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QUALITY CONTROL & FISCAL METERING

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DESIGN PHILOSOPHY AND EXPERIENCE WITH QUALITY CONTROL SYSTEMS FOR FISCAL METERING STATIONS

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1 INTRODUCTION

The long-term aim of Norsk Hydro is to be able to purchase a self contained fiscal metering station, with a fully automated quality control system requiring a minimum of manual preventive maintenance, supervision and routines to operate reliably over long periods of time.

Norsk Hydro has for a number of years worked on improving the design of quality control systems for Fiscal Metering Stations both on existing and new oil installations in the North Sea.

This paper gives a review of the design philosophy and experience with Quality Control Systems for Fiscal Metering Stations, operated by Norsk Hydro. This paper will cover both a manual system for use on existing oil installations, and a fully automated system for new oil installations.

This paper also introduces a new design philosophy for a self-contained Fiscal Metering System not requiring external computer facilities and dedicated interface designs to be operable and maintainable.

The implementation of some of these concepts in the revised NORSOK standards for Fiscal Metering will also be covered.

The paper will conclude with recommendations for implementation of quality control systems for Fiscal Metering Stations.

2 BACKGROUND

Why do we need a better quality control system?

The author started working for Norsk Hydro in December 1992. During 1993 - 94 the following problem areas / challenges were identified within Norsk Hydro:

- Written operations and maintenance procedures were incomplete and difficult to follow.
- Preventive maintenance work descriptions were incomplete or lacking.
- Mix of experienced / inexperienced maintenance technicians on new and old installations.
- Each shift performed preventive maintenance differently on the same equipment, on all installations.
- A wide span of opinions and misconceptions on how to operate and maintain a fiscal metering station on all levels in the operational organisation.
- A very high percentage of measurement errors were due to preventive maintenance, see Table 1.
- Reduction in manning on installations with respect to operation and maintenance of fiscal metering stations. Multi disciplinary functions in stead of dedicated personnel.
- Constant manning onshore but an increase in number of installations over the next few years.

Table 1 - Cause of measurement errors in fiscal metering stations from September 1993 - September 1995.

Platform	Number of measurement errors	Errors due to equipment failure	Errors due to preventive maintenance	Average duration of measurement errors
A	40	25,00%	75,00%	39,54 days
B	19	36,84%	63,16%	79,03 days
C	33	66,67%	33,33%	28,87 days

Based on this it was concluded that a common basis for rational operation and maintenance of all fiscal metering stations operated by Norsk Hydro must be developed. This effort started in May 1993.

A common set of procedures was developed by August 1993 containing templates for check/calibration forms and templates for writing maintenance work descriptions. The maintenance work descriptions have an Actions-Details Format [1] see Fig 1, so both experienced and inexperienced technicians can use them.

Calibration check of temperature element {installation} WORK DESCRIPTION See check form in annex x.y		
GENERAL Calibration check of the temperature element is performed at operating temperature as a single point check. The temperature reference must comply with the criteria for a reference normal for temperature measurement, given in chapter z.x.		
	ACTIONS	DETAILS
_ **[1]**	Connect the normal for temperature measurement.	If you use a thermometer, it must stabilize for at least 4 minutes, after connection.
_ **[2]**	Write into form all data for equipment. Write down the temperatures, in °C, and calculate deviation.	Read value from flow computer and normal for temperature simultaneously.
_ **[3]**	If deviation is greater than ± 0,20 °C, change the temperature element and repeat the calibration check for the new element.	First check for faults and try to get deviation within acceptance limits.
_ **[4]**	Write in "Performed calibration check for temperature" in the logbook.	Write tag no., line/ position and sign.

Fig 1 Template for writing maintenance work descriptions.

The basic idea was to improve the quality of maintenance of fiscal metering stations by moving the effort from periodic maintenance of all equipment, 1 month interval is the requirement from the Norwegian Petroleum Directorate (NPD), to frequent maintenance of problem equipment and more infrequent maintenance of good equipment.

The study of the cause of measurement errors had revealed that the equipment failed, was damaged or was operated in the wrong way during preventive maintenance. Focus was put on developing a non-intervention maintenance philosophy leaving alone fully functioning equipment. **If it works don't fix it!**

The aim was to be both more effective and efficient, see Fig 2. To achieve that we had to completely rethink our approach on how to do maintenance. Unfortunately the words effective and efficient translates to the same word in Norwegian "effektiv" which despite the way it's written normally is perceived as "being more efficient". So we do the same as always only faster. Our conclusion is given in Fig 2. Better maintenance — less work. Turn from interval based to condition based preventive maintenance for fiscal metering stations.

2.1 Start at Oseberg C

At the same time, in November 1993, the maintenance technicians on the Oseberg C platform had started an improvement program. They were looking at test methods and procedures to increase / maintain the quality and at the same time reduce the use of resources on maintaining the fiscal measurement equipment (do the same as always only faster).

Norwegian translation

EFFECTIVE = Effektiv (Useful)

and

EFFICIENT = Effektiv (Skill level)

⇓

Do the right thing in a better and more rational way,

and not

Do the same as always only faster

⇓

For fiscal metering stations this imply :

From

Interval based preventive maintenance

⇓

To

Quality control using

CONDITION BASED PREVENTIVE MAINTENANCE

Fig 2 Quality control through condition based preventive maintenance.

