

TECHNICAL PUBLICATION

Title: **A Common Sense Approach to Intelligent Completions Through Improved Reliability and Lower Costs**

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Authors: **Tim Conn – PROMORE, A Core Laboratories Company**
Dan Themig – Packers Plus Energy Services

Publication Number: **PROMORE 002**

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ABSTRACT:

The need for intelligent completions has been illustrated as indicated by the number of publications in much of the industry technical literature. While many systems have been installed worldwide, many are plagued by continued reliability problems and high costs. Operators continue to look for a cost effective way to apply the technology. This paper illustrates a focused approach to both of these issues through a strategic alliance combining world class proven monitoring, isolation, and control system from two industry leading technology companies.

Technology Overview

Intelligent completions remain out of reach for most operating areas in the world, due primarily to high costs. The service industry has dedicated a considerable R&D budget to systems development, with most of this expenditure aimed at the high end market (subsea wells for example). These types of installations make reliability an even more key issue. Downhole electronics, variable adjustable chokes, IPC addresses with electric over hydraulic controls, all contribute to a less than stellar reliability record for systems installed to date. While intriguing from a technology development standpoint, the reality is that most operators are, as of yet, unable or unwilling to venture into this technology due to its costs, complexity, and reliability.

Moving forward

ZoneBoss™ is a land-based intelligent well system which provides a unique and cost sensible method to isolate, monitor and control multiple zones in vertical and horizontal wells.

To date, the technology has been used in the following applications:

- **Sour gas injection/disposal wells**
- **Multiple zone production control**
- **Injection wells**

The technology is well suited for land-based lower producing environments where operators need the benefits of intelligent well technology without the high costs.

Field proven integral downhole components of ZoneBoss™

include isolation packers, hydraulic sliding sleeves and several instrumentation choices. Surface components include data acquisition and hydraulic control systems. Intervention methods, the number of zonal control valves and instrumentation components will vary from system to system dependent on client requirements and available budget.

ZoneBoss™ Engineering philosophy eliminates the need for downhole electronics. Instead the system utilizes passive electric over hydraulic systems for instrumentation and control aspects that are more reliable and less costly than other approaches.

The evolution of ZoneBoss™ was caused by the increasing need of operators to mitigate various production problems to maintain or increase existing reserves. In higher profile “smart well systems” touted in much of the industry technical literature, the advent of these types of systems was primarily driven by reducing the amount of well intervention concurrent with increasing access to high volume reserves. With ZoneBoss™, land-based operators can now achieve the benefits of smart well technology without the high costs.

ZoneBoss™ Components

MONITORING

ZoneBoss Monitoring components typically include pressure and temperature sensors. Options for placement downhole will depend on the data required to make adjustments in production.

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ERD™ Downhole Electronics Free Pressure and Temperature Sensors

When a more detailed temperature is required, fiber optic sensors are installed developing a distributed temperature profile for the well.



FibreNET Sensors provide temperature readings every 0.5 meters (1.6 feet)

Monitoring provides operators a number of benefits, including:

- Real-time assessment of zonal performance
- Zone by zone fluid mobility
- Proactive production control

The availability of real time temperature and pressure data bring intelligence into the decision making process to optimize production and reservoir monitoring decisions. However, the ability to adjust production is greatly enhanced if the downhole control systems are incorporated into the completion design. The primary control mechanisms are isolation and control. Isolation is the ability to segment the well into controllable sections. Control mechanism can take several forms from rig intervention to surface controlled downhole equipment or computer remote control downhole equipment.



ISOLATION

The ability to isolate produces a measure of control over the well. The producing well, whether vertical, horizontal, or multilateral, is normally segmented into specific producing intervals. In some cases, it may consist of producing, monitoring, or injection intervals, all in the same wellbore.

The equipment for isolation will generally require the ability to feed instrument cables as well as control lines through a packer in the casing. Multiple control lines may be required and specialized packers and conveyance conduits may be necessary. The relative permanence of the producing system as well as the cost to install and pull, make reliability a key issue.

The system designed to transmit electric signals and hydraulic pressures to the surface may also require downhole connectors and splices as well as the ability to band and protect and lines to surface.



Open Hole

Open hole completions present a special need for dependable long term isolation. While several options exist for open hole isolation, very few will provide sealing integrity equivalent in pressure capability and long-term life equivalent to those for cased hole packers. However, the ability to isolate using a solid element system has proven to be reliable long term in some very challenging applications. Inflatable packers generally have a very high failure rate (50-75%) in long term producing conditions. This is in part due to the requirement to maintain an inflation pressure greater than differential and to the dynamic nature of the sealing system. Failure may result from hardening of the rubber system or a very small loss in inflation fluid. The prospect of cement filled inflates would make retrievability impossible and therefore a bad choice for intelligent completions.

