Main Index

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Scaling problems in the oil metering system at the Veslefrikk Field

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SCALING PROBLEMS IN THE OIL METERING SYSTEM AT THE VESLEFRIKK FIELD.

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Summary

The fiscal oil metering at the Veslefrikk platform was in operation without significant problems from start up in December 1989 until June 1992. At that time a new well was brought into operation and introduced a major problem in the metering system.

The new well's formation water turned out to contain significant amounts of barium and strontium ions. These ions reacted chemically with the sulphate ions of injection water from one of the other wells and formed bariumsulphate and strontiumsulphate. These sulphates have very low solubility in water.

Because of their low solubility, the sulphates will have a tendency to deposit on the inside of flowlines and process equipment. At Veslefrikk such a deposition formed a layer of scale on the internal parts of the metering system.

Other parts of the process plant at Veslefrikk have also been affected by deposition of scale but the oil metering system have given more problems than other equipment.

This paper describes the problems of scale deposition in the metering system and the attempts made to cope with the problem.

At the time when this paper is written, it seems that the problem may be very much reduced or even solved by adding a scale inhibitor to the well stream and in addition polishing the internals of the meter runs to a very high degree of surface smoothness.

1. The Veslefrikk oil metering system

The system is a conventional North Sea oil metering system. Figure 1 is an early P & I drawing. It is not accurate in all details, but gives a general overview of the design of the system.

The system has 3 meter lines, each with a 4" conventional turbine meter. The bi-directional prover has a nominal diameter of 10". Each meter line has an in-line density meter to enable direct reading of mass as well as standard volume.

The main data for the metered oil stream are as follows:

Oil type:	Stabilised crude oil, standard density 825 kg/Sm3, water content 0.1 - 0.3%.

Maximum flowrate: 285 m3/hr per meter line.

Operating temperature: 75 deg. C.

Operating pressure: 10 bar(g)

The system is a fiscal metering system, metering Veslefrikk's stream of oil into the pipeline of the Oseberg Transportation System.

2. Start of the scaling problem

In June 1992, a very rapid increase of the K- factors of the two turbine meters in use, started.

Up to this time the K-factors had been almost constant, but suddenly there was a daily increase of the order of 0.3-0.6 % per day. Figure 2 shows the K-factor of one of the meters during a period of 15 months before the start of the scaling problem.

As both meters in use were affected, the main suspects were the prover and the four way valve.

The third meter was brought into operation and behaved in the same manner as the two others. This meter was then shut down and taken out for inspection. The inspection revealed that the internals of the meter had a thick, hard deposit.

Analysis of the deposit and further investigations lead to the conclusion that the deposit was scale, the scale consisted mainly of bariumsulphate and that the source of the problem was a new well that had just been brought into operation.

3. Reason for scale formation

The new well's formation water contained significant amounts of barium ions (and smaller amounts of strontium ions). At the time when the well was completed, there had been injection water breakthrough into one of the other wells. The injection water is seawater and contains sulphate ions.

When the formation water of the new well mixed with the seawater coming from the other well, the barium and strontium ions reacted chemically with the sulphate and formed bariumsulphate and strontiumsulphate. Both of these compounds have very low solubility in water.

This mixing of formation water and seawater takes place in the wells' production header. From that point on the water of the produced oil, oversaturated by bariumsulphate and strontiumsulphate, tends to leave deposits inside the oil processing equipment.

In addition to the oil metering system, the seals of the pipeline pumps have been seriously affected.

A simplified flow diagram of the Veslefrikk oil processing plant is shown in fig. 3.

4. Details of the scaling problem in the oil metering system

In addition to the problem of drifting meter factors, the scale deposits also lead to excessive pressure loss in the metering system and to problems with the liquid density meters.

Pressure loss

The normal pressure loss over the metering system, with no scale deposits, is of the order of 2.0 bar.

When the scale problem started the pressure loss would increase up to 4 bar during a short period of time. At this pressure loss, the suction pressure of the pipeline pumps was very close to the trip-limit of the pipeline pumps.