Why not adopt the new ideas on this platform?

The Oseberg C platform agreed that they should serve as a pilot installation for developing the idea of quality control through condition based preventive maintenance. During the spring of 1994 we together defined the basis for a manual quality control system, improved the content of the preventive maintenance work descriptions and improved test methods.

In the summer of 1994 our EDP department started developing a database application for use in condition based preventive maintenance. This application enables the maintenance technician to verify the condition of the measurement equipment over time and to determine its condition against predefined quality criteria using long-term trend curves, see Fig 3.

Norsk Hydro's plan for implementation of an improved quality control system through condition based preventive maintenance was presented to NPD in a meeting 19.08.1994. Based on feedback from NPD the implementation on the Oseberg C platform started in September 1994.

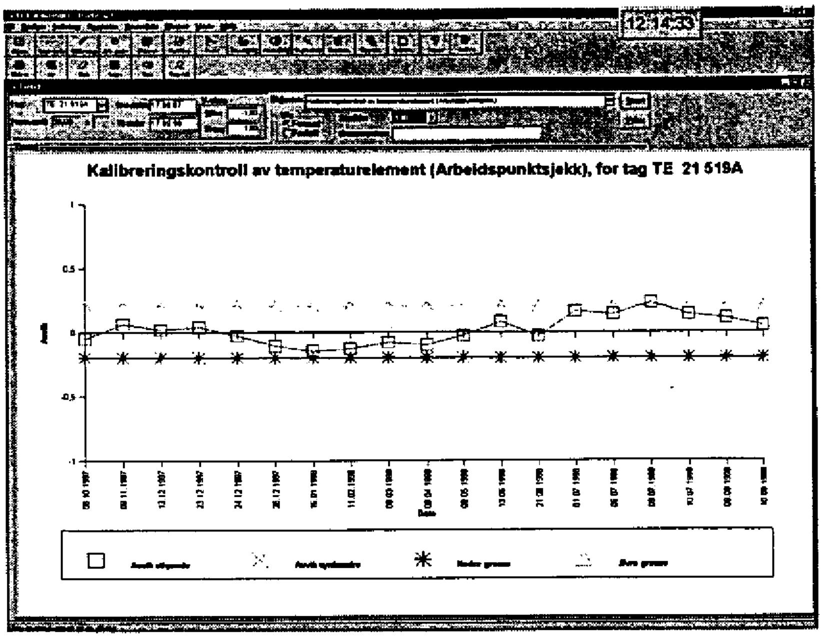
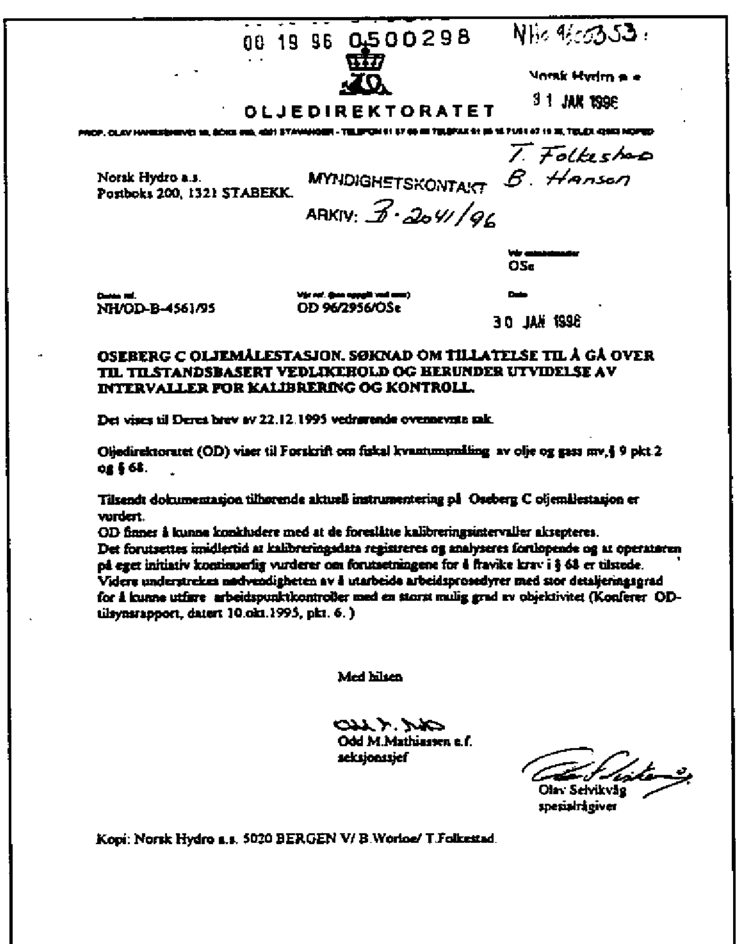


Fig 3 Screen shot showing trend curve function in database application.



