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WATER MANAGEMENT TECHNOLOGY FOR OIL PRODUCTION

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TROLL FIELD WELL 31/3-1
toring Quality of Completion luids for Production Tests

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TROLL FIELD

WELL 31/3-1

Results of Monitoring the Quality of Completion Fluids for Production Tests in the Gas Zone

Report Prepared by
Oil Plus Limited

For Statoil

November 1983

LIST OF CONTENTS

SECTION 1.

INTRODUCTION

SECTION 1. INTRODUCTION

This report presents the results of monitoring the quality of seawater and calcium chloride brine circulated in Well 31/3-1 in the Troll Field, in preparation for the production tests in the gas zone.

The two main production tests involved internal gravel pack completions. The first test was in the 1519m to 1529m zone. The second test was in the 1373m to 1383m zone.

The cleanliness of all fluids pumped downhole, and that of the returns, was carefully monitored. The cleanliness of the fluids and rate of clean up have a direct effect, not only on the skin factor of the producing zone, but also the entrained fines within the gravel when placed, and the subsequent near well bore permeability.

The completion fluid monitoring tests were performed by Oil Plus on rig Deep Sea Bergen between 8th September and 29th September 1983.

SECTION 2.

CONCLUSIONS AND RECOMMENDATIONS

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1. The results of brine quality monitoring indicated that the procedures used had been successful in achieving a high standard of cleanliness of the brine, casing and gravel pack string prior to perforations for the two tests in the 1519m to 1529m, and 1373m to 1383m BRT Zones.

   Higher degrees of cleanliness than for previous completions in Troll Field were attained, and provided a standard which subsequent completions should strive to achieve.

2. Turbidity values of just greater than 1 NTU (Nephelometric Turbidity Unit) were recorded for the calcium chloride brine in the hole prior to each perforation job, as compared to a best of 3.8 NTU for previous completions in the Troll Field.

   Coulter Counter readings were:-

   400 - 500 particles of diameter greater than or equal to 3 microns per 0.05 ml.

   and less than

   100 particles of diameter greater than or equal to 5 microns per 0.05 ml.

   Subsequent completions should strive for brine returns of this quality, as this corresponds closely to the average quality of the brine at the outlet to the filter system.

3. Procedures of well clean up operations often state that brine circulation should continue until the solids level of the returns had reached a minimum. It is unlikely that an irreducible solids concentration would be reached because once the casing, and gravel pack string have been cleaned the filter system will still continue to remove a certain percentage of particles on each pass through the filters.

   If it proves impractical to achieve the target quality as specified above, we recommend that brine circulation should be continued until the 'clean up rate', or reduction in particle counts (of particles of diameter greater than or equal to size which will critically block the formation, in this case considered to be 3 microns) in the returns reduces by less than 5% in the time of one circulation.

4. To be able to achieve a similar brine cleanliness for subsequent completions, as was attained for this completion, it will be important to repeat the following steps:-

   i). Thoroughly clean the casing and gravel pack string before RIH. Use minimum pipe dope whilst making up the string.

Section 2. Continued....

ii). Thoroughly flush and circulate seawater through the mud system, all lines to be used during the gravel pack, and the choke and kill lines, before circulating brine. The quality of the fluids flushing these lines should be carefully monitored to measure the efficiency of the clean up. It is important to recognise that seawater from the rig seawater main is a very clean fluid, even in comparison to the filtered brine, and should be used to the maximum benefit to clean up the topsides equipment and the well prior to brine circulation.

iii). Transport the brine to the rig in lined tanks on the deck of the supply boats to ensure that the brine can be filtered by the fine filters. After transportation to and filtration on the rig, brine of turbidity of less than 3 NTU should be achieved. If not investigations into the cleanliness of the brine producing and transporting system should be made. Brine of this quality is vital to the swift and successful clean up operation.

iv). Ensure lines used to transfer the brine from the supply boat to the rig are clean, and are not contaminated with diesel oil or other contaminants.

v). Always use the complete filter system, including the fine filters when filtering the brine.

vi). Thoroughly hose down the parts of the mud system to be used for the brine circulation, and circulate seawater through it so that the solids pick up in the system can be monitored prior to the introduction of the brine.

As a further assurance of brine cleanliness, thought should be given to the feasibility of bypassing the mud system altogether when circulating the seawater and brine.

vii). Use a standby system when changing filters, and ensure that enough filters are on-line to cope with the prevailing flow rate. Failure to do so will result in a deterioration of brine quality.

viii). Use a water soluble oil to lubricate the pistons of the Dowell high pressure pump unit. This prevents insoluble oil particles picked up from the pump adding to the suspended particle counts level of the brine. Water soluble oil should also be used for the pump which transfers the brine from the supply boat to the rig.

Section 2. Continued ...

ix) Fittings should be available to provide sample points in the chicksan downstream of the Dowell high pressure pump during the brine circulation.

A sample point should also be available at the drill floor during seawater circulation, downstream of the mud pumps and the mud lines to the drill floor to distinguish between solids picked up in the mud system, and those picked up in the well.

x). The pH of the calcium chloride should be kept below 10 to prevent any magnesium present precipitating which would increase the solids level of the brine.

SECTION 3.

ANALYTICAL TECHNIQUES

SECTION 3. ANALYTICAL TECHNIQUES

This section describes the techniques used to analyse the completion fluids, in terms of particle size distribution, turbidity and the weight of suspended solids.

3.1 Seawater and Calcium Chloride Brine Quality Monitoring

3.1.1. Particle Size Analysis

The particle size analysis of the seawater and calcium chloride brine samples were conducted using a Model D Industrial Coulter Counter, counting particles of diameter between 1.0 to 15.0 microns.

This equipment measures the volume of a particle, and the particle size is expressed as the diameter of a sphere having an equal volume.

3.1.2. Turbidity

Turbidity was measured using a Hach 2100A turbidity meter. This instrument measures the amount of light scattered, at 90° to the incident light, by the suspended particles. The results are given in Nephelometric Turbidity Units (N.T.U.).

The readings are dependent on the particle size distribution and particle shape, as well as the suspended solids concentration. Thus, two waters having the same turbidity may well be quite different in terms of particle size and their distribution.

Nevertheless, the readings provide a useful check for monitoring variations in water or brine quality.

3.1.3. Millipore Filter Tests

All Millipore tests were run using pre-weighed Millipore membrane filters of 47 mm diameter and 0.45 micron pore size. these tests were run in accordance with the National Association of Corrosion Engineers Standard TM-01-73. "Methods for determining water quality for sub-surface injection using membrane filters".

The method used by Oil Plus involved taking a 10 litre sample of water into a pressure cell which was then pressurised and held at 20 psig; water flowed from this cell through the Millipore filter, discharging to atmosphere.

3.1.3. Millipore Filter Tests (Contd) ...

Simultaneously, 'Slope' tests were conducted by measuring the volume passing through a Millipore membrane with time. The rate of change of the flowrate gives an indication of the water quality. The dirtier the water the more rapid the decline in flow rate.

After conducting these tests the Millipores were flushed through using 0.45 micron filtered, de-ionised water to remove all traces of salt water which would otherwise crystallise on the membrane and give false results. After drying, the Millipore membranes were weighed and suspended solids calculated.

SECTION 4.

RESULTS AND DISCUSSIONS

SECTION 4. RESULTS AND DISCUSSIONS

4.1. Introduction

This section presents and discusses the results of completion fluid monitoring performed by Oil Plus during the production test programmes in the gas zone of Well 31/3-1, of the Troll Field.

The section is divdided into four parts.

Firstly the well clean up operation for the production tests in the 1519m to 1529m zone.

Secondly the well clean up operation for the production tests in the 1373m to 1383m zone.

Thirdly filter performance and finally brine quality on arrival on the rig Deep Sea Bergen.

4.2. Production Zone 1519m to 1529m BRT. Internal Gravel Pack Completion

4.2.1. Clean Up Procedure

Following RIH with a 9⅝" casing scraper, and with the 8½" bit on bottom a 50 bbl spacer was pumped followed by seawater to displace the drilling mud from the well.

The seawater circulation system is illustrated in Figure 4.1.

After the well had been displaced to seawater a 20 bbl pill of viscosified seawater containing a surfactant and sand was pumped. (The object of circulating this pill containing sand was to score off and clean up any corrosion products still adhering to the inside of the casing).

This pill was followed by a similar pill, but without the sand. These pills were circulated out with seawater. Another viscous pill was introduced after another half hole volume had been pumped. These pills were circulated out with seawater and discarded.

This treatment was followed by 2000 gallons of 7½% HCL acid containing a corrosion inhibitor.

The seawater was then circulated as fast as possible, with the returns being dumped. Circulation was continued until the solids level had reached a practical minimum, as measured by the Coulter Counter. Ideally, this would have been when the solids level going into the well was the same as the returns from the well.

4.2.1. Clean Up Procedure

Once the solids level of the seawater returned had reached a practicle minimum the drill string was pulled. It was replaced by the string to be used during the gravel pack operation, so that it would be cleaned during subsequent seawater and brine circulations.

With the gravel pack string RIH, seawater circulation was recommenced and was again continued until the solids level of the seawater returns reached a minimum. During this time the choke and kill lines, and the parts of the mud system which were to be used during the brine circulation were flushed with the clean seawater returns. Prior to this the relevant parts of the mud system had been thoroughly hosed down to remove all traces of mud.

When the mud system had been flushed with seawater the seawater was circulated out of the well with 20 bbls of viscosified seawater, followed by filtered 1.16 SG calcium chloride brine.

The calcium chloride brine was then circulated and filtered using the system illustrated in Figure 4.2. The brine circulation continued until the solids concentration in the brine had levelled off at the lowest practical level as measured by the Coulter (particle) Counter and the turbidity meter.

The perforating was then performed followed by a short flow test and PBU prior to the setting of the internal gravel pack.

Three attempts at setting the gravel pack were required before a successful pack was completed. This was due to formation sand blocking the screens.

4.2.2. Seawater and Brine Quality During Clean Up Procedure

The results of the turbidity and particle count measurements for the circulation of seawater and 1.16 SG calcium chloride brine are illustrated in Figures 4.3 and 4.4 respectively. The results are presented in Tables 4.1 to 4.7.

The results of the membrane filter slope tests, prior to perforation, are illustrated in Figure 4.5 as 'Barkman and Davidson Plots'. The steeper the gradient of the plot, the better the water quality. In essence the plots for the worst water qualities plot closest to the X-axis. The volume of sample which passed through the membrane filter in 30 minutes during the seawater circulationn is plotted in Figure 4.6. Suspended solids concentrations, in milligrammes per litre are presented in Table 4.7.

4.2.2. Contd ...

With the drill string RIH, approximately five complete circulations were required to reduce the turbidity of the seawater returns from 80 NTU to a steady minimum level of approximately 10 NTU (following the viscous sand and acid pill treatments).

When the string to be used for the gravel pack installation had been RIH, and the seawater circulation restarted the turbidity of the seawater returns fell from a maximum of 310 NTU, finally levelling off at approximately 12.5 NTU after just over one circulation. This rapid rate of clean up is a direct result of thorough cleaning of the gravel pack string including Tubulars and casing prior to RIH. This practice avoids unnecessary contamination of the seawater and saves rig time by reducing the number of circulations required during the clean-up.

A sample taken from the rig seawater main (the input to the seawater circulation system) had an average turbidity of just 0.25 NTU, much less than the minimum for seawater returns. Oil Plus' experience of monitoring water injection tests using mud pumps has shown that significant levels of solids can be picked up from the mud pump and the mud lines to the drill floor even after extended periods of time. This results from the vibration, induced during pumping, loosening mud from pump and mud line surfaces. The affect is increased where unlined pipes, or pipes with damaged linings are used as the initial amounts of mud adhering are greater. Prior to a clean up operation involving seawater circulation a sample point should be provided on the drill floor, at the inlet to the well. This would enable distinctions to be made between solids picked up in the well and contamination due to the mud pump and mud lines. If the solids pick up in the well was found to cease before that in the mud system, circulation time could be reduced and rig time saved.

An indication that a lot of the solids picked up by the brine originated from the mud pumps and mud lines to the drill floor was given by the subsequent circulation of filtered brine. The problem with the mud lines to the drill floor is that they are inaccessible and are not cleaned in any way, apart from the flushing with seawater.

In the case of the brine circulation prior to perforation the turbidity of the brine returns fell from a maximum of 8.0 NTU, to a minimum of just 1.1 NTU, in the course of just over three circulations.

The final turbidity of the brine returns represented an improvement on the final turbidity of the seawater returns. This may be attributed to the brine not picking up solids

4.2.2. Contd ....

from the mud lines to the drill floor. The average turbidity of the brine at the well inlet was 1.4 NTU compared to an average for the rig seawater main of 0.25 NTU.

During brine circulation prior to perforation the brine turbidity at the well inlet (downstream of the Dowell pump) fell from 2.9 NTU to 0.37 NTU. Figure 4.8 compares the turbidity at the well inlet and outlet. Figure 4.9 illustrates the results of the membrane filter slope tests during the brine circulation, whilst Figure 4.10 plots the volume passed through the membrane filter in 30 minutes. All results show the gradual improvement in the quality of the brine returns.

The final turbidity of the brine returns represents an improvement in brine quality in comparison to previous completions in the Troll field. This may be attributed to a successful cleaning of the mud system prior to brine circulation, and of the tubulars prior to RIH, and also due to the use of a water soluble oil to lubricate the pistons of the Dowell high pressure pump unit. The use of a water soluble oil, precludes insoluble oil droplets being picked up in the pump and increasing turbidity.

The results of monitoring turbidity and particle size distribution of brine returns during circulations associated with the three gravel pack attempts are illustrated in Figures 4.11 to 4.14 inclusive. The results of the membrane filter slope tests prior to the first gravel pack attempt are shown in Figure 4.15. Volumes passed through the membrane filter in 30 minutes are illustrated in Figure 4.10, whilst the suspended solids concentrations are plotted in Figure 4.7.

At all times the turbidity of the final brine returns was comparable to the best obtained during previous completions in the Troll field, i.e., less than 5 NTU.

