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Norwegian
Society of
Chartered Engineers

NORTH SEA FLOW MEASUREMENT WORKSHOP

OCTOBER 22. - 24. 1991
SOLSTRAND FJORD HOTEL, BERGEN - NORWAY

FIELD EXPERIENCE WITH CORIOLIS MASS METER ON HYDROCARBON LIQUID

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HYDRO

FIELD EXPERIENCE WITH CORIOLIS MASS METER ON HYDROCARBON LIQUID

Sveinung Myhr
Norsk Hydro a.s. Rafnes

0. SUMMARY

At Norsk Hydro's petrochemical plant at Rafnes, we have used Coriolis mass meters, for custody transfer metering of hydrocarbon liquid, for nearly 2 years.

The Coriolis meters are installed in series with a turbine meter in three different metering stations.

During the time of operation we have found that the Coriolis meters show about 1 % lower readings than the turbine meters. This is also proved from in situ calibration of a Coriolis meter.

The linearity of the Coriolis meters was found to be within ± 0.2 % when the flowrate was above 10 % of the sensor maximum flowrate. Below this limit the meters tends to drop off. In addition to the observed offset, this necessitate an in situ calibration of the Coriolis meter at operating condition.

Eccept from the above mentioned, the Coriolis meters have shown stable performance, and there have not been any operational problems with them.

CONTENTS

1. INTRODUCTION

Hydro Rafnes petrochemical facility lies in the southeastern part of Norway, about 200 km from Oslo.

The facility consist of three different plants, one ethylene plant, one vinyl chloride plant and one chlorine plant.
The ethylene plant has an annual production of 420 000 tons of ethylene and 80 000 tons of propylene. The raw material is NGL, shipped to Rafnes mainly from Teesside.
The VCM plant has an annual production of 480 000 tons of vinyl chloride monomer (VCM). The raw material is ethylene and chlorine. The major part of the chlorine is produced in the chlorine plant at the facility. This plant has an annual production of 130 000 tons of chlorine, and 142 000 tons of sodium hydroxide (NaOH) as a by-product.

There are about 700 employees at Hydro Rafnes.

The three Coriolis installations which are refered to in this paper are all installed in the ethylene plant.

2. METERING STATIONS

At Hydro Rafnes we have three installations with Coriolis mass meters on hydrocarbon liquid for custody transfer metering. There are two metering stations on propane and one on propylene.

The three metering stations are constructed as shown in fig. no. 1. Meter A is a turbine meter, and a density meter, which in combination with the turbine gives the mass reading from this meter. Meter B is a Coriolis meter. The two meters are connected directly in series, and the mass reading from the two meters can then be compared to each other. A compact prover can be connected to the metering station upstreem meter A, in order to calibrate the meters in situ at operating conditions.

3. METERING RESULTS

Metering Station no 1.

Operating condition:

Medium: Propane
Temperature: 10 - 15 °C.
Pressure: 15 bara.
Density: 520 - 540 kg/m³.

The Coriolis meter in this metering station has been in operation since November 1989. The meter was installed with the origional meter factor from the water calibration at the factory.
The turbine meter was last calibrated in-line by the compact prover in February 1988, and was not recalibrated until November 1990.
During the first year of operation, the relative deviation between the two meters was within ± 0.5 %. After recalibration of the turbine meter in November 1990 we found a shift of 1 % in the meter factor. We did not calibrate the Coriolis meter at this time, and after adjusting the turbine meter factor, the readings from the Coriolis meter was now systematically 1 % lower than the turbine meter. The long term repeatability and the linearity of the Coriolis meter seemed however to be quite good. (See diagram no. 2).

Metering Station no 2.

Operating condition:

Medium: Propylene
Temperatur: 25 - 30 °C.
Pressure: 20 - 30 bara.
Density: 500 - 520 kg/m³.

The Coriolis meter was installed in February 1990. The origional meter factor from the water calibration at the factory was used. For the first month of operation the relative deviation between the turbine meter and the Coriolis meter was within ± 0.2 %. The turbine was last calibrated in December 1989. After recalibration of the turbine meter in March 1990, the meter factor shifted 1 %. The readings from the Coriolis meter was now systematically 1 % lower then from the turbine meter. The long term repeatability and the linearity has been quite good for this Coriolis meter too. (See diagram no. 3).

Metering Station no 3.

Operating condition:

Medium: Propane
Temperature: 20 °C.
Pressure: 75 bara.
Density: 525 – 550 kg/m^3.

