ELECTRONIC WELLHEAD MEASUREMENT AND CONTROL

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This publication presents a non-technical discussion of the dynamic forces currently active in the petroleum industry. These forces mandate the implementation of electronic systems to monitor, optimize and control the production of petroleum products.

Once the producer comprehends these dynamic forces and their impact, the latest tools available will be discussed. The information presented will enable the reader to gain an over-view appreciation of these tools and how they will provide needed functionality for today's known challenges and tomorrow's unknown requirements.

TECHNOLOGY IN TODAY'S MARKET PLACE

The technology required to retrieve accurate information from remote production and transportation sites has been available for some time. The problem has been cost, accuracy, reliability, and acceptance. Now that these factors have been satisfied by recent advances in manufacturing and the acceptance of electronic devices in all areas of our lives, we have the ability to manage oil and gas production and transportation with accurate information available virtually instantaneously.

Electronic wellhead measurement and control combines these latest technologies into a practical solution. The technology as depicted must be integrated within a producer's operations. The key to this integration is the development of peoples skills to understand, evaluate, implement and operate these advanced tools.

WHY IS THE IMPLEMENTATION OF THIS TECHNOLOGY REQUIRED

Changing Operations:

Today's operation is different from yesterday's, and tomorrow's will be different from today's. Successful operations will require accurate and timely information for proper system management.

Speed and Accuracy:

The luxury of receiving technical information from charts pulled by hand on weekly or monthly cycles no longer exists in the market place.

No longer are owners or purchasers willing to wait weeks or months for production / sales data. Increased involvement requires data to be available immediately upon the transfer of the product.

Information that is dated is information that does not allow the producer the opportunity to react to the market place or to the individual characteristics of the well. Knowing that pressure changes had indicated the need to change orifice plate diameter hours or days after that need occurred can be costly in terms of lost production.

Open Access:

Producers must be able to respond to the windows of opportunity that present themselves in today's market place.

The ability to flow gas in response to market demand gives a producer the ability to capture a sales opportunity and to maximize profit potential that might have otherwise been lost.

Customer Demands:

Customers are demanding quicker access to more accurate information.

The ability to instantaneously report on and control gas flow can and will be required in future contracts.

Profits:

The producer must have total control of his operation in his hands, and he must have immediate access to all system data required for the fast and accurate decision making necessary to insure profitability in today's market.

The Bottom Line:

The bottom line in today's highly competitive market place is, as always, profitability at competitive pricing. Accurate and timely information means resources are not wasted, decisions are based on facts and profits are maximized.

ELECTRONIC WELLHEAD MEASUREMENT AND CONTROL SYSTEM COMPONENTS

Utilizing the combination of electronic flow measurement and supervisory control and data acquisition technology, the producer can gather and manage the information required to react to the requirements of the market place.

The use of the terms electronic flow measurement system, and supervisory control and data acquisition system, (EFM/SCADA) carries with it a broad scope of interpretation, just as the term car may include definitions varying from the family station wagon to the formula one racer.

We can define the minimum acceptable attributes of an EFM/SCADA system and its various components by defining the information that it must supply.

Figure 1

An electronic wellhead measurement and control system includes four basic components: 1) the input sensors and the output control devices; 2) the remote terminal unit; 3) the data communications system; and 4) the master terminal unit.

SENSING INSTRUMENTS, AN ABSTRACT OF APPLICATIONS

The sensing instruments used at the well site today are no less important now, than they were yesterday and they will continue to be a vital part of gas measurement and wellhead control for many years to come.

The sensing instruments themselves have become more sophisticated and technologically advanced because of customer demand, quality control, and field compatability requirements.
The compatability factor as well as cost effectiveness has launched wellhead automation into the realm of well site data acquisition control and management, allowing you, the producer more control and accessability.

Wellhead Automation does not eliminate the need for sensing instruments but is rather a key to unlock the treasure chest of information these instruments offer and then bring that information home, to you, quickly and accurately.

The Wellhead Automation System will gather the information from virtually any sensing instrument, perform calculations and act upon or store this information.

This in turn allows you fingertip access to accurate and vital information without physical on site inspection.

Some typical sensing instruments that could be used in conjunction with the Wellhead Automation System are:

Analog Sensors

Analog sensors return a value that is representative of a continuously varying device.This data is necessary for AGA calculations, such as static pressure, differential pressure and flow temperature. Analog sensors can also return values representative of levels and flow rates.