A slight rise in the turbidity of the final brine returns after perforation was due to contamination by sized calcium carbonate particles from the lost circulation pills. To simulate the effect of acid treatment on the turbidity and particle counts of the brine, 15% HCL was added to the brine samples. The changes in turbidity and particle counts due to the addition of 15% HCL, a third of the volume of the sample, are presented in tables 4.8 and 4.9 respectively.
On average a 57% reduction in turbidity was achieved through acidifying the sample.

4.2.3. Brine pH and Stability of Solids Level

No pH greater than 10 was recorded for the brine, indicating that the brine was kept below the pH at which any magnesium present would precipitate. The stability of the brine's solids level, at surface conditions, for the period of one circulation, was checked. The results are presented in Table 4.10. No significant change in the solids level was found confirming the stability of the brine.

4.3. Production Test Zone 1373m to 1383m BRT. Internal Gravel Pack

Following the production test in the 1519m to 1529m zone a cement plug was set to block off that layer prior to the production test in the 1373m to 1383m zone.

The 1.16 SG brine used for the previous completion was replaced by 1.30 SG brine.

The 1.30 SG brine was circulated and filtered until an acceptable solids level for the brine returns had been obtained.

The casing was then perforated between 1373m and 1383m BRT, after which there was a short flow test followed by a pressure build up test.

Subsequent circulation followed, before the setting of the gravel pack.

The results of monitoring the turbidity and particle size distribution of the brine returns are illustrated in Figures 4.16 to 4.17 respectively. The results are presented in Table 4.11.

As for the 1519m to 1529m zone, between three and four complete circulations of brine were required before the turbidity of the brine returns fell to just over 1 NTU.

4.4. Filtration System and Filter Performance

The brine filtration system is illustrated in Figure 4.2. 4 pods, each housing 18, 5 micron nominal Hytrex cartridge filters, arranged in parallel, act as the pre filter to 4 pods, also arranged in parallel, each containing 32, 10 micron absolute Pall cartridge filters. This is the filtration system, suggested by Oil Plus, for previous completions in the Troll field.

Each pod containing the Hytrex filters can take a maximum flow of 5 bpm without adversely affecting filter performance. For the Pall filters the maximum recommended flow rate is 2 bpm per pod. As the maximum flow rate for the brine was approximately 6 bpm, 2 pods of Hytrex filters and 3 pods of

4.4. Contd ...

Pall filters should be online. The other pods should be filled and on standby ready for when the differential pressure reaches that requiring a change of filters. The maximum allowable differential pressures for the Hytrex and Pall filters is 20 psi and 40 psi respectively.

The increase in differential pressure across the filters represents a build up of filter cake on the filter surface which improves filter efficiency. The 5 micron nominal Hytrex filters are coarse enough to let sufficient particles to pass for a filter cake to build up on the Pall filters, yet still fine enough to enable a reasonable filter life for the Pall filters. The filter system is a compromise between filter efficiency and a reasonable filter life.

Filter change overs are an important aspect of filtration. The system of standby filters mentioned above should be adopted. This enables a quicker filter change to be made and also guards against the need to bypass a filter stage during filter change out.

If the coarse filtration has to be bypassed during filter changes the life of the fine filters will be dramatically reduced. If the fine filtration stage has to be bypassed during filter changes, brine of substandard quality will enter the well, lengthening the time required to reach the desired brine quality at the well outlet. Thus, efficient filter changes, adopting a standby system will lengthen filter life and save rig time during the brine circulation system.

A standby system in which only one new pod of filters is introduced at one time will also help to maintain filter efficiency, again saving rig time. As mentioned above, as a filter cake builds up on filters and the differential pressure increases, filter efficiency will also increase. If all of the filter pods are changed at once the benefit to filtration due to filter cake build up will all be lost and has to be regained gradually as the filter cakes redevelop. Changing only one pod at a time will be less detrimental to filter efficiency.

The average filtration efficiency for the 5 micron nominal Hytrex filters on their own was 46.4% for particles of diameter greater or equal to 3 microns and 55.2% for particles of diameter greater or equal to 5 microns. In comparison the efficiency with the Pall filters as the fine filtration stage was 89.1% and 92.8% respectively at the particle sizes mentioned above.

The average filter efficiency, as indicated by turbidity, for the Hytrex filters on their own, and the complete filtration system was 34.2% and 87.2% respectively.

4.4. Contd ....

This illustrates the better filtration provided by absolute cartridge filters as opposed to nominally rated filters. Also apparent is the obvious benefit of using the complete filtration system, including the Pall filters, and not just the Hytrex filters, for example when transferring brine from the supply boats to the Dowell Storage tanks on the rig.

Thought should be given to the feasibility of re-using the more expensive Pall filters by washing the surfaces of the filters after use, with a high pressure hose. This may be time consuming, yet some increase in filter life will be achieved. Also, the filter cake left will produce a high initial filter efficiency when first put back on-line.

4.5. Brine Quality as Received on Board the Rig from the Supply Boat

Great effort was made to present the brine at the rig in as clean a condition as possible. Providing clean brine to the rig reduces the circulation required to reach the desired brine quality and also saves on the number of filters used on the rig.

To this end the brine was filtered twice onshore by 5 micron nominal Hytrex cartridge filters, and transported to the rig in lined storage tanks on the deck of the supply boat.

During some previous completions in the Troll field the brine had to be transported to the rig in the supply boats' own tanks often resulting in contamination of the brine which negated the effects of onshore filtering. This meant that the brine could only be filtered by the coarse filters during transfer to the rig, and on those occasions, brine of substandard quality was placed in the rig storage tanks.

The results of monitoring the quality of the brine as it was transferred onto the rig from the supply boat are presented in Table 4.21. The average turbidity of the brine from the storage tanks on the supply boat was 20.9 NTU. The brine was of sufficient quality that it could always be filtered by the complete filter system incorporating the fine Pall filters.

The results of monitoring the brine quality in the rig storage tanks after filtration and transferring it from the supply boat are presented in Table 4.22. The average turbidity of the brine in the storage tanks was 1.7 NTU.

4.5. Continued....

The importance of obtaining clean brine in the Dowell rig storage tanks prior to the displacement of the well to brine cannot be over emphasised. It should be possible to have brine in the storage tanks, with a turbidity of 3 NTU or less using the present filtration and transportation system. Investigation into the cleanliness of the equipment used should be made if brine of this quality is not obtained.

The quality of the brine used to perform the initial displacement of the well will greatly effect the time required to reach the target brine quality. As shown in Figure 4.2. the brine is not filtered on passing from the Dowell residence/storage tank to the Dowell pump (the brine is filtered before it enters the Dowell tank). Thus the quality of the brine when it reaches the rig is all important in saving rig time whilst performing the clean up operation.

If seawater circulations performed prior to the brine circulation have been successful, and the mud system has been thoroughly cleaned, theoretically the brine should pick up a relatively low level of solids on being circulated through the well.

Providing the brine is clean at the well inlet the circulation and filtration will soon result in acceptable brine qualities. The importance of inlet brine quality, thorough cleaning of the system and successful seawater circulations are all crucial in achieving satisfactory completion fluid quality.

SCHEMATIC OF SEAWATER CIRCULATION SYSTEM

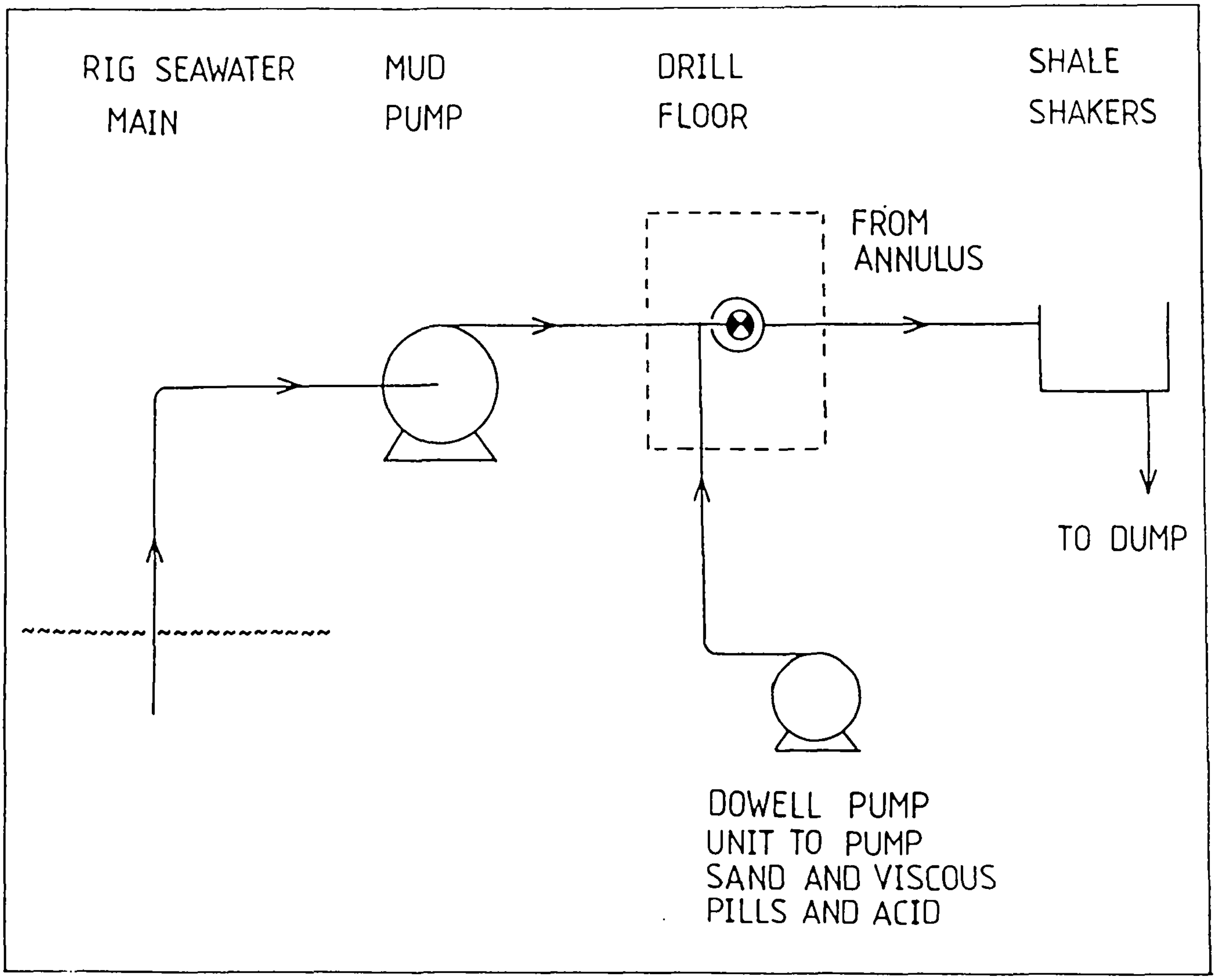

FIG 4.1.

SCHEMATIC OF $CaCl_2$ BRINE CIRCULATION AND FILTRATION SYSTEM DEEP SEA BERGEN

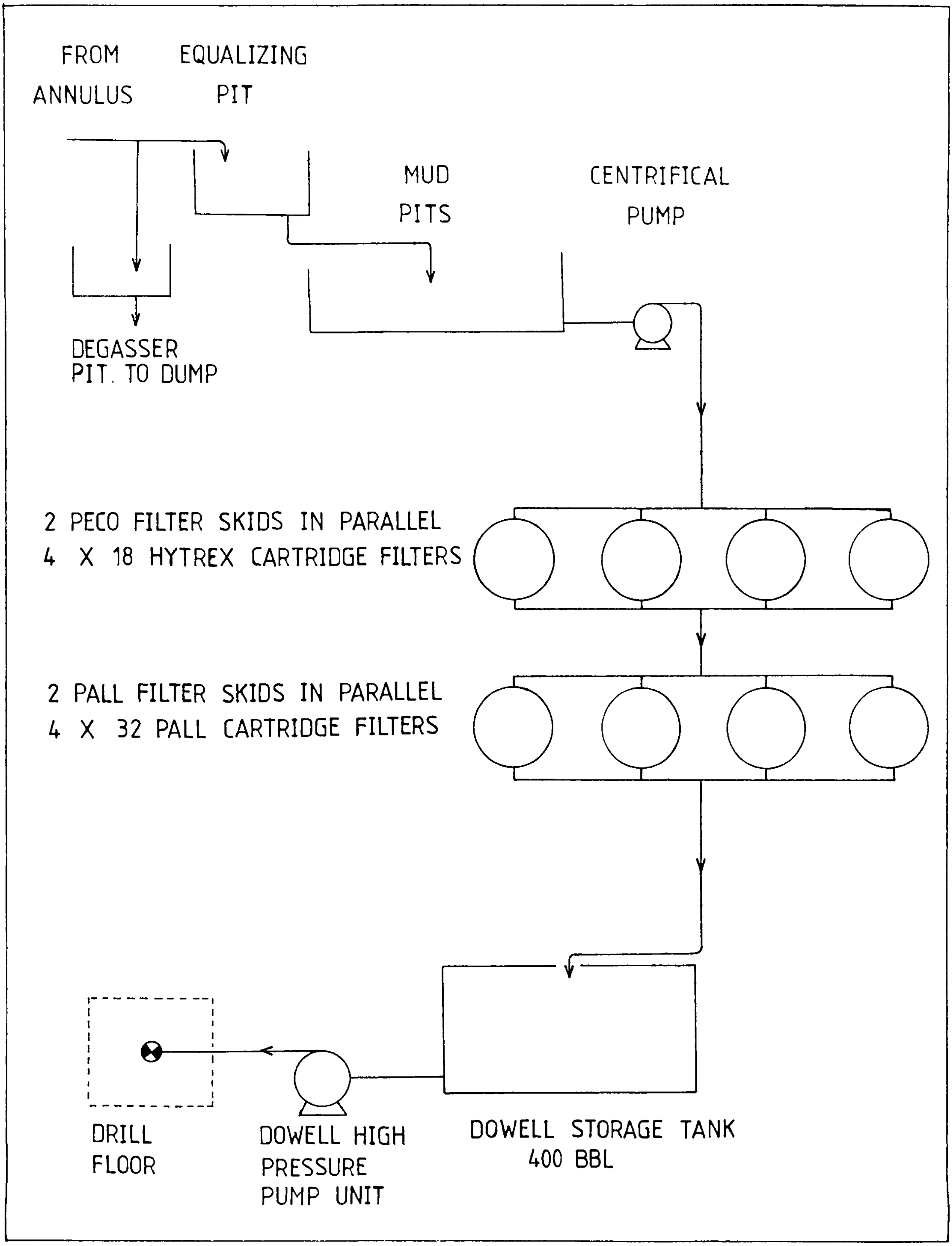

FIG 4.2.

