



**Norwegian Society of
Chartered Engineers**

NORTH SEA FLOW METERING WORKSHOP

Rica Maritim Hotel, Haugesund

October 24-26, 1989

**"Quartz Pressure Standards for high-performance
measurements and automatic transmitter calibration"**

Lecturer:

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PTL A/S

NEW APPLICATIONS FOR

DIGIQUARTZ®

PRESSURE SENSORS.

THE QUARTZ PRESSURE SET

A COMPLETE SYSTEM FOR HIGH-PERFORMANCE PRESSURE MEASUREMENTS

You may already know that DIGIQUARTZ® are pressure sensors with superior accuracy, proven stability and ruggedness. Now there is a new version for applications in hazardous areas and with direct computer interfacing.

The Intrinsic safe DIGIQUARTZ® transducers and PTL signal telemetry package transmits real-time quartz pressure and temperature data through a centre conductor or a two-wire, shielded-electric line.

The Quartz Pressure Set give you the possibility to replace existing low or medium accuracy transducers or transmitters with high accuracy DIGIQUARTZ® sensors and communication on RS232 data format. All this with minimal modification to existing analog sensor installations.

- * **TWO-WIRE FIELD MOUNTED QUARTZ PRESSURE SET**
Ideal for installations where central data processing and control are required. Minimal installation costs.
- * **HAZARDOUS AREA INSTALLATION**
Intrinsically safe when used with approved safety barrier.
- * **HIGH-PERFORMANCE PRESSURE MEASUREMENTS**
0.01 % accuracy, 5×10^{-8} resolution, calibrated over wide temperature range.
- * **INTERFACE TO PAROSCIENTIFIC INC. PRESSURE PRODUCTS**
The Quartz Pressure Set interface directly to model 700 Pressure Computer and series 1000 Intelligent Transmitters.
- * **CONDITIONED QUARTZ CRYSTAL FREQUENCY OUTPUTS**
Conditioned signal to drive a frequency counter.

FEATURES AND APPLICATIONS

The two-wire field mounted Quartz Pressure Set, with DIGIQUARTZ® or Well Test Instruments, Inc. sensor, are designed to continuously measure pressure in industrial processes.

The set includes all the circuitry necessary for the measurement and transmission of a modulated current signal representing the sensor crystal pressure and temperature output frequency. The conditioned signal can be processed by a data acquisition system by including a Universal Counter or directly by a Paroscientific, Inc. model 700 Pressure Computer or series 1000 Intelligent Transmitter. The series 1000 Intelligent Transmitters have remote control option and makes all information and communication available on a RS232 interface port.

Pressure sensors are available in full scale absolute pressure ranges from 15 psi through 10,000 psi and may be calibrated over wide temperature range.

The field mounted electronic printed circuits are protected from the environment by weather-proof, corrosion resistant enclosures. No field calibration is required. The system is certified intrinsically safe when installed with an approved barrier.

SOME PETROLEUM INDUSTRY APPLICATIONS:

- * Onshore and offshore precise pressure measurements.
- * Pressure calibration systems
- * Pressure standards for oil and gas metering stations.
- * Energy exploration and well testing applications.

OTHER APPLICATIONS:

- * Deep-sea oceanographic experiments.
- * Draught measurements.
- * Sub-sea wellhead pressure measurements
- * Center conductor, armoured-electric line applications.

HOW IT WORKS

The vital components in the Quartz Pressure Set are; DIGIQUARTZ Quartz pressure sensor with built in quartz temperature sensor, STX Signal Converter and SDX Signal Decoder. The STX and SDX represents the telemetry package.

The quartz crystal resonator in the pressure sensor changes its resonance frequency as a function of applied pressure. However, temperature changes also. The built in quartz temperature sensor, which is protected from the applied pressure, detects thermal gradients within the pressure sensing element and its output signal is used for thermal compensation of the measured pressure signal.

Specifically designed to process the pressure and temperature -related signals from DIGIQUARTZ® or Well Test Instruments, Inc. sensors, and part of the PTL Signal Telemetry Package, the STX Signal Converter condition and transmit the frequency signals through a center conductor or a two-wire electric line to a signal decoder. The Signal Converter also supplies dc operating power to the sensor.

The SDX Signal Decoder operates as the Telemetry Package Receiver. The SDX decode and conditions the signal to drive a frequency counter or a Paroscientific Inc. pressure computer board. Abnormal operating condition is indicated by two LED's; one indicates loss of pressure signal and the other indicates loss of temperature frequency.

