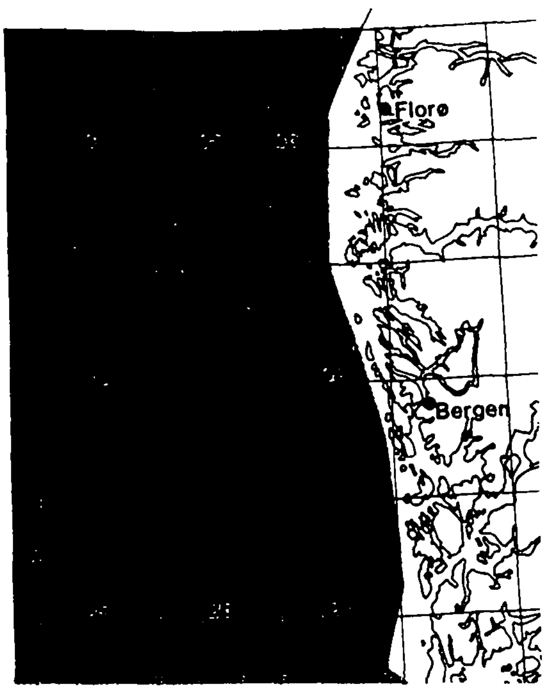
Saga
Petroleum a.s.



WELL PROGRAMME

31/3-3

October, 1984

Saga
Petroleum a.s.

Licence	: 085
Partners	: STATOIL/NORSK HYDRO/SAGA
Date	: OCTOBER 1984
Revision no.	:
Date of revision	:
Word Processing	:

WELL PROGRAMME

31/3-3

Norwegian Continental Shelf

Classification / Distribution [x] Saga and partners

	Exploration	Petr.Tech.	Drilling
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36	"	"	"	"	
37	"	"	"	"	
38	"	"	"	"	
39	"	"	"	"	(Wilh. Wilhelmsen)
40	"	"	"	"	(Wilh. Wilhelmsen)
41	"	"	"	Florø/Kristiansund N	

CONTENTS:

Page

1. LICENCE PARTICIPANTS AND LOCATION DATA

1.1 Licence 085

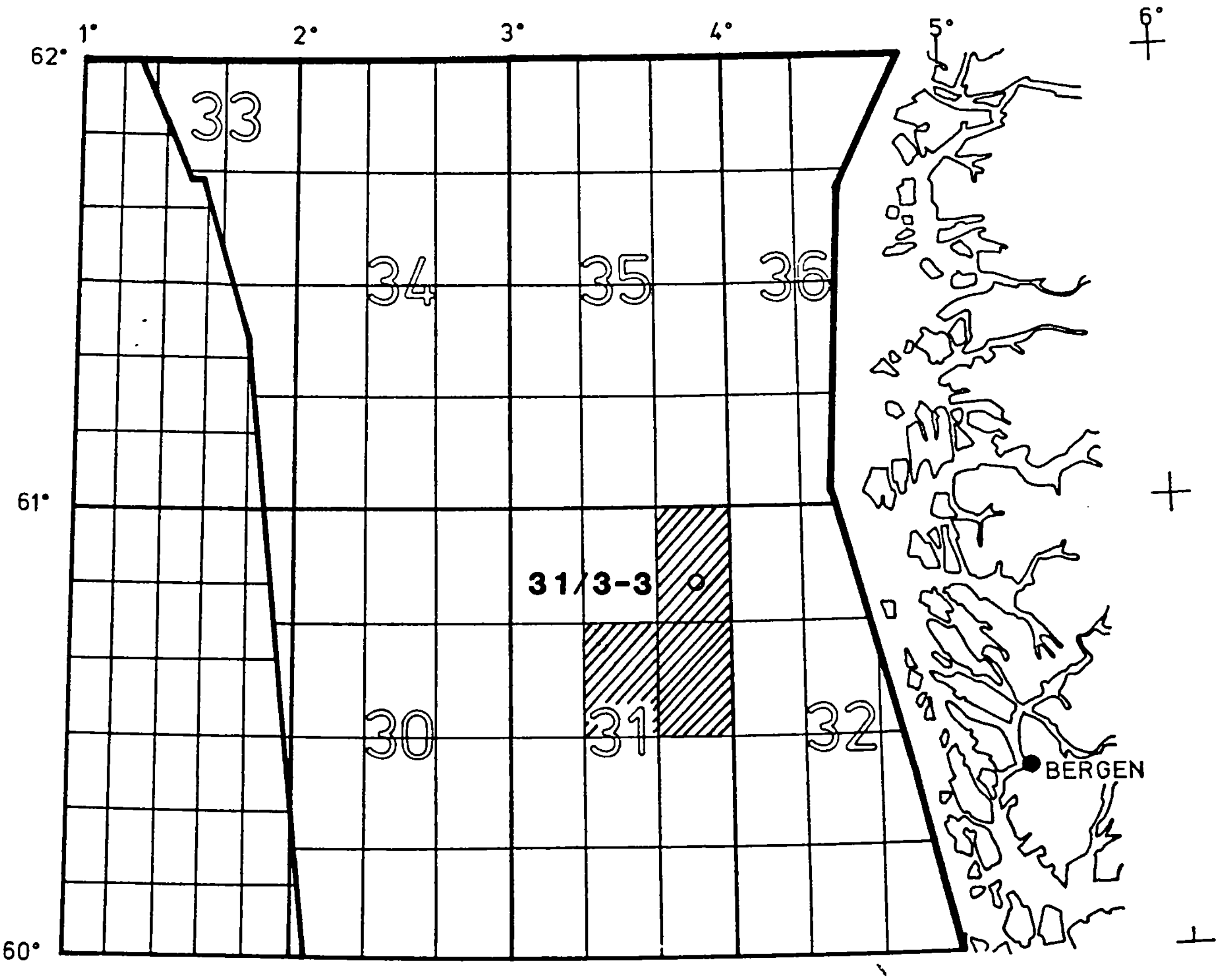
Licence 085 was awarded July 8th 1983 and covers blocks 31/3, 31/5 and 31/6. Together with 31/2, these blocks compose the Troll field. The location map is shown in fig. 1.1.

1.2 Operators

	Net Interest
Saga Petroleum a.s.	6 %
Statoil	85 %
Norsk Hydro	9 %

1.3 Location

Well	:	31/3-3
Location	:	ST 8007-347, SP 781
Preliminary coordinates	:	60° 50' 01.93" N
	:	03° 50' 38.46" E
Rig	:	"Treasure Saga"
Water depth	:	335 m (MSL)
	:	332 m (LAT) from the rig location survey
KBE	:	26 m
Estimated T.D.	:	2525 m RKB



Location map

Scale ca.1 : 1.650.000

Fig. 1.1

2. OPERATOR'S ADMINISTRATION AND DATA COMMUNICATION

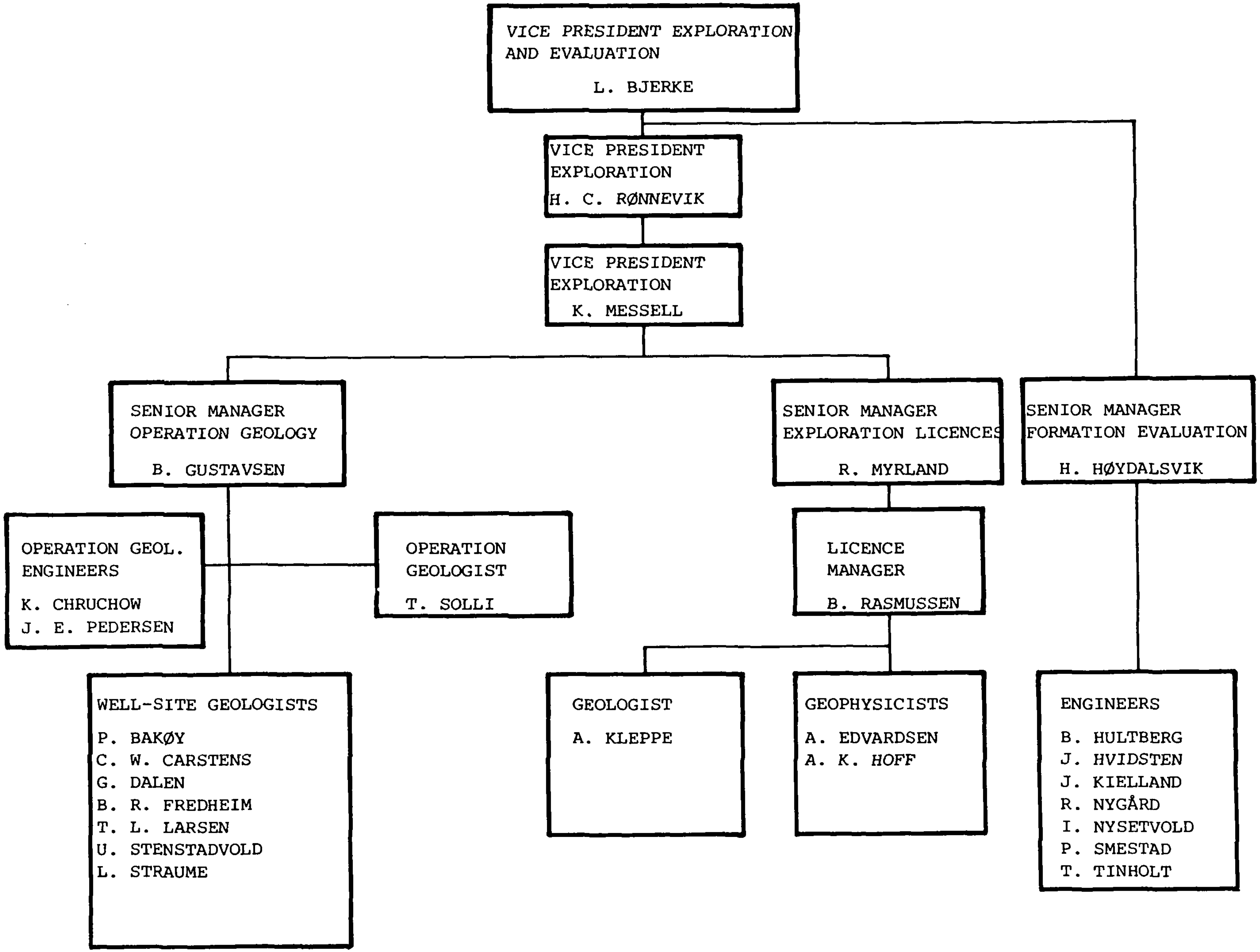
2.1 Personnel

Organization charts and telephone lists for the operator's personnel in the Technical Division of pertinence for well 31/3-3 are given on the next 4 pages. Company personell and telephone numbers for partners are also included.

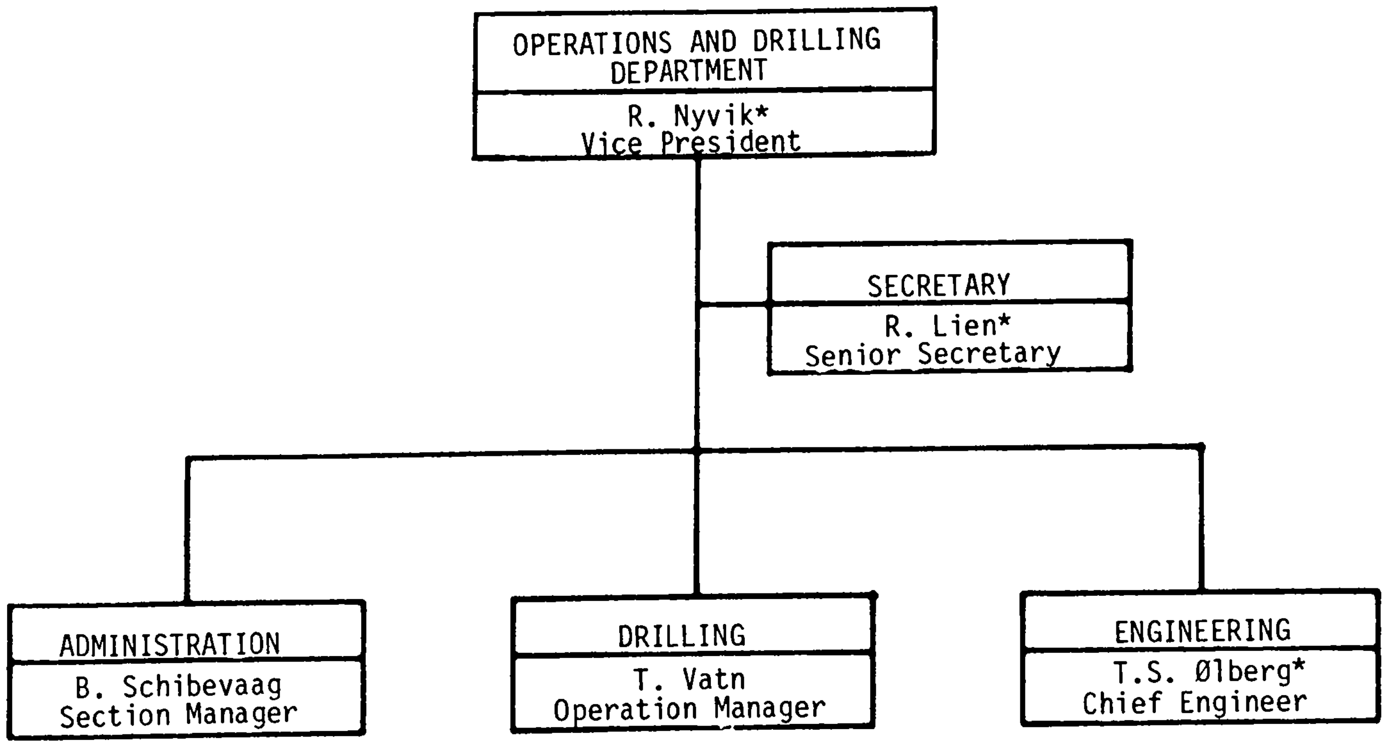
All questions concerning the operation and interpretation of data should be put to relevant key personnel as specified on the organization charts.

All other queries are to be directed to Saga's Vice President, External Relations, Roy Halvorsen or Senior Manager, Public Relations, Bjørn Glenne.

ersonnel, Exploration and Evaluatio ivision, Well 31/3-3, Oslo Office



O R G A N I Z A T I O N   C H A R T



* Acting

5.4.84

Address and Telephone List

NAME	ADDRESS	TELEPHONE
SAGA PETROLEUM a.s.	P. O. Box 9, 1322 HØVIK	(02) 120111
L. Bjerke, Vice President, Exploration and Evaluation	Baches vei, V. Nøste, 3000 Drammen	(03) 833685
H. C. Rønnevik, Vice President, Exploration	Askerhagen 2B, 1370 Asker	(02) 795832
K. Messell, Vice President, Exploration	Skogtunet 17, 1320 Stabekk	(02) 535901
B. Gustavsen, Senior Manager, Operation Geology	Trollhaugen 18, 1370 Asker	(02) 789640
T. Solli, Operation Geologist	Lille Utsikten, 3425 Reistad	(03) 840186
R. Myrland, Senior Manager, Exploration Licences	Erlandsvei 39, 1393 Østenstad	(02) 787230
B. Rasmussen, Licence Manager	Granfossbakken 6, 1324 Lysaker	(02) 123465
H. Høydalsvik, Senior Manager, Formation Evaluation	Nordliveien 9 B, 1320 Stabekk	(02) 574344
B. Gustavsen	Office - after office hours	(02) 120952
	Mobil telephone	(094) 25191
H. Høydalsvik	Office - after office hours	(02) 120744
	Mobil telephone	(094) 25190
Mobil telephone, geologist on duty		(094) 15412
	(back-up)	(094) 25192

Address and Telephone List

NAME	ADDRESS	TELEPHONE
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R. Nyvik, Vice President, Drilling Operations	Krykkjeveien 34, 4042 Hafrsfjord	(04) 591456
		(094) 74752
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		(094) 74754
T. S. Ølberg, Chief Engineer	Ulabrandvn. 45, 4020 Hundvåg	(04) 548565
L. K. Ueland, Material Supervisor	Dusavikveien 200, 4000 Stavanger	(04) 541401
B. Schibevaag, Section Manager, Adm.	Snorres gt. 25, 4042 Hafrsfjord	(04) 559395
Engineer on duty, Stavanger		(094) 74186
Material man on duty, Stavanger		(094) 74753
Material man on duty, Florø		(094) 74756

Company Personnel and Telephone Numbers

STATOIL

Name	Title	Telephone	
		Office	Home
Sund, T.	Vice President Expl.	04-578178	04-560235
Bergseth, S.	Licence Manager, Troll	04-578180	04-559322
Kjeldstad, K.	Drlg. Manager	04-541099	04-591437
Gjedrem, T.	Expl. Drlg. Manager	04-541099	
Helgøy, T. S.	Oper. Coord. Op. Techn.	04-577297	04-661757
Lie, E.	Oper. Coord. Geol.	04-578162	04-620918
Aga, O. J.	District Expl. Manager	04-533180	04-534739
Røise, P.	Geol./Geof. Coord., Troll	04-578168	04-550369
Self, J.	Oper. Techn. Supervisor	04-533180	04-550824
Syrstad, S. O.	Oper. Geol. Supervisor	04-533180	04-587429
Kræmer, R.	Area Supervisor	04-533180	04-620039

NORSK HYDRO

Name	Title	Telephone Office	Telephone Home
Oppebøen, K. A.	Ass. Vice President	02-543920	02-500027
	Mobile:	094-16274	
Sæbøe, A.	Area Expl. Manager	02-543920	02-535327
Egeberg, T.	Area Group Leader	02-543920	
Leivestad, S. I.	Chief Geologist	02-543920	02-121546
Nordberg, H. E.	Chief Geophysicist	02-543920	03-846444
Lærkerød, B.	Supervisor Oper. Geol.	02-543920	02-790073
Davies, A.	Operation Geologist	02-543920	02-563441
Hæger, K. O.	Operation Geologist	02-543381	02-543381
Geologist on duty	Mobile:	094-26284	

2.2 Contractors and Service Companies

Drilling Unit:	"Treasure Saga"	
Wilh. Wilhelmsen		
Norseabasen, Dusavik		
4000 STAVANGER		Tlf.: (04) 536080
Base Manager:		
Øyvind Jordanger		Tlf.: (04) 560831
Drilling Superintendent:		
Einar Grønlie-Olsen		Tlf.: (04) 446259
Supply Boats:	"Nordfonn"	
Sig. Bergesen		
Postboks 44		
N-4001 STAVANGER		Tlf.: (04) 527500
Austevoll Supply	"Skandi Beta"	
N-5394 KOLBEINSVIK		Tlf.: (04) 384420
Standby Boat:	"Standby Master"	
Vardal Fiskeriselskap a.s.		
N-6170 Vardal		Tlf.: (070) 42066
Helicopter Service:		
Helicopter Service A/S		
4033 FORUS		Tlf.: (04) 575722
Wireline Services:		
Dresser Atlas		
Postboks 55		
4040 SUNDEBROTET		Tlf.: (04) 590166

Mud Logging:
Exploration Logging Norge A/S
Postboks 72
5065 BLOMSTERDALEN Tlf.: (05) 227495

Mud Engineering:
Promud A/S
4056 TANANGER Tlf.: (04) 696677

Production Testing:
Flopetrol Int. SA
4033 FORUS Tlf.: (04) 652277

Cementing and Pumping Services:
BJ Hughes B.V.
c/o Aker Norsco Base
4056 TANANGER Tlf. (04) 696533

2.3 Data Communication

A daily drilling report will be submitted by telex or equivalent to partners and relevant authorities every working day during operations.

