. in this interval. If the well kicks with a mud weight and porepressure of 1.20 S.G. at 2785m, a kick height of 403 m can be controlled by closed BOP. (See fig. 1). This is equal to a volume of 22.4m^3 influx.

Drilling below 9 5/8" casing:

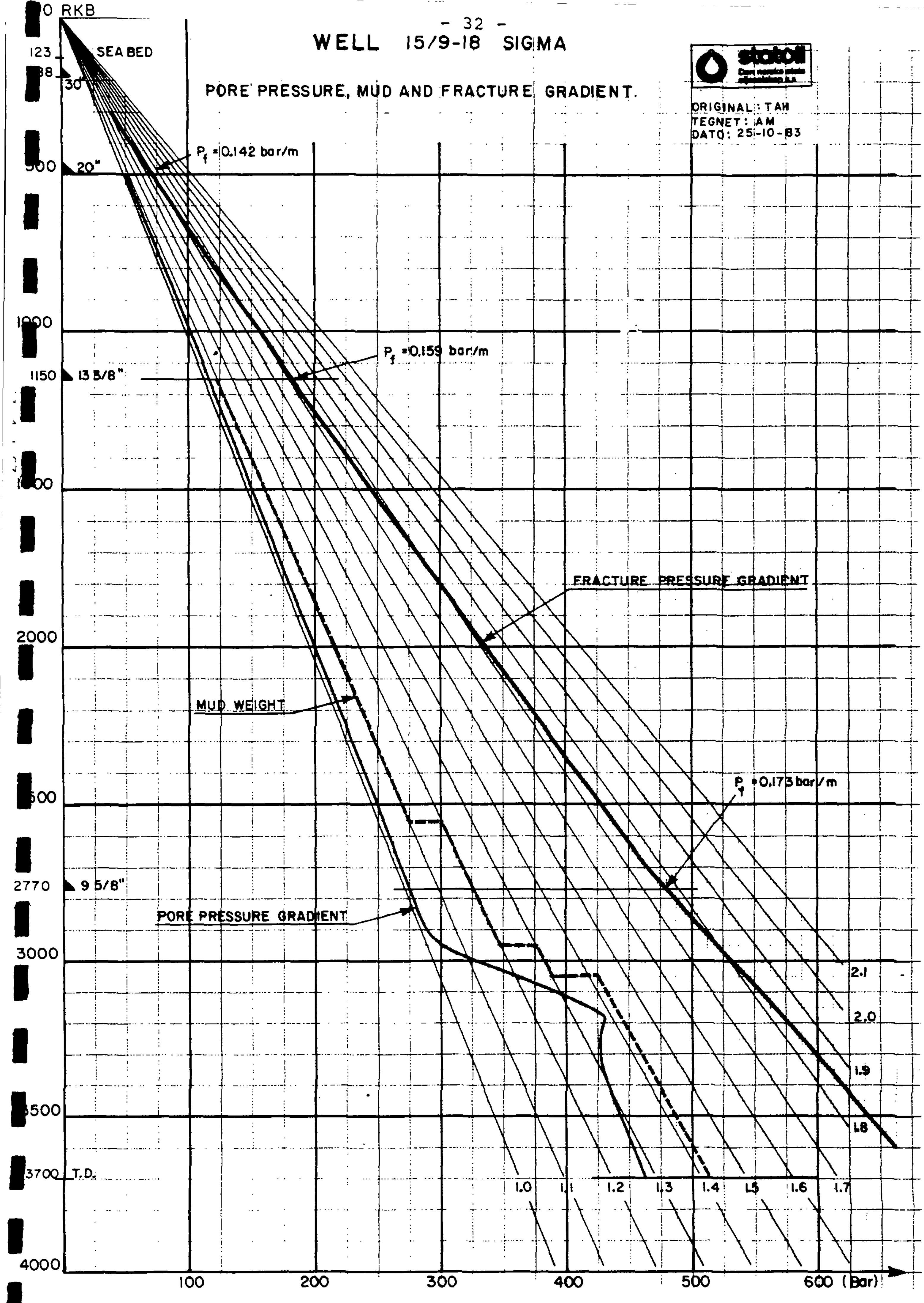
Formation integrity below the 9 5/8" shoe at 2770 m is estimated to be 1.76 S.G. The maximum porepressure gradient while drilling is expected to be 1.38 S.G. at 3180m. Necessary riser margin with additional 7 bars at this depth is 0.05 g/cm^3. A mudweight of 1.42 S.G. should be sufficient to control the well.

If the well kicks at 3180 m with a porepressure equivalent to 1.38 S.G. or at T.D. with a porepressure of 1.28 S.G., there is no limit for the kickheight (see fig. 1.)

KICK LIMITATIONS 15/9 - 18



ORIGINAL: TAH
TEGNET: AM
DATO: 1-11-83


WELL 15/9-18 SIGMA
PORE PRESSURE, MUD AND FRACTURE GRADIENT.
statoil
ORIGINAL: TAH
TEGNET: AM
DATO: 25-10-83
0 RKB
123 SEA BED
188 30"
500 20"
1000
1150 13 3/8"
1500
2000
2500
2770 9 5/8"
3000
3500
3700 T.D.
4000
P_f = 0.142 bar/m
P_f = 0.159 bar/m
P_f = 0.173 bar/m
FRACTURE PRESSURE GRADIENT
MUD WEIGHT
PORE PRESSURE GRADIENT
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
100
200
300
400
500
600 (Bar)

Nomenclature

X	= Casing setting depth (m)
W_D	= Drilling depth below X (m)
Z	= Depth from RKB to seabed (m)
Z_1	= Water depth (m)
G_i	= Mud gradient when cementing casing (bar/m)
G'_i	= Mud gradient at W_D (bar/m)
G''_i	= Mud gradient while testing (bar/m)
G_p	= Normal pore pressure gradient (bar/m)
G'_p	= Pore pressure gradient at reservoir depth (bar/m)
G''_p	= Pore pressure gradient at W_D (bar/m)
G_f	= Fracture gradient at casing seat (bar/m)
G_{gas}	= Gas gradient (bar/m)
L	= Lenght from shoe to float collar (m)
G_{c1}	= Lead cement slurry gradient (bar/m)
G_{c2}	= Tail in cement slurry gradient (bar/m)
M_c	= Casing mass gradient (kg/m)
P_B	= Burst load (bar)
P_C	= Collapse load (bar)
T	= Tension load (tons)
RES_B	= Burst resistance (bar)
RES_C	= Collapse resistance (bar)
RES_T	= Tensile resistance (tons)
$S.F._B$	= Safety factor, burst = 1.18
$S.F._C$	= Safety factor, collapse = 1.25 (1.3 for 13 3/8" and larger
$S.F._T$	= Safety factor, tension = 1.5

20" Casing Design 15/9-18

X =	500 m	G_f =	0,142 bar/m
W_D =	1 165 m	G_i =	0,108 bar/m
Z =	123 m	G'_i =	0,108 bar/m
Z_1 =	100 m	G_{gas} =	0.01 bar/m
L =	12 m	G_{c1} =	0,153 bar/m
G_p =	0,1 bar/m	G_{c2} =	0,187 bar/m

Design Criteria:

BURST : Entire casing filled with light gas.

COLLAPSE : Collapse load during cementing.

TENSION : Tension load when bumping plug.