The immediate remedy for this was to clean the meter runs' strainers with a frequency as high as once a day the worst periods. In addition, with a lower frequency, the meter runs' internals were cleaned by shotblasting. The flowstraightener was the element that probably gave the largest contribution to the pressure loss downstream of the strainer.

Fig. 4 shows scale deposits on a flowstraightener.

Density meters getting out of calibration

For reasons which are outside the scope of this lecture, two types of direct insertion density meters were in use at the time when the scaling started: Sarasota ID 781 and ITT-Barton model 668.

The Sarasota instrument has a small filter in the shield around the sensing element which is a vibrating cylinder. The scale was deposited on this filter but not on the sylinder itself. This resulted in errors in the density reading, alarmed by excessive differences of density of meter lines operating in parallel.

The ITT-Barton instrument has an unshielded vibrating vane as sensing element. It got a gradually increasing amount of scale on its vibrating vane, leading to an increase of the reading of the instrument.

Drift of the K-factors of the turbine meters

Drift of the K- factors became a serious problem.

A graph showing typical drift of the K- factor of one of the turbine meters during January 1993 is shown in fig. 8. There is an irregular increase of K-factor from day to day leading to a maximum value about 2% higher towards the end of the month than at the beginning of the month.

This graph shows less drift of the K-factor than at the time when the problem started. This is mainly due to that scale inhibitor is in use in the period shown on the graph.

Fig. 5 shows scale deposits on the impeller of one of the turbine meters.

5. Solutions

The immediate measures taken to keep the system going, like dismantling and shotblasting, proving the meters every day, recalibration of densitometers etc. were not very desirable as a long term solution to the scaling problem.

The following has been tried as long term solutions:

Injection of scale inhibitor

Injection of scale inhibitor into the production header was started ten days after the scale had been identified. Although not fully eliminating the problem, it has reduced it .

An additional problem that may have been caused by the scale inhibitor was that the prover ball was chemically attacked by the oil stream, see fig. 6. This problem was solved by using prover balls made from nitril instead of polyurethane.

Plating of internal parts of the meter runs

Because deposits will have less tendency to stick to the surface of a noble metal, silver plating of the flowstraighteners and the internal parts of a turbinemeter was tried.

Our experience from this was that there was no deposition of scale on the silver plated parts. On the other hand we could not get the plating to stay, it broke loose after less than a month of operation of the turbine meter. The flowstraightener kept its silver plating longer, but it also came off gradually.

As a consequence of this, silver plating has been abandoned.

Epoxy coating was tried on a flowstraightener, it worked in preventing scale deposition but developed blisters and was abandoned.

Polishing

Polishing the internal parts of the the meter run to a mirror surface is the remedy that is being tried at the time when this paper is written.

This one seems to work. A polished flowstraightener was installed in a meter run in december last year and was removed for inspection this summer. There was no scale deposit on it.

Also, a turbine meter with polished internals was installed on 15th august this year. Fig. 9 indicate very clearly why we think polishing will be the solution to the scaling problem in the meter runs.

Fig. 7 shows this turbine meter.

6. Status as per 1st. september 1993.

At this moment, injection of scale inhibitor and polishing the flowstraightener and the turbine meter to a mirror finish seem to be able to cure the metering problem that the scale deposits have given us.

Polishing of flowstraighteners, the inside surface of the meter line and of the turbine meters on all meter lines will be made within this year.