SEAWATER AND BRINE CIRCULATION PRIOR TO PERFORATION IN 1519m TO 1529m ZONE. TURBIDITY OF RETURNS

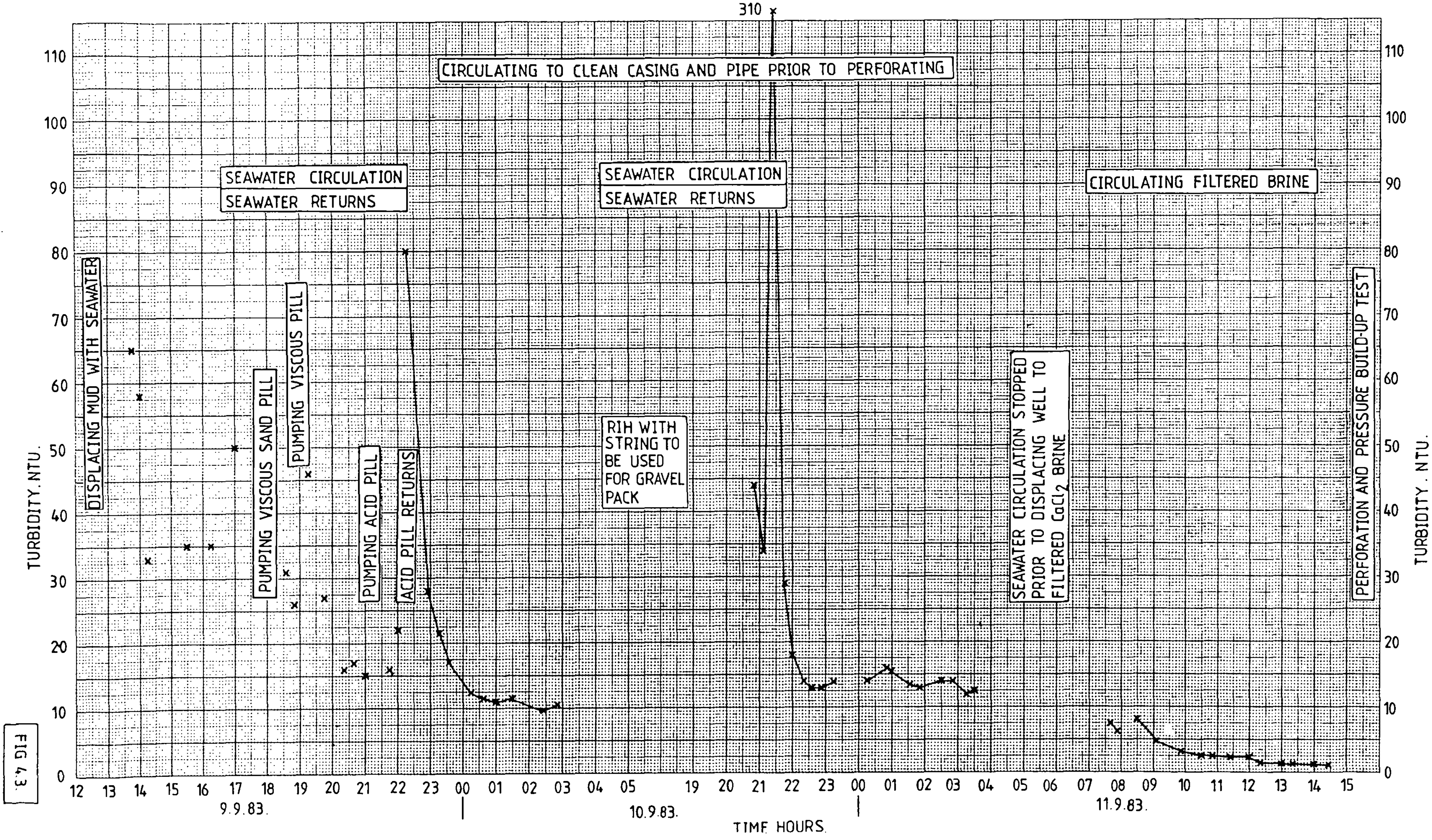

FIG 4.3.

SEAWATER AND BRINE CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519m TO 1529m BDF ZONE. PARTICLE COUNTS OF RETURNS

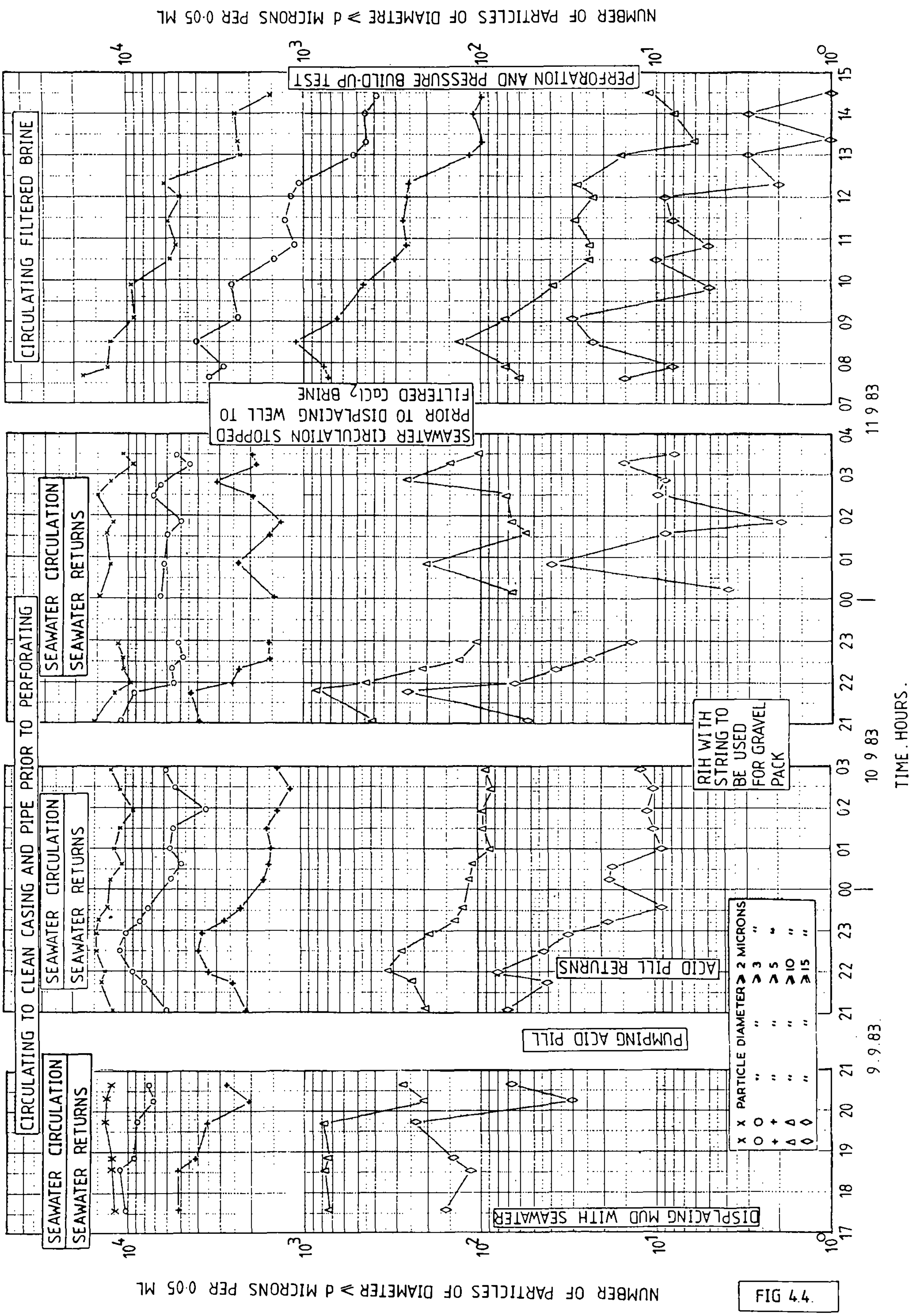

FIG 4.4.

1519m TO 1529m ZONE
SEAWATER CIRCULATION
MEMBRANE FILTER SLOPE TESTS

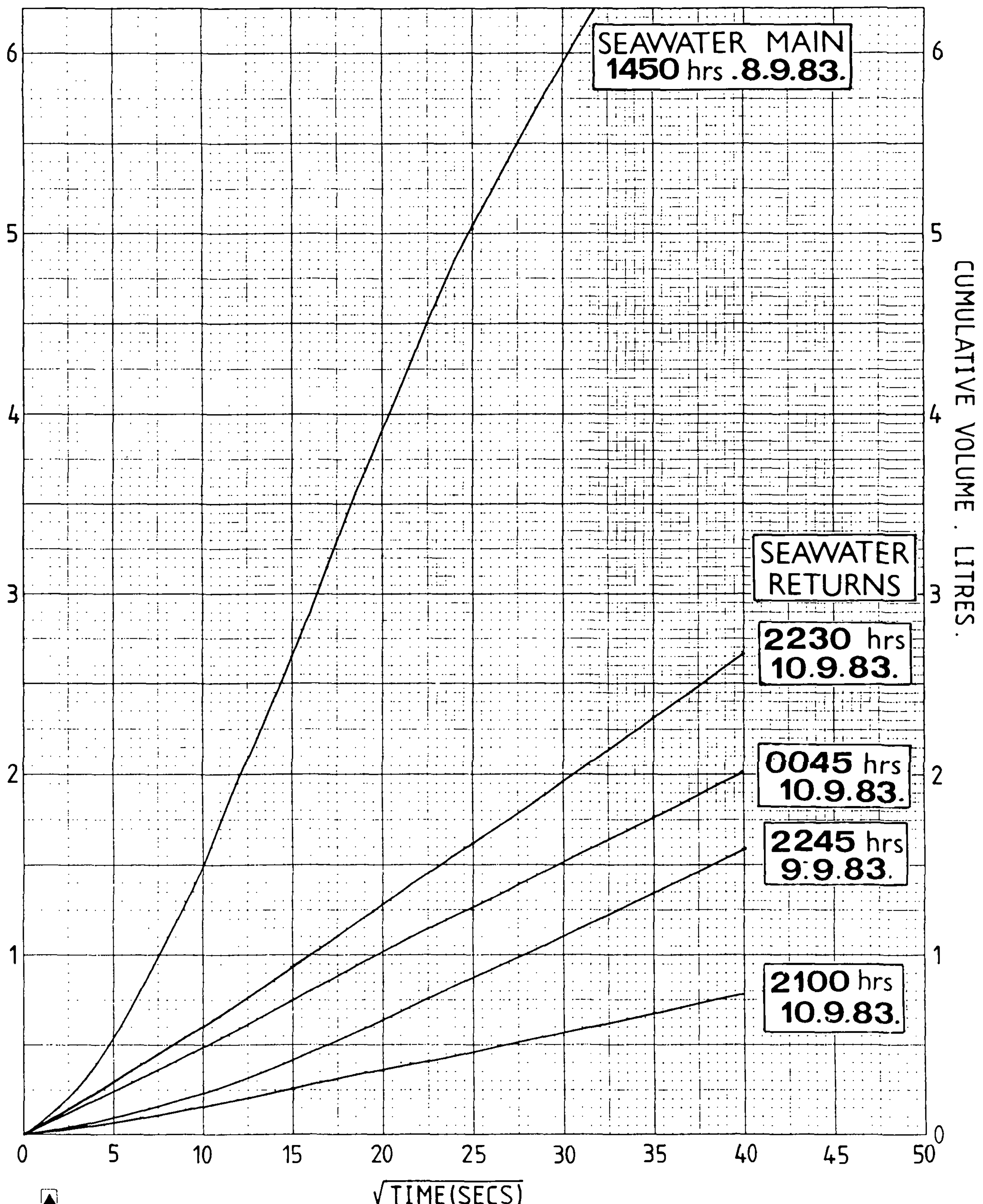

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FIG 4.5.

