L-7 CONFIDENTIAL TAUSHETSPLIKT .3

AMOCO NORWAY OIL COMPANY

FINAL REPORT - WELL 2/8 - 1

ID/OLJE
00621 *- 1.6.69
SAKSB:
ARKIV:

BA 69-1913-1

PERTINENT DATA

Area: Norwegian North Sea
Co-ordinates: 56° 17' 47.2"
3° 26' 59.7"
K.B. Elev: 55' (Above mean sea level)
Water Depth: 228' (Below mean sea level)
Date Spudded: November 28, 1967
Date completed: July 2, 1968
Total Depth: 8515'
Plug back Depth: Sea Floor
Classification Before Spudding: Exploration
Classification After Completion: Plugged and abandoned.
Rig Type: "Drillship"

STRATIGRAPHY

	Top	Lithology (No samples above 1183')
Quaternary - Pleistocene	?	Clay-grey to dark grey, marine often silty, glauconitic and containing broken shell fragments throughout. Rare very fine grained sand.
Tertiary-Pliocene	2249'(-2194')	Clay-grey, sometimes light beige, often silty.
Miocene	2810'(-2755')	Clay-greyish brown and greyish olive, occasional marl streaks some siltstone - brownish grey and dark olive grey, soft to medium hard. Close to top scattered thin stringers of sandstone which are greyish brown and silty to very fine grained.
Oligocene	4867'(-4812')	Shale-dark brownish grey and dark grey, occasionally silty becoming very finely fissile below 5043'. Some siltstone.
Upper Eocene	5387'(-5332')	Shale-light to dark brown, firm, calcareous, fissile occasionally grey, soft and silty.

Lower Eocene
(and Upper Paleocene) 5721'(-5666') Shale-light to medium brown and dark greenish grey, sometimes dark grey, occasional thin stringers of sandstone - cream colored fine grained, generally hard, slightly calcareous. Below 6210 some traces of dolomite and dolomitized silty limestone - blocky, hard and some marl - light beige, soft to medium hard. Increasing amounts of dolomite and limestone below 8450'.

HYDROCAROBON SHOWS

1395' - 1485'	Traces of methane.
1485' - 1525'	Average 0.18% methane. Maximum 0.25% at 1510'.
1525' - 2115'	Traces of methane.
2115' - 2310'	Average 0.1% methane. Maximum 0.15% at 2185'.
2310' - 3095'	Traces of methane.
2960' - 3040'	Sandstone stringers with some live light to medium gravity oil, giving very slight cut and bright yellow fluorescence. Side well cores at 2997' and 3040' show good medium gravity oil impregnation with heavy cut and bright yellow fluorescence.
3840' - 4315'	Average 0.7% methane. Maximum 0.92% at 3900', 1.04% at 4090', 0.95% at 4250'.
4315' - 5075'	Average 0.3% methane. Maximum 0.66% at 4550'.
4810' - 4945'	Siltstone stringers with very slight cut and spotty yellow fluorescence. No apparent live oil.
5075' - 5270'	Average 0.8% methane. Maximum 1.1% at 5170'.
5365' - 5590'	Average 0.1% methane. Maximum 0.25% at 5390'.
5895' - 5990'	Good traces of methane.
6115' - 6637'	Average 0.2% methane. Maximum 0.3% at 6280', 0.55% at 6475', 0.37% at 6595'.
7160' - 7220'	Limestone, dolomite and marl streaks in part with yellow fluorescence and rare very slight cut.
7780' - 7800'	Marl and limestone streaks with occasional yellow fluorescence.

8060' - 8190'	Traces of methane.
8190' - 8240'	Average 0.1% methane. Maximum 0.14% at 8230'.
8240'.- 8300'	Good traces of methane.
8300' - 8420'	Average 0.17% methane. Maximum 0.7% at 8315'.
8420' - 8515'	Good traces of methane.

LOGS

	Run	Interval	Scales
Sonic-Gamma Ray	1	1065' - 6631'	1:500, 1:200
Induction-Electrical-SP	1	1065' - 6637'	1:500, 1:200
Formation Density	1	1065' - 6638'	1:500, 1:200
Epithermal Neutron	1	1065' - 6309'	1:500, 1:200
Laterolog	1	1065' - 6306'	1:500, 1:200
Microlaterolog	1	1065' - 6304'	1:500, 1:200
Continuous Velocity (SSL)	1	1100' - 3800'	1:500
Continuous Velocity (SSL)	2	1970' - 4000'	1:500
Continuous Velocity (SSL)	3	964' - 5700'	1:500

SIDEWALL SAMPLES

Requested 19, recovered 18

FORMATION TESTER (WIRE LINE)

Attempted test at 3040', test failed due to poor hole conditions.

