Main Index

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EXPERIENCE WITH A SMART "DP" TRANSMITTER

2.4

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DRIFTSDIVISJON STAVANGER

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LIST OF CONTENT

EXPERIENCE WITH A ST3000 SMART TRANSMITTER

1. INTRODUCTION

1.1 Presentation content

This presentation will include test results and experience in application of Honeywell ST3000 smart pressure transmitters. Both differential pressure and static pressure transmitters have been utilized on the Statfjord field since early 85.

The transmitters are installed in fiscal gas metering stations for measurement of differential pressure and line pressure in orifice meter runs.

The gas is fed to the Statpipe system on Norwegian sector and to NLGP/FLAGS on the UK sector.

The main objective with the presentation is to summarize experience from the following phases:

a) Selection of equipment.
b) Installation and commissioning.
c) Operation.

The comments are made based on experience from personnel involved with maintenance work.

The main references for the overall quality of the transmitter will be based on the following:

a) High accuracy
b) User friendly
c) Availability
d) Reliability
e) Stability in calibration

1.2 Summary

1.2.1 Description

The transmitter features a new concept in the measurement of process parameters. Communication via its 4-20 mA loop makes this transmitter unique and provides the capabilities of remote transmitter adjustments and diagnostics. This is accomplished via a hand held communicator and enables the operator to perform changes in transmitter configuration from the control room.

The sensor is a piezo resistive element and microprocessor based electronics provide enhanced accuracy by compensation of output signal (temperature and static pressure compensation for differential pressure measurement).

1.2.2 Experience

Problems occurred during the selection and commissioning phase. During the onshore testing phase, prior to purchase, leakage and accuracy problems were revealed: leakage in process head during ambient temperature test and problems with compliance with manufacturers specification during measurement accuracy testing.

However, these problems were resolved and we will concentrate on experience from the operational phase.

The main requirement we emphasized during selection phase was the transmitter's accuracy. In general the ST3000 have been a reliable, user friendly and in our opinion probably one of the best instruments available on the market today. However, other manufacturers offer transmitters based on the same smart concept with similar high quality specification. We have experience with ST3000 only and this presentation will not include comparison with other manufacturers.

The calibration stability of the ST3000 have proven to be very good and we have been able to reduce maintenance cost since calibration intervals have been extended.

2. DESCRIPTION OF INSTRUMENT

Ref. Fig. 1 and specification sheets.

2.1 Introduction

The intention is not to fully describe all the details of the transmitter's features and functions. Please refer to the technical manual for details.

This presentation will concentrate on the transmitters main new features.

The ST3000 microprocessor based transmitter performs measurement of differential, gauge or absolute process pressure. The piezo resistive sensor combined with the microprocessor based electronics and digital to analog converter provides an analog 4-20 mA output signal proportional to the measured signal.

The ST3000 was designed as a direct replacement for conventional analog transmitters. It uses the existing 4-20 mA lines for power, signal transmission and communication.

One of the new main features include remote communication with the transmitter through the Smart Field Communicator (SFC). This unit provides the capabilities of remote adjustments and diagnostics.

The ST3000 family includes instruments for a wide range of application areas with measurement of the following process parameters:

a) Absolute pressure
b) Gauge pressure
c) Differential pressure

This presentation will concentrate on the measurement of differential pressure.

2.2 Sensing element

The ST3000 transmitter utilize a piezo resistive sensor with no mechanical parts.

The piezo resistive straingauge sensor is an electric wheatstone bridge circuit ion-implanted onto a silicon chip. The sensor is sealed and isolated from the process by metal diaphragms and silicone fluid.

This integrated sensor provides three analog signals; process pressure, sensor temperature and static pressure.

These three analog signals are converted to digital signals for input to the microprocessor. The processor utilizes factory calibration data stored in PROM and calculates appropriate output values, compensating for the existing temperature and static pressure conditions.

This value is then converted back to an analog signal, resulting in an 4-20 mA output signal.

2.3 Electronics

The housing contains separate compartments for the electronics module and an integral junction box separated from the electronics.

The electronics module is replaceable and interchangeable with any other ST3000 model.

2.4 Communication with the transmitter (SFC)

See Fig. 1.

Communication with the transmitter is performed with a handheld communicator hooked up to the 4-20 mA instrument loop.

This unit may be utilized for the following operations:

a) Configuration
b) Troubleshooting, diagnostics
c) Calibration
d) Display data
e) Monitoring of measurement results

2.5 Summary of the transmitter's main features

a) Improved accuracy

Live compensation measurement in conjunction with calibration data from factory stored in memory provides improved accuracy and stability. See specification sheet.

Important aspects giving effect for overall measurement uncertainty:

- Static pressure effect on differential pressure measurement.

- Ambient temperature effect.

- Hysteresis.

b) High turndown ratio

Large range of span adjustments gives a maximum of 400:1 in turndown ratio.

- This feature allows a lower number of various transmitter models on stock to cover the ranges required.

- Provision of range changing flexibility.

c) Remote adjustability

Communication with the transmitter is performed from control room.

This feature allows the operators to perform changes in functions and reranging without having to enter the process location and remove transmitter.

d) Diagnostics and start up

The concept of remote communication is timesaving in diagnostics work.

e) Commissioning

The transmitter may be utilized as a current generator and thereby commissioning on total loop work may be completed in a shorter time.

In general the remote communication concept provides great improvement during commissioning and startup work where configuration changes are required to "tune" the process.

In our application ranges are fixed and thereby the possibility of reranging does not apply for our present installation.

3. CALIBRATION. METHODS AND PROCEDURES

3.1 Requirement

Fiscal measurement of petroleum products has to comply with regulations from authorities. Norwegian Petroleum Directorate has issued regulations for gas:

> Regulation for fiscal measurement of gas produced in internal waters, in Norwegian territorial waters and in the part of the Norwegian Continental Shelf which is subject to Norwegian sovereignty.

In these regulations it is stated (§63) that calibration intervals for transducers are every month. Based on experience wiht equipment, dispensation from regulations may be granted.

Additionally, industrial practice within custody transfer set requirements for gas sales.

The calibration method and procedure should be approved (recognized) by authorities, partners and buyers.

3.2. Differential pressure and static pressure

3.2.1 Introduction

The differential pressure (DP) is a vital parameter in an orifice measurement system. We have therefore emphasized the importance of the quality of the DP-measurement in order to keep the overall station measurement uncertainty as low as possible.

The static pressure measurement is utilized in secondary correction to the gas flow measurement. However, it is considered to be an important parameter and we have therefore aimed for high quality instrumentation during selection phase of test equipment and transmitter.

The following description gives an outlined version of the detailed calibration procedures and test equipment.

This procedure is included in the

> Gas Metering Calibration and Maintenance Manual for The Statfjord Field

Test and calibration work is performed both offshore and onshore (DP). For static pressure we perform calibration offshore only.

3.2.2 Testing and calibration

Requirement

All fiscal measurement will require test equipment with very high accuracy and certified traceability to national standards.

Requirement for onshore calibration:

0-100 mbar: 0.275%
0-500 mbar: 0.15%

Traceability

For differential pressure measurements we have certified traceability to the French National Standard via LNE (Laboratorie National d'Essai)

For voltage measurement (measurement for transmitter output across a precision resistor) we have certified traceability to the British National Standard via NPL (National Physical Laboratories).

Equipment. Differential Pressure

Ref. fig. no. 2.

Onshore

Des Granges et Huot pressure standard 5303
Des Granges et Huot devider 1500

This system features the capability of applying differential pressure to the transmitters at a given static pressure.

Voltage & Resistor

Voltage measurement: Solartron 7081
Precision resistor: Cropico RS3

The transmitter (4-20 mA) output is measured across a 250 precision resistor.

Offshore

Pressure

AMETEK pneumatic DWT.

Voltage & Resistor

Solartron 7150
Precision resistor for computer input (250)

Outlined procedure for differential pressure

The calibration procedure for differential pressure transmitter includes 5 different tests.

Onshore (test lab)

1) Atmospheric test

This test includes verification of differential range at atmospheric pressure. The objective is to monitor calibration shift between onshore testing. No adjustments.

2) Calibration at static pressure

The transmitter is calibrated at operational static pressure. Adjustments may be performed.

3) "Footprint test"

A "footprint" of the transmitter's range at atmospheric pressure is recorded.

NB: No adjustment is performed.

Offshore

1) Offshore "footprint" verification test

This includes a verification of the transmitter's "footprint" established onshore. This is done after the transmitter is installed.

The objective is to verify that no calibration shift has occurred during transportation from shore to platform.

If the "footprint" test is completed and results are within the set tolerance the transmitter is put in use.

2) Offshore "footprint" as found test

The test includes a verification of the transmitter's "footprint" after it has been used in process.

The objective with the test is to monitor output stability.

This test completes the period for the transmitter and it will be sent to shore for testing as stated under previous paragraph.

Testing is performed at 5 different points over the transmitter's range.

Outlined procedure for static pressure transmitters

These transmitters are calibrated offshore only (installed in the process).

Equipment

Pressure reference

AMETEK DWT (hydraulic).

Voltage measurement

Solartron 7150.

Procedure

Pressure is applied to the transmitter with the dead weight tester and transmitter output is measured in the control room across a 250 precision resistor at flowcomputer input.

Testing is performed at 5 different points over the transmitter's range.

4. PRACTICAL EXPERIENCE FROM APPLICATION OF ST3000

4.1 Application area

4.1.1 Process parameters and installation

Honeywell ST3000 transmitters are utilized in fiscal gas metering stations for measurement of differential pressure (DP) and line pressure in orifice meter runs.

