GUNBARREL TANKS

Could Yours Be Obsolete?

A focus on Eliminating Oilfield Tank Fires

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

A Technical Paper

Prepared for

Facility Engineers and Designers

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EXECUTIVE SUMMARY

For over 140 years the gunbarrel tank has been an industry standard; an icon in the field of oil processing. It has been one of the most widely used go-to upstream facility components ever developed.

So how can it possibly be considered obsolete?

This paper answers the question and explains why. It also strives to change the way we think about this age-old icon. It explains why the gunbarrel tank worked so well in the past, why it fails so miserably today, and what has caused this dramatic change.

This paper explains why today's higher water cut production is so detrimental to the performance of every gunbarrel tank, and how its design defeats it in high water cut operations. Understanding how the process conditions have changed sheds new light on how an alternate design can be a game changer in the 21st century.

This paper proposes a viable, economic, and practical tank design that solves today's gunbarrel problems! It describes a brand-new design; a design that was first tried over three decades ago, and one that now numbers over three thousand successful applications stretching from the Baaken in the north through the Permian in the south, from Mexico to Brazil, and from Iraq to India.

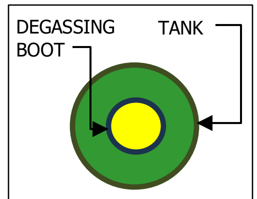
Best of all, the solution discussed in this paper has only scratched the surface. While it has been widely accepted in newer SWD Plants, it may fit best as a replacement for gunbarrels used for primary production separation in tank batteries where those with gunbarrel tanks struggle to perform as they once did.

Intrigued? If so, read on …!

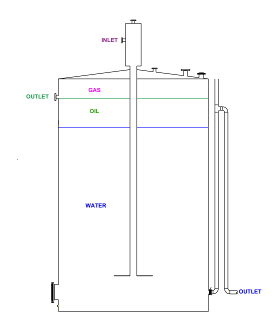
WHAT IS A GUNBARREL TANK?

Since 1865 the oil industry has faced the challenge of separating co-produced water and oil. In the earliest days, this separation was accomplished in open earthen pits, but common windblown contaminants drove oil producers to move away from open pits and into closed storage tanks to better preserve the quality of their oil. This led to the desire to improve the separation process within tanks, and by 1875 producers were using a design known as the "gunbarrel".

What makes the gunbarrel design unique is the fact that it resembles the barrel of a gun. That is, viewed from the top, the gunbarrel tank appears to be a pair of concentric circles, just like looking into the barrel of a gun.



GUNBARREL TANK (TOP VIEW)



TYPICAL GUNBARREL TANK

In fact, the gunbarrel tank is designed with a vertical pipe down through the center of its tank as shown in the graphic at the left. This pipe, referred to as the "downcomer," is the conduit that sends the incoming mix of water and oil (emulsion) into the tank. The downcomer pipe extends through the roof of the tank and ends inside the tank near its bottom. The produced fluids enter the downcomer pipe near its top. Liquids flow downward inside this pipe, while gas separates and equalizes into the das space in the top of the tank. At the bottom of the downcomer pipe is a distributor designed to spread the incoming water-oil mixture throughout the cross section of the tank. Separated water flows downward and exits the tank near the tank bottom. Oil rises and exits the tank near its top. These are the key design considerations that make a gunbarrel a gunbarrel.

SEEMS SIMPLE ENOUGH. DOES IT WORK?

This is an uncomplicated design, and it does work! The caveat is that the inlet liquids must be mostly oil. And, in the earliest days of the industry they were. The gunbarrel was then designed to be at least 3/4th full of oil, with only a shallow layer of oil near the tank's bottom. This was to "wash" the oil through a shallow water layer, and to maximize the time the oil itself spent inside the gunbarrel. This maximized oil retention time was to give the water plenty of time to separate. Under these conditions the gunbarrel worked quite well … for decade after decade. Over the next 80 years the gunbarrel became a "standard of the industry", used to dewater most produced oil.

IF IT WORKED ONCE, WHAT HAPPENED?

After WWII, the oil industry began to experiment with water flooding. This enhanced dwindling oil production in older oil fields and spelled longer productive life for newer ones.