CORES

None

DST's

None

HOLE SIZE

36"	to	520'
26"	to	1151'
17½"	to	5579'
12-1/4"	to	8515'

CASING RECORD

30" casing show at 472'. Cemented with 1200sx cement with 3% $CaCl_2$ followed with 200 sx neat cement.

20" casing shoe at 1074'. Cemented with 2300 sx Portland cement.

13 3/8" casing shoe at 5554'. (DV tool at 1015') Cemented in two stages.
First stage: 3000 sx Norge cement with 12% gel, followed with 300 sx neat cement.
Second stage: 1200 sx neat cement.

BIT RECORD

2	17½"	Hughes OSC - 1GJ
2	17½"	Hughes OSC - 3AJ
7	12 1/4"	Hughes X3AJ
1	12 1/4"	Hughes XVJ open
1	36"	Security Hole opener
1	26"	Security Hole opener
1	17½"	Security Hole opener

The well was plugged back with cement from 5600 to 5450 feet and from 460 feet to the sea floor.

ATTACHMENTS

1. Final Well Log.
2. Stratigraphic summary - paleontological report.

North Sea.

Stratigraphic Summary No. 20.

Amoco Norway 2/8/1

The following species of foraminifers, diatoms, and radiolarians represent apparent first occurrences. Ditch cuttings from 1190 to 8510' were examined; side wall cores at 2995, 3037, and 3056 A were also examined.,

Quaternary - 283 - 2249

* first sample: 1190-1220

Elphidiella arctica var. A	*
Elphidiella arctica var. B	*
Elphidium selseyensis	*
Buccella frigida	*
Cassidulina carinata	*
"Nonion affinis"	1550-80
Cibicides lobatulus	1550-80
Bulimina elongata	1580-10
Elphidiella arctica var. C(?)	2150-80

Tertiary - 2249 - 8515 (T.D.)

Pliocene - 2249 - 2810

top on basis of Neutron, Gamma Ray, Sonic, and Calipher Logs.

Elphidium incertum var.	2540-70

Upper Miocene - 2810 - 3967 (?)

top on basis of Sonic and Gamma Ray Logs

Elphidium incertum	2810-40
Rotalia beccarii var. globosa	2810-40
Sigmoilopsis agglutinans	2810-40
Martinottiella communis	2870-00
Nonion boueanum	SWC 3056 A
Eponides umbonatus	SWC 3056 A
Textularia gramen	SWC 3056 A
Uvigerina hosiusi	3230-60

Middle-Lower Miocene - - - - - - - - - - - - - - - - - - 3967(?) - 4867

top on basis of Sonic and Gamma Ray Logs

Elphidium inflatum	*
Asterigerina staeschei	*
(* see remarks following)	
Glomospira charoides (upper zone)	4610-40
Bathysiphon sp. A	4610-40

Tertiary (cont'd)

Oligocene (Middle and Lower) - - - - - - - - - - - - - - - - - - 4867 - 5387'
top on basis of Sonic and Gamma Ray Logs

Karreriella siphonella (?)	4850-80
Uvigerina sp. A (Nordsee M-1, 835 m)	4880-10
Siphonina fimbriata	4880-10
Gyroidina soldanii var.	4970-00
Rotaliatina buliminoides	*

(* see remarks following)

Upper Eocene - 5387 - 5721
top on basis of Sonic-Gamma Ray Log

Globorotalia centralis	5390-20
Globorotalia cocoaensis	5390-20
Uvigerina cf. U. farinosa	5390-20
Cyclammina cf. C. placenta	5620-50

Middle-Lower Eocene; (* see remarks) - - - - - - - - - - - - 5721 - 7560
top on basis of Sonic-Gamma Ray Log

Spirosigmoilinella cf. S. compressa	5780-00
Bathysiphon eocenica	5780-00
Coscinodiscus sp. 1	5800-20
Cyclammina cancellata	5960-80
Ammodiscus sp. indet.	6220-40
Ammodiscus incertus	6400-20
Glomospira charoides (lower zone)	6500-20
Pelosina cf. P. caudata	6500-20
Rhabdammina eocenica	6500-20
Coscinodiscus sp. 2	6500-20
Eggerella aff. E. bradyi	6580-00
Haplophragmoides cf. H. eggeri	6580-00
Thurammina erinacea (top?)	6700-20
Verneuilina sp. (S & H, 1940, pl. 37)	7140-60
Gaudryina eocenica	7480-00

Paleocene (* see remarks) - - - - - - - - - - - - - - - - - - 7560 - 8515 T.D.
top on basis of paleontology, lithology

Spiroplectammina spectabilis	7580-00
Allomorphina halli	7900-10
Phacodiscus (?) sp. A	7950-60
Textularia cf. T. agglutissima	8100-10

Remarks:

The well apparently contained only one zone with reservoir properties; this involved the basal Pleistocene silts and sandy clays, 2090-2250'. The unit was semi-coquinoid in part, containing common to abundant barnacles and mollusks.

