OFFSHORE EXPERIENCE WITH THE ENDRESS AND HAUSER WATER IN HYDROCARBONS MONITOR

by

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INTRODUCTION

In order to reduce the considerable expense involved in transporting oil from offshore production platforms to onshore terminals, it is now common practice for several different platforms to use the same pipeline. For accounting purposes, each contributor to the pipeline must obviously monitor both the quantity and the quality of the fluid which it exports. This information is of great interest (mainly financial !) to the contributor, its pipeline partners, and to the Department of Energy.

In this context, Shell U.K. Exploration and Production Ltd has mandatory and contractual obligations to measure and record the water content of the oil it produces in the Northern Sector of the North Sea. This measurement, commonly referred to as "B.S. & W." within the industry, has proved a difficult one to make using continuous means. The intention of this paper is to briefly describe the problems encountered, and to show how these have led to our present programme of installing and evaluating the "Aquasyst" sensor manufactured by Endress & Hauser (U.K.) Ltd.

BACKGROUND

The most obvious means of determining the water content of oil in a pipeline is to draw off a sample for analysis in a laboratory. However this technique is beset by two major problems.

Firstly, it is not continuous, allowing short peaks of high water levels to pass undetected between samples. This applies during process upsets or when the wells in use are being changed over.

Secondly, it is cumbersome and is acknowledged to need improvement. Recent work indicates that the geometry of the sampling point and the method of analysis can have a dramatic effect on accuracy.

In an attempt to overcome these problems, many platforms have been fitted with sensors which provide continuous measurement. These take the form of a cylinder within the oil pipework which acts as a fixed geometry capacitor. The different dielectric constants for oil and water allow the water content to be inferred from the capacitance measured.

Most sensors of this type are without formal certification of their suitability for use in hazardous areas. Only one unit is covered in this way, and it has therefore been used widely in the North Sea.

Some problems have been experienced with this unit. In a few instances, the cylindrical section within the oil pipe has broken off, probably due to turbulent flow. This has been caused, or accompanied, by a failure of the main connecting stud joining the cylinder and the electronics housing, allowing oil at pressure to flood the instrument electronics. In some cases, the oil actually made its way up the signal cable. With this in mind, we continued to make the measurements required of us, but looked for some improvement on the methods available.

ONSHORE EXPERIENCE

Our search for a replacement led to the Endress & Hauser "Aquasyst" instrument. This device had been developed in conjunction with B.P. and carried a suitable specification, deriving its capacitance measurement from change transfer characteristics of the fluid instead of the impedance method of earlier instruments. Early trial reports seemed encouraging. It was not covered by formal certification of its suitability for use in hazardous areas, although it has been submitted to BASEEFA for approval. It has, however, been given a Letter of Conformity for the appropriate CENELEC standards by SIRA Ltd. It can therefore be regarded as meeting the engineering requirements for an Intrinsically Safe system, and we have chosen to accept this pending full certification cover.

We therefore purchased one unit - the dual cell model with Class 900 piping specification and 5% range. To gain some experience quickly, without the obvious disadvantages of working on a "live" offshore platform, we pursued a brief programme of onshore testing.

A small pumped test rig as used (see Figure 1) with gas oil as the fluid, since this has a dielectric constant similar to that of our crude oil. Measured quantities of water were added, and the resulting mixture analysed by the Karl Fischer titration method. The results obtained (Appendix A) indicated three main characteristics for the instrument.

1. Linear response.

2. Good repeatability.

3. Rapid and stable response to "step" changes in water level.

Our instrument gave sensible readings up to 5.5% water in oil, then simply continued to display this figure at all higher water levels. These results were deemed satisfactory, and the instrument was taken offshore.

OFFSHORE INSTALLATION

The first unit purchased was installed on the North Cormorant platform. For operational reasons, the instrument had to be installed without shutting down the platform, resulting in the sensor being mounted in a densitometer bypass loop, with the sample flowing vertically downwards (see Figure 2). Although the manufacturers recommend that the sample should flow upwards ideally, this option was not available at the time.

Two points regarding the installation are worthy of note. Firstly the weight of the sensor itself demands attention. At 98 kg, it cannot simply be mounted at the side of a pipe - proper structural supports are essential, especially since the inlet and outlet connections are made via one inch pipework.

Secondly, we chose to use a manual bypass valve in parallel with the sensor. No figures were available for the flow resistance presented by this sensor, so we needed a means of controlling both the flow rate through the sensor (to exceed recommended minimum velocity) and the flow resistance in the main sample loop (to avoid overloading the pumps and prevent gas break-out within the instrument).

x
5
0

Using this arrangement, we then carried out several series of comparisons between the readings generated by the intrument and the corresponding sample analyses using laboratory techniques. The results of these tests are discussed in the next section.

In view of the importance of the measurement, a further two instruments were installed - one on the Fulmar Alpha platform and one one the Fulmar Floating Storage Unit (F.S.U.). In both cases, the sensor was again mounted in a pumped densitometer loop, but with the sample flowing vertically upwards as recommended. Both instruments were monitored as above. By this stage, Endress & Hauser had replaced the original electronics module with a microprocessor based unit, but the sensor remained unchanged.

Further installations are planned on three more platforms at present, with some improvements. Additional isolation valves with dedicated calibration and drainage connections should help both commissioning and maintenance. A local flow indicator will ensure that the minimum recommended flow velocity through the sensor is consistently exceeded. (See Figure 3).

TEST RESULTS

After initial commissioning of the North Cormorant instrument, its readings were recorded and compared with a sample taken some way downstream and analysed by the centifuge technique.