Fiscal metering of gas on the Statfjord field includes 4 metering stations.

	No ST3000 DP	No ST3000 Line Pressure	Capacity of Station Approx (MSm3/D)
Statfjord "A"	6	3	7.67
Statfjord "B" Statpipe	4	2	5.5
Statfjord "B" UK-Offtake	4	2	3.0
Statfjord "C"	4	2	5.5

The flow measurement is performed in accordance with ISO 5167.

The applied ranges and estimated uncertainty for the transmitters are listed in table 1. Differential pressure measurement across the orifice plate is performed with two transmitters per meter run.

Table 1

	Range	Est. Uncertainty(%)
DP Transmitter A	0-100 mbar	0.3
DP Transmitter B	0-500 mbar	0.2
Line pressure transmitter	0-250 bar	0.25

4.2 Results from testing of transmitters

Prior to start up of Gas Sales from Statfjord the Operator (Mobil Exploration) performed a market survey in 1983 in order to select a high quality differential pressure transmitter. The uncertainty of measurement was emphasized and was considered to be the major checkpoint.

Honeywell supplied 3 ST3000 transmitters for testing.

The main objective with this test was to verify the manufacturers uncertainty specification including the output shift with varying static pressure.

4.2.1 Conclusion from market survey

The test revealed problems for one of the ST3000 test objects; it was found to be outside manufacturers specification.

However, the overall evaluation of the transmitters main features concluded that a cooperation should be established with Honeywell. The test objects were of the very first generation and further testing convinced us that we should choose ST3000 for the gas metering stations.

4.2.2 Test results from ambient temperature effect on DP measurement

In order to verify ambient temperature effect on differential pressure measurement it was decided to test 4 ST3000 DP-transmitters at various ambient temperatures.

Test Arrangement

The four transmitters were located in a thermal test chamber.

Pressure was applied (differential pressure over the transmitters range at a given static pressure) from a common pressure source. Transmitter output values were monitored with a digital voltmeter hooked up across a 250   resistor.

Monitoring of temperature in chamber was performed with a termo couple probe.

All test instruments have traceability to National Standards (UK).

Test procedure and objectives

The objective was to evaluate the transmitter measurement results over the temperature range of 0°C - 75°C at differential spans of 100, 200, 500 and 1000 mbar.

Calibration of transmitters were performed at room temperature and at 140 bar and atmospheric pressure. The upper range values were set before commencing the test at the four differential pressure spans.

Transmitters were exposed to 4 different ambient temperatures; nominal values: 0°C, 20°C, 50°C and 75°C.

The transmitters output results were recorded at each of the temperatures and at static pressures of 140 bar and atmospheric for the applied differential pressures over the range at 0%, 25%, 50%, 75%, 100% and 110% and the same testpoints down. This was done for all 4 spans.

Please refer to attached graphs (Fig. 3-6). Nominal testpoints were:

1, 2, 3, 4, 5 volts

Output signal was measured across a 250   resistor.

The discrepancies from the ideal value is presented in bar diagram.

We have attached results only for 2 transmitters from 4 tests.

Conclusion

Severe leakage problems in process head were revealed at $0^{o}C$ ambient temperature with three transmitters. The torque setting of the bolts were checked and the problem was rectified.

The manufacturers excuse to this problem was explained with the torque setting during the assemblance at the factory. Their quality assurance/quality control system obviously needed some improvement.

1 transmitter failed at a temperature in excess of $50^{o}C$.

With these described failures in mind users start to ask questions about the quality of the cells.

All our cells were checked for correct torquesetting and pressure tested (a calibration verification).

The ambient temperature in our application will most likely not exceed $50^{o}C$, so the overall conclusion will be based on the tests below $50^{o}C$.

If we exclude the leakage problem and failure for 1 cell at 75% the overall results from the test is good and may be summarized with the following values:

In general the temperature effect was better than ± 0.2% of calibrated range for a temperature range of $50^{o}C$. However, one cell indicated output within ± 0.3 of span over the same temperature range.

This test verified that the quoted estimated uncertainty in DP measurement was achieveable.

4.2.3 Test performed by other laboratories

Other independent test laboratories have performed testing on the ST3000 and the general conclusion is that the cells operates within manufacturers specification.

4.2.4 Stability in calibration

Ref. fig. 7-12, table 2 and calibration procedures.

The attached graphs represents comparison in test results from onshore calibration at static pressure and the "footprint" of the transmitter from one period to the next.

The results are presented as difference in output in % of span from one period to the next.

Two DP-cells and one gauge pressure transmitter are included in this presentation. These are typical for the transmitters in operation on Statfjord.

Conclusion

The transmitters have proven to be extremely stable in calibration. We have therefore reduced maintenance cost since the calibration intervals have so far been increased from every month to every second month, and foresee 3 monthly intervals in the future.

Table for transmitter monitoring:

Table 2

	Range	Ser. no.	Time in use	No. of Tests	No. of Adjustm.
DP Transmitter A	0-500 mbar	8525-004	Aug 85-Apr 87	8	1 at zero
DP Transmitter B	0-100 mbar	8511-020	Jul 85-Apr 87	7	1 at zero of span
P Transmitter C	0-250 bar	8510-031	8 months	8	None

4.2.5 Reliability and availability

After approximately 2.5 years months in operation with ST3000 we have had no downtime due to transmitter failures.

The transmitters have proven to be very reliable and based on our experience the availability rating is very high.

4.3. Summary and general conclusion for field experience

We faced some problems during the early stages of ST3000 applications and over the time the communication with the Honeywell vendor contained some negative statements concerning the quality of the transmitters.

However, these problems were resolved and the cooperation have been very good.

Comparing the transmitter with conventional instruments it was certainly a great improvement within process measurement field.

The transmitters have proven to be user friendly, reliable and the stability in calibration is very good.

The present calibration concept is under evaluation and based on the good quality of the instruments the calibration procedure may be simplified.

5 FUTURE TRENDS IN PROCESS MEASUREMENT

The future trends within the transmitter field indicates several new important developments. To our knowledge Honeywell was the first manufacturer who released transmitters with the smart concept. Since then other manufacturers have introduced transmitters with similar specifications.

For the pressure measurement the trend seem to divert into application of quartz crystal in standard field instruments for the process industry.

Application of microprocessors require digital techniques. Transmission from field to control room is performed via an analog signal. This requires D/A and A/D converters.

The new systems includes the option of digital transmission and thereby improves overall loop uncertainty.

Application of "intelligence" (microprocessors) in the primary elements is a very important improvement and is utilized for a number of different process parameter measurement. In future applications this concept will be applied to a large extent.

This will improve measurements and probably contribute to lower maintenance cost.

ST 3000 DIFFERENTIAL PRESSURE TRANSMITTER

1984 SPECIFICATION

Specifications

Operating Conditions

		Reference Condition	Rated Condition	Operative Limits	Transportation and Storage
Ambient Temperature	°C °F	25 ± 1 77 ± 2	− 40 to 85 − 40 to 185	− 40 to 93.3 − 40 to 200	− 55 to 125 − 67 to 257
Meter Body Temperature	°C °F	25 ± 1 77 ± 1	− 40 to 110* − 40 to 230	− 40 to 125 − 40 to 257	− 55 to 125 − 67 to 257
Humidity	%	10-55	—	0-100	—
Supply Voltage and Load Resistance		See Figure 2.			
Overpressure	psi	0	3000 psi	3000 psi	
In Vacuum Region	mm Hg Abs	atmospheric	atmospheric to 25	atmospheric to 2	

Performance Under Rated Conditions

Upper Range Limit	400 inches H_2O
Turndown Ratio	400:1
Minimum Span	1 in H_2O
Zero Elevation and Suppression	Regardless of output specified, zero elevation and suppression must be such that neither the span nor the upper or lower range value exceed 100% of the upper range limit. 4-20 mA dc maximum elevation: 40,000% of calibrated span. Maximum zero suppression: 39,900% of calibrated span.
Accuracy (Reference) (includes combined effects of linearity, hysteresis, and repeatability)	± 0.1% of calibrated span or upper range value, whichever is greater, terminal based. NOTE: Below 50 in H_2O accuracy equals $0.05 + \left(0.05 \times \frac{50 \text{ in } H_2O}{\text{span in } H_2O}\right)$
Combined Zero and Span Temperature Effect per 28°C (50°F)	± 0.25% of calibrated span, between reference span and Upper Range Limit. NOTE: Below 50 in H_2O accuracy equals $0.2 + \left(0.05 \times \frac{50 \text{ in } H_2O}{\text{span in } H_2O}\right)$
Combined Zero and Span Static Pressure Effect per 1000 psi	± 0.2% of the calibrated span, between reference span and Upper Range Limit. NOTE: Below 100 in H_2O accuracy equals $0.2\left(\frac{100 \text{ in } H_2O}{\text{span in } H_2O}\right)$
Hysteresis % of Span	0.02
Output (two-wire)	4 to 20 milliamps
Supply Voltage Effect	0.005% of span
Damping Time Constant	Adjustable from 0 to 32 seconds
RFI Protection (Standard)	20 to 1000 MHz at 30 volts per meter

Physical

Materials Process Interface	*Process Barrier Diaphragms:* 316 S.S., Hastelloy C-276, Monel *Process Head:* 316 S.S., Carbon Steel, Monel, Hastelloy *Head Gaskets:* Teflon *Bolting:* Carbon steel, 17-4 PH stainless steel
Mounting Bracket	Carbon Steel (zinc plated)
Fill Fluid	Silicone oil or fluorolube
Electronic Housing	Low Copper Aluminum Meets NEMA 4 (watertight) and NEMA 7 (explosion-proof)
Process Connections	1/4 inch NPT (optional 1/4 inch PT)
Wiring	Accepts up to 16 AWG (1.5 mm diameter)
Mounting	See Figure 3.
Dimensions	See Figure 4.
Net Weight	7 Kg (15.4 pounds)
Hazardous Conditions	Designed to meet requirements of explosion-proof and intrinsically safe systems for North American classifications Class I, Group A, B, C, and D, Division I and European EEX, ia, II, C, T6. Contact Fort Washington for approval body codes

*For fluorolube fill fluid, the rating is − 15 to 110°C (5 to 230°F).

