# INNOVATIVE DEVELOPMENTS IN CASING PLUNGERS BROADEN FIELD APPLICATIONS AND INCREASE PRODUCTION IN UPPER ANADARKO BASIN

Robert L. Moore and Windel O. Mayfield
P.A.A.L., LLC

## ABSTRACT

An innovative patented casing plunger offers production increases in Texas/Oklahoma Panhandle reservoirs. Several years ago, casing plungers were introduced to Panhandle oil and gas reservoirs. While several applications responded well, others were limited by wellbore conditions and reservoir fluids. Those problems have been addressed in a recently patented casing plunger, providing substantial increases in daily production and recoverable reserves. Design details, working models and production data will be presented to encourage broader applications of casing plungers as reserves and bottom-hole pressures continue to decline. Current applications have been successful in all weights of 4-1/2" casing tapered strings common in the Upper Anadarko Basin. Wellbore fluids of all combinations of oil, gas, condensate and water have been produced with the new casing plunger. Applications for 5-1/2" casing are also presented. Reasonable installation costs and recoverable tangible assets can be expected.

## HISTORY

Casing plungers were introduced into the Upper Anadarko Basin in 1996, utilizing a design for use in gas/oil formations of Ohio and New York. Adaptations were required to accommodate the deeper reservoir depths of the UAB. The tool design employed a sealing rubber cup that had an O.D. greater than the I.D. of the casing. The UAB practice of some producers to run tapered casing strings of various weight pipe (i.e. 11.6 x 10.5 x 11.6 #/ft 4 ½ " casing) presented difficulties. In addition, gas/water or gas/condensate production made the efficiency more unpredictable. The presence of oil, even in very small quantities, greatly enhanced the performance and reliability of proper casing plunger operations. Many Morrow and Chester reservoirs produce gas without oil leaving a water wet or condensate wet pipe I. D. Since the sealing cup design employed a cup O.D. greater than the pipe I.D., the higher friction factor in the non-oil wet pipe sometimes caused the plunger to stop in the pipe on the way to the bottom of the hole. This might occur at the cross-over from larger I.D. to smaller I.D., but not always. If additional fall time did not allow the plunger to fall, subsequent production created a "loaded" condition. Frequently, the only remedy required the use of slick-line units to either bump the plunger to bottom or retrieve the plunger with few, if any, solutions to prevent the hang-up on the next trip. Additionally, the larger cup always increased the wear factor and accelerated the replacement of cups at additional expense. Some features of the mechanical design created down hole problems, notably the sealing cone would part and require the use of special magnets and slick-line units to recover the tools for repair. The manufacturer did make design modifications to the center shaft which reduced the thread failure on top of the cone, but we experienced thread failure on the smaller diameter locking thread that allowed the cone to back off the tool, requiring the use of magnets and slick-line units for recovery. The replacement of a failed center shaft was a substantial expense. Honesty requires notice that in the several wells in which the existing tool worked reliably, it worked well.

We found very few wells in which the casing plunger worked efficiently. In more of the wells, we encountered various problems that resulted in marginal efficiencies and economics. However, in the wells that worked, the dramatic increase in production, the reduction of normal lease operating expenses of rod pumps, tubing leaks, motor repairs and pumping units drove us to examine other design possibilities.

## INNOVATIVE DESIGN

The major problems seemed to be on the way down the hole. If the tool reached bottom without cup wear failure, the tool would generally seal and start up the hole. Our design focused on two major modifications. First, we chose to seal the inner by-pass chamber at the top of the tool, instead of the bottom, eliminating the possibility of "cone-like" pieces being left at the bottom of the hole. Our bypass seal assembly is assisted by the gas flow and the increasing pressures beneath the by-pass seal applied to the larger cross-sectional area of the sealing ball. It does not rely on O-rings that are fluid sensitive and of limited life. Furthermore, this allowed the increasing pressure to act within the body of the plunger, providing an additional force to increase the effective seal of the top cup to the casing wall.

Second, we redesigned the shape and function of the cup to be smaller than the pipe inside diameter and eliminated any cup wear or cup friction to hinder the fall of the tool to the bottom of the hole. The key element is the mechanical mechanism whereby the cup is expanded and sealed against the casing wall at the bottom of the hole. The upper and lower edges of the cups are sealed in such a way that the weight of the tool and pressure forces cause the cups to expand and seal against the inside wall of the casing, but only at the bottom of the hole. A two piece shaft that separately closes the by-pass and sequentially seals the cups, first the lower, then the upper, became the heart of the patents already awarded and pending.