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OLJEDIREKTORATET

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31 JAN 1996

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ARKIV: B-2041/96

OSe

NH/OD-B-4561/95

OD 96/2956/OSe

30 JAN 1996

OSEBERG C OLJEMÅLESTASJON. SØKNAD OM TILLATELSE TIL Å GÅ OVER TIL TILSTANDSBASERT VEDLIKEHOLD OG HERUNDER UTVIDELSE AV INTERVALLER FOR KALIBRERING OG KONTROLL.

Det vises til Deres brev av 22.12.1995 vedrørende ovennevnte sak.

Oljedirektoratet (OD) viser til Forskrift om fiskal kvantumsmåling av olje og gass mv,§ 9 pkt 2 og § 68.

Tilsendt dokumentasjon tilhørende aktuell instrumentering på Oseberg C oljemålestasjon er vurdert.
OD finner å kunne konkludere med at de foreslåtte kalibreringsintervaller aksepteres.
Det forutsettes imidlertid at kalibreringsdata registreres og analyseres fortløpende og at operatøren på eget initiativ kontinuerlig vurderer om forutsetningene for å fravike krav i § 68 er tilstede.
Videre understrekes nødvendigheten av å utarbeide arbeidsprosedyrer med stor detaljeringsgrad for å kunne utføre arbeidspunktkontroller med en størst mulig grad av objektivitet (Konferer OD-tilsynsrapport, datert 10.okt.1995, pkt. 6.)

Med hilsen

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Fig 4 Letter of approval from NPD for quality control through condition based preventive maintenance.

An application for approval was sent to NPD 22.12.1995 and approval was given 30.01.1996. As the first oil company in the Norwegian sector of the North Sea, Norsk Hydro had gained approval from the NPD for use of a quality control system through condition based preventive maintenance on fiscal metering stations, see Fig 4.

3 QUALITY CONTROL SYSTEM

The instrumentation in a fiscal metering station consists of a number of different types of sensors including flow sensors that transmit measured values to a flow computer via instrument loops. All these elements of the metering station must be calibrated and checked in a systematic way to ensure that given quality criteria / uncertainty limits are met.

Maintaining quality through condition based preventive maintenance and not using fixed intervals (1-month interval is the requirement from NPD), requires the identification of suitable conditions to verify and the definition of quality criteria for these conditions. Ideally if a condition always remains within acceptable quality limits, no maintenance is ever required for that equipment.

Condition monitoring can be divided into 3 practices:

1 *Automatic monitoring.* Fiscal metering stations with a minimum of 2 parallel meter runs in operation can be automatically monitored by comparing the same measured values on all meter runs in operation. The quality of this check is limited by the similarity in operating conditions that exists between meter runs in operation. Double instrumentation for the same measured value can be automatically compared and will give high quality condition monitoring.

2 *Daily quality check.* Manual check to compare across parallel meter runs and from day to day using trend curves. Gives lower quality condition monitoring.

3 *Single point check at operating conditions.* The operating conditions on our platforms are very stable and the operating range very small, for most measured values. A single point check at operating conditions is therefor a very god indication of the overall condition of the measurement sensor and will give a very high quality condition monitoring. This is the recommended practice and can be combined with practice no. 1 to give a fully automated quality control system.

Since the operating range is very small, for most measured values, sensors can be calibrated within a range just encompassing the operating range, giving increased measurement accuracy.

Single point check at operating conditions can be performed using several methods depending on the type of sensor and accessibility. Common to all these methods is the use of a measurement reference connected in parallel to the measurement sensor. The difference between the two single point measurements reveals the condition of the sensor. Slowly emerging errors can be detected as well using long-term trend curves.

Several methods for single point check at operating conditions, were evaluated for the Oseberg C platform:

a) *Temperature measurement — 3 possible methods*:

i) Reference temperature instrument in separate thermowell in close proximity to the temperature sensor to be checked. This will give a check of the temperature sensor as well as the instrument loop. This is a very accurate method.

ii) Double instrumentation using a double Pt-100 element mounted in the same thermowell as the temperature sensor to be checked. This will give a check of the temperature sensor as well as the instrument loop. This is the most accurate method because exactly the same operating condition applies to both measurements, and it can be automated by using a temperature transmitter for both elements.

iii) Comparison across 2 parallel meter runs in operation. This is the least accurate method because of the uncertainty in similarity in operating conditions for both measurements *b) Pressure measurement — 2 possible methods:*

i) Reference pressure instrument temporarily connected to the same pressure tapping point as pressure sensor to be checked. This will give a check of the pressure sensor as well as the instrument loop.

ii) Double instrumentation using a permanently mounted extra pressure sensor connected to the same pressure tapping point. This will give a check of the pressure sensor as well as the instrument loop. This can be automated.

c) Density measurement — 2 possible methods:

i) Manual spot sampling and simultaneous reading of measured value from density sensor. This can be a fairly accurate method for stabilised crude oil but difficult to use for gas and unstabilised crude oil. Not a very accurate method.

ii) Double instrumentation using two density sensors mounted in parallel or series. This is the most accurate method because almost exactly the same operating condition applies to both measurements, and it can be automated.

d) Differential pressure measurement:

i) No acceptable manual method was found so dp-transmitters must be calibrated periodically in a calibration laboratory.

ii) Double instrumentation using two dp-transmitters mounted in parallel. This is the most accurate method because almost exactly the same operating condition applies to both measurements, and it can be automated. This method requires averaging.