Calculations:

BURST:

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

$$P_{B1} = X \times G_f - (X - Z)G_{gas} - Z_1 \times G_p$$
$$= 500 \times 0{,}142 - (500 - 123) \times 0{,}01 - 100 \times 0{,}10 = \underline{57.3 \text{ bar}}$$

Burst load at casing shoe, when pressure testing casing to 60 bar.

$$P_{B2} = 60 + X \times G_i - (X-Z+Z_1)G_p =$$

$$60 + 500 \times 0.108 - (500 - 23) \times 0.1 = \underline{66.3 \text{ bar}}$$

COLLAPSE:

Maximum collapse load at float collar depth during cementing
Volume of tail in slurry is : 10 m^3
Inside 20 casing : L = 12 m eq. to 2.2 m^3
Annular capasity : 0.140 m^3/m which leaves 55 m in annulus.

$$P_C = (55-L)G_{c2} + (X - 55 - Z)G_{c1} + Z_1 \times G_p - (X - L)G_p$$
$$= (55-12) \times 0,187 + (500-55-123) \times 0,153 + 100 \times 0,1 - (500-12) \times 0,1$$
$$= \underline{18,5 \text{ bar}}$$

Collapse load is zero at wellhead.

Select: 106 - 500 m : 20", 140 kg/m (94 lb/ft), X - 56, Vetco LS

RES_B = 152 bar
RES_C = 36 bar
RES_T = 676 tons

Safety factor: Collapse:

$$S.F._C = \frac{RES_C}{P_C} = \frac{36}{18,5} = \underline{1,95}$$

Safety factor: Burst:

$$S.F._B = \frac{RES_B}{P_{B1}} = \frac{152}{66.3} = \underline{2,29}$$

TENSION:

Weight of casing string in air:

$$T_C = (X - Z) \times M_C = (500 - 123) \times 140 \times 10^{-3} = \underline{52.8 \text{tons}}$$

Casing inside diameter: ID = 48.6cm

Extra tensile load when bumping plug with 55 bar:

$$T_{cem} = (55 - P_C) \times 0,98 \left(\frac{ID}{2}\right)^2 \times 3.14 \times 10^{-3}$$

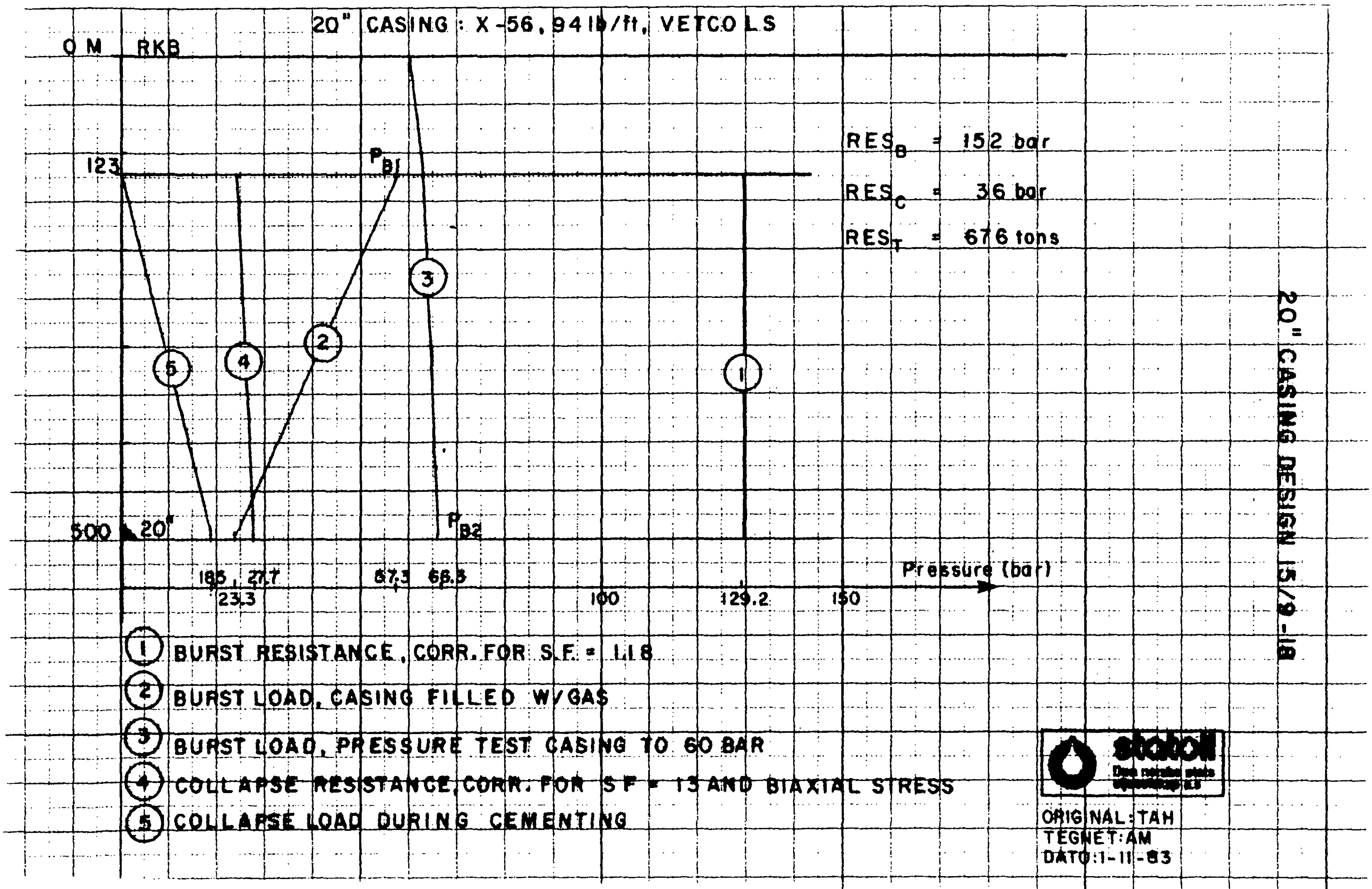
$$(55 - 18,5) 0.98 \times \left(\frac{48,6}{2}\right)^2 \times 3,14 \times 10^{-3} = \underline{66.4 \text{ tons}}$$

Total weight load at wellhead : $T = T_c + T_{cem}$

$(52,8 + 66,4)$ tons = <u>119,2 tons</u>

<u>Safety factor: Tension</u>

$$S.F._T = \frac{RES_T}{load} = \frac{676}{119,2} = \underline{5,65}$$


20" CASING DESIGN 15/9-18
20" CASING : X-56, 94 lb/ft, VETCO LS
0 M RKB
123
500
20"
P B1
P B2
RES B = 152 bar
RES C = 36 bar
RES T = 676 tons
18.5 , 27.7
23.3
67.3 66.3
100
129.2
150
Pressure (bar)
1 BURST RESISTANCE, CORR. FOR S.F. = 1.18
2 BURST LOAD, CASING FILLED W/GAS
3 BURST LOAD, PRESSURE TEST CASING TO 60 BAR
4 COLLAPSE RESISTANCE, CORR. FOR S.F. = 1.3 AND BIAXIAL STRESS
5 COLLAPSE LOAD DURING CEMENTING
statoil
ORIGINAL: TAH
TEGNET: AM
DATO: 1-11-83

13 3/8" Casing Design

W_d = 2785 m
X = 1150 m
L = 24 m
Z = 123 m
Z_1 = 100 m
G_i = 0,108 bar/m
G'_i = 0,118 bar/m

G_p = 0,1 bar/m
G_f = 0,159 bar/m
G_{gas} = 0,02 bar/m
G_{c1} = 0,153 bar/m
G_{c2} = 0.187 bar/m

Design Criteria:

1) Entire casing filled with gas.
2) Collapse load during cementing.
3) Collapse load, lost circulation.
4) Tension load, when bumping plug.

BURST:

Burst load at wellhead if the entire casing is filled with gas.

$$P_{B1} = X \times G_f - (X - Z) \times G_{gas} - Z \times G_p$$

$$= 1150 \times 0{,}159 - (1150 - 123) \times 0{,}02 - 123 \times 0{,}1 = \underline{150 \text{ bar.}}$$

Max burst load while testing casing to 172 bar

$$P_{B2} = 172 + X \times (G_i - G_p)$$

$$= 172 + 1150 \times (0.108 - 0.1) = \underline{181{,}2 \text{ bar}}$$

SELECT: 123 - 1150 m: 13 3/8", 68 lb/ft, K-55, buttress.