PRODUCTION TEST 1N 1519m TO 1529m
SEAWATER CIRCULATION.
VOLUME PASSED THROUGH MEMBRANE FILTER IN 30 MINUTES

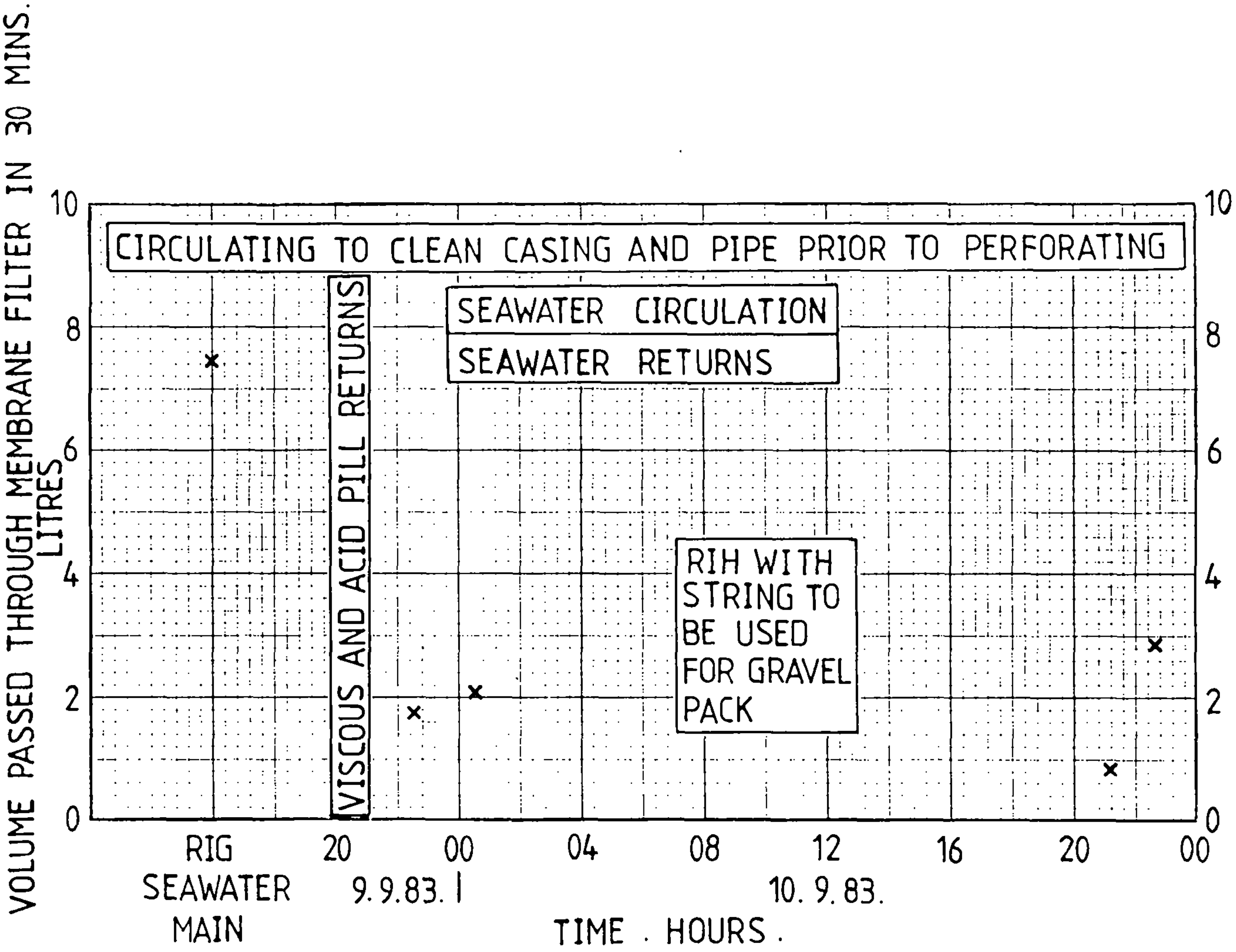

FIG 4.6.

SUSPENDED SOLIDS OF RETURNS. CIRCULATION PRIOR TO PRODUCTION TEST IN 1519m TO 1529m ZONE

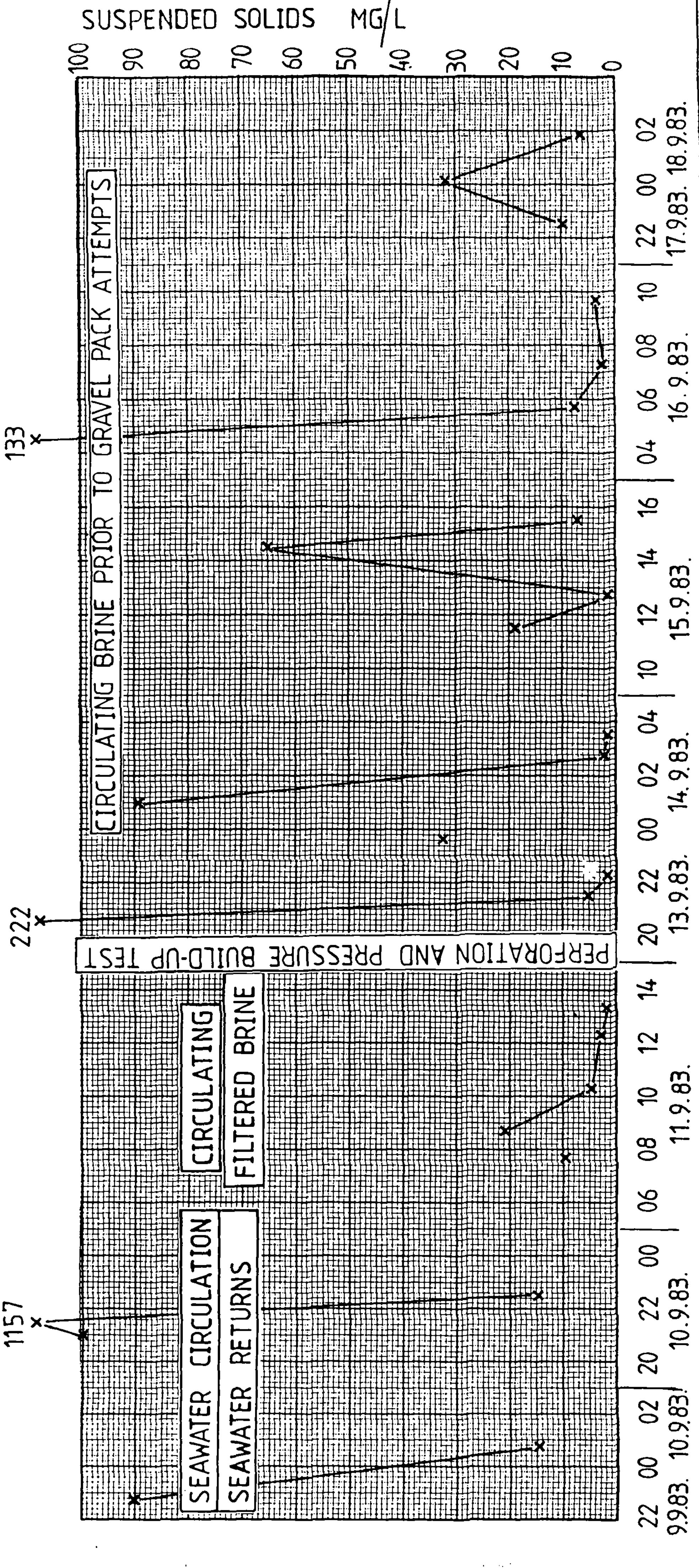

FIG 4.7.

PRODUCTION TEST IN 1519m TO 1529m Zone.
BRINE CIRCULATION PRIOR TO PERFORATION

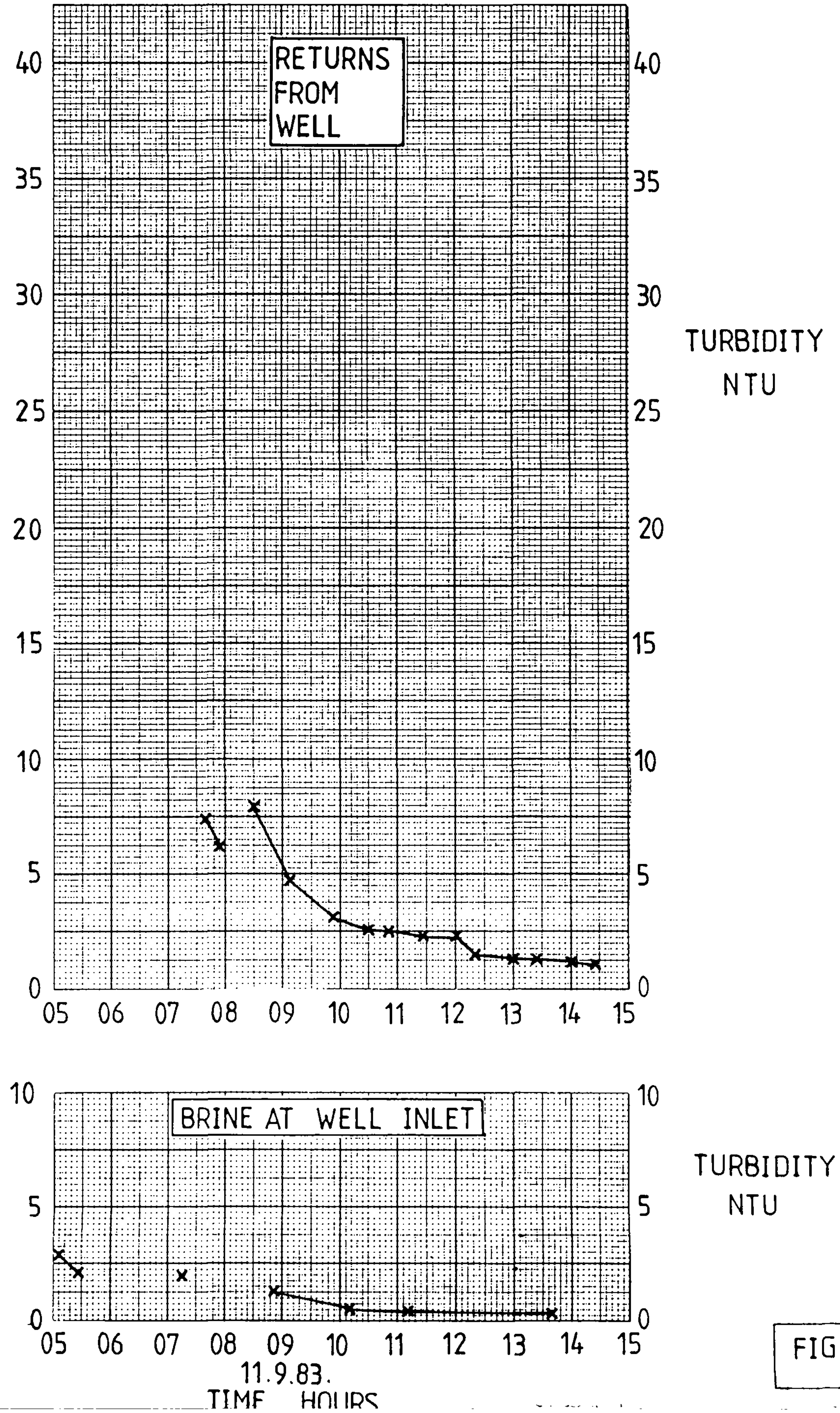

FIG 4.8.

1519 m TO 1529 m ZONE
BRINE CIRCULATION BEFORE PERF.
MEMBRANE FILTER SLOPE TESTS

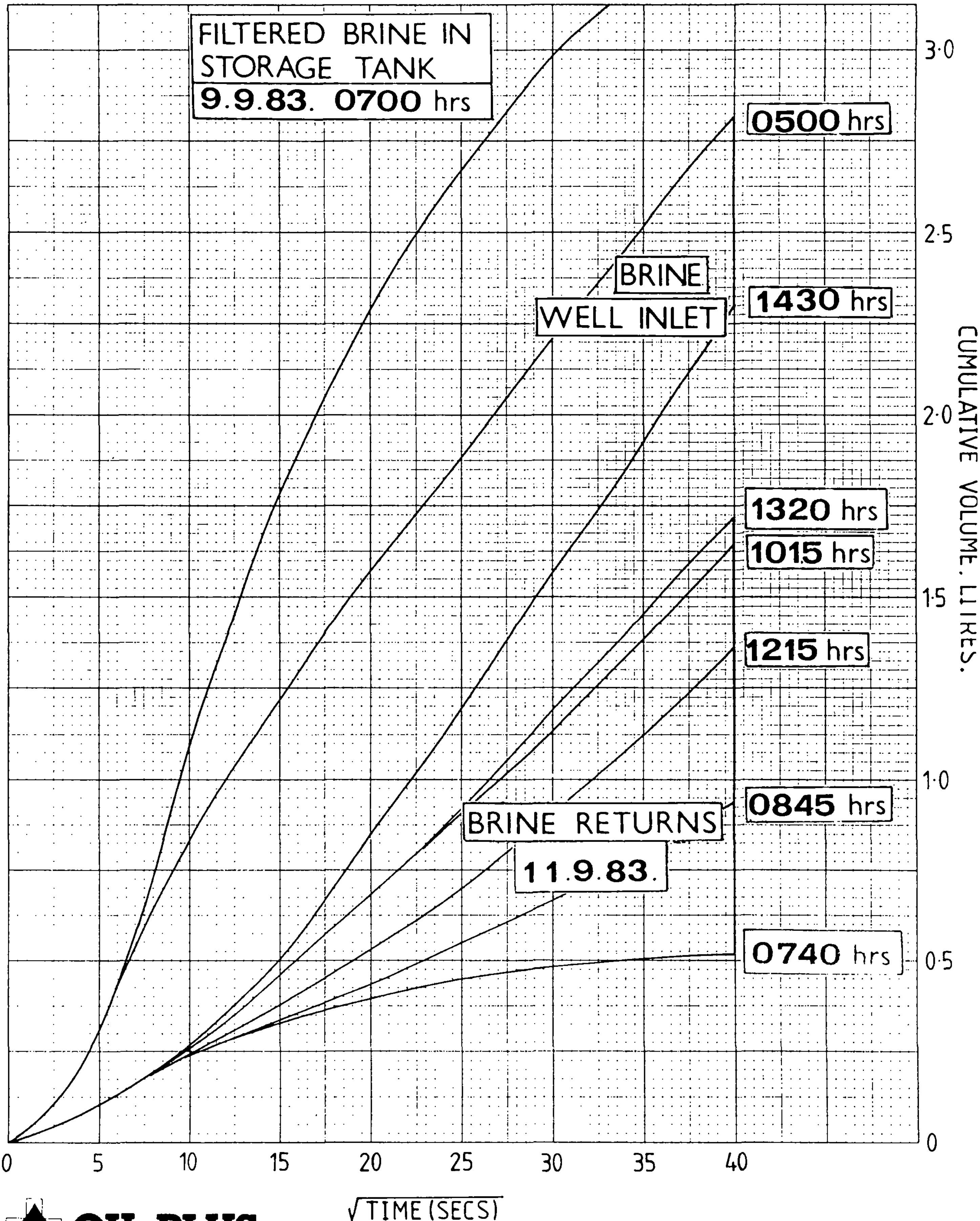

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FIG 4.9.

BRINE CIRCULATION PRIOR TO GRAVEL PACK IN 1519m TO 1529m ZONE.