4 MANUAL QUALITY CONTROL THROUGH CONDITION BASED MAINTENANCE

A manual Quality Control System for Fiscal Metering Stations on existing installations in the North Sea operated by Norsk Hydro, was first developed at the Oseberg C platform. The design utilises manual Condition Based Maintenance to ensure the quality of measured fiscal quantities.

A comprehensive database application was developed along with detailed procedures to accomplish a high quality control system for Fiscal Metering Stations. The reduction in man-hours spent on preventive maintenance has been significant, at least 25%. Also a significant reduction has been achieved in measurement errors introduced during preventive maintenance along with the reduction in the work involved in correcting these errors. The overall result is a more reliable metering station.

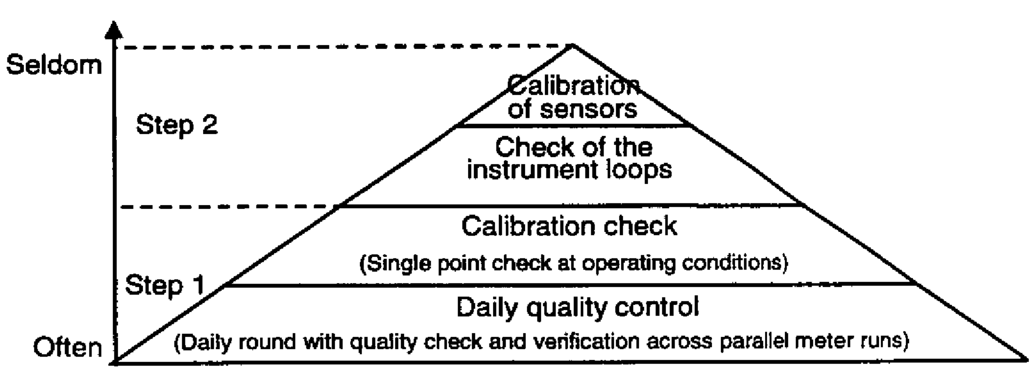

Fig 5 Quality control using manual condition based preventive maintenance. A two-step process.

Manual Condition Based Maintenance is a two-step process consisting of preventive and corrective maintenance see Fig 5 and 6.

Step 1, preventive maintenance, consists of daily quality control and calibration check.
Step 2, corrective maintenance, consists of check of the instrument loops and calibration of sensors.

Step 1 is performed regularly. Only on indication of error will step 2 be performed. NPD requires still that step 2 shall be performed at fixed intervals, but now with much longer intervals (at least 1 year).

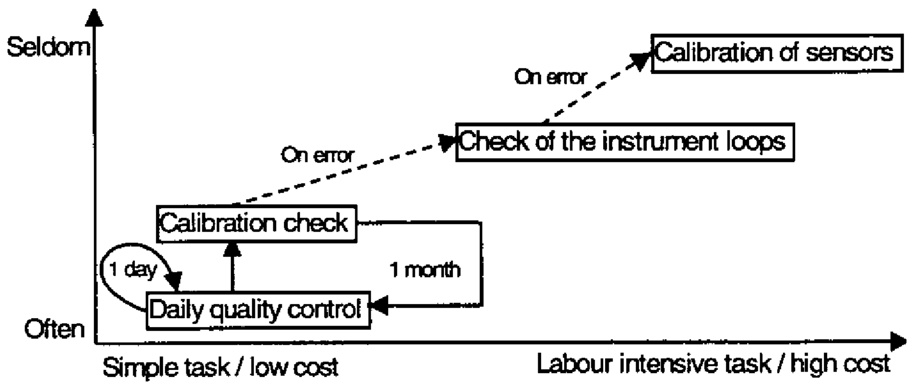

Fig 6 Quality control using manual condition based preventive maintenance. Part of preventive maintenance redefined as corrective maintenance.

All activities relating to condition based preventive maintenance, are registered in the database application, see Fig 3. This database application calculates deviations and enables the maintenance technician to graphically trend the condition of the measurement sensor. This is important in order to follow the development in condition over time and to be able to reveal tendencies of drift or failure in the sensors, as early as possible.

5 AUTOMATED QUALITY CONTROL THROUGH CONDITION BASED MAINTENANCE

A fully automated Quality Control System for Fiscal Metering Stations on new installations in the North Sea operated by Norsk Hydro, was first developed for the Visund platform, to be put in operation in the autumn 1998. The design utilises fully automated Condition Based Maintenance to ensure the quality of measured fiscal quantities.

A comprehensive functional design specification for design of both novel and conventional metering stations has been developed since 1996 to accomplish a high performance fully automated quality control system for Fiscal Metering Stations. The functional design specification has been developed in co-operation with Kongsberg Offshore (KOS) the frame agreement supplier of fiscal metering stations for Norsk Hydro. The key design features are to use double instrumentation in each measurement point wherever applicable as well as utilising the computer resources to perform automatic monitoring of critical functions and automatic verification and calibration of flow elements. The man-hours spent on operation and preventive maintenance will be reduced by at least 80% and the measurement errors introduced during preventive maintenance will be almost eliminated. A significant reduction in Life-cycle-cost for a metering station will be achieved. The overall result will be a considerably more reliable metering station.

