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# Operation, calibration and maintenance of accuracy of orifice metering systems for gas measurement - experience from the St. Fergus gas terminal

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# OPERATION, CALIBRATION AND MAINTENANCE OF ACCURACY OF ORIFICE METERING SYSTEMS FOR GAS MEASUREMENT - EXPERIENCE FROM THE ST FERGUS GAS TERMINAL

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## SUMMARY

The Frigg gas field was discovered in July 1971 and gas began flowing to St Fergus shore terminal in September 1977. Approximately one third of Britain's gas is supplied by Frigg, which underlines the importance of the gas custody transfer metering system at St Fergus. The operation and methods of calibrating the metering system is described in this paper, together with the metering experience gained over the past five years.

## 1. INTRODUCTION

Gas from the Frigg field is transported 365 km to a shore terminal through two 0.81 m diameter pipelines. The shore terminal is at St Fergus, Scotland, and it is here that the gas is treated and metered before hand over to the British Gas Corporation.

At an intermediate platform, MCP01, situated 170 km from shore, the Frigg pipeline takes in additional gas from Occidental's Piper field and will soon - end of 1982 - also take gas from Texaco's Tartan field.

A Norwegian association and a UK association share the field ownership in the approximate ratio 60 : 40 respectively, since the Frigg field was found to straddle the dividing line of the Anglo-Norwegian shelf (Blocks UK 10/1 and NW 25/1). The members of the Norwegian association are Elf Aquitaine Norge (42%), Norsk Hydro (33%), Total Marine Norsk (20%) and Statoil (5%). The members of the UK association are Elf UK (40%), Total Oil Marine (33%), Aquitaine UK (22%) and BP (1%). Elf are the operators on the field and Total Oil Marine are operators of the pipeline, the intermediate platform and the shore terminal.

The present maximum capacity of the two lines is approximately 67 x $10^6$ $sm^3$/day, with an additional average daily quantity of 200 tonnes of condensate extracted at St Fergus. In late 1983 compression will be installed on MCP01 for one gas line, and then the maximum capacity will be boosted to approximately 75 x $10^6$ $sm^3$/day.

Metering of the gas is carried out at three locations : Frigg for the Frigg field gas production (metering done by Elf); MCP01 for Piper gas and later for Tartan gas (metering done by Total Oil Marine); St Fergus gas terminal for the combined gas handed over to BGC. In this paper we shall be concentrating on the gas custody transfer metering system at St Fergus which is the responsibility of Total Oil Marine.

The accuracy of the metering is of great importance, because flow and energy measurements form the basis for contracts. Such contracts include those between buyer and seller of the gas, between partners of the field, between companies who enter into agreements to share facilities such as the pipeline. In addition, the British and Norwegian governments are interested in the amounts of gas metered for their Royalty payments. Finally, measurements are required for the proper control of production, transportation, or treatment, where in these cases the measurements are process parameters producing reactions from operators or on control loops.

The metering at St Fergus gas terminal is open for inspection at any time by UK Department of Energy and Norwegian Petroleum Directorate inspectors, and Total Oil Marine is pleased that it has built up a good relationship with these inspectors by maintaining the accuracy of the metering system to the best of its ability.

## 2. ST FERGUS GAS CUSTODY TRANSFER METERING SYSTEM

At St Fergus the gas is treated to meet the specification set by BGC. This treatment involves : separation of entrained liquid; chilling and then removing the resulting condensate; reheating; and then metering.

The metering system was designed as two identical metering stations to ISO R541 recommendations for measurement of flow using orifice plates with flange taps. Each metering station comprises six 61 cm diameter metering tubes with normally four tubes on line, one tube on standby, and one tube being off line for calibration purposes. Every week one tube per station is calibrated, which means that all tubes are checked once every six weeks.

The volume flow rate, Qv, in standard $m^3$/hour is calculated according to ISO R541 using :

$$Qv = \frac{0.039986}{1.22495} \cdot \frac{\alpha \varepsilon d^2 \sqrt{\Delta p . \rho}}{s} \qquad (1)$$

where $\alpha$ = flow coefficient (ISO R541, section 6.6.1.1)

$\varepsilon$ = expansibility factor (ISO R541, section 6.6.1.3)

d = diameter of orifice, mm

$\Delta p$ = differential pressure across orifice plate, mbar

$\rho$ = operating density upstream of orifice plate, $kg/m^3$

s = relative density

Hence, the volume flowed is obtained by multiplying Qv by the time in hours.