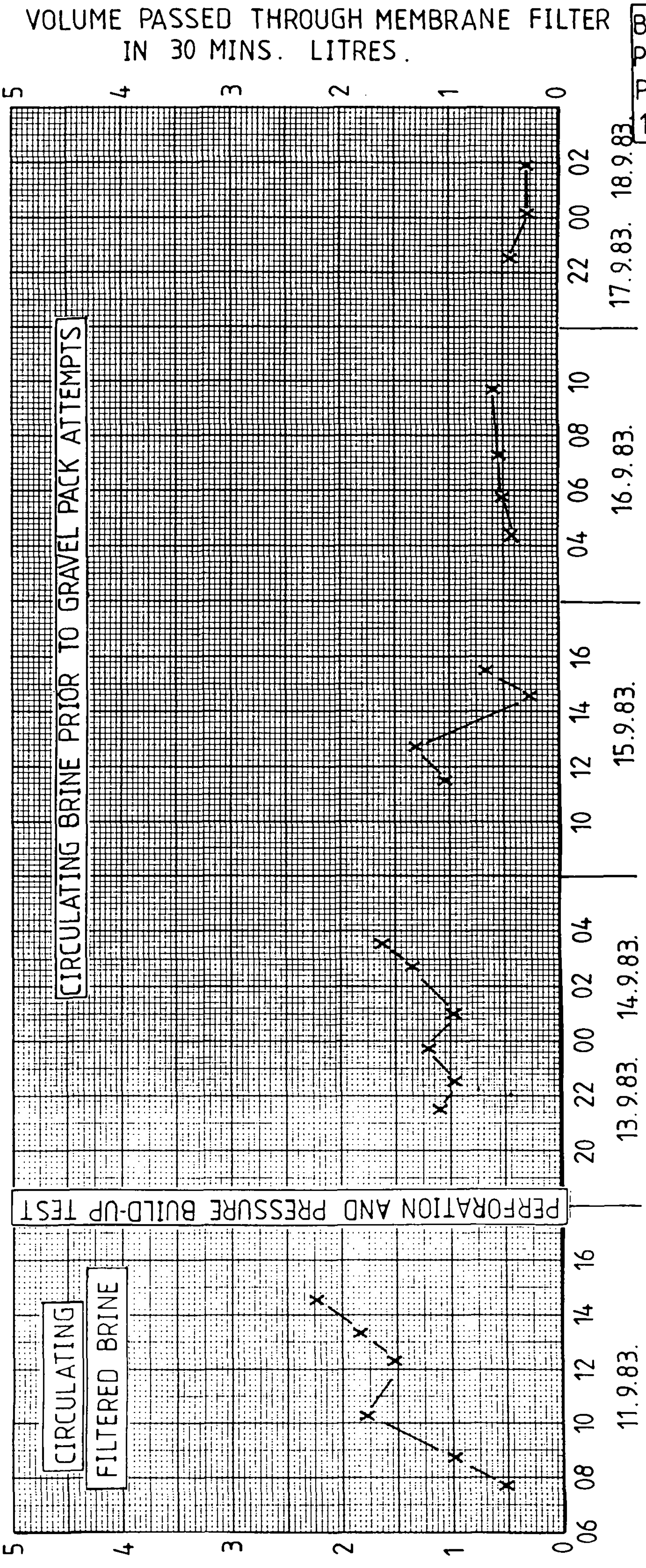

FIG 4.10.

BRINE CIRCULATION PRIOR TO FIRST TWO GRAVEL PACK ATTEMPTS IN 1519m TO 1529m ZONE TURBIDITY OF RETURNS

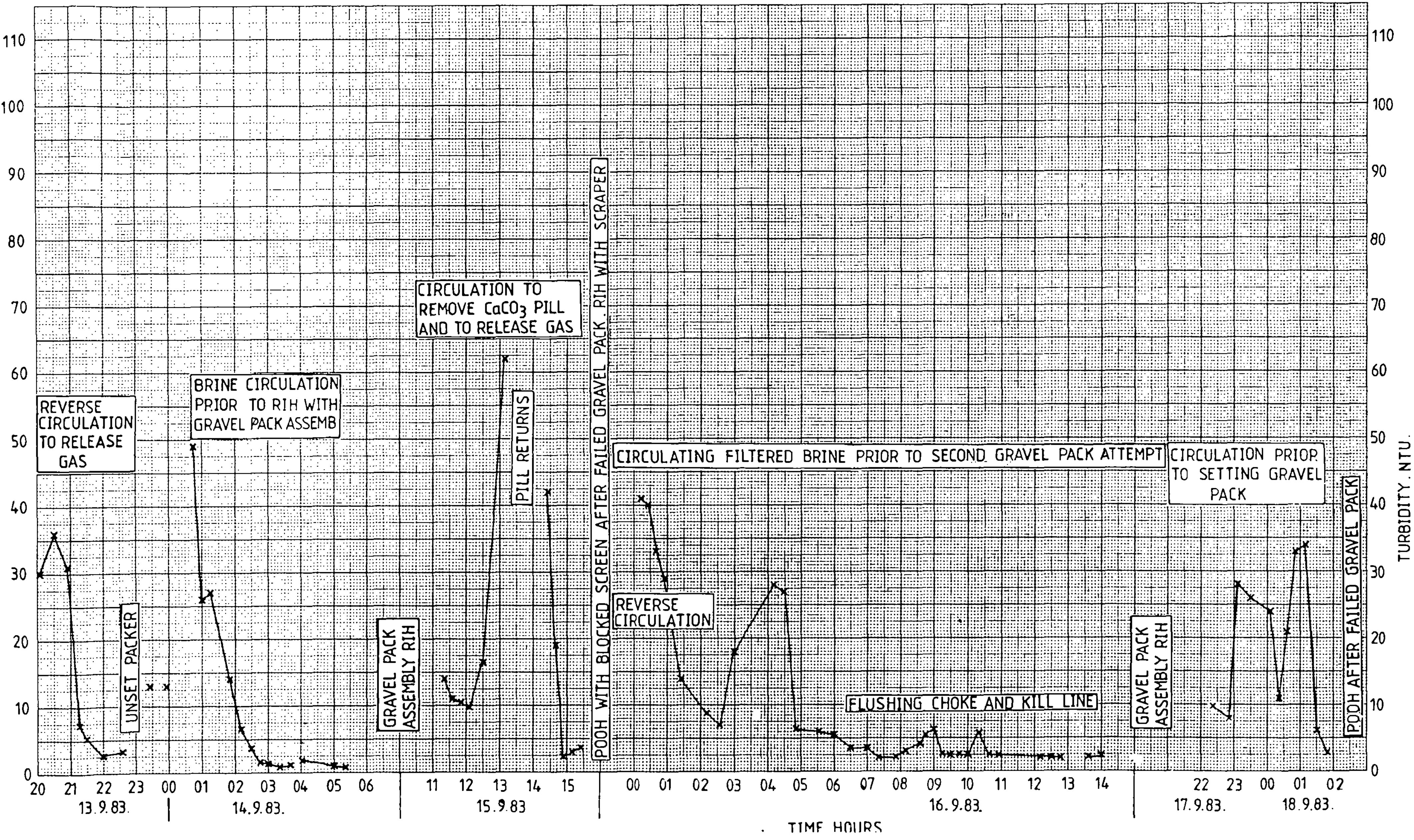

FIG 4.11.

BRINE CIRCULATION PRIOR TO THIRD AND FINAL GRAVEL PACK ATTEMPT IN 1519m TO 1529m ZONE. TURBIDITY OF RETURNS

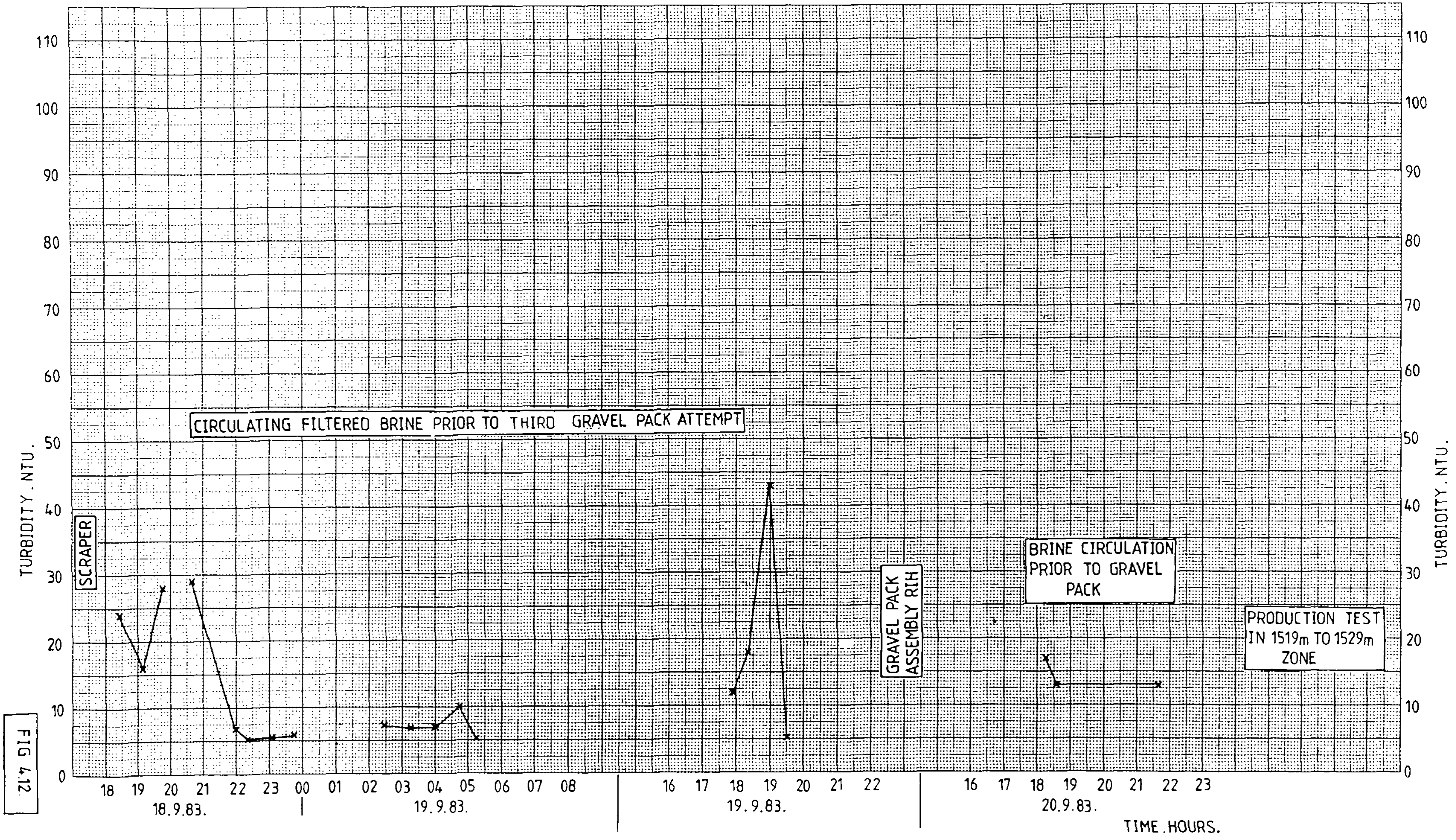

FIG 4.12.

BRINE CIRCULATION PRIOR TO FIRST TWO GRAVEL PACK ATTEMPTS IN 1519m TO 1529m ZONE PARTICLE COUNTS OF RETURNS.