Waterflooding also changed the process conditions, adding huge volumes of produced water! As a water-dominant mix flowed into gunbarrels at higher and higher concentrations, water rates accelerated and resulted in it flowing from the inlet directly to the outlet at ever-faster flow rates. As flow rates increased, the time for oil to separate decreased, until oil-water separation ceased and oil was carried out of the gunbarrel with the water.

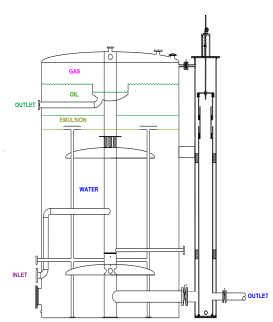
The water leaving a gunbarrel usually flows into a dedicated set of water storage tanks. Once full, the water is pumped out. The pump is turned on and off by a tank level start-stop switch, starting when the tanks are nearly full and stopping when they are nearly empty. The pump normally moves the water into a water injection or disposal system, or off site to a salt water disposal plant.

As produced water volumes increased operators noticed that the water tanks accumulated more and more oil; oil carried over from the gunbarrel just upstream. In an industry-wide reaction to this reality, more downstream water tanks were added to collect more of the otherwise lost oil. Eventually, most facilities used one gunbarrel followed by three or four downstream water storage tanks. Lease operators skimmed whatever oil separated in these added water tanks, but most carried over into disposal wells.

However, as water flow rates increased the amount of time for separation to occur shrank, and considerable quantities of oil did not separate. Water containing higher and higher quantities of oil was injected into injection or disposal wells. This causes serious downhole disposal and injection plugging. Plugging increased the surface pressure needed to dispose of the water, increasing the frequency of costly well disposal/injection well acidizing, stimulation, and workovers. By the late 1980s, oil industry costs associated with lost revenue from oil carryover and well stimulation had reached an all-time high.

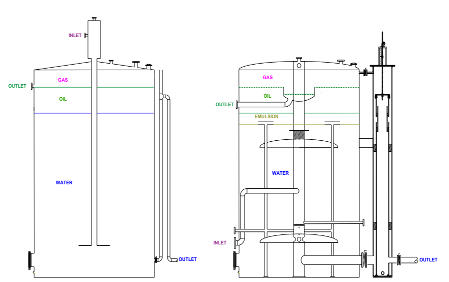
THE ULTIMATE SOLUTION

In 1989 a patent was filed for a gunbarrel replacement, at last. This patent outlined a radical innovative design correcting the flow deficiencies of the gunbarrel in the more dominant high water cut applications of the day. This patented design was identified by the acronym HWSB® (hydro-dynamic water separation breakthrough). Its original patent was improved upon and was subsequently through the first two decades in the 21st century. The gunbarrel tank's water retention time of 35 seconds increased to 45 minutes, yielding enough time to remove all separable oil from water! KBK Industries owns these patents.



TYPICAL HWSB SKIM TANK

A SIDE-BY-SIDE COMPARISON SHOWS THE DIFFERENCE



TYPICAL GNBARREL TANK TYPICAL HWSB SKIM TANK

The HWSB® is an amazingly efficient design compared with a gunbarrel, as can be seen here.

The flow into the gunbarrel starts at the top. All water and oil flow down a center pipe to near the bottom. Water flows directly across the tank into the water leg. This water flow path is so short that its velocity exceeds the separation velocity of most oil droplets, so most of the oil leaves this tank before it has time to separate.

The HWSB® flow paths are longer than those inside the gunbarrel tank, so it has over thirty times the actual retention time. This translates to a much higher degree of oil-water separation.

The flow into a HWSB® enters the center pipe on tangent and spirals upward. Any settleable solids in the inlet stream are centrifugally thrown to the ID of the center pipe and sink, collecting above the blanking plate. A dedicated draw-off allows operators to drain off collecting solids. This minimizes the frequency of tank cleaning events.

The oily water rises in the center pipe and exits just below the oil-water interface. This minimizes the distance oil droplets travel before assimilating into the oil layer above.