A geological report will be submitted daily by telex during operations whenever new section is penetrated or relevant interpretations are available.

Wireline log films will be handcarried to the Oslo office by the well- site geologist. Sepia and paper copies of all log scales (1:200 and 1:500) will be transmitted from Oslo after copying. Rush-print paper copies will be made at the well-site when pay zones are encountered. Mud logs, pressure logs and lithological logs will be distributed at each casing depth.

All other relevant data and reports will be sent to the partners and NPD at the earliest convenience.

Each month, an operating and progress report, including summary of available data and tentative interpretations, will be distributed.

Samples will be distributed upon completion of the well.

For other information the following is valid:

> All questions concerning the operation and interpretation of data shall be put to relevant key personnel.
>
> All other questions shall be directed to our Vice President, External Relations, Roy Halvorsen or Senior Manager, Public Relations, Bjørn Glenne.

3. GEOLOGICAL PROGRAMME

3.1 Purpose of the Well

Well 31/3-3 is a wildcat drilled on structure A outside the Troll Field (fig. 3.1). The main prospect is Upper Jurassic sandstones which are gas/oil bearing in the Troll Field. The extension of these sandstones are expected to continue into the well location, but the top of the prospect, however, is structural deeper than the oil/water contact in the area.

Well 31/3-3 will penetrate a mapped stratigraphic trapped Lower Cretaceous sequence, which is a secondary prospect. Also small closures of the Brent Group and the Statfjord Formation will be drilled through. The well will be terminated in Triassic at a total depth of approximately 2525 m RKB.

3.2 Stratigraphic Prognosis (see enclosure 1)

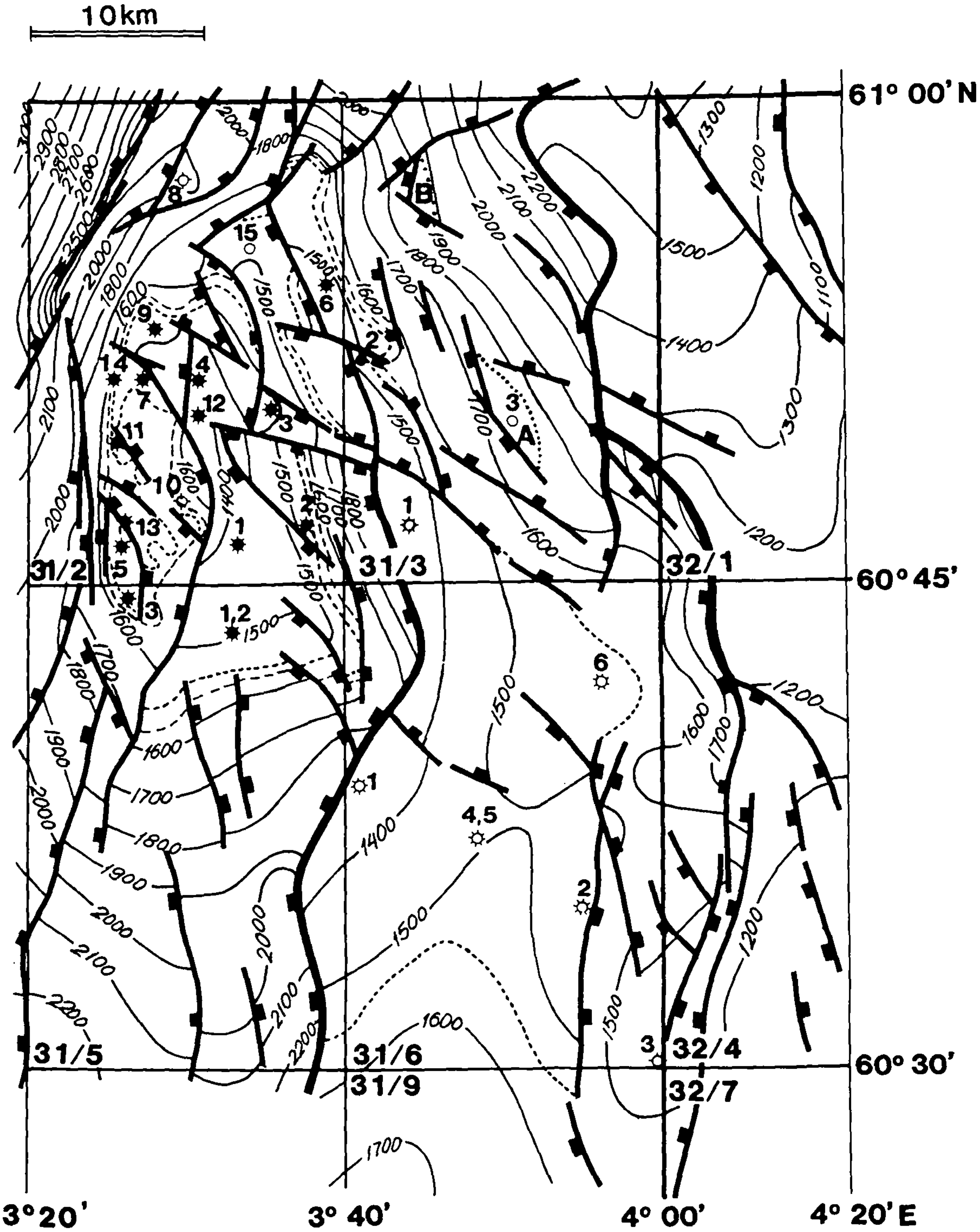
The stratigraphic prognosis can be predicted using geological data from the two nearest wells 31/3-1 and 31/3-2. Seismic tie from these wells to 31/3-3 location is demonstrated, and no major stratigraphic breaks are expected. However, some lateral lithological facies changes are likely.

The Tertiary sediments consist of various types of silty, occasionally sandy clay/claystone with stringers of sandstone and siltstone. It is divided into Nordland, Hordaland and Rogaland Groups.

The Nordland Group consists predominantly of greyish silty clay, which is soft and sticky. Moraine materials are expected in parts of the group. The bottom of the Nordland Group consists of fine to very fine grained loose sand.

TROLL FIELD

TOP RESERVOIR (TOP SOGNEFJORD FM.)
DEPTH



.... POSSIBLE HYDROCARBON/ WATER-CONTACT

-------- GAS/OIL-CONTACT

– – – – OIL/WATER-CONTACT

FIG.3.1
SEPT.84

At the location the Hordaland Group is composed of sediments of Eocene age. The lithology consists of silty and sandy clay/claystone of various colours with stringers of sand/sandstone and silt/ siltstone.

The upper part of the Rogaland Group is dominated by multicoloured tuffaceous siltstone and claystone. The rest of the group consists of claystone which is partly silty. The colours vary from grey to grey-green, occasionally brown. Stringers of marl and argillaceous limestone are present.

The Shetland Group consists of marl and limestone with some thin layers of claystone. The marl/limestone is white to light grey, soft to moderate hard, and argillaceous in parts. Occasionally, the limestone is crystalline and hard. The claystone is light to dark grey and moderate hard. Sometime it graded into marl.

The Cromer Knoll Group consists of marl/limestone as described in the Shetland Group, except that the limestone is occasionally chalky and the group may be silty and sandy in sections.

The Viking Group is divided into the Draupne Formation, the Sognefjord Formation, the Heather Formation, the Fensfjord Formation and the Krossfjord Formation.

The Draupne Formation consists of claystone which is medium to dark grey, occasionally black to dark brown in colour. The formation is moderately hard, slightly silty and carbonaceous with trace of limestone streaks.

The Sognefjord Formation consists of micaceous sandstone and siltstone. The sandstone varies in grain size from silt to coarse, occasionally granules. It is predominantly loose, but partly calcite cemented. The siltstone is medium to dark grey and moderately hard. Some coal is probably present.

The Heather Formation is divided into Unit A and Unit B with Fensfjord and Krossfjord Formations between the two units. In block 31/6 a Unit C is defined above the Sognefjord Formation. Unit C is not prognosed at the location, but if it is present, it will probably consist of siltstone.

The Heather Formation, Unit B, is made up of siltstone and sandstone similar to those described for the Sognefjord Formation.

Both the Fensfjord Formation and the Krossfjord Formation are dominated of fine to coarsed grained sandstone, partly micaceous and calcite cemented. Siltstone, shale and limestone, however, occur in layers or stringers.

The Heather Formation, Unit A, consists mostly of sandstone and siltstone, but stringers of claystone/marl and limestone are also encountered. The claystone/marl is white to light grey and moderately hard.

The Brent Group is dominated by sandstone interbedded with siltstone and shale. Layers of black coal are present. The sandstone is clear to white and fine to coarse in grain size. The shale is dark brown to black and carbonaceous.

The Dunlin Group is divided into four formations: Drake, Cook, Amundsen and Johansen.

The upper part of the Drake Formation consists mostly of sandstone with minor layers of siltstone, shale and limestone. Shale, however, dominates the lowermost part of the formation with some siltstone stringers. The sandstone is clear to white, fine to coarse grained and partly calcite cemented. The siltstone is light to medium grey, and the shale as described for the Brent Group.

The Cook Formation consists of milky white to clear sandstone with stringers of shale and limestone. The descriptions for the shale and sandstone are similar to those for the Drake Formation.

The Amundsen Formation is divided into an upper and lower part, separated by the Johansen Formation. The Upper Amundsen Formation is more shaly than the Cook Formation above, but the descriptions of the lithology is similar. The Johansen Formation consists of medium to coarse, occasionally fine sandstone. The Formation is micaceous and partly calcite cemented.

The Statfjord Formation is made up of interbedded sandstone and claystone/shale with minor amounts of coal layers. The sandstone is clear to white, occasionally light grey in colour and partly cemented. The grain size varies from medium to coarse, but occasionally fine to very coarse grains occur. The claystone/shale is red-brown to grey, firm and non calcareous. The coal is black, brittle and hard.

The Hegre Group consists of interbedded claystone/shale and sandstone. The claystone/shale is red-brown, purple and green in colour. They are partly silty and moderately hard. The sandstone is clear to white, occasionally red-brown coloured. The grain size is normally medium to coarse, but fine to very coarse grains occur. The sandstone is partly calcite cemented. Stringers of white, sometime pink in colour, limestone is present.

3.3 Velocity Functions and Depth Convertion

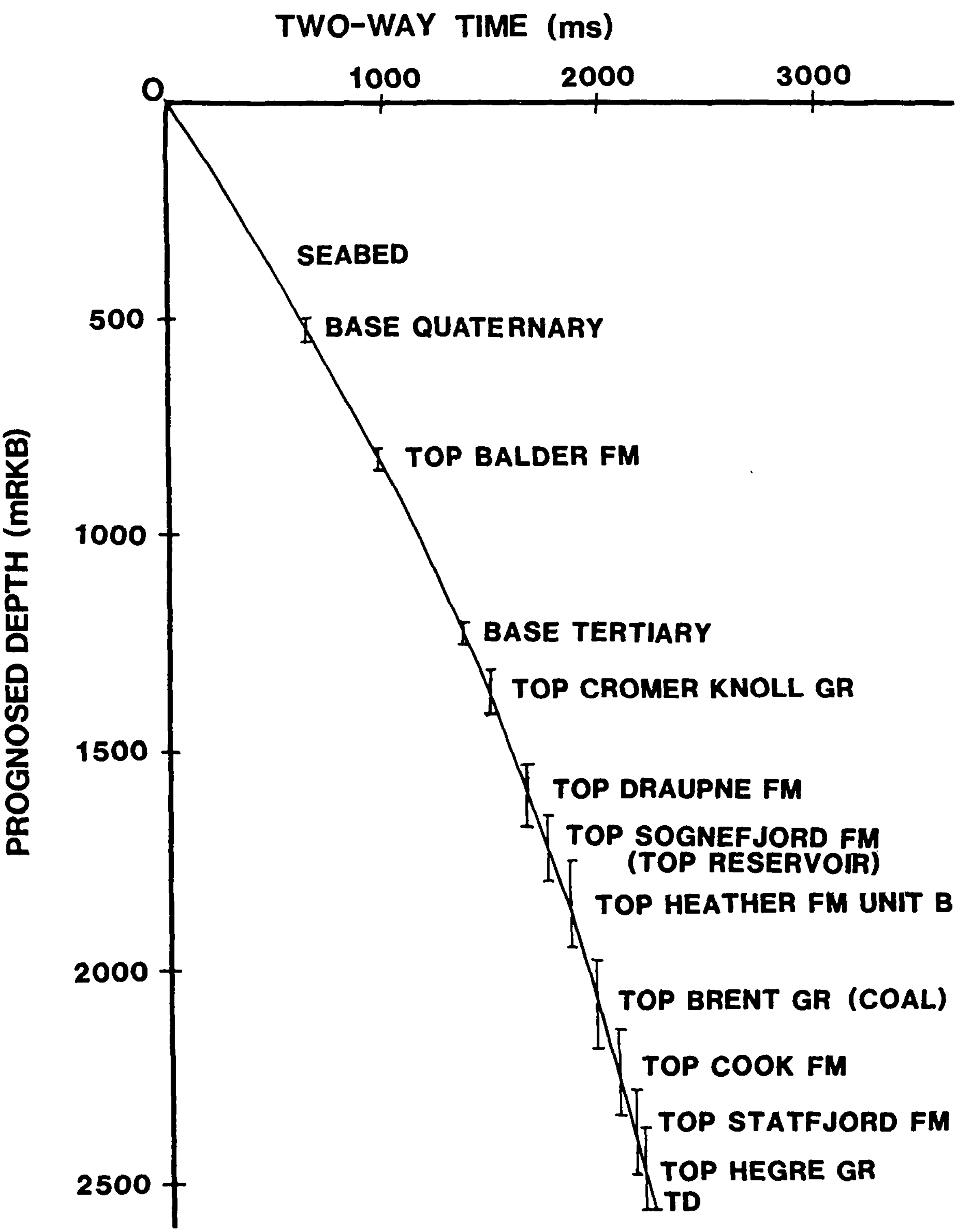
The two closest wells 31/3-1 og 31/3-2 are used to estimate the velocities for well 31/3-3 (see table 3.1). This well is placed on a separate structure outside the gas filled Troll Field. The reservoir sand (Sognefjord Formation) is structurally deeper than the other wells, so the well 31/2-8 and the stacking velocities from the seismic lines have been taken into account.

Because of rather thin layers in Cretaceous and Upper Jurassic, the interval velocities will have great uncertainties. For that reason the average velocities to the main reflectors is correlated.

The time/depth curve for well 31/3-3 with the uncertainties marked, is found in fig. 3.2. The well prognosis is listed in table 3.2.

	31/3-1			31/3-2		
Reflector	Two-way time (ms)	Depth (m MSL)	Av. velocity (m/s)	Two-way time (ms)	Depth (m MSL)	Av. Velocity (m/s)
Seabed	450	334	1484	460	340	1478
Base Quaternary	654	508	1553	680	515	1515
Top Balder Formation	1084	908	1675	1298	1096	1689
Base Tertiary	1375	1202	1748	1608	1427	1775
Top Cromer Knoll Group	1416	1250	1766	1666	1490	1789
Top Draupne Formation	1456	1297	1782	1683	1516	1802
Top Reservoir						
(Top Sognefjord Formation)	1484	1329	1791	1706	1542	1808
Top Heather, Unit B	1610	1474	1831	1798	1681	1870
Top Brent Group (coal)	1820	1773	1948	1943	1914	1970
Top Cook Formation	1920	1922	2002	-	-	-
Top Statfjord Formation	2018	2082	2063	-	-	-
Top Hegre Group	2050	2137	2085	-	-	-

Table 3.1: Depth, two-way time and average velocities to the main reflectors in the two closest wells, 31/3-1 and 31/3-2.



T-D CURVE
WELL 31/3-3

FIG.3.2

Reflector	Two-way time (ms)	Average velocity (m/s)	Depth (m MSL)	Depth (m RKB) (KB = 26 m)	Uncertainty in depth (m)	Thickness (m)	Interval velocity (m/s)
							1480
Seabed	455	1480	335	361	+/- 5		
						164	1690
Base Quaternary	650	1540	500	525	+/- 20		
						300	1820
Top Balder Formation	980	1630	800	825	+/- 20		
						395	2080
Base Tertiary	1360	1760	1195	1220	+/- 25		
						145	2230
Top Cromer Knoll Group	1490	1800	1340	1365	+/- 50		
						240	2910
Top Draupne Formation	1655	1910	1580	1605	+/- 50		
						115	2420
Top Reservoar (Sognefjord Formation)	1750	1940	1695	1720	+/- 75		
						130	3060
Top Heather, Unit B	1835	1990	1825	1850	+/-100		
						230	3290
Top Brent Group (coal)	1975	2080	2055	2080	+/-100		
						165	3300
Top Cook Formation	2075	2140	2220	2245	+/-100		
						135	3600
Top Statfjord Formation	2150	2190	2355	2380	+/-100		
						80	3560
Top Hegre Group	2195	2220	2435	2460	+/-100		
							3710
T.D.	2230	2240	2500	2525			

Table 3.2: Well Prognosis, 31/3-3.

3.4 Formation Pressure Prognosis

The formation pressure prognosis is presented in fig. 3.3.

Well 31/3-3 will be drilled to test the reservoir rocks on a structurally deeper level than the other wells in the Troll area. It is therefore possible that the pressure regime is different from the other wells. The spill point of this separate structure is calculated at 1755 m RKB (1729 m MSL), and the top reservoir is prognosed at 1720 m RKB (1694 m MSL).

In this pressure prognosis it has been taken into consideration the pressure behavior of the nearest wells (31/3-1 and 2). In well 31/3-1 a normal hydrostatic pressure gradient from the sea bed to T.D. was obtained. Well 31/3-2 showed a slight pressure build-up in the lower part of the Hordaland Group.

A normal hydrostatic pressure gradient (1.03 g/cm^3) is expected in the Nordland Group and upper part of the Hordaland Group in this well. From around 800 m RKB a slight pressure build-up is expected. This continues to rise to about 1.15 g/cm^3 (9.6 PPG) E.M.W. in the Shetland Group (around 1250 m RKB). This will probably be the maximum pressure/depth ratio of the well. From this level the pressure/depth ratio probably decreases back to normal hydrostatic at the prognosed GWC (structural spill point) at 1755 m RKB.

From the GWC to the top reservoir a gas gradient of 0.16 psi/m is anticipated. This gives a pressure/depth ratio of 1.05 g/cm^3 (8.75 PPG) E.M.W. at top of the reservoir (1720 m RKB).