This is our latest installation of Coriolis meter. It has been in operation since May 1991. Also for this meter we have used the original meter factor from the water calibration.
The turbine meter at the time of installation of the Coriolis meter was last calibrated by the prover in January 1988. During the first two months of operation, the Coriolis meter showed systematically 2 % lower readings then the turbine meter. In August 1991 we replaced the turbine meter. This meter was overhauled and calibrated with water in our calibration lab. The relative deviation of the Coriolis meter in proportion to the turbine meter was after this time – 1.5 %. (Fig. no. 4).
We have not been able to calibrate this turbine meter in-line with the prover yet, due to some operational problems in the plant. As for the two other Coriolis meters, the offset in proportion to the turbine meter has been stable, and the long term repeatability and linearity seem to be good.

4. CALIBRATION RESULTS

As mentioned above, the Coriolis meters were installed by using the origional meter factor from the water calibration. It was two reasons for this. Firstly, we were not sure how to calibrate these meters in situ because there were no international recommendation regarding this, and secondly, we wanted to collect metering data to see how the Coriolis meters perform in proportion to the turbine meters.

We have however calibrated the Coriolis meter in the propylene metering station lately, by using the master meter method. We used the turbine meter in the metering station in series with the Coriolis as the master meter.
The flowrate was varied from 5 to 30 m^3/h, that means 2.5 – 15 t/h. This represent 3 – 20 % of the sensor maximum capasity. The pressure varied from 20 bara by minimum flowrate to 27 bara by maximum flowrate.
First we calibrated the turbine meter by the compact prover, to find the

meter factor at the actual flowrate. Then we reprogrammed this new meter factor into the prover computer and the turbine meter flowcomputer. Simultanious readings were taken from the two meters over a period of time, for each flowrate. To keep the unsertainty of the readings at approximately 0.1 %, we found that we had to displace about 8.5 tonns through the meters during the test period. This was also chosen under consideration of the available time for the whole calibration operation.
During the complete test period the Coriolis meter was calibrated against the turbine meter, the turbine meter was calibrated by the prover, to keep the meter factor under control. Over the whole flowrange the repeatability for the turbine meter was better than 0.03 % (Fig. no. 5).

As mentioned earlier, we used the origional meter factor from the factory calibration with water for the Coriolis meter. The meter was then calibrated over a range of 2.5 - 25 t/h. (Fig. no. 6).

From the master meter calibration we found that the Coriolis meter showed 1 % lower readings than the master meter in the range of 7 - 15 t/h. This is the same offset that we have experienced during normal operation with the Coriolis meter.
Below 7 t/h the error in proportion to the master meter increased, and at 2.5 t/h the reading from the Coriolis meter was 2.5 % lower than the master meter. (Fig. no. 7).

