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Innovative Technology for Today's Land Rigs - FlexRig ã

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Abstract

With successes and lessons learned from six highly mobile land rigs built in 1997-98, Helmerich & Payne IDC (H&P) continues to utilize engineering technology and innovative rig design with the current FlexRig™ construction project. The rigs were engineered using "HSE and value by design" that minimizes hazards to personnel and the environment and improve efficiencies for both contractor and operator. Documented improvements have been made for the following: improved safety for rig personnel, decreasing flat line times, rig move time reduction, improved penetration rates, and round mud tank efficiencies. The use of technology has proven to reduce the cost of drilling wells for both the contractor and the operator. This presentation will discuss field successes resulting from the design features and technology utilized in the new rigs.

Introduction

The US Land industry has an opportunity to change perceptions and expectations for land rigs. With the philosophy of "HSE by design", the prevention of safety and environmental incidents are possible by eliminating and controlling hazards during design and fabrication of a drilling rig. Additionally, "value by design", can improve operator and contractor efficiencies by focusing on the critical path to reduce cycle times and improve drilling efficiencies controlled by the contractor. The critical path refers to those essential tasks that must be accomplished in order, with no slack time in-between, to accomplish the objective at hand within the shortest timeframe possible.[1]

The first generation FlexRig™ concept was developed from the learnings of the highly mobile rigs H&P acquired in 1994. The new rigs were designed to be "depth flexible", allowing them drill economically for customers at depths from 8000 feet to 18,000 feet (see figure 1). The economies are derived from rig move costs and cycle times being competitive with a highly mobile rig (see Figure 3), as well as having equivalent engine horsepower, mud pumping hydraulics and the rotary capabilities of a conventional 1500 horsepower rig that are required for 18,000 foot wells.

Decreasing well cycle time reduces cost for the operator and adds time value to the revenue stream from early oil and gas production that creates earnings opportunities that are otherwise lost. Examples of decreased flat line time will be shown for BOP nipple up and down, mud displacement and mud tank cleaning timesaving and rig move timesaving. Improvements in BOP handling systems and round mud tanks improve flat line time efficiencies.[2]

Drilling optimization can be accomplished by using technology by manufacturers of advanced technology drilling systems. We utilized MD-Totco's Auto Driller Block Control System (AD/BCS) on the first six new rigs. The electronic driller has the ability to supply near steady state weight on bit that improves drilling efficiency and reduces wear and tear on bits.[3]

Working on a drilling rig has never been an easy job and today's major challenge for the drilling contractor is attraction and retention of employees. New technology rigs will help attract new personnel into the drilling contractor industry if designs are used with improved ergonomics and a safe work environment in mind.

HSE and Value by Design

The foundation for safety and environmental protection of any operation is determined long before people, procedures and equipment come together to provide a service or produce a product. It is determined during the design and construction. Implementation of the systems safety approach impacts directly on safe, productive and cost effective operations though all stages of development and production.[4] Improved safety, environmental protection and efficiencies add value to both operator and contractor.

HSE Improvements

Improvement of HSE principles to include personal, wellbore and equipment safety continue to grow as corporate values throughout the petroleum industry. Proper training and procedures have always been important in maintaining a safe working environment. However, Roger Brauer, a Safety Systems Expert, says "procedures and training are the least effective means of hazard control in the workplace".[5] "Safety by Design" is a systems safety approach to incident prevention, which is instrumental in eliminating and controlling hazards before personnel are introduced to the workplace. This improved environment enables and encourages employees to work safely.[6]

H&P engineering and field operations teamed with the mast, sub and drawworks manufacturer, IRI (now National/Oilwell), and identified 80 plus improvements related to improved personnel safety and reduced environmental impact. These advances facilitate a more user-friendly rig up and a safer daily work environment on the rig. A major improvement was the addition of disc brakes to the drawworks that improves traveling block control and adds redundancy to the prevention of dropped blocks. An indirect benefit of the disc brakes is elimination of noise pollution common with the high decibel screeching of conventional band brakes. Other changes associated with safety improvements involved adding work platforms, fall protection anchor points and elimination of pinch points that caused many hand and finger injuries in old designs. The H&P patented round mud tank system eliminated the need for employees to get into tanks with shovels and buckets during clean out as is required with conventional square mud tank systems. This eliminates hazards associated with entry into a confined space.[7]

Environmental improvements included the following: lubrication systems to eliminate buckets and spills, integrated fluid containment for rig floor and substructure, fluid containment built into mud pump skids, standardization of factory made hose connections and mud system clean-up features.