Figure 2

Digital Sensors

Digital sensors return either an on or off status. Usually a switch, they are used to monitor high / low level indicators, valve positions or other status indicators.

Pulse Transmitters

Pulse transmitters, usually mounted on flow meters or counters, provide a signal or pulse for each specific unit of flow measured.

Diaphragm Meters

These positive displacement instruments measure gas volume which is passed through it using the physical displacement of a known amount of gas for each stroke of the diaphragm.

With its positive displacement type operation, it is especially accurate for low flow conditions.

Gas Turbine Meters

A gas turbine meter is a velocity sensing instrument used to calculate gas volumes by the number of rotations of the turbine rotor.

The majority of offshore pipeline systems today are using turbine meter measurement.

The turbine meter is used where extreme, rapid and frequent load changes occur and accurate measurement is demanded. Future demand will cause the turbine meter to be more widely used in the areas of gas measurement, industrial application measurement, city gate measurement, dry / wet production measurement, and compressor fuel measurement.

Orifice Meters

An orifice meter is a conduit with a restriction to create a pressure drop.

It is useful in determining flow accurately and without the need of actual flow calibration.

The orifice meter is probably the most widely accepted instrument for measurement of natural gas in a pipeline.

RTU ELECTRONIC FLOW MEASUREMENT CAPABILITY

Electronic flow measurement is a proven method of obtaining accurate and timely gas flow data. Today's EFM systems are gaining widespread acceptance, and contracts are being written to reflect these new devices and their capabilities. The following requirements are the minimum conditions that should be met in order to obtain accurate flow data.

The remote terminal unit (RTU) and input sensor requirements are:

Figure 3

AGA Calculations:

The RTU must have the capability onboard to perform AGA 3, 5, & 7 calculations. These calculations should be performed at least once per second. The device must be able to provide true fully-calculated values, and not rely on the use of "look-up" tables for its data inputs.

NX-19:

The RTU must be able to calculate the supercompressibility factor of the product. This calculation should be performed at least once per minute.

AGA 8:

Though not currently in wide use, the RTU should be able to perform AGA 8 calculations on an acceptable schedule when AGA 8 becomes part of the producer's contracts.

Historical Data:

Historical data must be maintained by the RTU for 35 days. This data should be stored for all inputted values on both an hourly and daily basis. This storage capability should be user definable, and it must be non-volatile and non-editable in order to serve as an audit trail.

Automatic Data Retrieval:

The retrieval, storage, display and processing of RTU data at the producer's central location should be automatic and not require a full-time operator.

Flow Measurement:

The RTU must be equipped with the capability of measuring the flow rates utilizing orifice meter, turbine meter, or positive displacement meter inputs. Multiple meter run capability increases the total system flexibility.

Transducer Inputs:

The RTU must be capable of accepting multiple analog, accumulator, and status inputs.

The RTU must have the flexibility to allow the operator to choose from the widest variety of transducers.

The operator must be free to select the transducers which provide the type of input and level of accuracy that he currently requires. It must be easy to change transducers when required by contract or as improvements in transducer technology occur.

The RTU should allow transducers to be stackable to provide the most accurate measurement across broad ranges.

Transducers:

The transducers must be selected to meet the range and accuracy requirements of the system.

Since the transducers may be the least accurate devices in the EFM/SCADA system they should be the highest quality available. They should be sealed devices capable of operation while exposed to a broad range of environments.

RTU Power:

The RTU must be capable of operating on a broad spectrum of available power sources.

The RTU should be capable of solar powered operation, and provide battery back-up for significant periods of operation without external power. The RTU must also supply battery back-up to protect all aspects of its onboard storage of historical data.

RTU WELLHEAD AUTOMATION/PRODUCTION CONTROL CAPABILITY

The utilization of wellhead automation technology is the tool that allows the producer to control and to optimize the well's production.

When an operator chooses an RTU with the computing power defined above, it can be used for functions beyond the simple measurement of gas.

The minimum RTU capabilities required to provide a producer with the ability to automate a well are as follows:

Intermitting:

The ability to intermit a well's production of product based upon interval timing.

RTU Outputs:
The RTU should provide multiple digital and analog outputs to control valves, pumps, and other equipment.

Production On/Off Control:
The RTU must have the ability to shut in a well remotely and automatically.

Production Volume Control:
The RTU must have the ability to control the volume of product produced and to shut the well in at the completion of delivery of the contracted volume.