While the upper cell followed the trend in water levels indicated by sample results, the lower cell drifted steadily to a high reading. The discrepancy between cells exceeded 1% water in oil within 24 hours. Closing in the bypass valve to increase the sample flow rate through the instrument cleared the discrepancy in some ten minutes. This "flushing" technique confirmed the manufacturer's warning that low flow rates can lead to water droplets settling out on the lower sensor. It has also proved useful when similar problems were encountered as a result of water slugs.

These early results (Appendix B) showed an encourging ability of the instrument to follow changes in the water content of the oil being analysed. In fact the recorder trace became a convenient tool for the platform operators to monitor short peaks of water during process upsets or well changes (Appendix C).

The absolute accuracy of the instrument readings still required further investigation however. By this stage, three instruments were installed. The testing programme was continued on all three locations, but with two distinct improvements.

Firstly, the samples were taken close to the instrument, within the sample loop, to provide a more representative sample. Secondly, the laboratory analysis was based on the Karl Fischer titration technique, which has been demonstrated to be more accurate than the centifuge technique, especially at low water levels.

Each series of tests covered one month, with samples taken every 12 hours (one per operating shift). Some of the results are displayed in Appendix D, and be summarised as follows:-

1. The instrument follows trends in water levels closely.

2. Occasional sudden divergences appear to be unrelated.

3. In the majority of cases, the instrument readings and the results of sample analysis differ in the second decimal place of percentage water in oil.

Throughout our work, the equipment has appeared robust, with failures limited to the safe area electronics, namely an opto-isolator and a power supply card.

FURTHER WORK

At the time of writing, our series of tests are still continuing. The major question marks lie in the areas of sample removal and analysis. Getting a representative sample of the fluid passing through a pipe is now recognised to be fraught with difficulties. In an ideal world several samples would be taken for independent analysis and comparison by dedicated laboratory personnel, but such luxury is not available on a busy offshore platform.

The relationship between pressure loss across the cell and flowrate has still to be determined if the instrument is to form part of a pumped analysis loop. We have attempted to calculate theoretical figures, but the assumptions made to cope with the internal geometry of the cell simply confirm that some practical testing is essential.

Full BASEEFA approval would clearly be desirable. The instrument range is now 40% water in oil, compared with the original 5%, so that it is now being looked at for other uses outside fiscal oil metering stations. In such applications (for example, within the separation process of an offshore platform) any increase in range beyond 40% water would be particularly attractive as the water levels encountered in our existing fields increase through time.