The diagnostic Middle Miocene species Elphidium inflatum and Asterigerina staeschei were found in abundance as apparent cavings below the wash-out section, 5040-5330', whereas they should have occurred much higher in the section, probably within the interval 3800-4600'.

The diagnostic Middle Oligocene species Rotaliatina buliminoides occurred as apparent cavings below the wash-out section, 5040-5330', whereas it should have occurred within or just above this section.

The seismic horizon at 6500' apparently coincides with a significant increase in numbers and species of arenaceous foraminifers. This coincidence is not at all clear, but the depth may be taken as marking the top of the "lower Eocene" sensu lato.

The diagnostic species Spiroplectammina spectabilis has an apparent geologic range in the North Sea from lowermost Eocene through Upper Paleocene (according to reports by the Danish, German and Netherlands Geological Surveys) here it is tentatively taken as marking the top of the Upper Paleocene (Landenian Stage). This horizon correlates with Amoco U.K. 38/16/1, 3750-80' and Amoseas U.K. 38/29/1, 4110-40'.

The interval 5721-8515' is a nearly uniform sequence of "gumbo" clays and shales characterized by common to abundant benthonic, arenaceous foraminifers, (particularly Cyclammina cancellata), which indicate open marine, deep water (several hundred feet, i.e., outer shelf or bathyal), possibly slightly stagnant environments. There were apparently no zones of planktonic foraminifers within this interval. The arenaceous foraminifers mentioned may be used for purposes of local correlation; most have a very long range through the Tertiary and Quaternary, but few, if any, range below the Tertiary.

In recent articles, El-Nagger (1967, Revue de Micropaléontologie) proposes the following stages within the Paleocene of northern Europe:

Upper Paleocene (Landenian)
"Zone of Globorotalia velascoensis"

Middle Paleocene (Heersian)
"Zone of Globorotalia angulata" = "Zone of Globorotalia inconstans"

Lower Paleocene (Danian)
"Zone of Globorotalia compressa/Globigerina daubjergensis"

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All of the foraminifers mentioned by El-Naggar are planktonics and consequently none of the subdivisions within the Paleocene are recognizable in the Amoco Norway 2/8/1 well. However, on lithological grounds, the well does not appear to have reached the lower Paleocene (Danian stage), a stage which is typified in the North Sea by chalky lithologies. The carbonate stringers encountered near total depth were cryptogenic (highly altered), finely crystalline, with no definitely recognizable microfauna. In these carbonates, very minor intra-crystalline porosity was predominant; minor fractures were present with the fractures being filled with calcite.

C. R. Haller

18 July 1968

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

ID/OLJE
00360 27.5.68
SAKSB:
ARKIV:

TAUSHETSPLIKT

CORE ANALYSIS RESULTS

Company Amoco Norway Oil Co. Formation ____ File UKCA 110
Well 2/8-1 Core Type Sidewall Date Report 13 May 1968
Field ____ Drilling Fluid ____ Analysts R.F.B.
County North Sea State Norway Elev. ____ Location ____

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS Ka	PERMEABILITY MILLIDARCYS Kl	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS
	2997	<0.01	<0.01	31.8	25.2	53.2	Sd, gy, vfg, bad filter cake intrusion.
	2997A	(3)		30.2	26.8	54.0	a.a.
	3040	527	497	35.3	31.2	51.9	Sd, gy, fg, very soft.
	3040A	492	462	37.4	32.4	56.7	a.a.