RES_C = 134 bar
RES_B = 238 bar
RES_T = 465 tons

Safety factor burst:

$$S.F._B = \frac{RES_B}{P_{B2}} = \frac{238}{181.2} = \underline{1,31}$$

COLLAPSE

Max allowable load while cementing:

$$(X - L) \times (G_f - G_i) = (1150 - 24) \times (0,159 - 0,108) = \underline{57.4 \text{ bar}}$$

Max. collapse load at float collar during cementing. (cement 100m into 20" casing). $10m^3$ tail in slurry leaves 126 m in annulus and 24 m inside casing:

$$P_{C1} = G_{c1} \times (X - 126 - 500 + 100) + G_{c2} \times (126 - L) -$$

$$G_i \times (X - L - 500 + 100)$$

$$= 0.153 \times 624 + 0.187 \times 102 - 0.108 \times 726 = \underline{36.1 \text{ bar}}$$

Reduced RES_C on top casing due to biaxial stress:

Weight load in air: $T_C = (X-Z) \times M_C = (1150-123) \times 100$
$= \underline{102,7 \text{ tons}}$

$$\frac{T}{RES_T} = \frac{102,7 \text{ tons}}{465 \text{ tons}} = \underline{0,22}$$

From the Ellipse of biaxial yield stress, this gives 12 % reduction in collapse resistance.

Safety factor collapse:

$$S.F._C = \frac{RES_C}{P_C} \times 0{,}88 = \frac{117{,}9}{36{,}1} = \underline{3.27}$$

TENSION:

Extra tensile load when bumping plug (neglecting steel buoyancy for extra safety) with 172 bar. Casing inside diameter: ID = 31,53 cm.

$$T_{cem} = (172 - P_{C1}) \times 0.98 \times \left(\frac{ID}{2}\right)^2 \times 3.14 \times 10^{-3}$$

$$= (172-36{,}1) \times 0.98 \times \left(\frac{31{,}53}{2}\right)^2 \times 3{,}14 \times 10^{-3}$$

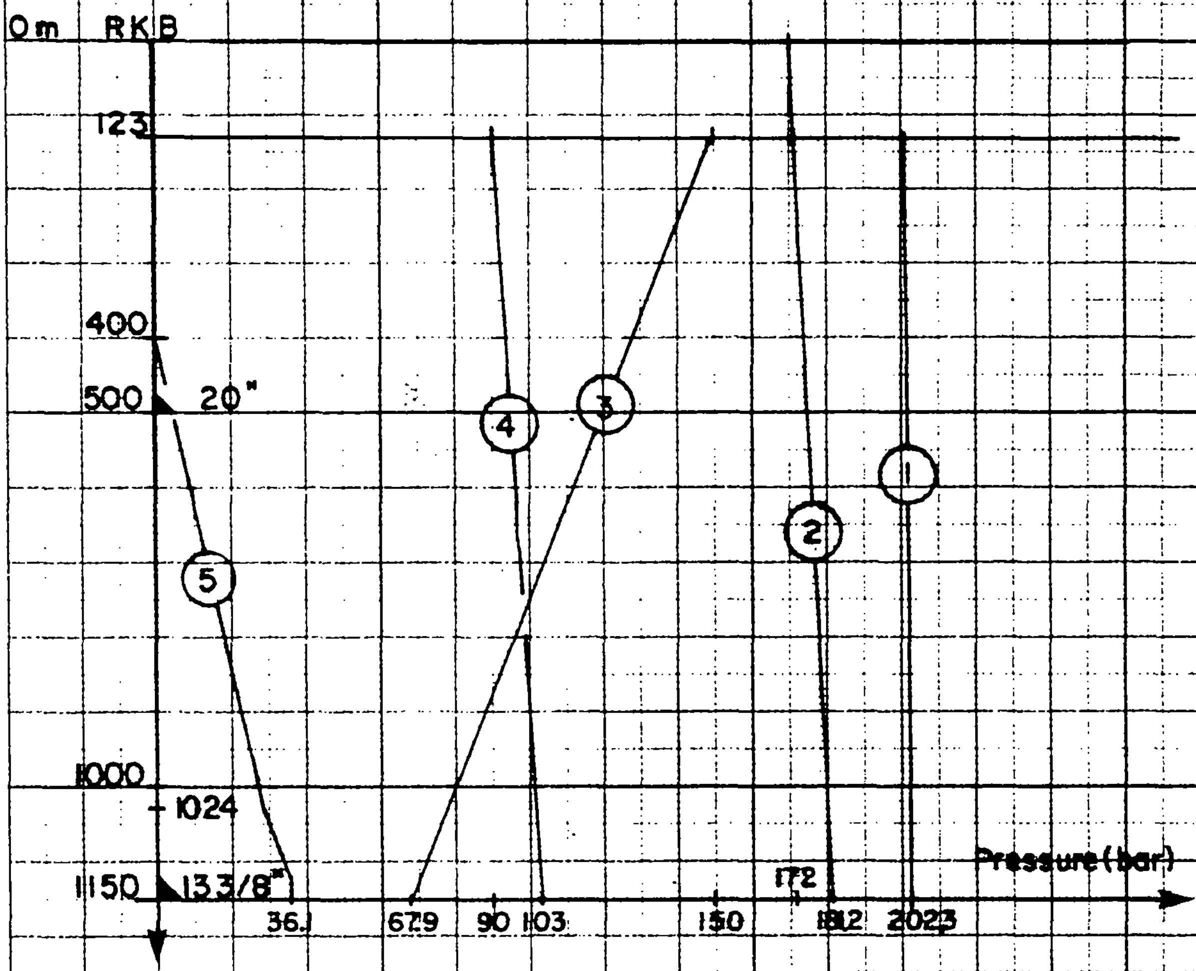
$$= 104 \text{ tons}$$

Total weight load: $T = T_C + T_{cem}$

$(102{,}7 + 104)$ tons = $\underline{206.7 \text{ tons}}$

$$SF_T = \frac{RES_T}{T} = \frac{465}{206{,}7} = \underline{2.25}$$

13 3/8" CASING DESIGN 15/9 - 18



13 3/8": 68 lb/ft, K-55, Buttress : RES_B = 238 bar
RES_C = 134 bar
RES_T = 465 tons

1. BURST RESISTANCE, CORR. FOR S.F. = 1.18
2. BURST LOAD, PR. TEST. TO 172 BAR
3. BURST LOAD, CASING FILLED W/GAS
4. COLLAPSE RESISTANCE, CORR. FOR S.F. = 1.3 AND BIAXIAL STRESS
5. COLLAPSE LOAD DURING CEMENTING

Statoil
Den norske stats oljeselskap a.s

ORIGINAL: TAH
TEGNET: AM
DATO: 1-11-83

9 5/8" Casing Design 15/9-18

X =	2770 m	G_f =	0.173 bar/m
W_D =	3700 m	G_i =	0.118 bar/m
Z =	123 m	G'_i =	0.139 bar/m
Z_1 =	100 m	G''_i =	0.135 bar/m
L =	21 m	G_{gas} =	0.023 bar/m
G_p =	0.1 bar/m	G_c =	0.187 bar/m
G'_p =	0.131 bar/m at 3240m		

Design Criteria:

BURST : Tubing leak while testing.

COLLAPSE : Collapse load during cementing.

TENSION : Tension load when bumping plug.