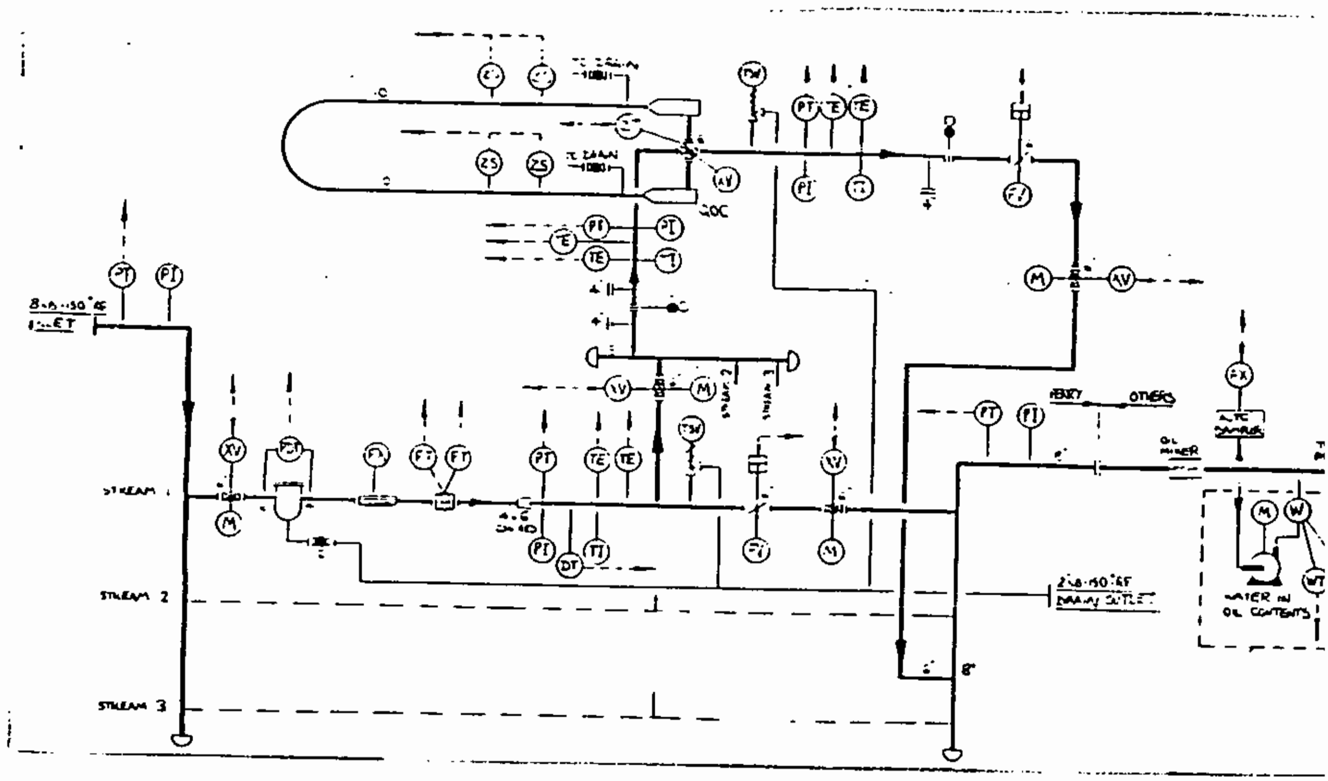

Fig. 1 P&I drawing for general overview of the Veslefrikk oil metering system
(Note: Not accurate in some details)