At the present time, since we are using analogue flow computers, the constants and are only calculated at one point and so the equation for volume flow rate actually used becomes :

$$Qv = \frac{K\sqrt{\Delta p . \rho}}{s} \tag{2}$$

where K is a constant which is only changed when the orifice diameter is changed. For each metering tube, differential pressure is measured by two transmitters. The low range transmitter and high range transmitter cover 0 to 62.5 mbar, and 62.5 mbar to 250 mbar respectively.

The corresponding energy flow rate, E, in megajoules/hour (MJ/hour) is obtained from :

$$E = Qv \times CV, \tag{3}$$

where CV is the calorific value of the gas in megajoules/$sm^3$. Then the energy supplied by the gas is obtained by multiplying E by the time in hours.

## 3. CALIBRATION CHECKS MADE EVERY SIX WEEKS

The following checks are carried out at six-weekly intervals on an individual metering tube and associated instrumentation :

3.1 Complete system "as found" when tube taken off line.

3.2 Operating density cell.

3.3 High and low differential pressure transmitters.

3.4 Flow Computer

3.5 Signal conditioners and alarms

3.6 Orifice plates

3.7 Local recorder

3.8 Complete system "as left" at end of calibrations

3.9 Operational check out

A complete system check is made when the tube is taken off line to ascertain the "as found" state, prior to commencing re-calibration.

The operating density cells on each tube are calibrated with high purity nitrogen. These density cells are installed in pockets in the metering tubes downstream of the orifice plates. Positioning the cells in the pockets ensures that the gas in the density cell is at the same temperature as the gas in the meter tube, and calibration is carried out "in situ".

The high and low differential pressure transmitters are again calibrated using the high purity nitrogen, at a nominal line pressure of 42 barg. They are calibrated at five points on the instruments' ranges 0, 25%, 50%, 75% and 100% of span on both rising and falling applied inputs.

The flow computer is checked by applying simulated values of differential pressure and density and comparing the observed output with the calculated value.

The signal conditioner from the relative density analyser to the flow computer is checked, together with all the alarms to the metering tube under calibration.

The orifice plate is physically removed from the orifice plate carrier and checked by eye for cleanliness, condition of the orifice edge, and the condition of the "O" ring on the plate.

The local recorder needed for standby metering measures upstream static pressure, differential pressure and temperature. The static pressure and differential pressure pens are calibrated at 0, 25%, 50% and 75% of span (75 bar) and 0, 12.5%, 25%, 37.5% and 50% of span (250 mbar). Temperature is only checked at one point, the gas temperature.

With the complete system having been checked and recalibrated where necessary, a check is made on the complete system "as left" at the end of calibration.

This is followed by an operational check out which compares the measured time for metering 20,000 $sm^3$ of gas and hence the measured flow rate, against a calculated flow rate.

## 4. CALIBRATION CHECKS MADE EVERY WEEK

For each metering station there are two relative density meters and two calorimeters. At any one time there are always one relative density analyser and one calorimeter on line, whilst the second instruments are on stand-by or are available for calibration. The calibration of the calorimeters is checked at one point, weekly, with high purity methane. The calibration of the relative density analysers is also checked weekly with the high purity methane and a mixture of methane and nitrogen.

## 5. MONTHLY CHECKS COMMON TO ALL TUBES

Once monthly on each station a check is made by comparing for one hour the flow obtained from the sum of the individual tube totalisers with the volume obtained on the station totaliser. In addition, a transmission check is made on the calorific value output at source and the actual value being inputted into the computer.

## 6. METERING IMPROVEMENTS OVER THE PAST 3 YEARS

The main changes made to the metering in the past 3 years are :

6.1 Change of high differential pressure transmitters

6.2 Change from operating density analysers out of the metering tubes to density analysers in tube pockets.

The original high differential pressure transmitters manufactured by Westinghouse kept drifting, and after evaluating 3 other types of transmitter, Rosemount transmitters were chosen as replacements. The Rosemount transmitters have been found to be extremely reliable, with little or no drifting taking place over the six week calibration interval.

The original operating density analysers were outside of the metering tubes and due to temperature discrepancies ocurring between the gas inside the metering tube, and the gas inside the analyser, these discrepancies caused errors in the measured value of operating density. To overcome the problem, two possible solutions were investigated. One solution was to place the analyser in a thermostatically controlled enclosure which maintained the enclosure at the same temperature as the gas in the metering tubes. The second solution was to change to analysers in pockets in the metering tubes. These pockets were placed downstream of the orifice plates. After a detailed comparison of the two possible solutions analysers in pockets were chosen as the preferred solution, and all the metering tubes were converted to take the new density analysers.