FIGURE 1 - ONSHORE TEST RIG

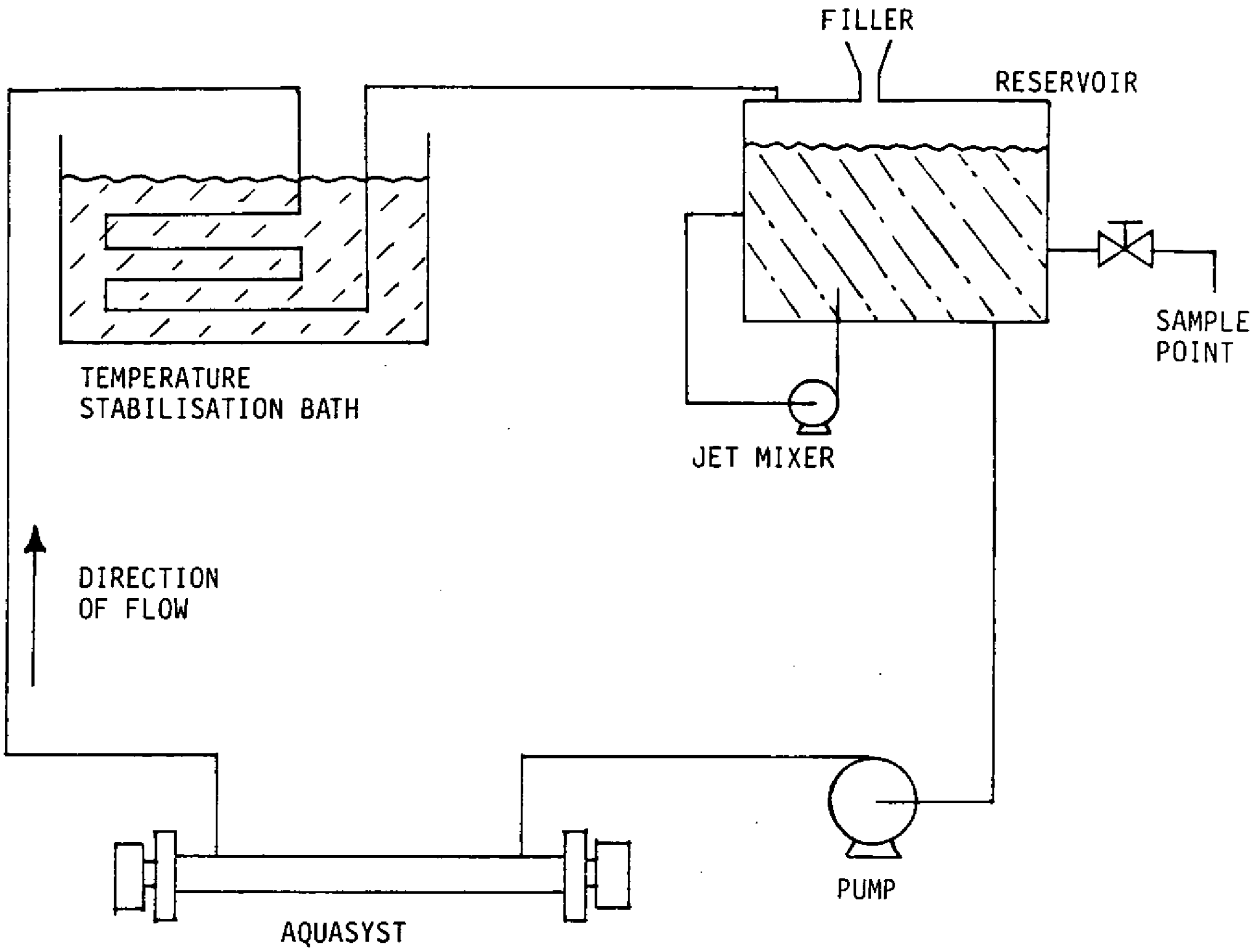