Figure 4

Optimization:
As opposed to the timed intermitting of the well, the RTU must be able to optimize production of the well by maintaining the well's critical velocity. This must be done by throttling or intermitting the well based upon the continuous monitoring of tubing pressure, casing pressure, line pressure, and flow rates.

Permanent Well Shutdown:
The RTU must have the ability to shut the well in based upon the occurrence of operator definable failures. This function would allow restart only by the operator.

Temporary Well Shutdown:
The RTU must have the ability to automatically shut-in the well based upon operator definable occurrences, then provide auto restart of the well when the occurrence has been resolved.

PID Loop Control:
The RTU must have the ability to adjust flow control valves based upon set-point values or operator defined parameters.

RTU EXCEPTION REPORTING CAPABILITIES
The automation and monitoring of a well can only be accomplished by an RTU that is capable of true exception reporting.
Exception reporting is the ability of an RTU to function automatically according to its operator selected programming until a defined situation occurs that requires operator notification. At that time the RTU initiates communications with the MTU.
True exception reporting gives the operator the ability to define each of the desired parameters that he wishes to treat as normal operating characteristics and parameters of which he desires to be immediately notified when changes occur.
Many operators would normally have an RTU notify by exception report when situations such as the following occur:

Failure:
The RTU must have the ability to send an alarm message when any operator-defined failure occurs.

Levels:
The RTU must have the ability to send an alarm message when any measured level reaches or exceeds an operator-defined point.

Temperatures:
The RTU must have the ability to send an alarm message when any operator-defined temperature is reached or exceeded.

Pressures:
The RTU must have the ability to send an alarm message when any operator-defined pressure is reached or exceeded.

Power:
The RTU must have the ability to send an alarm message upon changing voltage conditions or the failure of its battery or primary power source.

COMMUNICATION CAPABILITIES

Any consideration for the use of remote telemetry for monitoring oil and gas production by necessity needs to address the communications aspects of the project as a primary function of system evaluation.

The EFM/SCADA system must be designed to accurately operate with various types of communication systems.

The communication protocol of the RTU/MTU combination should be written with the transmission of the data as a primary design criteria. The communications capability of the system cannot be handled as an afterthought to system design.

The RTUs that are utilized in the field are of little or no value if the information that they gather and process is not immediately available for the use of production management personnel.

Figure 5

Radio:
Because of the remote locations of most well sites, the use of two-way radio data collection systems is often the most attractive method of communications available to the producer.

In order for a system to operate utilizing radio as the data transmission medium, several basic communications considerations must be provided by the system.

These considerations are:

Frequency:
The system must include the flexibility to operate and be licensable on a variety of frequencies authorized by the Federal Communication Commission under parts 90, and 94 of FCC regulations.

These sections of the commission's rules cover frequencies in the low band, high band, ultra-high band, and microwave frequency ranges. They provide for licensability on the point to multipoint frequencies and on dedicated data channels in the 900 Mhz range.

The frequency chosen will often determine the transmission baud rate of the systems data. This determination thus requires the system to be operable at various baud rates. Systems should offer selectable transmission rates from 150 to 9600 baud.

The system should also provide the capability of communicating over commercially available trunked SMR systems and cellular telephone systems.

The communications protocol must be designed with programmable timing delays to allow for such radio specific characteristics as transmitter attack time and soft-carrier de-key delay.

Path:
The communications paths between the RTUs and MTU transmitter should be designed to allow for substantial fade margin. This will insure path reliability.

Data Integrity:
Transmitted data should be made up of short data strings which include error checking capability. The transmitted data should be designed to eliminate the need for hand-shaking between the RTU and MTU.

Store and Forward:
The RTU must be able to offer the ability to store and then forward data to RTUs that do not have a direct communications path to the MTU.

This capability is essential in providing the utmost flexibility in radio system design.

Wireline:
The system should also incorporate protocol that will allow it to communicate over wireline, (both dedicated and dial up) where available. This would also include the system's capability of being used over satellite and other commercial communications mediums.

MTU CAPABILITIES

The EFM/SCADA system must be able to supply meaningful and accessible information to the production office staff enabling them to effectively monitor the activities of the wells. The system must provide them with the information required to enhance their ability to manage their wells or transport their product.

The master terminal unit (MTU) must be able to do the following in order to meet the above criteria:

Trending:

The MTU must be able to graphically trend data for a period of hours or days. These trend charts must be able to simultaneously display at least three values and provide hard copies of the trended charts to the operator upon request.

The X axis of the trend chart should be individually adjustable for each trended value.