The payback period will be less than 1 year after start of operation, for the investment in a fully automated quality Control System for the Fiscal Metering Stations on the Visund platform.

Fully automated Condition Based Maintenance is like the manual version also a two-step process consisting of preventive and corrective maintenance.

Step 1, preventive maintenance, consists of quality control and calibration check and is performed automatically by the Metering station database computer.
Step 2, corrective maintenance, consists of check of the instrument loops and calibration of sensors.

Step 1 is performed automatically. Only on indication of error will step 2 be performed. NPD requires (letter to all operators dated 18.11.1997) that step 2 shall be performed at fixed intervals, but now with much longer intervals (tentatively set to 3 years). Since all instrument loops are digital communication (HART) loops, loop checks are performed only on indication of error.

The fiscal metering stations are prepared through design for fully automated condition based maintenance. This includes the possibility to automatically verify the condition of every measured parameter in the metering station, like pressure, temperature, density, flow values (flow rate, K-factors, "health check" in ultrasonic meters) measured level in sample container (compared to predicted level and accumulated production in the sampling period) and so on. Verification of current condition is done using double instrumentation and without intervention in mounted equipment.

The Metering station database computer can store and trend any measured parameter or condition. A quality report can be generated automatically, or on request. Each condition in the quality report is verified against predefined quality criteria and has an alarm function. See Fig 7a-c for an example of a quality report from the KOS database computer for the oil metering station on the Visund platform. The alarm function is active on a continuous basis (every 10 seconds all conditions are verified) and gives an alarm to the process operator.

```
------------------------------------------------------------------------------
1998/06/15  00:01          Visund Oil Metering Station              KOS FCM 212
                                 QUALITY REPORT                     Page 1 of 3
------------------------------------------------------------------------------

LINE STATUS :

Line No          Status
----------------------
   1     !       CLOSED
   2     !         OPEN
   3     !         OPEN
----------------------

CURRENT PRESSURE :

               Pressure A  Pressure B   Pressure
                Measured    Measured    Deviation   Alarm
Line No          bar g       bar g        bar       Status            Mode
---------------------------------------------------------------------------
   1     !       8.00        8.01        0.01                    MEASURED A
   2     !       8.00        8.01        0.01                    MEASURED A
   3     !       8.00        8.01        0.01                    MEASURED A
---------------------------------------------------------------------------

Pressure deviation between open lines :  0.00       OFF

CURRENT TEMPERATURE :

                 Temp. A      Temp. B    Temperature
                Measured     Measured     Deviation   Alarm
Line No           Deg C        Deg C        Deg C     Status          Mode
---------------------------------------------------------------------------
   1     !       50.00        49.99        0.01                  MEASURED A
   2     !       50.00        49.99        0.01                  MEASURED A
   3     !       50.00        49.99        0.01                  MEASURED A
---------------------------------------------------------------------------

Temp. deviation between open lines :     0.00       OFF

CURRENT DENSITY :

                 Dens. A      Dens. B      Density
                Measured     Measured     Deviation   Alarm
Line No           kg/m3        kg/m3        kg/m3     Status          Mode
---------------------------------------------------------------------------
   1     !       807.45       821.45       14.00       HIGH     DENSITOM.A
   2     !       807.45       821.45       14.00       HIGH     DENSITOM.A
   3     !       807.45       821.45       14.00       HIGH     DENSITOM.A
---------------------------------------------------------------------------

Density deviation between open lines :   0.00       OFF
```

Fig 7a Quality control report, page 1.

1998/06/15 00:01 Visund Oil Metering Station KOS FCM 212
QUALITY REPORT Page 2 of 3

CURRENT DENSITY PRESSURE :

Line No	Pressure A Measured bar g	Pressure B Measured bar g	Pressure Deviation bar	Alarm Status	Mode
1 !					MEASURED A
2 !					MEASURED A
3 !					MEASURED A
Common !	8.01	8.02	0.01		

CURRENT DENSITY TEMPERATURE :

Line No	Temp. A Measured Deg C	Temp. B Measured Deg C	Temperature Deviation Deg C	Alarm Status	Mode
1 !				HIGH	MEASURED A
2 !				HIGH	MEASURED A
3 !				HIGH	MEASURED A
Common !	50.01	49.89	0.12		

CURRENT PROVER PRESSURE :

	Pressure A Measured bar g	Pressure B Measured bar g	Pressure Deviation bar	Alarm Status	Mode
Inlet !	8.00	8.01	0.01		MEASURED A
Outlet !	8.10	8.09	0.01		MEASURED A

CURRENT PROVER TEMPERATURE :

	Temp. A Measured Deg C	Temp. B Measured Deg C	Temperature Deviation Deg C	Alarm Status	Mode
Inlet !	49.89	49.87	0.02		MEASURED A
Outlet !	49.80	49.81	0.01		MEASURED A

Fig 7b Quality control report, page 2.