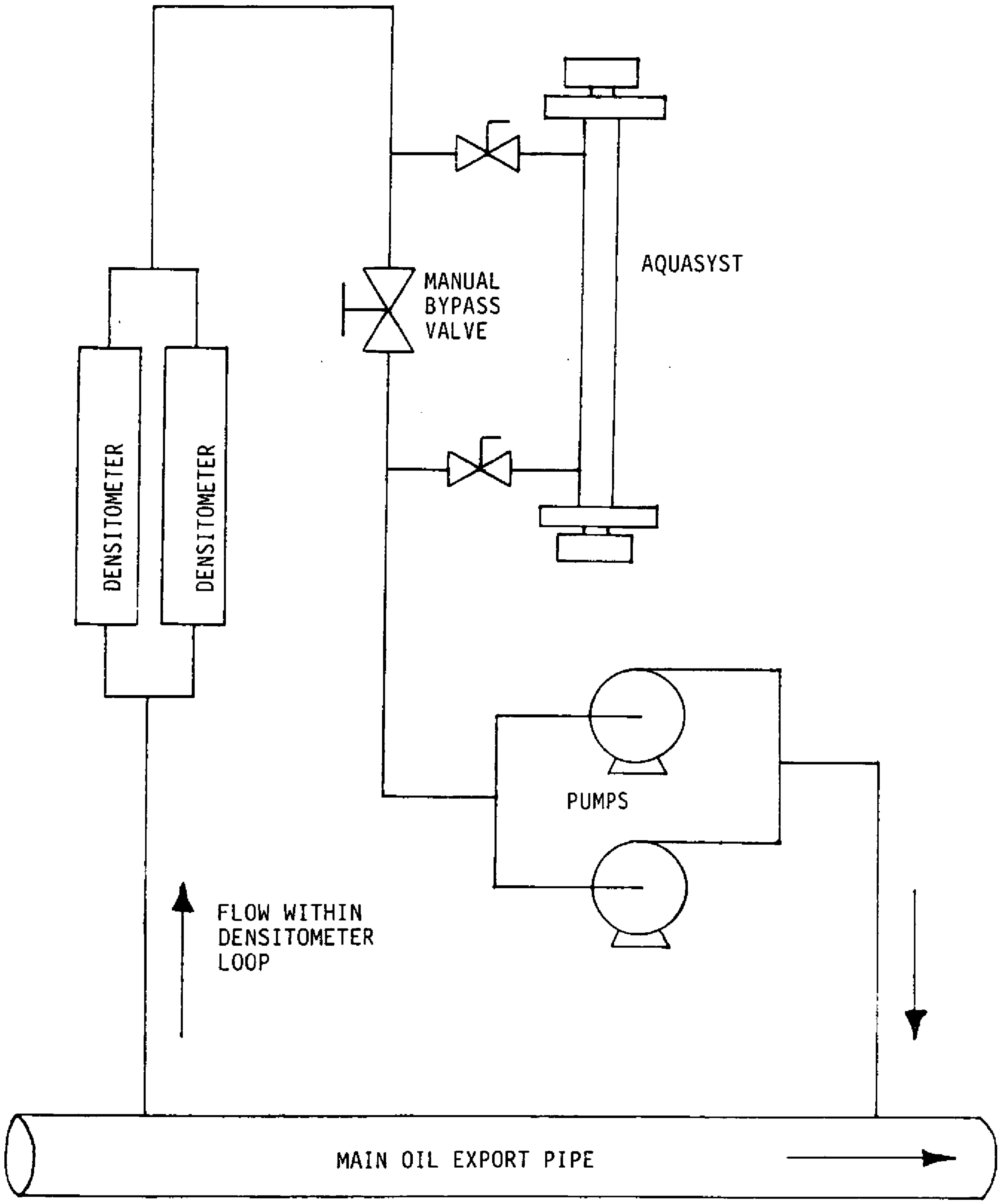
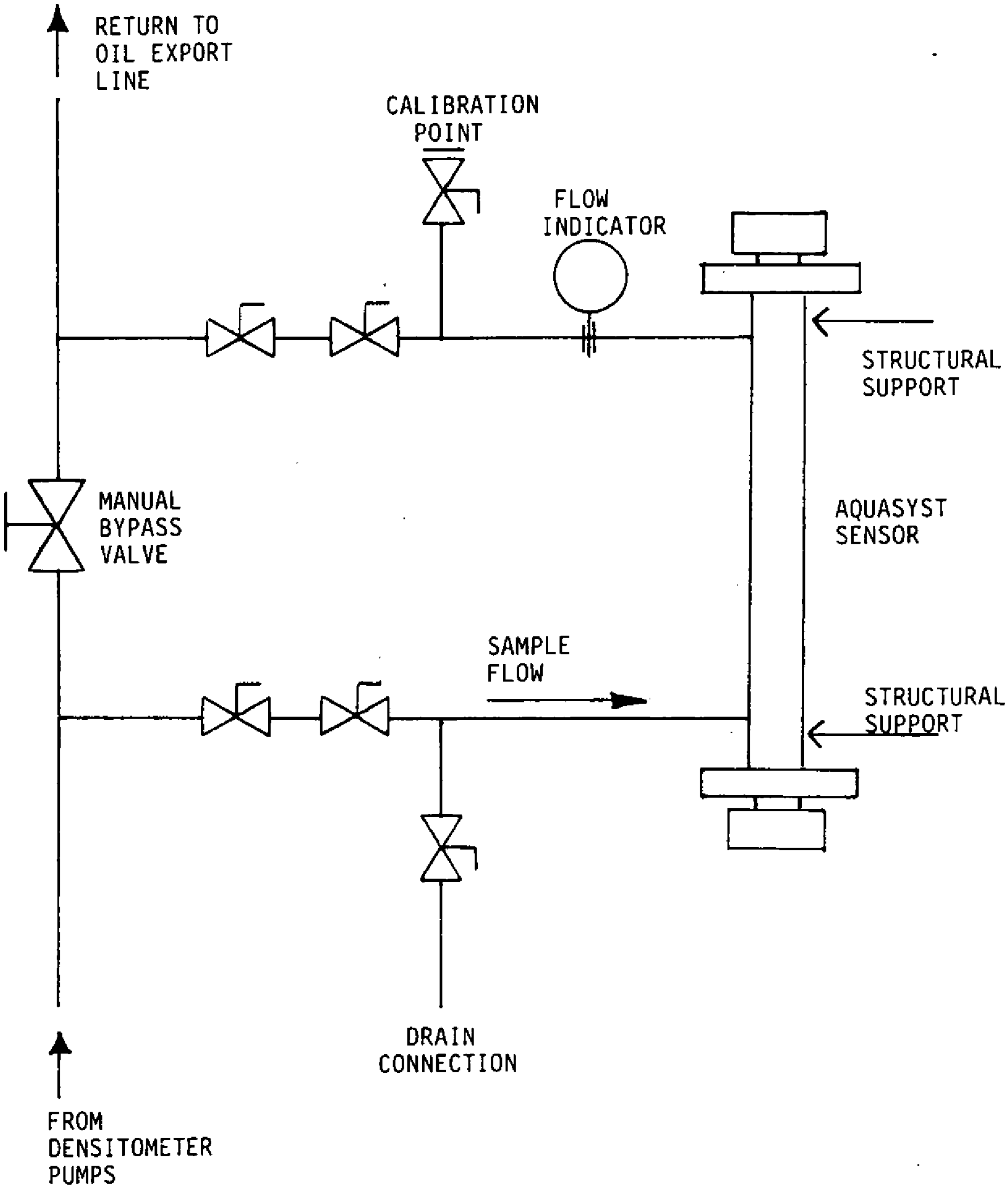