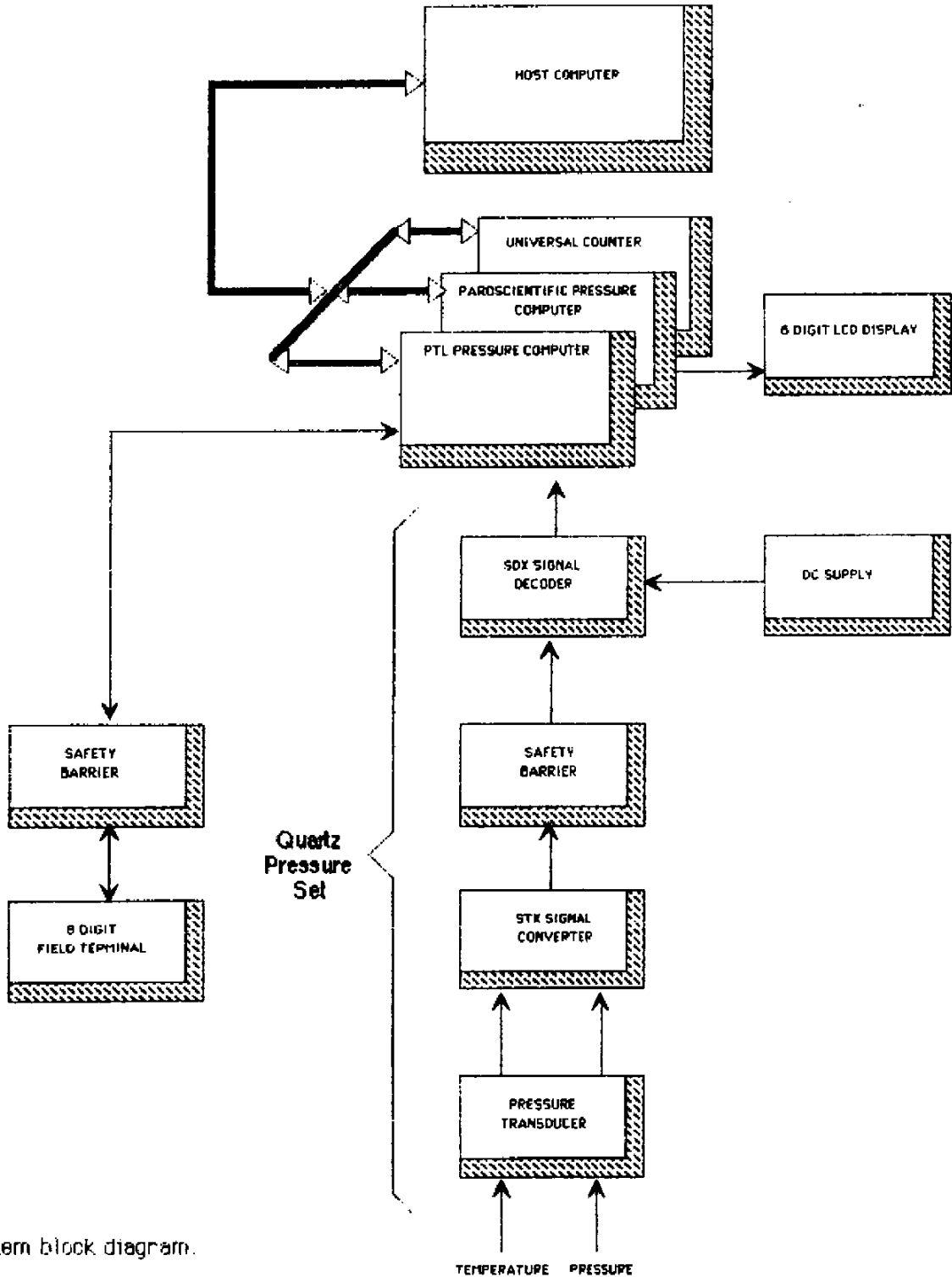
The SDX Signal Decoder supplies dc operating power to the STX Signal Converter and require no adjustments or tuning during operation

The pressure and temperature related outputs from the SDX Signal Decoder can drive a frequency counter, or if directly connected to a Series 1000 Intelligent Transmitter card present RS232 pressure data for direct communication to any computer using this data format.