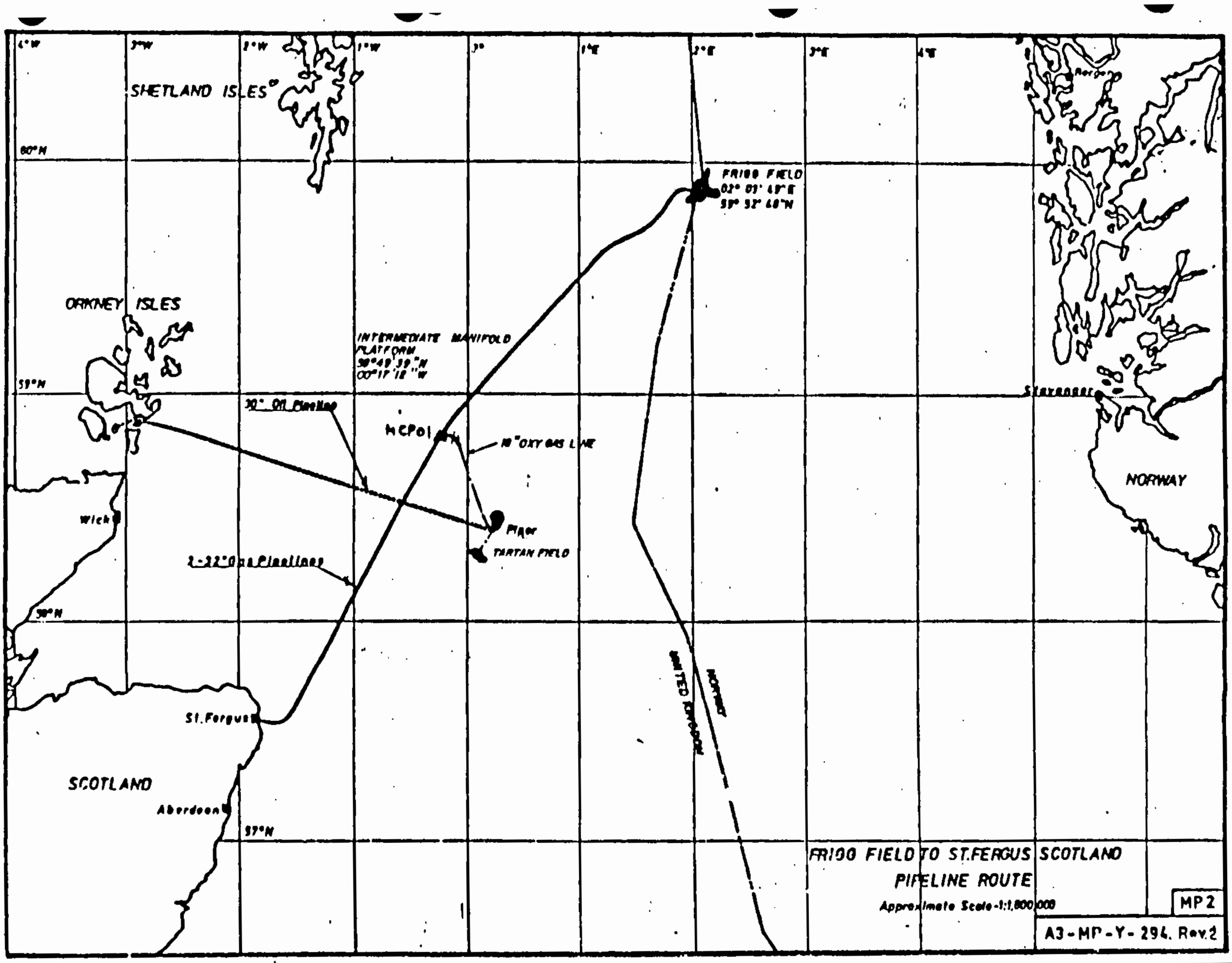
## 7. FUTURE PLANS

At this moment, the performance of Solartron relative density analysers are being evaluated with the intention of using them in place of the ageing Spanner-Pollux analysers.

To increase the present capacity of the metering, Total Oil Marine is in the process of uprating the differential pressure transmitters to 500 mbar. This uprating is expected to be completed by Autumn 1982.

It is also proposed to change the metering standard from ISO R541 to ISO 5167 at the same time as the change is made on MCP01 and Frigg. This change will take place towards the end of 1982.