Burst:

Burst load at wellhead if there is a tubing leak just below the wellhead while testing at 3240m.

$$P_{B1} = G'_p \times 3240 - G_{gas} (3240 - Z) - Z \times G_p$$

$$= 0.131 \times 3240 - 0.023(3240 - 123) - 123 \times 0.1 = \underline{340.5 \text{ bar}}$$

Burst load at 2620m (7" liner top) if tubing leak at wellhead.

$$P_{B2} = P_{B1} + (2620 - Z) \times G''_i - (2620 - 1150) \times G_p$$

$$- (1150 - Z) \times G_i$$

$$= 340.5 + (2620 - 123) \times 0.135 - 1470 \times 0.1$$

$$- (1150 - 123) \times 0.118 = \underline{409.4 \text{ bar}}$$

Max burst load when testing casing to 380 bar

$$P_{B3} = 380 + (G_i - G_p)\ (X - 1150 + Z)$$

$$= 380 + (0.118 - 0.1)\ (2770 - 1150 + 123)$$

$$= \underline{411.4 \text{ bar}}$$

Select: 123 - 2300m: 47 lb/ft, N-80 buttress

RES_C = 328 bar
RES_B = 474 bar
RES_T = 472 tons

Select: 2300 - 2770m: 47 lb/ft, P-110 buttress

RES_C = 366 bar
RES_B = 651 bar
RES_T = 646 tons

Test pressure at 2300m:

$$P_{B4} = 380 + (G_i - G_p)(2300 - 1150 + Z)$$

$$= 380 + (0.118 - 0.1) \times 1273$$

$$= \underline{403 \text{ bar}}$$

Safety factor burst

$$S.F._B = \frac{RES_B}{P_{B3}} = \frac{651}{411.4} = \underline{1.59} \quad \text{for P-110 at 2770 m}$$

$$S.F._B = \frac{RES_B}{P_{B4}} = \frac{474}{403} = \underline{1.18} \quad \text{for N-80 at 2300 m}$$

Collapse:

During cementing (cement 100 m into 13 3/8" casing)

$$P_C = (G_c - G_i)\ (X-(1150 - 100))$$

$$= (0.187-0.118)(2770 - 1050) = \underline{118.7 \text{ bar}}$$

Tensile load at wellhead

$$\underline{T} = T_1+T_2=(X - Z) \times M_c=(2770 - 123)\text{m} \times 70 \text{ kg/m} = \underline{185.3 \text{ tons}}$$

$$\frac{T}{RES_T} = \frac{185.3}{472} = \underline{0.39}$$

From the Ellipse of Biaxial Yield Stress, this gives 26% reduction in collapse strength.

Safety Factor Collapse

$$S.F._C = \frac{RES_C}{P_c} \times 0.74 = \frac{328}{118.7} \times 0.74 = \underline{2.04}$$

Tension:

Weight load in air (casing used as running string):

$$T_c = X \times M_C = 2770\text{m} \times 70 \text{ kg/m} = \underline{193.9 \text{ tons}}$$

Extra tensile load when bumping plug at 172 bar (neglecting buoyancy of steel):

Casing inside diameter : ID = 22.05 cm

$$T_{cem} = (172 - P_C)\ 0.98 \times \left(\frac{ID}{2}\right)^2 \times 3{,}14 \times 10^{-3}$$

$$= (172-118.7)\ 0.98 \times \left(\frac{22{,}05}{2}\right)^2 \times 3{,}14 \times 10^{-3} \qquad = \underline{19{,}9 \text{ tons}}$$

Load weight of 7" liner: $T_l = (W_d - X + 150) \times M_c$

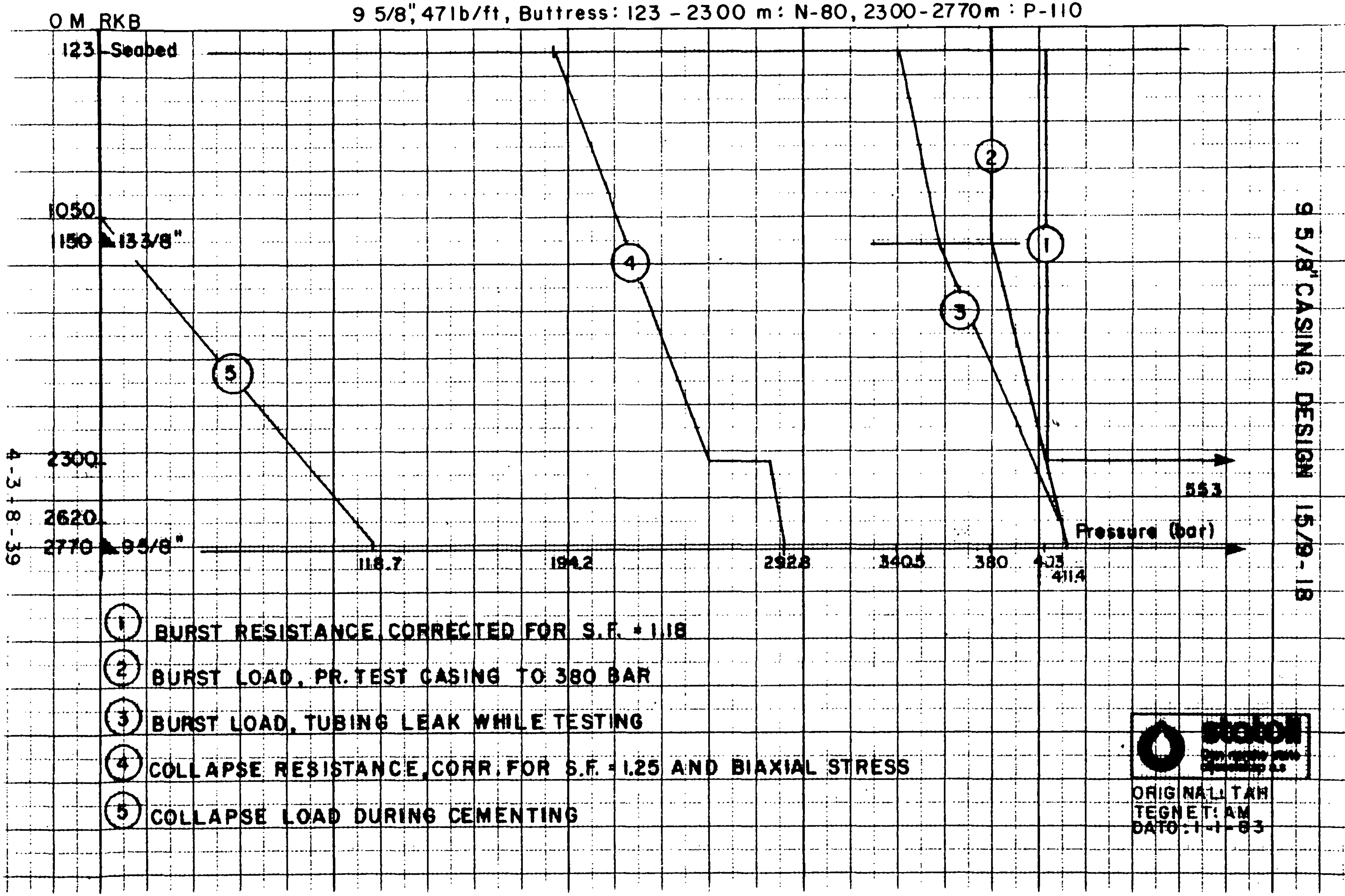
$$= (3700-2770 + 150)\text{m} \times 43{,}15 \text{ kg/m} \qquad = \underline{46.6 \text{ tons}}$$