Logging:

The MTU must be able to display the status of all inputs, switches, analog values, and calculated values in an easily accessible and understandable format. Hard copies of these system status displays must be available to the operator upon request.

Alarming:

The MTU must be able to handle and display system alarms and exception reports. It must provide the operator with an audible alarm capability activated by operator selected parameters.

Displayed alarm conditions must be depicted in a manner which will enable the operator to review all alarms that have occurred in the order of occurrence and provide the operator with a hard copy of the alarms upon request.

Mimic Display:

The system should be capable of graphically displaying the relative location of devices and the interactive nature of the various inputs and outputs dynamically.

Figure 6

Report Generation:

The MTU must be able to supply the operator with various types of reports on the information collected and processed in a format of operator design. The unit must be capable of generating these reports automatically at times selected by the operator.

The unit must have the ability to transmit reports to data collection points, and to be accessed by these locations to allow for remote monitoring of system activity.

Parameter Changes:

The MTU must be capable of downloading information to the RTUs to facilitate changes in their operating characteristics as defined by the operator.

RTU Interrogation:

The MTU must be able to interrogate the RTUs in the system on an operator defined schedule, or upon operator request.

FUTURE SYSTEM REQUIREMENTS

No one can determine precise future needs of an EFM/SCADA system. Therefore, it is imperative in this area of rapidly changing technology that systems be designed for ease of expansion and addition of new applications.

This requires the following considerations:

Expandability:

The system should be expandable by the addition of inputs and outputs without redesign or major changes.

The ability to add expansion cards is extremely desirable in the design of the RTU.

Communications:

The system must have the capability of interconnecting with all forms of communications by operator selection without additional programming requirements.

Application Enhancements:

The system should have a wide range of applications built in to prevent, where possible, the requirement for reprogramming.

Where application enhancements are necessary, they should be straightforward and easily installed.

Research and Development:

The system should be supported by continued product development that enhances the overall system capabilities without obsoleting current systems. Continuing system compatibility is absolutely necessary.

CONCLUSION

The technology and the equipment are now available to provide accurate information on a timely and cost-effective basis for producers and transporters of petroleum products. This information is necessary to make timely decisions that affect the profitability of today's operations. Many factors must be considered when purchasing equipment for this purpose. If care is exercised in the selection of the equipment, it will fill the current need as well as future needs and improve the profit margins of operating companies in a rapidly changing environment.

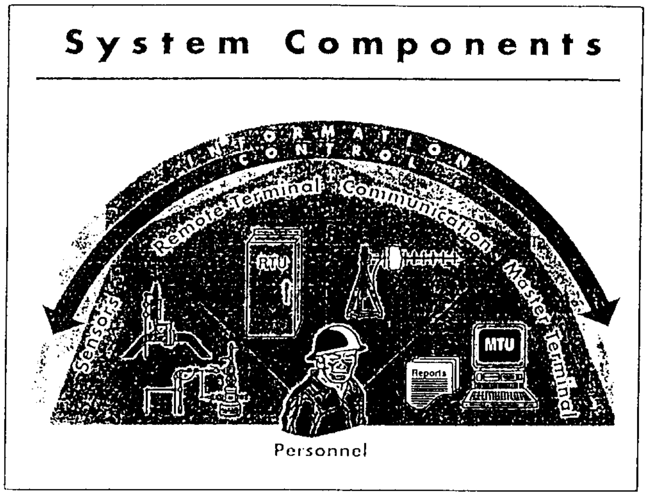
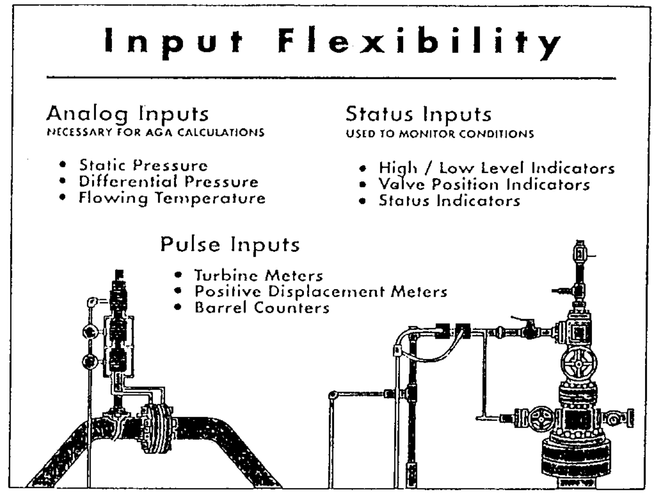


