FIELD EXPERIENCE USING CORIOLIS MASS METERS - 11

by

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FIELD EXPERIENCE USING CORIOLIS MASS METERS
PART II

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I REASONS FOR INSTALLATION

On the Ninian Central Platform, operated by Chevron Petroleum (UK) Limited, part of the hydrocarbon production is available as liquified petroleum gas (L.P.G.) which is injected (i.e. spiked) into the main oil production after the fiscal metering system. This LPG stream can amount to about 800 tonnes per day which is up to 5% of the total production from the platform. The LPG production is gradually declining both as a flow rate and as a percentage of the whole.

As the platform was originally designed and built, the LPG was measured by means of an orifice plate with high and low range differential pressure transducers, an insertion type density meter and an analogue style flow computer-totaliser. When the platform changed from exporting 'dead' crude oil to the export of 'live' and 'spiked' crude oil, it was recognised that there was a need to upgrade the accuracy of the LPG measurement. A new system was installed for measuring LPG using 3" Kent type PMF turbine flow meters, high pressure Solartron type 7830 density meters with all these inputs combined together and integrated to measure mass flow by means of a Spectra-tek Model 869M flow computer.

As the quantity of LPG was small in proportion to the production of crude oil, and because the LPG had to be measured at high pressure (60 bar or possibly higher) the routine calibration of the turbine and density meters was performed by sending the turbine meters to the proving facilities at the Sullom Voe Terminal, and by sending the density meters back to the manufacturer or his agent. The flow meters were checked at approximately three monthly intervals and their repeatability has been very good. The only cause of any significant errors has been the deposition of a thin layer of sticky material usually thought to be mercaptans but these only occur very rarely and can be washed away quite easily with the appropriate solvent.

However, the LPG metering set-up has neither been provided with its own built-in proving system nor provided with duplicate densitometers to catch any short-term variations in performance. It was estimated that such a system would cost about £250,000 to install and could introduce additional safety problems. After discussion with the Gas and Oil Measurement Branch of the Department of Energy, it was agreed that some means of checking the short-term performance of the turbine meter and densitometer system was required, which would not be subject to any common-mode errors with the existing system.

It was found that a Coriolis style mass flow meter could be installed for about £40,000. By putting one of these new meters in series with the existing metering system it was considered that a completely independent cross-check could be made, because there was no fault condition that could be expected to cause equal errors in both meters (except co-incident power failure).

II CHOICE OF METER

At the time when the new Coriolis type of meter was needed there were only two different manufacturers offering suitable models on the market. We were assured that both manufacturers could comply with our specifications and certification requirements, and could also provide calibration documentation that was traceable to NBS standards. Chevron's choice was made on the basis of competitive price and compliance with specifications.

There were three minor reasons why we were pleased that the EXAC meter was financially more attractive than the Micro Motion Meter. Firstly we knew that another oil company operating in the North Sea would be trying out a Micro Motion meter on a similar duty, and we agreed to share and exchange experiences with them. Secondly, the EXAC meter seemed to have a more streamlined flow path and might be expected to have less pressure drop across it. Thirdly, the EXAC factory was not too far from the Chevron headquarters in California, which made progress chasing and quality assurance visiting a little easier.

III PURCHASE AND SUPPLY

The purchase order was for an EXAC Model EX1200 sensor with 2" Class 1500 ring type joint flanges working with a series 8100 flow transmitter. Materials in contact with the metered fluid were specified to be to NACE MR-01-75 specification for sour service. All pressure containing welds were to be radiographed and the assembly was required to be pressure tested to 225 bar g. Electrical circuits going to the sensor were required to be intrinsically safe to Cenelec design standards.

The fluid to be metered was defined as liquified petroleum gases at normal conditions of 60 bar g., and 15°C with a density of 500 Kg/m^3. The maximum flow rate was expected to be 800 Kg/min (i.e. 1200 TE/Day). The output required was a summation of mass flow in tonnes and an analogue output of fluid density.

During the progress of the order it became obvious that EXAC were not familiar with the requirements of our specifications, but with the assistance of Orca Corporation, Engineering and Inspection Services dealing with material matters and with technical guidance from SIRA Safety Services Ltd dealing with I.S. matters, we eventually obtained a meter to our requirements, albeit about two months later than we had originally expected. It must be recognised that the meter was going to be used for an arduous duty on an offshore platform and handling a hazardous flammable fluid, so that very high standards of quality assurance were required and obtained.