Total weight load: $T = T_C + T_{cem} + T_e$

$$= (193.9 + 19.9 + 46.6)\text{tons} \qquad = \underline{260.4 \text{ tons}}$$

$$S.F._T = \frac{RES_T}{T} = \frac{472}{260.4} = \underline{1.81}$$

9 5/8" CASING DESIGN 15/9-18



7" Liner Design 15/9-18

X	= 3700m		
W_D	= 3700m	G_p	= 0.1 bar/m
Z	= 123 m	G'_p	= 0.131 bar/m at 3240m
Z_1	= 100 m	G_{gas}	= 0.023 bar/m
G_i	= 0.139 bar/m	G_c	= 0.187 bar/m
G'_i	= 0.139 bar/m	G''_i	= 0.135 bar/m

Design criteria:

BURST : Tubing leak while testing
Pressure testing casing/liner
COLLAPSE: Collapse load while cementing
TENSION : Tension load when bumping plug

Burst:

Burst load at packer setting depth if there is a tubing leak just below the wellhead and the pressure build up in the annulus is not bled off, when testing at 3240 m (Packer at 3210 m).

$$P_{B1} = G'_p \times 3240 + (3240 - Z) \times (G''_i - G_{gas}) - (1150-Z) \times 0.118 - (3210 - 1150 + Z) \times G_p$$

$$= 0.131 \times 3240 + (3240-123) \times (0.135-0.023) - (1150-123) \times 0.118 - (3210-1150+123) \times 0.1$$

$$= \underline{434,3 \text{ bar}}$$

Burst load when testing 7" liner /9 5/8" casing to 330 bar with 1.42 S.G. mud.

$$P_{B2} = 330 + G_i \times X - (1150-Z) \times 0.118 - (X-1150+Z) \times G_p$$

$$= 330 + 0.139 \times 3700 - (1150-123) \times 0.118 - (3700-1150+123) \times 0.1$$

$$= \underline{455.8 \text{ bar at 7" shoe}}$$

At 2300m, i.e. at bottom of 9 5/8", 47 lb/ft, N-80

$\underline{P_{B3}} = 330 + G_i \times 2300 - (1150-Z) \times 0.118 - (2300-1150+Z) \times G_p$

$= 330 + 0.139 \times 2300 - (1150-123) \times 0.118 - (1150+123) \times 0.1$

$= \underline{401.2 \text{ bar}}$

From 2620 - 3700 m select : 7", 29 lb/ft, N-80, Buttress

$RES_C = 484$ bar
$RES_B = 563$ bar
$RES_T = 294$ tons

$S.F._B = \frac{RES_B}{P_{B2}} = \frac{563}{455.8} = \underline{1.24}$ for 7"

$S.F._B = \frac{RES_B}{P_{B3}} = \frac{474}{401.2} = \underline{1.18}$ for 9 5/8", 47 lb/ft, N-80

<u>Collapse:</u>

7" liner is set at bottom with 150 m overlap in 9 5/8" casing.

Collapse load during cementing:

$P_C = (G_c - G_i) \times (X-2620) = (0.187-0.139) \times (3700-2620)$

$= \underline{51.8 \text{ bar}}$

Minimum flowing bottom hole pressure when testing at 3240 m

$P_{WF} \text{ min} = 3240 \times G'_p - \frac{RES_C}{1.25}$

$P_{WF} \text{ min} = 3240 \times 0.131 - \frac{484}{1.25} = \underline{37.2 \text{ bar}}$

Tension:

Weight load in air:

T_c = (X-2620) x M_c=(3700-2620)m x 43,15kg/m = 46.6 tons

Liner I.D. = 15,71 cm

Extra tensile load when bumping plug with 172 bar:

$$T_{cem} = (172 - 51.8) \times 0.98 \times \left(\frac{15.71}{2}\right)^2 \times 3.14 \times 10^{-3}$$

= 22.8 tons

Total tensile load T = $T_c + T_{cem}$
= (46.6 + 22.8) tons = 69.4 tons

$$S.F._T = \frac{RES_T}{69.4} = \frac{294}{69.4} = 4.24$$

30" CASING CEMENT DATA AND CALCULATIONS, 15/9-18

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

WELL DATA:

Depth kb-sea bed.........................:	123 m
Depth kb-last shoe.......................:	
Depth kb-casing set point................:	188 m
Open hole dia............................:	36"
Annulus capacity, cased hole.. ....:	- l/m
Annulus capacity, open hole...... ......:	200.0 l/m
Internal capacity, 30" casing 1.0"thickness	397.0 l/m
Mud weight...............................:	1.10 g/cm³
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

		LEAD SLURRY		TAIL-IN SLURRY	
CEMENT SLURRY COMPOSITION		CLASS "G"cement 4.0 l/100 kg Econolite		CLASS "G"-cement	
Mix water	l/100 kg	92.4	sea	44.0	sea
Total liquid	l/100 kg	96.4		44.0	
Slurry weight	g/cm³	1.56		1.91	
Slurry yield	l/100 kg	128.2		75.8	
TEST DATA AT BHCT					
Thickening time at BHHP, hr:min		4:30		3:30	
Crit. Turb.Flow rate:m/s (l/min)					
Fluid loss,					
TEST DATA AT BHST, BHHP					
Compr. strength,	bar 12 hr				
	bar 24 hr	28		62	

REMARKS:

Fann VG Readings
600/300/200/100

Volume calculations (30" casing):

Annular volume	: 0.200 m^3/m x (188-123)m	= 13.0 m^3
3 m plug at shoe	: 0.397 m^3/m x 3 m	= 1.2 m^3
150% excess in open hole :		= 19.5 m^3
Total volume		= 33.7 m^3

Lead slurry : Class G-cement + 4.0 l Econolite/100 kg cement mixed with seawater to 1.56 g/cm^3
18500 kg cement equivalent to 23.7m^3 slurry

Tail-in slurry : Class G-cement
cement mixed with seawater to 1.91 g/cm^3.
13200 kg cement equivalent to 10.0m^3 slurry

Chemicals needed: Total volume of Econolite needed: 740 l

20" CASING CEMENT DATA AND CALCULATIONS, 15/9-18:

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

WELL DATA:

Depth kb-sea bed.........................:	123 m
Depth kb-last shoe.......................:	188 m
Depth kb-casing set point................:	500 m
Open hole dia............................:	26"
Annulus capacity, cased hole.. ....:	194.0 l/m
Annulus capacity, open hole...... ......:	139.4 l/m
Internal capacity, 20"casing 94 lbs/ft :	185.3 l/m
Mud weight...............................:	1.10 g/cm^3
Bottom hole hydrostatic pres. (BHHP).......:	54 bar
Est. bottom hole static temp. (BHST)......:	35 °C
Est. bottom hole circulating temp. (BHCT).:	30 °C
Est. formation integrity.................:	0.142 bar/m

		FILLER/LEAD SLURRY		TAIL IN SLURRY	
CEMENT SLURRY COMPOSITION		CLASS "G"cement + 4.0 l/100 kg Econolite + 0.09 l/100 kg HR-6L		CLASS "G"cement	
Mix water	l/100 kg	92.4	sea	44.0	sea
Total liquid	l/100 kg	96.5		44.0	
Slurry weight	g/cm^3	1.56		1.91	
Slurry yield	l/100 kg	128.2		75.75	
TEST DATA AT BHCT					
Thickening time at BHHP, hr:min		4:30		3:25	
Crit. Turb.Flow rate:m/s (l/min)					
Fluid loss, ml/					
TEST DATA AT BHST, BHHP					
Compr. strength, bar 12 hr					
bar 24 hr		47.2		136	

REMARKS:

Fann VG Readings
600/300/200/100

Volume calculations (20" casing):

Annular volume	: 0.1394 m^3/m x (500-188)m	= 43.5 m^3
Volume between csg's:	0.194 m^3/m x(188-123) m	= 12.6 m^3
12 m plug at shoe	: 0.1853 m^3/m x 12m	= 2.2 m^3
100% excess in open hole:		= 43.5 m^3
Total volume		=101.8 m^3

Lead slurry : Class "G"-cement + 4.0 1/100 kg Econolite + 0.09 1/100 kg.
HR-6L mixed with seawater to 1.56 g/cm^3.
71600 kg cement equivalent to 91.8m^3 slurry.