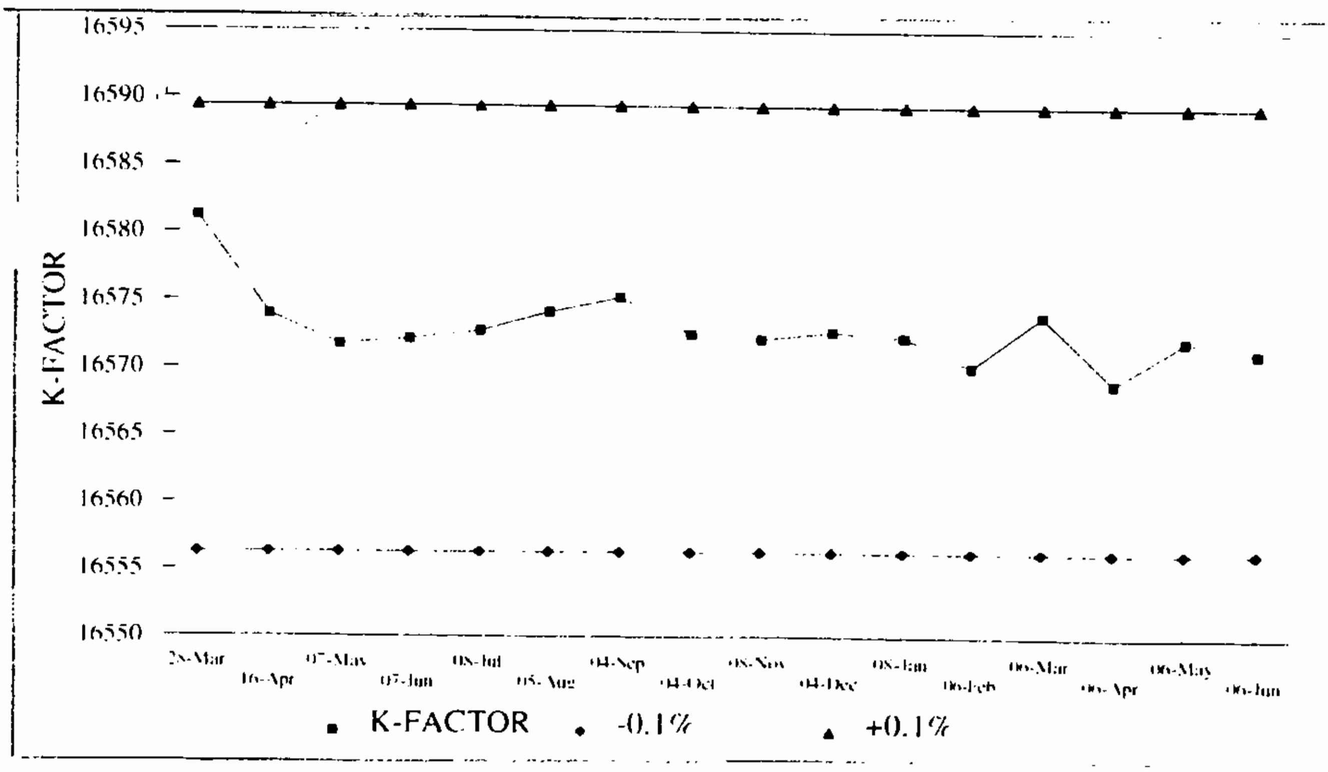

Fig. 2 Before the scaling problem, typical K-factor values as a function of time for one of the turbine meters.

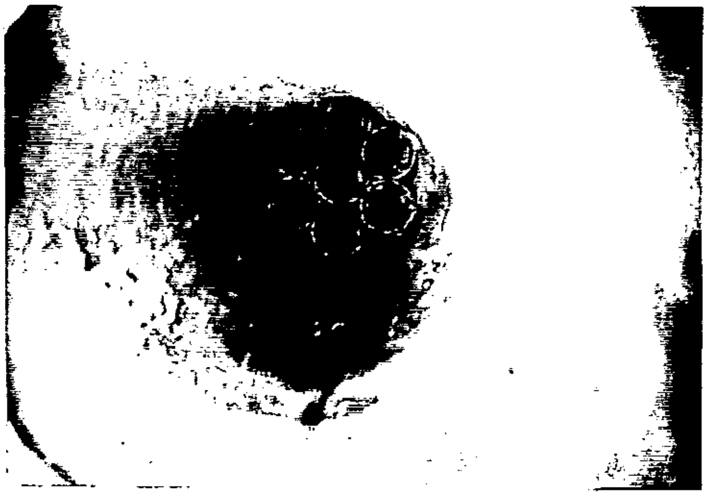

Fig. 4 Scale deposits on flowstraightener

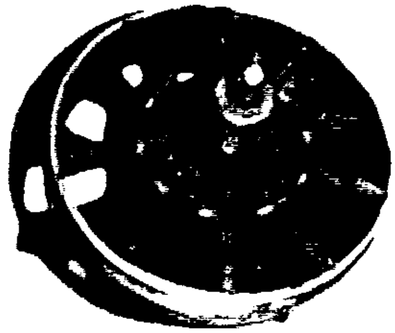

Fig. 5 Scale deposits on impeller of turbine meter.