From the GWC to T.D. a normal hydrostatic gradient (1.03 g/cm^3) is expected.

FORMATION PRESSURE PROGNOSIS
31/3-3

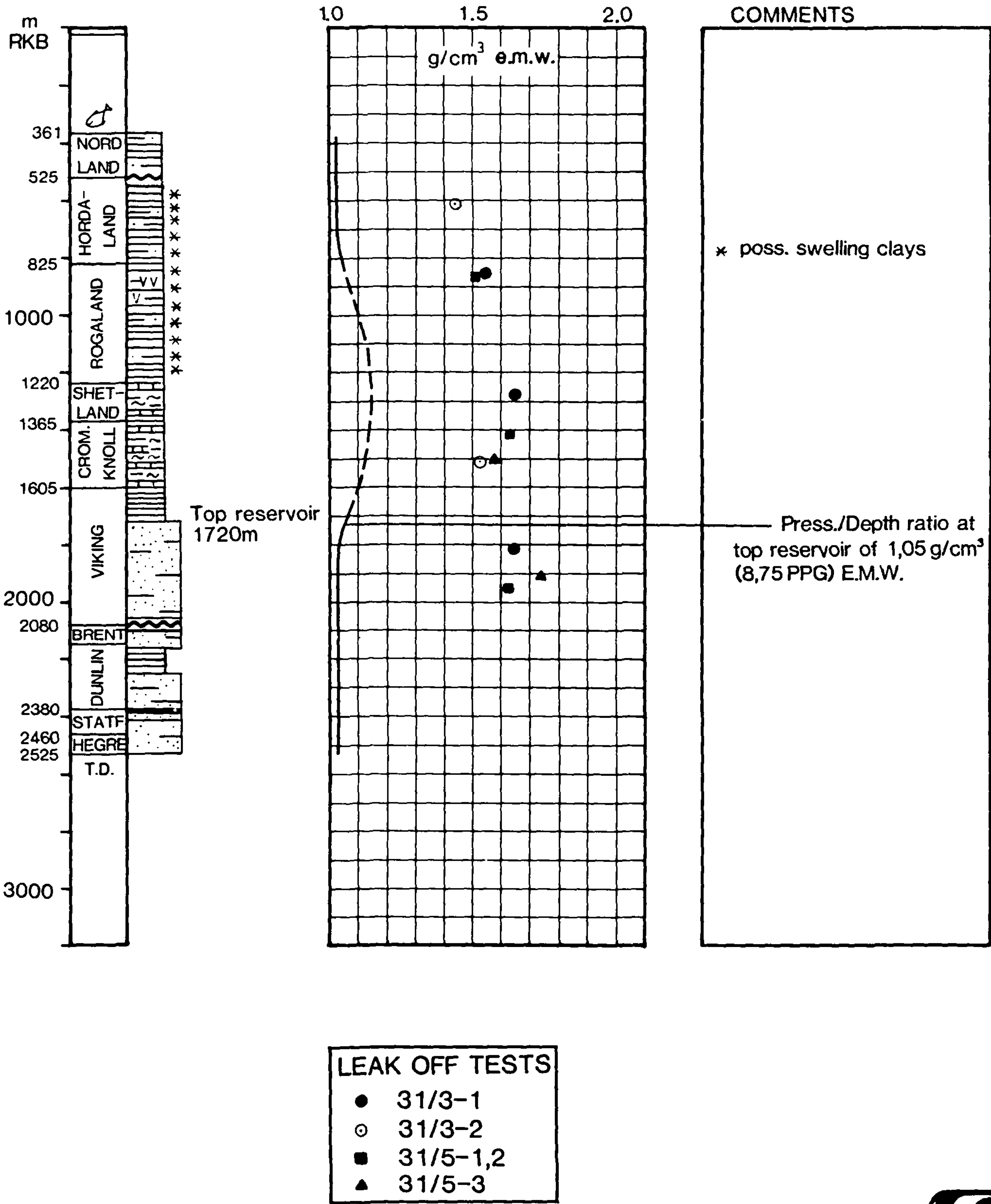


Fig. 3.3

Saga Petroleum a.s.

DATO	FORF.
TEGN. AV	GODKJ.
REF.	

3.5 Formation Pressure Detection

For the formation pressure detection a computerized mud logging unit, operated by Exlog, will be utilized.

The pressure detection procedure will include:

1. a. Exlog, both manually and automatically.
   b. Saga well-site geologist.
   c. Both the Stavanger and Oslo offices.

2. Watching hole stability.

Saga at present considers the following parameters most significant in pressure detection:

- Rate of penetration (ROP), (m/hr)
- D-exponent (d_x), (dimensionless)
- Corrected d-exponent (d_{xc}), (dimensionless)
- Weight on bit (WOB), (tons)
- Revolutions per minute (RPM)
- Total gas (TG), (%)
- Connection gas (CG), (%)
- Trip gas (TPG), (%)
- Shale density, (g/cm^3)
- Calcimetry, (%)
- Equivalent circulating density (ECD), (g/cm^3, ppg)

The Saga Formation Pressure Evaluation Sheet will include all these parameters in addition to lithology, formation changes and apparent unconformities.

3.6 Rig Location Survey

A/S Geoteam carried out a rig location survey for borehole site 31/3-3 in the period 23.08. - 03.09.1984 with the survey vessel M/S "Geo Scanner".

The survey had a digital and an analog part. The digital work (fig. 3.4) was done on a 5 x 5 km grid using an airgun source. For the anaolog programme (fig. 3.5) the vessel was equipped with sidescan sonar, deep tow sparker and multi-tip sparker. The analog programme had a triangular grid where the lines tied on to a previous analog survey run by A/S Geoteam in 1983 for the companies Statoil, Norsk Hydro and Saga.

The objectives of the rig location surveys were:

- to plot the bathymetry and map the seabed features using an echosounder and side scan sonar to determine if any obstacles or other hazards to a drilling operation are present.

- to determine the immediate sub-surface strata using a deep tow sparker and multi-tip sparker.

- to investigate the deeper sedimentary layers and detect any possible shallow gas pockets by use of a digital high resolution recording with airgun as energy source.

Survey systems

Refer to "Borestedsundersøkelse på lokasjon 31/3-3" Report No. 9634.02, September 1984 done by A/S Geoteam.

SITE SURVEY, BLOCK 31/3
DIGITAL PROGRAM

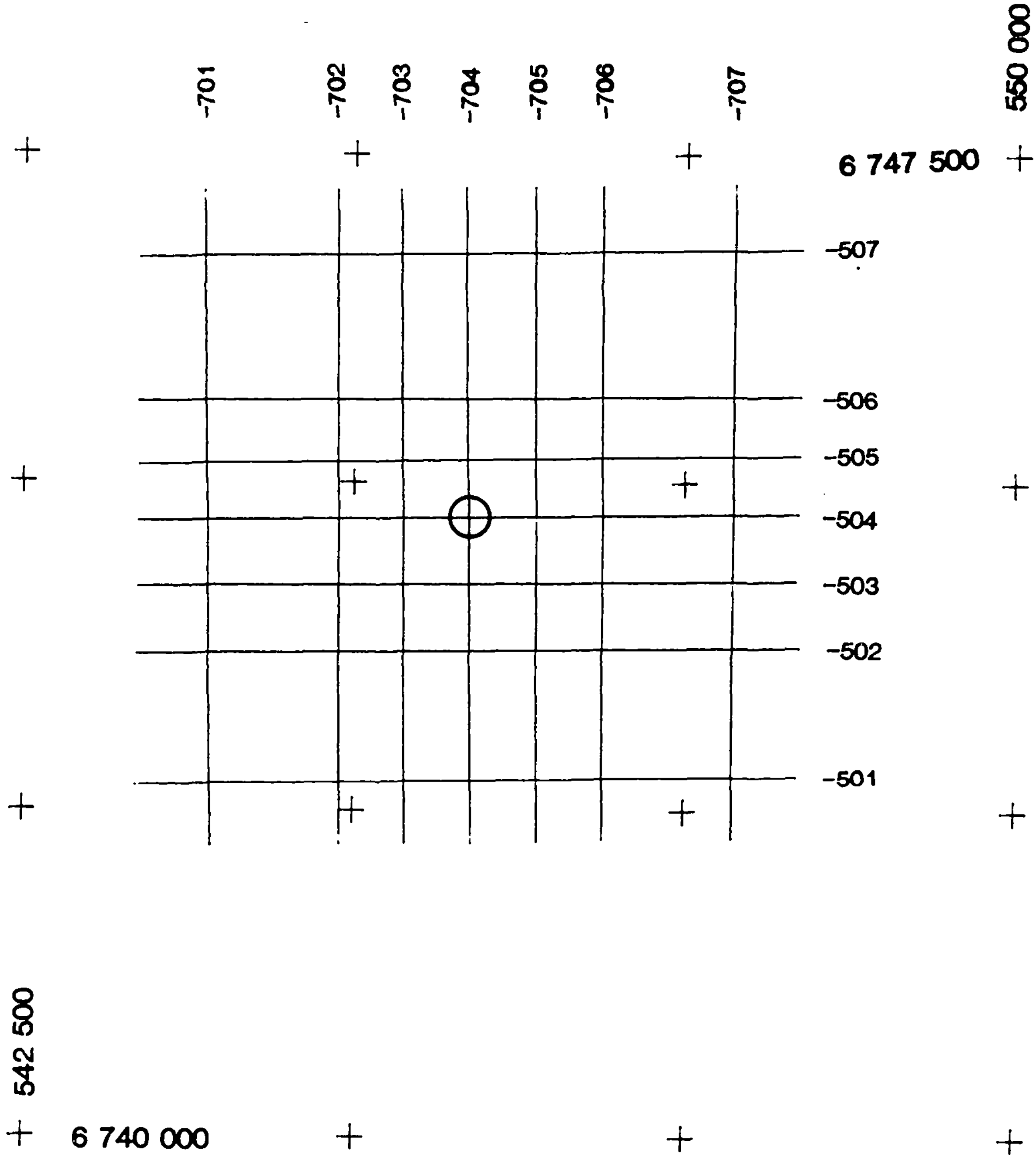


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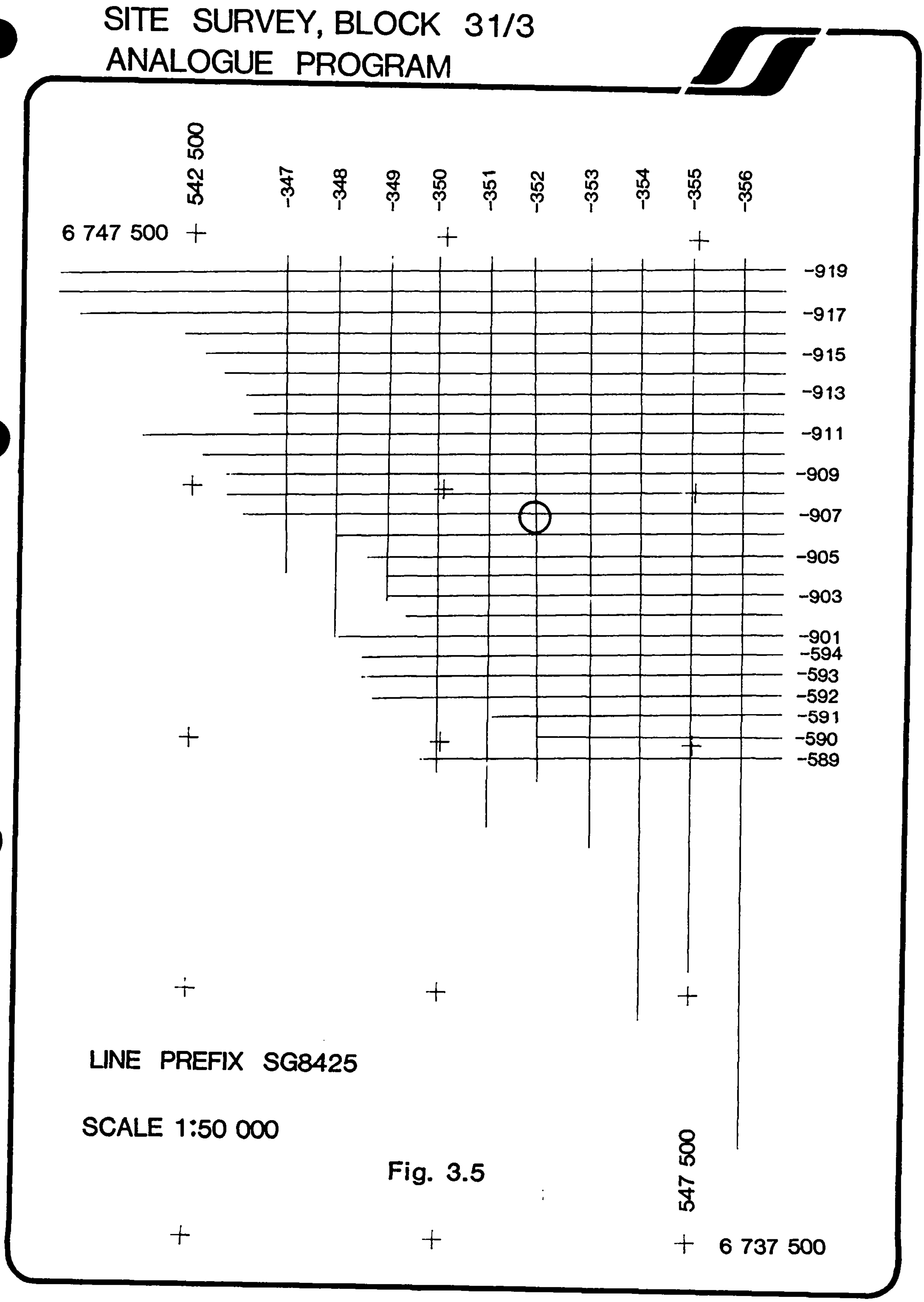
Fig. 3.4


SITE SURVEY, BLOCK 31/3
ANALOGUE PROGRAM
542 500
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6 747 500
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LINE PREFIX SG8425
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547 500
6 737 500

Fig. 3.5

3.7 Rig Navigation and Positioning

The rig move is proposed to be conducted using the syledis chain West Norway operated by A/S Geoteam. The Syledis beacons will be located on the following points:

1. Elsfjell
2. Førdesveten
3. Pollatind

The Syledis antenna will be mounted in the top of derrick. Antenna cable calibration was performed early June 1983 onboard D/B "Treasure Saga".

Dynamic move

The rig will approach location on a course equal to the diagonal of two anchors. The diagonal to be chosen depends on the desired heading of the rig and the weather conditions.

The first anchor will be held in position just above seabed and dropped in correct position during run-in towards location.

When the rig is near the intended location the diagonal anchor will be set. Remaining procedures will depend on weather situation.

Final positioning

The final positioning is performed using satellite systems in translocation. Data acquired from approximately 50 satellites will be reprocessed, and the final position determined to an accuracy better than +/-5 m. The translocation point will be Eigeberg.

3.8 Mud Logging

For the mud logging service, Exploration Logging will be employed. A fully computerized unit will be utilized. On a continuous basis the data operator will handle and machine plot all relevant drilling parameters related to pressure detection. 5 metres averages of drilling parameters will be submitted to Stavanger/Oslo offices on a twice-daily basis (6 a.m. and 2 p.m.). Partners will be provided with a drilling data pressure log, a temperature data log and a pressure analysis log in addition to the mud log. Shale densities and calcimetry values will be measured.

3.9 Wireline Logging

See fig 3.6 for a tabular description of logging programme.

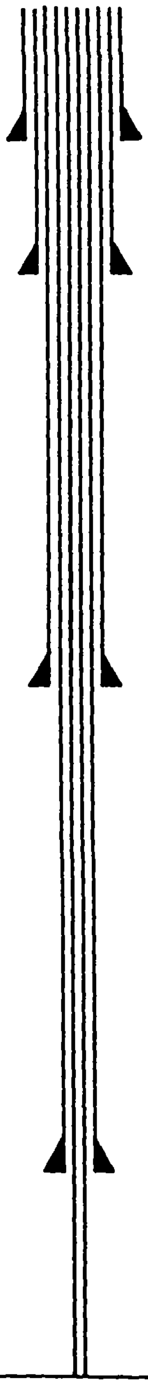
Actual logging programme will be chosen according to actual formations and fluids encountered, and is to be coordinated between the operational geology department and the formation evaluation department. All tools are to be mobilized to the rig.

As unconsolidated sand sections are expected, waveform taping should be made from LSBHC in 12 1/4 inch section, and possibly also in 8 1/2 inch section.

Spectra log is not run if high potassium muds (such as KCl Polymers) are used.

FMT to be fitted for high permeability sands, gas, oil and water are all possibilities.

DLL is run if INDUCTION reads higher than 20 ohm m in POROUS SECTIONS.

Casing Size/Depth RKB	Hole Size	Logs required	Logs optional
		GR to seafloor	
30" 481 m 20" 800 m	17 1/2" pilot	DIFL - LSBHC - GR	CDL - CNL COREGUN
	17 1/2"	DIFL - LSBHC - GR CDL - CNL - GR COREGUN	FMT DLL - MLL - GR
13 3/8" 1610 m	12 1/4"	DIFL - LSBHC - GR (+ WAVEFORM TAPING) CDL - CNL - GR HRDIP FMT COREGUN	DLL - MLL - GR SPECTRA LOG
9 5/8" 2100 m T.D. 2525 m	8 1/2"	DIFL - LSBHC - GR CDL - CNL - GR SPECTRA LOG HRDIP VELOCITY SURVEY	COREGUN FMT DLL - MLL - GR

DLL - MLL - GR if significant hydrocarbons, FMT if shows.
COREGUN at well-site geologist's request.
CNL in upper section if gas.

Fig. 3.6: Logging programme.

3.10 Velocity Survey

Well velocity surveys will be carried out in conjunction with wire-line logging at T.D. An option would be a VSP. If considered necessary a survey will be carried out at 13 3/8" casing point.

3.11 Sampling

Ditch cutting samples will be collected at 10 m intervals through the Tertiary. For the rest of the well the sampling interval will be every 3 m. The decision in changing the sampling interval will be made by the well-site geologist.

The well-site geologist may also order intermediate samples to be taken in zones of interest.

The following samples will be collected from first sample return to total depth:

1. Six wet samples (1/2 kg)
   - A. Stratlab a.s.
   - B. Norsk Hydro
   - C. Statoil
   - D. Statoil (trade set)
   - E. NPD
   - F. Saga

2. Two washed and dried samples.
   - A. Saga
   - B. NPD

3. One set of canned samples and one set of mud gas in vacucontainers will be collected at 10 m composite intervals through Tertiary, and at 9 m composite intervals from Top Cretaceous - T.D. for geochemical analysis.

From each test the following samples will be collected for geochemistry:

1. One jerrycan (min. 20 l) of oil or oil fraction of a condensate taken from the separator.

2. Two pressurized bottles (0.60 l each) at well-head pressure.

3.12 Coring

It is possible that cores will be taken in the Cretaceous. The reservoir sandstones of Upper Jurassic age will be cored down to top of the Fensfjord Formation.

