# "PnP"
# A 21st Century Technology That may be Right for You!

*Innovation has been slow in the oil and gas industry. A key reason is the paradigm "Because we've always done it that way." Maybe together, we can change that!*

## A Technical Paper

Prepared for

## Facility Engineers and Designers


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KBK

## EXECUTIVE SAMMARY

The term PnP stands for "plug and play." It was first coined in the 1990s related to aftermarket personal computers components. These PnP components were designed for quick and easy installation without additional cables or software. The idea was to make it so easy to change or upgrade a PC that anyone could do it. PnP revolutionized the PC industry, just as it now has revolutionized the oil and gas industry these many years later.

As PnP became common two more significant changes were occurring simultaneously. The first was the growth of Walmart, whose success was based on having all inventory on the shelf, and on the demise of mega-corporation Enron. Enron had grown rapidly, and gambled on an increased demand for natural gas that did not materialize. Enron had to declare bankruptcy. Key Enron management seized on this opportunity to recapitalize and renew Enron. They secured a huge loan and with it reformed as EOG Resources.

Contrary to the top-down management style of most large oil companies, EOG's management team embraced a bottom-up management style, presuming that people closest to any situation understood it better than people at headquarters. Such innovative thinking revolutionized EOG, and eventually the entire oil and gas industry. It also made EOG Resources the largest oil producer in the USA.

This paper focuses on the details of what it took to make this happen, and how it might apply to increase your own profitability.

## THE KEY INFLUENCES OF ENRON AND WALMART

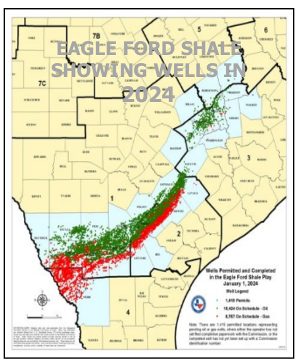
Before its demise Enron had acquired mineral rights throughout the Austin Chalk formation and is oil bearing formation known as the Eagle Ford shale. This formation had been drilled in for decades, but few wells ever produced enough oil to be economical. EOG's goal was to turn this around by trying radically innovative approaches. One of these was the attempt to complete an oil well horizontally. Drilling technology had advanced to the point where the drilling engineer always knew precisely where the drill bit, and the bit could be directed from the surface without having to pull the drill pipe.

Most oil wells had previously been drilled vertically through the oil-rich layer, or

"A zone." The pay zone in marginal wells may be 5-10 feet thick, while it may be 400-600 feet in more prolific wells like those in the Middle East.

EOG postulated that if the drill bit could be guided into oil bearing shale horizontally, the normally shallow vertical interval could be dramatically expanded horizontally. They postulated that this could improve the typical production from a vertically completed well with twenty feet of producible shale pay zone producing four barrels per day to a well that might produce two hundred barrel per day from a one-thousand feet of horizontal pay interval. While there were few economically viable wells in the tight Eagle Ford formation, EOG's staff reasoned that they could leverage their substantial lease hold position in the Eagle Ford by drilling horizontal wells that produced enough oil to quickly pay off their reorganization debt.

Success did not come overnight. Soon, however, through the efforts the efforts of their reservoir engineers working with Halliburton, Schlumberger, and other key players, they proved that the Austin Chalk could be produced. New wells continued to exceed expectations as horizontal completion technology evolved. As they did, EOG's reservoir engineers set out to exceed their own predictions by studying the effects of each type of completion so they could improve performance well after well. This meant they needed well performance data 24/7. To get it they looked to the facilities engineers to develop central tank batteries that could measure the performance of each well 24/7. This needed to change the way the facilities groups approached CTB designs. Overnight they had to shift away from testing wells once a month to testing every well 24/7/365. Every well needed its own dedicated well test separator; something that had not been done before! And every separator had to be extremely efficient during IP, after IP, and during the rapid production decline that followed in these horizontally completed wells. The days of a CTB with a single FWKO and a single heater treater were gone forever.