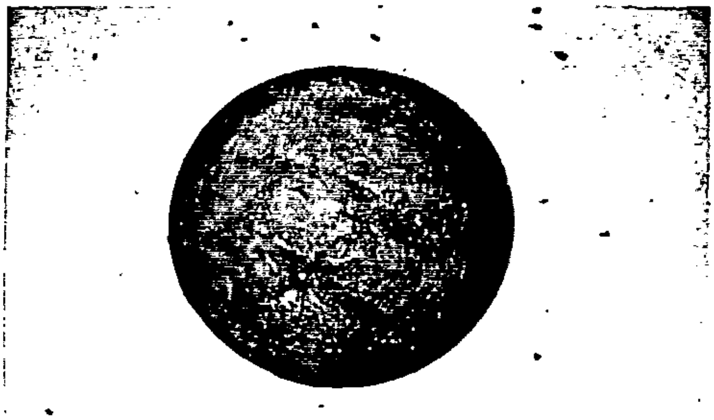

Fig. 6 Polyurethane sphere

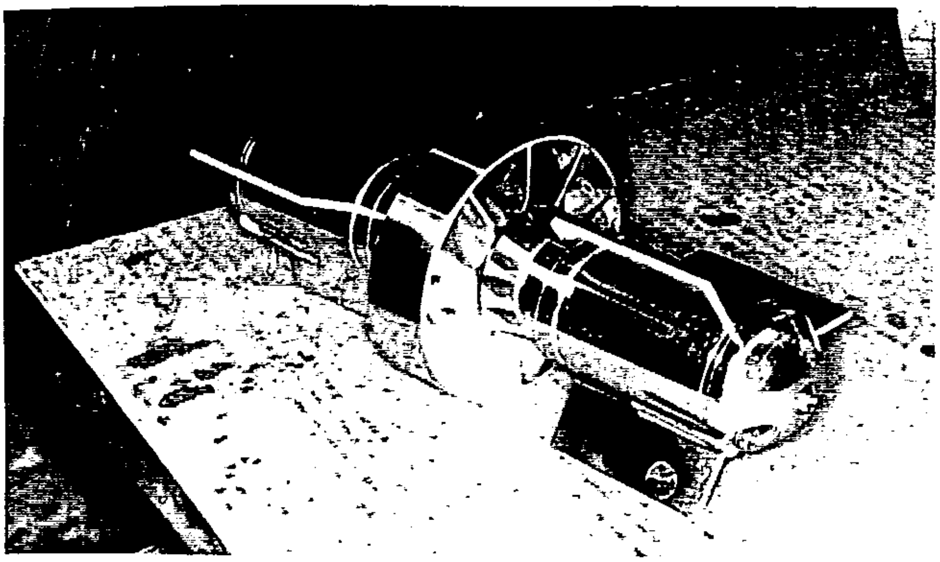

Fig. 7 Polished internals of turbine meter

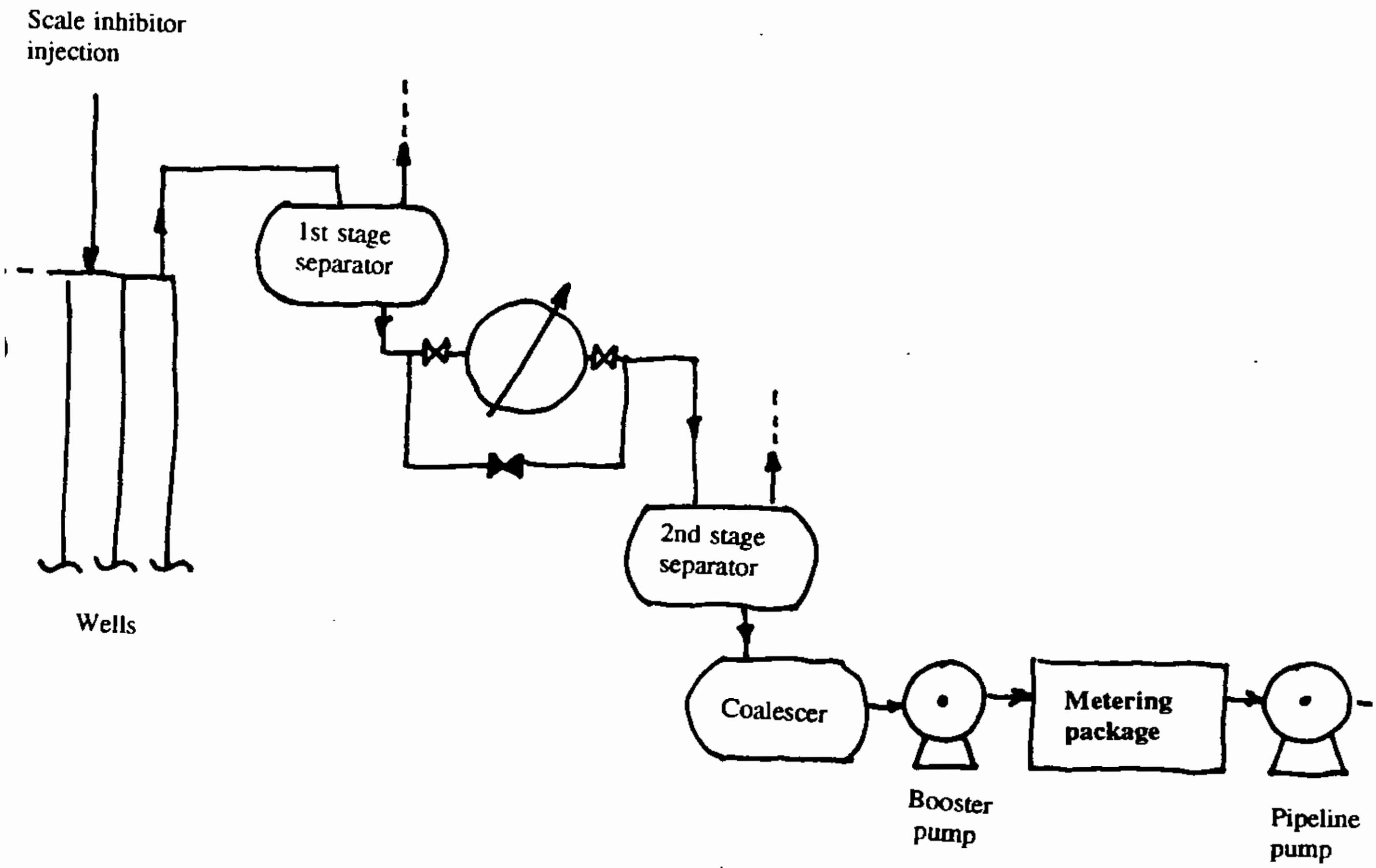