Otherwise, all sands with significant hydrocarbons shows encountered will be cored.

The decision to start and terminate coring will be taken by the well-site geologist in cooperation with the Oslo office.

3.13 Sidewall Coring and FMT

Two guns of 25 shots (1 1/4" diam.) each will be available on the rig. Sample intervals will be decided after analysis of logs, but uncored sections of the reservoir will be covered by double set of SWC at 5 m intervals.

An FMT-tool will be available on the rig from below 20" casing and will be run in porous and permeable zones of interest after evaluation of logs.

3.14 Testing

If one or more hydrocarbon reservoirs are indicated by samples and logs, the well will be tested.

The tests will be designed to:

a. obtain representative fluid samples

b. evaluate the formation parameters

c. obtain initial static pressure data

The testing programme will be designed after logging possible prospective intervals. Approval by the partners will be requested before testing is initiated.

3.15 Sample Analysis

Wet samples will currently be submitted to Stratlab a.s. for biostratigraphic analysis.

Cores will be sealed and sent to Geco for analysis.

All SWC will be sent to Saga's laboratory. Fluid and gas samples will be sent to a contractor for analysis.

4. POSSIBLE DRILLING HAZARDS

4.1 Boulder Zones

Stones and boulders may be expected near ice erosion surfaces at depths of 395 m RKB and 465 m RKB. Scattered stones might otherwise exist within the whole glaciomarine sequence between 373 m RKB and 465 m RKB.

4.2 Shallow Gas

A reflection anomaly is identified at a depth of 508 m RKB.

At 533 m RKB there is a small reflection anomaly approximately 130 m west of the borehole site. This corresponds to a sandy deposit which extend across the Troll area. Small amounts of shallow gas have been encountered along this reflector in block 31/5.

4.3 Seabed Features

No seabed features which could cause an obstruction to the drilling prosess have been encountered. The nearest pockmark is located approximately 400 m from the site.

5. DRILLING PROGRAMME

5.1 Detailed Drilling Programme

All measurements in this programme refers to RKB (Rotary Kelly Bushing).

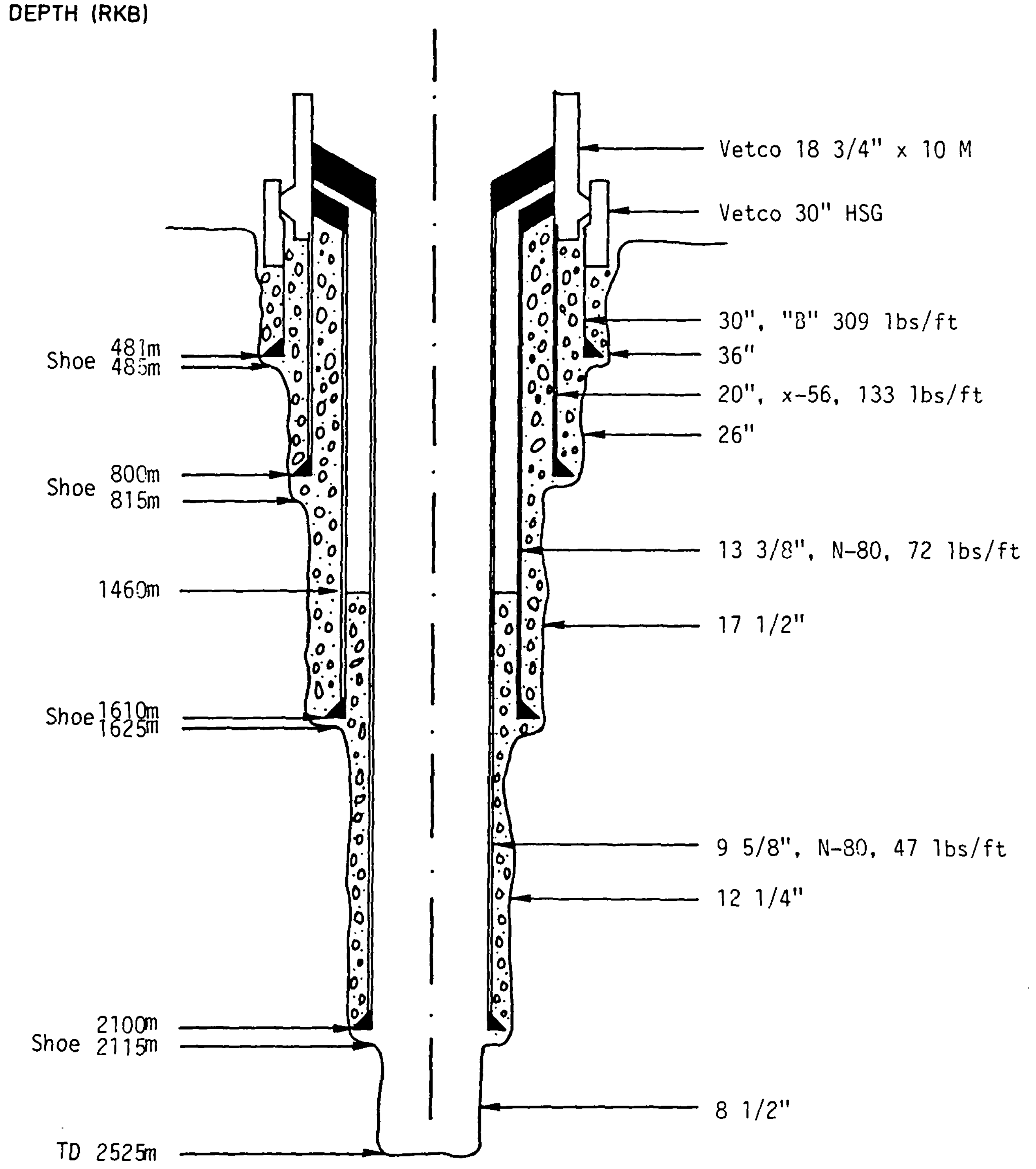


Fig. 5.1. Wellbore Schematic, 31/3-3

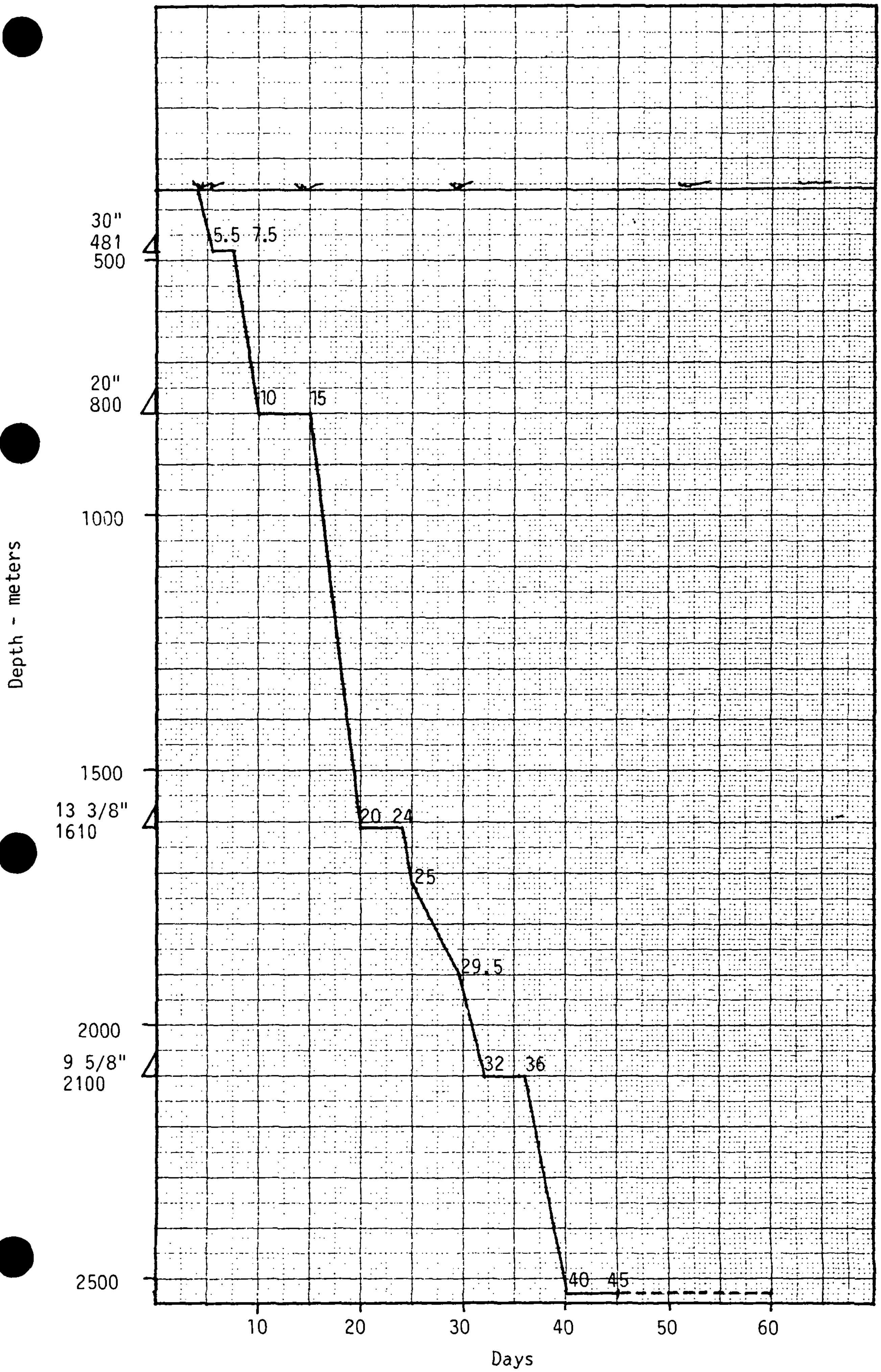


Fig. 5.2. Estimated depth vs. Rig Time, 31/3-3

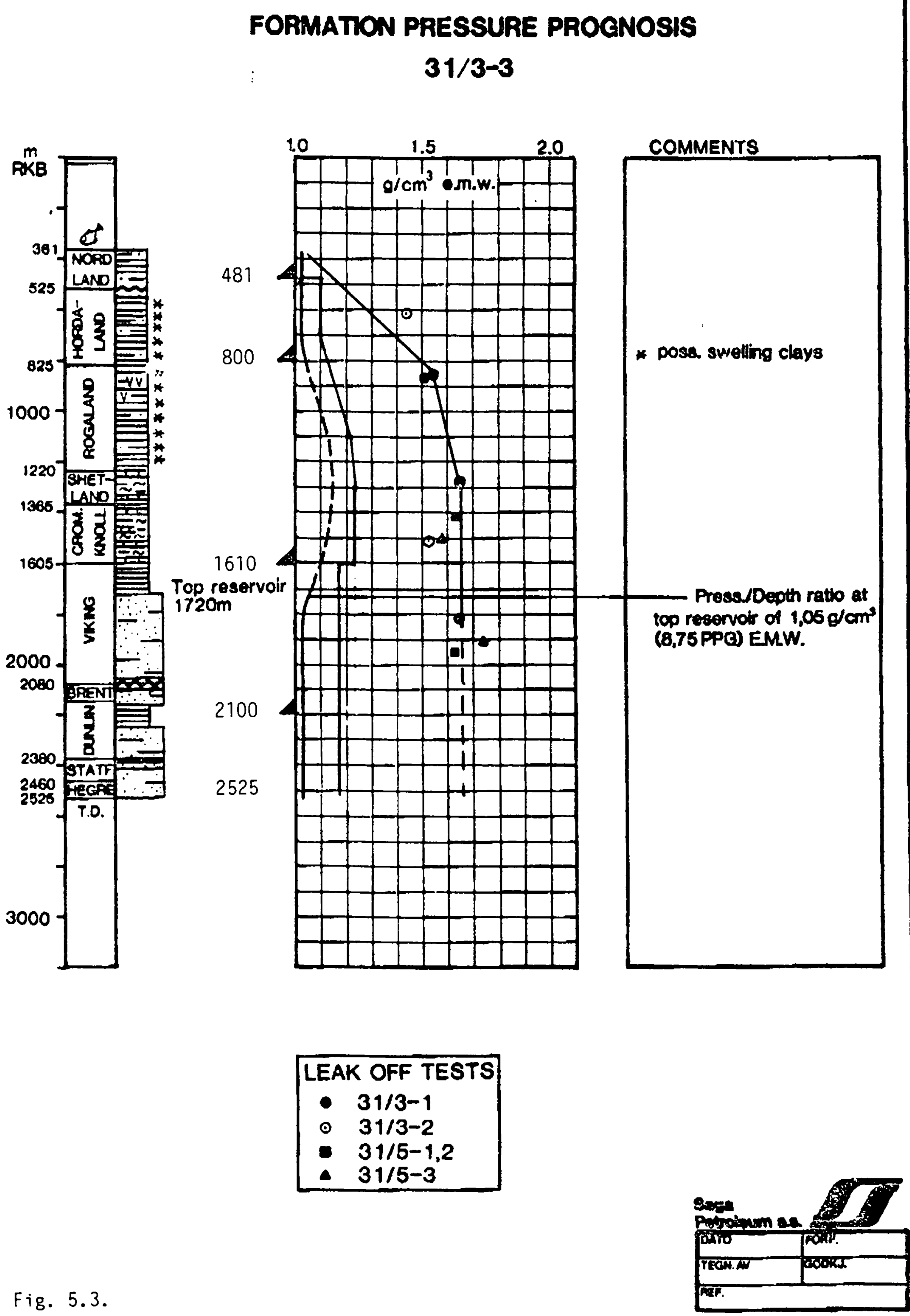

FORMATION PRESSURE PROGNOSIS
31/3-3
m RKB
361
525
825
1000
1220
1365
1605
2000
2080
2380
2460
2525
3000
NORD LAND
HORDA-LAND
ROGALAND
SHET-LAND
CROM. KNOLL
VIKING
BRENT
DUNLIN
STATF
HEGRE
T.D.
1.0
1.5
2.0
g/cm3 e.m.w.
481
800
1610
Top reservoir 1720m
2100
2525
COMMENTS
* poss. swelling clays
Press./Depth ratio at top reservoir of 1,05 g/cm3 (8,75 PPG) E.M.W.
LEAK OFF TESTS
● 31/3-1
⊙ 31/3-2
■ 31/5-1,2
▲ 31/5-3
Saga Petroleum a.s.
DATO
FORR.
TEGN. AV
GODKJ.
REF.

Fig. 5.3.

5.1.1 36 Inch Hole Section

Interval: 361m to 485m

1. Position the rig and run T.G.B. with slope indicator installed down to seabed.

2. Note and record the following data on the IADC report;
   a) RKB to water level,AG (air gap)
   b) RKB to seabed, SB (seabed)
   c) Water depth and time when data was recorded.

3. Drill the 36" hole using a 26" pilot bit and a 36" holeopener.

Note: While drilling the first joint, circulation shall be kept at a minimum (300 GPM) and only gradually raised over the next two joints.

4. Take deviation surveys on first two connections, and then as required.

5. Drill 36" hole using seawater and slugs with 15 to 25 bbls of spud mud prior to making connections. Should it become difficult to keep the hole open, increase the gel slug size prior to making connections. Displace 100 bbl hi-vis mud around when at bottom.

6. Drop deviation survey and make a short wiper trip to the seabed to check the hole. Retrieve the survey.

7. RIH and displace the hole with a viscous mud and POOH.

8. Pick up 30" shoe joint and run the 30" casing. Attach guiding mechanism to the float shoe. Fill up every joint after splash zone is passed.

9. Pick up the 30" housing joint and make it up to the 30" casing string.

10. Run a 5" drillpipe stinger inside the 30" casing to within 30 m of the float shoe.

11. Make up the running tool in the housing and run the string through the rotary table.

12. Install the permanent guide base with slope indicator on the moon-pool trolley. Move trolley to center position of moon-pool and make the PGB up to the 30" housing. Attach the guide lines to the guide base.

13. Lower the casing and fill the drillpipe before every connection. Land casing with permanent guide base in the temporary guide base.

14. Displace the drillpipe and casing volume below stinger with seawater. Mix cement according to the cement programme and displace the cement with seawater.

15. Leave approximately 10 m of cement inside the 30" casing. Five sacks of mica pumped ahead of the cement will aid in identifying the cement return.

16. Check the float shoe. If it does not hold, shut in at the surface and allow the cement to initial set before releasing the pressure.

17. If necessary, hold tension until the casing is cemented.

18. Back off running tool and pull out of hole with the drillpipe and cement stinger.

5.1.2 26 Inch Hole Section

Interval: 481 to 815 m

1. RIH with 26" bit and drill out the cement, 30" shoe and rathole. POOH.

2. Pick up and run the riser with 30" hydraulic latch and dump valve.

3. Latch on to 30" housing. Pull test with 20.000 lbs.

4. Pick up 17 1/2" bit and MWD tool. RIH. Install the diverter packing element. Function check the diverter properly, and pump seawater through the lines to assure that they are open.

5. Be aware of potential shallow gas zones when drilling the pilot hole to planned depth.

6. Drill with prehydrated gel mud. BHA shall be according to Saga Petroleum a.s.'s drilling manual for this section.

7. After reaching T.D., circulate the hole clean and sweep hole with a 50 bbls highly viscous pill and POOH to the 30" wellhead housing. Displace riser to seawater, open dump valve. Monitor dump valve for flow with sub sea TV for 30 minutes. RIH. Circulate bottoms up. POOH.

8 Run logs as per programme.

9. RIH with a pilot bit and a 26" underreamer and open the hole to 26".

10. When reaching T.D. circulate the hole clean. POOH to 30" casing shoe.

11. Prior to disconnecting the riser the hydrostatic head in the wellbore with the seawater column must exceed the hydrostatic head during flowcheck.

12. Displace the riser to seawater. Observe for flow for 15 minutes with the T.V. camera on bottom. If the hole is static, P.O.O.H. slowly.

13. Release 30 inch hydraulic latch and pull the riser.

14. Make check trip with 26" bit.

15. Pick up the 18 3/4" wellhead housing joint. Inspect the wellhead to ensure that a nominal seat protector is not installed in the wellhead. Make up plug launching assembly on left hand thread running tool and make up into wellhead housing with 5 turns to left with chain tongs. Stand back in derrick.

16. Have a 20" swage available on the rig floor while running casing.

17. Run the 20" casing. Check float shoe and float collar for proper installation, and use ropes and shackles for guidance on shoe joint.

18. Once casing is below water level, fill each joint with mud at required weight as it is run.

19. Install the 18 3/4" wellhead in the casing string.

    Pipe should continously be filled after making up running tool and running the landing string.

20. Install a circulating head on the last joint of the running string and break circulation with mud before 18 3/4" wellhead housing is landed in the 30" housing. Land the casing, pull 30000 lbs over casing weight to verify that the 18 3/4" head is in place. Circulate 20 bbls of mud at required weight to ensure float is not plugged.