FIGURE 2 - INSTRUMENT INSTALLATION (NORTH CORMORANT)

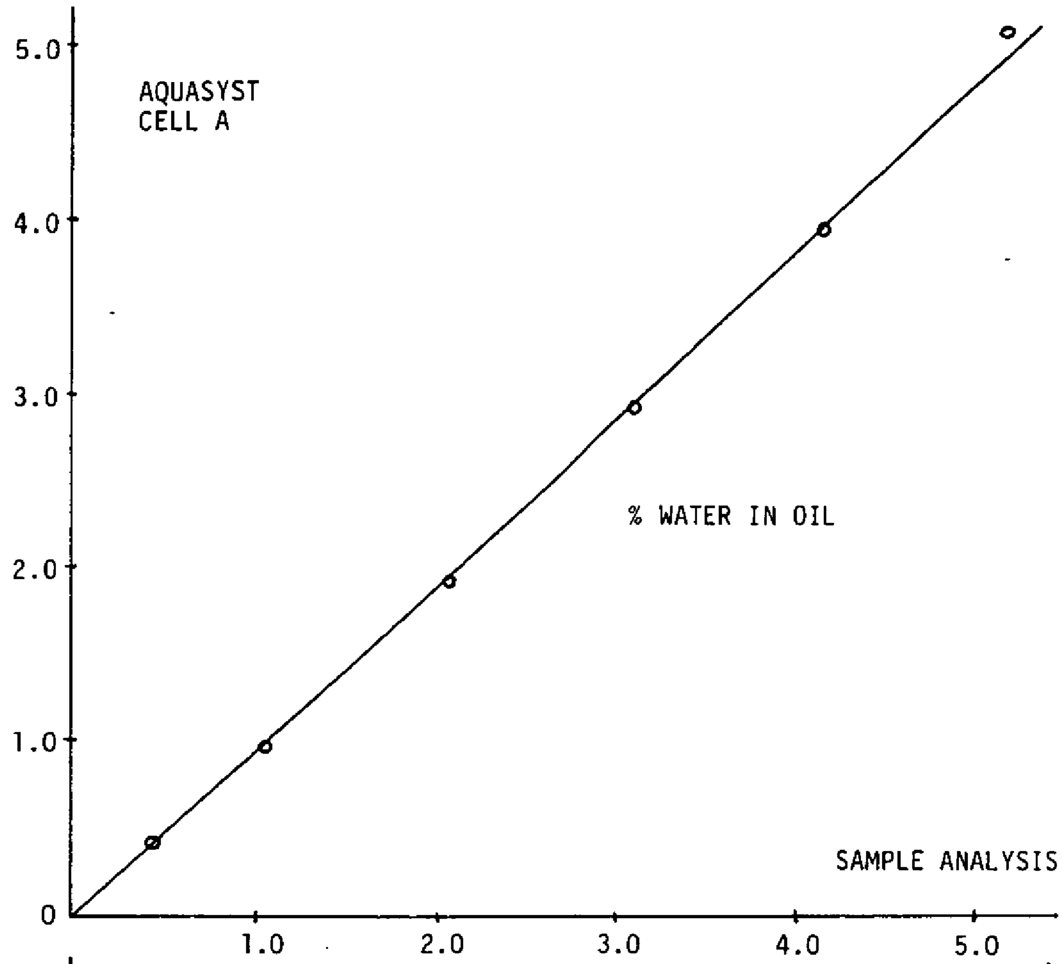


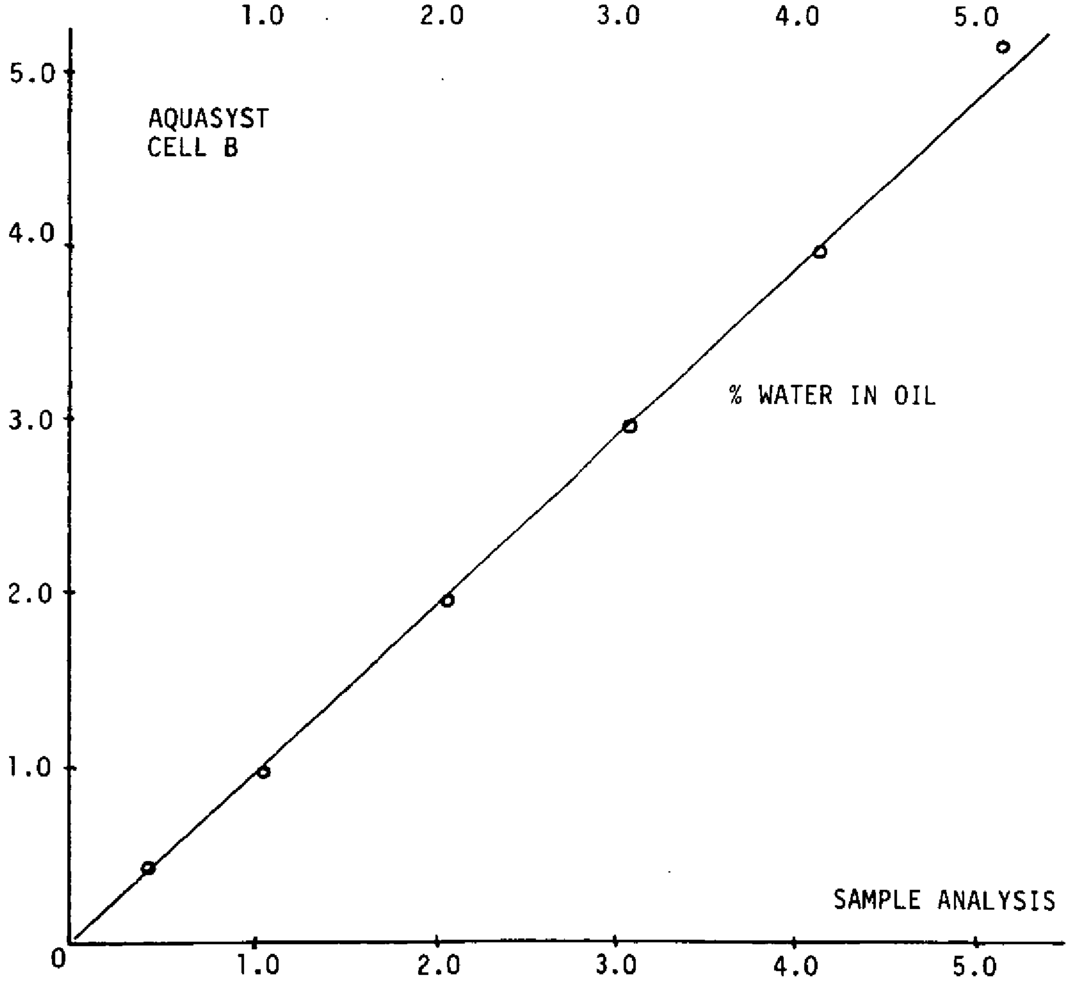
x50

FIGURE 3 - PROPOSED INSTALLATIONS

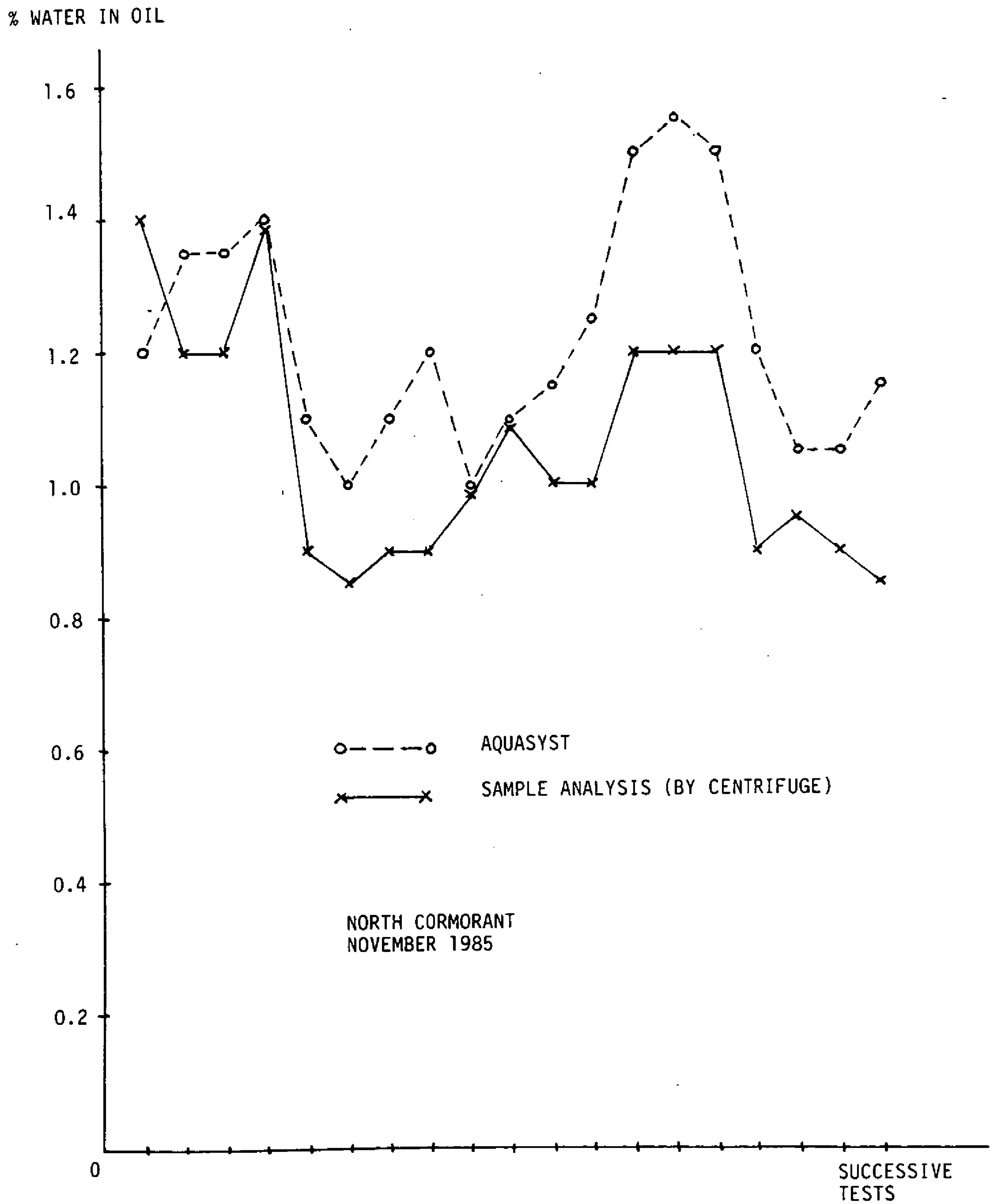