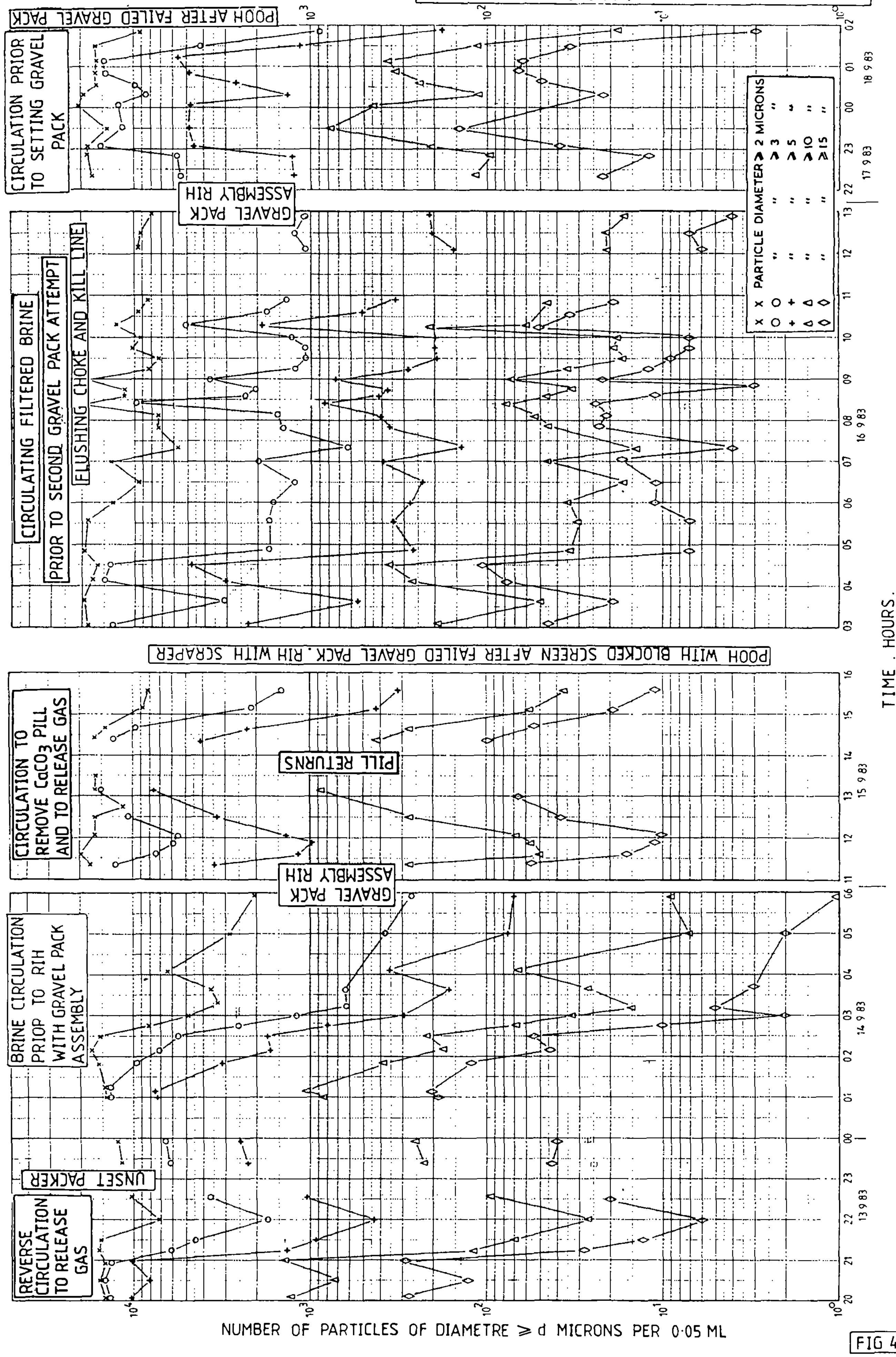

FIG 4.13

PRODUCTION TEST IN 1519m TO 1529m ZONE
BRINE CIRCULATION AFTER PERFORATION.
PARTICLE COUNTS OF RETURNS

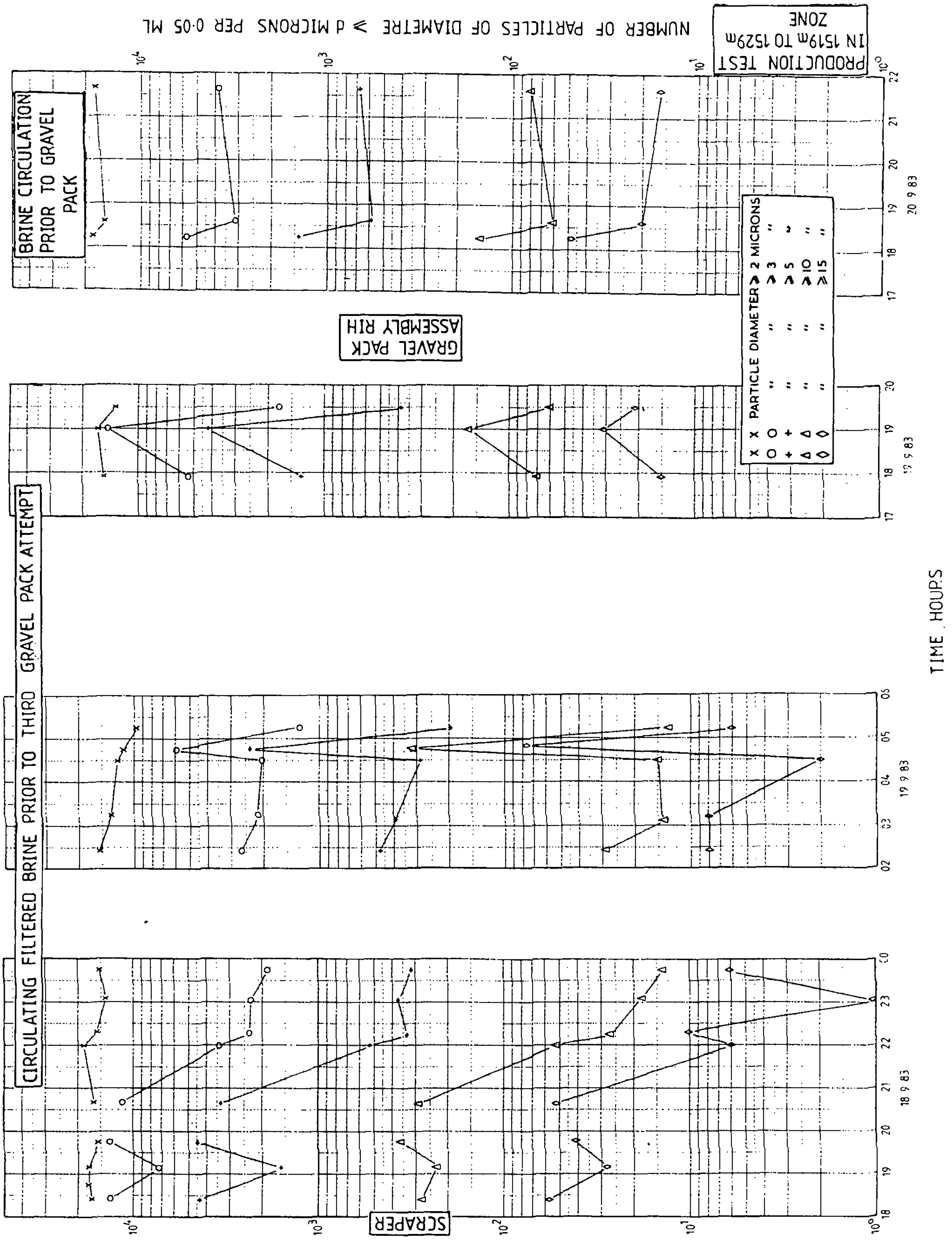

FIG 4.14

1519 m TO 1529 m ZONE.
MEMBRANE FILTER SLOPE TESTS.
BRINE RETURNS AFTER PERF.

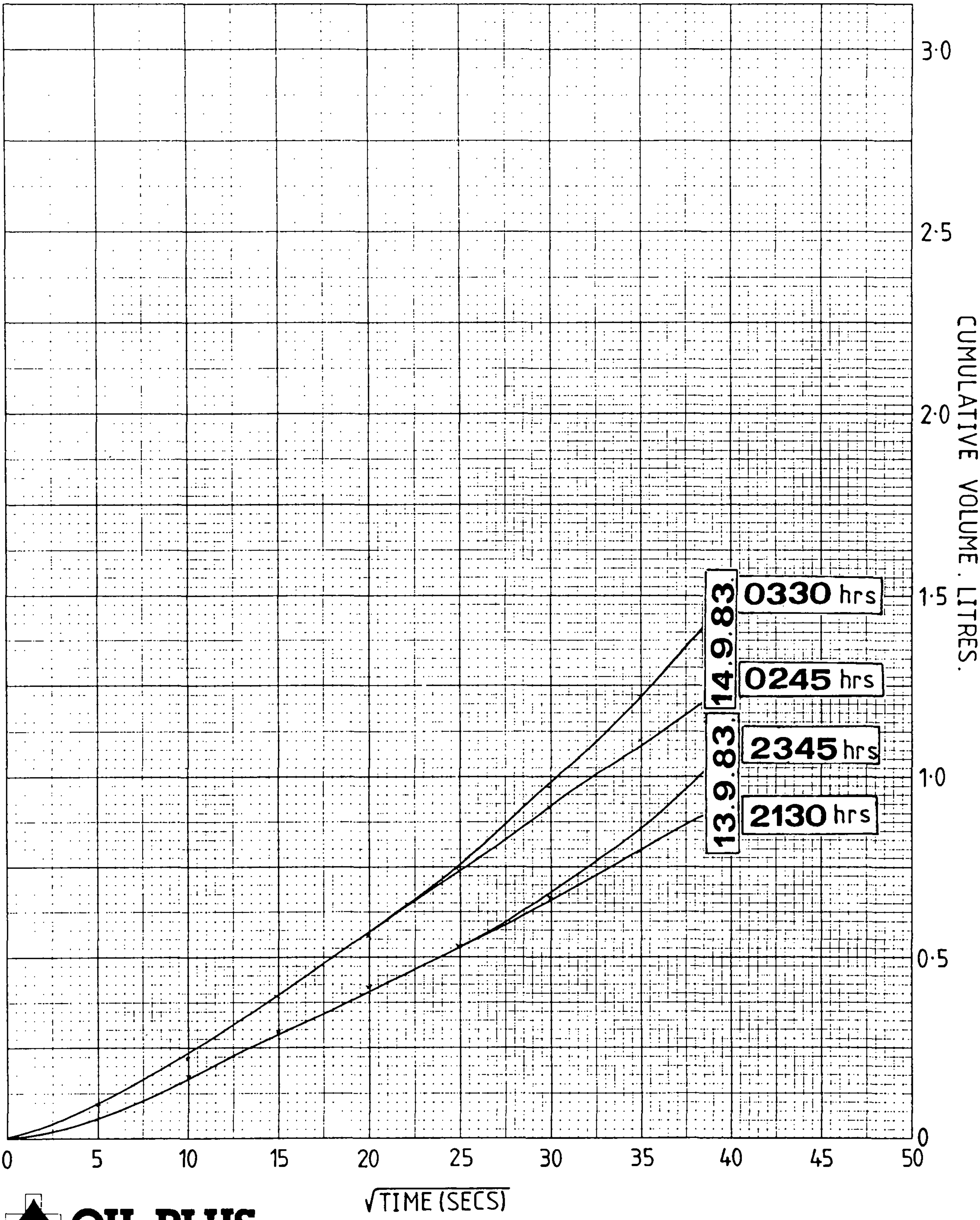

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FIG 4.15.