ST 3000 DIFFERENTIAL PRESSURE TRANSMITTER

1987 SPECIFICATION

Specifications

Operating Conditions

		Reference Condition	Rated Condition	Operative Limits	Transportation and Storage
Ambient Temperature	°C	25 ± 1	−40 to 85	−40 to 93	−55 to 125
	°F	77 ± 2	−40 to 185	−40 to 200	−67 to 257
Meter Body Temperature	°C	25 ± 1	−40 to 110*	−40 to 125	−55 to 125
	°F	77 ± 1	−40 to 230	−40 to 257	−67 to 257
Humidity	%	10-55	0-100	0-100	0-100
Supply Voltage and Load Resistance		(See Figure 2.)			
Overpressure	psi	0	3000 psi (210 bar)	3000 psi (210 bar)	
In Vacuum Region (Min Press.)	mm Hg Abs	atmospheric	25	2 (Short term)	

Performance Under Rated Conditions

Upper Range Limit	400 in H_2O (1000 mbar)
Turndown Ratio	400:1
Minimum Span	1 in H_2O (2.5 mbar)
Zero Elevation and Suppression	No limit (except minimum span) within ±100% URL. Specifications valid from −5% to +100% URL.
Accuracy (Reference) (Includes combined effects of linearity, hysteresis, and repeatability)†**	*Analog Mode :* ±0.10% calibrated span or upper range value (URV), whichever is greater, terminal based. For URV below reference span (25 in H_2O) accuracy equals : $0.05 + \left(0.05 \times \frac{25 \text{ in } H_2O}{\text{span in } H_2O}\right)$ or $0.05 + \left(0.05 \times \frac{62 \text{ mbar}}{\text{span mbar}}\right)$ in % span *Digital Mode :* ±0.075% span / ±0.15% reading See Digital Communications Mode Specification 34-ST-03-27 for explanations of transmitter accuracy and system accuracy.
Combined Zero and Span Temperature Effect per 28°C (50°F)**	*Analog Mode :* ±0.175% of span. For URV below reference span (50 in H_2O) effect equals : $0.125 + \left(0.05 \times \frac{50 \text{ in } H_2O}{\text{span in } H_2O}\right)$ or $0.125 + \left(0.05 \times \frac{125 \text{ mbar}}{\text{span mbar}}\right)$ in % span *Digital Mode :* ±0.125% reading For readings below reference span (50 in H_2O) effect equals : $0.075 + \left(0.05 \times \frac{50 \text{ in } H_2O}{\text{rdg in } H_2O}\right)$ or $0.075 + \left(0.05 \times \frac{125 \text{ mbar}}{\text{rdg mbar}}\right)$ in % reading
Combined Zero and Span Static Pressure Effect per 1000 psi	*Analog Mode :* ±0.2% of span, except 0.2 in H_2O (0.5 mbar) minimum. Typical performance is ±0.1%, except 0.06 in H_2O (0.15 mbar) minimum with stainless steel diaphragms. *Digital Mode :* Same except in % reading
Output (two-wire)	4 to 20 milliamps, or digital communications mode
Supply Voltage Effect	0.005% of span per volt
Damping Time Constant	Adjustable from 0 to 32 seconds digital damping
RFI Protection (Standard)	Negligible effect (20 to 1000 MHz at 30 volts per meter)

Physical

Materials	
Process Interface	*Process Barrier Diaphragms :* 316L SS, Hastelloy C-276, Monel, Tantalum *Process Head :* 316 SS, Carbon Steel, Monel, Hastelloy *Head Gaskets :* Teflon, Viton *Bolting :* Carbon steel, A-286 SS (NACE)
Mounting Bracket	Carbon Steel (zinc plated)
Fill Fluid	Silicone oil or CTFE (chlorotrifluoroethylene)
Electronic Housing	Low Copper Aluminium Meets NEMA 4 (watertight) and NEMA 7 (explosion-proof)
Process Connextions	1/4 inch NPT (optional 1/2 NPT with adapter)
Wiring	Accepts up to 16 AWG (1.5 mm diameter)
Mounting	(See Figure 3.)
Dimensions	(See Figure 4.)
Net Weight	7 Kg (15.4 pounds)
Hazardous Conditions	Designed to meet requirements of explosion-proof and intrinsically safe systems for North American classifications Class I, Groups A, B, C and D, Division (explosion-proof systems, Groups B, C, D only), European (CENELEC) EEX, ia, IIC, T6 and BASEEFA Type N.

* For CTFE fill fluid, the rating is −15 to 110°C (5 to 230°F).
** Specification does not apply to ST 3000 with tantalum barrier diaphragms.
† Accuracy includes residual error after averaging successive readings.

Specifications

Operating Conditions

		Reference Condition	Rated Condition	Operative Limits	Transportation and Storage
Ambient Temperature	°C	25 ± 1	− 40 to 85	− 40 to 93.3	− 55 to 125
	°F	77 ± 2	− 40 to 185	− 40 to 200	− 67 to 257
Meter Body Temperature	°C	25 ± 1	− 40 to 110*	− 40 to 125	− 55 to 125
	°F	77 ± 1	− 40 to 230*	− 40 to 257	− 67 to 257
Humidity	%	10-55	10-90	0-100	
Supply Voltage and Load Resistance		See Figure 2.			
Overpressure	psi	0	9,000 psi (620 bar)	9,000 psi (620 bar)	
In Vacuum Region	mm Hg Abs	atmospheric	atmospheric to 25	atmospheric to 2	

Performance Under Rated Conditions

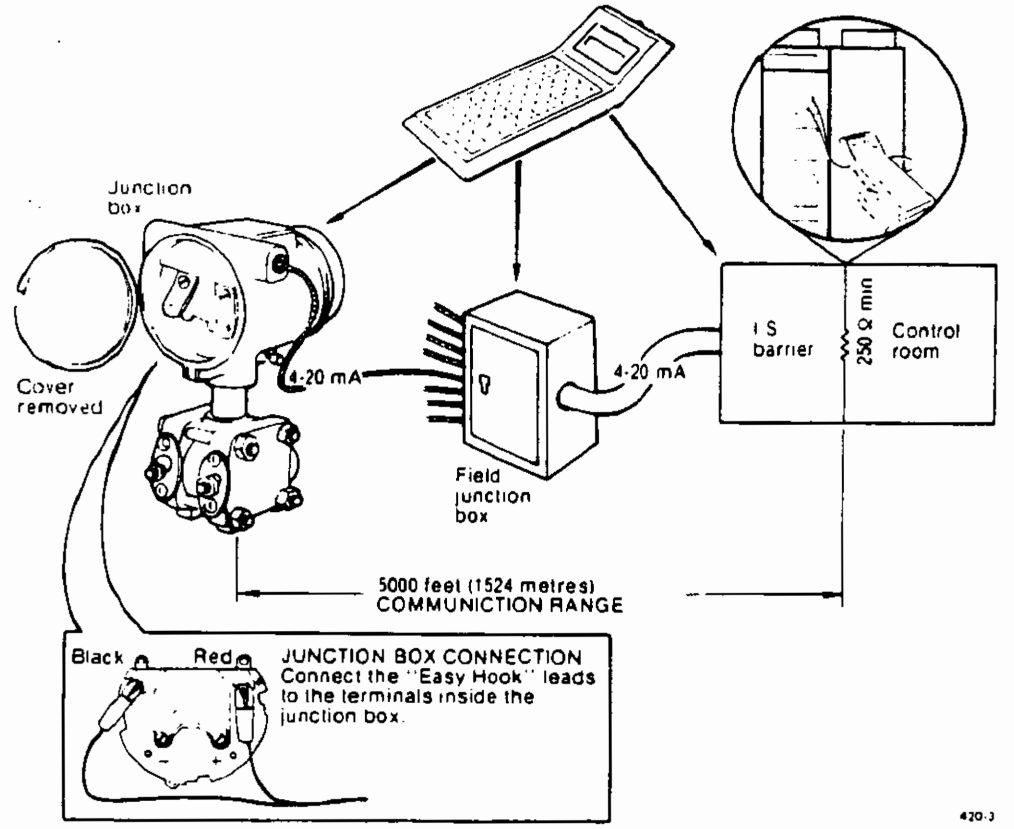
Upper Range Limit	6,000 psi (415 bar)
Turndown Ratio	60:1
Minimum Span	100 psi (7 bar)
Zero Elevation and Suppression	Regardless of output specified, zero elevation and suppression must be such that neither the span nor the upper or lower range value exceed 100% of the upper range limit. Maximum Zero Elevarion: 14.7% of calibrated span. Maximum zero suppression: 5,900% of calibrated span.
Accuracy (Reference) (includes combined effects of linearity, hysteresis, and repeatability)	± 0.15% of calibrated span or upper range value, (URV) whichever is greater, terminal based. NOTE: For URV below 1000 psi accuracy equals $0.10 + \left(0.05 \times \frac{1000\text{ psi}}{\text{span in psi}}\right)$ or $0.10 + \left(0.05 \times \frac{70\text{ bar}}{\text{Span in bar}}\right)$
Combined Zero and Span Temperature Effect per 28°C (50°F)	0.25% of calibrated span. NOTE: For URV below 1000 psi effect equals $0.2 + \left(0.05 \times \frac{1000\text{ psi}}{\text{span in psi}}\right)$ or $0.2 + \left(0.05 \times \frac{70\text{ bar}}{\text{Span in bar}}\right)$
Output (two-wire)	4 to 20 milliamps
Supply Voltage Effect	0.005% of span per volt
Damping Time Constant	Adjustable from 0 to 32 seconds digital damping
RFI Protection (Standard)	Negligible (20 to 1000 MHz at 30 volts per meter)