APPENDIX A - ONSHORE TEST RESULTS



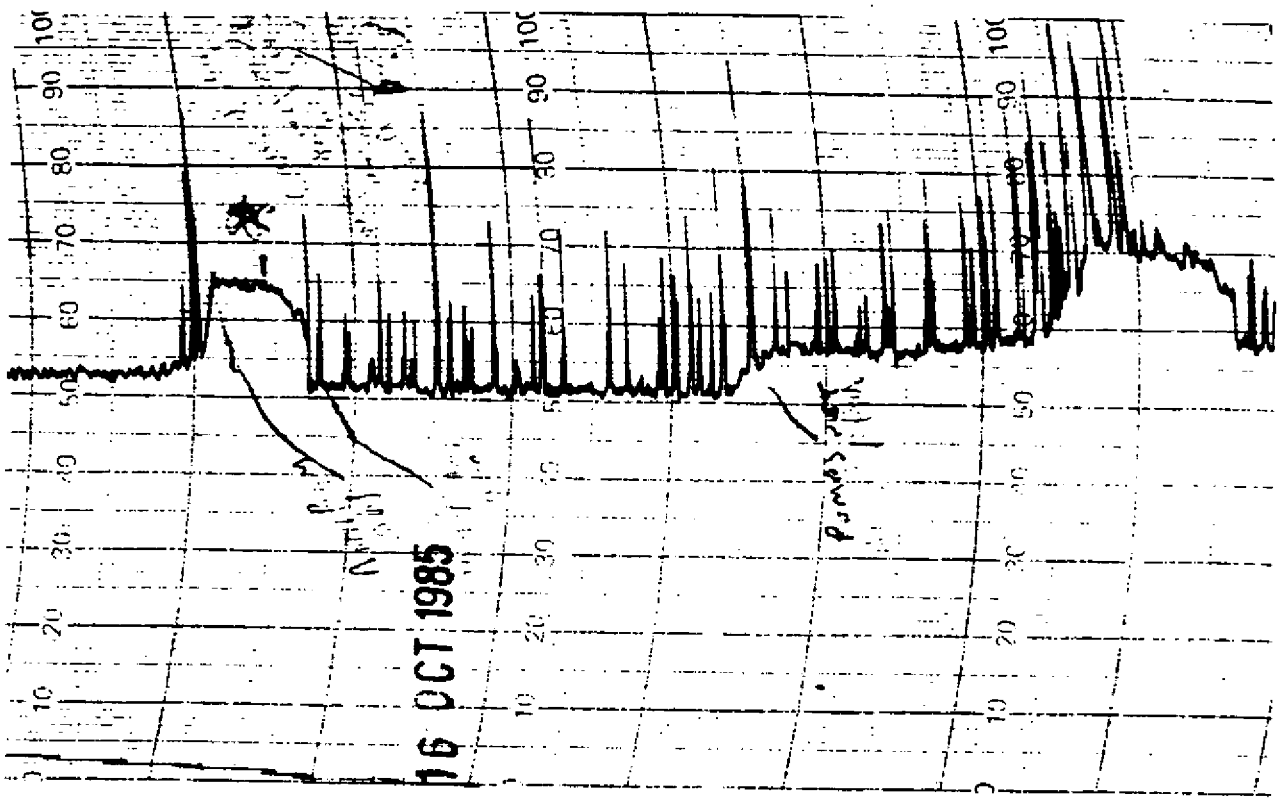


APPENDIX B - OFFSHORE RESULTS

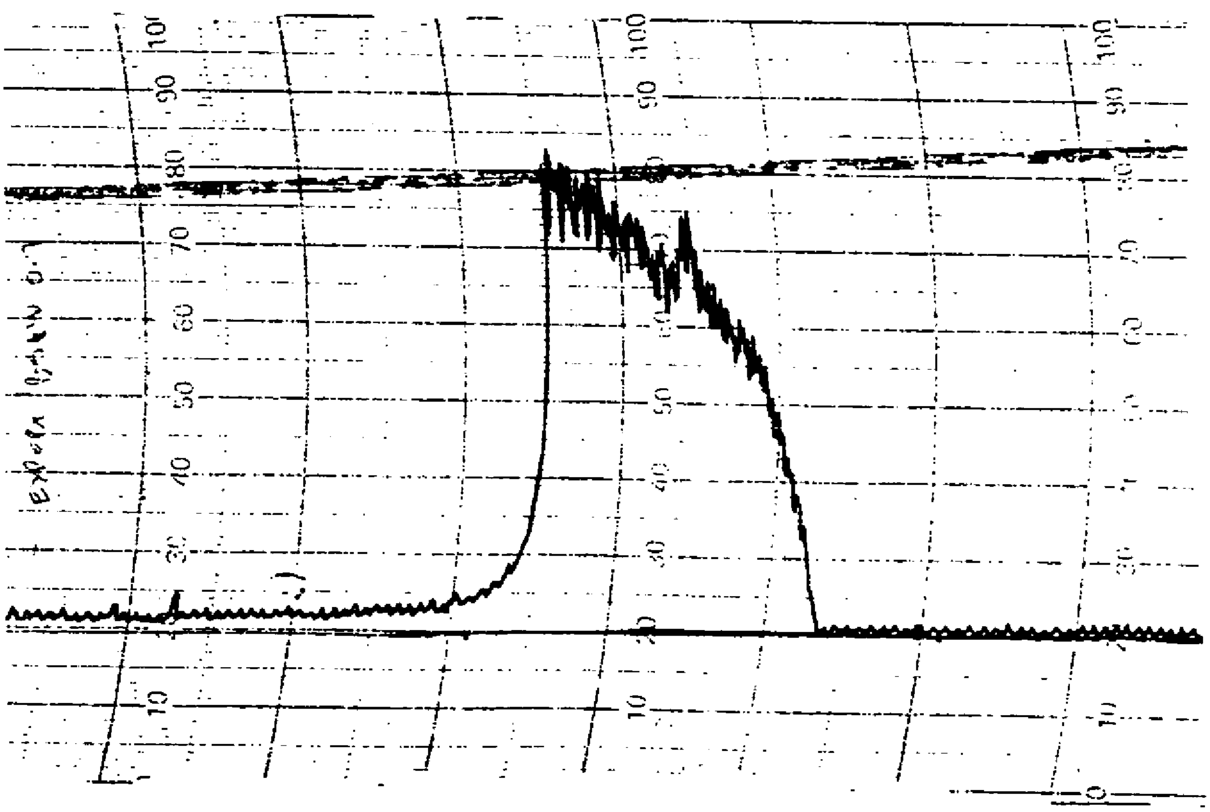


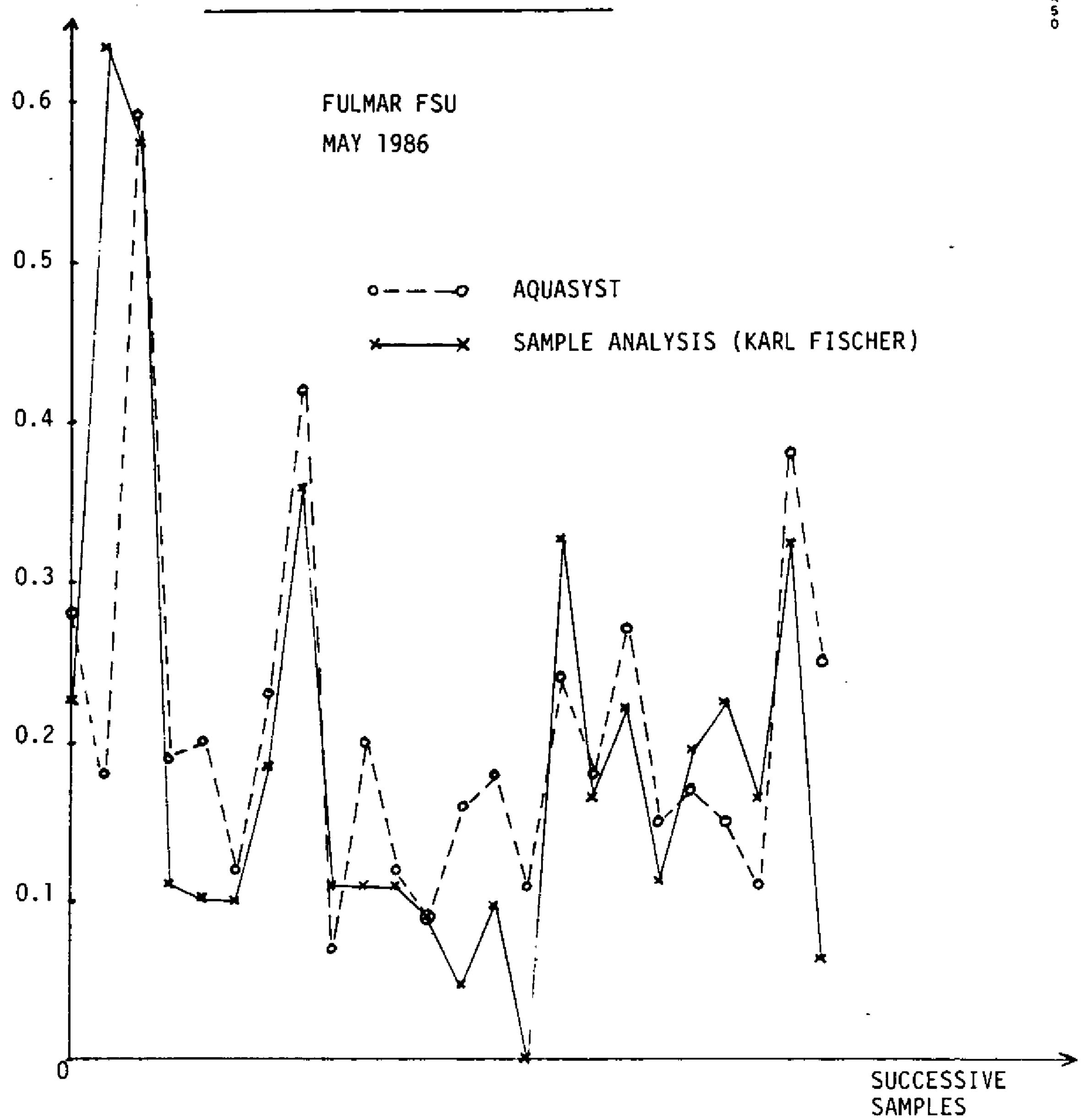
