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Scaling problems in the oil metering system at the Gyda Field

by

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1. Introduction

The Gyda field is an oil field located in the south-westerly corner of the Norwegian Continental Shelf. Gyda is an integrated production, drilling and quarter platform .

The Gyda reservoir (Late Jurassic sandstone) is estimated to contain recoverable reserves of some 200 million barrels of light, low-sulphur crude oil. The reservoir depth is 3,600 meters and has a temperature of 156 ^{0}C, the hotest producing field in the Norwegian sector.

The current production rate is around 70,000 barrels a day. About 90,000 barrels of water are injected daily to maintain the reservoir pressure and improve sweep efficiency .

The reservoir fluid goes through a separator where oil, gas and water are separated in a 2 stage separator process. The crude oil is then cooled before passing through the metering station. The gas and oil is transported in pipelines to Emden and Teesside respectively through Ekofisk center.

The Gyda metering system is designed and manufactured by Jordan Kent Metering Systems, UK. The oil metering system comprises of three 4 inches Kent turbine meters, and a 14 inches bi-directional prover.
Maximum capacity is 560 m3/hr through two streams.

Densitometers: ITT Barton model 668 (in-line densitometer with vibrating vane). One densitometer in each line. No check densitometer installed.

Operating conditions:

Oil density :	750 kg/m3.
Operating pressure:	20 barg
Operating temperature:	80 ^{o}C.
Water cut, weight %:	0.5 to 1.5

2. Scaling in the oil metering system

Oil production on Gyda started in July 1990. During the first months of operation BPN had some problems with the prover ball due to high export temperature. This has been presented on this conference in 1991.

The scaling problem probably started very soon after first oil but due to the prover ball problem it is difficult to determine exactly when .

2.1 The Gyda Scale.

The scaling in the Gyda metering system is caused mainly by Zinc compounds in the produced water which again deposit in the platform facilities.

Chemical reaction: $Zn + H_2S = ZnS$

Chemical analysis of scale sampled from a turbine meter gave the following results:

Zinc sulphide , ZnS	~ 90 %
Organic materials (Asphaltens)	~ 10 %.

Conventional scale inhibitors do not seem to prevent formation of this type of scale.

Removal of scale by use of acid: $ZnS + 2\,HCl = ZnCl_2 + H_2S$

Formation of ZnS increases the potential for other types of scale to deposit, ie. $BaSO_4$ and $SrSO_4$ which adheres to particles.

(The H_2S level in export gas has been constant since start up. (Approx. 20 ppm))

2.2 Effect on turbine meters.

Early in 1991 BPN saw a steady increase in K-factors for all turbine meters. In March 1991 the K- factor increased on average for all streams of around 27 counts (equals 0.12 % - K-factors around 22 100 pls/m3) on each daily prove. In some cases the K-factor suddenly dropped before the increase started again. Inspection of turbine meters taken out of service revealed that the internals of the turbine meter waere covered with a layer of scale.

BPN believe that the reason for the sudden decreases is probably due to scale that has fallen off the impeller. We have seen evidence that some of the scale has flaked off. This will effect the turbine meter characteristics.

In extreme cases the K - factors have dropped dramatically, up to 1000 pulses/m3. Reason in all cases: bearing failure.

In spite of the unstable K-factors there has been few problems with repeatability during proving.

From time to time the turbine meters linearity have been checked after a shift in the K - factors. BPN have never seen any linearity problems due to the scale, only a shift in the linearity curves.

2.3 Injection water breakthrough.

In the first days of March 1992 we had injection water breakthrough in one of the wells on Gyda. The water cut through the metering station increased from about 2 to over 4 weight per cent in less than three weeks.
The K-factors were stable in the first part of the this period, but after a couple of weeks we experienced severe scaling problems in all the turbine meters. Six turbine meters were changed for inspection and cleaning. All meters were completely covered with scale.

One turbine meter had restart problems after shutdowns, most probably due to high friction in the bearing at low flow rates.

The produced water treatment system was commissioned in May 1993. After some weeks with optimising the operation of the system, in particular chemical usage, the water cut through the metering station was down to a more normal level again. We still had some scaling but not as severe as before.

This spring a well with very high water cut was shut in. The well produced more than 90 % of the total produced water . The produced water treatment system was shut-in at the same time due to the drop in the produced water rate. This resulted in a higher water cut in the oil and an increase in the K-factors variations until the produced water system was put back in operation.

2.4 Pressure loss.

Due to the scale problem the pressure loss over the metering system has increased. The pressure before the main oil pipeline pumps is very close to the trip-limit for these pumps (low suction pressure). In order to reduce the pressure drop, all three metering streams are used during normal operation.

2.5 Densitometers.

So far there is no clear indication that the scaling has any effect on the densitometers. BPN have seen a tendency of decrease in readings after a couple of weeks in service which may be due to scaling. More data is required before BPN can draw any conclusions or relate this to the scaling problem.

3 Measures taken to reduce the problems

3.1 Increased proving frequency.

According to the NPD regulations all turbine meters should be proved at least every fourth day. Due to the variations in the K- factors all turbine meters are proved on a daily basis to improve the measurement accuracy.