Physical

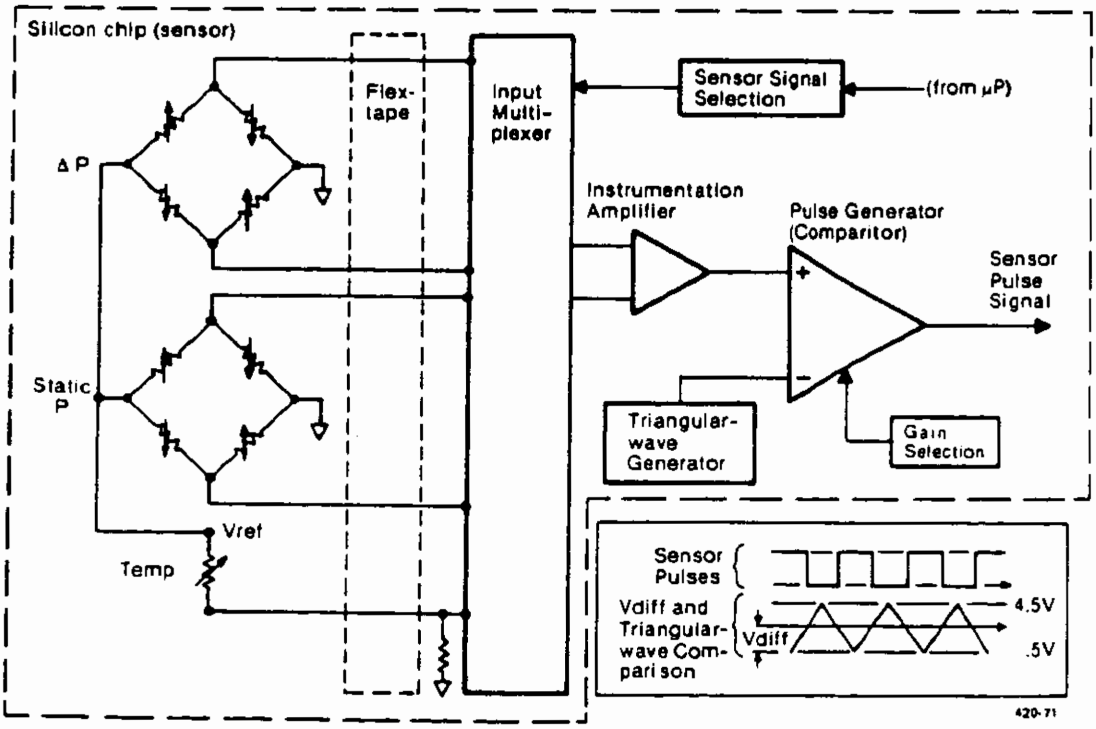
Materials	
Process Interface	*Process Barrier Diaphragms:* 316L S.S., Hastelloy C-276, Monel *Process Head:* 316 S.S., Carbon Steel *Head Gaskets:* Teflon, Viton *Bolting:* Carbon steel, 17-4 PH stainless steel
Mounting Bracket	Carbon Steel (zinc plated)
Fill Fluid	Silicone oil or fluorolube
Electronic Housing	Low Copper Aluminum Meets NEMA 4 (watertight) and NEMA 7 (explosion-proof)
Process Connections	1/2 inch NPT
Wiring	Accepts up to 16 AWG (1.5 mm diameter)
Mounting	See Figure 3.
Dimensions	See Figure 4.
Net Weight	6.5 Kg (14 pounds)
Hazardous Conditions	Designed to meet requirements of explosion-proof and intrinsically safe systems for North American classifications Class I, Group A, B, C, and D, Division I and European (CENELEC) EEX, ia, IIC, T6. Contact Fort Washington for approval body codes.

*For Fluorolube fill fluid the rating is − 15 to 110°C (5 to 230°F).

FIG 1



SFC AND SMART TRANSMITTER COMMUNICATION LOOP



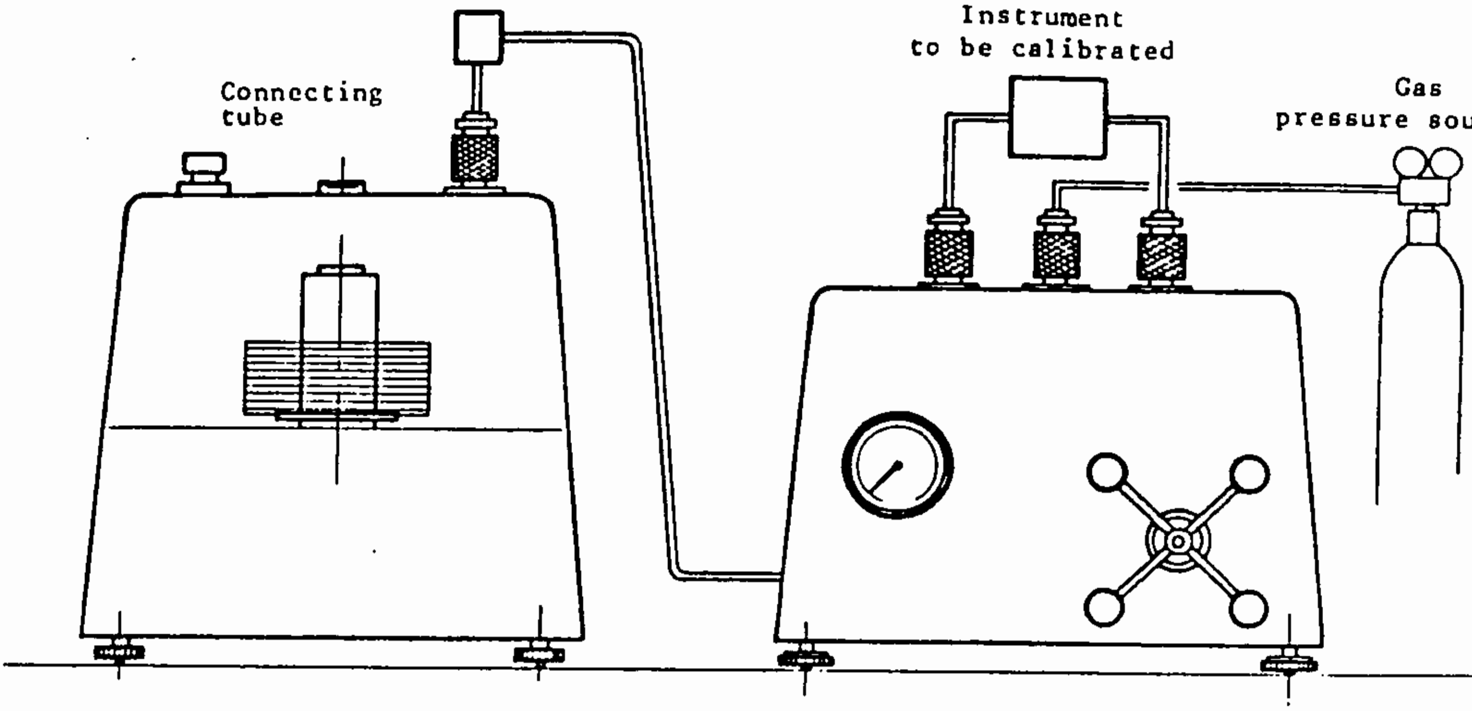
SENSOR SIGNAL SELECTION AND A/D CONVERTION

Schematic

1) PRESSURE

DIVIDER MODEL 1500

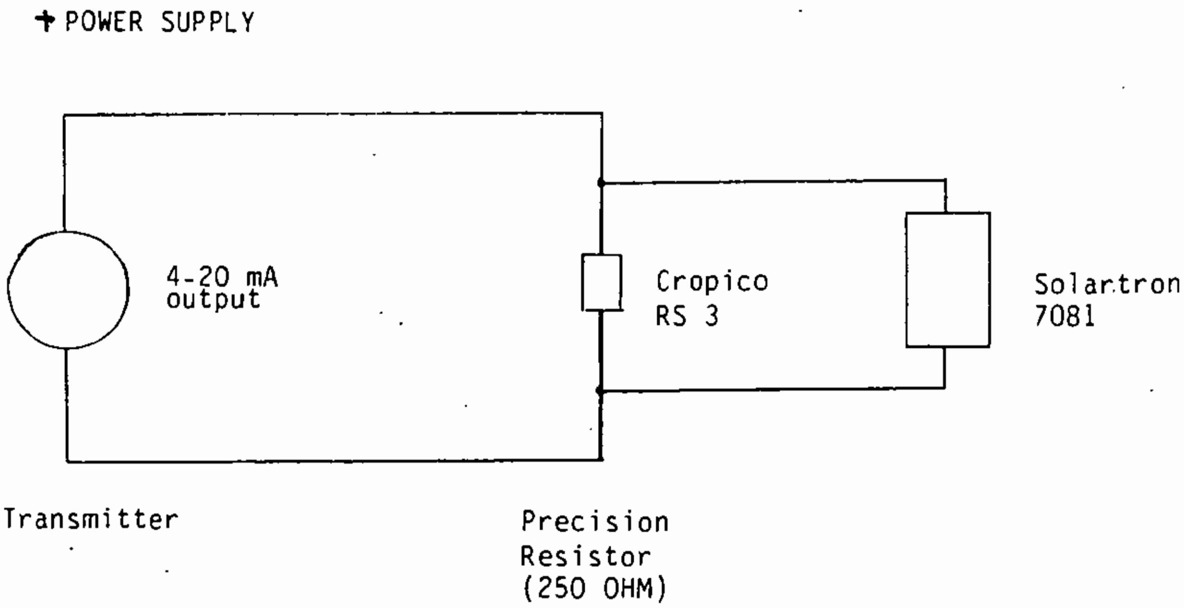
Installation Schematic



Oil-operated standard
Type 5300

Divider Model 1500

2) ELECTRICAL



Calibration hook-up fig.