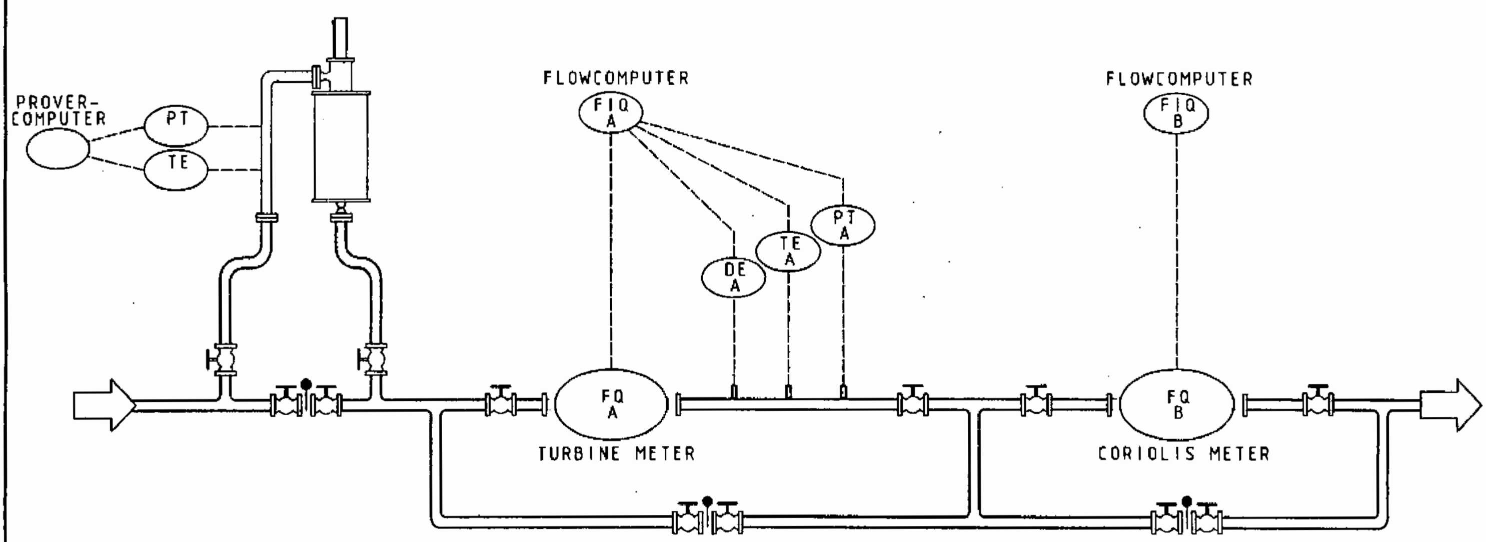
5. CONCLUSION

What has been told earlier, that the Coriolis meters are to a very small degree sensitive to changes in pressure, density and viscosity, and that a calibration with water in a calibration lab can be transfered to an installation on "any" fluid, do not seem to be the fact in the "real life".

Our experience is that the Coriolis meters also have to be calibrated in situ with the actual medium at operating conditions to get control over the systematic error.
The linearity of a Coriolis meter in an actual installation is not as good as from a water calibration of the sensor. This could be due to pressure effects and installation effects. The meter accuracy tends to drop off when the flowrate is below 10 % of the sensor maximum flowrate.