The counters signal can be converted to pressure and temperature readings when processed with the calibration data in a desktop computer

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Quartz Pressure Standards Configuration.

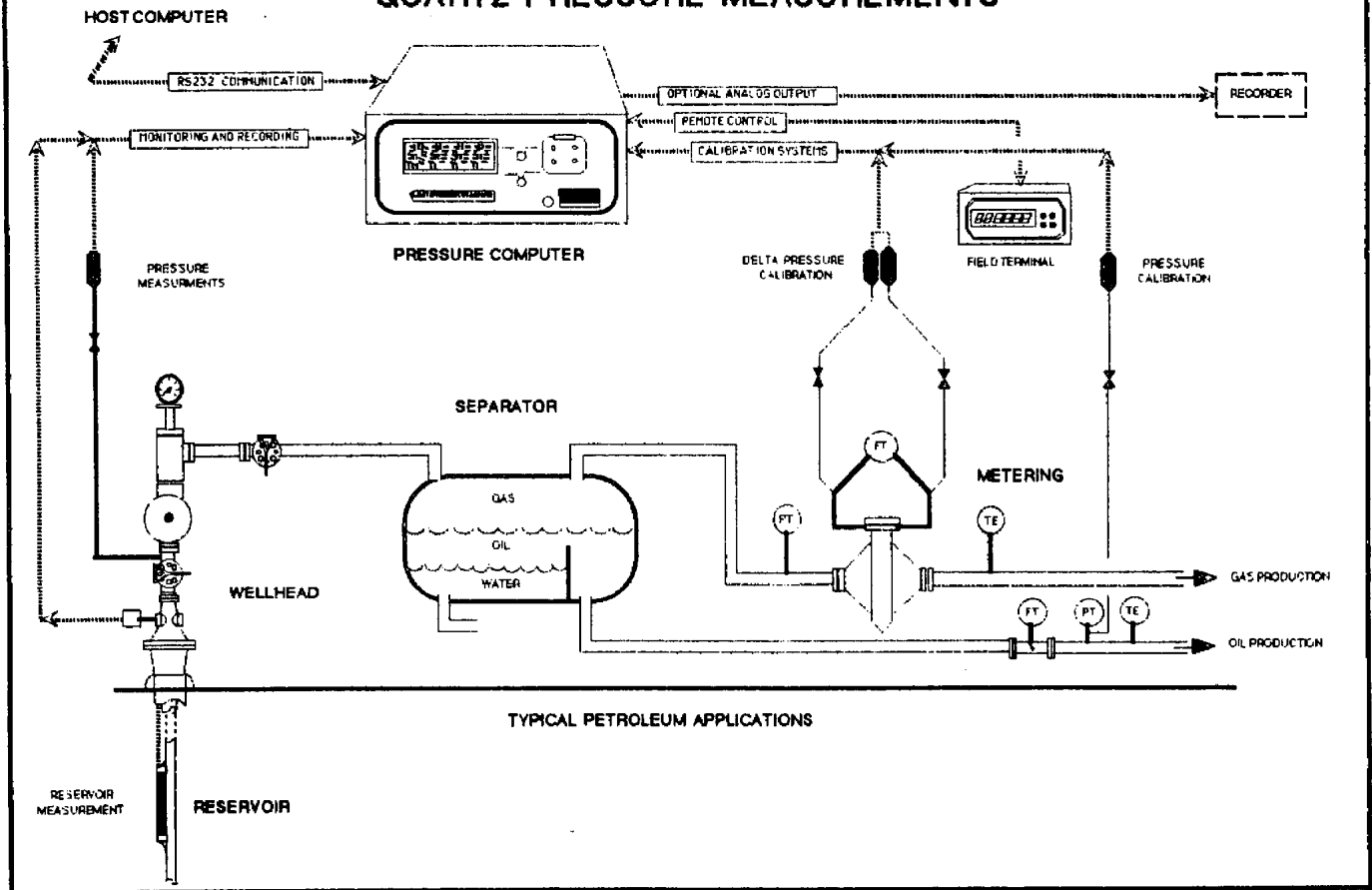


System block diagram.

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QUARTZ PRESSURE MEASUREMENTS



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THE Series 1004 DIGITAL PRESSURE COMPUTER CONCEPT

Released Oct. 1989

The first transfer standard that can read absolute, gage and differential pressures up to 10000 psi line pressure.