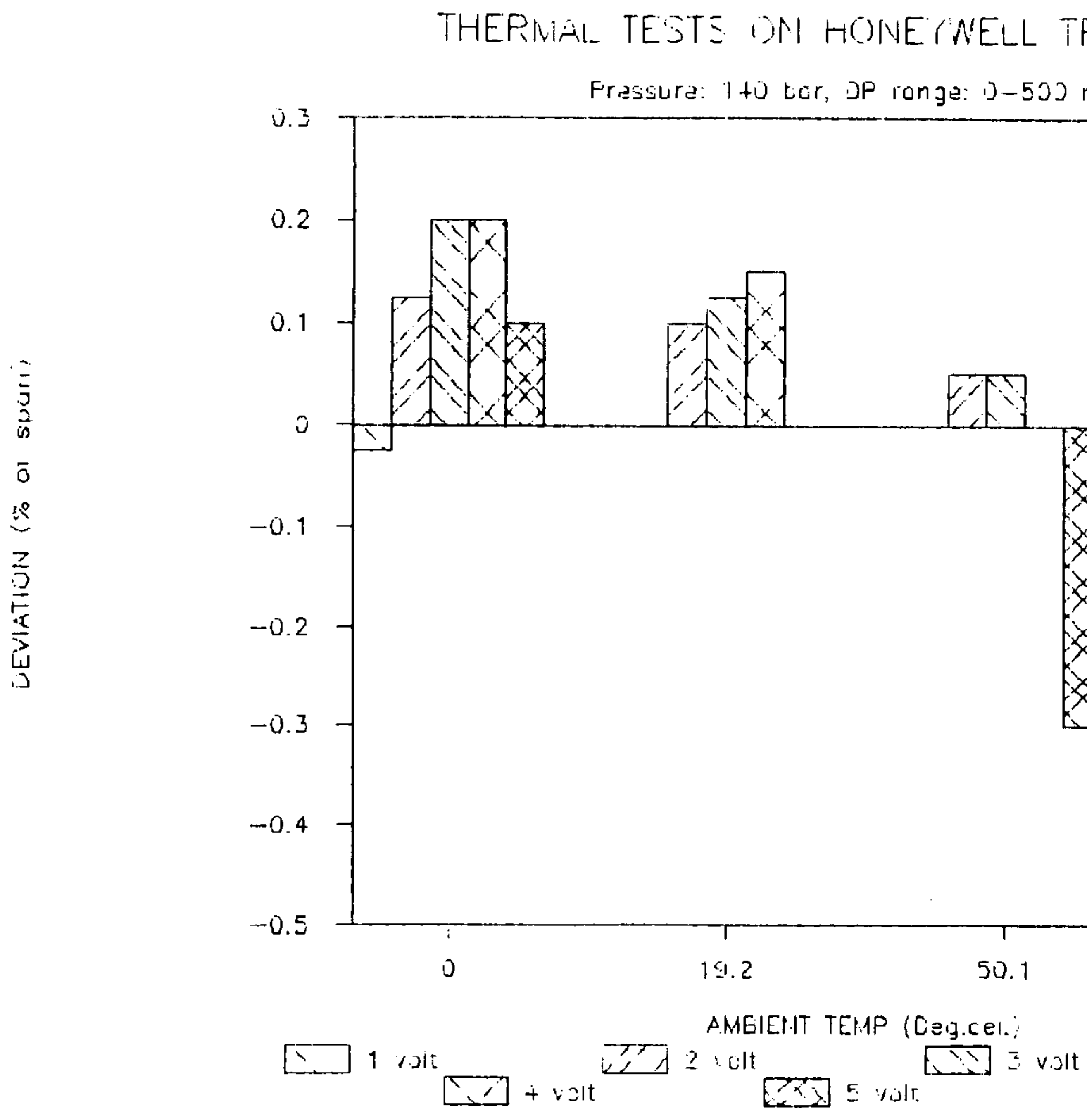


FIG 3 SER..NO:8525-008

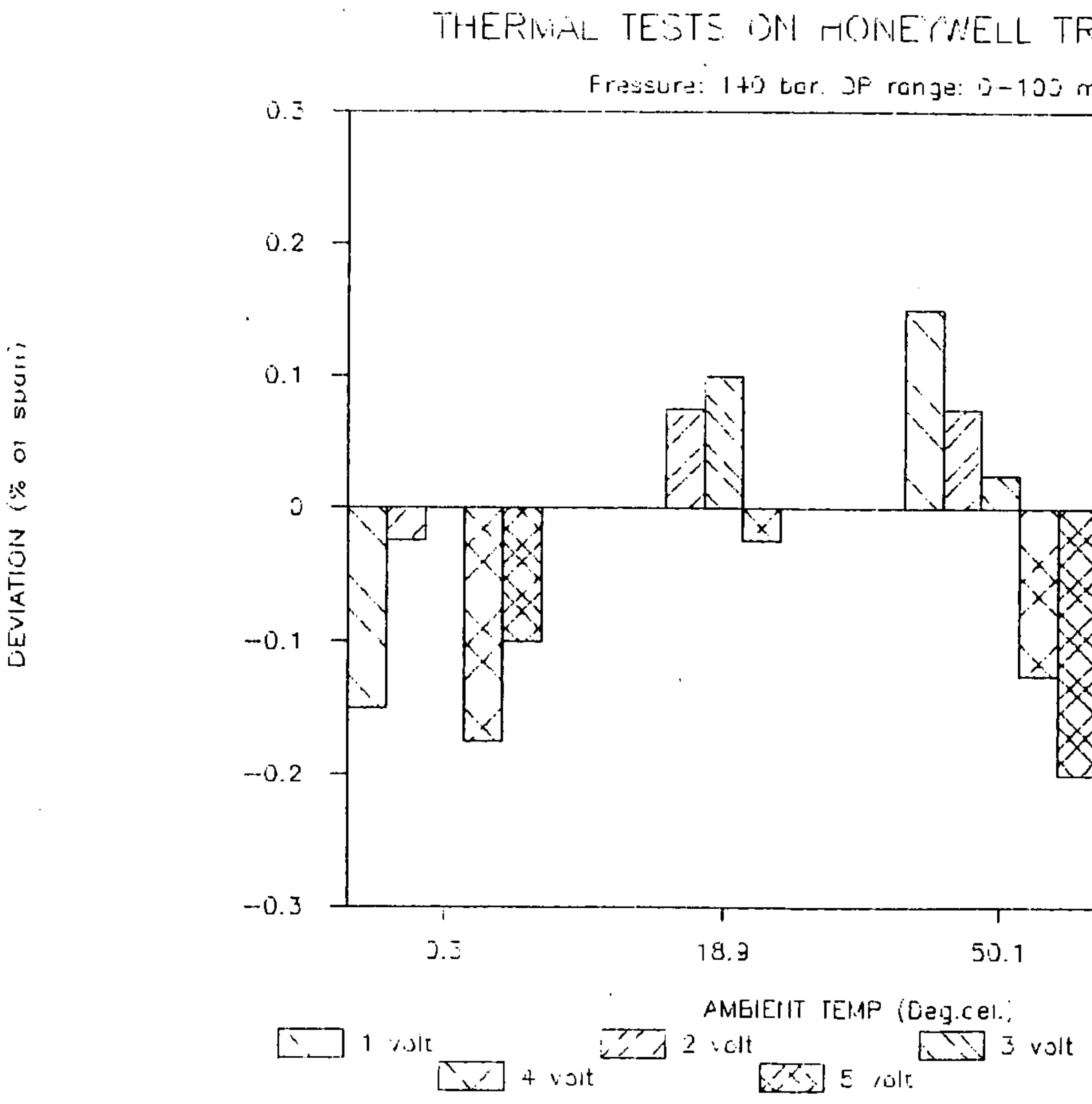


FIG.4 SER.NO:8525-008

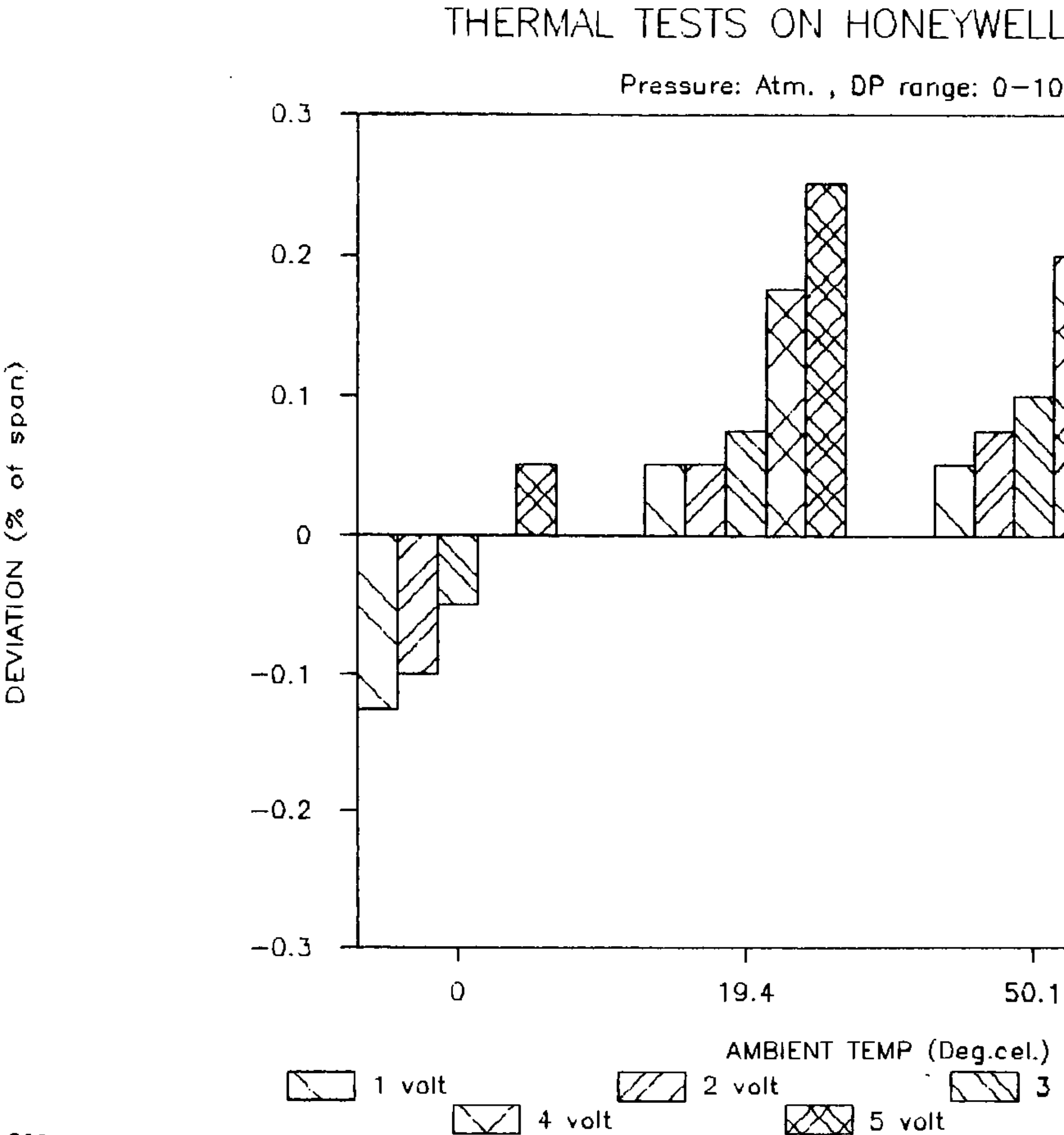


FIG5

SER.NO:8511-003

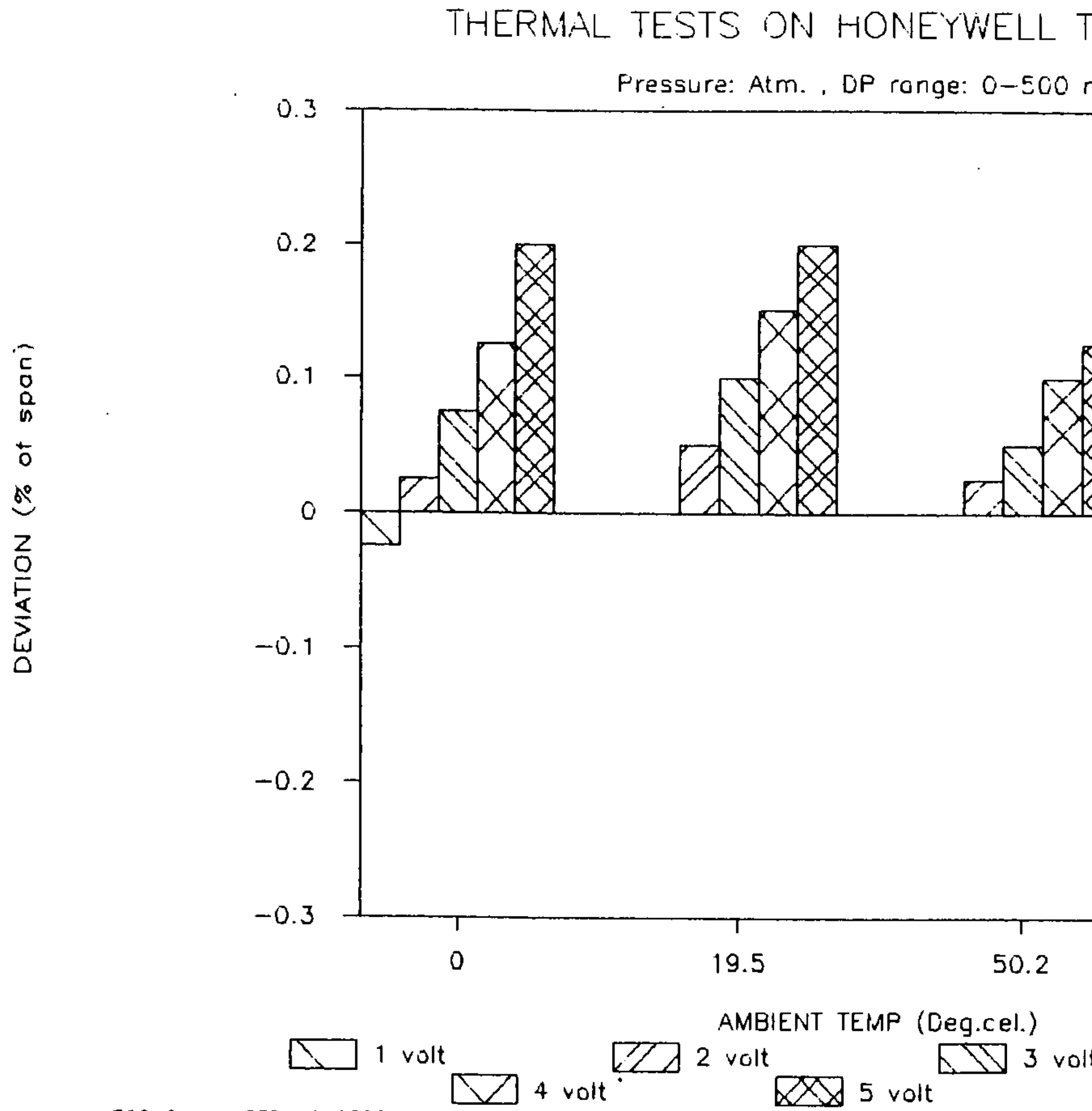


FIG 6 SER.NO:8511-003

FISCAL METERING - TEST SERIES
OVERVIEW ONE CYCLE
DP-TRANSMITTER
HONEYWELL SMART

| ONSHORE STATIC PRESSURE TEST/CALIBRATION
| ONSHORE FOOTPRINT TEST
| OFFSHORE FOOTPRINT TEST
| OFFSHORE AS FOUND FOOTPRINT TEST

START P

| ONSHORE ATMOSPHERIC TEST
| ONSHORE STATIC PRESSURE TEST/CALIBRATION
| ONSHORE FOOTPRINT TEST
| OFFSHORE FOOTPRINT TEST
| OFFSHORE AS FOUND FOOTPRINT TEST

1. PERIO

| ONSHORE ATMOSPHERIC TEST

2. PERIO

FIG 7

HONEYWELL SMART 3

DIFFERENTIAL PRESSURERANGE :

