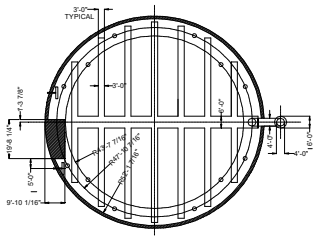
# Gunbarrels then & Now - 2021

*Crude Oil Dehydration in Atmospheric Tanks*

## A Technical Paper

Prepared for

## All oilfield personnel concerned with Gravity Separation



**PLAN VIEW**
CONCEPTUAL OIL DISTRIBUTOR
LAYOUT DETAIL

HEGB™ DISTRIBUTION SYSTEM
Patented Design

Paper by:


## Breakthrough Engenuity

*Where Engineering Meets Ingenuity*

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## PREFACE

Too little effort had been given to the selection of process equipment in the past. 2021 will not be the exception! The results will cost oil companies millions of dollars.

The most common mistake in 2021 will be made by many oil operators who simply pick order a separator, a gunbarrel or heater treater, an oil tank, a water tank exactly as they ordered it last time. In 2021 you'll find very few engineering firms or equipment suppliers can properly determine ideal vessel sizing or provide the application engineering needed a specific production processing application.

Why? They presume you know what you want, even when what you want may not be what you need! Ask yourself, "Why am I ordering this?" If the answer is, "Because we've always done it this way" … please stop and give this some more thought! In 2021 this justification simply no longer justified!

This approach holds us back. It handcuffs us mentally. It forces us to perpetuate the mistakes of the past. None of these are good for us, or our companies. In 2021 we need to dig a little deeper to find out what's out there. We need to stop assuming that just because something was okay in the past it may not be okay today. We need to catch up with technology! And once we do, we need to order the best equipment to meet our needs and process conditions in 2021!

Every part of the oil industry is different. Every location has its unique features. There really is no "normal". But the technologies we have in 2021 are completely different than they were when our predecessors tried to find the best approach for them in their time. Most of the equipment we use today was designed in a different time for different production conditions like higher GORs, much lower water cuts, higher pressures, less stable emulsions, lower amounts of iron sulfide, sand, $CO_2$, paraffin, etc.

Not too far in the past, the "norm" was high oil volumes and very little produced water. Today, most operating conditions are just the opposite! It shouldn't be too surprising that today's conditions demand different technologies and process system designs.

It also shouldn't be too surprising that yesterday's process equipment designed for low water cut conditions doesn't fit well in today's higher water cut operations. And when we don't keep up with today's technologies, older equipment can cost the oil industry a small fortune!

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Let's see what really causes this, and what we can do about it once we decide we should.

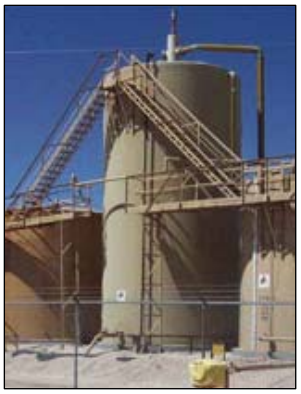
## PAST CONDITIONS

Oil-water separation became a necessity in Drake's fist well in Titusville. As this well began to water out a system to separate the water needed to be developed. The so-called "Gunbarrel" tank answered the call.

Gunbarrel designs took a couple of generations to mature. But when they finally did, they became a standard of the industry that has survived ever since, rightly or wrongly. The "Gunbarrel", or in some circles, a "Wash Tank", became universally applied when the industry needed to separate smaller quantities of water from larger streams of produced oil.

Since the Gunbarrel design evolved to successfully separate small amounts of water from large amounts of oil it became an industry standard. In the early day, most oil wells produced less than 25% water. Most also produced enough natural gas to cause the early Gunbarrel designers to add a liquids-gas separator to their Gunbarrel tank designs. Removing the gas before the oil and water entered the Gunbarrel was observed to be necessary since the gas evolving from liquids tends to stir or mix the water and oil, hindering its separation. Even then, 162 years ago, it was obvious that mixing is the opposite of separation. So, a gas separator was added. It was referred to as a "Degassing Boot", or simply a "Gas Boot". As the industry evolved the Gunbarrel became well known as the preferred way to pre-condition crude oil in preparation for refining.