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AMOCO NORWAY OIL COMPANY

SIDE WALL CORE DESCRIPTION WELL 2/8-1

N°	DEPTH	REC.	DESCRIPTION	ODOR	IMPREGNATION	CUT	FLUORESCENCE
1,2	3056'	*Full	Shale, med gray-green, soft, silty,				
			micaceous, mod. calc.sl.Glauc,sl.sdy,				
			V.fn. qtz.	Nil	Nil	Nil	Nil
3,4	3052'	Full	Shale, Similar to above,Sl. waxy.	Nil	Nil	Nil	Nil
5,6	3040'	Full	Sandstone, gray-tan,V.Fn.,v.loose,fri,	Oil	Exc., med. dk.brn.	Heavy: streaming	good, bright grn.
			good to exc.poros.,Well-sorted,sl.mic.,	Good	med. oil impreg.	throughout	Yell.
			some grn and black min content.	Odour			
7,8	3037'	Full	Shale, as at 3056': sl.calc-soft,sticky	Nil	Nil	Nil	Nil
			and lighter green-grey.				
9,10	3034'	Full	Shale, med./dk. gray-green, soft,micac.				
			sl. silty, with rare shell frag.: sl.calc	Nil	Nil	Nil	Nil
11,12	3026'	Full	Shale, similar to that at 3034'.	Nil	Nil	Nil	Nil
13,14	3023'	Full	Shale, as at 3052';sl. waxy: soft,light	Nil	Nil	Nil	Nil
			to med. gray-green, sticky.				
15.16	2997'	Full	Shale, med. gray-green, soft, silty,				
			Micac.: with beds of sandstone. v. fn.	Oil	Exc. in sandstone.	Heavy:Streaming	Good, bright grn
			loose to firm, grey-tan,fair to good	Good	Med. Dk.brn,med. oil	in sandstone.	Yell.,in sandst.
			poros., part shaly.	Odour	Impregnation		and pt. of silty
							shale.
17.18	2995'	Full	Shale, similar to that at 3052': but v.				
			micaceous.	Nil	Nil	Nil	Nil
19	1754'	None	--				
*Full	recovery	= 1	3/4", approx.				

AMOCO 2/8-1

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APPENDICIES

INTRODUCTION

The concept of rotating a large, single hull vessel while drilling operations are carried on in 230 feet of water was new and untried when first considered by AIOC and its partners - Amerada, Texas Eastern and a consortium of 20 Norwegian firms. Studies were therefore made to investigate different anchoring arrays and resulting anchor chain tensions expected from wind and wave forces predicted for the location of the concession area in the North Sea.

These studies indicated it would be necessary to maintain the ship's heading essentially into or away from resultant wind and wave forces if the mooring and hoisting equipment design limits were not to be exceeded. The decision was then made to evaluate the concept in drilling an exploratory well on a concession near the western limit of the Norwegian sector of the North Sea. The location of the well (2/8-1) and its relative geographical position to recent gas discoveries is shown in Figure 1.

It is the purpose of this report to review the events and details of problems encountered while using the vessel named the DRILLSHIP to drill well 2/8-1 on the concession. Also included as a part of the appendix are basic data on the vessel, mooring, station keeping, drilling and subsea equipment. While these data are not directly relevant to the current discussion, they should prove useful reference sources when considering and evaluating designs and equipment for other moored drilling structures.

SUMMARY

Repeated failures of the anchor mooring chains at tension loads of only 10 to 50% of their rated breaking strength was the basic factor leading to the decision to abandon well 2/8-1 and terminate the drilling agreement with the contractor. The premature and unexpected failure of an anchor chain resulted in failure of the BOP stack and well head after drilling operations had reached a total depth of 8,515 feet. This experience clearly demonstrated that the unreliability of the anchor chains would not allow drilling operations to continue safely.

Deficiencies in the chain handling equipment before repairs and modifications were made are considered to have contributed to the unreliability of the anchor chains. The weather in the North Sea was substantially more severe than had been predicted and this produced wind and wave forces of unexpected magnitudes which also contributed to the mooring problems experienced.

DISCUSSION

A chronological listing of the operation of the DRILLSHIP from the time the vessel was accepted under terms of the contract on November 13, 1967 until the contract was terminated on July 17, 1968 is summarized in Attachment 1 of this report. General data regarding the vessel and the drilling equipment is summarized on Attachment 2.

While the discussion in this report will be based on the summary in Attachment 1, additional details are presented under major subject headings as follows:

Chain Handling Equipment

A description of the windlass, chain stopper, idler and chock system used in mooring the vessel is included as

Attachment 3. The following discussion relates difficulties experienced with specific items of this equipment.

a. Windlass Brake System

Problems were encountered with the anchor chain windlass brake system during the initial anchoring and positioning of the DRILLSHIP. It was found that the drum type brake on the windlasses was not adequate to control the 3 inch anchor chain as the anchor and chain was pulled by work-boats to position. Consequently, the brake drum and lining would be rapidly heated and the coeffecient of friction between the drum and lining would be progressively reduced. This would result in the chain leaving the chain locker at a very rapid rate and when the entire length of chain had passed over the windlass wildcat, either the "weak link", which had been installed near the shipboard end of the chain, would part or the pin in the last link, connecting it to the bottom of the chain locker, would fail and the chain would thus be lost overboard. The loss of anchor chain Number 4 on November 19-20 (item 20 in the chronological summary in Attachment 1) was caused by a brake failure.

In other instances the winch operator might operate the chain stopper in an effort to control the anchor chain. In either case, immeasureable shock loads would be imposed on the chain.