We also obtained a traceable calibration certificate which was of practical use during our accuracy investigations.

IV INSTALLATION AND COMMISSIONING

The new meter was installed in series with and immediately upstream of the existing metering system. Isolation and bypass valves were provided, and the meter was supported by pipe clamps that were the minimum recommended distances (i.e. equal to the meter length) upstream and downstream of the meter. There was a 90 degree bend immediately upstream of the meter. Since the surrounding pipework is to 4" Class 1500 specification great care was taken in making up the closing spoolpiece so that no major stresses were imposed on the new meter. It is possible to check that no adverse stresses have been introduced into the meter by measuring the drive voltage required to maintain its internal vibrations both before and after securing the pipe connections. There was no significant alteration, and this built-in diagnostic feature was considered to be of great value.

Once installed, the meter was commissioned according to the manufacturers instructions. It functioned immediately and has continued to operate as expected ever since with no failures.

The installation has been disturbed in several minor ways since the initial commissioning but none of these have caused a malfunction. Anti-vibration pads have been added to the pipe support clamps, the meter has been sent away for independent calibration, a bursting disc has been added to the meter case and a new micro-chip computer installed in the flow transmitter, but in all cases the meter performed as expected without any failures.

V PERFORMANCE AND ACCURACY

Since the meter is being used to measure hydrocarbons for fiscal purposes, we would have liked to achieve an accuracy of 0.1%. However, since this stream is only a small part of the total production from the platform, it was realistic to aim for 0.25%, which was the sort of performance claimed by the manufacturer. In this application the essential requirement, however, is to provide a short-term check on the existing turbine-meter and densitometer system, and for this function it is the meter's repeatability that is important.

Neither the accuracy nor the repeatability can be measured directly from our results, but estimates of the uncertainties can be deduced from a study of two sets of graphs.

The first set of graphs Fig. 1 is a daily plot of the difference of L.P.G. production as metered by the Coriolis meter and by the turbine-meter with densitometer system. The graphs show this difference in two ways, first as a simple difference in tonnes for the whole day but also as a percentage of the day's production (as indicated by the original metering system) which is itself also shown for reference purposes. This difference has been plotted for every day that the system has been in use with notes about any external influences or alterations added at the top of the sheet. These results are analysed in more detail later but the difference between the meters seems to indicate that the Coriolis meter reads low with a zero error rather than a span error.

The other graph Fig. 2 shows the results obtained when our meter was sent to the SIRA Institute Flow Calibration Laboratory at Chislehurst where it was calibrated against kerosene using their BCS certified weigh tanks. The results are plotted as percentage error against flow rate, but the sequence in which the tests were carried out is also shown by the numbers alongside each plot because this is important. The overall conclusion is again of a negative zero error.

VI EXAMINATION OF THE RESULTS

A) Both graphs show that the meter takes a long time to stabilise its zero calibration. Large errors in October 1986 and in the test points nos 3 to 10 of Fig. 2 were due to drift of zero calibration during the first 24 hours after switching on.

B) After the first 24 hours zero stability was much better, but some drifting does occur. The drift seldom produces an error of more than 2 tonnes per day.

C) Both the average difference from Fig. 1 and the general shape of points 1,2,11 to 15 in Fig. 2 indicate a small but persistent zero error which is not adjusted out when the meter's automatic zeroing procedure is activated. For reasons of security it is not possible to force the meter to register a flow when nothing is flowing through, but the overall performance over our working range would be better if a deliberate zero offset of about 1 TE/DAY could be introduced.

D) Because the percentage difference shown in Fig. 1 was consistently low and because the calibration of Fig. 2 also showed a small span error, the accuracy of the initial span calibration was rechecked. It was found that the test weights used were on average 0.1% light and that no compensation had been made for the bouyancy of air (about 0.12% for water tests). It was accepted that these facts would fully justify an adjustment of the meter's span calibration by 0.22%. The adjustment was made in November 1987 and performance during December 1987 was very good.

E) When the L.P.G. production rate is low, Fig. 1 shows that the difference between the two meters changes sign. Fig. 2 shows that the EXAC meter performs well at low flow rates. It is known from the characteristic curves of the turbine meters when checked against propane that their rangeability is limited with a well documented loss of performance at low flow rates. With this clear cut evidence that (for our application) the low flow rate performance of the Coriolis meter is better than the low flow rate performance of the turbine meter, the platform staff have been authorised to declare the EXAC meter result on the production report, if production is less than 300 TE/DAY.