Tail-in slurry : Class "G"-cement mixed with seawater to 1.92 g/cm^3.
13200 kg cement equivalent to 10.0m^3 slurry.

Chemicals needed: Total volume of Econolite needed : 2860 l
Total volume of HR-6L needed : 70 l

Hydrostatic pressure at 20" csg. shoe

Height of tail-in slurry : $(10.0-2.2)m^3/0.1394\ m^3/m$= <u>56 m</u>

Hydrostatic head of lead slurry :

0.153 bar/m x (500-123-56)m = 49.1 bar

Hydrostatic head of tail-in slurry :

0.187 bar/m x 56 m = 10.5 bar

Hydrostatic head of sea-water :

0.101 bar/m x (123 - 23)m = 10.1 bar

Total hydrostatic pressure = 69.7 bar

Equivalent pressure gradient at 20" shoe:

$$\frac{69.7\ \text{bar}}{500\ \text{m}} = 0.139\ \frac{\text{bar}}{\text{m}}$$

Estimated formation integrity : 0.142 bar/m.

13 3/8" CASING CEMENT DATA AND CALCULATIONS, 15/9-18

GENERAL: The cement volume is calculated at the basis of the theoretical annulus volume and the casing to be cemented 100 m into the 20" casing.

WELL DATA:

Depth kb-sea bed.........................:	123 m
Depth kb-last shoe.......................:	500 m
Depth kb-casing set point................:	1150 m
Open hole dia............................:	17½"
Annulus capacity, cased hole.. ....:	94.5 l/m
Annulus capacity, open hole...... ......:	64.4 l/m
Internal capacity, 13 3/8"casing 68 lb/ft :	78.1 l/m
Mud weight...............................:	1.10 g/cm^3
Bottom hole hydrostatic pres. (BHHP)......:	124 bar
Est. bottom hole static temp. (BHST)......:	46 ^{o}C
Est. bottom hole circulating temp. (BHCT).:	37 ^{o}C
Est. formation integrity.................:	0.159 bar/m

		LEAD SLURRY		TAIL IN SLURRY	
CEMENT SLURRY COMPOSITION		CLASS "G" cement 4.0 l/100 kg Econolite		CLASS "G" cement	
Mix water	l/100 kg	89.2	fresh	44.0	fresh
Total liquid	l/100 kg	93.2		44.0	
Slurry weight	g/cm^3	1.56		1.9	
Slurry yield	l/100 kg	125		75.75	
TEST DATA AT BHCT					
Thickening time at BHHP, hr:min		6:16 +		4:00 +	
Crit. Turb.Flow rate:m/s (l/min)					
Fluid loss, ml/30 min, 70 bar					
TEST DATA AT BHST, BHHP					
Compr. strength, bar 18 hr		44		87.2	
bar 24 hr					

REMARKS:

Fann VG Readings
600/300/200/100

Volume calculations (13 3/8" casing):

Annular volume	: 0.0644 m^3/m x (1150-500)m	= 41.9 m^3
Volume between csg's:	0.0945 m^3/m x 100 m	= 9.5 m^3
24 m plug inside casing	: 0.0781 m^3/m x 24m	= 1.9 m^3
Total cement slurry volume		= 53.3 m^3

Lead Slurry : Class G-cement + 4.0 l/100 kg Econolite mixed with freshwater to 1.56 g/cm^3.
34600 kg cement equivalent to 43.3 m^3.

Tail-in slurry: Class G-cement mixed with fresh water to 1.9 g/cm^3.
13200 kg cement equivalent to 10.0 m^3 slurry.

NOTE: Amount of excess cement should be based on evaluation of the hole conditions and caliper log to give the top of cement 100 m into 20" csg. The amount of excess should be discussed with the operation office before any decision are made.

Chemicals needed:

Total volume of Econolite needed: 1380 l

Remarks: Adequate samples of cement, additives and drillwater should be forwarded to Statoil's Mud and Cement Lab, Forus, for testing prior to the cement job.

Height of tail-in slurry: $(10.0 - 1.9)m^3/0.0644m^3/m$ = <u>126 m</u>

Hydrostatic pressure calculations:

Height of mud: (500-100)m = <u>400 m</u>

Height of slurry : (1150-500-126 + 100)m = <u>624 m</u>

Hydrostatic head from mud: 0.108 bar/m x 400m = 43.2 bar

Hydrostatic head from lead slurry : 0.153 bar/m x 624 m = 95.5 bar

Hydrostatic head from tail-in slurry : 0.187 bar/m x 126m = <u>23.5 bar</u>

Total hydrostatic head at 13 3/8" shoe = <u>162.2bar</u>

Equivalent pressure gradient at 13 3/8" shoe :

$\frac{162.2 \text{ bar}}{1150 \text{ m}}$ = <u>0.141 bar/m</u>

Estimated formation integrity at 13 3/8" shoe : = <u>0.159bar/m</u>

Hydrostatic head at 20" shoe:

43.2 bar + 0.153 bar/m x 100 m = <u>58.5 bar</u>

Equivalent pressure gradient at 20" shoe : $\frac{58.5 \text{ bar}}{500 \text{ m}}$ = <u>0.117bar/m</u>

Estimated formation integrity at 20" shoe = <u>0.142bar/m</u>

9 5/8" CASING CEMENT DATA AND CALCULATIONS, 15/9-18:

GENERAL: The cement volume calculations is based on the theoretical hole volume and the casing should be cemented 100m into the 13 3/8" casing.

WELL DATA:

Depth kb-sea bed.........................:	123 m
Depth kb-last shoe.......................:	1150 m
Depth kb-casing set point................:	2770 m
Open hole dia............................:	12 1/4"
Annulus capacity, cased hole.. ....:	31.0 l/m
Annulus capacity, open hole...... ......:	28.9 l/m
Internal capacity, 9 5/8"casing 47 lbs/ft :	38.2 l/m
Mud weight...............................:	1.20 g/cm^3
Bottom hole hydrostatic pres. (BHHP)......:	326 bar
Est. bottom hole static temp. (BHST)......:	92 °C
Est. bottom hole circulating temp. (BHCT).:	64 °C
Est. formation integrity.................:	0.173 bar/m

		LEAD SLURRY		TAIL IN SLURRY	
CEMENT SLURRY COMPOSITION		CLASS "G"cement + 2.57 1/100 kg CFR-2L + 0.34 1/100 kg HR-6L		CLASS "G" cement + 2.57 CFR-2L + 5.33 HALAD-10L + 0.18 HR-6L	
Mix water	1/100 kg	42.7	fresh	37.7	fresh
Total liquid	1/100 kg	45.6		45.8	
Slurry weight	g/cm^3	1.90		1.90	
Slurry yield	1/100 kg	77.4		77.5	
<u>TEST DATA AT BHCT</u>					
Thickening time at BHHP, hr:min		4:34		6:00	
Crit. Turb.Flow rate:m/s (1/min)					
Fluid loss, ml/30 min, 70 bar		717		52	
<u>TEST DATA AT BHST, BHHP</u>					
Compr. strength, bar 16 hr		221		258	
bar 24 hr					

REMARKS: K/N
N_{RE} turb/plug
Fann VG-readings

Volume calculations (9 5/8" casing):

Annular volume	: 0.0289 m^3/m x (2770-1150)m	= 46.8 m^3
Volume between csg's:	0.0310 m^3/m x 100 m	= 3.1 m^3
24 m plug inside casing	: 0.0382 m^3/m x 24m	= 0.9 m^3
Total cement slurry volume		= 40.8 m^3

Lead slurry : Class G-cement + 2.57 1/100 kg CFR-2L + 0.34 1/100 kg HR-6L mixed with freshwater to 1.90 g/cm^3
52700 kg cement equivalent to 40.8 m^3 slurry.