1998/06/15 00:01 Visund Oil Metering Station KOS FCM 212
QUALITY REPORT Page 3 of 3

PROVER :

Line No	Previous Calibration	Hours since Previous Calibration
1 !	1998/06/14 21:05	3
2 !	1998/06/14 21:15	3
3 !	1998/06/14 21:35	3

CURRENT FLOW RATES :

Line No	Mass Flow tonne/h	ActVolume Flow m3/h	Std. Volume Flow Sm3/h
1 !	0.000	0.000	0.000
2 !	414.914	515.103	499.317
3 !	423.021	516.351	500.396
Station !	837.935	1031.454	999.713

SAMPLER :

	Production since start of sampling Sm3	Calculated level %	Actual level %	Deviation %
(A) Daily !	999.7	76	72	-4
(B) Monthly !	13926.3	37	35	-3

STANDARD DENSITY :

Line No	Density Measured kg/Sm3	Density from Lab kg/Sm3	Density Deviation kg/Sm3
1 !	830.96	845.01	14.05
2 !	830.96	845.01	14.05
3 !	830.96	845.01	14.05

Fig 7c Quality control report, page 3.

There is also a function for automatic proving of turbine meters with long term statistical check of K-factor. New K-factors will be automatically accepted after comparison with a standard K-factor (average of earlier accepted K-factors or fixed) and predefined acceptance limits of variation. The process operator will only be involved if the K-factor is outside the acceptance limits.

The critical valves in the fiscal metering station have automatic leakage detection.

The following figure illustrates how a fiscal oil metering station can be instrumented for fully automated quality control, see Fig 8.

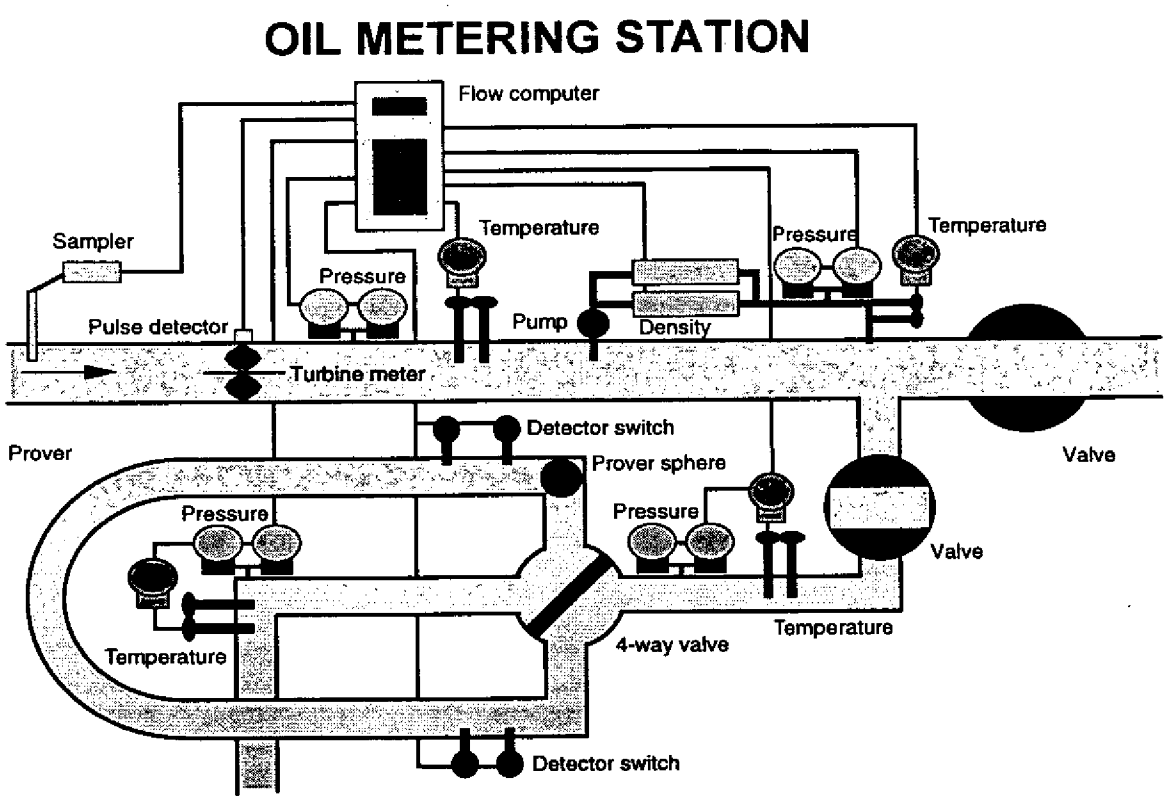

Fig 8 Typical oil metering station with instrumentation for fully automated quality control.

6 SELF CONTAINED FISCAL METERING STATION

Norsk Hydro would like to introduce a design philosophy for a self contained fiscal metering station not requiring external computer facilities and dedicated interface designs. Within this concept the Metering station database computer will communicate with the overall control system and other external computer systems via standard interfaces e.g. X-windows, see Fig 9 and 10.

A lot of effort is normally put into defining, designing and checking these various interfaces between computers. Dedicated programs need to be written to handle the data and commands transmitted over these interfaces as well, and identical screen pages have to be built on separate computers displaying the data and commands. We suggest a future solution were all these interfaces are practically obsolete, see Fig 10, where all other systems log onto the metering station database computer as a server. DISCOS is the Distributed Supervisory Control and Safety system while OPIS is the Oil Production Information System in Fig 9 and 10.