Fig. 3 Simplified flow diagram, Veslefrikk oil processing plant

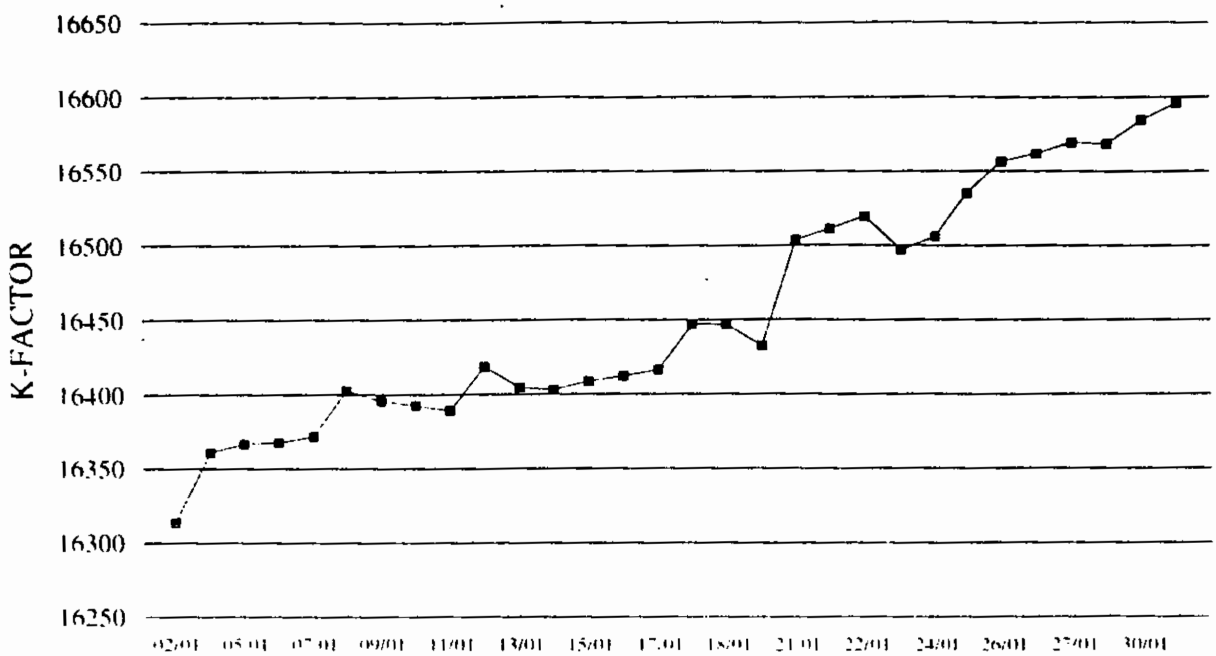

Fig. 8 Typical K-factor values as a function of time in a time period when scaling takes place and scale inhibitor is being used.