This test set is specifically designed to meet the pressure calibration requirements of the offshore metering workshop. Designed for shop and field applications, it uses rugged quartz pressure transducers (Digiquartz®) combined with monoconductor telemetering to provide excellent accuracy, resolution and long-term stability.

The PTL Series 1004 Pressure Computer allows *in situ* calibration of transducers and transmitters in absolute, gage or differential pressure mode over a wide pressure range when using the Quartz Pressure Set technology. A remote Field Terminal assists the *in situ* operation.

Each unit is uniquely designed for the customer's pressure application and you need no longer have to sacrifice accuracy to get portability or precise measurements from harsh environments.

The 1004 Pressure Computer is self contained with dc supplies to the sensors, the telemetry package and the Field Terminal. Each of the field mounted units operates on a traditional two-wire transmitter electric line.

The local 1004 front panel and the remote terminal prompts the operator(s) through the calibration and system operation.

Complete automation of calibrations are possible when connected to a host computer.

The unit is supplied with built-in House-Keeping functions such as; signal error detection, audible pressure alarm, a *Rezeroing* process that improves long-term stability, Key-Lock functions, one protecting the transducer calibration coefficients and one disabling manual system operation, and finally a software *Overpressure Event Recorder* to avoid system use if sensors have been bursted and to improve system reliability.

The unit may be delivered as portable.

Accuracy to 0.01 % FS - and intrinsic safe.

The maximum uncertainty for the linearity, repeatability, hysteresis and temperature compensation is the three sigma value of 0.01 % FS. This includes temperature compensation over the entire operating range without further correction.

In addition to the accuracy specification, the stability and sensitivity slope is better than 0.01 % FS per year. By using the Series 1004 Pressure Computer and the

built-in Rezeroing function stability and sensitivity effects are nearly eliminated. These uncertainty specifications are valid for all pressure ranges from 15 psi through 10000 psi.

The uncertainty for the differential pressure mode is based on simple error analyses of the quartz pressure sensors. Each sensor are digitally calibrated. The digital calibration is performed without potentiometers or analog adjustments; constants are stored and secured in the 1004 EEPROM.

The rate of conformity or nonconformance is small and indicating a boundary of 0.05 mBar differential pressure uncertainty. Differential pressure uncertainty is not affected by the line pressure and is valid for line pressures above 0.1 percent of transducer full scale pressure (FS).

Automatic functions make it easy to use.

This instrument provides transfer-standard accuracy yet it is easy for unskilled personnel to operate. The transducer(s) is not effected by temperature, local gravity, attitude or vibration. All operations are performed from the front panel, host computer or the remote Field Terminal.

Software displays pressure and temperature in selected units (by computer) and prompts the operator through the rezeroing process. Both front panel mounted and the field mounted displays are large and easy to read.

Applications

- * Accurate transfer standard for field and calibration labs.
- * Convenient *in situ* calibration - almost anywhere.
- * Absolute, Gage and Differential pressure measurement systems.
- * Precision pressure standard for oil and gas metering stations.
- * Fluid-density measurements.
- * Energy exploration and oil / gas well testing applications.
- * Centre conductor, armoured-electric line applications.

SYSTEM OPERATION

Power can be either 115 or 230 V , from 50 to 60 Hz, covering a wide range of electrical sources. Battery power and capacity is maintained at maximum by the internal automatic battery charger. Front panel mounted LED indicates battery and charge status.

Media can be either dry or wet gas, or oil.

System communication port is standard RS232 serial data port . Available baud rates are; 1200, 2400, 9600, and 19.2 k baud. Handshaking is not required, the 1004 Pressure Computer is always ready to receive commands.

Computer control mode is selected at the front panel. The CONTROL mode switch can be set to; REMOTE , LOCAL, or HOST . REMOTE enable calibration from field at

the Field Terminal, LOCAL selects local 1004 front panel control and finally HOST that enables the entire pressure calibration system to be automatically controlled by a host computer. The default CONTRTOL mode is HOST when the Operational Key-Lock (EFPK) is activated.

Ranges available in intrinsic safe and standard versions are: 15, 30, 100, 200, 300, 400, 900, 2000, 3000, 6000, and 10000 psi. The accuracy for all ranges degrades slightly when measuring below 0.1 percent of full scale pressure value. In the Tare mode the maximum gage pressure is the net difference between the full scale and the value removed as the tare, i.e., barometric in gage pressure mode and the static line pressure in the Delta (differential) mode.