If the change in K-factor is more than 30 counts, which equals 0.14 %, the stream is reproved to verify this new K-factor and the next proving is carried out after another 12 hours.

If the change in K-factor is more than 100 pulses/m^3, the stream will be shut in, and the turbine meter removed for inspection and cleaning if necessary.

3.2 Frequent change out and cleaning of turbine meters.

The turbine meters are sent onshore for cleaning, removal of scale, and inspection. The first step in the cleaning process is to put the meter into an ultrasonic bath. If still scale on the turbine meter, it will be soaked in an acid solution (10 % sulphuric acid) for about one hour.
In some cases even acid is not dissolving the remaining scale. The scale is then removed mechanically by carefully using a small knife and a steel brush.

3.3 Test of helicon type turbine meter.

A helicon type turbine meter has been tested three times. It failed every time due to destroyed bearings. The meter performance was good with very stable K-factors before the bearing problems started.

3.4 Scale inhibitors - metering station.

In August this year trials with scale inhibitor injection were started. The scale inhibitor was injected in the crude oil stream just before the Low Pressure Separator. Four weeks later the injection point was moved to the Low Pressure Separator outlet.

The effect of this injection seems to be positive, but it is difficult to draw any conclusions at this stage. The trial is going to be continued for at least another month.

4. Modifications

4.1 Turbine meters.

The internals of a turbine meter was coated with Teflon, and the sleeve bearing was replaced with two sealed ball bearings to reduce the crude oil flow through the bearings . After only a few weeks in service the bearings broke down. Later BPN have tried with another type of sealed ball bearings. This meter also broke down after a short period.

The Teflon coating seems to be a step in the right direction as the amount of scale on the turbine meter was reduced. The flow straightners were also Teflon coated to reduce the pressure drop over the metering system. But it is very important to use the right type of coating. The coating company changed the coating specification on some of the flow-straightners and BPN ended up with blistering problems.

4.2 Filter baskets.

Two of the filter baskets were coated with Teflon summer 1991 after the fine start - up mesh had been removed.

After some weeks they where removed for inspection and very little scale was found on surface. Unfortunately, the filters where sandblasted to remove the small amount of scale. The coating was destroyed. No other trials has been carried out.
BPN do not have problems with high pressure drop over the filters.

5 Measurement accuracy

Due to the variations in the K-factors an uncertainty analysis of the whole oil metering system has been carried out. The K-factor's contribution to the total uncertainty is about 1/3.
The main conclusion of the study is that the Gyda oil metering accuracy is in compliance with the NPD regulations.

6 Cost impact of the scaling problem

The frequent proving has in periods led to continuos problems with the 4 - way valve and hundreds of extra man-hours for our mechanics. Together with the frequent change out and cleaning of turbine meters this has significantly increased the operating costs for the Gyda metering station.

7 Not affected by the scale problem.

BPN have not seen any impact on the:

- prover volumes
- samplers
- static mixer
- valves (leaks)

8 Future plans

Later this autumn or this winter BPN plan to Teflon coat another turbine meter, and put it in to service in parallel with a brand new standard turbine meter .

BPN are still thinking about bearing modifications, for instance to try roller bearings instead of ball bearings. No decision has been made yet.