For the next 15 decades the Gunbarrel design remained essentially the same, staying true to its original and very simple design. The tank was to be 1/3rd full of water and two-thirds full of oil.



This 1800s design used a pipe inserted through the roof of a standard atmospheric tank, extended a few feet above the roof to form the gas boot, and extended down to within a few feet above the tank bottom so the liquids would distribute into the water layer. A horizontal plate was attached to the bottom of the "downcomer" pipe at its bottom to help distribute the inlet oil through the water in the bottom of the tank. Oil rose through the water where the water in the tank was thought to "wash" the water out of the oil. The oil rose in the tank in a layer above the water. Most folks believed that the oil layer needed to be large enough to contain about 8-24 hours-worth of crude oil production.

As the decades flew by more and more people accepted the fact that the depth of the oil layer needed to be based on the density difference between the oil and the water. It was found that lighter oil

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could be dehydrated in fewer than eight hours of calculated oil retention time in a gunbarrel, while heavier oil might require 24 hours or more. At last, a small amount of science was finally being applied to the Gunbarrel design!

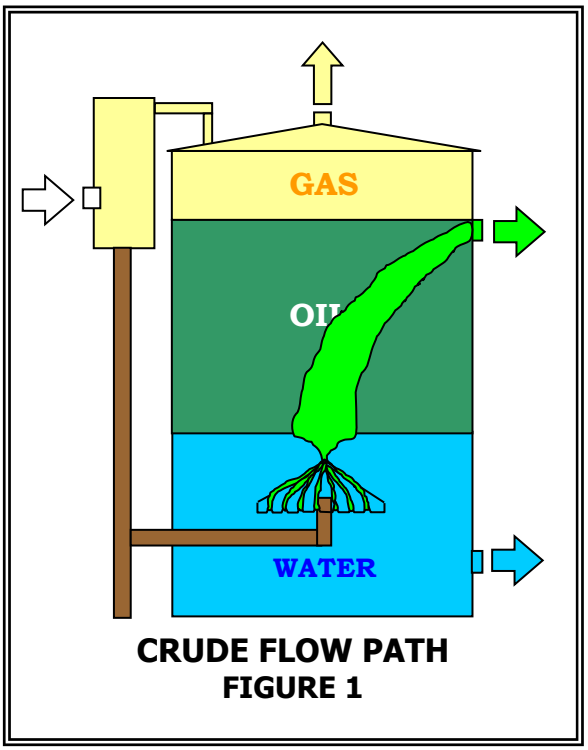
Some Gunbarrel manufacturers, bowing to the wishes of their customers, placed the gas boot and downcomer outside the tank to minimize the corrosive effects of salt water on that piping. When a Gunbarrel was configured this way it was often referred to as a "Wash Tank". When the gas boot was located concentrically on top of the tank (as in Figure 1) it was most often referred to as a Gunbarrel, since when viewed from above it resembles the image of the barrel of a gun. The physical difference is obvious at a glance, but the processing results are identical.

This design remained unchanged and unchallenged for nearly 75 years! It was the standard of the industry until the 1930s when vertical "Heater Treaters" were developed to help lower crude oil viscosity by applying heat, and thus aid is reducing emulsions plaguing refineries at that time. These "Treaters" were pressure vessels designed to separate the otherwise vented natural gas stream under pressure so it could be pipelined to gas processing plants at last.

In fields where gas production was non-existent, or depleted, the Gunbarrel was, and still is, the system of choice.

Finally, in the 1970s, this oilfield "standard" was challenged in some of the industry's more forward-thinking oilfield R&D labs. The results were unexpected and startling. They were also very disappointing!

Report after report showed that the hydraulic efficiency of Wash Tank/Gunbarrel were extremely low, most ranging from 1% to 3%. Bigger had been thought to be better, but in most cases, bigger was not proven to be




**CRUDE FLOW PATH**
**FIGURE 1**

better, but instead, worse! Oil industry separation systems had always been assumed to work as we had always thought they work!

For many decades it had been presumed that fluids naturally distributed uniformly and flowed uniformly through the entire

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Gunbarrel tank, providing the ideal retention time needed for efficient separation. Instead, these R&D studies proved that the oil and water predictably take the paths of least resistance, as depicted in Figure 1 above.