Abow this limit, the linearity of the Coriolis meter has proven to be within the specification of ± 0.2 %.

6. LIST OF FIGURES

Fig. no 1



METERING STATION WITH CORIOLIS MASSMETER

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d:\hcl\ustn\dgn\i_sva01.dgn Sep. 23, 1991 12.24.32

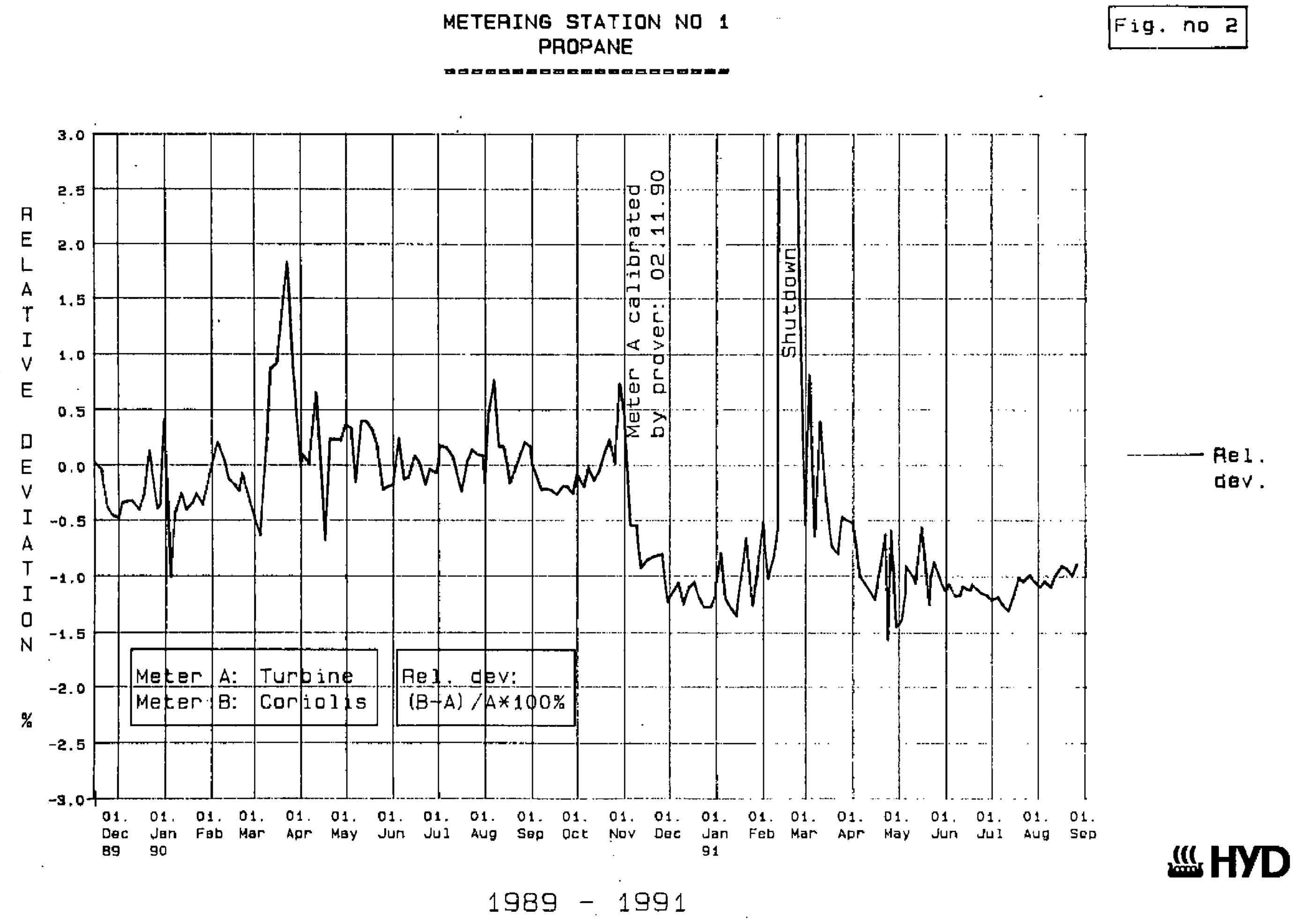
METERING STATION NO 1
PROPANE
Fig. no 2
RELATIVE DEVIATION %
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Meter A calibrated by prover: 02.11.90
Shutdown
Meter A: Turbine
Meter B: Coriolis
Rel. dev:
(B-A)/A*100%
Rel. dev.
01. Dec 89
01. Jan 90
01. Feb
01. Mar
01. Apr
01. May
01. Jun
01. Jul
01. Aug
01. Sep
01. Oct
01. Nov
01. Dec
01. Jan 91
01. Feb
01. Mar
01. Apr
01. May
01. Jun
01. Jul
01. Aug
01. Sep
1989 - 1991
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Fig no 3