F) At times of plant start-up, shut-down or operational disturbance the turbine meter system can be confused if there is liquid in the densitometer and gas in the turbine meter. In these circumstances the Coriolis meter does seem to work well and does not appear to give false results.

G) The Coriolis meter is installed in a platform module that also contains some reciprocating compressors. The vibration levels at the meter were measured and found to be quite low and particularly at its operating frequency of about 80 Hz. However, in an attempt to reduce the zero calibration problem, extra flexible pads were introduced as parts of the pipe supports. These did reduce the overall measured vibration but did not have any noticeable effect on the meter's performance.

H) Whenever a turbine meter was changed as part of its routine 3 monthly offsite proving programme, there was no significant or simultaneous step in the difference graphs. This gave reassurance that the turbine meter system was not subject to meter drift problems, which was one of the reasons for installing the Coriolis meter in the first place.

VII CONCLUSIONS

The Coriolis meter has performed the function for which it was purchased. It has given independent evidence that the turbine meter/densitometer system is accurate when working within its design limitations. The meter does not in its present state of development achieve 0.1% accuracy. The primary source of inaccuracy appears to be associated with zero stability, but apart from this the meter has performed well and has been very reliable.

NCP LPG EXAC vs SPECTRA-TEK MASS FLOW METERS

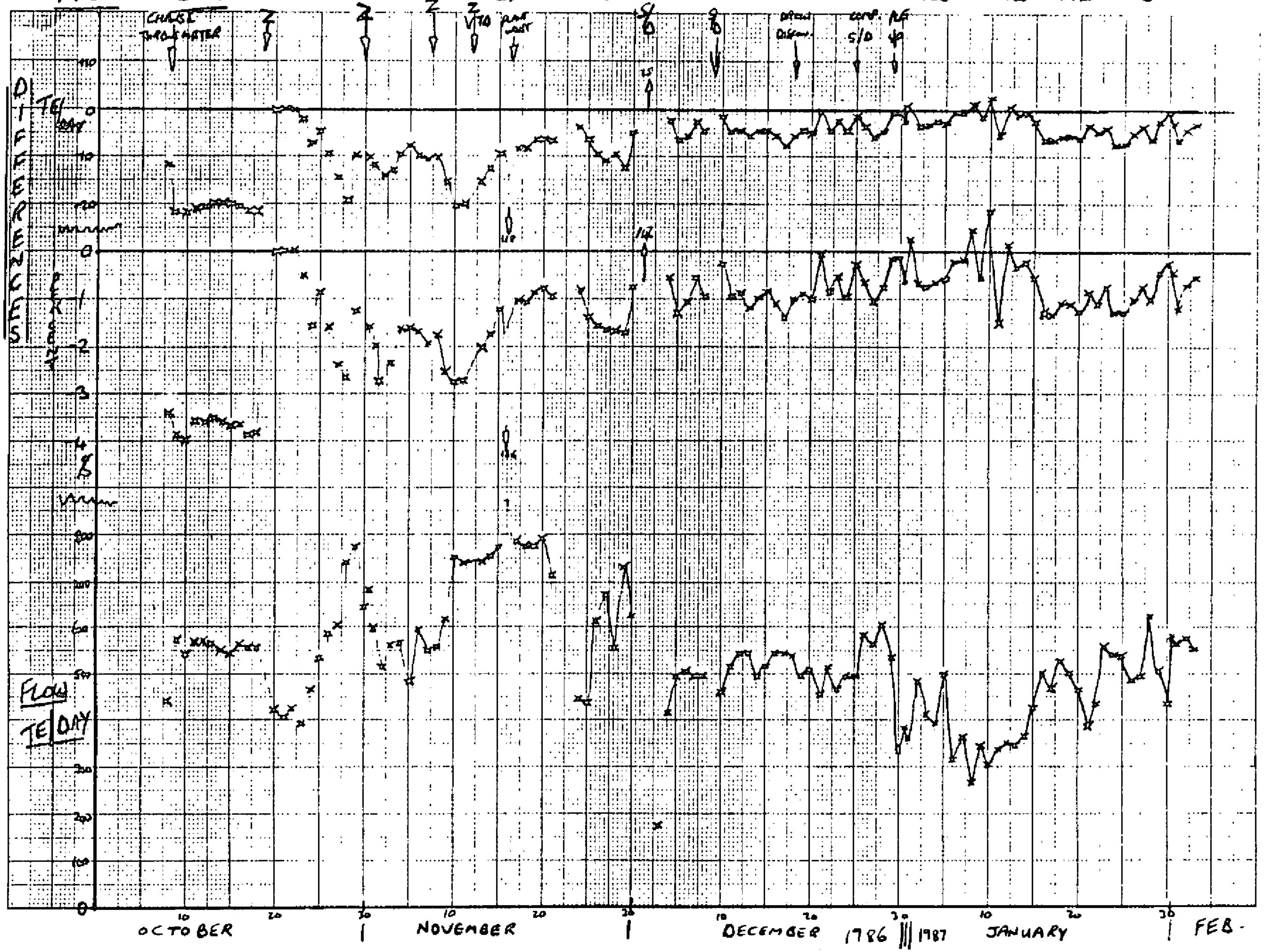

Fig 1 (g)

NCP - LPG EXAC vs SPECTRA-TEK MASS FLOW METERS

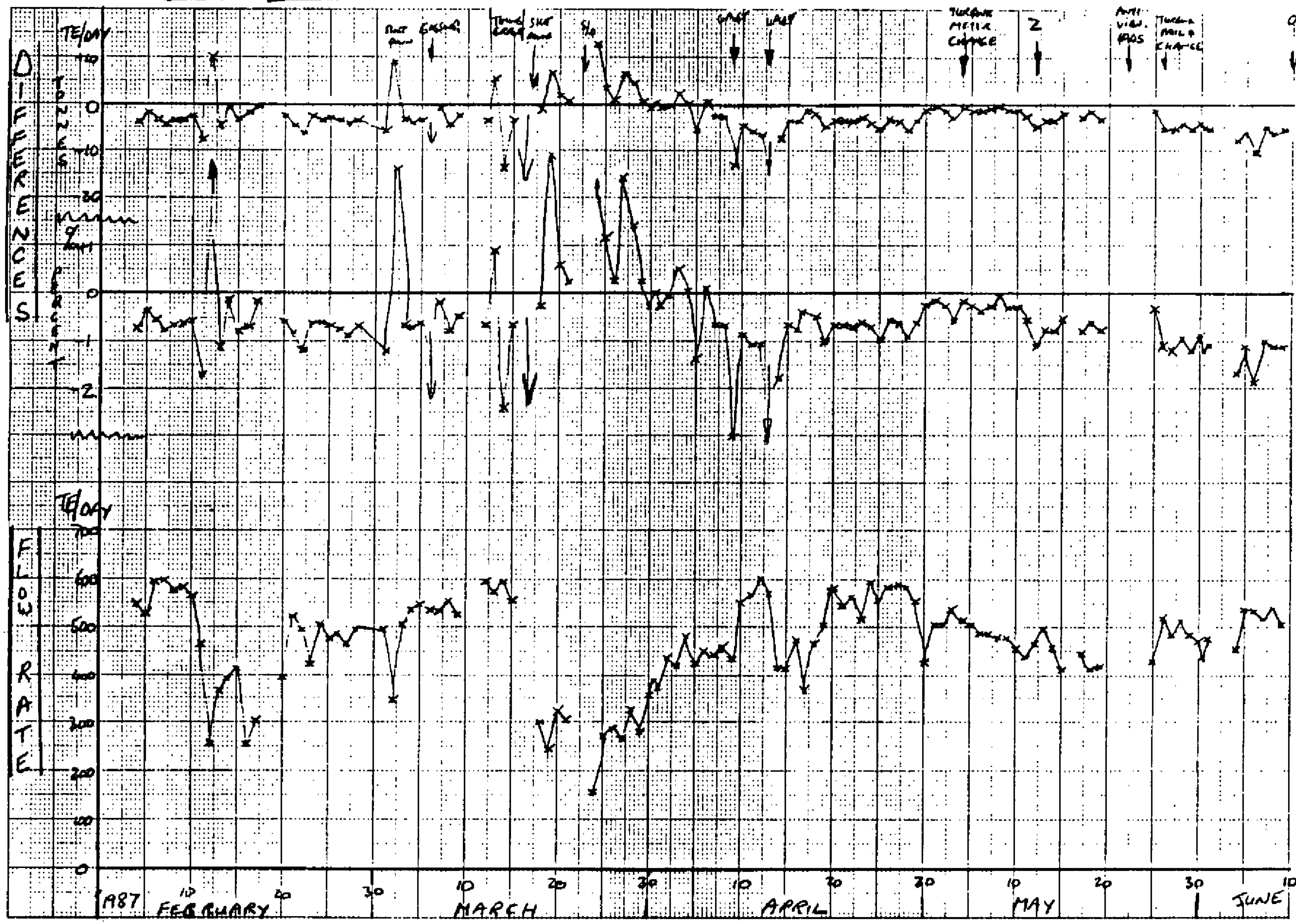

Fig 1 (b)