We can offer a tool that has addressed most of the field problems encountered with available casing plungers. We have eliminated the drag and wear of oversized cups on descent of the tool. We have eliminated the possibility of leaving odd shaped junk in the hole. We have provided for the tool to seal at the bottom and begin the ascent to the top of the hole with increasing pressure from the formation.

We provide the necessary accessories to adapt this tool to many varied production scenario's and well conditions.

Some of the accessories available for both 4 ½ and 5 ½ casing include: full bore ball valves for well-head control, functional lubricators for insertion and retrieval of the casing plunger from the well, gas-operated and manual catcher/trip mechanisms, and micro-processors for ultimate flow control and maximum production. The overall system is both functional and user friendly.

## PRODUCTION RESULTS

### Mewbourne—Baker

The Baker is a Morrowan completion at about 7350 feet in Ochiltree County, Texas. The casing is 11.6-10.5-11.6 lb/ft 4 ½ inch. Initial production began in 2000 and shortly thereafter presented normal loading evidence. Typical remedies of soap and swabbing were ineffective. The tubing was laid down and the casing prepared by broaching. A casing plunger was installed in November 2001. During the initial stages of the casing plunger production, several periods of reduced production occurred while modifications were made to the equipment. In addition, this location is in the middle of plowed farm land and winter/wet spells prevented well site entrance for remedial work when preferred.

### Marlin—Ward

The Marlin Ward is a Morrowan zone completed in 1985. Production declined to 8-12 mcf per day with no fluid produced but with loading evident. Swabbing produced short-term benefits, although uneconomical, and soap produced no benefits. A casing plunger was installed in March, 2003. Immediate benefits were achieved with the average gas rate exceeding 30 mcf/day and fluid production of 1-3 barrels per cycle. The gas rate has leveled off at about 30 mcf/day and the fluid production has decreased to about 3 barrels per month. In very small gas wells such as this, fluid production does not have to be excessive to become restrictive over time. Some inefficiencies have occurred due to field personnel inexperience with the casing plunger. Adequate training and focus are mandatory.

### Moore—Carnagey

The Moore Carnagey was a deep Morrow well of about 8200 feet. It was being produced by typical tubing plunger with a pressure sensitive controller. In order to efficiently produce oil and water, the active casing pressure was maintained at about 180 psig. The average production was 35 mcf/day with 16-28 bbls fluid per month. A casing plunger was installed in March, 2003, with modest results. The operating pressure has been lowered to 80 psig for production into a 45 psig line. Normally, the operating pressure for casing plungers more nearly approaches the line pressure. In this well, restrictions in the casing inside diameter prevented the recommended broaching operation. The restrictions were encountered high in the wellbore and would have normally indicated a poor choice for a casing plunger. We ran a casing scraper to clean the casing walls, and relied on the smaller cup diameter of our tool to rescue us. We have experienced the successful running of the casing plunger, with some surface equipment modifications. The plunger falls without hindrance. On the trip to the surface, with the cups expanded and loaded with fluid, the plunger would hang up in a tight spot about 1800 feet from the surface. We used the former tubing plunger surface controller to time the ascent. After a predetermined trip time, the controller opens the flow line to the stock tank for 2 minutes, just long enough for the sudden reduction in back pressure to "bump" the plunger up through the tight spot. Although the increase in production has been insignificant, the fluid production has become more regular and the production pressure reduction is considered favorable for the increased recovery of reserves.

The fluid production has become more stable at about 30 bbl/mo and will, therefore, represent a very modest increase in annual oil production. The overall effect of the casing plunger installation is considered to be cost effective.

## INSTALLATION

Installation procedures and cost will vary from well to well and within company safety guidelines. A typical installation consists of removal of the wellhead assembly to the top of the casing in the casing head. For low gas volume wells we have simply made "hot weld" connections by welding a bell nipple with 8 rd thread pin looking up. We have used a chimney vent stack to divert the gas flow while welding the nipple in place. When that procedure is either unsafe or contrary to company policies, we have a flange with a secondary casing seal that can be installed on the well head in typical flange fashion. The flange has been modified in the shop to have either a casing collar or 8 rd pin looking up. We then install a full port ball valve immediately above the bell nipple or flange. A lubricator to permit insertion and removal of the casing plunger is installed. The lubricator is equipped with hammer union connections to facilitate any down hole well work required. In the event that conventional production with tubing becomes necessary, the full port ball valve can be removed and a threaded casing/tubing hanger such as Huber or Hinderliter can be installed.