Key switch functions (locks) protects the transducer calibration constants from overwriting (accidental from host computer) the other key function enable local and remote calibration / operation (*in situ* at the field terminal) and it disables these features when the key-lock is activated. The key-lock functions are named: CAL= Calibration Enable , and EFPK = Enable Front Panel Keys:

Pressure, temperature and period output display have normally a conversion period of 100 ms, updating every 250 ms Each display show an average of the n previous conversions. The n factor is selected by the digital filter mode (WWDF).

The remote terminal display is parallelly connected to the front panel display and display the same output.

Walking window filter mode is activated when front panel push button "WWDF" is activated (WWDF= Walking Window Digital Filter). The walking window size n is determined by host computer command and can be any integer from 5 to 30.

The first result presented in the display is the average of n. Thereafter new measurements are added, while the earliest ones are discarded. Thus each output is the most recent measurements.

Walking window filter mode deactivates when repushing the front panel switch WWDF.

Pressure measurement mode is activated by host computer command or manually on the Series 1004 front panel. Pressure measurement mode is activated by pressing the " TARE", or, the "DELTA", or both. Default (no key is activated) the system operates in absolute pressure mode.

The TARE feature subtracts the value of the ambient reading before the instrument is connected to the device under test, allowing gage pressure measurements.

When DELTA mode is selected TARE is used as a equalizer . When TARE is activated the ambient reading from each sensor derives a differential pressure reference point (equalizing point) and allows any change in pressure, high or low, to be displayed as a differential pressure.

TARE and DELTA also deactivates their modes by n by repushing the function key.

Sensor select position defines the sensor to be displayed in gage or absolute pressure mode. In DELTA mode it defines the system high-pressure sensor select.

REZEROing once a month improves the stability value and helps the internal oil filled system to be evacuated and refilled with pressure fluid, further reducing overall uncertainty. With a quality vacuum pump, the instrument can be rezeroed simply at a

push of a button when 100 microns of vacuum is achieved. CAL key must be activated to get any Rezeroing response.

Linear engineering units enable the operator to perform calibration quickly, without conversion tables. The differential pressure is displayed as an absolute value when positive and as a negative value when negative. There are no rounding errors from look-up table interpolations. Engineering units are selected by special function host computer commands only.

Calibration is protected and the unit is suited with externally mounted calibration key-lock CAL to enable calibration constants write cycle. All calibration constants are stored in EEPROM.

PASS READING command enables the operator to signal the host computer when calibration is in progress and a reading from the Series 1004 Pressure Computer is to be stored as a valid calibration point. When function is activated the 1004 sends last conversion to the host computer as a high priority message telegram. The reading is acknowledged by toggled LED at the front panel and the remote terminal as the host accepts the reading.

House-keeping functions improves system reliability and helps the operator to avoid overpressure situations. The Quartz Pressure Sets have built-in Error Detection that alerts the operator if parts of the pressure sensing system fails to operate. Error can occur due to power failure, faulty connections or damaged safety barrier etc.. The Error Detection is only viewed at the 1004 Pressure Computer front panel and abnormal conditions are illuminated with red LED's.

If pressure exceeds 100 percent FS value an audible alarm will activate and maintain until pressure is brought back within the operating pressure range. The audible alarm is located at the 1004 front panel.

Overpressure can damage sensor calibration and discard sensor performance. To provide maximum system reliability the unit is equipped with an internal "Event Recorder". If pressure exceeds 120 percent full scale value it is most likely that sensor calibration is damaged. The Overpressure-Event trigger the 1004 Pressure Computer who fetches and stores the maximum pressure reading in its EEPROM.

The operator may use this information in his operating procedures to yield best possible system reliability and avoid using the system when sensors have been bursted.

The Rezeroing process is also part of the House-keeping features.

Two-wire operated Field Terminal and Quartz Pressure Set (transducers and telemetry package). The entire system requires minimal installation costs and is intrinsically safe when installed with safety barriers. The Field Terminal and the Quartz Pressure Sets are easily connected to the 1004 Pressure Computer back panel by electrical quick connectors. Field outputs may be connected directly to the safety barriers.

INSTRUMENT HOUSINGS. The 1004 Pressure computer case is rugged and designed for 19" rack mounting. Transducers are made in stainless steel and the field terminal and signal converter in reinforced polyester with IP65 protection.