Water leaving the center column contacts a set of vertical spiral fins shaped to distribute it counterclockwise and in a helical path. The helix reduces flow velocity to maximize oil-water separation. As oil separates flow upward and overflows into a dedicated chamber. This chamber is large enough to prevent the tank overflowing even in periods of higher-than-normal inlet flow rates. This means that all collected oil freely flows to nearby oil sales tanks, rather than onto the ground!

A large elliptical baffle is located below the spiral inlets. It spreads the inlet water horizontally outward toward the tank walls. The water flows parallel to the underside of the oil layer in this area of the HWSB®, decelerating as it flows toward the tank walls. As the flow slows, more time is available for oil droplets to separate out of the water layer and into the oil layer above.

As water flows towards the tank walls, it reaches the outside edge of the upper spreader baffle. It flows down and over the OD of the upper baffle, changing direction from horizontal to vertical. The change of directions, and the annular space between the baffle and the tank walls, creates a pressure drop that pulls the water under this baffle, redistributing it horizontally throughout the cross section of the tank. As the fluid redistributes its velocity decreases so any remaining microdroplets of oil counterflow upward. The result is in near-perfect "plug flow," maximizing both retention time and oil separation.

As the water nears the tank bottom it encounters another large baffle. This baffle again changes the flow direction, this time from vertical to horizontal. The water then changes direction s again and flows down around a lower large baffle, identical to the one above it. The now clarified water re-enters the center pipe just below the under-side of the lower baffle, flows downward through the center pipe, which extends clear to the tank bottom. The water flows down the center pipe to the outlet pipe near the bottom of the tank. The clarified water exits the tank and flows into an engineered "water leg."

The water in KBK's HWSB® achieves up to sixty times more retention time than it has in a gunbarrel of the same size.

This is an engineered adjustable water leg, hydraulically balanced to assure steady-state liquid levels inside KBK's HWSB®. It is larger than the gunbarrel "gooseneck" water leg so each HWSB® cannot overflow. It is adjustable with zero downtime so operators can manage the retention time of the oil layer so oil is dehydrated before overflowing to the oil tanks.

From the above it is clear that KBK's patented HWSB® design is quite different from a gunbarrel tank. Where the gunbarrel design was focused on maximizing oil retention time to separate remnant water, the HWSB® design is focused on maximizing water retention time to separate and sell all remnant oil.

IS REPLACING MY GUNBARREL AFFORDABLE?

The typical 750-barrel gunbarrel costs about $35,000. The same size HWSB® costs about three times as much! Seems like the answer might be, "No," but let's dig a little deeper!

If we use the gunbarrel we need to add at least three and probably four 500-barrel tanks downstream in an effort to catch carryover oil. Each adds about $15,000 to the cost. One of these tanks is necessary to serve as a surge tank for the water transfer pumps, so it cannot be deleted. But, since the HWSB® eliminates the oil carryover issue, the other three tanks can be deleted. Each 500-barrel tank costs about $15,000. Deleting three of these saves $45,000. The associated transportation and installation costs for piping, valves, and fittings adds least another $15,000.

Selecting the HWSB® reduces costs by $60,000, making it cheaper to use a HWSB® than a gunbarrel and its associated tanks!

Experience has shown us a single gunbarrel and its four downstream tanks will carry over 0.1% to 1.0% oil. At just 0.1% oil carryover in 15,000 BWPD, lost oil sales will be 5,475 barrels/year, or $383,250/year (WTI oil price

$70/barrel). Add one disposal well stimulation job and the annual carryover cost accelerates to over a half a million dollars!

In contrast, the HWSB® captures about 99.99% of all oil. Clarified water leaves with less than 30 ppm oil. That is eighty-three times better than the gunbarrel oil capture rate! Downstream tanks are no longer required. Oil sales add at least $383,250 to income each and every year!

CONCLUSIONS

Gunbarrel tanks were designed for low water cut applications, and they work well there. However, they were never intended for high water cut applications. In high water cut applications, where water volumes exceed oil volumes, gunbarrel performance suffers while KBK's HWSB® performance excels. The footprint and heights of both are often identical. Existing piping works with minimal modifications. Replacing an existing gunbarrel with a new HWSB® is quick and easy. The HWSB® works better, cuts OP-EX costs, and increases owner cash flow. KBK's HWSB® is a win-win.

ABOUT THE AUTHORS

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