Tail-in slurry: Class G-cement + 2.57 1/100 kg CFR-2L + 5.33 1/100 kg HALAD-10L + 0.18 1/100 kg HR-6L mixed with freshwater to 1.90 g/cm^3
12900 kg cement equivalent to 10 m^3 slurry.

NOTE : Amount of excess cement should be based on evaluation of the hole conditions and the caliper log to give the top of cement 100 m into 13 3/8" csg. The amount of excess should be discussed with the operation office before any decision are made.

Chemicals needed:	Total volume of CFR-2L needed	: 1700 l
	Total volume of HR-6L needed	: 200 l
	Total volume of HALAD-10L needed	: 700 l

Remarks: Pump 3.2 m^3 of weighted mudsweep ahead of slurry.
Spacer weight 1.60 g/cm^3.

The Statoil supervisor is responsible for sending in cement,drillwater and additives from the rig. The operation office is responsible for making arrangements to have the slurry composition tested before the cement job.

Hydrostatic pressure calculations:

Height of spacer/preflush: 3,2 m^3/0.031 m^3/m = <u>103 m</u>

Height of mud : (1150-100 - 103)m = <u>947 m</u>

Height of slurry :(2770-1150 + 100)m = <u>1720 m</u>

Hydrostatic head from spacer/preflush: 0.157 bar/m x103m = 16.2 bar
Hydrostatic head from mud : 0.118 bar/m x 947m = 111.7 bar
Hydrostatic head from slurry : 0.187 bar/m x 1720 m = <u>321.6 bar</u>

Total hydrostatic head at 9 5/8" shoe = <u>449.5 bar</u>

Equivalent pressure gradient at 9 5/8" shoe :

$\frac{449.5 \text{ bar}}{2770 \text{ m}}$ = <u>0.162 bar/m</u>

Estimated formation integrity at 9 5/8" shoe = <u>0.173 bar/m</u>

Hydrostatic head at 13 3/8" shoe:
(16.2+111.7) bar + 0.187 bar/m x 100 m = <u>146.6 bar</u>

Equivalent pressure gradient at 13 3/8" shoe :

$\frac{146.6 \text{ bar}}{1150 \text{ m}}$ = 0.128 bar/m

Estimated formation integrity at 13 3/8" shoe : <u>0.159 bar/m</u>

7" LINER CEMENT DATA AND CALCULATIONS, 15/9-18

GENERAL: The cement volume is calculated at the basis of the theoretical annulus volume and the liner to be cemented 150 m into the 9 5/8" casing.

WELL DATA:

Depth kb-sea bed.........................:	123 m
Depth kb-last shoe.......................:	2770 m
Depth kb-casing set point................:	3700 m
Open hole dia............................:	8½"
Annulus capacity, cased hole.............:	13.3 l/m
Annulus capacity, open hole..............:	11.7 l/m
Internal capacity, 7"liner 29 lb/ft.......:	19.4 l/m
Mud weight...............................:	1.42 g/cm^3
Bottom hole hydrostatic pres. (BHHP)......:	516 bar
Est. bottom hole static temp. (BHST)......:	114 °C
Est. bottom hole circulating temp. (BHCT).:	86 °C
Est. formation integrity.................:	0.185 bar/m

			SLURRY
		CLASS "G"	CEMENT
CEMENT SLURRY COMPOSITION		+ 7.10 1/100 kg	HALAD-10L
		+ 1.95 1/100 kg	CFR-2L
Mix water	1/100 kg	36.7	fresh
Total liquid	1/100 kg	45.8	
Slurry weight	g/cm^3	1.90	
Slurry yield	1/100 kg	77.5	
TEST DATA AT BHCT			
Thickening time at BHHP, hr:min		4:30 +	
Crit. Turb.Flow rate:m/s (l/min)			
Fluid loss, ml/30 min, 70 bar		96	
TEST DATA AT BHST, BHHP			
Compr. strength, bar 16 hr		256	
bar 24 hr			

REMARKS:

Fann VG Readings
600/300/200/100

Volume calculations (7" liner):

Annular volume	: 0.0117 m^3/m x (3700-2770)m	= 10.9 m^3
Volume between csg's:	0.0133 m^3/m x 150 m	= 2.0 m^3
24 m plug inside casing	: 0.0194 m^3/m x 24m	= 0.5 m^3
Total cement slurry volume		= 13.4 m^3

Slurry : Class G-cement + 7.10 l/100 kg HALAD-10L + 1.95 l/100 kg CFR-2L mixed with freshwater to 1.90 SG.
17300 kg cement equivalent 13.4 m^3 slurry.

NOTE: Amount of excess cement should be based on evaluation of the hole conditions and caliper log to give the top of cement at the liner hanger (150 m into 9 5/8" csg.). The amount of excess should be discussed with the operation office before any decision are made.

Chemicals needed:

Total volume of HALAD-10L needed : 1230 l
Total volume of CFR-2L needed : 340 l

Remarks: Pump 1.6 m^3 of mudsweep ahead of slurry. Spacer weight 1.7 g/cm^3.

Adequate samples of cement, additives and drillwater should be forwarded to Statoil's Mud and Cement Lab, Forus, for testing prior to the cement job.

Hydrostatic pressure calculations:

Height of spacer/preflush: 1.6 m^3/0.0249 m^3/m = 64 m

Height of mud : (2770-150-64)m = 2556 m

Height of slurry : (3700-2770+150) = 1080 m

Hydrostatic head from spacer/preflush: 0.167 bar/m x64m = 10.7 bar

Hydrostatic head from mud: 0.139 bar/m x 2556 m = 355.3 bar

Hydrostatic head from slurry : 0.187 bar/m x 1080 m = 202.0 bar

Total hydrostatic head at 7" shoe = 568.0 bar

Equivalent pressure gradient at 7" shoe :