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The RockSeal II open hole packer series are a solid element packer with a mechanically locked element system. The reliability have been proven long term, and systems have been in service for more than 2 years at 275F and 4000 PSI differential pressures in harsh environments in a number wells in North America.¹

The RockSeal Packer system contains single or dual elements and can be provided with several elastomer choices including HPHT and sour service and will be equipped, depending on well requirements and producing conditions. Furthermore, it remains a retrievable packer system even when it has been used in a long term application.

The ability to set up long-term isolation enables operators to cost effectively use intelligent completions in open hole horizontal or multilateral wells. Not only can horizontal wells be successfully segmented, but Level 1 multilateral wells (open hole sidetrack wells) can now be applied to complex producing reservoirs without costly multilateral drilling systems. The result is an extremely cost effective solution for development drilling. Reliability in providing long-term isolation is a key issue in the application of well intelligence to a producing area.

CONTROL



Flow control is the third key to successful application of intelligent wells. The cost of interventions is generally a key factor in the selection of the appropriate form for inflow or injection control. The importance of inflow control may be as simple as rig or coiled tubing intervention, to remote controlled downhole valves and chokes.

The ZoneBoss system provides several options for long-term flow control. The long term reliability or conventional sliding sleeves may be questionable, especially in applications with corrosive downhole conditions or with elastomer unfriendly producing fluids. In addition, scaling tendencies may yield a sliding sleeve inoperable.

Packers Plus offers an alternative hybrid system that operates initially as a sliding sleeve, but has a backup optional insert to allow the seals and operating latch system

to be retrieved from the well and re-dressed with each running. Operating life can be increased indefinitely and flow areas are maximized, for high volume wells.

Operations are simplified for running in horizontal wells as the fundamental locating device is no-go operated. Coil tubing running procedures are simplified and all operations can be conducted using shear or flow release running tools. This approach reduces the requirements for tally correlation accuracies.

For surface control downhole valve systems, the approach is full hydraulic electronics free operating systems. Field proven reliability of hydraulics and a greatly simplified approach to remote control issues, produce improved reliability as well as greatly reduced costs. The HOV2 valve system, for example, can be configured to control a single inflow point or multiple intervals, with a minimum number of control lines.

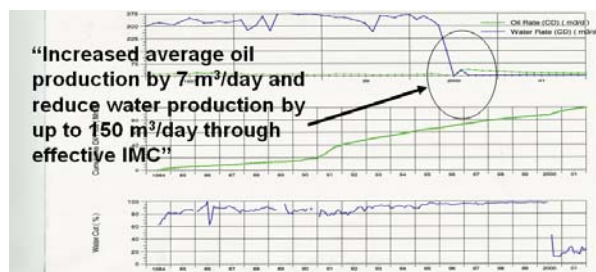
The ZoneBoss approach produces multi-tier completion options to downhole control of flow or injection to allow well intelligence to be applied over a vast array of applications.

ZoneBoss™ Example Applications

The following examples demonstrate the applicability of intelligent well completions in land-based producing environments.

Multiple Zone Production Control

A land-based operator is utilizing ZoneBoss in a multiple zone vertical reservoir to:



- Increase oil production
- Decrease water production
- Understand zonal performance with real-time monitoring
- Proactively manage production profiles
- Optimize and protect artificial lift equipment

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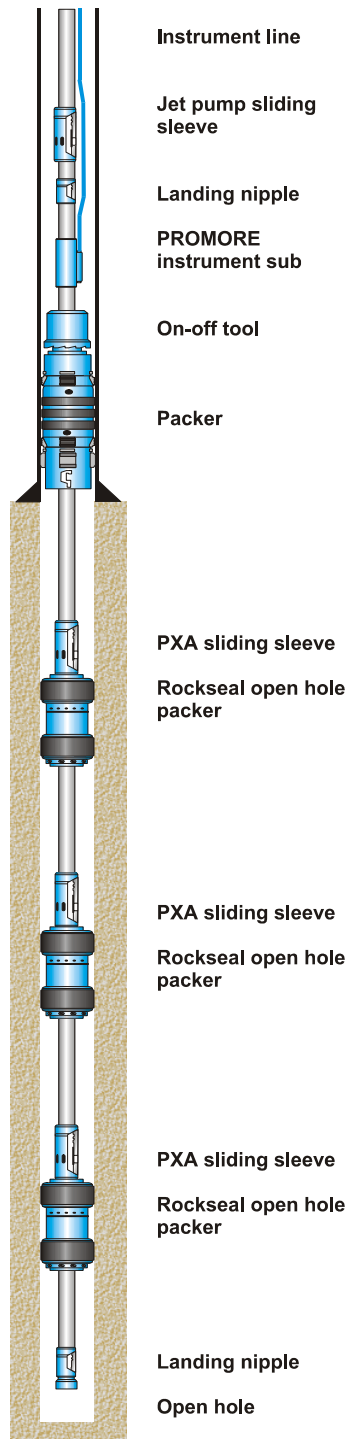
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Injection Wells