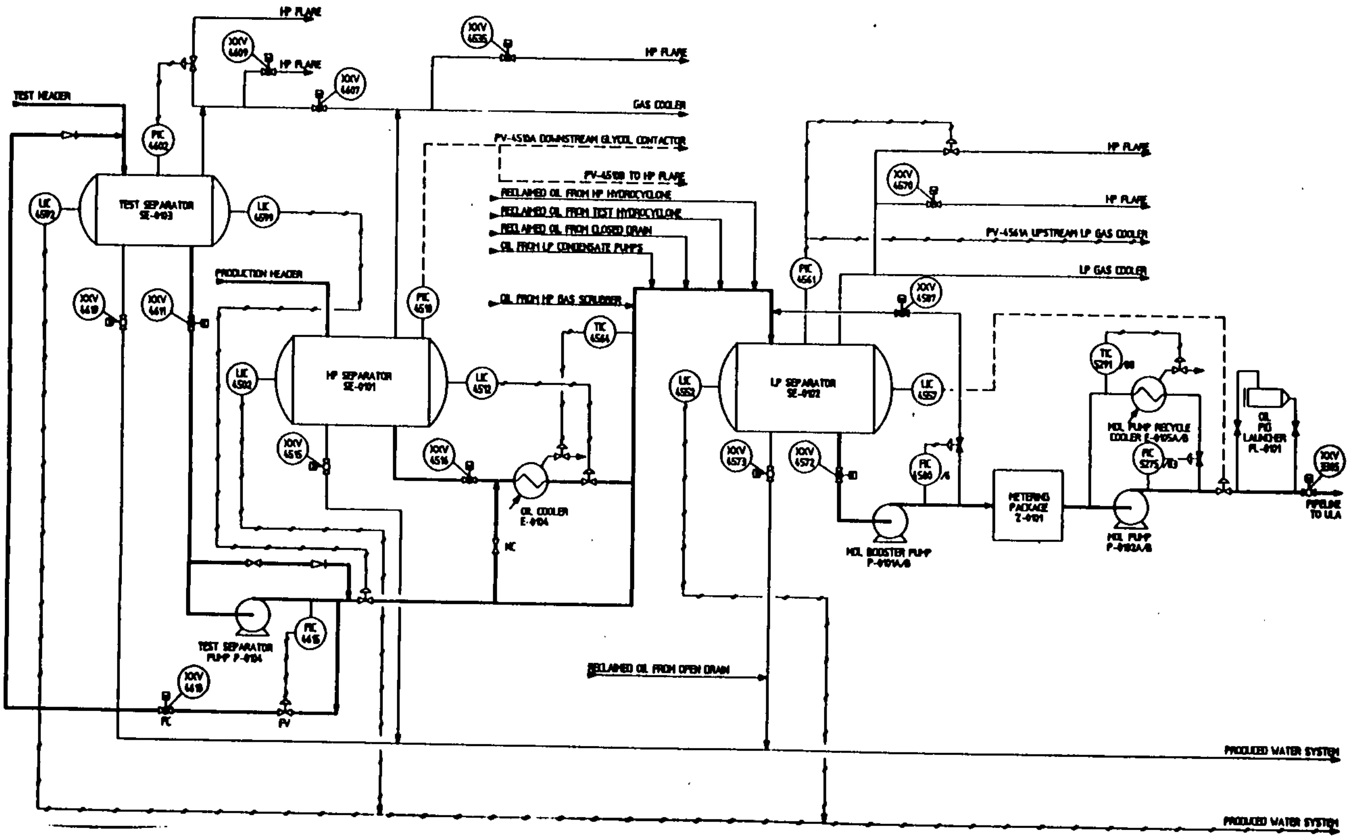


Figure 1 Gyda oil production system

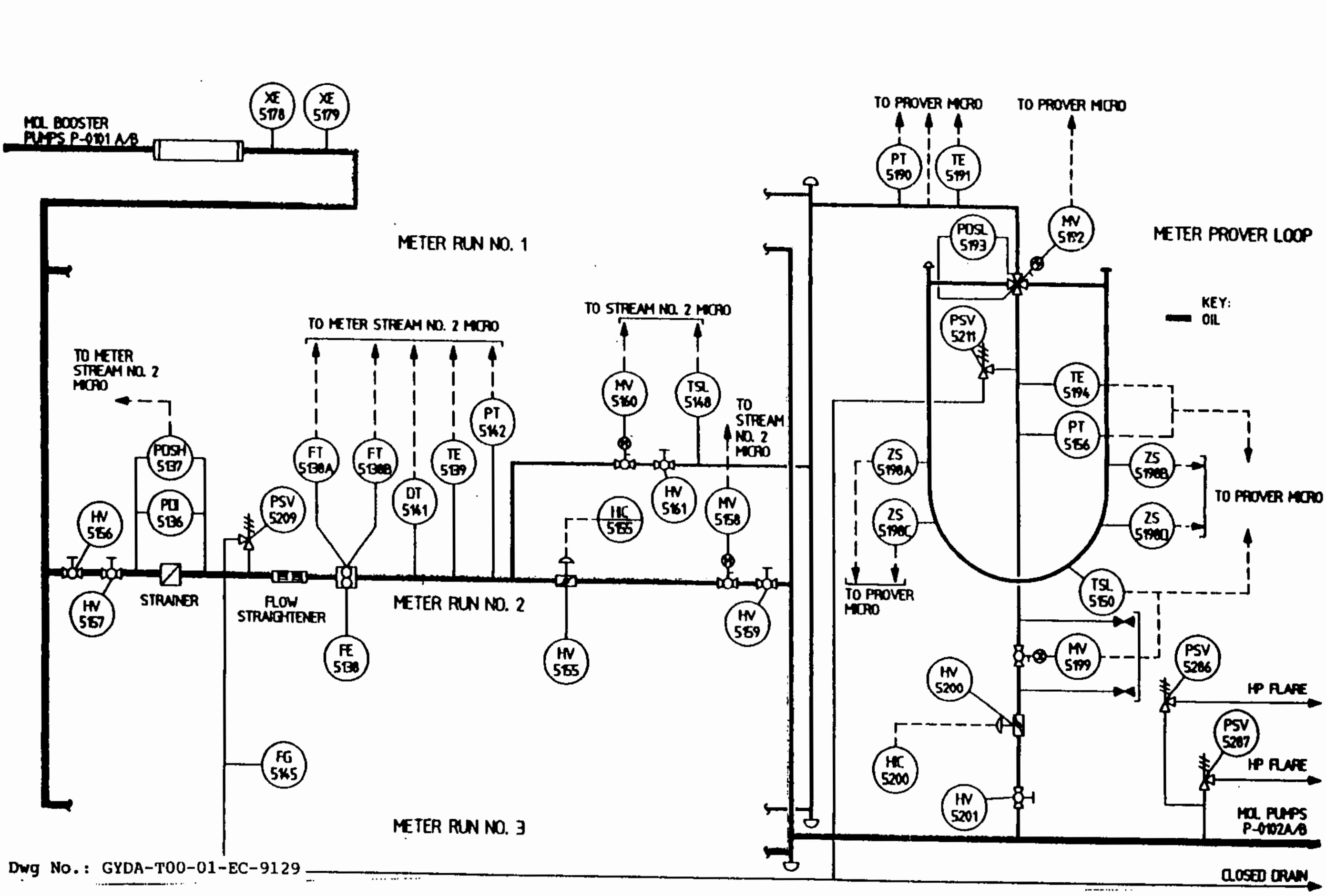