Field Terminal has an 8 digit LCD display and updates every 250 ms.. The terminal has additional two prompt LED's and push button switches for operator (field) control.

The field mounted push button functions are the "TARE" and the "PASS

READING". The LED's indicate the function activated and prompts the operator when the host computer accepts calibration data "PASSED" down the communication line.

The Field Terminal operates in a two-wire mode and is intrinsically safe when connected to a safety barrier.

OPTIONS.

The system may be ordered with the following options:

- * IEEE-488 / GPIB interface bus.
- * Long-distance current modem (serial).
- * Portable system with built in sensors.
- * Aluminium carrying case. Air-line approved.
- * Analog 4 to 20 mA output. Software configurable 12 bit DA.
- * High quality vacuum pump for Rezeroing.
- * Quartz Pressure Set ratings to 175 deg C.
(Well testing or in-line applications)

PTL Limited Warranty

PTL warrants the instrument against defective materials and workmanship for a period of one year from the date of shipment to the purchaser.

SPECIFICATIONS: 1004 PRESSURE COMPUTER and QUARTZ PRESSURE SET

Ranges:	Low pressure series;	15, 30, 100, 200, 300, 400, and 900 psi
	High pressure series;	2000, 3000, 6000, and 10000 psi
Pressure modes:	Absolute, Gage and Differential pressure mode. Line pressures to FS value.	
Linearity:	< 0.003 % FS value.	
Repeatability:	< 0.001 % FS value.	
Hysteresis:	< 0.002 % FS value.	
Temperature compensation:	< 0.004 % FS value.	
Accuracy:	< 0.01 % FS value. (RSS of the above for one year) < 0.05 mBar in differential pressure mode.	
Stability / year:	< 0.01 % FS. Reduced by periodic rezeroing.	

Resolution: down to $5^{\circ} E-08$ (0.05 ppm) FS, (0.02 mBar).

Overpressure: 120 % FS without recalibration.

Temperature range: 0 to 50 degrees centigrade .

Warm-up time: 5 minutes

Calibration report: Standard certificate of compliance.

Display: 8 digit LCD, conversion period 100 ms. Update time for local and remote terminal display are 250 ms.

Engineering Units: psi, mBar, Bar, mmWC, kPa, Pa, and mmHg.

Output: Serial RS232 communication port. 1200, 2400, 9600, and 19.2 k baud. No handshake or parity required.

Pressure media: Dry or wet gas and all non-corrosive fluid-filled systems.

Pressure connection: Standard Cajon VCO quick connections, 1/4 " ,Size 4.

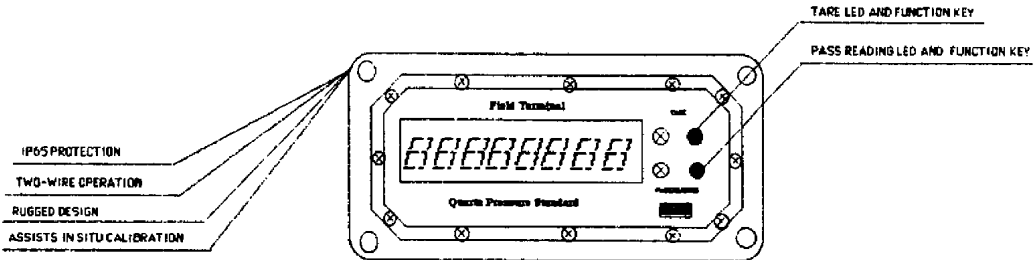
Power: 115 or 230 Vac , 50 to 60 hertz.

Computer housing: Standard 19 " Rack mounting, 3HU.