Serial no 8525 - 004

Onshore Footprint Test

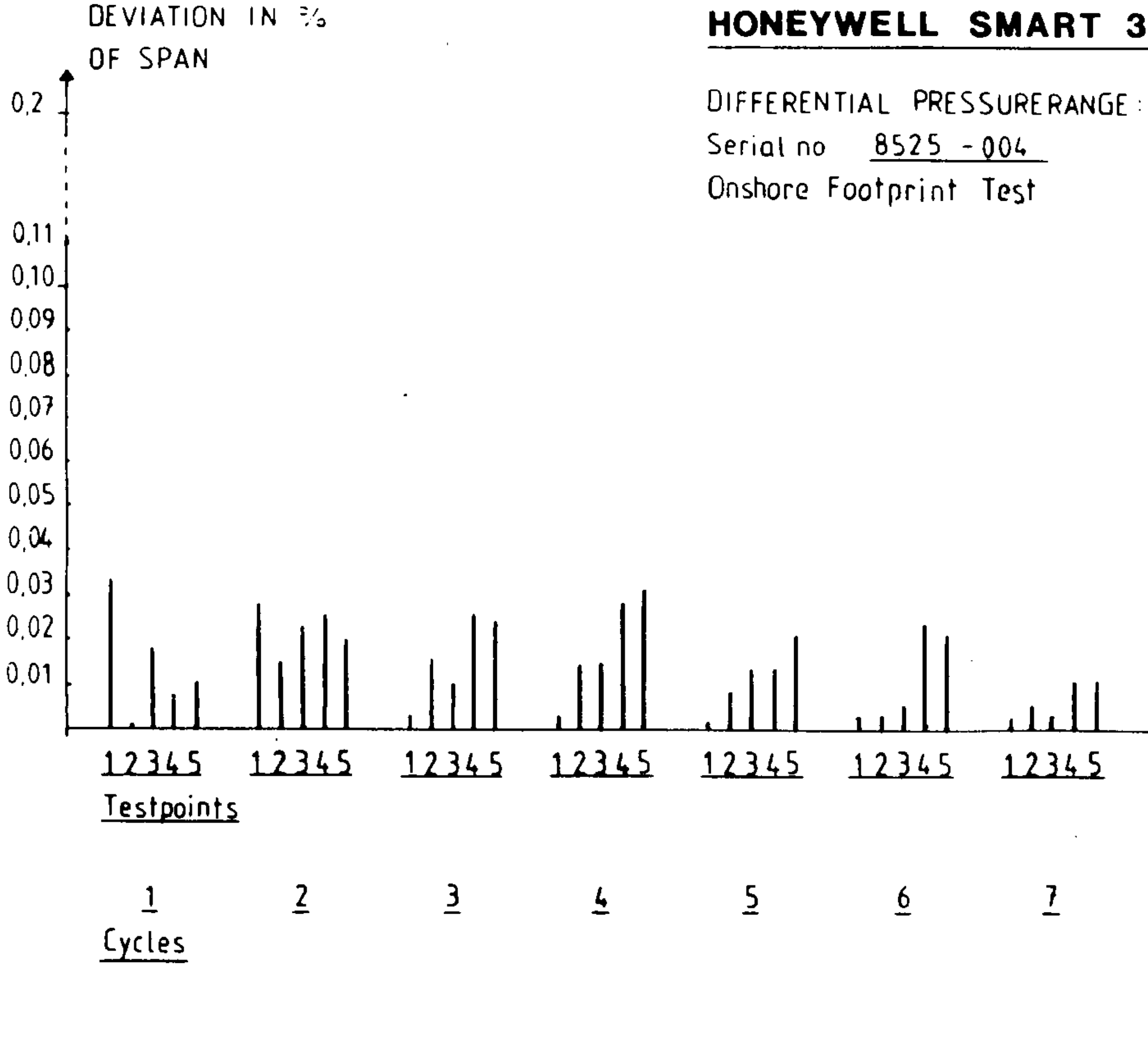


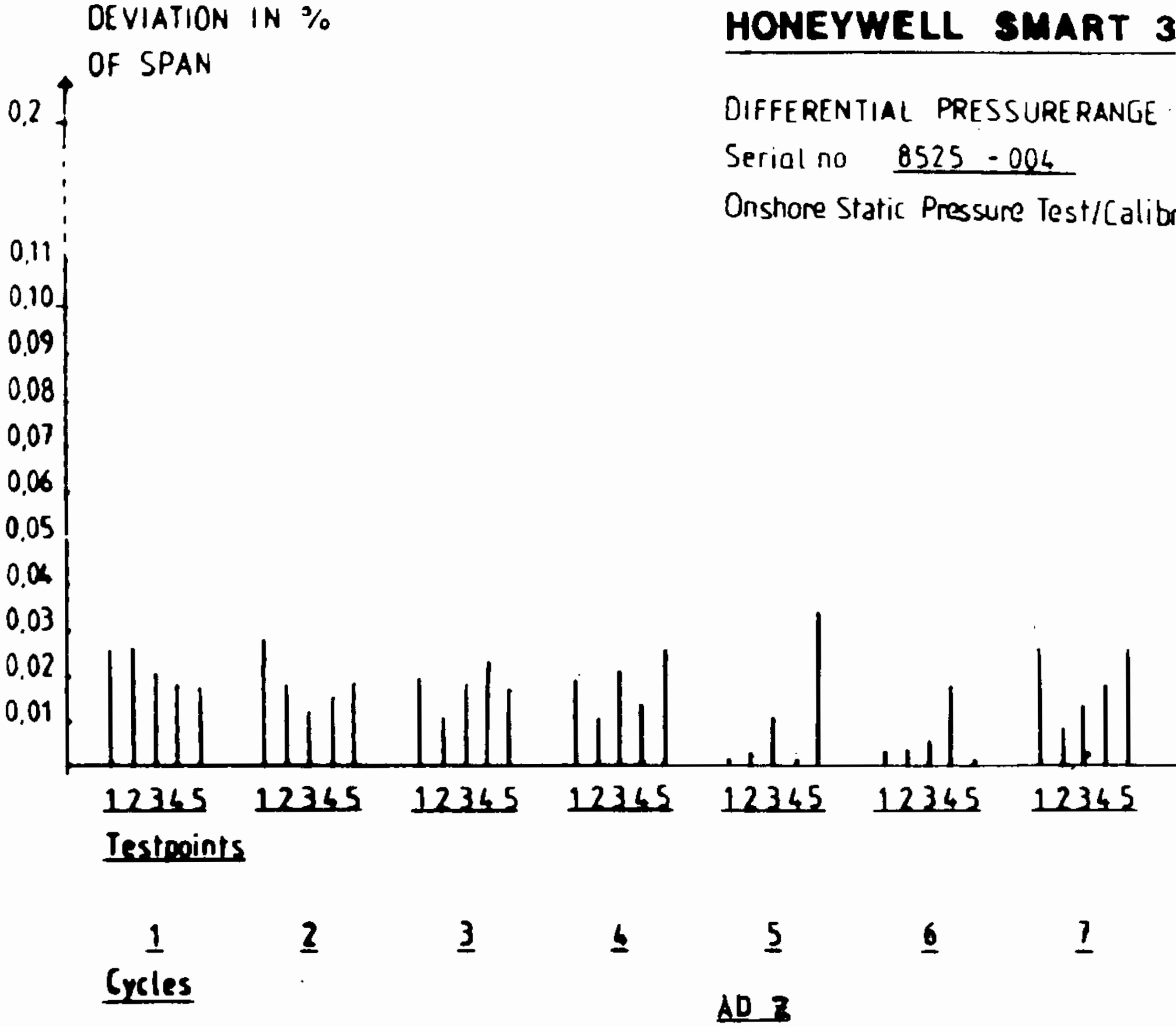
FIG 8

HONEYWELL SMART 3

DIFFERENTIAL PRESSURERANGE

Serial no 8525 - 004

Onshore Static Pressure Test/Calibr



AD 2

FIG 9

HONEYWELL SMART 3

DIFFERENTIAL PRESSURERANGE : 0

Serial no. : 8511 - 020

Onshore Footprint Test

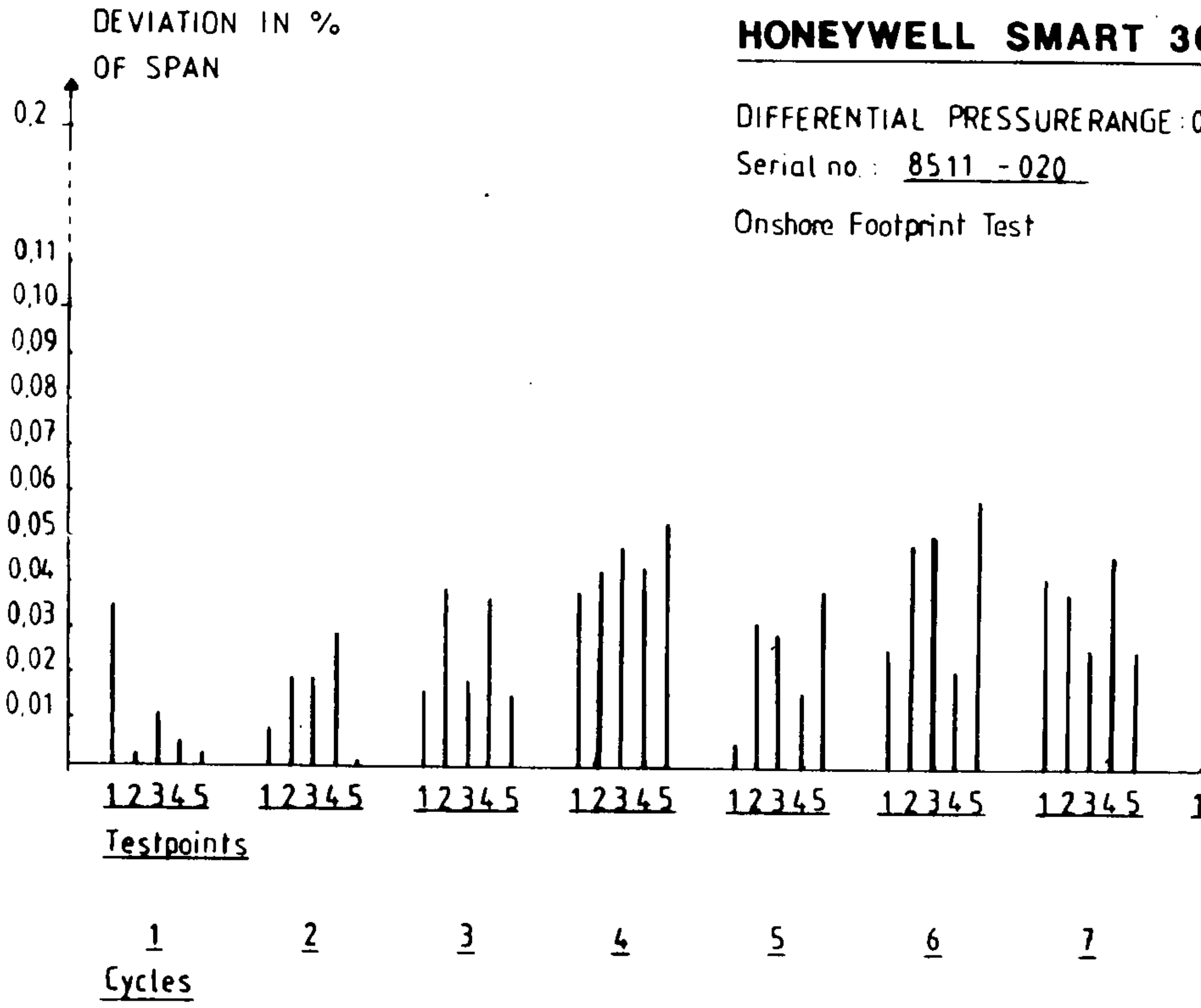


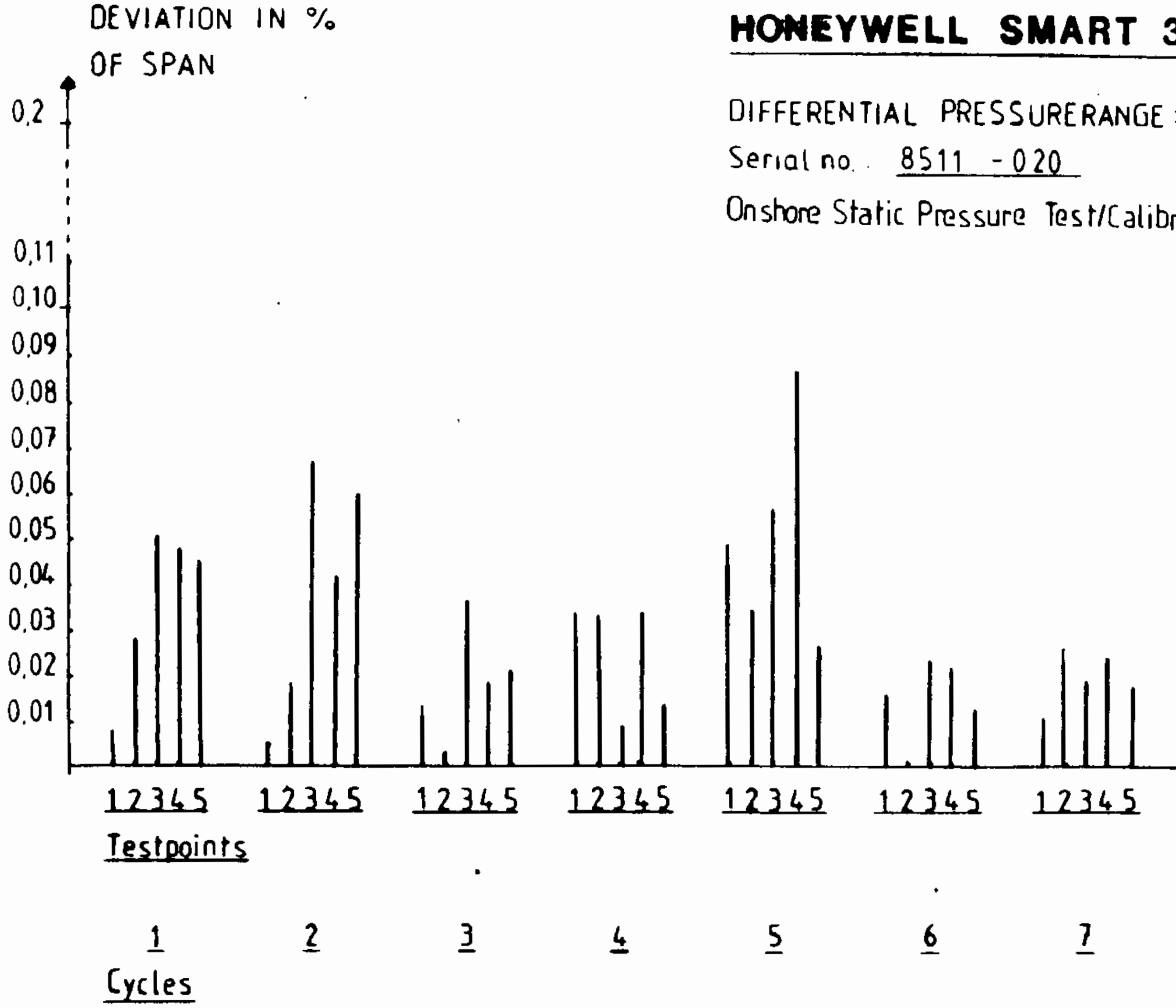
FIG 10