Inspection of the windlass brake system revealed that the manufacturer had bolted a stainless steel wear band (approximately 1/4 inch thick) to the brake drum. A small depression was formed in the band where each counter sunk bolt penetrated the band so that the effective surface area in contact with the brake lining was significantly reduced. Each wear band was also formed from two lengths of seamless steel and the butt type junction where the two ends met did not perfectly conform to the radius of the underlying brake drum. The resulting irregularity also contributed to rapid wear of the break linings and further complicated the braking problem.

The bolts attaching the seamless steel wear band to the brake drum were sheared on at least two occasions and the lining extruded. Figure 2 is a photograph of one of the extruded linings. As would be expected, when the lining was expelled, this scored the surface of the underlying brake drum and decreased the effective area of contact between the drum and brake lining.

An attempt was made to circumvent the brake deficiencies described above by engaging the windlass clutch and slacking off the chain with the motor powering the windlass rather than controlling the chain with the brake. This was not successful as the workboat was not able to maintain a true course at the maximum rate the chain could be slacked under power (approximately 25 feet per minute).

b. Wildcat Wheel

The chain was also subjected to even more severe shock loading when attempts were made to slack or heave the chain under tension. This resulted from the chain working up out of the wildcat pockets (Figure 3) as the chain was being moved under fairly high tension. When this occured, the chain would be accelerated rapidly and when it again engaged a pocket on the windlass, the resulting shock load would be instantaneously applied to the chain and windlass. While the magnitude of these loads is not calculable, the stresses produced are considered a significant factor in several chain failures subsequently experienced.

The shock loading imparted to the windlasses when the chain is thus suddenly stopped is also considered directly responsible for shearing a number of foundation anchor bolts in the bearings for the clutch drive shaft on windlass 3-4 (item 7, Attachment 1). A subsequent inspection of the other 3 windlasses revealed that a number of bolts had been parted or cracked in windlass 7-8 and these were repaired before complete failure occurred.

It will be noted that a transmission chain (item 7) and sprocket (item 2) failed in two of the windlasses. These failures are also attributed to shock loading caused by the chain jumping the windlass sprockets when the chain was being heaved or slacked under tension.

c. Chain Stoppers

The original stopper design was quite inflexible in that the guillotine gate would not accomodate any significant rotation of the anchor chain and still operate as intended. Attempts to force the guillotine over the partially canted chain contributed to gouging of the individual chain links.

The thickness of the original guillotine (Figure 4) nearly equalled the space between the chain links over which the guillotine gate fitted in the closed position. The limited tolerance and the fact that the gate was also enclosed within the chain stopper case, which prevented the stopper operator observing the action of the guillotine, caused additional physical damage to the chain.

Due to its internal mounting, the guillotine was in frictional contact with the chain stopper case so that it could not freely transfer chain tension forces to the Martin-Decker sensing devices incorporated in the chain stoppers. Consequently, accurate chain tension data were not available to operating personnel with the original chain stopper design.

Chain Handling Equipment Modifications

During the seven weeks the DRILLSHIP was in the shipyard (January 19 - March 9, 1968) the following major changes were completed to the DRILLSHIP'S mooring equipment.

1. The chain pockets on the wildcat wheels were reshaped to better handle the 3 inch anchor chain under tension.

2. The hawse pipes to the chain lockers were moved to provide a greater arc of contact between the chain and the wildcat wheel.

3. Plate type supports were constructed to crowd the anchor chain links into the wildcat pockets.

4. The stainless steel wear bands were removed from the windlass brake drums and thicker brake blocks installed to compensate for the reduced drum diameter.

5. The chain stoppers were revised so that the guillotine gate would accomodate canted chain links and the gate was externally mounted so as to be visible to the windlass operator. (Figure 5). This design also eliminated friction binding between the gate and the stopper case so that the Martin-Decker sensors transmitted accurate chain tension data thereafter. Attachment 3 describes the chain handling equipment and the Martin-Decker tension measuring system.

6. A 100,000 pound capacity winch was installed fore and aft to permit making anchor chain repair connections onboard the DRILLSHIP in lieu of the workboat.

The first three modifications were designed to alleviate the problem of the chains jumping in the wildcat windlass wheel while the anchor chains were being heaved or slacked. Solution of this problem was basic to successfully rotating the DRILLSHIP while drilling operations were underway.

Installation of a winch fore and aft was made to save time when reconnecting broken anchor chains. Most chain breaks occurred during a storm and from 1 to 3 days would often be required before the sea would calm to a state that the workboat could handle the chains and/or anchors. Consequently considerable time was being lost due to this factor.

Prior to installing the winches on the DRILLSHIP, the workboat would hoist the anchor end of the parted chain onboard and then pass a line to the DRILLSHIP to pull the shipboard end of the chain to the workboat deck (Figure 6) to join the two ends. A fairly calm sea was required for this operation, otherwise the workboat winch line would be parted. Installation of the winches on the DRILLSHIP was expected to decrease the time previously lost waiting for suitable weather in which the workboat could operate effectively.