BRINE CIRCULATION PRIOR TO GRAVEL PACK IN 1373m TO 1383m ZONE.
TURBIDITY OF RETURNS

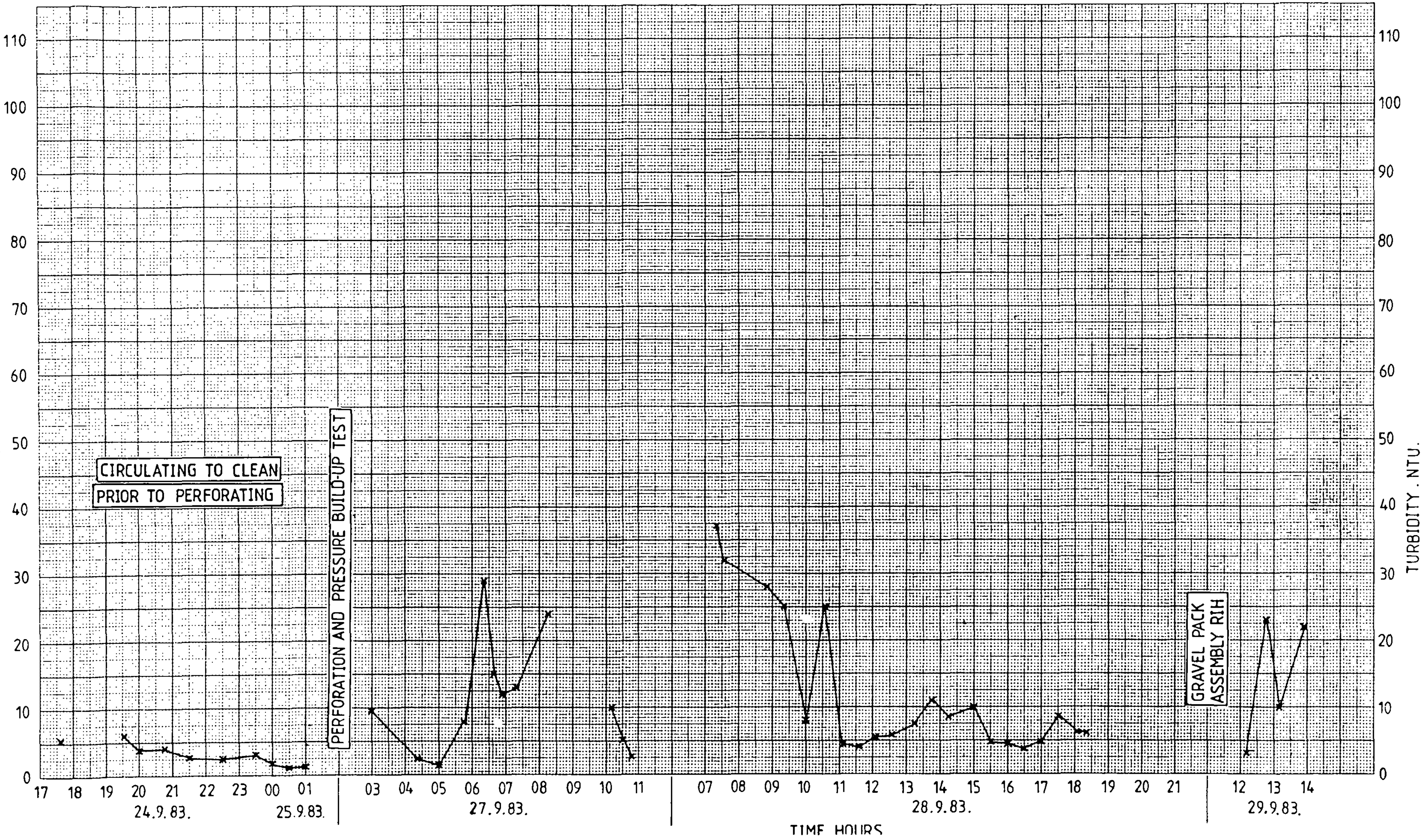

FIG 4.16

PRODUCTION TEST IN 1373m TO 1383m ZONE
BRINE CIRCULATION. PARTICLE COUNTS OF RETURNS

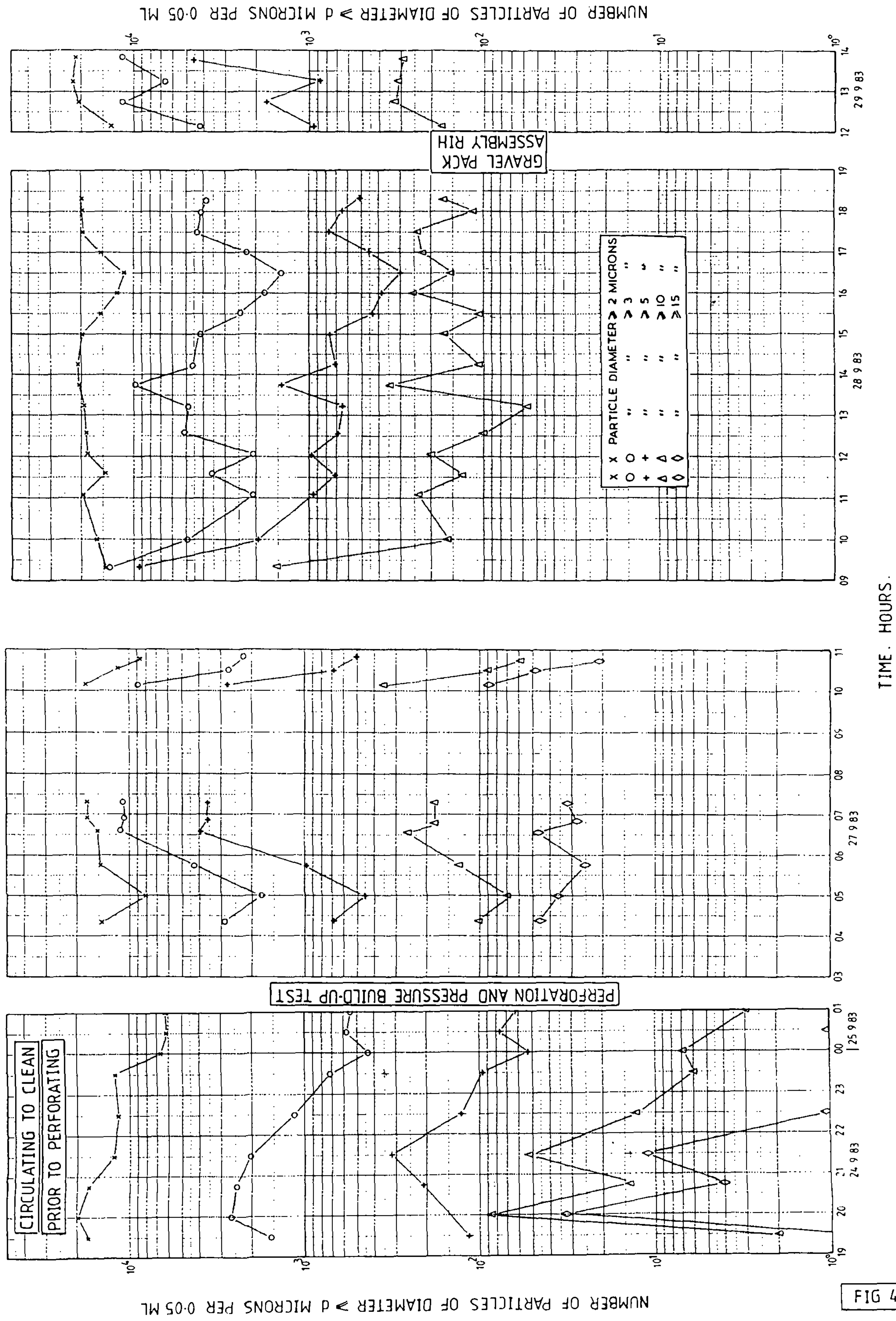

FIG 4.17.

TABLE 4.1

SEAWATER CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519m TO 1529m BDF ZONE
SEAWATER MAIN
TURBIDITIES, PARTICLE COUNTS AND SUSPENDED SOLIDS

Sample Point	Rig Seawater Main	
Date	8.9.83	8.9.83
Time. Hours	1450	1900
Particle diameter microns	Number of particles of diameter ≥ d microns per 0.05 ml.	
2.0	1389	2646
2.5	501	662
3.0	268	275
4.0	152	161
5.0	106	96
7.5	23	24
10.0	2	5
15.0	0	2
Turbidity NTU	0.19	0.30
Suspended Solids mg/l	0.55	

TABLE 4.2

SEAWATER CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519 m TO 1529 m BDF ZONE
SEAWATER RETURNS AT INLET TO SHALE SHAKERS
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83
Time hrs	1345	1400	1415	1530	1615	1700	1835	1850	1915	1945	2020	2040
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.00	Too dirty for particle count						12682	12275		13266	13019	12574
2.50							11957	10535		11590	8606	9128
3.0							11050	9290		8826	7060	7595
4.0							7433	6016		4682	3557	4331
5.0							5191	4135		3553	2046	2727
7.5							2199	1864		1624	584	758
10.0							777	746		791	210	277
15.0							116	143		232	30	67

Dissolved Iron ppm							0.9				0.25	
Total iron ppm							1.5				0.50	

Turbidity NTU	65	58	33	35	35	50	31	26	46	27	16	17

Comments	Initial displacement of mud with seawater						Pumped viscous sand pill at 1745 hrs	Pumped viscous pill at 1900 hrs		Sand and viscous pill returns @ 1930 hrs and 2010 hrs.		

TABLE 4.3

SEAWATER CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519 m TO 1529 m BDF ZONE
SEAWATER RETURNS AT INLET TO SHALE SHAKERS
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	9.9.83	10.9.83	10.9.83	10.9.83	10.9.83
Time hrs	2100	2145	2200	2215	2230	2255	2315	2335	0015	0035	0100	0130
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.00	12190	13733	13075		14436	14664	14038	12745	12133	10589	11754	10980
2.5	8274	9431	10671		11975	11673	10142	8393	7279	6442	7077	6946
3.0	5816	7617	9132		10806	9885	8199	7421	5523	4873	5563	5310
4.0	3425	3875	5280		6287	5928	4394	3576	2741	2407	2423	2452
5.0	2045	2434	3349		3802	3651	2704	2198	1627	1523	1483	1570
7.5	511	670	889		813	876	579	469	391	332	362	383
10.0	194	236	329		270	184	136	122	113	108	86	95
15.0	68	41	76		42	31	18	9	18	17	9	10
Dissolved Iron ppm 25					10					0.15		
Total Iron ppm 25					10					0.4		
Turbidity NTU	15	16	22	80	29	28	22	17	12.5	11.5	11	11.5
Suspended solids mg/l					90					14.5		
Comments	Pumped acid at 2110 hrs		Acid returns at 2210 hrs									

TABLE 4.4

SEAWATER CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519 m TO 1529 m BDF ZONE
SEAWATER RETURNS AT INLET TO SHALE SHAKERS
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	10.9.83	10.9.83		10.9.83	10.9.83	10.9.83	10.9.83	10.9.83	10.9.83	10.9.83	10.9.83	11.9.83
Time hrs	0225	0250		2050	2105	2125	2145	2200	2220	2235	2255	0015
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.00	10826	12047		14336	14964		12007	9761	10616	10738	11588	14689
2.5	7200	7821		13952	12928		10488	6825	6942	6745	7228	9635
3.0	5055	5833		13673	11111		9241	5433	5549	4876	5230	6459
4.0	1779	2266		10374	6279		6159	3463	3080	2396	2591	2822
5.0	1140	1393		7552	3904		4419	2532	2308	1554	1593	1482
7.5	329	380		2825	1150		2071	1140	674	398	326	215
10.0	87	91		118	409		848	449	216	131	107	67
15.0	10	12		267	55		255	64	38	24	14	4
Dissolved Iron ppm												
Total Iron ppm												
Turbidity NTU	9.7	10.5		44	34	310	29	18	14	13	13	14
Suspended solids mg/l					100.1	1157				14.3		
Comments			Pooh to RIH with string to be used for gravel pack.									

TABLE 4.5

SEAWATER CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519 m TO 1529 m BDF ZONE
SEAWATER RETURNS
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83
Time hrs	0050	0100	0135	0150	0230	0250	0315	0330
Particle dia. d microns	Number of Particles ⩾ d µm (microns) in 0.05 ml							
2.0	12915	12828	13481	12136	15092	10270	9338	10753
2.5	8053	7763	8246	7343	10003	7317	5812	6949
3.0	6268	6324	5889	4939	7008	6424	4407	5262
4.0	3621	3096	2800	2375	3409	4421	2608	3050
5.0	2307	2117	1535	1355	1936	3156	1875	1971
7.5	703	733	286	300	362	1033	546	448
10.0	208	212	56	68	74	269	152	105
15.0	40	11	9	2	10	9	16	8
Dissolved Iron ppm								
Total Iron ppm								
Turbidity NTU	16	15.5	13.5	13	14	14	12	12.5
Suspended solids mg/1								
Comments	Flushing through mud system					Stopped circulating at 0350 hrs prior to displacing well with brine.		

TABLE 4.6

FILTERED BRINE CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1519 m TO 1529 m BDF ZONE
BRINE QUALITY AT WELL OUTLET
TURBIDITIES, PARTICLE COUNTS AND SUSPENDED SOLIDS

WELL 31/3-1

Date	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83
Time hrs	0740	0755	0830	0905	0955	1030	1050	1125	1200	1220	1300	1320	1400	1425
Particle dia. d microns	Number of Particles ≥ d μm (microns) in 0.05 ml													
2.0	17968	12904	12422	9109	9474	5724	5278	5984	5045	6158	2299	2356	2442	1501
2.5	9720	5868	7321	4669	5031	2794	2331	2579	2306	2071	1341	908	918	851
3.0	3415	2825	4056	2371	2546	1461	1106	1270	1193	1045	535	446	452	389
4.0	1372	1332	2069	1174	1037	630	510	565	517	452	215	219	182	183
5.0	723	774	1101	656	467	308	265	273	260	254	115	98	110	98
7.5	158	140	302	163	112	75	62	55	72	51	27	25	31	24
10.0	60	73	132	73	38	24	24	29	23	28	16	6	8	11
15.0	15	8	23	30	5	10	5	8	9	2	3	1	3	1
Dissolved Iron ppm		0.5												
Total Iron ppm														
Turbidity NTU	7.4	6.3	8.0	4.7	3.2	2.6	2.5	2.3	2.3	1.5	1.3	1.3	1.2	1.1
Suspended solids mg/1	9.4		20.9			4.5				2.6		1.7		
Comments														

TABLE 4.7

FILTERED BRINE CIRCULATION PRIOR TO PERFORATION FOR TEST
IN 1519 m TO 1529 m BDF ZONE
BRINE QUALITY AT WELL INLET
TURBIDITIES, PARTICLE COUNTS, AND SUSPENDED SOLIDS

WELL 31/3-1

Date	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83	11.9.83
Time hrs	0505	0525	0715	0850	1010	1110	1340
Particle dia. d microns	Number of Particles ≥ d μm (microns) in 0.05 ml						
2.0	5523	2715	7050	3151	2555	1662	1307
2.5	2273	941	2258	1236	830	459	407
3.0	1035	435	851	556	307	220	185
4.0	461	164	322	216	120	71	73
5.0	204	81	175	100	50	27	29
7.5	24	26	19	13	9	6	5
10.0	13	12	5	7	2	3	2
15.0	1	3	2	1	1	0	0
Dissolved Iron ppm							
Total Iron ppm							
Turbidity NTU	2.9	2.1	1.9	1.3	0.6	0.47	0.37
Suspended solids mg/1	3.2						
Comments							

TABLE 4.8

BRINE CIRCULATION AFTER PERFORATION FOR TEST
IN 1519M TO 1529M ZONE
IMPROVEMENTS IN QUALITY OF BRINE RETURNS
DUE TO ACIDIFICATION AFTER INTRODUCTION OF
SIZED CALCIUM CARBONATE

Date	Time Hours	Turbidity NTU		% Reduction
		Pre-Acid	After Acid	
15.9.83	1400	115	21	81.7
	1425	42	5.4	87.1
	1440	19	2.8	85.3
	1510	3.1	1.3	58.1
	1525	3.7	0.9	75.7
16.9.83	0010	16	8.5	46.9
	1000	2.6	1.5	42.3
	1040	2.5	2.0	20.0
	1230	2.1	1.7	19.0

TABLE 4.9

BRINE CIRCULATION AFTER PERFORATION FOR TEST IN 1519M TO 1529M ZONE

IMPROVEMENTS IN BRINE QUALITY DUE TO ACIDIFICATION AFTER INTRODUCTION OF SIZED CALCIUM CARBONATE

WELL 31/3-1

Date	15.9.83			15.9.83		
Time hrs	1455			1525		
Sample	Pre Acid	After Acid	% Reduction	Pre Acid	After Acid	% Reduction
Particle dia. d microns	Number of Particles ⩾ d µm (microns) in 0.05 ml					
2.0	22382	9094	59.4	8035	3511	56.3
2.5	14774	3127	78.8	3154	724	77.0
3.0	4827	1046	78.3	1420	330	76.8
4.0	615	247	59.8	601	127	78.9
5.0	193	50	74.1	320	53	83.4
7.5	70	11	84.3	89	24	73.0
10.0	29	4	86.2	37	5	86.5
15.0	16	1	93.8	11	3	72.7

Pump Rate BPM		

Filters in use		

Turbidity NTU	2.3	0.9	60.9	3.7	0.9	75.7

Suspended solids mg/l						

Comments	Brine at well inlet	Brine at well outlet

TABLE 4.10

STABILITY OF SOLIDS LEVEL OF BRINE AT SURFACE FOR PERIOD OF ONE CIRCULATION

WELL 31/3-1

Date	19.9.83			20.9.83 - 21.9.83		
Time hrs	1945	2130		2255	0015	
Sample	Filter Outlet		% Change	Storage Tank		% Change
Particle dia. d microns	Number of Particles ≥ d μm (microns) in 0.05 ml					
2.0	3128	3131	0.1	6872	6709	2.4
2.5	982	1072	9.2	2530	2186	13.6
3.0	426	398	6.6	971	833	14.2
4.0	142	116	18.3	354	325	8.2
5.0	49	40	18.4	195	154	21.0
7.5	12	8	33.3	39	34	14.7
10.0	1	0		22	19	13.6
15.0	0	0		10	8	20

Pump Rate BPM		

Filters in use		

Turbidity NTU				1.9	2.0	5.3

Suspended solids mg/1						

Comments		

TABLE 4.11

BRINE CIRCULATION PRIOR TO PERFORATION FOR TEST IN 1373M TO 1383M ZONE QUALITY OF BRINE RETURNS

WELL 31/3-1

Date	24.9.83	24.9.83	24.9.83	24.9.83	24.9.83	24.9.83	25.9.83	25.9.83	25.9.83
Time hrs	1931	2000	2045	2130	2230	2330	0000	0030	0100
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml								
2.0	18133	19924	17306	12265	11880	12197	6662	6135	6208
2.5	9533	7678	7028	5335	3779	2613	1433	1704	1712
3.0	4256	2607	2463	2101	1168	720	438	577	546
4.0	1647	878	640	652	343	195	145	171	201
5.0	805		210	318	127	96	53	76	62
7.5		387	34	86	31	17	10	14	9
10.0		86	14	53	13	6	7	7	3
15.0		33	4	11	1	0	0	1	0
20.0		10	3	6	0	0	0	0	0
Dissolved Iron ppm									
Total Iron ppm									
Turbidity NTU	6.0	3.8	4.0	2.8	2.5	3.1	1.9	1.2	1.4
Suspended solids mg/1				23.0					
Comments									