APPENDIX C - EXTRACTS FROM RECORDER TRACES

RESPONSE TO VESSEL LEVEL CONTROL PROBLEM
WITHIN SEPARATION PROCESS



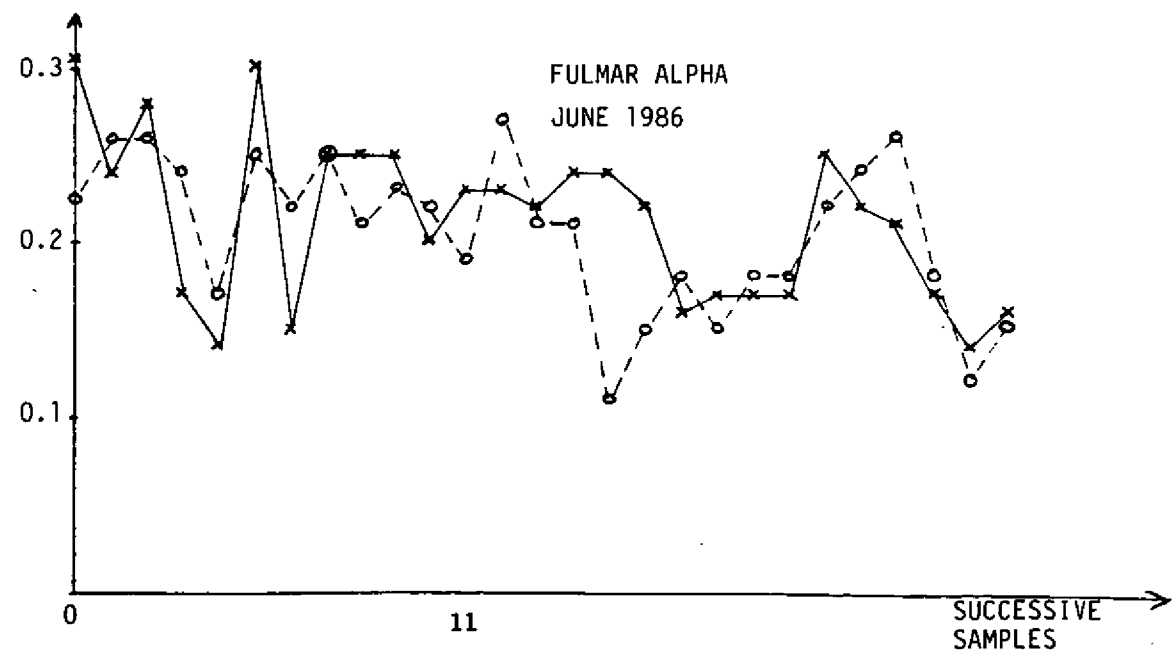
RESPONSE TO WELL CHANGE





0.6
0.5
0.4
0.3
0.2
0.1
0
FULMAR FSU
MAY 1986
AQUASYST
SAMPLE ANALYSIS (KARL FISCHER)
SUCCESSIVE SAMPLES

% WATER IN OIL



0.3
0.2
0.1
0
FULMAR ALPHA
JUNE 1986
SUCCESSIVE SAMPLES

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.