The results of the safety by design effort are reflected by the OSHA performance for the first six rigs (See Figure 2). Summarized, the FlexRig™ OSHA rate was 17% better than the rest of H&P's rig fleet over a three year period, and over 200% better than the IADC average. Further proof of the safety performance improvements are demonstrated by 173 rig moves accomplished by six rigs in three years and only two OSHA recordable incidents. Historically a rig move is considered one of the most dangerous periods in a rig operating cycle.

Flat Line Time Improvements

The flat line time of a well is any time not drilling and is considered in the critical path of a complete well cycle. In the past, when committing operations to go faster, often it meant working personnel faster and harder. During design, by minimizing or even eliminating non-value adding, repetitive or manual labor tasks, the forward progress of the well can be significantly improved.

The flat line times discussed in this section are BOP nipple up and down, mud system displacements and clean up and downtime for repairs. We also consider the rig move, rig up and rig down as flat line time operations and are a significant factor in the complete well cycle and economic impact to both the contractor and operator and it is addressed in the next section.

1) BOP nipple up and down has been improved by the addition of three BOP dollies incorporated into the substructure. This allows the BOP's to be set in the sub during rig up and eliminates the need for a truck to set in the BOP's during nipple up time. The choke manifold and gas buster are unitized onto one skid that includes rig hydraulics assistance in raising and lowering the gas buster. This design has an average surface nipple-up and test of 8.7 hours and nipple down at TD of 6.5 hours, a conventional 1500 hp rig takes 24 hours and 12 hours, respectively.

2) Mud displacement - Displacement of unweighted mud with weighted mud or water base with oil base mud can take 24 hours to complete and can now be accomplished in 8-12 hours using the 750 barrel patented round mud tank system. Estimated cost savings by several operators are up to $1000 per hour. The cost savings are a result of a reduction in 3rd party labor, fewer hours of rig dayrate and other rig support costs associated with this activity. More details on the round mud tank system are discussed in a later section.

3) Mud tank cleaning - Efficiencies for cleaning operations are substantial when comparing round mud tank designs to conventional square tank systems. Savings from reduction of 3rd party labor, rentals and rig rate costs has been documented to show savings of $10,000 to $24,000 per well. Additional benefits include eliminating confined space entry issues associated with personnel entering tanks to clean out material that has settled. More details on the round mud tank system are discussed in a later section.

4. Downtime for repairs – Downtime on a drilling rig is costly for both operator and contractor. As rig dayrates and operator daily spread costs increase the importance is magnified. The history of downtime percentage for the rigs in 1999 was 0.75% and in 2000 was 0.48%. This

compares favorably to the rest of H&P's U.S. Land fleet of 0.76% and 0.80%, respectively.

Rig Move Time Improvements

Rig moves are in the critical path of a full well cycle and are typically a non-profitable time for both operator and contractor. The rig move is a process that can be mapped and the rig designed more efficiently to move, rig up and rig down. The increased productivity during a rig move reduces cost for the operator and enhances revenue and cashflow for the contractor.

H&P's highly mobile rig design is accomplished by reducing the number of loads, elimination of suitcases and pulling electric cables, hydraulically raised and lowered equipment, and one time handling of equipment. See Figure 2 for rig move performance comparison, but on average in South Texas, a FlexRig™ moves 4.4 days faster and saves $75,000 as compared to a conventional 1500 hp rig. Additionally, rig move equipment requirements are significantly reduced since a crane is not required to rig up or down, and the time required for oil field trucks is reduced by at least 2 days.

In the introduction it was stated that decreasing well cycle time reduces cost for the operator and adds time value to the revenue stream from early oil and gas production that creates earnings opportunities that are otherwise lost. An example of this is seen when considering an operator using two rigs for one year to drill wells that average 30 days from spud to TD. Use figure 3 data and assume the first rig takes 6.6 days and the second rig takes 2.2 days to complete the move cycle of rig down, move and rig up. After one year the first rig will have drilled 9.9 wells and the second rig will have drilled 11.3 wells. The second rig will have drilled 1.4 more wells at the completion of one year of drilling. Each well drilled by the second rig would have gas or oil to the pipeline sooner and the time value of money for the revenue stream would be improved.