21. Cement as per programme to seabed using only a top wiper plug. Displace the cement with mud. Hold pressure for 5 minutes, then bleed off and check for backflow. Displacement pressure should <u>not exceed 1000 psi.</u>

22. If float is holding, release running tool and retrieve running string. If not, maintain back pressure until cement has set up.

23. Observe wellhead on subsea T.V. camera.

5.1.3 17 1/2 Inch Hole Section

Drilled interval	815 - 1625m
Max expected B.H.P.	175 bar (2540 psi)
Gas Gradient	0.0090 bar/m (0.13 psi/m)
85% of the maximum burst pressure of the 20" casing	179 bar (2600 psi)
B.O.P. pressure test at wellhead	164 bar (3750 psi)
20" casing pressure test (differential pressure)	164 bar (2375 psi)

1. A complete pressure test to 10.000 psi should be performed with the 18 3/4" B.O.P. on the test stump. The pressure chart should show absolute constant 10.000 psi pressure for 10 minutes. (Upper spherical to 3500 psi, lower spherical to 7000 psi).

2. Run the B.O.P. stack on 21" riser, and land carefully on the wellhead. Tension up with 50000 lbs above the stack weight, to ensure the connector is latched.

3. Test B.O.P. stack for 10 minutes. Install seat protector. Make up 17 1/2" bottom hole assembly, and R.I.H.

4. Install diverter bushing and close diverter bag on drill pipe and pump through the system in both directions.

5. Clean out the casing to 5 m above shoe. Pressure test 20" casing for 10 minutes. Drill out cement and clean out the rat hole. Drill 5 m of new hole and circulate the hole clean. Perform a leak-off test.

6. Drill 17 1/2" hole to predetermined depth and cut cores if required.

7. When having drilled down the section, circulate until shakers are clean. Make a wiper trip to the 20" shoe. POOH.

8. Log hole as per logging programme, should the logging tool fail to go to bottom, R.I.H. increase the viscosity and yield point of the mud and make a second wiper trip.

9. Pick up 18 3/4" x 13 3/8" casing hanger. Make up running tool with the sub sea plug launching assembly attached. Stand back in derrick.
   Note: Pack-off should be run with casing hanger.
   Ensure locking ring on hanger is removed.

10. Retrieve the seat protector.

11. Run the 13 3/8" casing as per casing and cementing programme.

12. Thread lock the first 2 connections. Fill casing with mud every 5 joint while R.I.H.

13. Run casing to wellhead and land the hanger in the wellhead as circulation is established. Have choke and kill lines open to atmosphere when running through BOP.

14. Check floats for circulation and circulate minimum the volume of casing + 25%. If lost circulation, leave the casing landed and contact the operation office onshore. If circulation, drop ball.

15. Mix cement, pump the dart and shear the wiper plug. Displace with the rig pumps. Bump plug with minimum pressure, build up and test casing for 10 mins. Check that floats are holding. If not, hold backpressure until the cement has set.

   Note: If the top wiper plug does not bump after the calculated displacement volume, never overdisplace more than 50% of the theoretical volum between the float collar and shoe to avoid overdisplacing the cement.

16. Set pack-off element and test same to max. expected bottom hole pressure minus gas gradient for next hole section to be drilled.

    Note: Monitor volumes carefully. Any pack-off leak will go against 13 3/8" - 20" annulus.

5.1.4 12 1/4 Inch Hole Section

Drilled interval	1610m to 2115 m
Max expected B.H.P	213 bar (3100 psi)
Gas gradient	0.0172 bar/m (0.25 psi/m)
85% of the maximum burst pressure of the casing	314 bar (4550 psi)
BOP pressure test	183 bar (2650 psi)
13 3/8" casing pressure test (differential pressure)	183 bar (2500 psi)

1. Test B.O.P. stack. Test pressures to be held for 10 minutes. Install wear bushing.

2. Clean out to the float using 12 1/4" B.H.A. Pressure test the 13 3/8" casing for 10 minutes, (only if the plug was not bumped). Drill out the remaining cement, rat hole and 5 m of new hole. Circulate until the shakers are clean. Perform a leak off test. Drill ahead to top of reservoir. POOH.

2. Cut cores as necessary.

4. When T.D. is reached for the 12 1/4" hole section, circulate bottoms up until the shakers are clean. Make wiper trip to the 13 3/8" shoe. POOH.

5. Log hole as per logging programme. Should logging tool fail to go to bottom, R.I.H. increase the viscosity and yield point of the mud and make a second wiper-trip.

6. Pick up 18 3/4" x 9 5/8" casing hanger. Make up running tool with subsea plug launching assembly attached. Stand back in derrick.

   Note: Ensure locking ring on the hanger is removed. Pack-off should be run with casing hanger.

7. Pull the 13 3/8" wear-bushing. Have a 9 5/8" swage available on the rig floor while running casing.

8. Run 9 5/8" casing. Thread lock the first 2 connections, check floats for circulation. Fill the casing with required mud-weight while running in the hole and calculate maximum running speed to keep surge pressure below the leak-off pressure on last casing shoe.

9. Run casing to approximately 10 m above T.D. and land the hanger in the wellhead as circulation is established. Open choke and kill lines to atmosphere.

10. Make up cementing head and circulate minimum the volume of casing + 25%. Drop ball and pump cement. If no return leave casing landed and contact the operation office onshore for instructions.

11. Drop the dart and shear the wiper plug and displace the cement with the rig pumps. Bump plugs with minimum pressure, build up and test casing for 10 minutes. Check that floats are holding.
    Note: Do not overdisplace cement.

12. Set pack-off element and test same.
    Note: Monitor volumes carefully. Any pack-off leak will go against 9 5/8" - 13 3/8" annulus.

5.1.5 8 1/2 Inch Hole Section

Drilled interval	2100m to 2525 m
Max expected B.H.P.	256 bar (3720 psi)
Gas gradient	0.0179 bar/m (0.26 psi/m)
85% of the maximum burst pressure of the 9 5/8" casing	403 bar (5840 psi)
BOP pressure test	217 bar (3150 psi)
9 5/8" casing pressure test (differential pressure)	217 bar (3150 psi)

1. Pressure test the B.O.P. stack. Test pressures to be held for 10 minutes. Install wear bushing.

2. Clean out casing to top of the float with 8 1/2" BHA. Pressure test 9 5/8" casing for 10 minutes (only if the plug was not bumped).

3. Drill out remaining cement inside casing and rat hole plus 5 m of the new hole below 9 5/8" casing shoe. Circulate until the shakers are clean. Perform a leak off test.

4. Drill down to T.D for this hole section.

5. Circulate the hole clean and make a wiper trip to 9 5/8" casing shoe. POOH.

6. Run logs as per logging programme. Should the logging tool fail to go to bottom, raise the viscosity and yield point of the mud and make a second wiper trip.

   Note: If a 7" liner is to be set, a liner programme will be issued.

5.2 Relief Well Programme

Detailed technical planning in advance, is neither possible nor needed, when drilling a relief well.

From the time rig is selected until the rig will arrive the location, there will be sufficient time to work out the relief drilling programme. However, the need for drilling a relief well should be considered already when planning the original well.

1. Site survey.

   An area of (5 x 5) sq. km is to be surveyed.
   The main objectives will be:

   - To plot the bathymetry and map all seabed features based on echosounder and sidescan sonar data, to determine if there will be any hazards to the drilling operation.

   - To determine the shallow geology using a deep tow-boomer system.

   - To investigate the deeper sedimentary layers and detect shallow gas pockets by using analogue and digital high resolution sparker.

2.

   A complete wellhead system shall be available on short notice, either from stock or from supplier. Casing and mud chemicals shall also be kept as back-up on the base. Location of base is dependent on location of rig (Stavanger, Florø, Kristiansund N or Sandnessjøen).

3.

A list of rigs and equipment available for the drilling/killing operation should be worked out. Make sure this list is regularly updated.

4.

The location for the relief well can not be established in advance of the blowout.
When selecting a location, the following factors must be considered:

- Sufficient water depth for the rig.
- Sufficient distance between the relief well and the blowing well to prevent risks of fire or damage to the crew and equipment operating on the drill site.
- Direction of wind and current.
- Geology of formation to be drilled, fluid content and pressure, strike and dip.
- Wellbore location of the blowing well.

A detailed drilling programme will be worked out in co-operation with a directional drilling company, and with reference to the relief well drilling manual.

5.3 Casing Design

5.3.1 Basic Well Data

RKB - Sealevel, AG	= 26 m
Water depth,	= 335 m
RKB - Seabed,SB	= 361 m
30" Casing shoe, $CS_{30"}$	= 481 m
20" Casing shoe, $CS_{20"}$	= 800 m
13 3/8 "Casing shoe, $CS_{13\ 3/8"}$	= 1610 m
9 5/8" Casing shoe, $CS_{9\ 5/8"}$	= 2100 m
Top reservoir,	= 1720 m
Total well depth	= 2525 m

5.3.2 Basic Design Criteria

The following assumptions apply:

5.3.2.1 Collapse pressures

During drilling operations

The possibility of lost returns when reaching the next casing setting depth can cause the fluid level inside the casing to drop to a level where the pressure excerted by the fluid (mud) column is balanced by the formation pressure, assuming a normal porepressure gradient (0,101 bar/m), see fig. 5.4.

If the calculated fluid level drop for the surface casing (20") is less than 250 m below the wellhead, 250 m shall be used as a minimum fluid level drop. However, if the fluid drop for the intermediate casing (13 3/8", 9 5/8") exceeds 40% of the present casing setting depth, measured from RKB, 40% shall be used as the maximum fluid drop.

The external load is excerted by a mud column outside the casing equal to the mud in which the casing was run. The internal or back-up fluid will be mud from top of the casing shoe. This mud is equal to the mud used down to the next casing shoe, see fig. 5.5.

<u>During testing operations</u>

If the casing string is set only for the purpose of performing a production test, the lost circulation criterion will not be applied. In this case the following criteria must be used.

The external pressure is excerted by a mud column outside the casing equal to the mud in which the casing was run.

Back-up fluid inside the casing above the sump packer but below the DST packer will be dieseloil if the reservoir is assumed to be an oil reservoir. This diesel oil extends all the way back to the surface. Above the DST packer (between the casing and the tubing) the back up fluid is assumed to be saltwater. However, if the reservoir is likely to produce gas, the casing shall be assumed empty between the two packers. The reason for this assumption is that the perforations may plug up when initiating the test resulting in an evacuated string. Back-up fluid above the DST packer will be saltwater.

Below the sump packer use the same mud as the casing was run in, see fig. 5.6.

5.3.2.2 Burst pressure

<u>During drilling operations</u>

The surface pressure is arbitrary and must not exceed the working pressure rating of the surface equipment used (maximum BOP working pressure).

The fracture pressure at the casing shoe, less the pressure from a gas column filling the casing, assuming a specific gas gravity equal to 0.6 (methane gas, air = 1,0) is used to design the burst load line, as long as the next casing setting depth is different from the main objective (TD). The gas weight is neglected for the surface (20") casing. The surface pressure is equal to the estimated pressure at the casing shoe less the pressure caused by a gas column inside the casing.

Back-up fluid outside the casing will be saltwater. If the 13 3/8" or the 9 5/8" casing strings are the last casing strings to be run before reaching total depth, the burst load line will usually not be limited by the fracture pressure at the casing shoe but by the maximum expected porepressure below the casing shoe. (The fracture pressure at the casing shoe in this case is usually greater than the maximum pore pressure below the casing shoe).

<u>During testing operations.</u>

Several assumptions have to be made;
The density of the packer fluid is assumed equal to the weight of the mud in the annular space behind the casing. This mud is similar to the mud in which the casing was run.

The second assumption is that there is a tubing leak near the surface, with the result that surface tubing pressure is introduced as a burst load over the entire length of the casing.

The surface tubing pressure is equal to the predicted reservoir pressure less a pressure equal to the weight of a gas column from top to bottom, see fig. 5.7.

The fracture gradient is not used when designing the production casing.

5.3.2.3 Tension load calculations

The maximum expected load during installation is the greater of

	weight	buoyancy	bending	pressure
either		+	+	+
	in air	force	force	testing load
	weight	buoyancy	bending	shock
or		+	+	+
	in air	force	force	load

5.3.2.4 Biaxial stress loads

A combination of outside pressure and tension in the casing string results in a reduction in collapse resistance, but an increase in burst resistance of the casing. The increase in burst resistance is neglected. Fig. 5.8 or table 5.1 can be used to find this reduction in collapse strength if required.

5.3.2.5 Design factors

Design factors for collapse, burst and tension loads will be: 1.1, 1.1, and 1.3 respectively.

5.3.3 Design Calculations

5.3.4 30" Casing Design - Setting depth 481 m

This string will consist of 119 m of API "B", 309,72 lbs/ft casing.

Burst, collapse, and tension loads are not considered to represent any problem.

5.3.5 20" Casing Design

- Setting depth	800 m
- Fracture gradient at the 20" casing shoe, (G_F)	1.50 SG
- Mudweight in which the 20" casing was run (G_M)	1.13 SG
- Maximum expected mudweight at the 13 3/8" casing shoe, (G_M')	1.22 SG
- 13 3/8" casing shoe	1610 m

5.3.5.1 Collapse pressure calculations

$$T_M = TD - \frac{(TD - AG)\, G_P}{G_M'} \qquad (T_M > 250 + SB)$$

$$T_M = 1610 - \frac{(1610 - 26)0.101}{0.120} = 273 \text{ m}$$

T_M = 273 m < 250 m below the wellhead =>

T_M = (250 + 361)m = 611 m

$$P_C = G_M(X-SB) + G_{SW}(SB-AG) \qquad SB < X < T_M$$

$$P_C^* = P_C - G_M'(X - T_M) \qquad T_M < X < CS$$

$P_{C,361}$ = 33.9 bar

$P_{C,MAX}$ = $P_{C,612}$ = 61.7 bar

$P_{C,800}$ = 60.0 bar

$P_{C,REQ}$ = (1.1 · 61.7) bar = 68 bar

5.3.5.2 Burst pressure calculations

$P_B = G_F CS - G_{SW} (X - AG)$ SB < X < CS

$P_{B,361}$ = 83.8 bar

$P_{B,800}$ = 39.6 bar

$P_{B,REQ}$ = (83.8 · 1.1) bar = 92.16 bar

X-56, 133 lbs/ft (197,9 kg/m) is strong enough to resist both the collapse and burst loads.

5.3.5.3 Tension load calculations

<u>Static load</u> (F_S)

$F_S = (W_N - F_B)\ CL + F_b$

$$F_S = W_N\ CL\ (1 - \frac{G_M}{G_{ST}}) + 19.222\ D\ O\ W_N$$

$$F_S = (197.9 \cdot 438\ (1-\frac{1.13}{7.85}) + 19.222 \cdot 20 \cdot 2 \cdot 197.9)9.81 \text{ Newton}$$

$F_S = 222 \cdot 10^4$ Newton

Tension loads due to pressure testing of the casing

Maximum design test pressure is set equal to 85% of the burst resistance for the actual grade.

$$P_T = P_{B,RES.} \cdot 0.85$$

$$F_{PT} = 10 \cdot P_T \cdot A$$
$$P_T = 0.85 \cdot 215 \text{ bar} = 183 \text{ bar}$$
$$A = 1776 \text{ cm}^2$$
$$F_{PT} = (10 \cdot 183 \cdot 1776) \text{ Newton} = 325 \cdot 10^4 \text{ Newton}$$

Shock load calculations

Average running speed for the casing string is set equal to 13 sec. per. joint. Average length of one joint is approximatly 12m.

$$F_D = 10^4 \cdot V_P \cdot W_N$$
$$F_D = (10^4 \cdot \frac{12}{13} \cdot 197.9) \text{ Newton} = 183 \cdot 10^4 \text{ Newton}$$

The greater of

$(F_S) + (F_{PT})$ or $(F_S) + (F_D)$ gives the tension loads on the casing string.

$$F_S + F_{PT} = (222 \cdot 10^4 + 325 \cdot 10^4)\text{Newton} = 547 \cdot 10^4\text{Newton}$$

is greater than

$$F_S + F_D = (222 \cdot 10^4 + 183 \cdot 10^4)\text{Newton} = 405 \cdot 10^4\text{Newton}$$

Maximum tension load will therefore be

$F_{T,MAX} = 547 \cdot 10^4$ Newton
$F_{T,REQ} = (1.3 \cdot 547 \cdot 10^4)$ Newton $= 711 \cdot 10^4$ Newton

Minimum tension strength of X-56, 133 lbs/ft csg is $948 \cdot 10^4$ Newton.

$F_{T,REQ} < 948 \cdot 10^4$ Newton implying that the chosen casing grade will resist collapse, burst and tension loads.

5.3.5.4 Actual design factors

Collapse : $DF_C = \frac{99}{62} = 1.60$

Burst : $DF_B = \frac{215}{84} = 2.56$

Tension : $DF_T = \frac{948 \quad 10^4}{547 \quad 10^4} = 1.73$

5.3.6 13 3/8" Casing Design

-	Setting depth	1610 m
-	Fracture gradient at the 13 3/8" casing shoe, (G_F)	1.66 SG
-	Mudweight in which the 13 3/8" casing was run (G_M)	1.22 SG
-	Maximum expected mudweight at the 9 5/8" casing shoe, (G_M')	1.18 SG
-	9 5/8" casing shoe	2100 m
-	Maximum expected pressure gradient at top reservoir (G_{TZ})	1.05 SG
-	Top reservoir at (TZ or TP)	1720 m

5.3.6.1 Collapse pressure calculations

$$T_M = TD - \frac{(TD - AG)\ G_P}{G_M'} \qquad (T_M < 0.4CS)$$

$$T_M = 2100 - \frac{(2100 - 26)0.101}{0.166} = 290m$$

Top of mud will not drop below wellhead

$$P_C \ = G_M(X-SB) + G_{SW}(SB-AG) \qquad (SB < X < T_M)$$
$$P_C^* = P_C - G_M'(X - T_M \qquad (T_M < X < CS)$$

$P_{C,361}$ = 25.7 bar
$P_{C,REQ}$ = (1.1·25.7)bar = 28 bar

5.3.6.2 Burst pressure calculations

$$P_B = P_{MAX} + (X - CS)G_G - G_{SW}\ (X - AG) \qquad SB < X < CS$$

$$G_G = \frac{P_{MAX} - P_S}{CS - SB}$$

$$P_{MAX} = G_F\ \ CS$$
$$P_{MAX} = 0.163\ \ 1610 = 262 \text{ bar}$$

$$P_S = \frac{P_{MAX}}{e^{\frac{G\ L}{16.3\ \ T_{avg}Z}}}$$

$$T_{avg} = T_{SB} + \frac{T(CS - SB)}{2}$$

$$T_{avg} = 4^o + \frac{0.036(1610 - 361)^o}{2} = 26^oC(539^oR)$$

$$P_S = \frac{262}{e^{\frac{0.6 \cdot 1248}{16.3\ \ 539\ \ 1}}} = 241 \text{ bar}$$

$$G_G = \frac{262 - 241}{1610 - 362} = 0.0172 \text{ bar/m}$$

$$P_{B,361} = P_{B,MAX} = 207 \text{ bar}$$
$$P_{B,1610} = 102 \text{ bar}$$
$$P_{B,REQ} = (207\ \ 1.1) \text{ bar} = 228 \text{ bar}$$

N-80, 72 lbs/ft (107.1 kg/m) casing will withstand these collapse and burst loads.