During the summer of 1983 it is proposed to change from the existing analogue flow computers to digital flow computers. The main reasons for the change are the increased computation accuracy to be gained, and increasing difficulty in obtaining spares for, and in maintaining, analogue flow computers.


SHETLAND ISLES
ORKNEY ISLES
INTERMEDIATE MANIFOLD PLATFORM
MCP01
Piper
TARTAN FIELD
Wick
St.Fergus
SCOTLAND
Aberdeen
NORWAY
Stavanger
FRIGG FIELD TO ST.FERGUS SCOTLAND
PIPELINE ROUTE
Approximate Scale-1:1,800,000
MP2
A3-MP-Y-294. Rev.2

Paul Wilcox

# PARTNERS IN FRIGG

| 60% | | 40% | |
|---|---|---|---|
| % | NORWEGIAN ASSOC. | U.K. ASSOC. | % |
| 42 | ELF AQUI. NORGE | AQUITAINE U.K. | 22 |
| 33 | NORSK HYDRO | ELF U.K. | 44 |
| 5 | STATOIL | TOTAL OIL MARINE | 33 |
| 20 | TOTAL MARINE NORSK | B.P. | 1 |

## CONTRACTUAL YEAR 1980 - 81

AVERAGE AMOUNT OF GAS $\approx 50 \times 10^6$ sm³/day,

AND $\approx$ 200 TONS OF CONDENSATE / day.

## MAXIMUM CAPACITY OF LINE

NOW (2 LINES) $\approx 67 \times 10^6$ sm³/day.

LATER - CAPACITY OF ONE PIPELINE TO BE BOOSTED TO $42 \times 10^6$ sm³/day BY COMPRESSION ON MCP01

## PARTIES INTERESTED IN THE METERING

FIELD DEVELOPERS

BRITISH AND NORWEGIAN GOVTS.

B.G.C.

OCCIDENTAL + TEXACO

WHY ? BECAUSE ALL CONTRACTS REQUIRE TO KNOW GAS QUANTITIES INVOLVED

- BUYER AND SELLER
- ROYALTIES
- OPERATING COSTS
- TRANSPORTATION COSTS

Additionally : REQUIRE METERING FOR THE PROPER CONTROL OF : PRODUCTION

TRANSPORTATION

TREATMENT.

# METERING AT 3 LOCATIONS

## 1. FRIGG – FRIGG GAS PRODUCTION

METERED BY ELF AQUITAINE NORGE, THE FIELD OPERATOR

## 2. MCP01 – PIPER (OXY) + TARTAN (TEXACO) GAS

METERED BY TOTAL OIL MARINE, THE PIPELINE OPERATOR

## 3. ST. FERGUS – GAS CUSTODY TRANSFER SYSTEM

METERED BY TOTAL OIL MARINE, THE TERMINAL OPERATOR

THE CONDENSATE IS ALSO MEASURED HERE.

# ALLOCATION

GAS METERED AT ST FERGUS, MCP01, AND FRIGG IS (OR WILL BE) A MIXTURE OF FLOWS FROM THE VARIOUS FIELDS

OWNERSHIP : GAS ANALYSIS AT SOURCE AND DELIVERY POINT.

COMPUTE SHAREOUT ACCORDING TO MATHEMATICAL RULES AGREED BETWEEN EACH SHIPPER OF GAS ENTERING FRIGG SYSTEM.

B.G.C. MODULATES NOMINATION OF GAS
ACCORDING TO :
- WEATHER
- HOLIDAYS
- SUPPLY FAILURE ELSEWHERE

FRIGG FIELD TAKES CARE OF THE VARIATIONS "PACKING" THE LINE IF NEED BE.

THUS "BANKING" THE GAS FOR TIMES OF PEAK DEMAND, OR SHORTAGE OF PRODUCTION.

# ST FERGUS GAS CUSTODY METERING SYSTEM

THE GAS IS FIRST TREATED TO MEET B.G.C.'s SPECIFICATION:

- SEPARATION OF ENTRAINED LIQUID
- CHILLING AND REMOVAL OF RESULTING CONDENSATE
- REHEATING
- METERING

2 IDENTICAL METERING STATIONS TO ISO R541, USING ORIFICE PLATES WITH FLANGE TAPS

IN AUTUMN 1982 INTEND CHANGING TO ISO 5167.

EACH METERING STATION COMPRISES 6 METERING TUBES OF 2 FT. (0.61m) O.D.