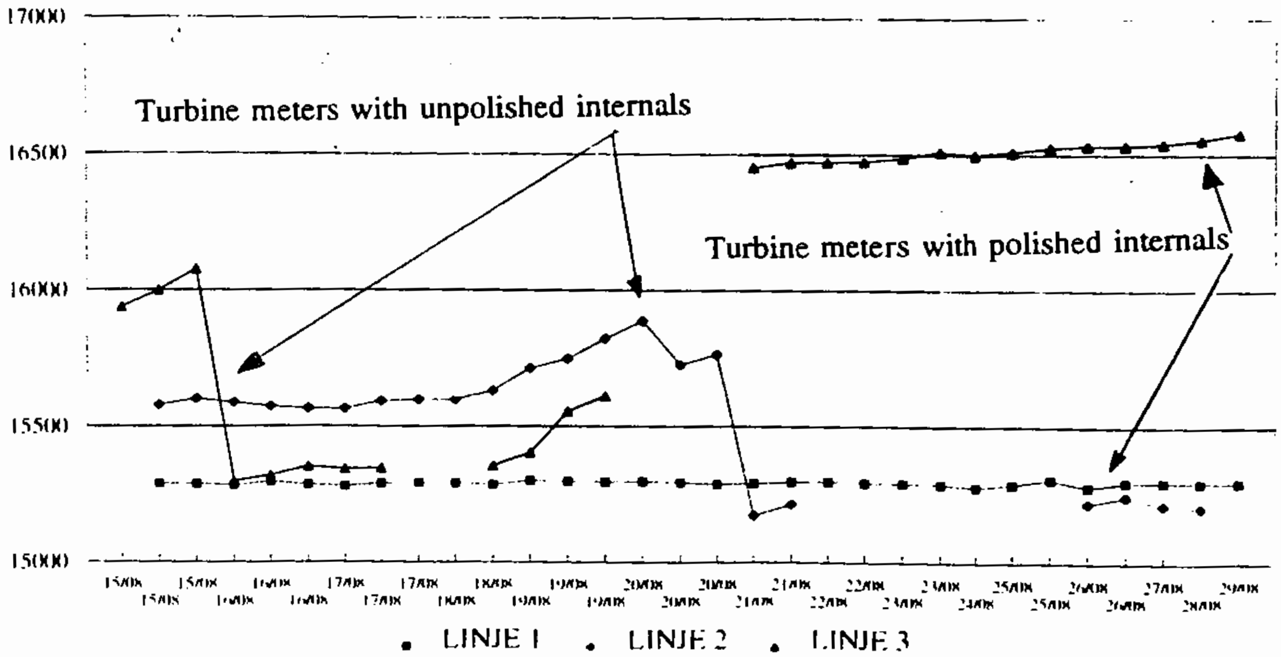

Fig. 9 K-factor values for turbine meters with and without polished internals.

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.