TABLE 4.12

DETAILS OF FILTERS USED FOR BRINE FILTRATION

1. PECO FILTER SKIDS

2 pods per skid.	18 filters per pod.
Manufacturer:	Hytrex
Media:	Polypropylene
Length:	36⅞ inches
Ratings of filter type used and product code	5 microns nominal (GX 05-336C)
Recommended Flow Rate	5 bpm per pod containing 18 filters
Recommended Δ p for change of filters	20 psi

2. PALL FILTER SKIDS

2 pods per skid.	32 filters per pod.
Manufacturer:	Pall
Media:	Resin impregnated cellulose (Epocel type)
Length:	40 inches
Product Code:	AB4LC4
Rating in virgin state of AB4LC4:	10 microns absolute 99% @ 5 microns 90% @ 2 microns
Recommended Flow Rate	2 bpm per pod containing 32 filters
Recommended Δ p for change of filters	40 psi

TABLE 4.13

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	8.9.83			8.9.83			8.9.83			8.9.83		
Time hrs	2100			2200			2300			0630		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.0				18407	19145		19537	17584	10.0	18780	18383	2.1
2.5				16089	15985	0.6	10256	8709	15.1	16195	13983	13.7
3.0				12969	11190	13.7	4187	3794	9.4	12520	7493	40.2
4.0				5162	3692	28.5	1416	1122	20.8	4326	2573	40.5
5.0				2012	1337	33.5	554	421	24.0	1598	987	38.2
7.5				191	124	35.1	96	46	52.1	216	166	23.1
10.0				52	28	46.5	39	9	76.9	58	40	31.0
15.0				5	2	60.0	22	2	90.9	15	4	73.3
Pump Rate BPM												
Filters in use	5 nominal Hytrex			5 nominal Hytrex			5 nominal Hytrex			5 nominal Hytrex		
Turbidity NTU	5.6	5.5	2	40	37	7.5	15.0	11.5	23.3	25.5	17	33.3
Suspended solids mg/l												
Comments	Filtering brine from supply boat into Dowell storage tanks on Deep Sea Bergen.											

TABLE 4.14

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	9.9.83			9.9.83			11.9.83			11.9.83		
Time hrs	0720			0800			0545			0925		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d μm (microns) in 0.05 ml											
2.0	17485	1144	93.5	17373	2334	86.6	20561	963	95.3	13192	615	95.3
2.5	11416	309	97.3	12855	551	95.7	17965	271	98.5	6944	131	98.1
3.0	6260	130	97.9	7787	484	93.8	13205	150	98.9	3311	49	98.5
4.0	2235	409	81.7	3009	28	99.1	4011	49	98.8	1493	25	98.3
5.0	961	26	97.3	1291	15	98.8	909	26	97.1	704	11	98.4
7.5	162	21	87.0	221	7	96.8	57	19	66.6	152	2	98.7
10.0	64	11	82.8	75	4	94.7	12	14	-	57	0	100
15.0	37	7	81.1	28	3	89.3	3	9	-	7	0	100
Pump Rate BPM										6		
Filters in use	5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall		
Turbidity NTU	18	0.8	95.6	21	0.7	96.7	15	1.5	90	6.4	0.4	93.8
Suspended solids mg/l												
Comments	Filtering brine whilst pumping from supply boat to Dowell storage tanks on Deep Sea Bergen.									Circulating brine in well.		

TABLE 4.15

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	11.9.83			14.9.83			16.9.83			16.9.83		
Time hrs	1215			1245			0135			0610		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.0	5905	155	97.4	17745	11327	36.2	15696	15604	0.6	16663	3694	77.8
2.5	2557	39	98.5	15344	4980	67.3	15269	5457	64.3	11018	275	97.5
3.0	1115	12	98.9	11251	1734	84.6	15118	1686	88.8	7132	78	98.9
4.0	442	8	98.2	5419	428	92.1	10249	466	95.5	3959	33	99.2
5.0	211	4	98.1	2801	133	95.3	6249	156	97.5	2425	11	99.5
7.5	34	3	91.2	703	17	97.6	1627	22	98.6	778	2	99.7
10.0	7	1	85.7	290	14	95.1	624	4	99.4	362	1	99.7
15.0	2	0	100	66	2	97.0	159	1	99.4	86	0	100
Pump Rate BPM				2			3.6					
Filters in use	5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall		
Turbidity NTU	2.9	0.42	85.5	16	1.0	93.8	36	8.4	76.7	9.8	0.58	94.1
Suspended solids mg/1												
Comments	Circulating brine through well.											

TABLE 4.16

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	16.9.83			16.9.83			17.9.83			18.9.83		
Time hrs	1350			1845			2315			1845		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ⩾ d µm (microns) in 0.05 ml											
2.0	16674	1082	93.5	21322	541	97.5	18287	10756	41	17549	8348	52.4
2.5	7160	88	98.8	18913	117	99.4	16755	554	96.7	16613	2387	85.6
3.0	2876	38	98.7	14416	38	99.7	11384	162	98.6	15224	771	94.9
4.0	1108	12	98.9	4702	8	99.8	5631	50	99.0	9370	244	97.4
5.0	496	7	98.6	1496	6	99.6	2829	17	99.4	5388	117	97.8
7.5	104	1	99.0	148	0	100	481	4	99.1	1029	16	98.4
10.0	29	0	100	77	0	100	135	1	99.3	353	3	99.2
15.0	6	0	100	44	0	100	14	0	100	37	2	94.6
Pump Rate BPM	6						5			6		
Filters in use	5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall		
Turbidity NTU	3.6	0.29	91.9				24	0.42	98.3	32	2.8	91.3
Suspended solids mg/1												
Comments	Circulating brine through well.			Filtering whilst transfering brine from supply boat.			Circulating brine through well.			Circulating brine through well.		

TABLE 4.17

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	18.9.83			19.9.83			19.9.83			20.9.83		
Time hrs	2100			1820			2115			1830		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d μm (microns) in 0.05 ml											
2.0	16989	12585	25.9	19191	3213	83.3	18015	3381	81.2	16965	1905	88.8
2.5	15417	2210	85.7	11490	1059	90.8	10941	875	92.0	11948	326	97.3
3.0	14257	855	94.0	5307	453	91.5	5548	265	95.2	7418	129	98.3
4.0	7932	292	96.3	2025	145	92.8	2173	70	96.8	3464	36	99.0
5.0	4211	130	96.9	1002	42	95.8	1000	13	98.7	1900	12	99.4
7.5	982	32	96.7	221	8	96.4	230	1	99.6	444	4	99.1
10.0	344	15	96.7	77	1	98.7	86	0	100	144	0	100
15.0	72	3	95.6	19	0	100	26	0	100	39	0	100
Pump Rate BPM	6			4			5			5		
Filters in use	5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall		
Turbidity NTU	32	3.4	89.4	18	2.8	84.4	19	4.1	78.4	18	2.6	85.6
Suspended solids mg/1												
Comments	Circulating brine through well.			Circulating brine through well.			Circulating brine through well.			Circulating brine through well.		

TABLE 4.18

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	20.9.83			20.9.83			24.9.83			24.9.83		
Time hrs	2055			2145			1750			2020		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.0	21478	2090	90.3	22160	21121	77.2	19504	21968	-	21500	16800	21.9
2.5	18311	710	96.1	17959	17683	90.7	15528	15095	2.8	10200	3183	68.8
3.0	12520	236	98.1	11883	11358	94.8	9113	5373	41.0	3280	672	79.5
4.0	4094	63	98.5	3770	3148	93.9	3821	1545	59.6	856	169	80.3
5.0	1289	39	97.0	1166	933	91.6	1731	494	71.5	290	61	79.0
7.5	140	12	91.4	217	108	73.3	410	49	88.0	70	8	88.6
10.0	36	8	77.8	130	59	67.7	134	23	82.8			
15.0	13	0	100	81	48	65.4	32	7	78.1			

Pump Rate BPM				

Filters in use	5u nominal Hytrex 10u absolute Pall	5u nominal Hytrex 10u absolute Pall	5u nominal Hytrex 10u absolute Pall	5u nominal Hytrex 10u absolute Pall

Turbidity NTU	16	1.7	89.4	17	2.2	87.1				6.8	2.8	58.8

Suspended solids mg/1												

Comments	Filtering whilst unloading brine from supply boat.	Filtering whilst unloading brine from supply boat.	Circulating brine through well.	Circulating brine through well.

TABLE 4.19

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	27.9.83			27.9.83			28.9.83			28.9.83		
Time hrs	0220			0520			0730			1500		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml											
2.0	17673	1117	93.7	17851	1378	92.2	17848	8830	53.6	20290	20606	-
2.5		195		15028	371	97.5						
3.0	17344	95	99.1	11823	190	98.4	16580	590	93.7	4403	4277	2.9
4.0	11960	35	99.7	6158	78	98.7						
5.0	6930	24	99.6	3543	43	98.8	6291	194	91.2	756	512	32.3
7.5	1394	2	98.8	1052	12	98.9	1459	103	95.3	313	110	64.9
10.0	515	1	97.8	399	1	99.7	591	75	74.8	211	40	81.0
15.0				51	0	100						
Pump Rate BPM												
Filters in use	5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall			5u nominal Hytrex 10u absolute Pall		
Turbidity NTU	23.5	0.37	98.4	6.9	0.84	87.8	32	0.37	98.8	10	4.8	52.0
Suspended solids mg/1												
Comments	Circulating brine through well											

TABLE 4.20

FILTER PERFORMANCE
PARTICLE COUNTS, TURBIDITY, SUSPENDED SOLIDS

WELL 31/3-1

Date	19.9.83			20.9.83			27.9.83			28.9.83		
Time hrs	2115			2055			0220			0733		
Sample	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %	Filter Inlet	Filter Outlet	Eff %
Particle dia. d microns	Number of Particles ⩾ d µm (microns) in 0.05 ml											
2.0	18015	16849	6.5	21478	13147	38.8	17673	15034	14.9	17848	19023	
2.5	10941	8187	25.2	18311	5628	69.3						
3.0	5548	3075	44.6	12520	2534	79.8	17344	1036	94.0	16580	9398	43.3
4.0	2173	1047	51.8	4094	935	77.2	11960	286	97.6			
5.0	1000	403	59.7	1289	411	68.1	6930	129	98.1	6291	2210	64.9
7.5	230	42	81.7	140	70	50.0	1394	16	98.8	2198	1459	33.6
10.0	86	9	89.5	36	32	9.0	515	5	99.0	591	298	49.6
15.0	26	1	96.2	13	1	92.3						
Pump Rate BPM	5											
Filters in use	5 u nominal Hytrex			5 u nominal Hytrex			5 u nominal Hytrex			5 u nominal Hytrex		
Turbidity NTU	19	16	15.8	16	4.4		23.5	6.5	72.3	32	17	46.9
Suspended solids mg/1												
Comments	Circulating brine through well			Filtering water whilst transferring brine from supply boat			Circulating brine through well			Circulating brine through well		

TABLE 4.21

QUALITY OF BRINE FROM THE SUPPLY BOATS

WELL 31/3-1

Date	8.9.83	8.9.83	9.9.83	9.9.83	9.9.83	11.9.83	20.9.83	20.9.83
Time hrs	2200	2300	0630	0720	0800	0545	2055	2145
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml							
2.0	18407	17584	18780	17485	17373	20561	21478	22160
2.5	16089	8709	16195	11416	12855	17965	18311	17959
3.0	12969	3794	12520	6260	7787	13205	12520	11883
4.0	5162	1122	4326	2235	3009	4011	4094	3770
5.0	2012	421	1598	961	1291	909	1289	1166
7.5	191	46	216	162	221	57	140	217
10.0	52	9	58	64	75	12	36	130
15.0	5	2	15	37	28	3	13	81
Dissolved Iron ppm								
Total Iron ppm								
Turbidity NTU	40	15	25.5	18	21	15	16	17
Suspended solids mg/l								
Comments								

TABLE 4.22

QUALITY OF BRINE IN DOWELL STORAGE TANKS AFTER FILTERING WHILST TRANSFERRING BRINE FROM SUPPLY BOAT

WELL 31/3-1

Date	9.9.83	9.9.83	9.9.83	9.9.83	11.9.83	20.9.83	20.9.83	20.9.83	23.9.83	24.9.83	24.9.83	25.9.83	25.9.83	29.9.83
Time hrs	0500	0500	0815	0930	0505	2255	2320	2335	1400	1120	1525	1040	1120	1900
Particle dia. d microns	Number of Particles ≥ d µm (microns) in 0.05 ml													
2.0	3784	6617	16716	4596	5523	6872	3641	4543	6718	3920	4400	1801	2822	4087
2.5	1642	2590	8320	1996	2273	2530	1572	1991	1357	1444	1354	413	928	
3.0	730	1122	3913	681	1035	971	648	935	577	567	517	182	383	882
4.0	277	394	1503	162	461	354	235	460	180	174	195	57	129	
5.0	131	181	677	63	204	195	127	322	81	81	68	24	58	86
7.5	15	30	112	20	24	39	19	90	17	39	29	15	10	25
10.0	6	10	22	5	13	22	12	35	7	6	9	8	3	20
15.0	1	1	7	1	1	10	5	19	2	3	5	4	1	
Dissolved Iron ppm														
Total Iron ppm														
Turbidity NTU	2.6	3.3	3.9	2.0	2.9	1.9	1.3	1.5	1.3	0.9	0.8	0.4	0.56	0.58
Suspended solids mg/l	2.1							0.91					0.77	
Comments	Brine filtered by 10 micron absolute Pall filters. Samples taken from the top of the tank.													