Oil and water move actually through the Gunbarrel tank in the shortest, narrowest, non-uniform flow paths of least resistance, between the fluid inlet and the fluid outlets. Retention time tracer surveys went on to prove that only a very small portion of the storage volume was actually in the flow paths of the water and oil. In some tests the inlet crude was found to actually only stay in the oil phase for matter of minutes, and the water for even less time. In a few tests the water retention time was measured at just a few seconds!

When compared with the original supposition that oil retention times were hours long, these tests were quite eye opening, and contrary to the assumptions made about Gunbarrel performance for over 100 years!

At this point, skepticism about the wisdom of the past began to filter in. New designs began to shift away from the assumed oil retention time of the past. Designers began to look for new ways to increase fluid distribution and collection systems to optimize the use of the entire vessel, and overall separation efficiency. Every conceivable idea was tried, and surprisingly, most failed!
From this work, more and more researchers agreed that as fluid flows and distribution were rendered more uniform the separation results were more improved. Most researchers agreed that truly uniform distribution of incoming crude and emulsion through the entire cross section of the oil layer would increase retention times enormously. In some cases the results were 35 times better!

The conclusions of these studies proved that designs based on proper fluid flow dynamics could produce amazing results.

When a Gunbarrel design is optimized, the size of the tank will produce better results regardless of the outside influences of conditions viscosity changes due to summer-winter swings in temperature. Optimized designs also result in much smaller tanks, reducing capital investment.

And most surprisingly, researchers discovered that process capacity and separation efficiency increased even more when the inlet crude and emulsion is **NOT** washed through the water phase, but is introduced into the emulsion rich layer just above the water-oil interface.

In fact, some studies showed that the inlet emulsion actually absorbs water from the water layer, **increasing** the BS&W concentration of the mix.

These tests were conducted in great "boom" of the 1970 and early 1980s, ending in 1985. While a great deal of the wisdom gained in those years was lost through "bust" cycle attrition and layoffs, we were able to apply the lessons learned to the next generation of

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Gunbarrels, a high efficiency Gun Barrel or HEGB®.

## HEGB® - A BETTER DESIGN

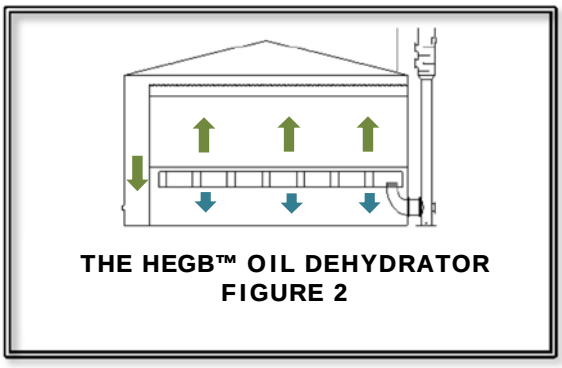
Knowing that efficient and effective physical separation is a function of efficient fluid distribution, efficient fluid collection, and the resulting retention time Breakthrough Engenuity has engineered a system that achieves these critical criteria.

In the physics of separation (retention) time in any oil dehydration application can be calculated using Stokes' Law.

However, once again, the key to effective oil-water separation in a facility design necessitates a focus on uniform fluids distribution and collection, which result in real retention time improvements and the desired overall separation. Breakthrough Engenuity's design approach in its HEGB® does just that.

Breakthrough Engenuity's "HEGB®" design uses a very unique dual phase hydraulics approach to achieve the desired uniform distribution and uniform collection of the crude oil in this 21st century patented Gunbarrel design.

Let's see how it works. As in all Gunbarrels/Wash Tanks, the inlet fluid in the HEGB® is first degassed in a degassing boot if gas is present. If not, the degassing boot is deleted. The degassing boot has internals to assure that the liquids are rendered gas-free when it is used. The gas free liquid then flows down into the tank, entering a very large horizontal hydraulic distributor. This distributor has of a series of horizontal inverted troughs, open on the bottom, closed on all other sides. The



THE HEGB™ OIL DEHYDRATOR
FIGURE 2

distributor trough is designed to slow the inlet fluid velocity so the inlet fluid distributes equally into each lateral.