5.3.6.3 Tension load calculations

Static loads

$F_S = (W_N - F_B)\ CL + F_b$

$F_S = W_N\ CL(1 - \frac{Gm}{G_{ST}}) + 19.222\ D\ O\ W_N$

$F_S \text{Newton} = (107.17\ \ 1248\ (1-\frac{1.22}{7.85})+19.222\ 13.37\ 2\ 107.17)\ 9.81\ \text{Newton}$

$F_S = 165 \cdot 10^4 \text{Newton}$

Tension load due to pressure testing

$F_{PT} = 10 \cdot P_T \cdot A$

$P_T = (0.85 \cdot 371)\text{bar} = 315\ \text{bar}$

$A = 772\ \text{cm}^2$

$F_{PT} = (10 \cdot 315 \cdot 772)\text{Newton} = 2433 \cdot 10^3\text{Newton}$

Shock load calculations

$F_D = 10^4 \cdot V_P \cdot W_N$

$F_D = (10^4 \cdot \frac{12}{13} \cdot 107.17)\text{Newton} = 99 \cdot 10^4\text{Newton}$

Maximum tension load will be

$F_{T,MAX} = (165 \cdot 10^4 + 244 \cdot 10^4)\text{Newton} = 408 \cdot 10^4\text{Newton}$

$F_{T,REQ} = (408 \cdot 10^4 \cdot 1.3)\text{Newton} = 531 \cdot 10^4\text{Newton}$

Minimum tension strength of N-80, 72 lbs/ft is $7377 \cdot 10^3$Newton

$F_{T,REQ} < 7377 \cdot 10^3\text{Newton}$

The chosen casing grade will resist collapse, burst, and tension loads.

5.3.6.4 Actual design factors

Collapse : $DF_C = \frac{184}{26} = 7.08$

Burst : $DF_B = \frac{371}{207} = 1.79$

Tension : $DF_T = \frac{738 \ 10^4}{408 \ 10^4} = 1.81$

5.3.7 9 5/8" Casing Design

- Setting depth 2100 m
- Mudweight, (G_M) 1.18 SG
- Top reservoir at 1720 m
- Maximum expected pressure gradient at top reservoir, G_{TZ} 1.05 SG
- Total well depth 2525 m

5.3.7.1 Collapse load calculations

During drilling operations

$$T_M = TD - \frac{(TD - AG)G_P}{G_M'} \qquad T_M < 0{,}4 \cdot CS$$

$$T_M = 2100 - \frac{(2100 - 26)\ 0.101}{1.1 \cdot 0.0981} = 158 \text{ m}$$

Top of mud will not drop below wellhead

$$P_{C,361} = P_{C,MAX} = 12 \text{ bar}$$

During drill stem testing

Gas reservoir

$P_C = G_M (X - SB) + G_{SW} (SB - AG)$ (TP < X < CS

$P_C = 0.116 (X - 361) + 0.101 (335)$

$P_C = 0.116 x - 361$

$P_{C,MAX} = 236$ bar

$P_{C,REQ} = P_{C,MAX} \cdot DF_C = 236 \text{ bar} \cdot 1.1 = 260$ bar

Calculated collapse pressures during Drill Stem Testing are higher than the collapse pressures during Drilling Operations.

5.3.7.2 Burst load calculations

$P_B = P_S - G_{SW}$ (SB-AG) constant from SB to CS

$$P_S = \frac{P_{MAX}}{e^{\frac{G\ L}{16.3\ T_{avg} Z}}}$$

$P_{MAX} = G_{TZ}\ TZ = 0.0981 \cdot 1.05 \cdot 1720 = 177$ bar

$$P_S = \frac{177}{e^{\frac{0.6\ \ 1738}{16.3\ \ 555\ \ 1}}} = 158 \text{ bar}$$

P_B = 158 bar constant for SB < X < CS

$P_{B,REQ}$ = (158 1.1) bar = 174 bar

N-80, 47 lbs/ft (70.0 kg/m) will withstand these collapse and burst loads.

5.3.7.3 Tension load calculations

Static load

$F_S = (W_N - F_B)CL + F_b$

$F_S = W_N \,.\, CL\ (1 - \frac{Gm}{G_{ST}}) + 19.222 \quad D \quad O \quad W_N$

$F_S = (70.0 \quad 1738(1-\frac{1.18}{7.85}) + 19.222 \quad 9.62 \quad 2 \quad 70.0) \quad 9.81\text{Newton}$

$F_S = 127 \cdot 10^4\text{Newton}$

Tension loads due to pressure testing

$F_{PT} = 10 \,.\, P_T \,.\, A$

$P_T = (0.85 \cdot 474)\text{ bar} = 403\text{ bar}$

$A = 382\text{ cm}^2$

$F_{PT} = (10 \quad 403 \quad 382)\text{Newton} = 154 \cdot 10^3\text{Newton}$

Shock load calculations

$F_D = 10^4 \cdot V_P \cdot W_N$

$F_D = (10^4 \cdot \frac{12}{13} \cdot 70)\text{Newton} = 65 \cdot 10^4\text{Newton}$

Maximum tension load will be

$F_{T,MAX} = (127 \quad 10^4 + 154 \quad 10^4)\text{Newton} = 281 \quad 10^4\text{Newton}$

$F_{T,REQ} = (1.3 \quad 281 \quad 10^4)\text{Newton} = 365 \quad 10^4\text{Newton}$

Minimum tension strength of N-80. 47 lbs/ft casing is 4816 10^3 Newton.

$F_{T,REQ} < 4816 \; 10^3$ Newton

The chosen grade N-80, 47 lbs/ft will withstand collapse, burst and tension loads.

5.3.7.4 Actual design factors

Collapse : $DF_C = \frac{328}{236} = 1.39$

Burst : $DF_B = \frac{474}{158} = 3.00$

Tension : $DF_T = \frac{4816 \; 10^3}{2810 \; 10^3} = 1.71$

Biaxial stress loads are not considered since the maximum tension loads occurs were the minimum collapse loads occurs.

See Table 5.2 for casing grades.

5.3.8 7" Liner

Detailed calculations for a possible 7" liner will be carried out later.

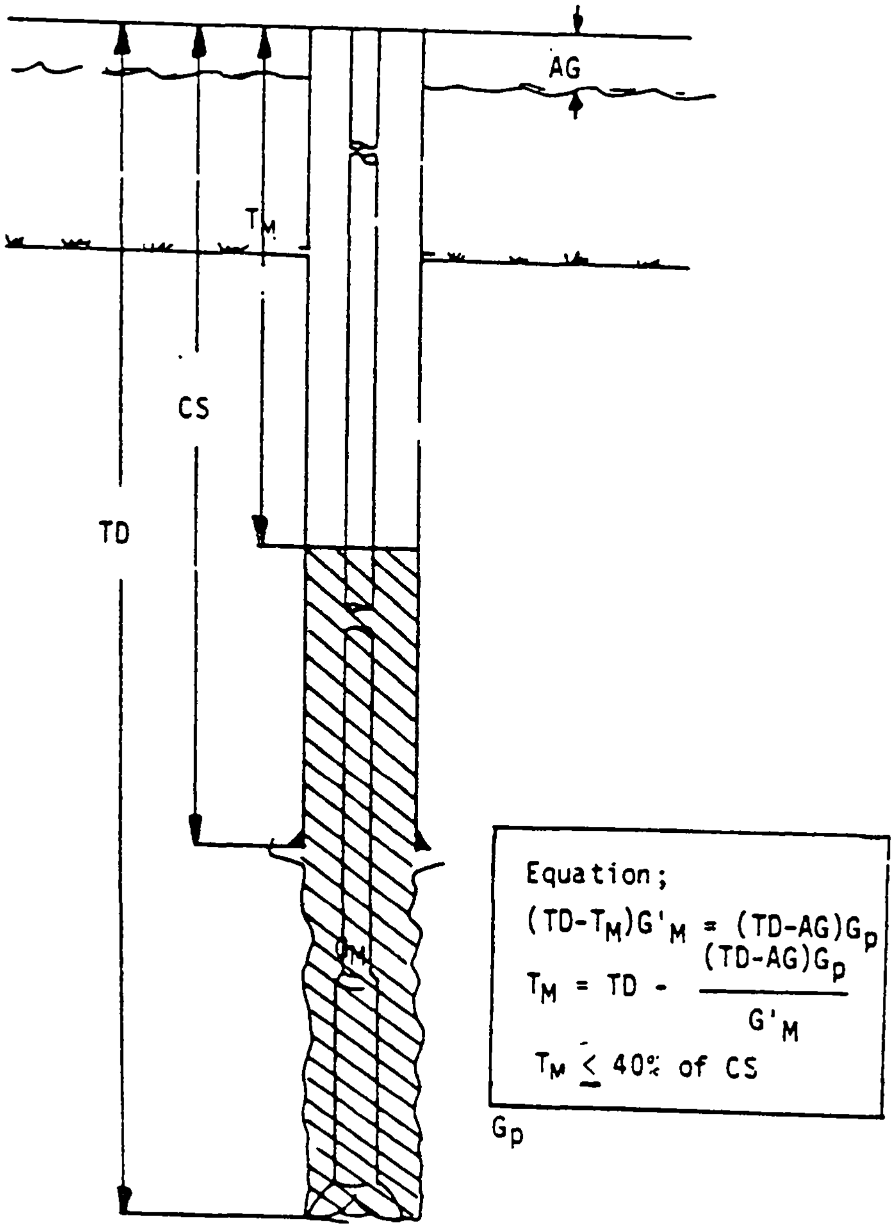


Fig. 5.4 Fluid level drop due to lost returns at the next casing seat.

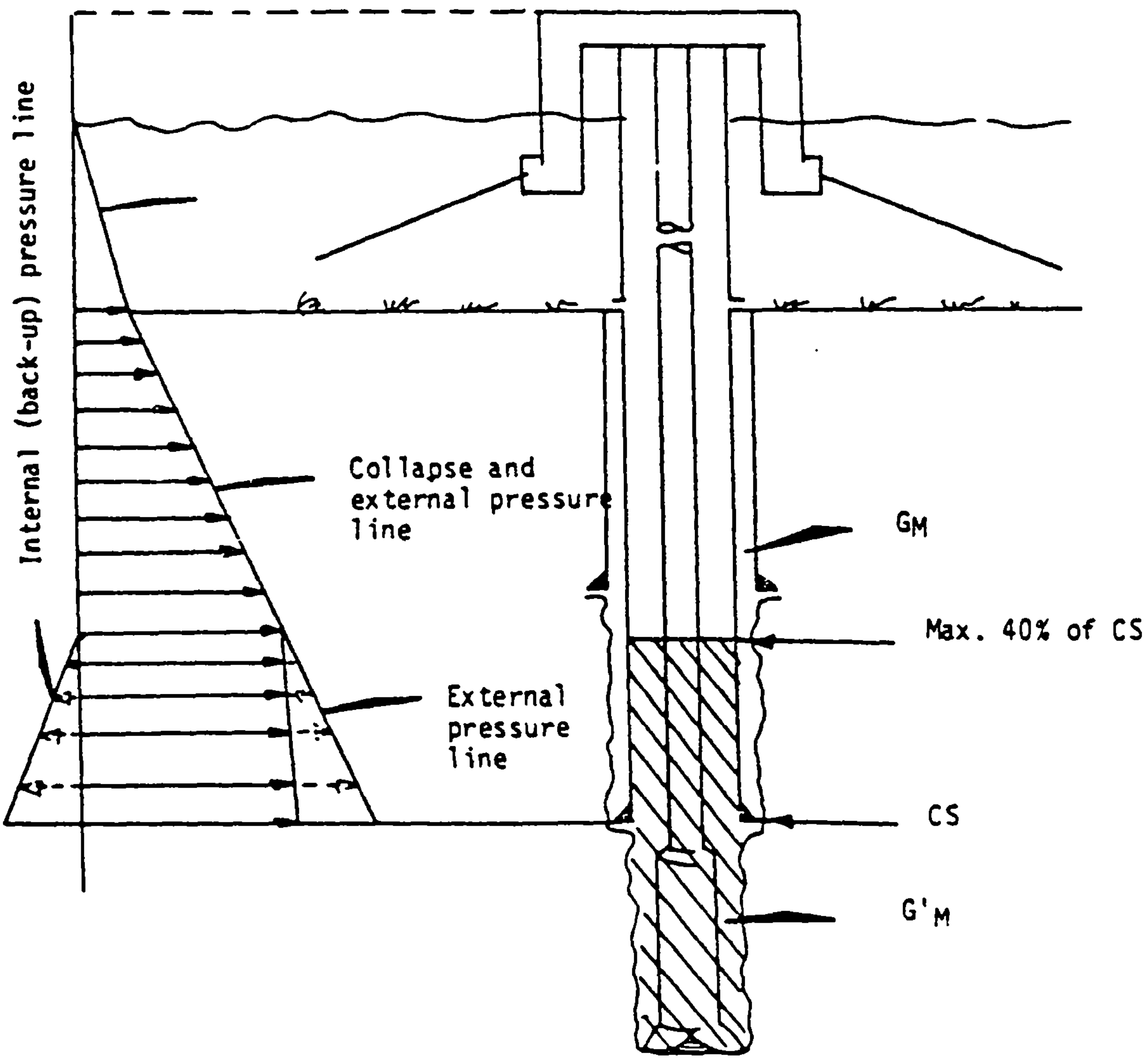


Fig. 5.5 Collapse pressure design criteria for casing exposed to drilling.

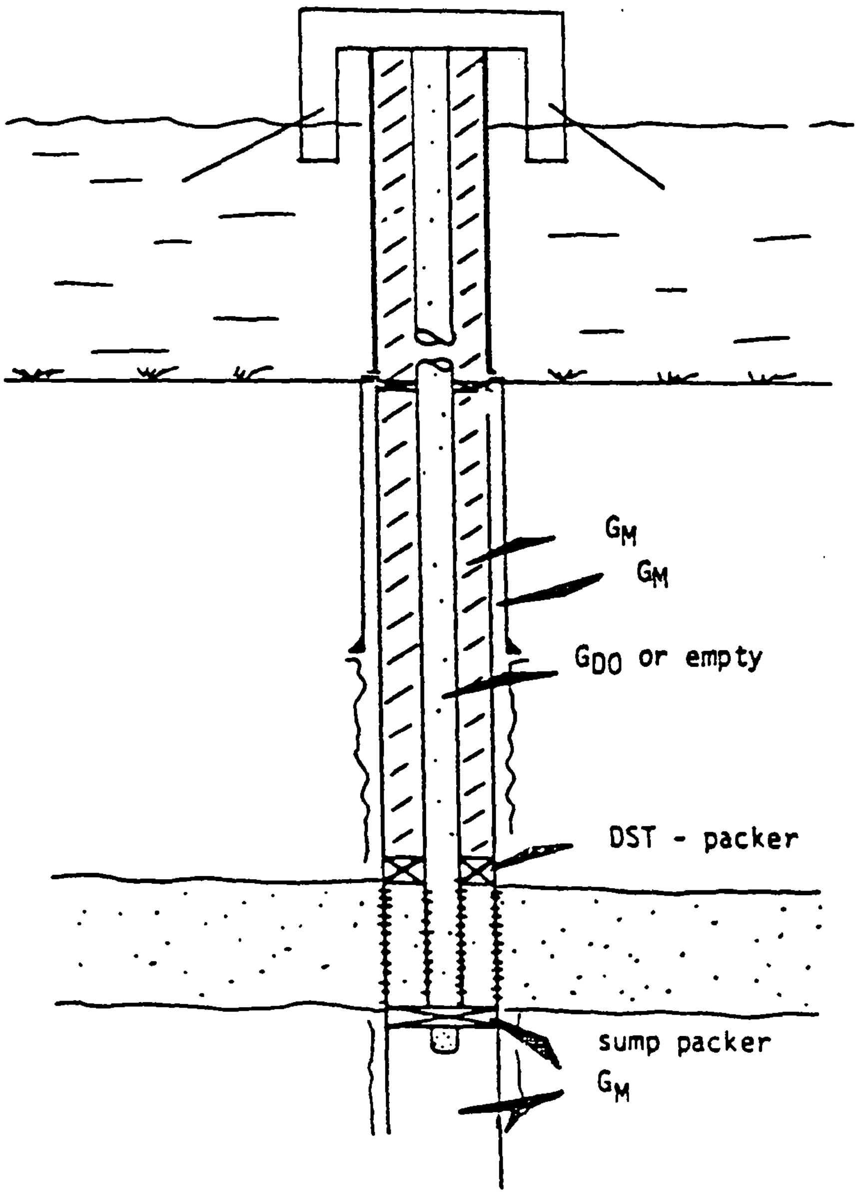


Fig. 5.6 Collapse pressure design criteria for the 9 5/8" csg. set for the purpose of making a DST - test.