Typical well service companies can usually provide the required skills to broach, run casing scrapers, and swab the casing. Naturally, some expertise will be required in each of these functions.

Additional cost benefits were achieved in the salvage value of the tubing and/or rods, the complete flanged well head, and the removal of pumping units, if any.

## CONCLUSIONS

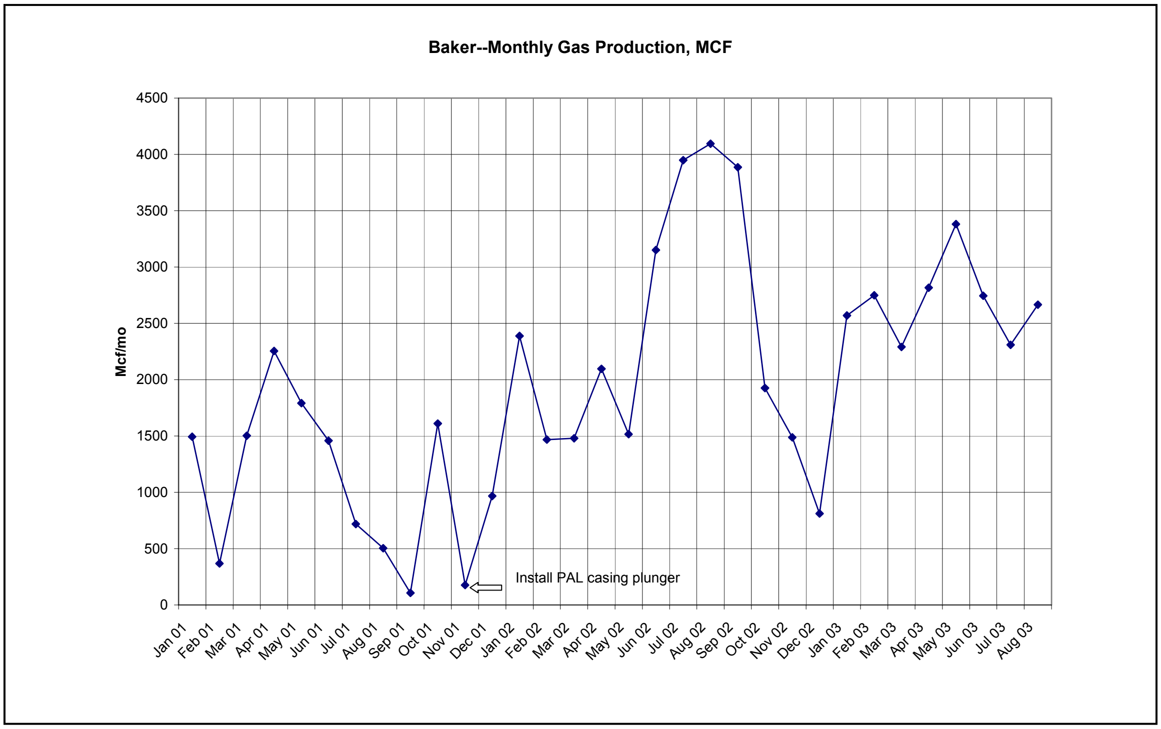
The innovative casing plunger described herein has met the demands of some of the well applications which could not previously be effectively satisfied with existing equipment available. The benefits of using a plunger with cup diameters less than casing inside diameters have eliminated "hang ups" on the way down hole. The expansion and inflation of the cups at the bottom of the hole have proven to be both innovative and field practical with substantial improvements in production and field operations. The predictable costs of installation have shown to be cost effective and reasonable for all future anticipated production methods.