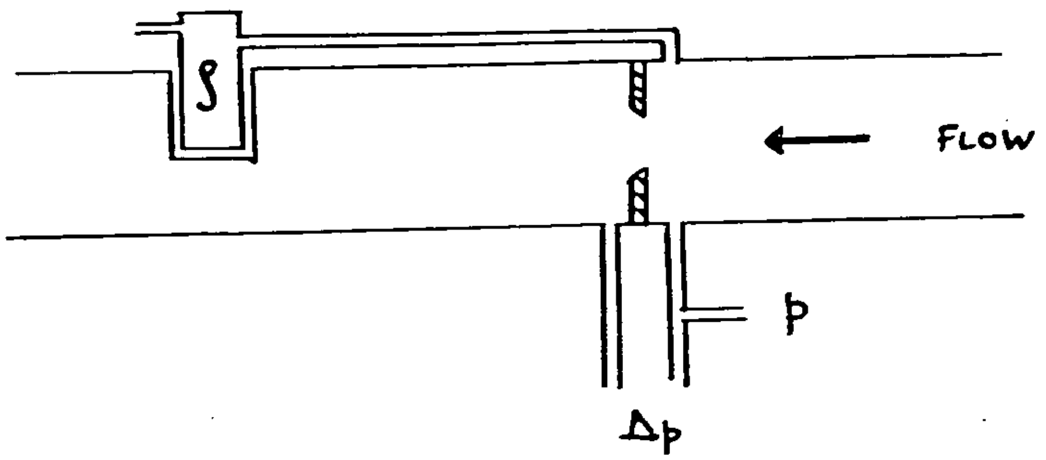
GENERALLY HAVE:

- 4 TUBES IN OPERATION
- 1 TUBE ON STANDBY
- 1 TUBE DEPRESSURISED FOR CHECKING AND CALIBRATING.

ONE TUBE CHECKED PER WEEK ⟹ ALL TUBES ARE CHECKED ONCE EVERY SIX WEEKS.

TWO METERING TECHNICIANS TO EACH STATION

# BASIC METERING SYSTEM




RD AND CV ARE MEASURED ON A GAS SAMPLE LINE.

$$\text{VOLUME FLOWED } (sm^3) = \frac{0.039986}{1.22495} \cdot \frac{\alpha \varepsilon d^2 \sqrt{\Delta p \cdot \rho}}{s} \times \text{time}$$

WHERE
- $\alpha$ = FLOW COEFFT. (R541, section 6.6.1.1)
- $\varepsilon$ = EXPANSIBILITY FACTOR (R541, 6.6.1.3)
- $d$ = ORIFICE DIAMETER, mm.
- $\rho$ = OPERATING DENSITY, $kg/m^3$
- $\Delta p$ = DIFFERENTIAL PRESSURE, mbar
- $s$ = RELATIVE DENSITY.

SINCE AT PRESENT USING ANALOGUE FLOW COMPUTERS, CONSTANTS $\alpha$ AND $\varepsilon$ ARE ONLY CALCULATED AT ONE POINT.

THEN :

$$\text{VOLUME FLOWED} = \frac{K\sqrt{\Delta p . \rho}}{S} \times \text{time} \quad (sm^3)$$

HERE K IS A CONSTANT WHICH IS ONLY CHANGED WHEN THE ORIFICE DIAMETER IS CHANGED.

CORRESPONDING ENERGY FLOWED :

$$E = \frac{K\sqrt{\Delta p . \rho}}{S} \times \text{time} \times CV \quad . \quad (MJ)$$

HERE CV IS THE GROSS CALORIFIC VALUE IN $MJ/sm^3$.

# CALIBRATION CHECKS EVERY SIX WEEKS

1. COMPLETE SYSTEM "AS FOUND" WHEN TUBE TAKEN OFF LINE.
2. OPERATING DENSITY CELL
3. HIGH AND LOW D.P. TRANSMITTERS
4. FLOW COMPUTER
5. SIGNAL CONDITIONER AND ALARMS
6. ORIFICE PLATES
7. LOCAL RECORDER
8. COMPLETE SYSTEM "AS LEFT" AT END OF CALIBRATION
9. OPERATIONAL CHECK OUT

1. COMPLETE SYSTEM "AS FOUND"

8. COMPLETE SYSTEM "AS LEFT"

A SIMULATED RANGE OF PROCESS INPUTS OF OPERATING DENSITY AND DIFFERENTIAL PRESSURE ARE APPLIED TO THE FLOW COMPUTER, USING HIGH PURITY NITROGEN.

THE OBSERVED OUTPUT IS COMPARED WITH THE CALCULATED OUTPUT OBTAINED FROM A COMPUTER PROGRAMME CALLED METCAL

DURING THESE TESTS THE RELATIVE DENSITY IS MEASURED ON THE GAS SAMPLE LINE.