Figure 1



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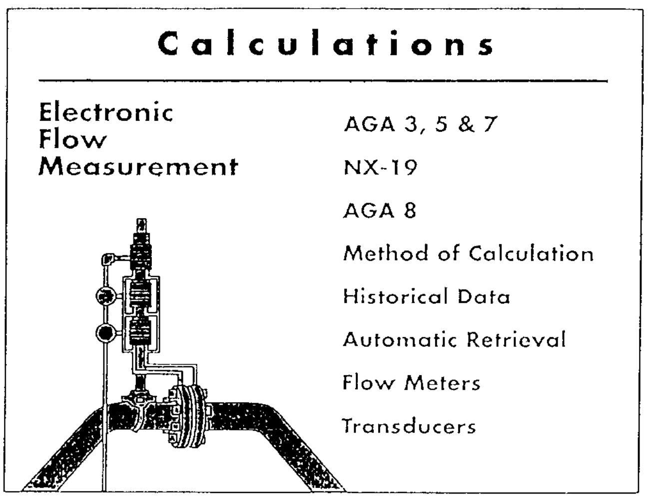

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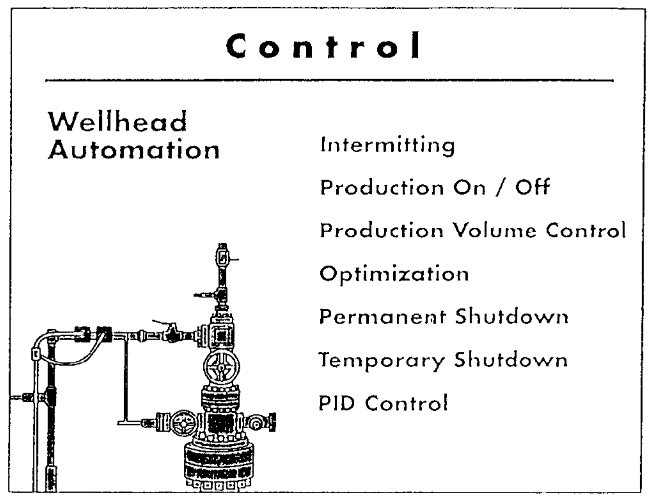

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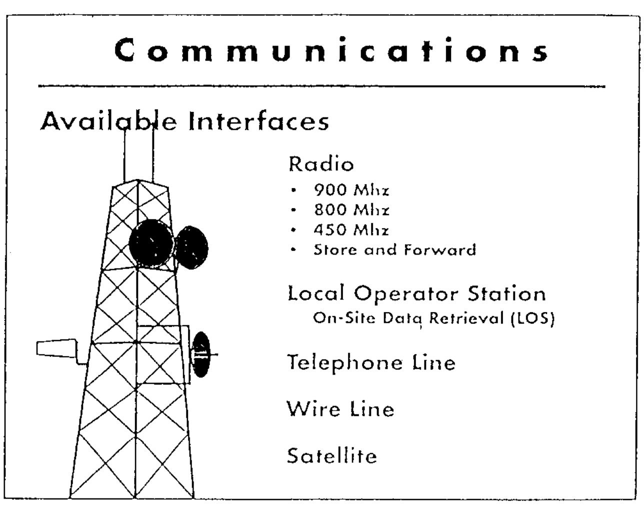

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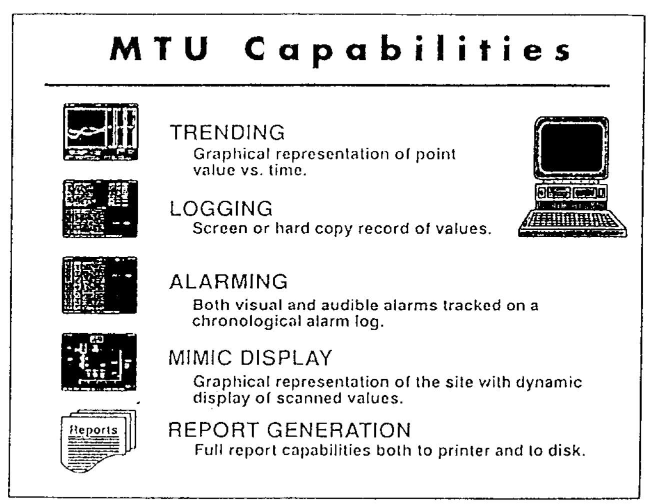

Figure 6