Their next challenges were to overcome the inefficiencies of process equipment and the time it took to build new central tank batteries.

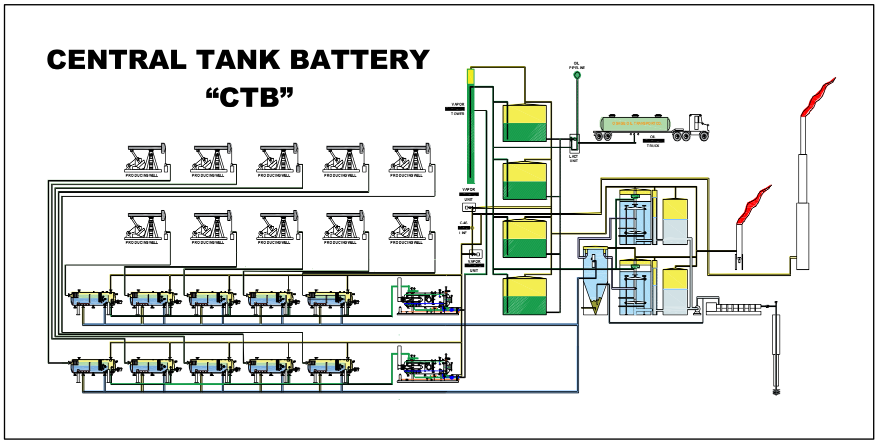
They needed a design team to develop better separators and treaters for their new prolific production conditions, and a master plan that allowed them to construct more central tank batteries than ever before. Their efforts to use local consulting engineering firms in both areas had failed because their approach exceeded the experience level of such firms. They needed a hands-on firm.

Coincidentally, one of EOG special projects managers had discovered and used some innovative designs of the co-author who had suggested that they work together to use more efficient processes and equipment designs to develop the master CTB design EOG needed. Once developed, EOG could build CTB facilities rapidly enough to keep up with their drilling program and the prolific production increases EOG was enjoying. EOG had never been able to build more than four CTBs a year, EOG's biggest constraint at that time.

To overcome this constraint, they reasoned that they needed to adopt the Walmart philosophy of having inventory readily available. EOG's facilities engineering group had grown with Walmart as it became the nation's number one retailer. Walmart's success hinged on having everything anyone could ever need on the shelf. EOG needed to do the same by stocking every part needed to build more CTBs.

Prior to this most oil companies purchased facility components as needed. That approach saved money but took much longer. EOG needed to build more CTBs faster to keep up with the growing production from horizontal completions. Doing so would allow them to quickly liquidate their reorganization debt. To do this they needed to standardize, purchase, and inventory everything for new CTBs. The goal was to increase from four CTB per year to at least twelve, and to eliminate all delays. The result was the construction of twelve CTBs the next year, and the year after that! This allowed for increased productivity.

By 2014 EOG was producing more oil than any other oil company in the USA due to PnP and off-the-shelf inventory practices. Most of the real credit goes to the reservoir engineers for developing new horizontal well drilling and completion technologies. These efforts combined to allow EOG to produce, process, and sell the more crude oil in 2014 and 2015 than any other oil company in the USA. Management's goal of paying off the reorganization debt was finally realized.




From 2014 point on every new CTB was constructed according to a master design like the one sketched at the left.

The mission was to eliminate all delays. As PnP was applied, the results were amazing! By the end of the first twelve months construction of twelve CTBs was complete, and it was repeated the year after that. The challenge of perfecting horizontal drilling and mastering massive frac job completions was met head on and it dramatically increased well productivity. CTB construction had followed suit through PnP and radically different procurement and inventory practices.