Drilling Optimization

Drilling optimization is controlled by many factors outside the control of the drilling contractor. However, the contractor does greatly influence efficiencies with respect to hydraulic horsepower at the bit, rotary RPM and torque, the efficient application of WOB and the quality of mud properties.

Drilling optimization was addressed by the first generation FlexRig™ using the following:

1) Disc brakes have replaced conventional band brakes on the drawworks creating a more efficient braking system.

2) The addition of the MD-Totco AD/BCS unitized with the disc braking system on the drawworks allows near steady state WOB as well as the ability to drill using delta P.

3) The Block control portion of the AD/BCS also allows the driller to control block speed to help mitigate surge and swab pressures. This function is very useful while running casing in lost circulation sensitive areas.

4) 1300 horsepower mud pumps were unitized with properly engineered suctions and pulsation dampening that reduces wear and tear on fluid end expendables, improves pumping efficiency and improves MWD signal.

5) The rotary table is independently driven by a DC electric motor with two-speed gearbox for improved torque and speed ratios to the drill string.

A drilling optimization study for the rigs in South Texas was completed in December of 1998 by our engineering staff. The results can be summarized as follows:

1) 17.7% savings in rotating time.
2) 33.9% fewer bit runs per well.
3) 6.7% more bits able to be re-run.
4) See figure 4 for drill curve performance versus offset wells.

We realize the results of the study were influenced by many factors including bit design, however we believe the ability to apply a near steady-state WOB delivers enhanced bit performance and improved ROP.

Round mud tank efficiencies

Since 1996, H&P have been building round mud tank systems. Conventional square mud tank designs have internal piping and corners causing *dead space* which encourages settling in the mud tank. The current patented design incorporates a set of elevated, round mud tanks with hemispherical bottoms and properly engineered agitators and turbulent flow inducing fins in each tank of the system to enhance stirring and mixing. By elevating the tank bottoms and placing suctions on the hemispherical bottom of the tank, all mud volumes are now accessible and useable volumes.

Efficiencies for the patented system can be cataloged in four distinct operations as follows:

1) Mud Mixing and Maintenance – Since the round mud tank design lacks dead space in the tanks, less volume is required or lost compared to the inefficiency of conventional square tanks. The savings involved in mud mixing and maintenance varies dramatically due to the many variations of mud types and costs. Our experience is the higher the mud cost per unit volume, the more savings the round mud tank design provides.

2) Mud Displacement – See Flat line times item 2 above.

3) Mud Tank Cleaning - See Flat line times item 3 above.

4) Mud disposal costs – If less mud is mixed, less mud is required to dispose of. This may not be an issue in some areas, however as environmental regulations become more stringent, disposal volumes will gain priority for both contractors and operators.

Conclusion

Additional drilling rigs will be required as rig productivity expectations are altered by operator and employee demands. New rigs should not be limited to new equipment only, but also improved engineering designs and advanced technology. The new rigs should enable personnel to accomplish HSE standards and productivity improvements not achievable with today's conventional rigs. As an operator's daily spread costs increase, drilling rigs and drilling systems requires greater efficiency. This can be accomplished by the reduction of flat line times, those activities that are in the critical path of the operator's objective of accomplishing the complete well cycle. One indirect benefit of better rig systems will be attraction and retention of more skilled personnel in the drilling contractor industry. Advanced technology rigs will help attract new personnel into the drilling contractor industry if designs are used with improved ergonomics and a safe work environment in mind.

Acknowledgements

Thanks to our customers that helped us quantify the data associated with the efficiency improvements of the FlexRig™.

Nomenclature

HSE = Health, Safety and Environment
BOP = Blow Out Preventer Equipment
WOB = Weight on bit
RPM = Revolutions per minute
TD = Total Depth
OSHA = Occupational Safety and Health Act
IADC = International Association of Drilling Contractors
hp = Horsepower
ROP = Rate of Penetration
P = Pressure
MWD = Measurement While Drilling