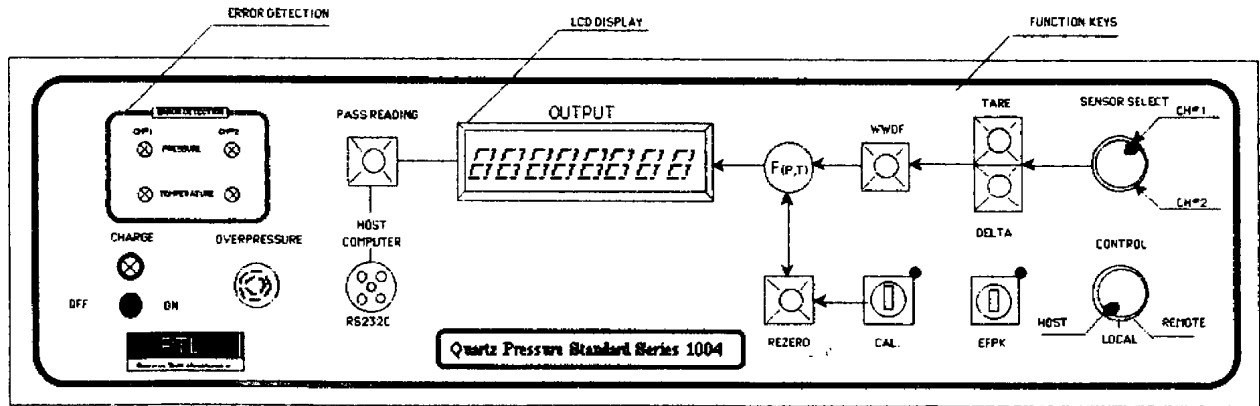
Field Equipment: IP65 Protection, EEx ia IIC T6