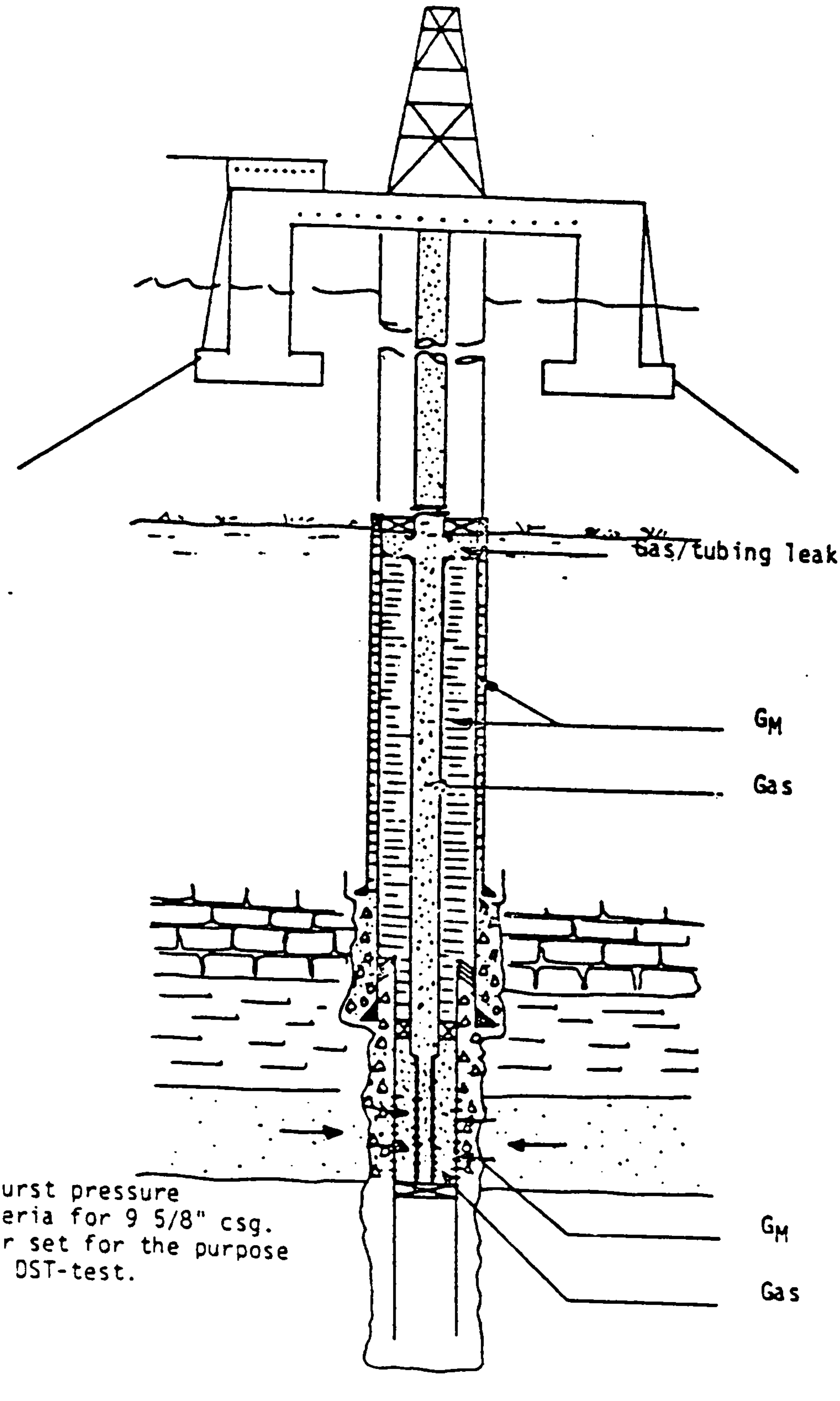


Fig. 5.7 Burst pressure design criteria for 9 5/8" csg. and 7" liner set for the purpose of making a DST-test.

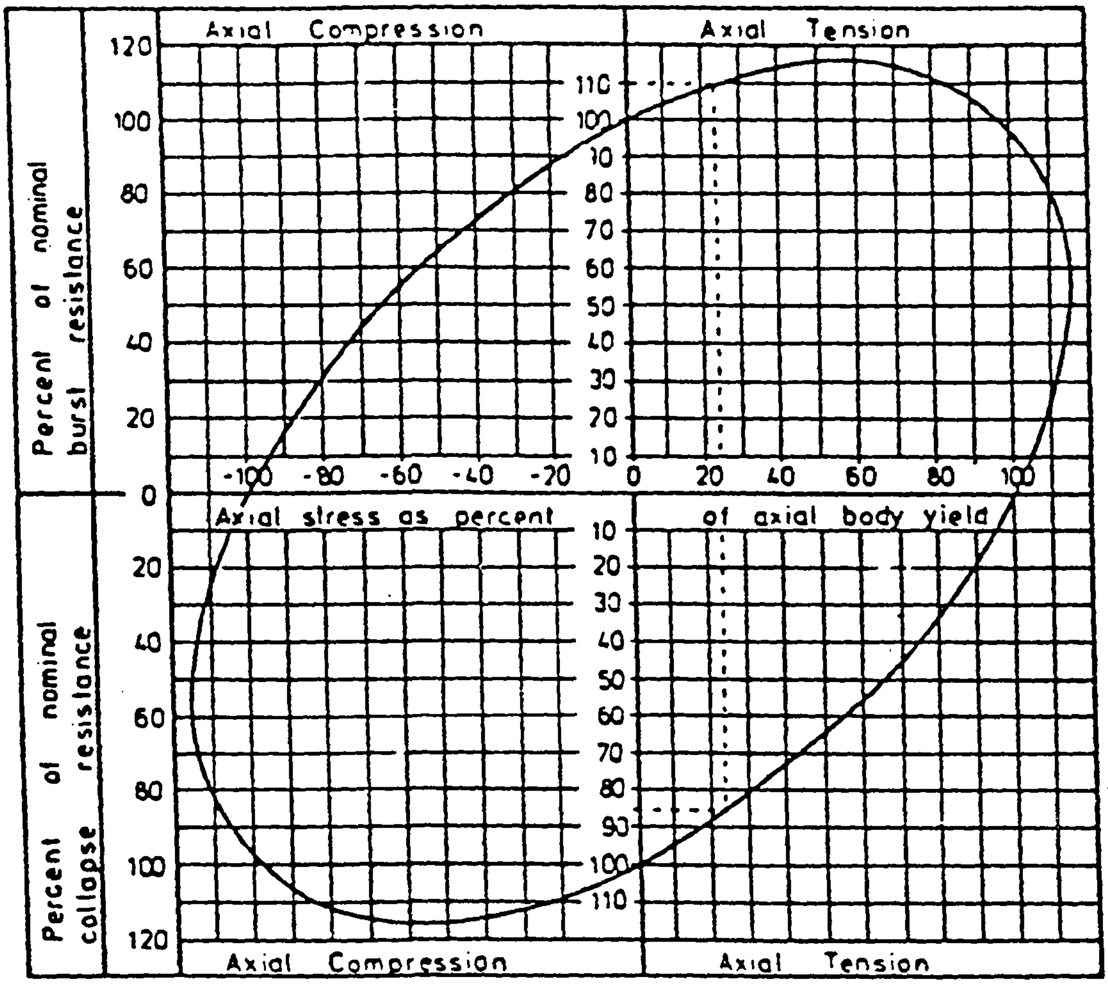


Fig 5.8 Ellipse of biaxial yield stress.

EXAMPLE (DOTTED LINE):

If axial tension is 22.8% of axial body yield, then actual burst resistance will be 110% of nominal burst resistance, and actual collapse resistance will be 86.5% of nominal collapse resistance.

Seamless-collapse curve factors

y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x
.002	.999	.082	.956	.162	.909	.242	.857	.322	.799	.402	.736	.486	.664	.570	.585
.004	.998	.084	.955	.164	.908	.244	.855	.324	.798	.404	.735	.488	.662	.572	.583
.006	.997	.086	.954	.166	.907	.246	.854	.326	.796	.406	.733	.490	.660	.574	.581
.008	.996	.088	.953	.168	.905	.248	.853	.328	.795	.408	.731	.492	.659	.576	.579
.010	.995	.090	.952	.170	.904	.250	.851	.330	.793	.410	.730	.494	.657	.578	.577
.012	.994	.092	.951	.172	.903	.252	.850	.332	.792	.412	.728	.496	.655	.580	.575
.014	.993	.094	.950	.174	.902	.254	.849	.334	.790	.414	.727	.498	.653	.582	.573
.016	.992	.096	.949	.176	.900	.256	.847	.336	.789	.416	.725	.500	.651	.584	.571
.018	.991	.098	.947	.178	.899	.258	.846	.338	.787	.418	.723	.502	.650	.586	.569
.020	.990	.100	.946	.180	.898	.260	.844	.340	.786	.420	.722	.504	.648	.588	.567
.022	.989	.102	.945	.182	.897	.262	.843	.342	.784	.422	.720	.506	.646	.590	.565
.024	.988	.104	.944	.184	.895	.264	.842	.344	.783	.424	.718	.508	.644	.592	.563
.026	.987	.106	.943	.186	.894	.266	.840	.346	.781	.426	.716	.510	.642	.594	.561
.028	.986	.108	.942	.188	.893	.268	.839	.348	.780	.428	.715	.512	.640	.596	.558
.030	.985	.110	.940	.190	.891	.270	.837	.350	.778	.430	.713	.514	.638	.598	.556
.032	.984	.112	.939	.192	.890	.272	.836	.352	.776	.432	.711	.516	.637	.600	.554
.034	.983	.114	.938	.194	.889	.274	.834	.354	.775	.434	.710	.518	.635	.602	.552
.036	.982	.116	.937	.196	.887	.276	.833	.356	.773	.436	.708	.520	.633	.604	.550
.038	.980	.118	.936	.198	.886	.278	.832	.358	.772	.438	.706	.522	.631	.606	.548
.040	.979	.120	.935	.200	.885	.280	.830	.360	.770	.440	.705	.524	.629	.608	.546
.042	.978	.122	.933	.202	.884	.282	.829	.362	.769	.442	.703	.526	.627	.610	.544
.044	.977	.124	.932	.204	.882	.284	.827	.364	.767	.444	.701	.528	.625	.612	.542
.046	.976	.126	.931	.206	.881	.286	.826	.366	.765	.446	.699	.530	.623	.614	.540
.048	.975	.128	.930	.208	.880	.288	.824	.368	.764	.448	.698	.532	.622	.616	.538
.050	.974	.130	.929	.210	.878	.290	.823	.370	.762	.450	.696	.534	.620	.618	.536
.052	.973	.132	.927	.212	.877	.292	.821	.372	.761	.452	.694	.536	.618	.620	.534
.054	.972	.134	.926	.214	.876	.294	.820	.374	.759	.454	.692	.538	.616	.622	.532
.056	.971	.136	.925	.216	.874	.296	.819	.376	.757	.456	.691	.540	.614	.624	.529
.058	.970	.138	.924	.218	.873	.298	.817	.378	.756	.458	.689	.542	.612	.626	.527
.060	.969	.140	.923	.220	.872	.300	.816	.380	.754	.460	.687	.544	.610	.628	.525
.062	.968	.142	.921	.222	.870	.302	.814	.382	.753	.462	.685	.546	.608	.630	.523
.064	.966	.144	.920	.224	.869	.304	.813	.384	.751	.464	.684	.548	.606	.632	.521
.066	.965	.146	.919	.226	.868	.306	.811	.386	.749	.466	.682	.550	.604	.634	.519
.068	.964	.148	.918	.228	.866	.308	.810	.388	.748	.468	.680	.552	.602	.636	.517
.070	.963	.150	.917	.230	.865	.310	.808	.390	.746	.470	.678	.554	.600	.638	.514
.072	.962	.152	.915	.232	.864	.312	.807	.392	.745	.472	.677	.556	.598	.640	.512
.074	.961	.154	.914	.234	.862	.314	.805	.394	.743	.474	.675	.558	.596	.642	.510
.076	.960	.156	.913	.236	.861	.316	.804	.396	.741	.476	.673	.560	.595	.644	.508
.078	.959	.158	.912	.238	.860	.318	.802	.398	.740	.478	.671	.562	.593	.646	.506
.080	.958	.160	.910	.240	.858	.320	.801	.400	.738	.480	.670	.564	.591	.648	.504
										.482	.668	.566	.589	.650	.502
										.484	.666	.568	.587	.652	.499

Table 5.1 Biaxial correction factors.

Saga Petroleum a.s.

CASING PROGRAM

31/3-3

Csg. Size	Setting Depth m RKB	Frac. Grad r.d.	Mud Wt. r.d.	Interval		Quant m	Casing Type			Min. Col-lapse bar	Min. Burst bar	Min. Ten-sion KN	Required			Actual Design Factor		
				From m (RKB)	To m (RKB)		Wt lb/ft	Grade	Thread				PC bar	P_b bar	Tens KN	Col-lapse	Burst	Tension
30"	481		1.1	361	481	120	309	B	Vetco ST2									
20"	800	1.50	1.13	361	800	439	133	X-56	VetcoLS	99	215	9476	68	92	7110	1.60	2.56	1.73
13 3/8"	1610	1.66	1.22	361	1610	1249	72	N-80	Buttress	184	371	7377	28	228	5310	7.08	1.79	1.81
9 5/8"	2100	1.66	1.18	361	2100	1739	47	N-80	Buttress	328	474	4816	260	174	3650	1.39	3.00	1.71

Table 5.2

5.4 Cement Calculations

5.4.1 Well Data

	Depth		TOC		BHST	
	(M)	(FT)	(M)	(FT)	(^{o}C)	(^{o}F)
(RKB-Seabed	361	1184				
30"	481	1578	361	1184	9	48
20"	800	2624	361	1184	20	68
13 3/8"	1610	5280	650	2132	50	122
9 5/8"	2100	6888	1460	4788	67	153

5.4.2 30" Casing Cementation

5.4.2.1 Data

Casing size	:	30 in	309 lbs/ft
Hole size	:	36 in	
Depth (R.K.B.) TVD, MD	:	481 m	
T.O.C. (R.K.B.) TVD, MD	:	361 m	
BHST	:	9 deg. C	
Open hole excess	:	150 %	
Mud type and density	:	Water base, S.G. = 1.025	

5.4.2.2 Job procedure

1. Circulate well.
2. Pump 20 bbls of sea water spacer.
3. Mix and pump lead and tail slurries.
4. Displace with mud.

5.4.2.3 Preflush

20 bbl. Seawater	S.G. = 1.025

5.4.2.4 Lead slurry

	Norcem Class 'G' Cement	
	4.0 l/100 kg A-3L	(0.45 gps)
	93.65 l/100 kg Sea water	(10.55 gps)
Density	S.G. = 1.56	(13.0 ppg)
Yield:	129.52 l/100 kg	(1.95 cuft/sk)
Thickening time at 9 deg. C	6:50 hrs:min	
Compressive strength	24 hrs at 9 deg. C: 25 bar	(360 psi)

5.4.2.5 Tail slurry

	250 sxs of	
	Norcem Class 'G' Cement	
	3.55 l/100 kg A-7L	(0.40 gps)
	40.92 l/100 kg Sea water	(4.61 gps)
Density	S.G. = 1.92	(16.05 ppg)
Yield:	76.38 l/100 kg	(1.15 cuft/sk)
Thickening time at 9 deg. C	3.20 hrs:min	
Compressive strength	24 hrs at 9 deg. C: 206 bar	(2988 psi)

5.4.2.6 Volume calculations

To be calculated on the rig.

5.4.2.7 Material requirements

To be calculated on the rig.

5.4.2.8 Centralizers and scratchers

No centralizers.

5.4.2.9 Guide shoe and float collar

A float shoe will be used.

5.4.2.10 Preflushes and displacement rates

Displace with seawater or lightweight mud leaving +/- 12 m of cement inside the casing.

5.4.2.11 Pressure testing

See drilling programme.

5.4.3 20" Casing Cementation

5.4.3.1 Data

Casing size and weight	:	20 in	133 lbs/ft
Hole sizes	:	26 in	
Depth (R.K.B.) TVD, MD	:	800 m	
T.O.C. (R.K.B.) TVD, MD	:	361 m	
BHST	:	20 deg. C	
Open hole excess	:	100 %	
Previous shoe depth	:	481 m	
Mud type and density	:	Water base, SG. = 1.10 - 1.13	

5.4.3.2 Job procedure

1. Circulate well.
2. Pump 30 bbls of sea water spacer.
3. Mix and pump lead and tail slurries.
4. Release top plug.
5. Displace with mud.

5.4.3.3 Preflush

30 bbl. Sea water S.G. = 1.03 (8.56 ppg)

5.4.3.4 Lead slurry

	Norcem Class 'G' Cement	
	3.55 l/100 kg A-3L	(0.40 gps)
	93.45 l/100 kg Sea water	(10.53 gps)
Density	S.G. = 1.56	(13.04 ppg)
Yield:	128.82 l/100 kg	(1.94 cuft/sk)

Thickening time at		
20 deg. C	7:10 hrs:min	
Compressive strength	24 hrs at 20 deg. C: 33 bar	(480 psi)
Free water:	0.4 %	

5.4.3.5 Tail slurry

	500 sxs of	
	Norcem Class 'G' Cement	
	2.66 l/100kg A-7L	(0.30gps)
	41.72 l/100kg Sea water	(4.70gps)
Density	S.G. = 1.92	(16.04 ppg)
Yield:	76.38 l/100 kg	(1.15 cuft/sk)
Thickening time at		
20 deg. C	3:25 hrs:min	
Compressive strength	24 hrs at 20 deg. C: 194 bar	(2820 psi)
Free water:	0.0 %	

5.4.3.6 Volume calculations

To be calculated on the rig.

5.4.3.7 Material requirements

To be calculated on the rig.

5.4.3.8 Centralizers and scratchers

Bow centralizers to be installed 3 m up on joint 1 and then across the collars of the bottom six joints. Pos. centralizers to be installed across the first two couplings above the 30" shoe.

5.4.3.9 Guide shoe and float collars

Float collar to be spaced 1 joint above the float shoe.

5.4.3.10 Preflushes and displacement rates

Circulate with mud. Displace with mud using the cement unit.

5.4.3.11 Pressure testing

See drilling programme.

5.4.4 13 3/8" Casing Cementation

5.4.4.1 Data

Casing size and weight	:	13 3/8 in 72 lbs/ft
Hole size	:	17 1/2 in
Depth (R.K.B.) TVD, MD	:	1610 m
Volume	:	According to caliper log, no excess in open hole.
T.O.C. (R.K.B.) TVD, MD	:	650 m
BHST	:	50 deg. C
Previous shoe depth	:	800 m
Mud type and density	:	KCL polymer, S.G. = 1.13 - 1.22

5.4.4.2 Job procedure

1. Circulate well.
2. Pump 35 bbls of Turbo Sweep.
3. Release bottom plug.
4. Mix and pump lead and tail slurries.
5. Release top plug.
6. Displace with mud.

5.4.4.3 Preflush

35 bbl Turbo Sweep. SG = 1.39.

To be mixed according to BJ Hughes procedures.

5.4.4.4 Lead slurry

	Norcem Class 'G' Cement	
	0.89 l/100 kg D-31LN	(0.10)
	2.25% by weight Gel	(2.25 %)
	90.72 l/100 kg Fresh water	(10.22 gps)
Density	S.G. = 1.56	(13.01 ppg)
Yield:	124.21 l/100 kg	(1.87 cuft/sk)
Thickening time at 41 deg. C	5:30 hrs:min	
Compressive strength	24 hrs at 50 deg. C: 83 bar	(1203 psi)
Fluid loss:	350 cc/30 min. with 1000 psi across a 325 mesh screen.	

Rheological properties:	600	300	200	100
	51	42	30	35

n'	0.2051
k'	0.1199
Turbulent flow rate:	13.4 BPM in a 13 3/8" by 17 1/2" annulus
Free water:	0%

5.4.4.5 Tail slurry

	500 sxs of	
	Norcem Class 'G' Cement	
	0.89 l/100 kg D-31LN	(0.10 gps)
	1.78 l/100 D-19LN	(0.20gps)
	41.29 l/100 kg Fresh water	(4.73 gps)
Density	S.G. = 1.90	(15.83 ppg)
Yield:	76.38 l/100 kg	(1.15 cuft/sk)

Thickening time at 41 deg. C:	3:10 hrs:min
Compressive strength	24 hrs at 50 deg. C: 331 bar (4799 psi)
Fluid loss:	103 cc/30 min. with 1000 psi across a 325 mesh screen.

Rheological properties:	600	300	200	100
	58	29	19	9

n'	1.040
k'	0.000435

Turbulent flow rate: 8.7 BPM in a 13 3/8" by 17 1/2" annulus

Free water: 1.4%

5.4.4.6 Volume calculations

To be calculated on the rig.