References

1. Shtub, A., Bard, J.F., and Globerson, S., Project Management: Engineering, Technology, and Implementation, Prentice Hall, New Jersey, 1994**.**
2. Gaddy, Dean A., "Critical Path Analysis Improves Rig-Moving Procedures", O&G Journal Nov. 16th, 1998.
3. Gaddy, Dean A. "Autodriller, Cylindrical Mud Tanks, Generate Breakthrough Developments in Drilling Technologies", Oil & Gas Journal, Dec. 14, 1998.
4. Hubler, Warren G., "Safety by Design as Applied to the Design and Fabrication of Rig 200", IADC/SPE 35115, presented at the 1996 IADC/SPE Drilling Conference, New Orleans, LA, March 12-15.
5. Brauer, Roger L., "Safety and Health for Engineers", Van Nostrand Reinhold, New York, NY (1990), 1994.
6. Brauer, Roger L., "Safety and Health for Engineers", Van Nostrand Reinhold, New York, NY (1990), 1994.
7. Gaddy, Dean A. "Autodriller, Cylindrical Mud Tanks, Generate Breakthrough Developments in Drilling Technologies", Oil & Gas Journal, Dec. 14, 1998.

Figure 1.

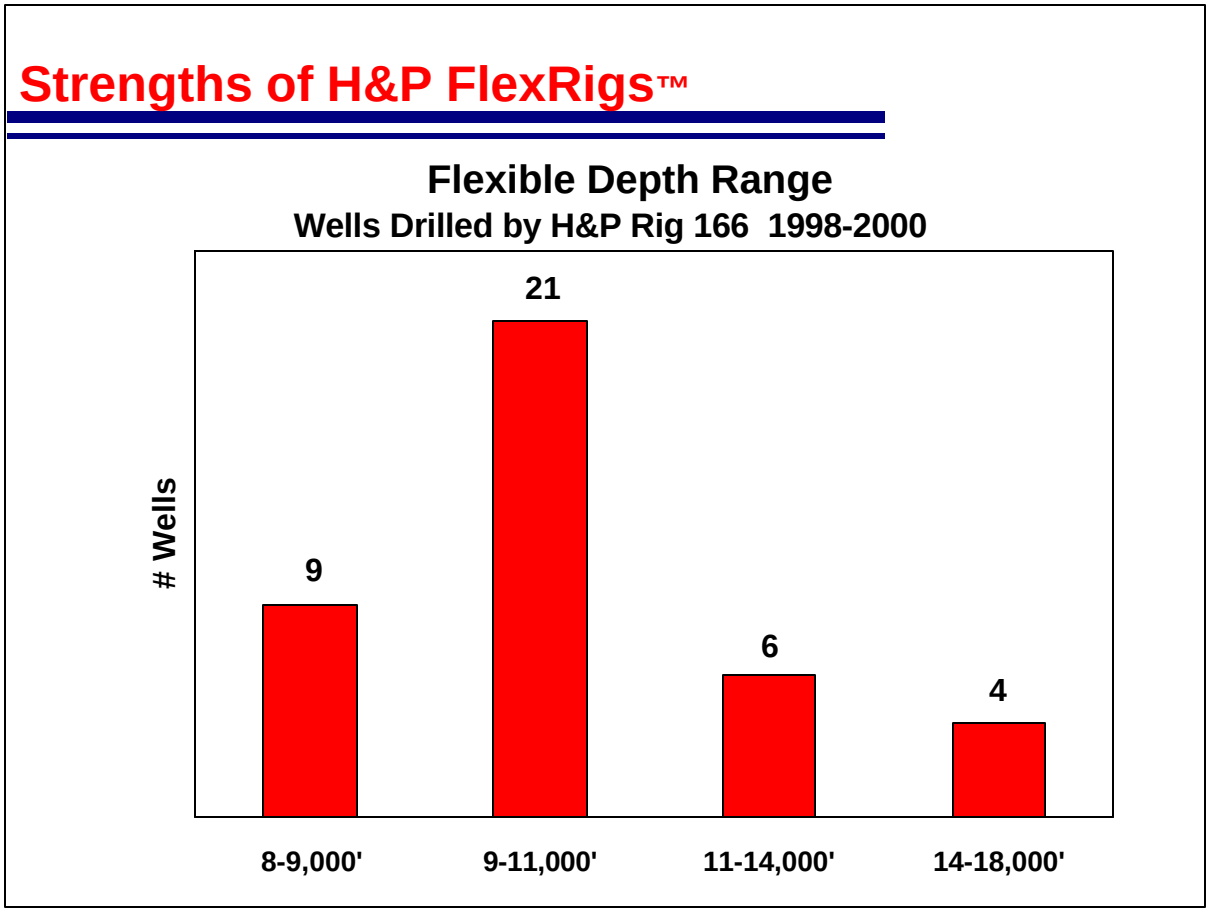

Strengths of H&P FlexRigs™
Flexible Depth Range
Wells Drilled by H&P Rig 166 1998-2000
Wells
9
21
6
4
8-9,000'
9-11,000'
11-14,000'
14-18,000'

Figure 2.