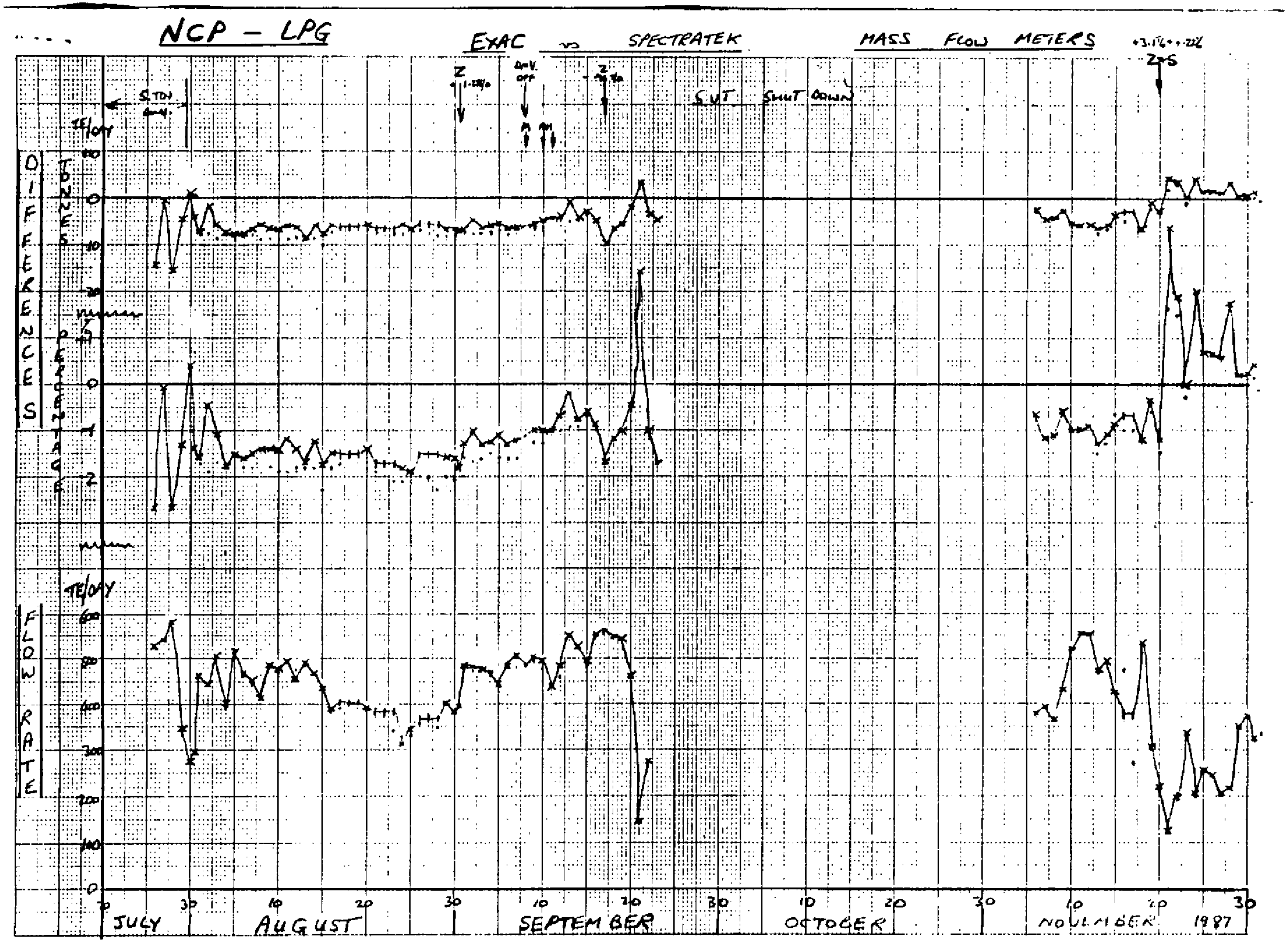
NCP – LPG
EXAC vs SPECTRATEK MASS FLOW METERS
DIFFERENCES
TONNES
PERCENTAGE
FLOW RATE
TE/DAY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER 1987
SHUT DOWN
Z
Z+S