## ACKNOWLEDGEMENTS

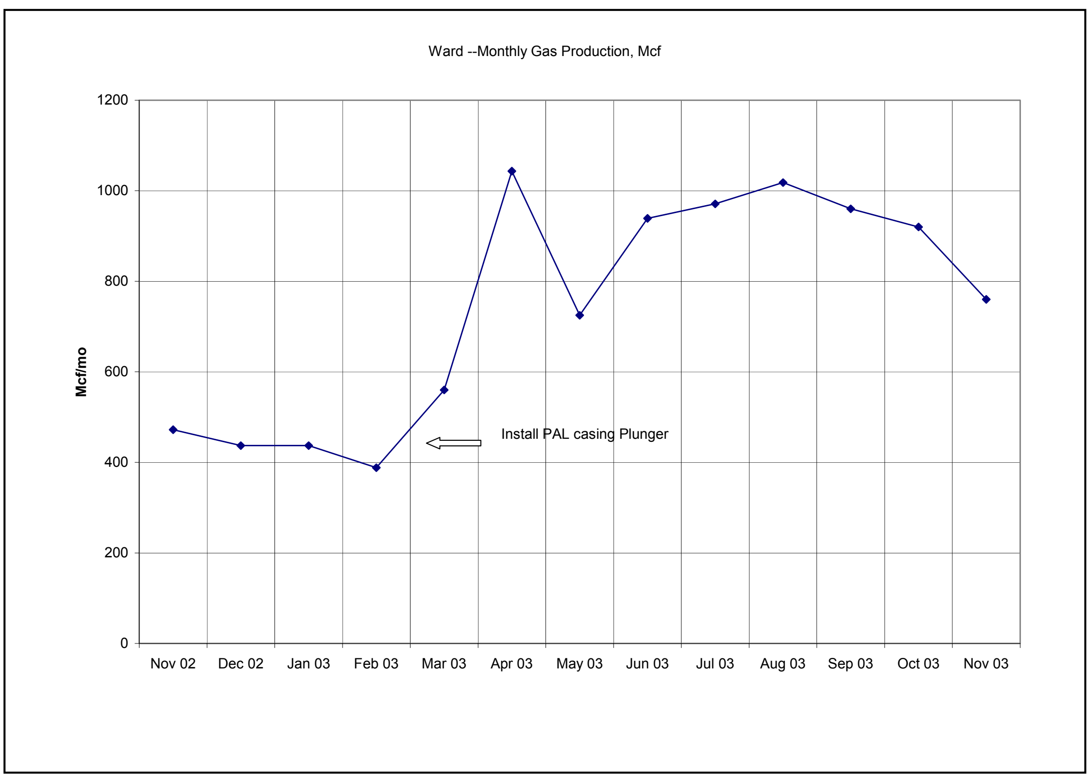
Mewbourne Oil, Perryton, Texas, assisted by providing one of the early test wells and sharing data for this paper.

Marlin Oil, Oklahoma City, Oklahoma, has been involved in the extension of casing plunger applications to the Oklahoma panhandle from the first application in 1998. Marlin has been both optimistic and resourceful in developing remedies for the existing casing plunger equipment and steadfastly involved in the development and applications of the innovative design described herein.

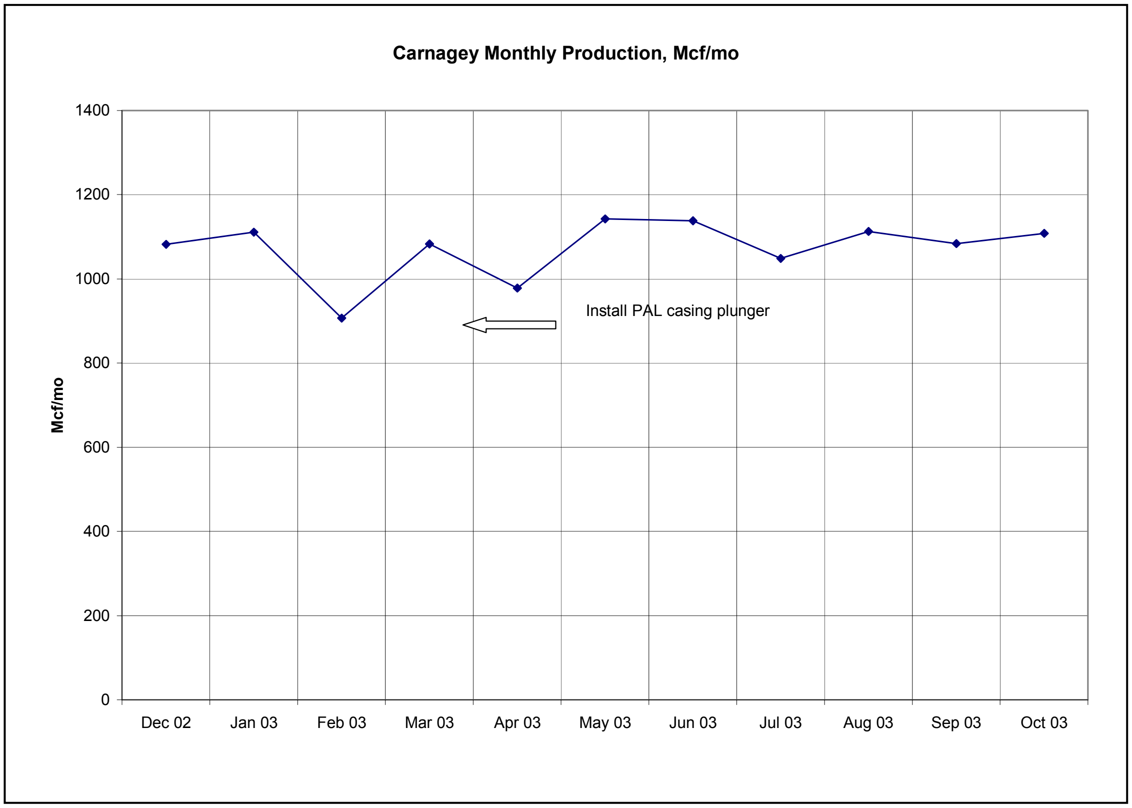
D. A. Daniel, Perryton, Texas, has provided the wire line service and tools and field experience to assist many ways.