RANGE OF APPLIED INPUTS :

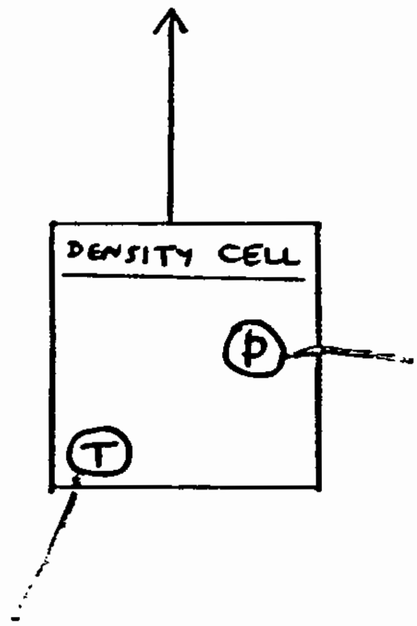
| DIFF. PRESS. | OPER. DENSITY |
| --- | --- |
| 100% HI - 250 mbar | ≈ 46 Kg/m³ |
| 75% HI - 187.5 mbar | ≈ 46 Kg/m³ |
| 75% HI - 187.5 mbar | ≈ 33.8 Kg/m³ |
| 50% LO - 31.25 mbar | ≈ 25 Kg/m³ |

## 2. OPERATING DENSITY CELL

CALIBRATION TEST CERTIFICATE ISSUED BY FACTORY USED AS A BASIS FOR THE VERIFICATION TEST ON THE TRANSDUCER.

OBSERVED FREQUENCY OUTPUT
— SOLARTRON 2602 TIMER/COUNTER

ATMOS. PRESSURE
— FORTIN BAROMETER




GAUGE PRESSURE OF WHITE SPOT $N_2$ — BUDENBER DEADWEIGHT TESTER TYPE 10445/246.

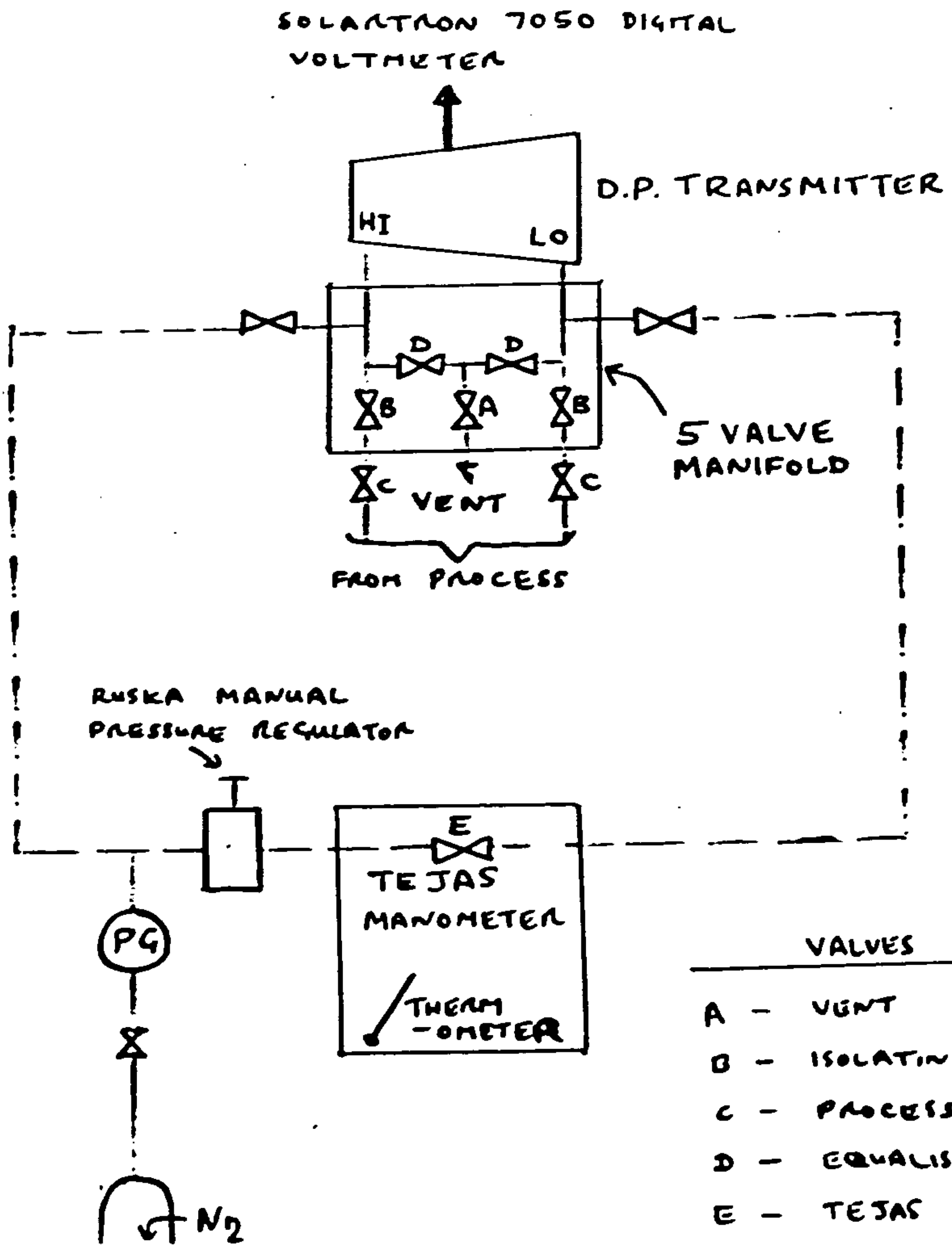
TEMPERATURE OF WHITE SPOT $N_2$
— SOLARTRON TYPE 100 RESISTANCE THERMOMETER WITH WHEATSTONE BRIDGE FOR MEASURING RESISTANCE, TYPE LEEDS AND NORTHRUP MODEL 19867/13.