Figure 2. Gyda oil metering system

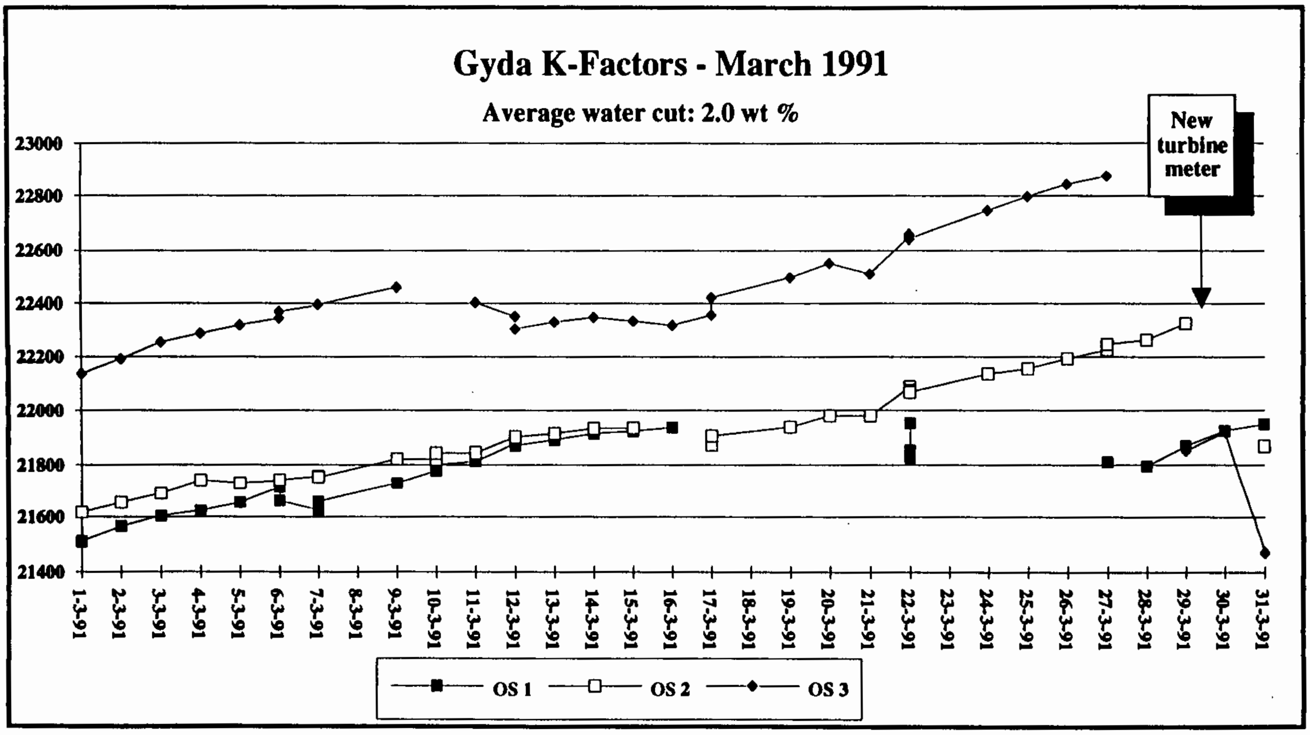
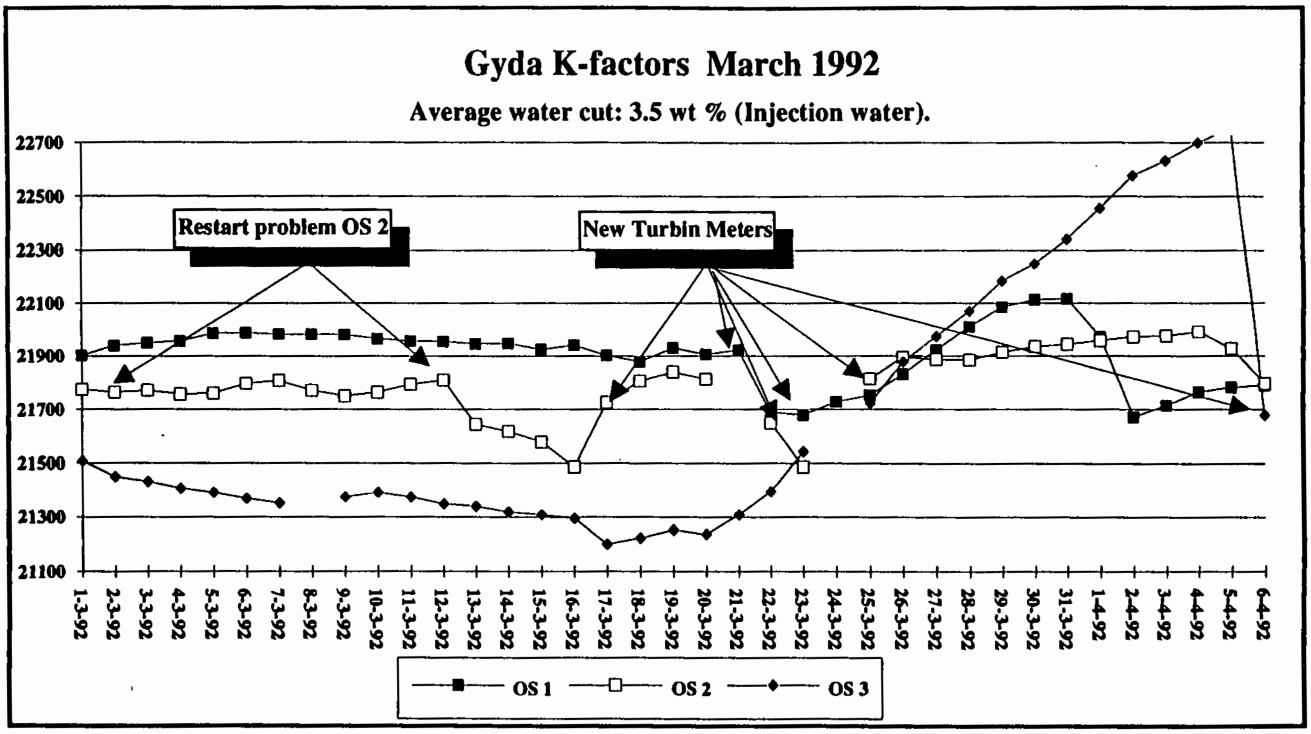