Anchor Chain Experience

A total of 14 chain failures occurred during the 6 months time the DRILLSHIP was operating in the North Sea (Items 6, 7, 11, 13, 14, 23, 27, and 30 - Attachment 1). The first 7 failures occurred when the Martin-Decker chain tension sensors were either inoperative or unreliable and the chain tension existing when those failures occurred is therefore not known.

After the tension sensing devices were modified as discussed earlier, a chain tension record was obtained on five of the 7 subsequent failures and these data are tabulated below:

Chain Number	Average Chain Tension (Pounds)	Remarks
6	70,000	Chain tension steady
1	150,000	Chain tension steady
6	160,000	Chain tension surging 100,000 to 250,000 pounds
6	140,000	Chain tension surging 45,000 to 370,000 pounds
8	160,000	Chain tension surging 40,000 to 510,000 pounds

These data show that the measured tension in the chain when failure occurred was significantly below the 700,000 pound proof test load each 500 foot length of chain was subjected to at the factory and substantially less than the chain's rated 1,045,000 pounds breaking strength. In analyzing the foregoing data, it is important that several factors be considered including the following:

1. The chain tensions were measured onboard the DRILLSHIP upstream of the fairlead chocks over which the anchor chain was in heavy friction contact. Therefore, any dynamic cycling forces of a relatively high frequency out board the chocks might be dampened sufficiently so that the full range of these forces were not recorded.

2. The response of the combination hydraulic - electrical chain tension measuring device may not have accurately recorded the peak tensions developed in the chain under cycling loads.

3. The anchor chains were subjected to very severe shock loads during the first several weeks the DRILLSHIP was on location. It is considered

probable the chains were overstressed during this period, and this was a significant factor in the chain failures subsequently experienced.

Analysis of Chain Link Failure

Only a few of the failed link sections were recovered and Figure 7 is a photograph of a link which failed adjacent the weld. In another case, the failed link had fractured and a metallurgical laboratory concluded that the fracture had originated in a mechanically gouged groove in the link.

Additional tests showed that the impact strength of the failed sample was only 50% of the minimum value and 20% of the maximum value reported by the manufacturer for any melt of the steel used in fabricating the chain. Additional tests indicated the manufacturer's normalizing process was probably responsible for the low impact resistance of the failed link sample analyzed. Supplementary data regarding the anchor chains and anchors are summarized in Attachment 4.

DRILLSHIP Neutral Heading and Anchor Pattern

The original anchor array oriented the eight 30,000 pound anchors symetrically about the ship's axis using angles of 30° and 90° and outboard chain lengths of approximately 2000 feet. The neutral heading of the vessel was 270° or due west. Selection of this anchor pattern was based on research studies that showed advantages over other patterns should one chain break and the load was assumed by other chains.

Experiences the first two months the vessel was on location indicated the two bow and stern chains should be oriented at a wider angle to the ship's axis in order to facilitate rotating and holding the vessel on station under quartering wind and sea forces.

Also, the experience gained during the major storm of January 14-15 (Item 7) clearly demonstrated that the ship's engines could be effectively used to offset the lack of anchors directly forward and aft of the vessel. Consequently, when the vessel returned to location on March 11, the two bow and stern anchors were run at an angle of 45° to the ship's axis. Both the original and final anchor patterns are shown on Figure 8.

The neutral heading of the vessel was also changed to a heading 20° north of due west (290°). The heading change was made as a result of studies of wind and wave data obtained during the two months the vessel was at sea. These findings indicated the sector from 315° to 5° should be considered as "critical" from the available wind fetch and probable maximum sea conditions.

North Sea Weather

The weather actually experienced at the Well 2/8-1 location was significantly more severe than was expected based on a meterological report obtained for the area. Several storms in the 25 to 30 year category were encountered and the storm on January 14-15 (Item 7 in the Operations Summary - Att. 1) would be expected to occur on an average interval of 70 to 90 years.

It was possible to maintain the DRILLSHIP within the mooring pattern during the severe gale on January 14-15 by using the ship's engines to maintain position and the bow anchor chains were used only to keep the vessel headed into the storm. Otherwise, all chains were slacked during the storm.

An indication of the sea state during this storm may be gained by comparing the photograph of the bow section of the DRILLSHIP taken from the bridge (Figure 9) during calm weather with the photographs made during the January

14-15 storm from the same location on the bridge (Figures 10-12). The significant wave height was estimated at 30-35 feet with maximum waves of 50-55 feet. Only negligible damage was incurred by the DRILLSHIP whereas two semi-submersible type rigs in the same general path of the storm were severely damaged, and had to be withdrawn from service for several weeks to months to repair storm damages.