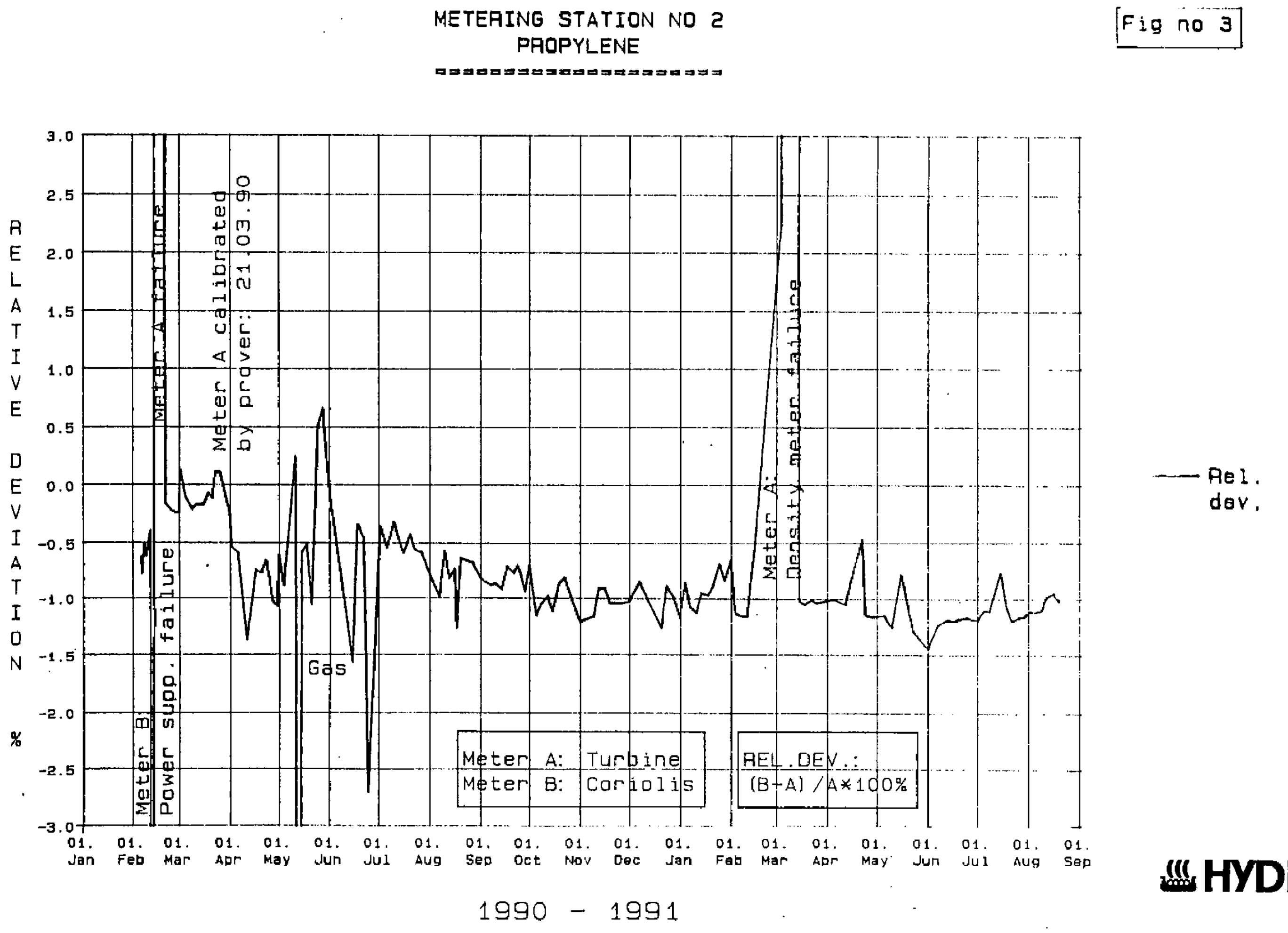

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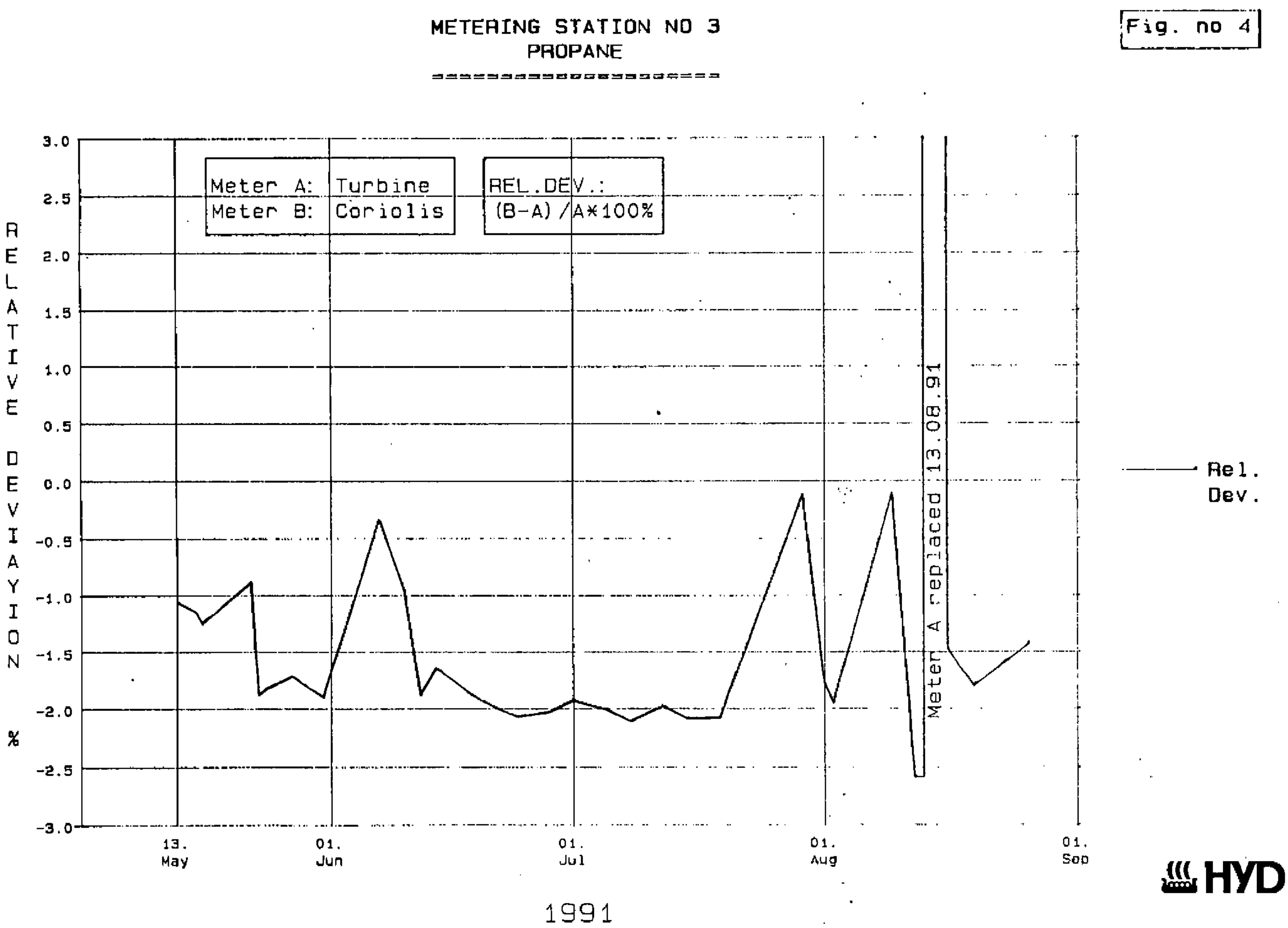
Fig. no 4