Safety Performance

OSHA Incidence Rate Comparison – 1998-2000

FlexRig™	All other H&P US Land Rigs	IADC US Land rigs (includes H&P)
2.55	2.99	9.43

Figure 3.

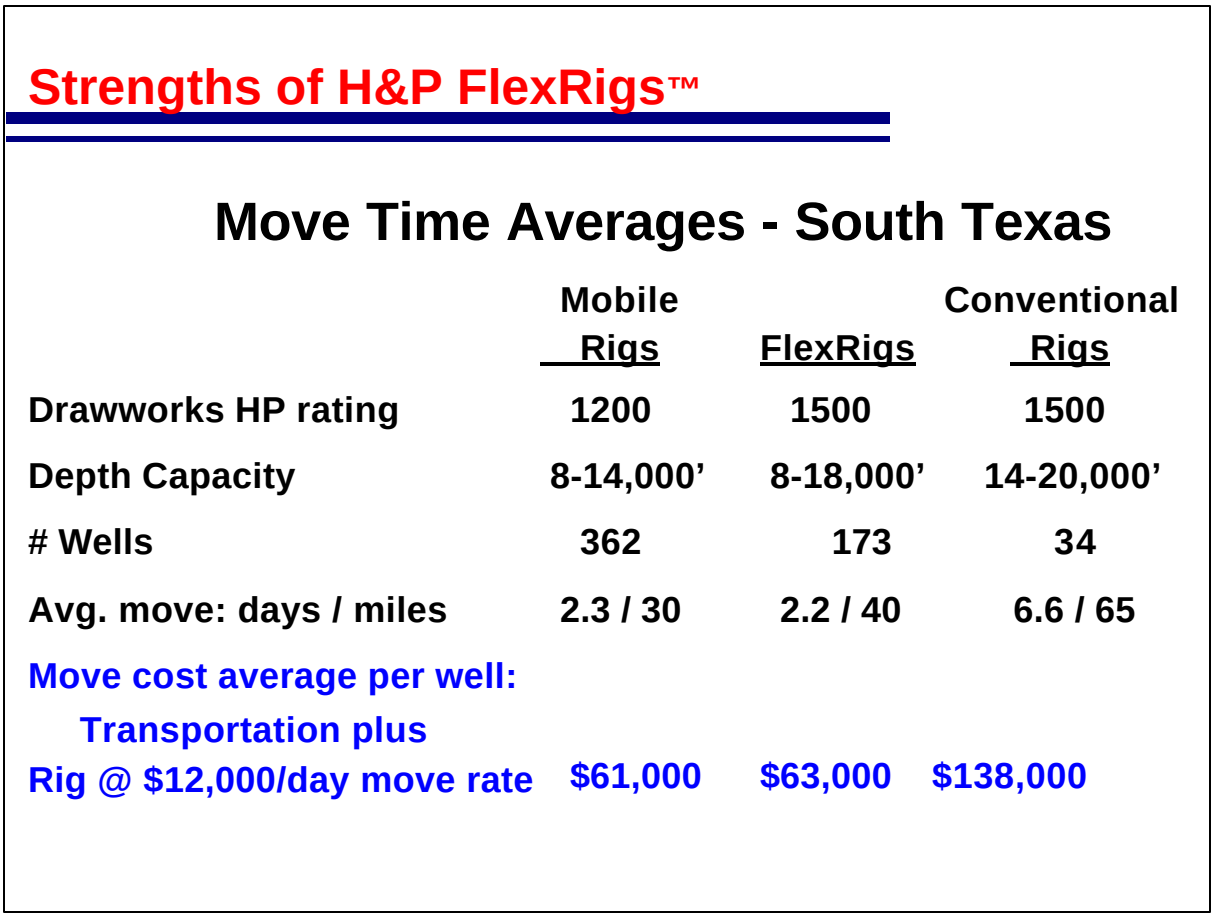
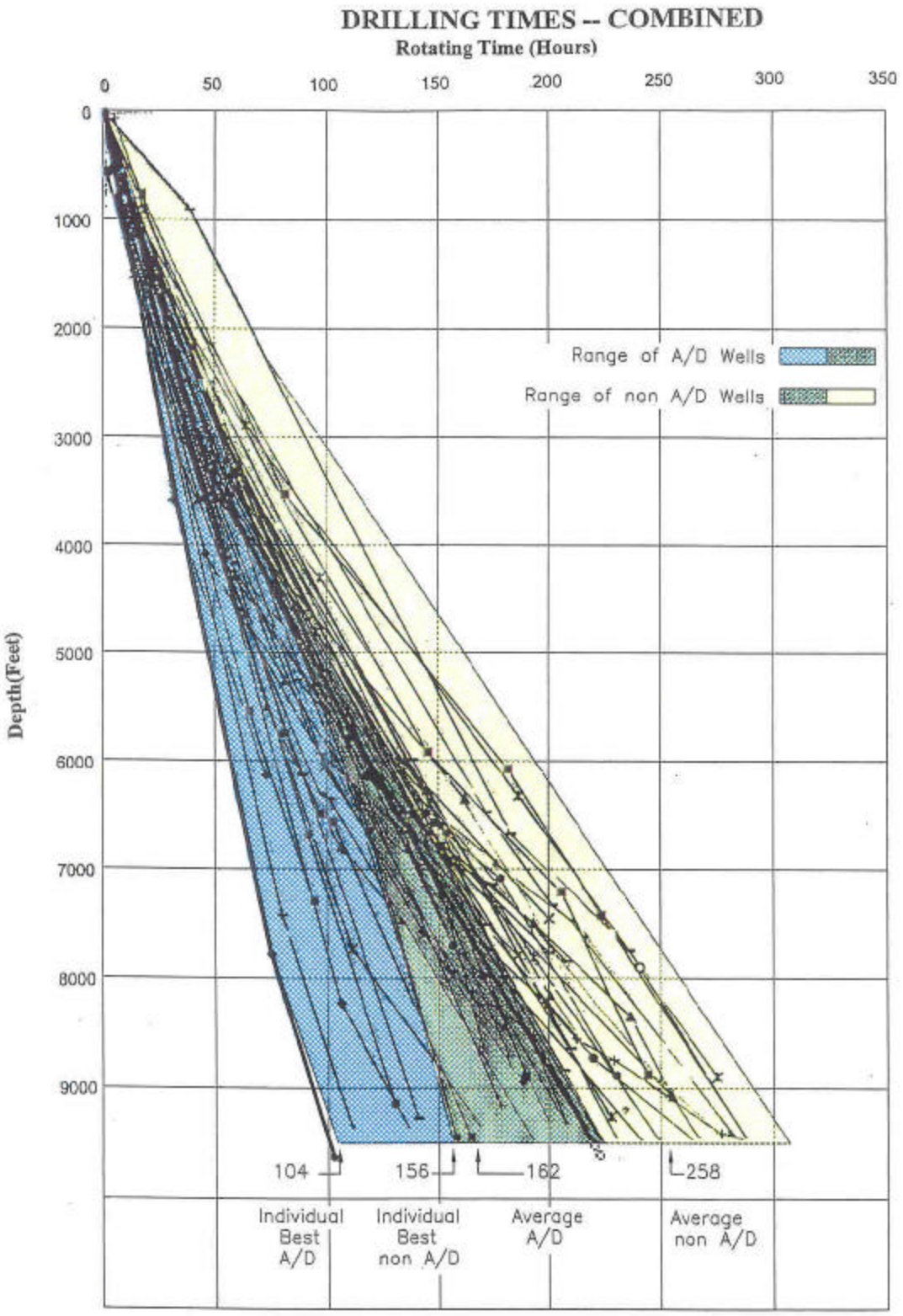

Strengths of H&P FlexRigs™
Move Time Averages - South Texas
Mobile Rigs
FlexRigs
Conventional Rigs
Drawworks HP rating
1200
1500
1500
Depth Capacity
8-14,000'
8-18,000'
14-20,000'
Wells
362
173
34
Avg. move: days / miles
2.3 / 30
2.2 / 40
6.6 / 65
Move cost average per well:
Transportation plus
Rig @ $12,000/day move rate
$61,000
$63,000
$138,000

Figure 4.


DRILLING TIMES -- COMBINED
Rotating Time (Hours)
0
50
100
150
200
250
300
350
Depth(Feet)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Range of A/D Wells
Range of non A/D Wells
104
156
162
258
Individual Best A/D
Individual Best non A/D
Average A/D
Average non A/D