5.4.4.7 Material requirements (no excess included)

Will be issued later.

5.4.4.8 Centralizers and scratchers

See 20" casing.

5.4.4.9 Guide shoe and float collars

Float collar to be spaced 2 joints above the float shoe.

5.4.4.10 Preflushes and displacement rates

Pump 35 bbls of Turbo Sweep in front of the slurry to achieve a better bond between casing/cement and cement/formation. Displace under turbulent flow, using mud.

5.4.4.11 Pressure testing

See drilling programme.

5.4.5 9 5/8" Casing Cementation

5.4.5.1 Data

Casing size and weight	:	9 5/8 in 47 lbs/ft
Hole size	:	12 1/4 in
Depth (R.K.B.) TVD, MD	:	2100 m
T.O.C. (R.K.B.) TVD, MD	:	1460 m
Cement volume	:	According to caliper log, no excess
BHST	:	67 deg. C
Previous shoe depth	:	1610 m
Mud type and density	:	Calcium carbonate, S.G. = 1.18

5.4.5.2 Job procedure

1. Circulate well.
2. Pump 35 bbls of Turbo Sweep.
3. Release bottom plug.
4. Mix and pump lead and tail slurry.
5. Release top plug.
6. Displace with mud.

5.4.5.3 Preflush

35 bbl. Turbo Sweep. SG = 1.37.

To be mixed according to BJ Hughes procedures.

5.4.5.4 Lead slurry

	Norcem Class 'G' Cement	
	1.78 l/100 kg D-31LN	(0.20 gps)
	2.25 % by weight GEL	(2.25 %)
	90.12 l/100 kg Fresh water	(10.15 gps)
Density	S.G. = 1.56	(13.01 ppg)
Yield:	124.66 l/100 kg	(1.88 cuft/sk)

Thickening time at
49 deg. C: 4:35 hrs:min

Compressive strength 24 hrs at 67 deg. C: 83 bar (1204 psi)

Fluid loss: 420 cc/30 min. with 1000 psi across a 325 mesh screen.

Rheological properties:	600	300	200	100
	15	8	6	4

n' 0.7325
k' 0.0008821

Turbulent flow rate: 1.75m^3/min (4.7) BPM in a 9 5/8" by 12 1/4" annulus

Free water: 0%

5.4.5.5 Tail slurry

	Norcem Class 'G' Cement	
	1.78 l/100 kg D-19LN	(0.20 gps)
	0.83 l/100 D-31LN	(0.10 gps)
	0.27 l/100 kg R-12L	(0.03 gps)
	41.76 l/100 kg Fresh water	(4.71 gps)
Density	S.G. = 1.90	(15.82 ppg)
Yield:	76.52 l/100 kg	(1.15 cuft/sk)
Thickening time at 49 deg. C:	3:25 hrs:min	
Compressive strength	24 hrs at 67 deg. C: 390 bar	(5650 psi)

Fluid loss: 43 cc/30 min. with 1000 psi across a 325 mesh screen.

Rheological properties:	600	300	200	100
	54	22	14	6

n' 1.206

k' 0.000123

Turbulent flow rate: 0.51 m^3/min (3.2 BPM) in a 9 5/8" by 12 1/4" annulus

Free water: 1.4 %

5.4.5.6 Volume calculations

To be calculated on the rig.

5.4.5.7 Material requirements (no excess included)

Will be carried out later.

5.4.5.8 Centralizers and scratchers

As for the 20" casing, but in addition, install centralizers through potential problem zones, key seats, sticking areas etc. Use the caliper log results and drilling history to pin point problem zones.

5.4.5.9 Guide shoe and float collars

See 13 3/8" casing.

5.4.5.10 Preflushes and displacement rates

See 13 3/8" casing.

5.4.5.11 Pressure testing

See 13 3/8" casing.

6. BLOW OUT PREVENTER EQUIPMENT

6.1 BOP Stack and Lower Marine Riser

One 18 3/4" 15,000 psi WP blowout preventer system consisting of the following components commencing from bottom of stack, (all equipment rated 15,000 psi unless otherwise stated).

- Vetco 18 3/4" H4 hydraulic connector to connect Contractor's 18 3/4" stack with Operator's 18 3/4" wellhead equipment.

- Two Hydril double ram type preventers with 15,000 psi side outlets. Top preventer dressed with blind/shear rams, balance dressed with 5" d/p rams.

- One Hydril GX annular BOP, rated 10,000 psi WP.

- One BOP stack mandrel, rated 10,000 psi WP.

- One Vetco high angle release H4, 10,000 psi WP, hydraulic connector between BOP stack and lower marine riser package.

- One Hydril GL annular BOP, rated 5,000 psi WP.

- One Vetco Uniflex joint, c/w Vetco type MR-6C pin connection and booster line termination.

- Eight CIW type DF 2 9/16", 15,000 psi WP failsafe valves. Six Nos. valves in kill and choke lines on BOP stack, failsafe close. Two Nos. valves, below flex loops in LMRP, failsafe open.

- Coflexip flex loops, 15,000 psi WP.

One BOP guidance system comprising of:

- Four post BOP frame on six foot radius centre complete with reinforcement and guide funnels as required.

- Lower marine riser guide frame with guide funnels on six foot radius centre complete with reinforcement as required.

- BOP and LMRP guidance system to suit NorMar transporter guidance.

All components exposed to well bore fluids are trimmed for H_2S service, including BOP components, choke and kill lines on stack and riser, BOP valves and choke manifold.

6.2 Marine Riser and Diverter Equipment

Vetco manufactured marine riser joints comprising of pipe body of 21" O.D. with 0.5" wall thickness, of material grade FG-47T. Vetco type MR-6C riser connectors are both welded to the pipe body and have a design tensile load of 1,500,000 lbs. The riser joints are furnished with two 15,000 psi WP, 2 9/16" ID, integral kill and choke lines and a 5" nominal schedule 40 booster line.

The riser joints are supplied with pin protectors. The following riser joints, to the specification above, are provided under this contract:

- 30 Nos. marine riser joints 50 ft length
- 1 No. " " " 20 " "
- 1 " " " " 15 " "
- 1 " " " " 10 " "
- 1 " " " " 5 " "

One Vetco manufactured slip joint, 55 feet stroke. 21" OD inner barrel grade FG-47T with 24" OD outer barrel, grade X52, complete with integral kill, choke and booster lines (as per marine riser joints) with standard Vetco slip joint terminal fittings and end connections Vetco type MR-6C and suitable preparation to accommodate Hughes Offshore type SDL support ring.

Albany International "Warcofloat" buoyancy modules for 20 Nos. Marine riser joints, of 50 ft length per joint.

Hughes Offshore (Regan) diverter assembly comprising of: One support housing and diverter assembly type KFDS, one support ring type SDL and one diverter handling tool type HT-2.

One Vetco 30" hydraulic latch assembly including Vetco 18 3/4" Uniflex joint, Vetco riser adapter and guide frame.

6.3 Equipment for BOP Stack and Marine Riser

- One test and storage stump, rated 15,000 psi WP, to be mounted on BOP transporter for 18 3/4" BOP stack.
- One test and storage stump, rated 10,000 psi WP, to be mounted on cellar deck area for 18 3/4" LMRP.
- One handling spider for Vetco 21" riser.
- Two Nos. handling subs for Vetco 21" riser.
- One No. test cap assembly for testing kill and choke lines.
- One utility guide frame.
- One remote guideline connector running and releasing tool.

- One guideline cutter and replacement tool.

- One remote guideline connector.

- One Vetco BOP emergency recovery system consisting of
  - stinger assembly, re-entry tunnels, holding fixtures, sling assembly, support arms and dart.

6.4 Choke and Kill Manifold

One No. Vetco fabricated kill and choke manifold including:

- Two Nos CIW 3 1/16" 15,000 psi WP hydraulically operated remote chokes complete with constant drillpipe control console situated in Driller's house, 2 Nos. J2 transmitters, hoses, stroke counter etc.

- One No. Thornhill Craver 2 9/16" 15,000 psi WP manual choke.

Downstream side will be 5,000 psi WP and has provisions for connection to mud/gas separator and production burners. High pressure side is 15,000 psi WP and is tied into rig's 2 9/16" 15,000 psi WP choke and kill and cementing lines and 5,000 psi WP mud standpipe manifold.

6.5 Hoses for Kill and Choke Lines

Two Nos. Coflexip 15,000 psi WP hoses, 75 ft long by 2 1/2" ID with BX 153 hub connections. H_2S service.

6.6 Standpipes

One dual standpipe 5,000 psi WP hoses, 75 ft long by 2 1/2" ID with BX 153 hub connections. H_2S service.

6.7 Standpipe Manifold

One standpipe manifold, 5,000 psi WP, 10,000 psi test pressure installed on drillfloor.

6.8 Safety Valves

- One No. Hydril full opening stabbing valve, 4 1/2" IF connections. 5,000 psi.
- One No. Gray inside BOP, 4 1/2" IF connections. 5,000 psi.
- One No. Gray inside BOP, 3 1/2" IF connections. 5,000 psi.

6.9 Pressure Testing

The stack should be tested on test stump prior to running.
Upper spherical to 3,500 psi
Lower spherical to 7,000 psi
Rams and valves to 10,000 psi

The blow-out preventer and all auxiliary equipment should be pressure tested.

1. When installed.
2. Weekly or on nearest trip out of hole.
3. After each casing string is run.

4. Prior to any drill stem testing.

a. Initial installation.

The blow-out preventors shall be pressure tested to the maximum expected pressure from wellbore.

b. Weekly test of the stack on the wellhead except shear/blind ram. The pressure shall be to the maximum expected pressure from the wellbore.

Auxiliary Equipment.
Choke Manifold - Same pressure as ram preventor.
Kelly Cocks, Safety Valves.
Inside BOP - 5,000 psi.
Function Testing.
Function test once per week.

7. DRILLING FLUID RECOMMENDATIONS

Waterdepth 335m

7.1 36" Hole

Interval 361m - 481m
Mud weight 1.10 sp.gr.
Funnel viscosity + 100 sec/qt.

7.1.1 Drilling Fluid Recommendation

Drill the 36" hole with seawater and high viscosity bentonite pills.

7.1.2 Additives

1. Premium grade Wyoming bentonite (bulk).
2. Soda Ash.
3. Caustic Soda.

7.1.3 Drilling Fluid Procedure

1. The drill water should be checked for total hardness and pH. These properties should then be adjusted to maximize the hydration of the bentonite clay.
2. Mix 25-30 ppb Wyoming bentonite to the drill water and allow 6 - 10 hours to hydrate.
3. The hole should be drilled with seawater and high viscosity and mud pills (30 bbls minimum) at each connection to optimize hole cleaning.
4. The hole should be displaced with spud mud in preparation to run and receive 30" casing.

7.2 <u>26" Hole</u>

Depth	481 - 815m
Mud weight	1.10 - 1.13 sp.gr.
Funnel viscosity	50 - 65 sec/qt.

7.2.1 Drilling Fluid Recommendation

The 26" hole section should be drilled with spud mud consisting of Wyoming bentonite prehydrated in treated drill water.

7.2.2 Additives

1. Premium grade Wyoming bentonite.
2. Caustic Soda.
3. Soda Ash.
4. Bicarbonate of Soda.

7.2.3 Drilling Fluid Procedure

1. Prior to drilling out the 30" casing shoe, 1800 bbls of spud mud should be built, consisting of Wyoming bentonite and treated drilled water. (Ref. chapter 7.1.3 pkt. 1).
2. The 30" casing shoe should be drilled with spud mud which has been pretreated with Bicarbonate of Soda. This is necessary to offset the effects of drilling cement. All mud severly contaminated by cement should be discarded.
3. The 26" hole should be drilled with the spud mud. Seawater dilution should be used, as needed, to maintain the desired mud weight and viscosity. Prehydrated bentonite should be used if an increase in viscosity is neede.
4. It may be desirable to sweep the hole with a high viscosity pill prior to running and receiving 20" casing.

7.3 17 1/2" Hole

Depth	800 - 1625m
Mud weight	1.13 - 1.22 sp.gr.
Funnel viscosity	45 - 55 sec/qt.
Yield point	25 - 30 lb/100 ft^2
Water loss	10 - 15 cc
pH	9.0 - 9.5
MBT	Max. 20 ppb

7.3.1 Drilling Fluid Recommendation

Drill the 17 1/2" hole section incorporating KCl-Milpolymer 302 system.

7.3.2 Additives

1. KCl.
2. Milpolymer 302.
3. Drispac and Pro Pol.
4. Permalose.
5. Potassium Hydroxide

7.3.3 Drilling Fluid Procedure

1. After having cemented the 20" casing, dump and clean all pits. Add drillwater to each pit and mix the following concentration and in the following order:

   a) 45 lb/bbl KCl
   b) 4 lb/bbl Permalose
   c) 0.75 - 1.5 lb/bbl Milpolymer 302*

   * Add Milpolymer 302 to obtain a desired viscosity. After the addition of Milpolymer 302 allow the fluid to mix and shear for a period of time.

2. Drill out the cement in the 20" casing and the rat hole with mud left in the hole and seawater, dumping all returns.

3. Displace the hole to KCl-Polymer fluid.

7.3.4 Daily Maintenance of Drilling Fluid

For daily maintenance of KCl-polymer fluid it is essential that the rig solds control equipment work at peak efficiency. However, it is expected that large quantities of whole-mud dilution will be necessary to maintain the fluids intergrity and achieve desired mud specifications while drilling. The mixing of individual products through the chemical hopper direct to the active system should be avoided. Necessary adjustments to mud properties should be made first to the premix. Under no circumstances is seawater to be added to this system, except as used to clean shale shaker screens. Drillwater should not be used in a polymer premix unless first treated for total hardness.

1. Inhibition.
   The KCl is to be maintained at a concentration of approx. 45 lb/bbl for maximum inhibition of swellling clays. While drilling, the KCl concentration will be adjusted as formation dictates.

2. Viscosity.
   Milpolymer 302 is recommended as the primary viscosifier. The Milpolymer 302 gives excellent fluid characteristics with low viscosity at the bit and high carrying capacity in the annulus. Drispac Regular and Pro Pol Regular are recommended a the secondary viscosifier.

3. Mud Weight.
   Mud weight will be adjusted as pore pressures and hole problems indicate. Decisions concerning fluid density will be made by Saga Petroleum representative only.

4. Yield point.

The yield point should exceed 20 lb/100 ft^2 for maximum hole cleaning. Experience has shown that the ten minute gel strength is critical. Once readings is excess of 30 lb/100 ft^2 are recorded, dilution of whole mud is required.

5. API fluid loss.

The fluid loss should be below 15 cc throughout this section by additions of Drispac Superlo, Pro Pol Low vis. and Permalose.

6. pH.

Maintain pH in the desired range by slow additions of Potasssium Hydroxide through a chemical barrel.

7. MBT.

A level of 20 lb/bbl bentonite equivalent is the maximum which should be allowed, at which stage whole mud dilution treatment should be applied.

Note: Mud detergent should be added only with the consent of Saga.

7.4 12 1/4" Hole

Depth	1610 - 2115 m
Mud weight	1.18 sp.gr.
Funnel viscosity	60 - 80 sec/gt.
Yield point	35 - 45 lb/100 ft^2
Waterloss	5 - 10 cc
pH	9.0 - 9.5

7.4.1 Drilling Fluid Recommendation

To drill the 12 1/4" section a Calcium Carbonate ($CaCO_3$) - polymer fluid is recommended. This fluid is specially designed to meet the requirements regarding hole cleaning, hole stability and minimum damage to the formations. This recommended system is soluble in acid and will therefore not effect the skin factor.

7.4.2 Additives

1. W.O. 21 - Hydroxyethyl cellulose, high yield polymer.
2. W.O. 22 - High yield polymeric viscosifier, containing a pH buffering agent.
3. Permalose.
4. Salt.
5. Prowate Fine - Calcium Carbonate.
6. Drispac and Pro Pol.

7.4.3 Drilling Fluid Procedure

1. Drill with the KCl-Polymer fluid to the 13 3/8" casing point. Reduce the KCl-Polymer volume on surface to a absolute minimum while running the 13 3/8" casing. Dump any excess KCl-Polymer fluid, clean the empty pits and prepare to mix the reservoir fluid.

2. After the 13 3/8" casing has been landed the rest of the KCl-Polymer fluid should be dumped and all pits cleaned. Commence to mix reservoir fluid while cementing casing. A total of 1600 bbls reservoir fluid should be mixed in the following order:

a)	Drillwater	
b)	Salt, NaCl	40 ppb
c)	Permalose	4 ppb
d)	W.O. 21	2 ppb
e)	W.O. 22	4 ppb
f)	Prowate Fine	80 ppb

Allow the polymers to hydrate and shear to obtain maximum efficiency.

3. Drill the cement and float collar with seawater. Displace the hole to $CaCo_3$ fluid prior to drilling through the 13 3/8" casing shoe.

7.4.4 Daily Maintenance of the Drilling Fluid

1. Viscosity.
Maintain sufficient yield point with addition of W.O. 21, W.O. 22, Drispac Regular and XC polymers. Alter these products to meet the specifications. Gel strengths are known to be critical in these types of drilling fluids systems. Close observation on the suspension ability and fill up in the hole and pits should be maintained.

2. Mud weight.
Maintain a Cl-concentration in the 60 - 70.000 mg/l-range with sodium salt. Further weight increase should be done with the addition of Prowate Fine. The Calcium Carbonate acts as an bridging agent, fluid loss reducer and weight additive.

3. API fluid loss.
   As stated above the Calcium Carbonate acts as a fluid loss agent and will produce a natural low waterloss. To futher reduce the fluid loss Permalose and/or Drispac Superlo can be added.

4. pH.
   Addition of Caustic Soda should not be necessary. A natural pH of 9.5 - 10.0 is expected.

NO BENTONITE NOR BARITE MUST BE ADDED TO THIS SYSTEM.

7.5 8 1/2" Hole

Depth	2100 - 2525 m
Mud weight	1.18 sp.gr.
Funnel viscosity	60 - 80 sec/qt.
Yield point	35 - 45 lb/100 ft^2
Waterloss	< 10 cc
pH	9.0 - 9.5

7.5.1 Drilling Fluid Recommendation

Continue with the same Calcium Carbonate reservoir fluid in the 8 1/2" section.

7.5.2 Additives

Same as for 12 1/4" hole (ref. chapter 7.4.2).

7.5.3 Drilling Fluid Procedure

Drill out the cement of the 9 5/8" casing using the fluid already in the hole. The polymer fluid is sensitive to high pH values and must not be used to drill soft cement.

To minimize the effects of drilling cement, 1/2 ppb of Sodium Bicarbonate could be added before drilling out the cement.

A pilot test should be run, prior to drilling cement to ensure the integrity of the drilling fluid.

7.5.4 Daily Maintenance of Drilling Fluid

Same as for the 12 1/4" hole. (Ref. chapter 7.4.4).