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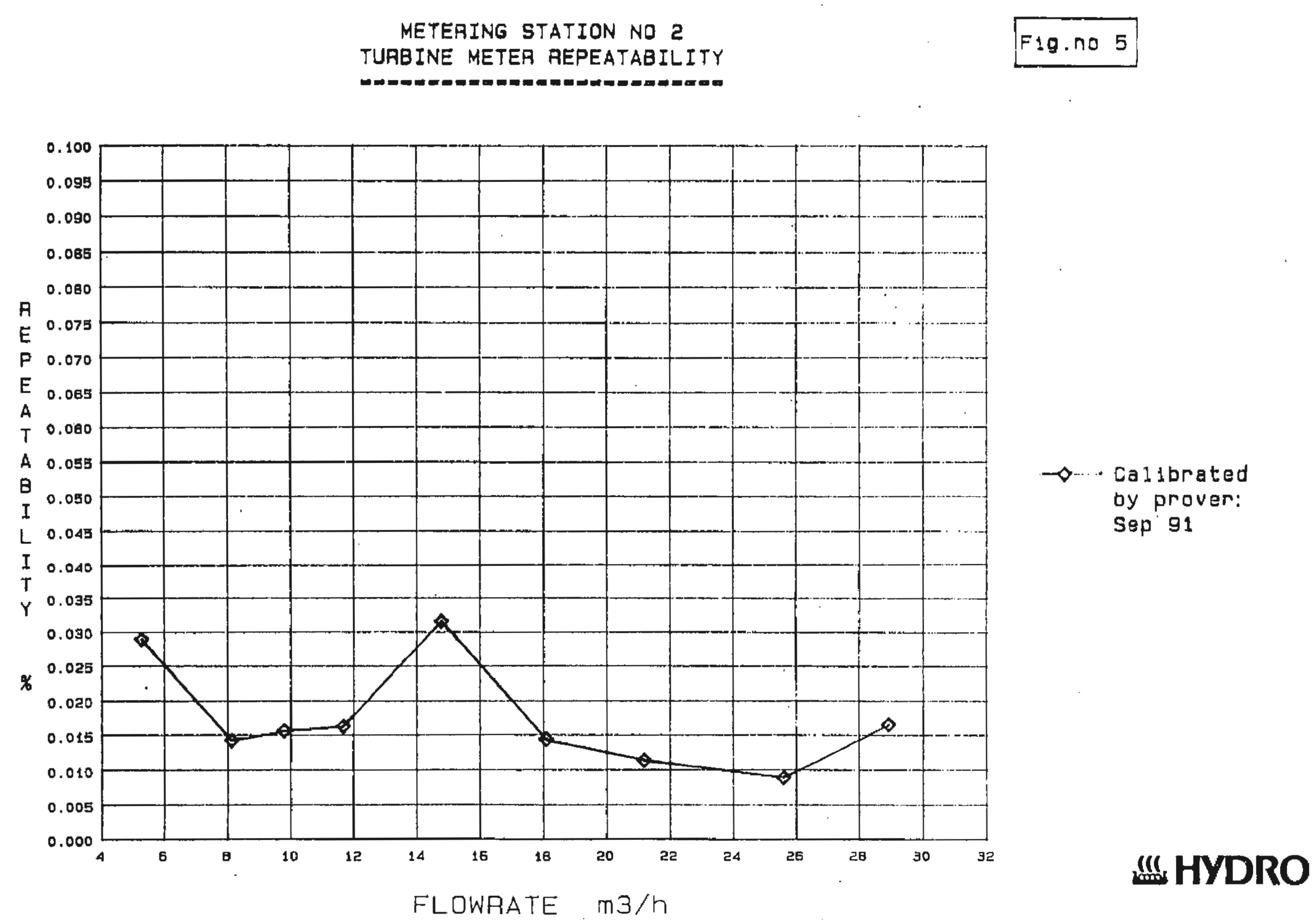
METERING STATION NO 2
TURBINE METER REPEATABILITY
Fig.no 5
REPEATABILITY %
0.100