A land-based operator is utilizing a ZoneBoss system to:

- Determine extent (if any) of cross flow between two separate zones through real-time monitoring of pressure and temperature
- Observe effects of offset well injectivity
- Confirm to regulatory authorities that zones are continually isolated
- Reduce costs associated with annual pressure survey requirements



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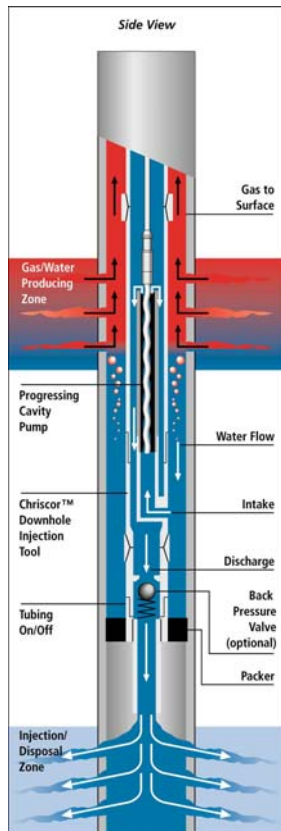
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Downhole Gas Water Separation and Disposal

A land-based operator is using a ZoneBoss system to:

- Isolate a production zone from a disposal zone.
- Separate gas and water.
- Inject water downhole and produce gas.
- Control separation/injection rate and avoid pump-off while using a progressive cavity pump.



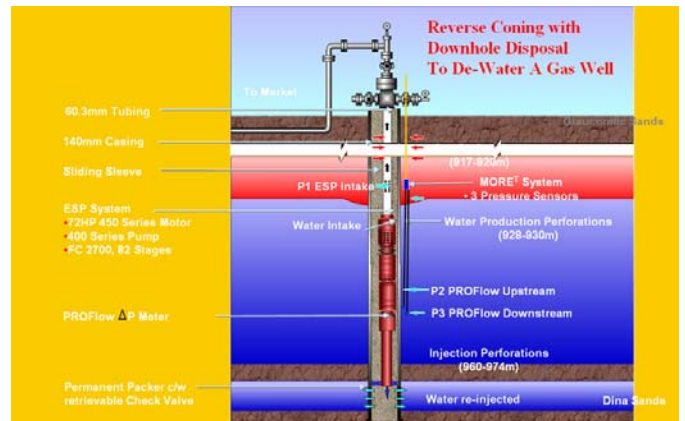
ZoneBoss™ Downhole Gas Water Separation incorporates the technology of PROMORE, Packers Plus Energy Services Ltd. and Kudu Industries Inc.

Gas Dewatering and Reverse Coning

ZoneBoss components can be utilized to help de-water gas wells with suitable reserves and water coning problems.

- Dual ESP's are used to suppress coned water from

- the upper production zone and to inject into a lower disposal zone
- Packer isolates both zones.
- Monitoring prevents pump burn out and measures disposed volumes as per government regulations.



Downhole Oil/Water Separation

ZoneBoss components can be utilized to help in the downhole oil/water separation process (DHOWS)