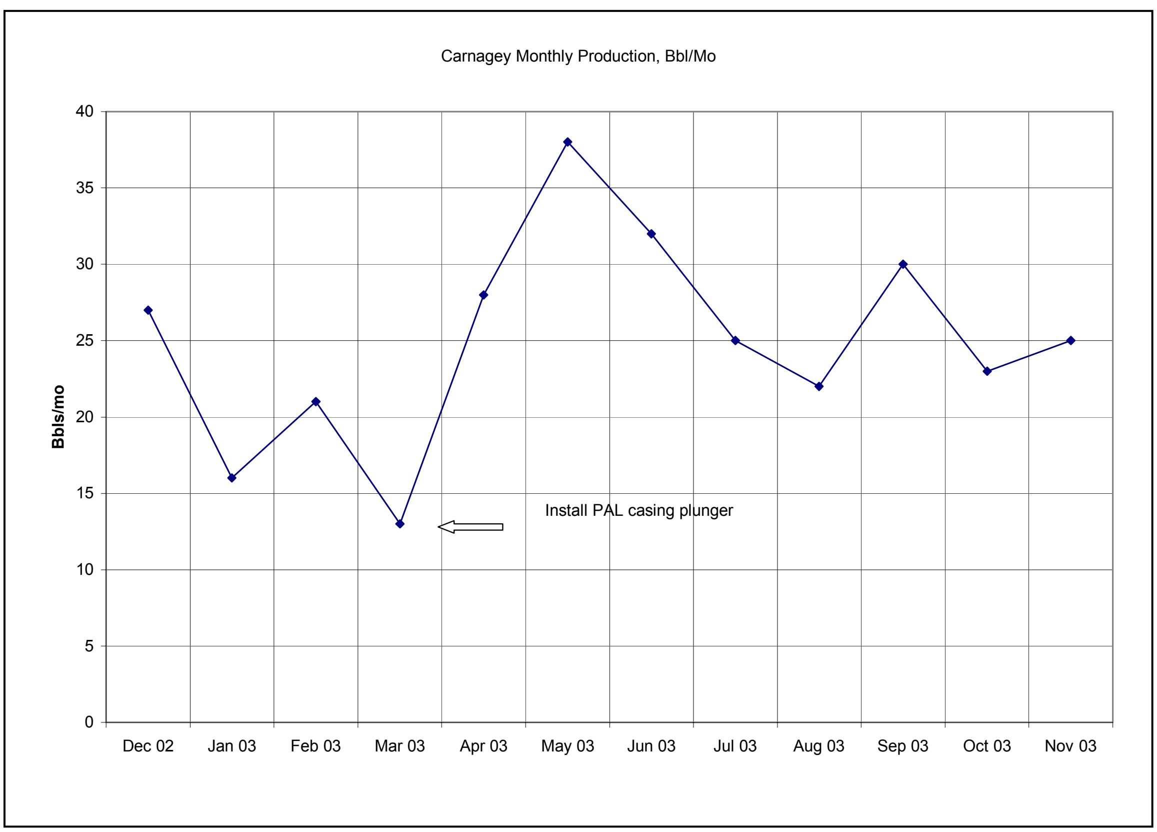

Mewbourne—Baker




Marlin- Ward




Moore-Carnagey




Moore - Carnagey