The word spread quickly and other oil companies adopted these technologies. Together they all learned another key lesson: horizontal wells decline at a much faster rate. While vertically completed wells traditionally declined slowly over a twenty-to-thirty-year period, these new horizontal wells declined much faster. In the past, all process equipment purchased for a new oil well stayed on the wellsite for the life of the well. But now, the rapid rate of decline in these new horizontal wells meant that the original process equipment was almost immediately oversized, often in 12 months or less! Oversized process equipment performs poorly. Inferior performance means inaccurate metering, throwing the reservoir group into a state of increased uncertainty. So, the next challenge was to find a way to match process equipment efficiencies with rapidly declining production rates, creating a whole new set of industry-wide challenges.

Looking back again, as the industry began to recover from the banking crisis of 2008 new facilities engineers were coming into the industry. They were young, fresh out of the university setting. Open-mindedness was engrained in them. They were the first generation to take personal computers for granted. When the need to change PC components arose, they naturally used PnP components to save time.

At the same time PnP was catching on in industry. PnP components and personnel were being injected into everyday factory life … so why not in the oil industry as well?

As it has, the result has been the use of staggered, scaled-down process equipment in new CTBs. Operators could start out with large-scale process equipment sized for IP (initial production) rates, and then scale down to medium, and eventually smaller equipment as wells aged and declined. Each needed to be skidded and pre-piped. All skid dimensions and elevations needed to be identical so each larger skid can be slid out of its position connected to a master PnP manifold system, and the next smaller vessel skid slid into its place.

Overnight, as well production increased more and more, downtime causing lost production became the industry's single most costly operating condition.

The new PnP approach kept downtime to a minimum. Separator and treater swap-outs kept more oil and gas wells generating more dollars more often. As a larger PnP skid became oversized it could be swapped out for the next smaller PnP skid. A smaller PnP replacement could be slid into place in minutes. The larger PnP skid could then be used to the next new CTB. This minimized CAPEX requirements! Eventually, only the smallest, least costly skids would need to be purchased, and then only in smaller and smaller quantities, keeping CAPEX to a minimum.

Looking back at PnP and the Walmart off-the-shelf inventory philosophy we see that both originated outside of the oil and gas industry. It took some fresh, creative, and open-minded thinking to realize that these business philosophies could fit in oilfield operations. After all, the paradigms of the past, particularly the "Because we've always done it that way" paradigm, could have stifled this process and prevented the success of this new era in oil industry success.

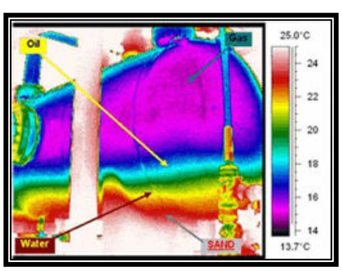
From now on, the use of PnP and the Walmart "off the shelf" inventory philosophy will prevail as more as more facility engineers discover the many benefits of this overall approach.

Moving forward, the PnP concept assures that properly sized process equipment can and will be used throughout the lifetime of each new oil well.

## PROPER SIZING ADDS OPEX

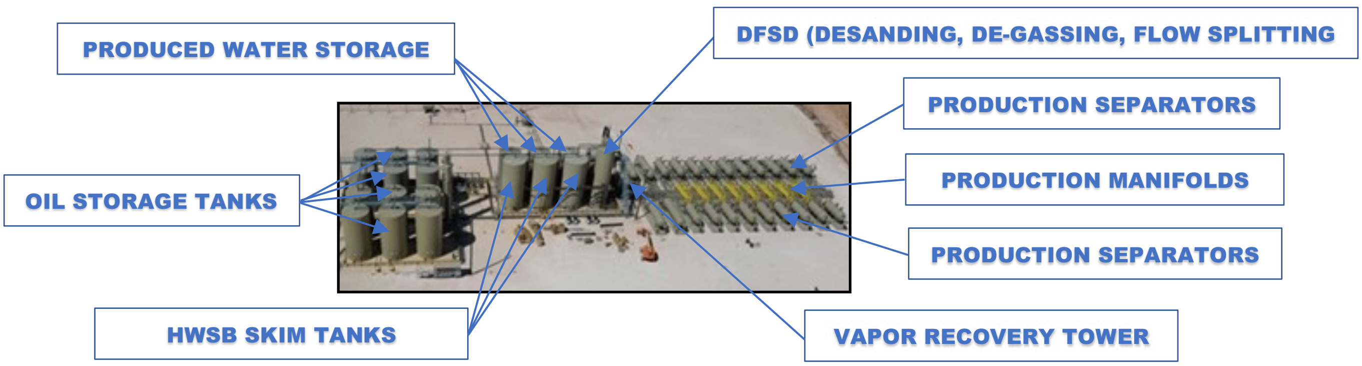
Today, a professionally designed PnP CTB might look like the one on the left. In this system all wells feed individual primary three or four phase metering separators. These separate are designed for 21st century production conditions, separating and metering oil, water, gas, and frac sand/formation fines. Metering is essential. The production data is needed by reservoir engineering groups so they can evaluate the results of their latest drilling and completion programs.