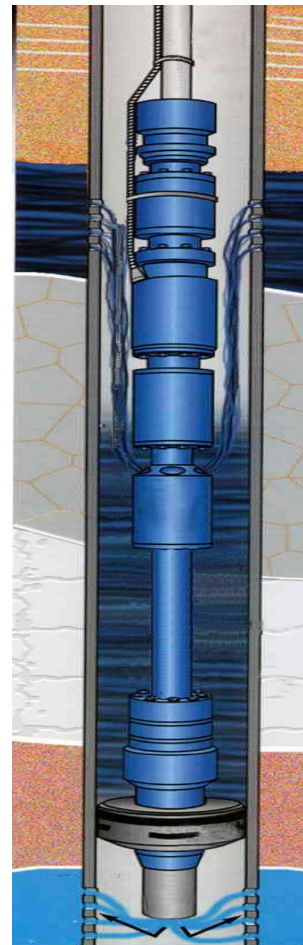
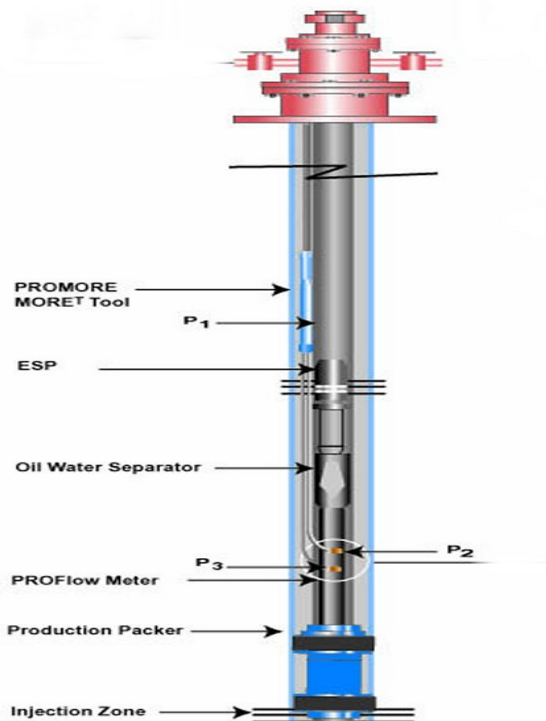
- Isolation packer system
- Pressure, temperature and flow rate monitoring
- Control of the DHOWS process and avoidance of ESP failures

Downhole oil water separation is an emerging technology driven by operators needs to increase reserves recovery and reduce water handling costs and environmental impact at surface.

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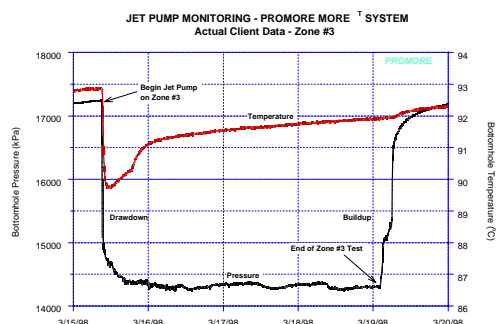
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In-Well Water Flood Pressure Support Applications

In lower pressure reservoirs typical of land-based environments, operators can utilize ZoneBoss components in conjunction with artificial lift equipment to increase reservoir sweep efficiency and ultimate recovery.

- Artificial lift equipment is utilized to produce water from an upper zone and inject into a lower zone for offset producing well pressure support.
- Isolation packers are utilized between the zones.
- Real-time monitoring systems protect artificial lift equipment
- Provides valuable measurement of injected fluid



Horizontal Well Applications

ZoneBoss™ is ideally suited in horizontal wells to mitigate production problems and increase reserves recovery. Many land-based horizontal wells require a more proactive approach to maintain or increasing production rates, especially during depleted production phases.

Conventional approaches to smart or intelligent well implementations although potentially beneficial, however cost constraints typically prevent their use in land-based applications. ZoneBoss™ fills the void and allows land-based operators to intervene, isolate, control and monitor in these applications.

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Conclusion

A more realistic approach to intelligent completions instead of the “star Wars” approach will make it an integral part of development strategies worldwide. This can be achieved by reducing overall costs, while improving reliability – the two primary drawbacks to utilizing this technology.

Author’s bibliography

Dan Themig Manager of Tech Services for Packers Plus Energy Services. He has served in various engineering and technical positions in the U.S. and Canada and has been involved in advanced horizontal and multilateral projects worldwide. He has a B.Sc. in Engineering from the University of Illinois and an MBA from Oklahoma State University. He is a registered professional engineer and a member of SPE.

Tim Conn is Marketing Manager for PROMORE, A Core Laboratories Company. He is a Certified Engineering Technologist with specialized experience in downhole memory and permanent monitoring instrumentation systems and their applications related to artificial lift, enhanced oil recovery and reservoir monitoring applications. He holds a Diploma of Technology. from the Southern Alberta Institute of Technology and is a active and published member of the CIM (Petroleum Society) and Society of Petroleum Engineers

¹Reference – Petroleum Society / SPE horizontal well conference – November 2001 – Successful open hole water shut-offs in deep, hot horizontal wells