$$\frac{568.0 \text{ bar}}{3700 \text{ m}} = \underline{0.154 \text{ bar/m}}$$

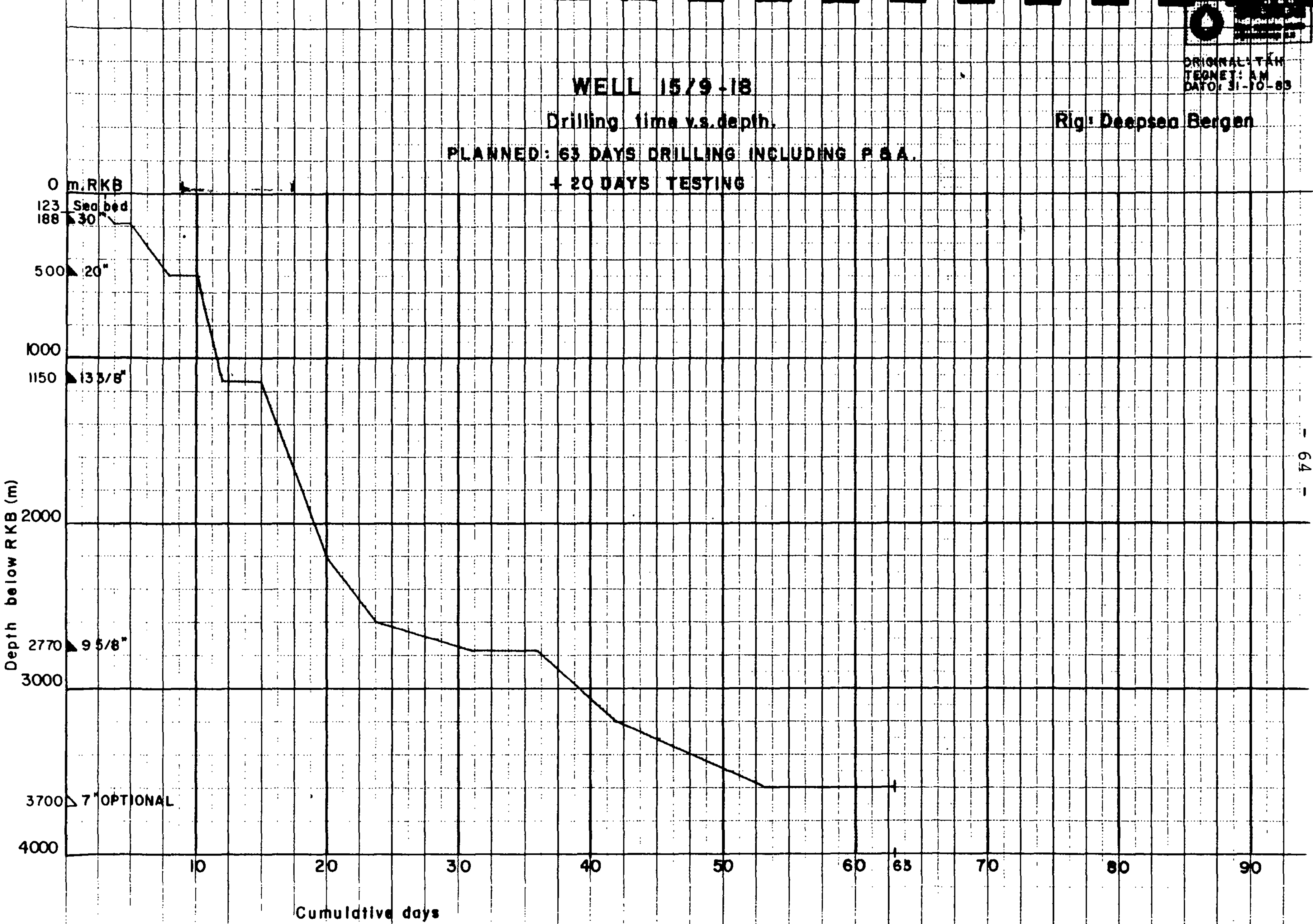
Estimated formation integrity at 7" shoe : = 0.185 bar/m

Hydrostatic head at 9 5/8" shoe:
(10.7 + 355.3) bar + 0.187 bar/m x 150 m = 394.1 bar

Equivalent pressure gradient at 9 5/8" shoe :

$$\frac{394.1 \text{ bar}}{2770\text{m}} = \underline{0.142 \text{ bar/m}}$$

Estimated formation integrity at 9 5/8" shoe = 0.173 bar/m


ORIGINAL: TAH
TEGNET: AM
DATO: 31-10-83
WELL 15/9-18
Drilling time v.s. depth.
Rig: Deepsea Bergen
PLANNED: 63 DAYS DRILLING INCLUDING P & A.
+ 20 DAYS TESTING
0 m.RKB
123 Sea bed
188 30"
500 20"
1000
1150 13 3/8"
2000
2770 9 5/8"
3000
3700 7" OPTIONAL
4000
Depth below RKB (m)
10
20
30
40
50
60
65
70
80
90
Cumulative days

WELL 15/9-18

(Not to scale)

30", grade B, Vetco ATD-RB
1 jnt. 1 1/2" wall th.
4 jnt. 1" wall th.

Cement to seabed + 150% excess

20", X-56, 94 lb/ft (123-500)m, Vetco LS

Cement to seabed + 100% excess

13 3/8", K-55, 68 lb/ft
(123-1150)m. buttress

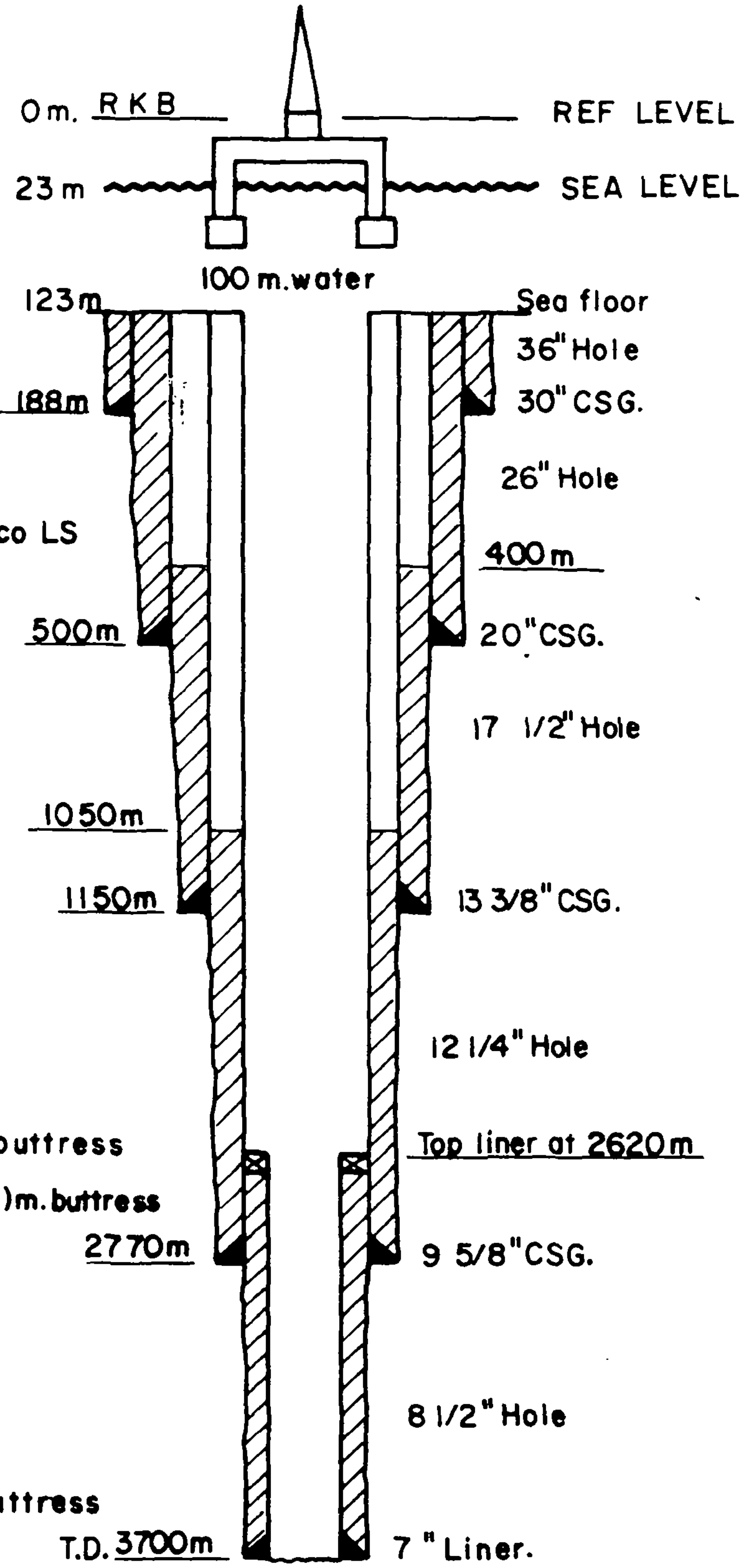
Cement to 400m

9 5/8", N-80, 47 lb/ft (123-2300)m. buttress
P-110, 47 lb/ft (2300-2770)m. buttress

Cement to 1050 m.

7", N-80, 29 lb/ft (2620-3700)m. buttress

Cement to full length.



statoil
Den norske stats oljeselskap a.s

ORIGINAL AV: TAH
TEGNET AV: AM
DATO: 1-11-83

4-3-8-41