Proper tank and vessel design is critical in this process. During IP (initial production) new wells typically produce at extremely high rates, so tanks and vessels are sized accordingly. This is where KBK Industries plays a key role by first applying the patented DFSD® de-sanding, degassing, and flow-splitting tank to manage all produced water. The tank is fabricated with proprietary de-sanding cyclones and is often a radical cone bottom design so sand can be drawn off without having to shut down or bypass this system. Any entrained gas separates and is piped off to sales. Remnant oil and all produced water exit this tank and flow to KBK's ultra-efficient HWSB™ skim tank. This patented tank is 99.5+% efficient at clarifying all produced water. In the process, it is documented to capture 5-10 barrels of saleable crude oil every hour during and after IP. The added revenue from these two KBK tanks pays for the entire CTB!




As IP production rates decline separation efficiency also declines. This happens because as flow rates decline, the fluid velocities inside a separator also decline. This allows fluids to thermally stratify as we see in the temperature thermograph at the left, where warmer liquids rise into smaller and smaller spaces, limiting the separation efficiency of each.

This incomplete separation reduces the time each has to separate, so fluid quality deteriorates. The result of poorer separation is that oil carries over with the outlet gas, water and sand carry over with the outlet oil, and oil and sand carry with the outlet water. The good news is that KBK's DFSD® and HWSB® eliminate the economic impact, but the unwelcome news is that carryover negatively impacts the accuracy of all metering, skewing the information the reservoir engineering group needs to tailor all future completion programs which would otherwise optimize future production.




Today's central tank battery (CTB) looks like this. This one will easily process 40,000 BOPD, 60,000 BWPD, and up to 100 MMSCFD gas. Here, eighteen oil wells feed eighteen well test separators which feed four heater treaters. The treaters feed pipeline quality oil to a vapor recovery tower (VRT) which helps control the Reid Vapor Pressure (RVP) of the crude, sending oil on to oil storage and then to a LACT Unit for oil sales. The solids and oily water flow out of the high-pressure separators and treaters into a single KBK cone bottom DFSD® tank which separates solids, de-gasses the liquids, and divides or splits the flow of the oily water into three HWSB™ skim tanks immediately downstream. The three HWSB® skim tanks separate over 99.5% of all remnant oil, sending it all to the oil sales tanks.

Without KBK's DFSD® and HWSB® all oily/sandy produced water would flow into the dedicated water disposal or SWD plant well where the oil would prematurely plug the well, reducing its injectivity and eventually shutting it down. The result is normally a costly well stimulation and/or well workover project, and considerable costly downtime!

## SUMMARY

With the shift from vertical oil well completions to long horizontal lateral well completions and successful shale oil production a change in basic assumptions has been taking place for about twenty years now. Process equipment designs of previous decades are obsolete for the most part and are being replaced with more appropriate and efficient 21st century designs. Operators are learning that the industry "standards" used prior to 2005 are no longer valid in today's process conditions and CTB facilities. This paper has attempted to highlight some of these issues and offer viable, practical solutions.

## ABOUT THE AUTHORS

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