The DRILLSHIP was the first vessel to be equipped with an acoustic positioning reference system to continuously reflect the lateral displacement of the rotary table to the well head on the ocean floor. A description of the system and its performance is included as Attachment 5.

The DRILLSHIP motion response was actually better than the anticipated performance in pitch, roll, heave and general stability. However, it was necessary to keep the vessel headed into the weather in order to maintain station. Although the majority of the North Sea weather originated from the west, it was not unusual to have a storm veer nearly 180° during a 6 to 12 hour period. This factor, coupled with the suddeness, intensity and unpredictability of the storms which developed, created situations where wind and wave forces would be on the DRILLSHIP'S beam and could not be satisfactorily quartered by rotation of the vessel.

Well Head Failure

The failure of the 20 inch well head and the later failure of the 13-3/8 inch well head and BOP stack (a list of the BOP stack components and the well head assembly are tabulated in Attachment 6 in the Appendix) were major factors in the decision to abandon further attempts to use the DRILLSHIP at Well 2/8-1 location. Chain No. 6 was being subjected to only moderate tension (cycling between 100,000 and 250,000 pounds) when it failed and allowed the vessel to move off location. As discussed in an earlier section of this report, other chain failures occurred where the maximum observed tension was only 10 to 50% of the chains rated breaking strength.

Since this chain failure resulted in breaking off the 13-3/8 inch well head and leaving the well with no mechanical control protection, other subsequent chain breaks could cause similar failures. Since the well was approaching the depth where significant gas kicks could be expected, it was judged that further drilling could not be conducted safely due to the known unreliability of the anchor chains. The location was therefore abandoned and the drilling contract terminated.

ATTACHMENT 1

CHRONOLOGICAL LISTING OF OPERATIONS

WELL 2/8-1

Item Number	Dates	Description of Operation
1	Nov. 13 to 18, 1967	Vessel accepted under contract. Loading at Stavanger and sailing to location.
2	Nov. 19-20	Arrived on location and start setting anchors. Windlass brake failed while running No. 4 chain, damaged chain stopper and lost chain overboard. Teeth on No. 5-6 windlass sprocket stripped.
3	Nov. 21-25	Reposition anchors 1 and 8, recover No. 4 chain and repair winch on No. 5-6 windlass. Mix mud for spudding well.
4	Nov. 26-28	Check anchors, holding o.k. Anchor chains jump in windlass when heaving or slacking under tension. Ran temporary guide base and spudded well at 2130 hours, Nov. 28.
5	Nov. 29 to Dec. 1	Ran and cemented 200 feet of 30 inch casing. Set at 472 feet (KB).
6	Dec. 2-3	Storm came in off starboard bow while drilling cement from inside 30" casing. Pulled drill string from hole and attempted to rotate ship into storm which had veered to starboard beam. Nos. 1 and 2 chains broke, attempted to slack No. 3 chain, chain broke. Disconnected from other 5 anchor chains. Wind gusts to 70 MPH, waves 30-35 feet.
7	Dec. 4, 1967 to Jan. 18, 1968	Made several attempts to resume operations. Weather generally too severe for workboats to reconnect all anchor chains so that vessel could be secured over hole to resume drilling. Broke chains No. 3 (twice) No. 6 and No. 7 during periods when anchoring operations were underway or completed.

Item Number	Dates	Description of Operation
		Transmission chain in No. 5-6 windlass failed. Experienced 75-100 year storm Jan. 14-15. Wind gusted to 85-100 MPH, steady blow of 70 MPH for 6 hours. Significant waves 30-35 feet, maximum waves of 50-55 feet. Maintained vessel within mooring pattern throughout the storm.
8	Jan. 18-19	Departed location for Oslo shipyard.
9	Jan 19 to March 10	Vessel in shipyard for equipment modification and repairs.
10	March 10-11	Vessel departed Oslo shipyard - arrived at location.
11	March 12-30	Frequent and severe weather delayed locating well head and anchoring operations. Chain No. 6 broken during this period.
12	March 31	Vessel anchored over hole; resumed drilling.
13	April 1-8	Chain No. 7 broke during storm. Weather delayed reconnecting chain and resuming drilling.
14	April 9-14	Resumed drilling. Chain No. 6 broke and repaired without delaying drilling operations.
15	April 15	Set 20 inch casing at 1074' and cemented with 2300 sacks.
16	April 16-21	Ran 20 inch BOP and 24 inch riser and checked out Payne control assembly.
17	April 22-28	Drill 12-1/4 inch hole to 6637 feet.
18	April 29 to May 2	Running logs, side wall coring and trips with drill pipe to condition hole. Lost wire line DST tool in hole.
19	May 3-12	Fishing for DST tool. Reamed 12-1/4 inch hole to 17½ inches to top of fish and recovered fish with overshot. Resumed reaming to 5579'. Lost circulation.