In order to achieve this the Metering station database computer will need increased storage capacity and functionality currently found in add-on programs on external computers.

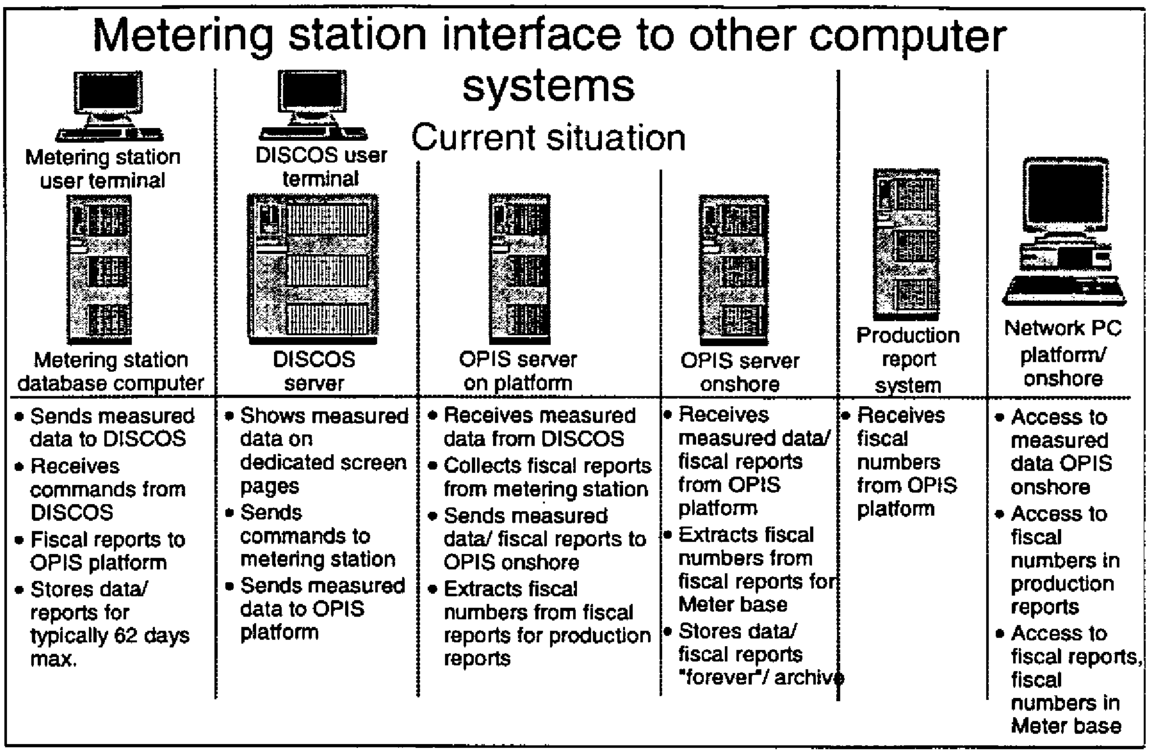

Fig 9 Current situation. A fiscal metering station dependant on external computer facilities to be operated and maintained.