Gyda K-Factors - March 1991
Average water cut: 2.0 wt %
New turbine meter
23000
22800
22600
22400
22200
22000
21800
21600
21400
1-3-91
2-3-91
3-3-91
4-3-91
5-3-91
6-3-91
7-3-91
8-3-91
9-3-91
10-3-91
11-3-91
12-3-91
13-3-91
14-3-91
15-3-91
16-3-91
17-3-91
18-3-91
19-3-91
20-3-91
21-3-91
22-3-91
23-3-91
24-3-91
25-3-91
26-3-91
27-3-91
28-3-91
29-3-91
30-3-91
31-3-91
OS 1
OS 2
OS 3

Figure 3.



Gyda K-factors March 1992
Average water cut: 3.5 wt % (Injection water).
Restart problem OS 2
New Turbin Meters
22700
22500
22300
22100
21900
21700
21500
21300
21100
1-3-92
2-3-92
3-3-92
4-3-92
5-3-92
6-3-92
7-3-92
8-3-92
9-3-92
10-3-92
11-3-92
12-3-92
13-3-92
14-3-92
15-3-92
16-3-92
17-3-92
18-3-92
19-3-92
20-3-92
21-3-92
22-3-92
23-3-92
24-3-92
25-3-92
26-3-92
27-3-92
28-3-92
29-3-92
30-3-92
31-3-92
1-4-92
2-4-92
3-4-92
4-4-92
5-4-92
6-4-92
OS 1
OS 2
OS 3

Figure 4.