Item Number	Dates	Description of Operation
20	May 13-15	Check BOP, riser and well head for lost circulation cause. Found 20 inch centralizing sub included in National well head broken approximately 5 feet below well head.
21	May 16-17	Ran 13-3/8 casing and cemented at 5554 feet.
22	May 18-25	Change out 20 inch BOP stack and riser with 13-3/8 BOP and 16 inch riser. Check and repair BOP controls.
23	May 26-30	Drill 12-1/4 inch hole to 7769 feet. Drill pipe stuck with bit at 6950' while making trip. No. 1 chain broke.
24	May 31 to June 10	Fishing. Unable to recover fish, top of fish at 6589 feet.
25	June 11-17	Set cement plug and drill side track hole around fish.
26	June 18-20	Drill 12-1/4 inch hole to 8515 feet. Drill pipe stuck while making trip. Bit at 7340 feet.
27	June 21-22	Attempting to back off drill pipe. Storm came in off port stern and No. 6 chain broke. With the 5 inch drill pipe under tension and the vessel off location, the 13-3/8 BOP stack and casing head were broken off and the drill pipe bent and parted at depth of 13-3/8 inch well head.
28	June 23-27	Recovered sub-sea well head equipment.
29	June 28 to July 2	Recovered 5 inch drill pipe to 6202 feet, left fish from 6202 - 7340 feet. Set 200 foot cement plug over 13-3/8 shoe and a second plug inside 13-3/8 casing from 460 feet to ocean floor.
30.	July 3-4	Recovering anchors. Chains Nos. 6 and 8 broke during storm.
31	July 5-17	Enroute to Stavanger, off-loading supplies and inventorying. DRILLSHIP enroute to final anchor south of Oslo. Contract terminated.

ATTACHMENT 2

VESSEL and DRILLING

EQUIPMENT DATA

DRILLSHIP

Overall length	639 ft
Beam	77-1/3 ft
Draft	32 ft
Gross Register	18,360 tons
Ship propulsion	Twin screws, diesel driven 6,000 BHP (total)
Potable and drilling water storage	8,500 barrels
Distillation plant capacity	300 bbls/day
Liquid mud tank capacity	Five tanks, 375 bbls each. One 275 bbl and one 100 bbl slug tank (2250 bbls. total).
Mud and Cement Storage	
a. Bulk	6 pneumatic silos, 920 cu ft each (5,520 cu ft total).
b. Sack	23,000 cu feet
Pipe rack area	300 ft 36" csg; 2,000 ft 20" csg; 6,000 ft 13-3/8" csg; 12,000 ft 9-5/8" csg; 20,000 ft 5" drill pipe.
Moonwell size	24 ft x 24 ft - octagonal
Helicopter deck	93 ft x 93 ft
Helicopter	French Frelon 3 jet engines (1500 HP each)
Navigation and Communication Equipment	Brown Gyro compass with 2 repeaters, Course recorder, Decca navigator-mark 12, Marconi depth recorder, Marconi radio direction finder, "Standard" main radio transmitter (ST 1400 A) and receivers (R 408), "Standard" emergency transmitter (IMR-113) and receiver (R 408), Redifon VHF radiotelephone Raytheon "Pathfinder" (0-40 miles).

DRILLING AND AUXILIARY EQUIPMENT

Derrick	Lee C. Moore 140 ft, 30 x 30 ft base, 1,100,000 lbs capacity. Equipped with traveling block guide dolly.
Drawworks	National 1320-UE, powered by 2 GE-752 HP/DC motors. Elmagco electric brake on drum.
Rotary table	National C-365 (36½ inch opening) powered by one GE-752 HP/DC motor. Gimbal type, pin drive rotary bushing.
Hook block and swivel	National 650 G 500, 500 ton rating.
Mud pumps	Two National N-1300, (7-1/4" x 16") each with 2 GE-752 HP/DC electric motors.
Shale Shaker	Hutchison "Rumba" 4860 dual type
Desander	Pioneer sandmaster TIO-6
Degasser	Wilson Supply with 25 HP Mission 6 x 6 centrifugal pump.
Cementing Unit	Diesel driven, B-J dual Pacemaker pumps.
Logging Units	Schlumberger OSU-C with WDA-B. Core Lab mud logging unit.
Diving Equipment	Ocean Systems ADS-IV with submersible and deck decompression chambers.
Material Handling Cranes	Two Link-Belt TC-108 B; 45 ton with 80 ft boom.
Power Supply	Diesel electric, 7 Catepillar D-398 coupled to 5 GE-752-T1 DC generators (750 HP each) and 2 GE-752-T1 AC generators (500 kw each)