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
FLOWRATE m3/h
Calibrated by prover: Sep 91
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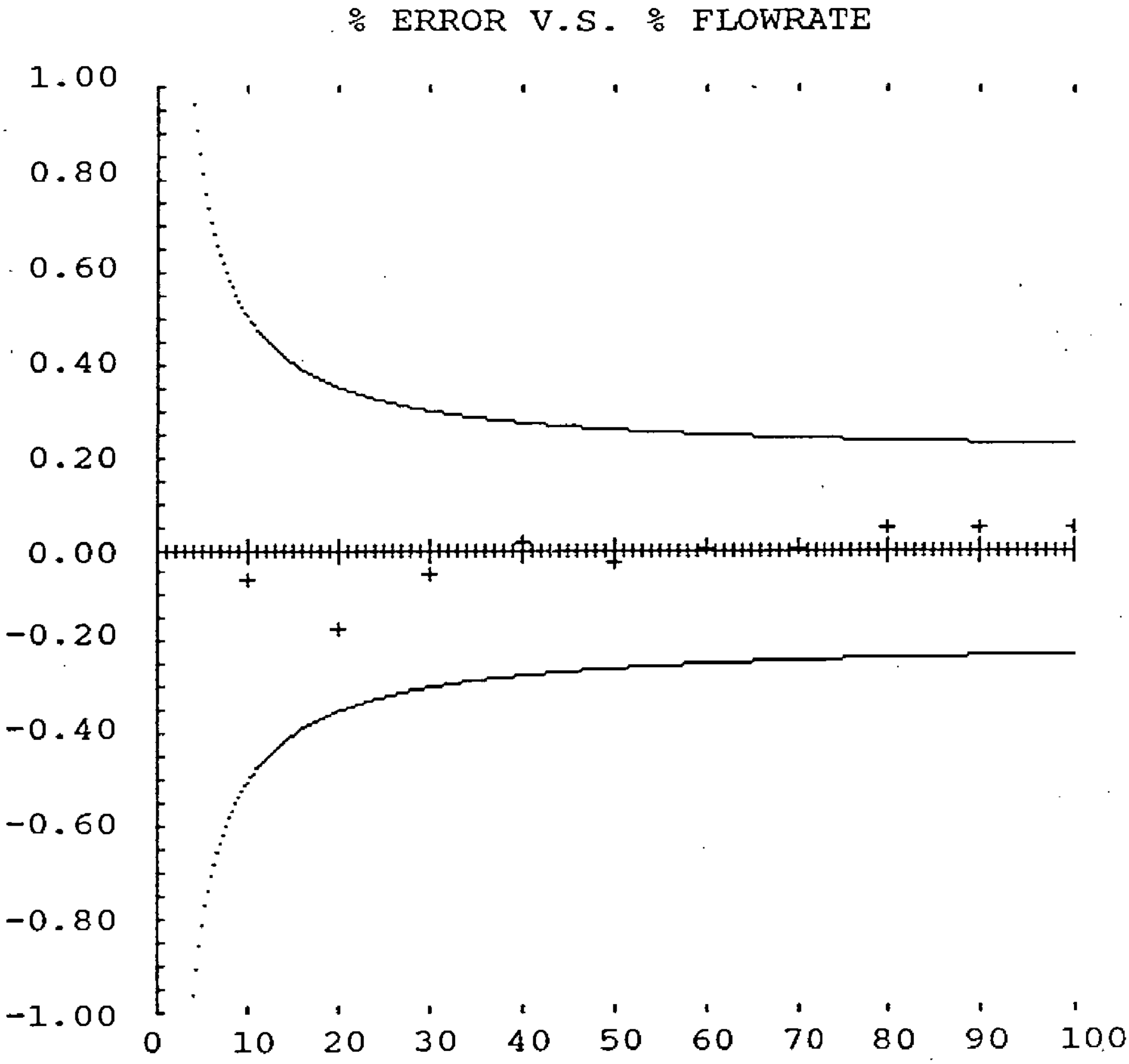
Fig. no 6