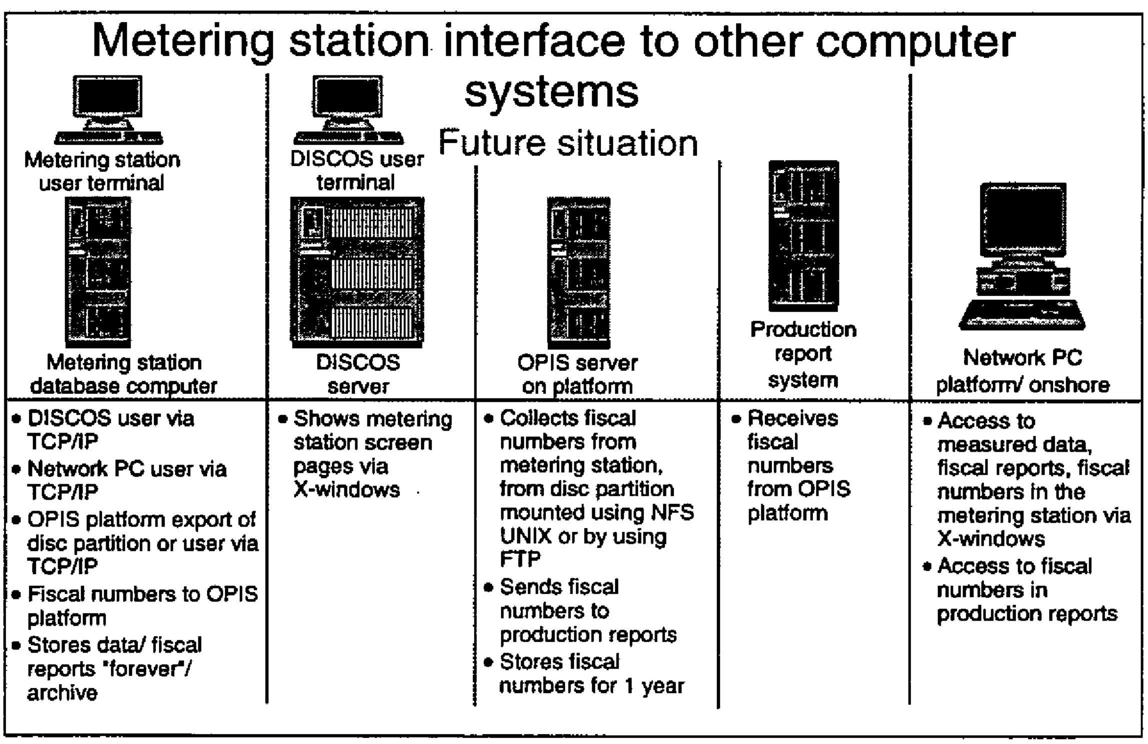

Fig 10 Future situation. A self contained fiscal metering station.

7 NORSOK STANDARDS

Some of the concepts mentioned in this paper have been included in the revised NORSOK standards for fiscal metering, see Fig 11.

NORSOK STANDARD

FISCAL MEASUREMENT SYSTEMS FOR HYDROCARBON GAS

I-104
Rev. 2, June 1998

NORSOK STANDARD

FISCAL MEASUREMENT SYSTEMS FOR HYDROCARBON LIQUID

I-105
Rev. 2, June 1998

Fig 11 Titles of the revised Norsok standards.

The requirements for an automated quality control system are given in Chapter 4 and 5 of the revised NORSOK standards, see Fig 12, while the detailed requirements are given in Annex A, see Fig 13.

4 GENERAL REQUIREMENTS

4.1 General

The measurement system which fulfils the functional and technical requirements and has the lowest life cycle cost shall be selected.

5.1.7 Maintenance Requirements

5.1.7.1 General

The field instrumentation should be chosen to ensure long maintenance and calibration intervals.

The maintenance requirements for automated condition based maintenance in Annex A shall apply. In addition, it should be easy to retrofit the instruments and flow elements for maintenance.

Fig 12 Text sections from the revised Norsok standards requiring an automated quality control system.

ANNEX A REQUIREMENTS FOR AUTOMATED CONDITION BASED MAINTENANCE (NORMATIVE)

A.1 General

The fiscal measurement station shall be designed for fully automated condition based maintenance. This includes the ability to automatically verify the current condition of all measured field tags that are of importance to the integrity of the fiscal measurement station. These field tags are typically pressure, temperature, density, differential pressure, flow values (turbine meter k-factor, ultrasonic meter values), level in sampling container (compared to calculated level) etc.

This verification of current condition shall preferably be carried out using calibrated reference meters. The condition based monitoring may however also be carried out using duplicated equipment or by any other relevant method.

Where possible comparative monitoring of parallel meter runs shall be carried out, i.e. when two or more meter runs are operating concurrently.

A.2 Software requirements

The software shall be prepared for easy and reliable verification of the accuracy of each independent program routine and totalization. The computer under test must measure the duration of the accuracy tests, when the duration of the accuracy tests is influencing the estimated values.

The measured field tags and parameters indicating the condition of each field tag i.e. deviations from reference values, shall be stored and trended graphically. Additionally, a current condition report shall be generated at predefined times or on demand. The current condition report shall include comparisons against predefined limits of deviation for each parameter, and a written alarm shall be given in the report, if any limit is exceeded. Generally, a verification of current condition shall not include any manual interference with the measurement equipment or computers. The current condition report may be combined with the report of the daily status of the measurement system. The fiscal measurement reports shall not be combined with the current condition report.

In a turbine meter station with prover, a function for automatic turbine meter calibration combined with statistical evaluation of previous K-factors, shall be implemented: It shall be possible for a new K-factor to be automatically accepted by comparison with the statistical K-factor (e.g. average of the last 30 accepted K-factors) and predefined limits for acceptance. Manual acceptance shall be invoked if the new K-factor exceed acceptance limits. It shall be possible to select a mode where a fixed K-factor is used in stead of the statistical K-factor.

Fig 13 Annex from the revised Norsok standards defining an automated quality control system.

8 CONCLUSION

New installations must be prepared for fully automated quality control through proper design choices. To implement this after start of operation or use a manual quality control system is not cost effective and very time consuming.

On existing installations a manual quality control system will often be the only option due to limitations in installed equipment. However, it can be a good investment to upgrade to a fully automated quality control system, but the payback period will be several years.

Norsk Hydro's current policy is that all new or modified metering stations shall be prepared for fully automated quality control and that all existing metering stations shall be prepared for manual quality control through condition based preventive maintenance.

As pointed out in the introduction Norsk Hydro wishes to be able to purchase a self contained fiscal metering station, with a fully automated quality control system requiring a minimum of manual preventive maintenance, supervision and routines to operate reliably. You the designers think of designing them to send into orbit if you like, but remember we don't have a NASA budget. We need a cost effective solution utilising currently available technology to its fullest potential.

9 REFERENCES

[1] Douglas Wieringa et al., "Procedure Writing. Principles and Practices," IEEE Press 1993.