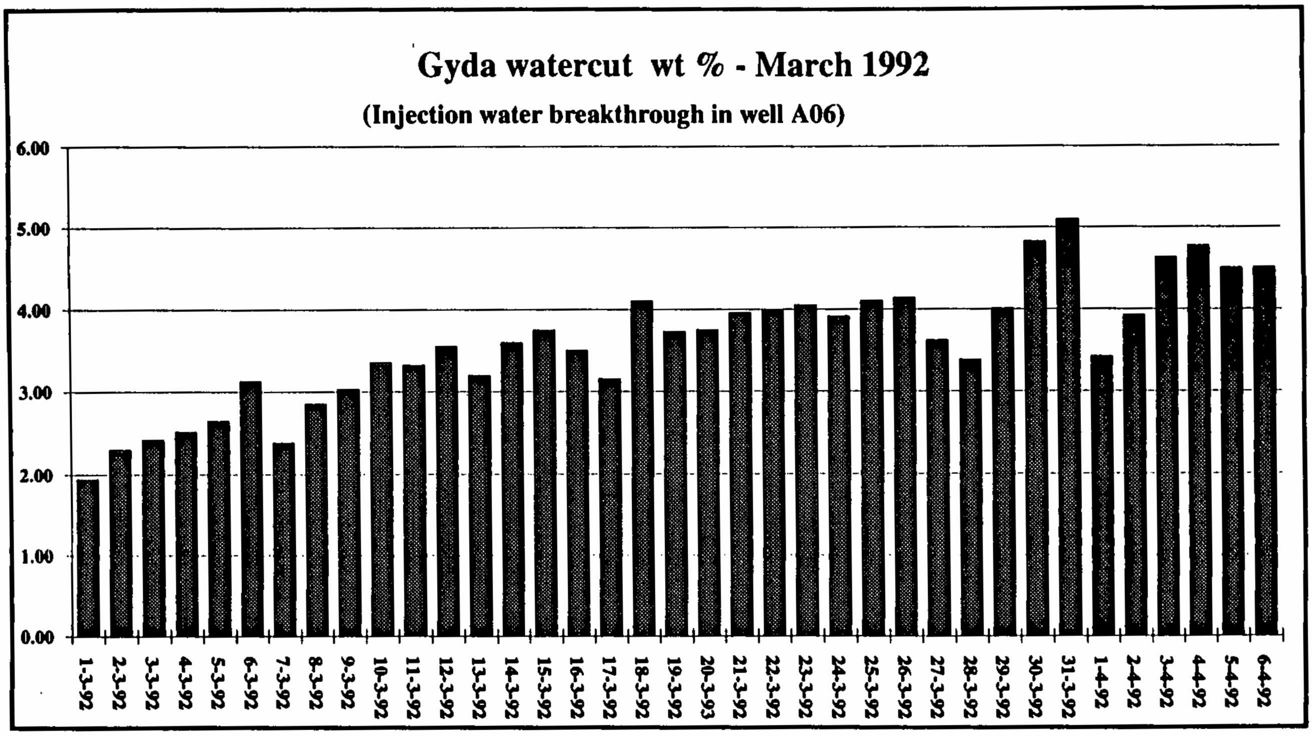
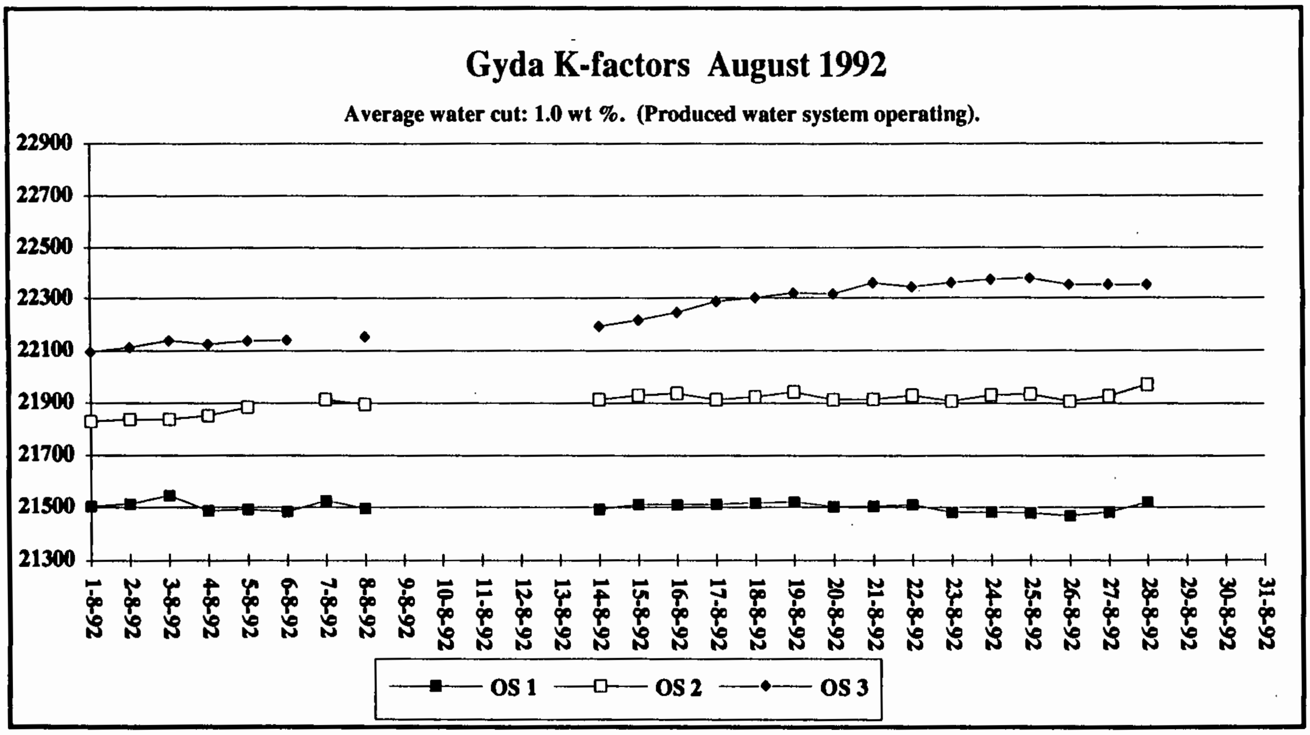

Gyda watercut wt % - March 1992
(Injection water breakthrough in well A06)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1-3-92
2-3-92
3-3-92
4-3-92
5-3-92
6-3-92
7-3-92
8-3-92
9-3-92
10-3-92
11-3-92
12-3-92
13-3-92
14-3-92
15-3-92
16-3-92
17-3-92
18-3-92
19-3-92
20-3-93
21-3-92
22-3-92
23-3-92
24-3-92
25-3-92
26-3-92
27-3-92
28-3-92
29-3-92
30-3-92
31-3-92
1-4-92
2-4-92
3-4-92
4-4-92
5-4-92
6-4-92

Figure 5.



Gyda K-factors August 1992
Average water cut: 1.0 wt %. (Produced water system operating).
22900
22700
22500
22300
22100
21900
21700
21500
21300
1-8-92
2-8-92
3-8-92
4-8-92
5-8-92
6-8-92
7-8-92
8-8-92
9-8-92
10-8-92
11-8-92
12-8-92
13-8-92
14-8-92
15-8-92
16-8-92
17-8-92
18-8-92
19-8-92
20-8-92
21-8-92
22-8-92
23-8-92
24-8-92
25-8-92
26-8-92
27-8-92
28-8-92
29-8-92
30-8-92
31-8-92
OS 1
OS 2
OS 3

Figure 6.