CALIBRATION DATA SHEET



HORIZONTAL AXIS : % OF FLOW
VERTICAL AXIS : % ERROR

CUSTOMER REFERENCE : AI 275
SERIAL NUMBER : 225490
100 % FLOW : 25 t/hr
DATE : 89- 8-28

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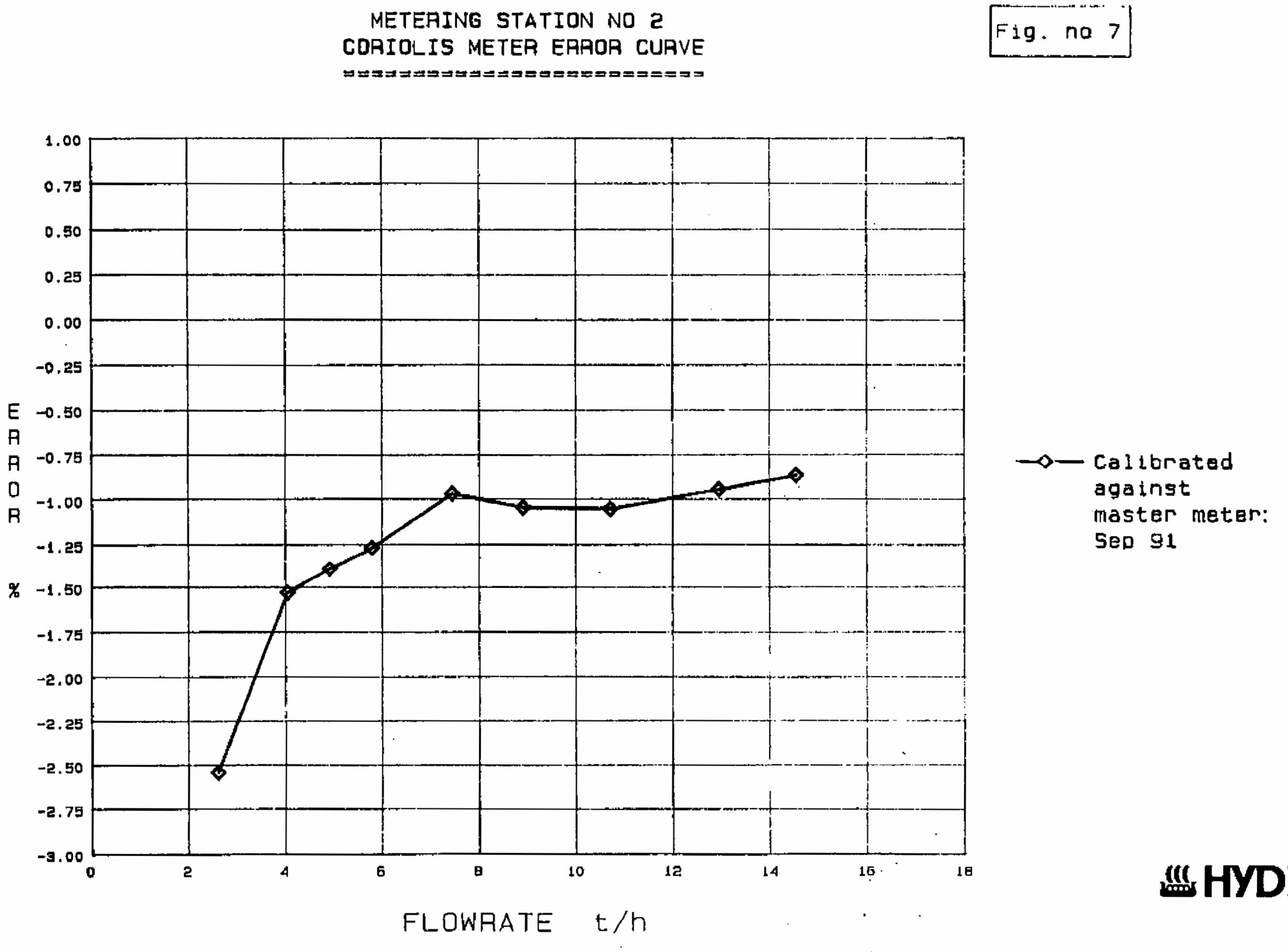
Fig. no 7



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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.