Fig 1 (c)

NCP - LPG EXAC vs SPECTRATEK MASS FLOW METERS
DIFFERENCES
TONNES
PERCENTAGES
FLOW RATE
TE/DAY
SHUTDOWN
ONLY INTERMITTENT USE
DECEMBER 1987
1988 JANUARY
FEBRUARY
MARCH
APRIL

Fig 1 (d)

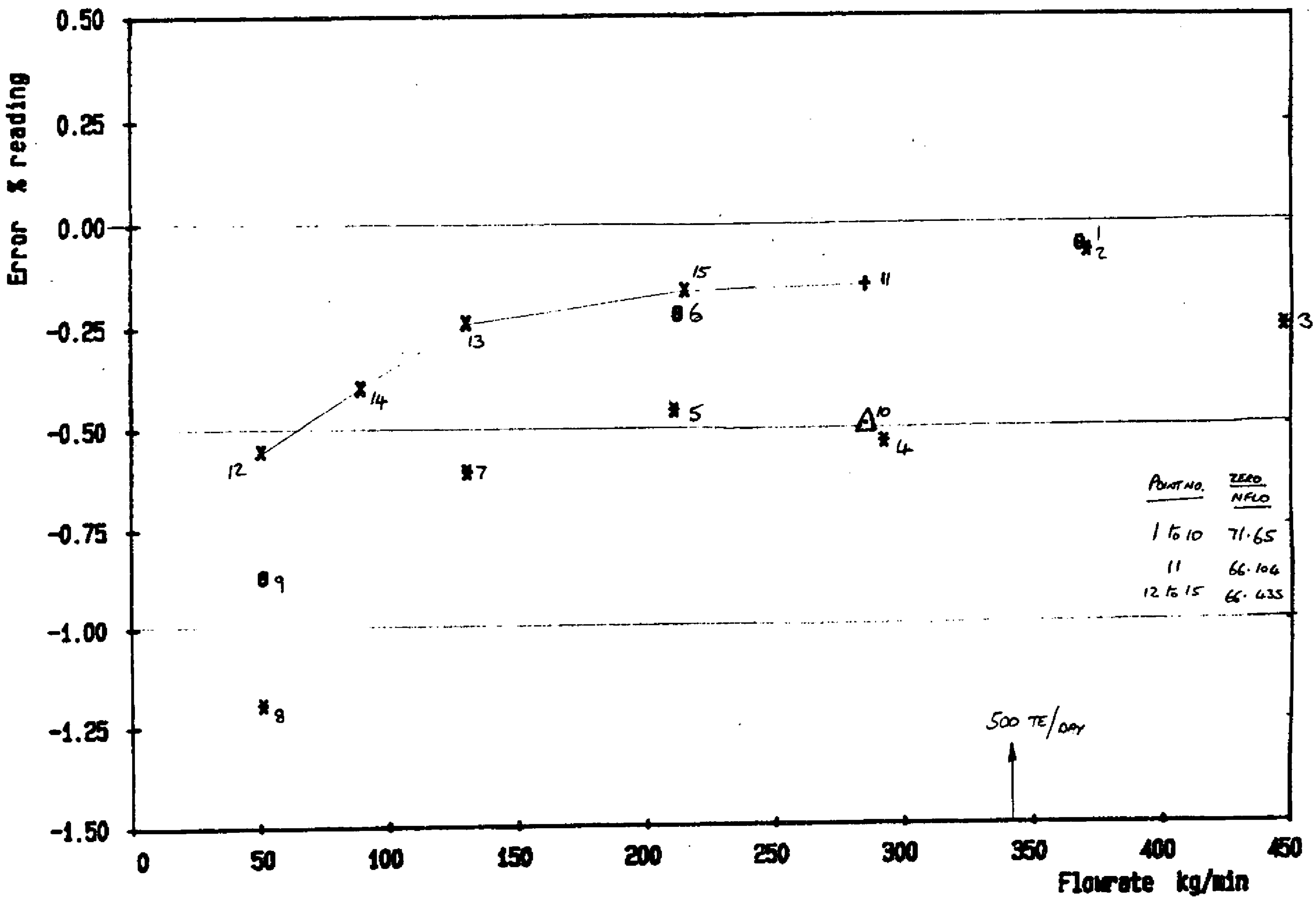

Fig 2 Chevron Exac Mass Flowmeter

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.