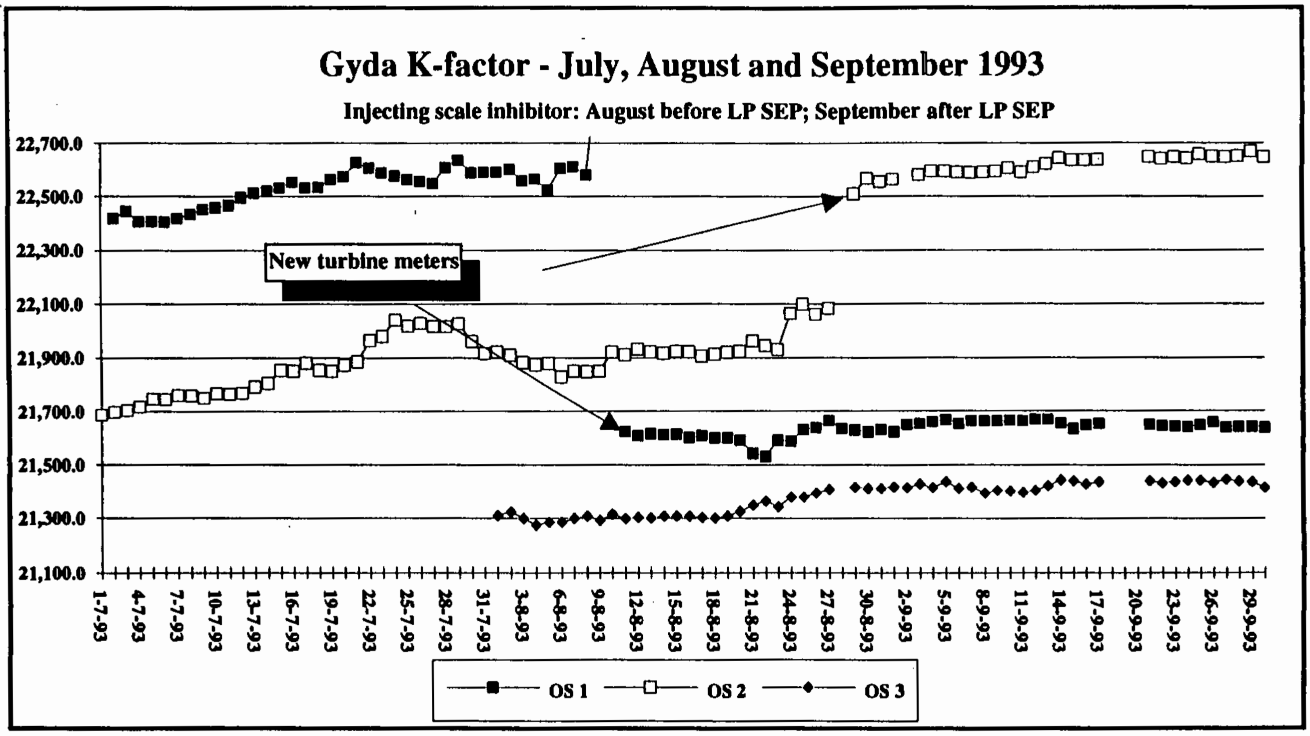

Gyda K-factor - July, August and September 1993
Injecting scale inhibitor: August before LP SEP; September after LP SEP
22,700.0
22,500.0
22,300.0
22,100.0
21,900.0
21,700.0
21,500.0
21,300.0
21,100.0
New turbine meters
1-7-93
4-7-93
7-7-93
10-7-93
13-7-93
16-7-93
19-7-93
22-7-93
25-7-93
28-7-93
31-7-93
3-8-93
6-8-93
9-8-93
12-8-93
15-8-93
18-8-93
21-8-93
24-8-93
27-8-93
30-8-93
2-9-93
5-9-93
8-9-93
11-9-93
14-9-93
17-9-93
20-9-93
23-9-93
26-9-93
29-9-93
OS 1
OS 2
OS 3

Figure 7.