HONEYWELL SMART 3

DIFFERENTIAL PRESSURERANGE :

Serial no. 8511 - 020

Onshore Static Pressure Test/Calibr



AD 2-5

FIG 11

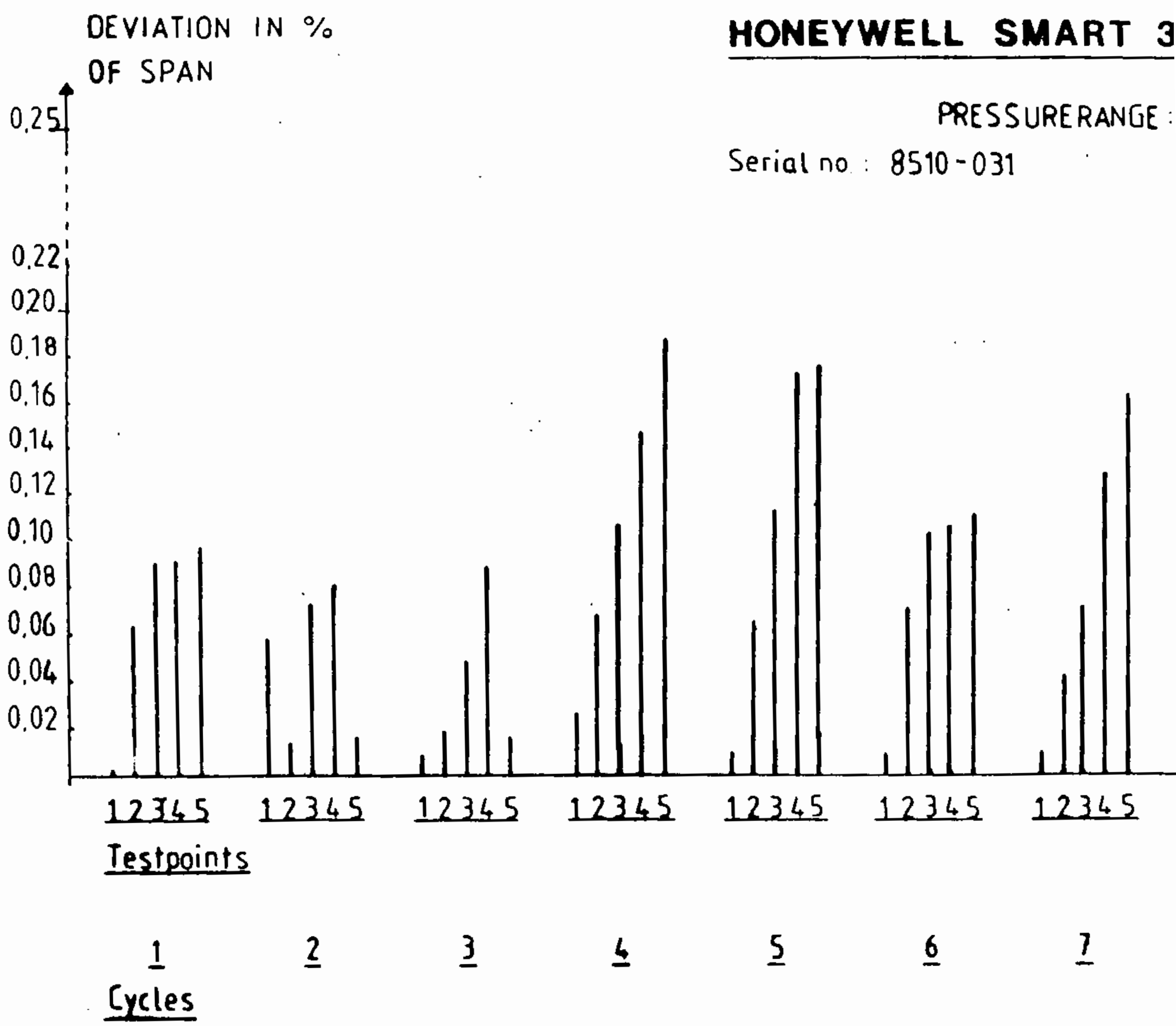

DEVIATION IN %
OF SPAN
HONEYWELL SMART 3
PRESSURERANGE :
Serial no. : 8510-031
0,25
0,22
0,20
0,18
0,16
0,14
0,12
0,10
0,08
0,06
0,04
0,02
12345
12345
12345
12345
12345
12345
12345
Testpoints
1
2
3
4
5
6
7
Cycles

FIG 12

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.