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THE SERIES 1004 PRESSURE COMPUTER FIELD TERMINAL

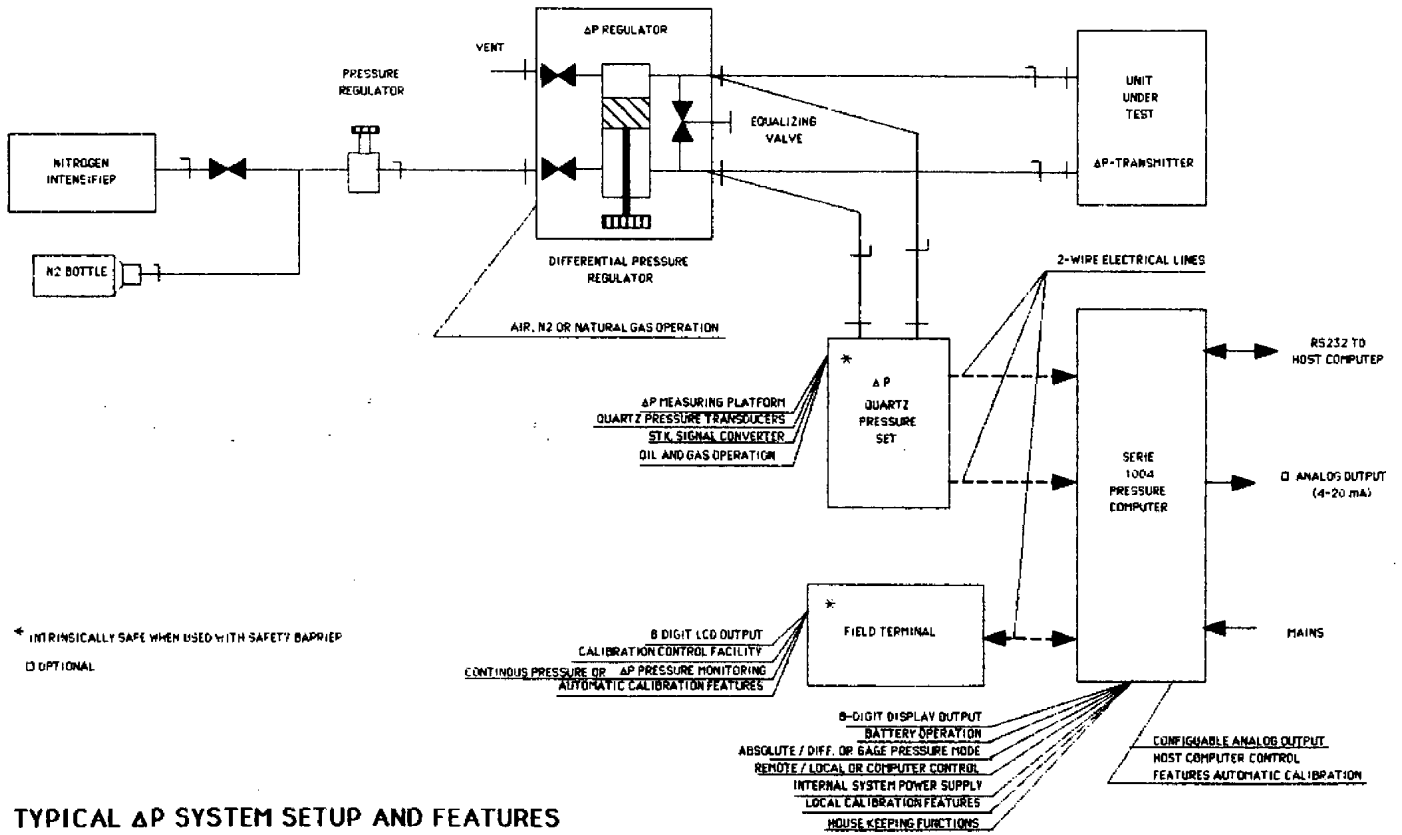


THE SERIES 1004 PRESSURE COMPUTER FRONT PANEL LAYOUT

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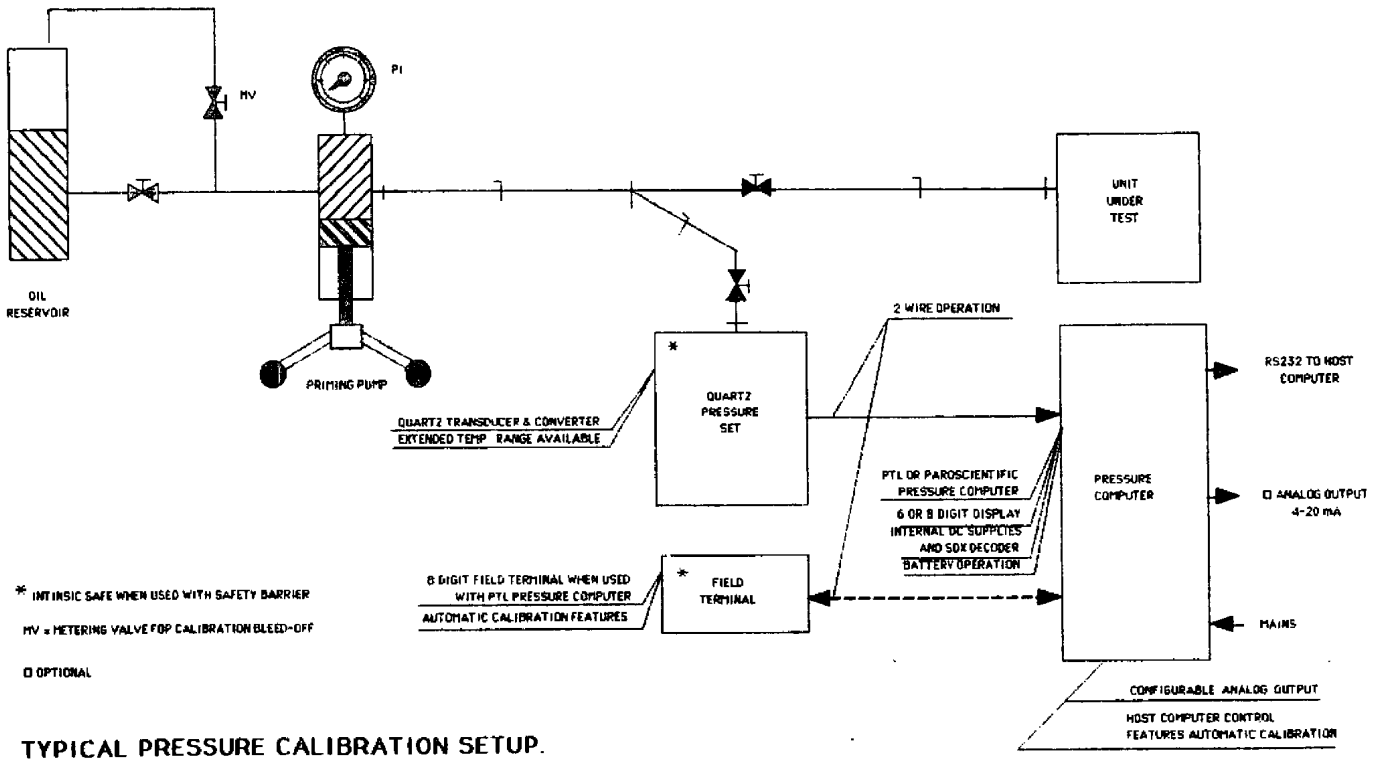
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ΔP QUARTZ CALIBRATION SYSTEM



TYPICAL ΔP SYSTEM SETUP AND FEATURES

QUARTZ PRESSURE MEASUREMENT AND CALIBRATION



TYPICAL PRESSURE CALIBRATION SETUP.

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.