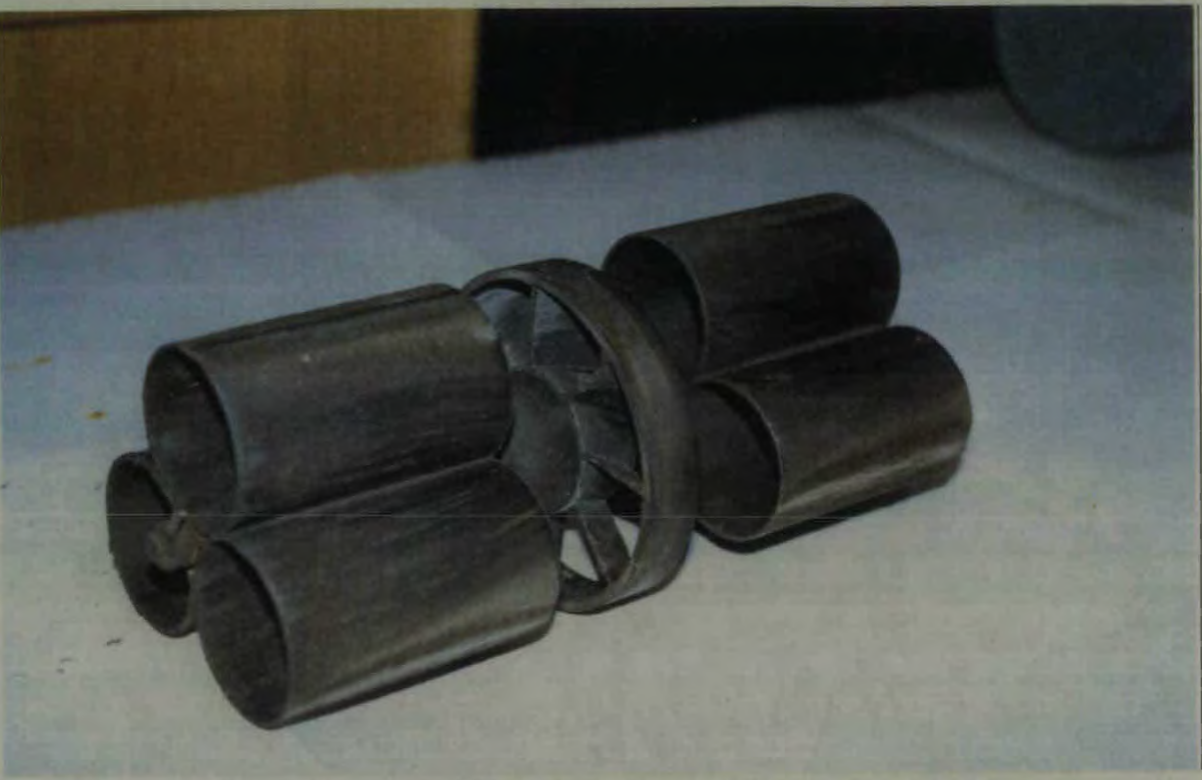


Figure 8. Scale deposits on internals of turbine meters.

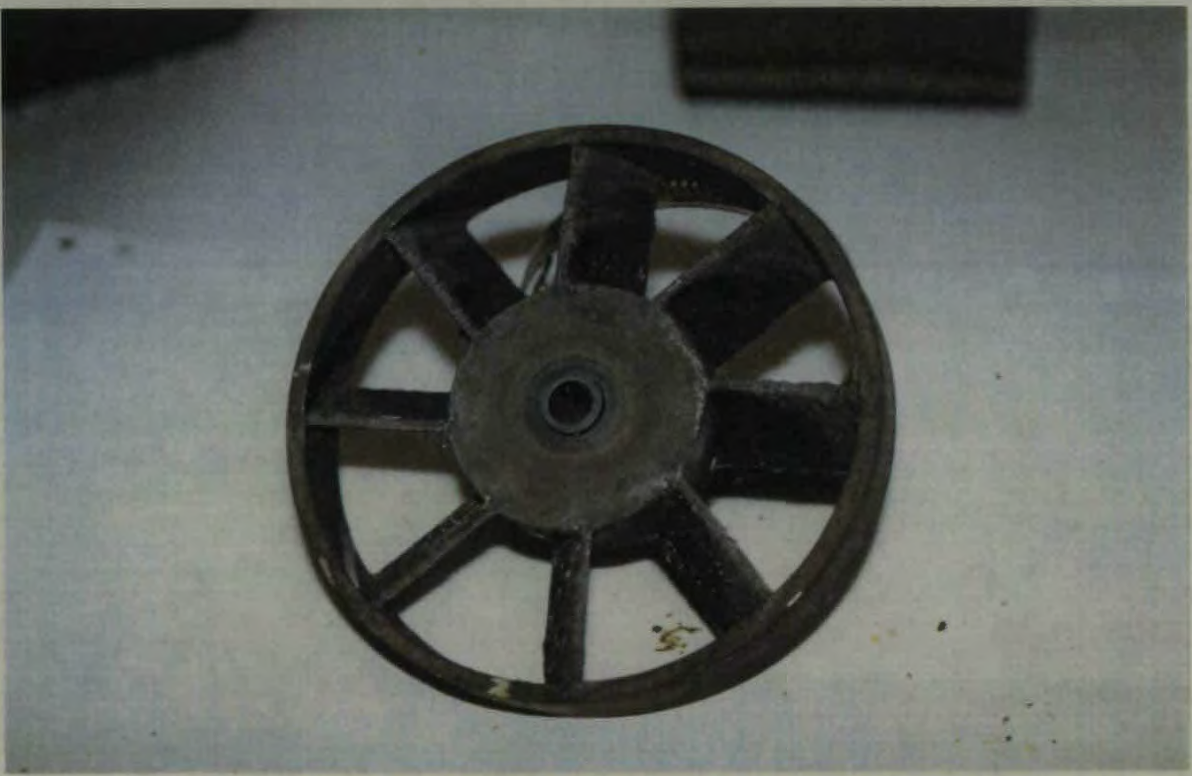


Figure 9. Scale deposits on impeller of turbine meter.

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.