The HEGB® design achieves the desired distribution. The troughs are strategically located in the BS&W layer where all naturally occurring and synthesized emulsion resolving chemicals naturally concentrate.

The oil-water interface inside each trough is depressed by the proper sizing of the oil outlet metering holes. This creates a uniform pressure drop across every metering orifice, assuring uniform and identical flow through each and every orifice. The result is very uniform oil distribution throughout the entire cross section of the HEGB®.

With uniform distribution accomplished, oil rises vertically and uniformly through the emulsion layer where emulsion droplet coalescing and growth can occur. Larger coalesced droplets counter-fall more rapidly downward through the emulsion layer into the water phase,

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dramatically reducing the water content of the oil. The oil rises at a reduced velocity, maximizing its retention time. This slower oil rise rate promotes the separation of the smaller water droplets of emulsion. As they separate, they coalesce and grow in size. Larger water droplets flow downward reaching the water layer below the oil more rapidly, completing the dehydration process to a degree not heretofore thought possible in atmospheric Gunbarrel systems.

As the oil nears the top of the oil layer, it is collected uniformly throughout the entire ID circumference of the tank, thus maximizing the utilization of the tank cross section and completing the HEGB® dehydration process.

## BREAKTHROUGH ENGENUITY

Breakthrough Engenuity was founded by Bill Ball. He has a distinguished history of oilfield separation system designs. He has accumulated an impressive list of twenty-one related patents. Bill's oilfield experience, and his career portfolio, make him an industry authority in facilities design.

After his university studies Bill launched his career in a 1,000,000 b/d waterflood operation where he was responsible for the selection, evaluation, performance, and improvement of all surface separation facilities. He's since sent most of his field work days crawling through the process equipment, querying the designers, and making improvements wherever possible.

This experience has been the equivalent of a real-world PhD in oilfield facilities design. In the early years Bill learned what works, and what doesn't. Bill needed this experience to develop and advance new concepts and technologies which have since become standards of the industry. Over time his accumulated separation experience and knowledge have led to over 20 patents, each of which speaks for itself.

In 1992 Bill founded High-Tech Consultants, Inc. (aka HTC). In the years that followed HTC became the premier SWD plant designer, all based on Bill's HWSB® Skim Tank design. In 2015 Bill rolled HTC into Breakthrough Engenuity LLC "*where engineering meets ingenuity*".

Bill's efforts to innovate have been well received by the industry.

Consider KOTREAT®, where its patent describes the combining of a free water knockout and a heater treater into a single vessel. This is the perfect vessel to process production from today's high water cut horizontally completed wells and waterfloods.

Another patent describes an ingenious innovation called MorOil™. MorOil™ condenses valuable C4+ hydrocarbon liquids present in the hot natural gas stream, stabilizes them, and adds them to oil in storage to generate increased cash flow. A mere 10°F reduction in gas

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temperature condenses 50% of the available natural gas liquids, and a 60°F reduction captures over 99%! These are high gravity "condensate" liquids that add significantly to operator cash flow.

These are just a few of Breakthrough Engenuity's unique contributions to the oil and gas industry.

Today, Breakthrough Engenuity is one of the industry's leading low-cost consulting engineering and facilities design firms, specializing in designs like the HEGB® and for the industry's most efficient high and low pressure, two and three-phase heated and unheated separators, complete processing facilities, as well as providing general engineering services geared to specialty subjects like:

- Natural gas handling to optimize income and liquids recovery.
- Proper line sizing to avoid turbulence, erosion-corrosion, and mixing energies.
- Specialty vessel internals designed to maximize separation performance.
- The application optimization of oilfield chemicals geared to reduce cost and improve performance.
- 3D modelling to avoid costly facility installation delays.

Now, more than ever, Breakthrough Engenuity can be found in every sector of the oil and gas industry, adding efficiency and cash flow and efficiency to upstream operations. Breakthrough is a full-service consulting engineering firm, and pledges to exceed each client's expectations.

## CONTACT

Please don't hesitate to call Bill Ball, Breakthrough Engenuity's owner and principal engineer, for assistance. You can reach Bill on his cell phone at 918-231-9698 seven days a week.

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