USING A COMPUTER PROGRAM WHICH HAS A STORED TABLE OF DENSITY VALUES OF WHITE SPOT $N_2$ FOR VARYING $p$ AND $T$, THE CALCULATED $N_2$ DENSITY (AND HENCE CALCULATED $N_2$ TRANSDUCER FREQUENCY AND PERIODIC TIME) IS OBTAINED

## 3. HIGH AND LOW D.P. TRANSMITTERS

CHECK CARRIED OUT AT 42 BARG. PRESSURE ON BOTH HIGH AND LOW D.P. TRANSMITTERS AT

0, 25, 50, 75, AND 100% OF INSTRUMENT RANGES ON BOTH **RISING** AND **FALLING** DIFFERENTIAL PRESSURES THE ACTUAL D.P. IS SET BY THE TEJAS.




VALVES

A – VENT
B – ISOLATING
C – PROCESS
D – EQUALISING
E – TEJAS BLOCK VALVE

## 4. FLOW COMPUTER

CHECK CONDUCTED IN TWO PARTS

### PART ONE

APPLYING SIMULATED INPUTS OF D.P. FOR TWO VALUES OF OPERATING DENSITY WITH RD FIXED.
CHECK OBSERVED FLOW RATE AGAINST CALCULATED FLOW RATE BY COUNTING TIME FOR 100 PULSES.

### PART TWO

AT SIMULATED FIXED VALUES OF DP AND $\rho$, VARYING RELATIVE DENSITY INPUT.

CHECK OBSERVED FLOW RATE AGAINST CALCULATED FLOW RATE BY MEASURING TIME FOR 100 PULSES

NOTE: TOLERANCES FOR THESE TESTS WERE OBTAINED FROM THE ORIGINAL MANUFACTURERS CERTIFICATIO TESTS ON THE FLOW COMPUTER.

# WEEKLY CALIBRATION CHECKS

## 1. CALORIMETERS

COLD BALANCE TEST

HIGH PURITY METHANE

Calorimeters completely stripped once in 3 months.

## 2. RELATIVE DENSITY ANALYSERS.

HIGH PURITY METHANE — 0.555

MIXTURE METHANE \ $N_2$ — 0.584

Spanner - Pollux tendency to drift.

# MONTHLY CALIBRATION CHECKS

1. FOR EACH STATION, A ONE HOUR CHECK IS MADE THAT THE FLOW OBTAINED FROM THE SUM OF THE INDIVIDUAL TUBE TOTALISERS
= VOLUME ON STATION TOTALISERS.

2. TRANSMISSION CHECK ON THE CV OUTPUT AT SOURCE = ACTUAL VALVE BEING INPUTTED TO COMPUTE

# STATISTICAL ANALYSIS OF THE CALIBRATION RECORDS

FROM THE 6-WEEKLY CALIBRATION SHEETS CARRIED OUT A STATISTICAL ANALYSIS

IT GIVES A GOOD INDICATION OF THE ACCURACY AND DRIFT OF THE SYSTEM

KNOWING THE APPLIED INPUT VALUE AND MEASURING THE INSTRUMENT VALUE READ IT IS POSSIBLE TO OBTAIN AN OBSERVATION OF THE SPOT DEVIATION OF THE INSTRUMENT.

IT CAN BE EXPRESSED AS :

$$\frac{(\text{READ} - \text{APPLIED})}{\text{APPLIED}} \times 100\%$$

FROM THESE RESULTS CAN THEN FIND :

OBSERVED MEAN DEVIATION $- \mu$

OBSERVED STANDARD DEVIATION $- \sigma$

UNCERTAINTY $= 2\sigma$

| | | HIGH DP CELL | OPERAT'G DENSITY CELL | RELATIVE DENSITY CELL | FLOW COMPUTER | CALORIMETER | INDIV. TUBE VOL. |
|---|---|---|---|---|---|---|---|
| AS FOUND | $\mu$ | -0.061 | -0.025 | -0.003 | +0.016 | +0.039 | -0.056 |
| | UNCERT'Y. (2$\sigma$) | 1.062 | 0.500 | 0.238 | 0.116 | 0.338 | 0.562 |
| AS LEFT | $\mu$ | -0.057 | -0.016 | -0.035 | +0.015 | -0.002 | -0.042 |
| | UNCERT'Y. (2$\sigma$) | 0.494 | 0.146 | 0.140 | +0.012 | 0.052 | 0.336 |

OUT OF DATE.

# METERING IMPROVEMENTS OVER THE PAST 3 YEARS

## 1. CHANGE OF HIGH D.P. TRANSMITTERS

ORIGINAL WESTINGHOUSE DRIFTING CONSIDERABLY

3 ALTERNATIVES TRIED, AND FINALLY ROSEMOUNTS CHOSEN.

ROSEMOUNTS FOUND TO BE EXTREMELY RELIABLE – LITTLE OR NO DRIFTING OVER 6 WEEKLY INTERVALS.

## 2. CHANGE TO DENSITY CELLS IN POCKETS

FOUND THAT WITH THE ORIGINAL OPERATING DENSITY CELLS OUTSIDE THE METERING TUBES, TEMP. VARIATIONS BETWEEN GAS IN ANALYSER AND GAS IN TUBES CAUSED ERROR IN $\rho$.

SO INVESTIGATED TWO SCHEMES

1. DENSITY CELLS IN POCKETS IN TUBES
2. DENSITY CELLS IN THERMOSTATICALLY CONTROLLED ENCLOSURES OUTSIDE METERING TUBES.

## 3. CHANGE TO SOLARTRON RELATIVE DENSITY ANALYSERS

PRELIMINARY TESTS HAVE SHOWN THAT THE SOLARTRON R.D. ANALYSERS ARE MORE STABLE THAN THE EXISTING SPANNER POLLUX ANALYSERS.

WE HAVE BOUGHT 4 WITH THE INTENTION OF USING THEM AT ST. FERGUS.

HOWEVER THERE IS A PROBLEM,

CALIBRATION MUST BE DONE AT 7 bar pressure.

COMPRESSIBILITY MUST BE TAKEN INTO ACCOUNT.

WE ARE AT PRESENT LOOKING AT THIS PROBLEM.

## 4. UPRATING METERING TO 500 mbar

TO INCREASE METERING CAPACITY

GIVES AN INCREASE THEORETICALLY FROM A

MAXIMUM OF $\approx 9.6 \times 10^6$ sm$^3$/day

TO $\approx 13.6 \times 10^4$ sm$^3$/day.

## METERING IMPROVEMENTS THAT DIDN'T WORK

1. USING ONE DESGRANGES + HUOT D.P. TRANSMITTER TO MONITOR THE PERFORMANCE OF SIX ROSEMOUNT TRANSMITTERS

2. COMPARISON TESTS BETWEEN A D+H AND A ROSEMOUNT D.P. TRANSMITTER

## FUTURE PLANS

1. CHANGE TO ISO 5167 - LATE 1982

2. ANALOGUE FLOW COMPUTERS TO DIGITAL FLOW COMPUTERS — SUMMER 1983.

Calibration of Gasmeters

by

H. Bellinga

ERRATA

| | |
|---|---|
| page 2 line 6 : | lightning must lighting |
| page 2 line 10: | manufactured gas was . . . . |
| page 12 line 16: | meters of 4000 $m^3$/h |
| page 14 line 2: | power must be prover |

# 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.