Treater Firetubes in Water or Oil?

"Where Engineering Meets Ingenuity"

INTRODUCTION

Fired oilfield vessels were first introduced around 1932 when vessel design expertise was in its infancy. So was electricity, electric welding, and the ASME. Common sense prevailed. In those days design engineers knew the basics; that water is a superior heat transfer medium, compared with oil. They concluded it is also safer than designing treater firetubes in oil. They correctly speculated that building a 2000°F fire inside a steel pipe good for 650°F would eventually cause that pipe to fail, and presumed that when it failed the water would rush in and put the fire out (it doesn't!). They knew that if the firetube was submerged in oil when it failed, the oil would catch fire, flow out into the surrounding area, and burn up everything in sight (it does!).

Very few of us questioned the wisdom of the day, so it's no surprise that most of today's heater treaters are still designed with the firetubes in water.

Taking on the paradigms of the past has been one of my life's most challenging and enjoyable tasks … particularly when they have been proven to be wrong! After all, just because we've always done something one way does not necessarily make it right!

So, this paper takes a fresh look at the paradigm of designing heater treaters with firetubes in the water phase, and questions it. It explains why it is so wrong to do this, and why it is so much better to locate treater firetubes in oil.

HEATER TREATER DESIGN: FIRETUBES IN WATER

It's safe to say that nearly all heater treaters in 1960 had firetubes in the water phase. By then there were over 400,000 treaters in operation. And by then, while the vast majority were vertical treaters with water covered firetubes, tens of thousands had experienced firetube failures. Most were completely destroyed. Most folks took it in stride. But this reality prompted some to *question the cause of these disastrous failures, and realized that the original logic was obviously flawed.*

Those who looked into these fires found that the fire tubes did not come apart and flood the burner with water, but instead failed from a small hairline crack instead, often in the most heat affected portion of the firetube where the burner flame had impinged on the tube ID, causing metal fatigue and some embrittlement. Since the treaters are pressurized, and the firetube is under atmospheric pressure, the pressure differential caused the water to leak or spray into the firetube through the crack, run down the bottom of the firetube, and out through the air intake onto the ground. The water cooled the crack, so it did not open wider. The leak continued until the water above the crack inside the treater was exhausted, and then oil began to leak into the tube. During all of this the burner continued to burn, so when the leak turned to oil the oil caught fire, burning oil leaked out and around the treater, and the treater was consumed in flames.

In a rational reaction to this the industry began to replace the open front burner assemblies with flame arrestor burners in an effort to make treaters safer and to limit fire related failures. In general terms, this effort was a bust because the burning oil would build up on the inside face of the aluminum flame arrestor elements, and the flames would melt a hole through the element, allowing the burning oil to once again consume the treater.

This situation exists today … mostly because of the 90 year old paradigm and the fact that as an industry we have literally "always done it that way!"

WE OVERLOOKED A KEY POINT … FOR 90+ YEARS!

Through all of these decades and failures we missed a key point! The fact is that heater treaters exist to dehydrate oil, and heating water adds nothing to the separation of oil from water! Only heating oil affects oil-water separation.

The reality of this is found in the physical law for gravity separation; Stokes' Law. Stokes' law tells us that the velocity of separation is equal to the gravitational constant times the radius of the water droplets we trying to separate times the density difference between the oil and the water, all divided by the viscosity of the oil.

The viscosity of the oil is temperature dependent, so the hotter the oil the less the viscosity and the faster the water separates. Cold heavy crude oils can reach 500 centipoise (cP) viscosity, and even medium gravity cold crudes can reach 20-50 cP. If we heat these we can often drive the viscosities close to 1 cP.

What this means is that gravity separation rates are dramatically affected by the viscosity of the oil. A droplet of water in a heavy crude that might separate at a rate of 1'/minute when hot, could take up to 500 minutes to separate one foot when cold!

So, heating oil is critical to the separation of water, or it's "dehydration".

Conversely, heating water alters its viscosity only slightly, since its viscosity very nearly 1 cP at from 33°F to 211°F while it's a liquid.

Additionally, the specific heat of water is 350 BTU/barrel per degree F, whereas the specific heat for crude oil is only 150 BTU/barrel per degree F! That means it takes 2.3 times as much energy to heat water as it does to heat oil.

So, heating water does not improve oil-water separation; not even a little. And it costs us 2.3 times as much to heat water as it does to heat oil!

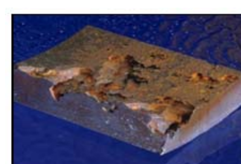
Somehow, we've missed this point … for over 90 years!

WATER = SCALE AND CORROSION

Firetubes fail for reasons other than flame impingement on the ID of the tube too.

Most oilfield produced waters are what we classify as "hard", meaning the water is loaded with scale forming minerals like calcium carbonate. Most these form due to pressure drop or temperature increase, and nowhere else do we have a higher temperature increase than on the skin of a firetube. We literally force the minerals to deposit on the OD of our water covered firetubes. When this happens the conduction heat transfer rates increases through the firetube steel, doubling for every 1/16th of an inch of scale that forms! In short order the steel reaches its fatigue temperature limits, and it fails.

Corrosion takes its inevitable toll of all steel surfaces. Firetubes are no exception. In fact, the high skin temperature of firetubes accelerates the normal corrosion rate and the normally protective hydrogen molecules are driven off the surface and out of each corrosion cell.



However, where there is no water there is no scale, and no corrosion! If we make sure our firetubes are in oil, we avoid the issues associated with scale and corrosion!

FIRETUBE COATING

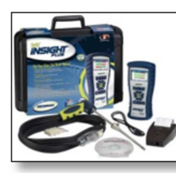
Coatings are a subject all to their own. While high temperature coatings exist, any coating on a firetube adds to the conductive heat transfer rate, increasing the steel temperature, and often shortening firetube life through metal fatigue, linearizing the normally random steel grain structure, embrittling the steel, and causing premature failure.

Coating preparation is the key to any effective coating application, and oilfield coaters are not generally known for their preparation knowledge or skills. When a coating begins to fail it concentrates the corrosion rate of the entire firetube area onto the failure point, actually accelerating corrosion … and all coatings fail sooner or later. I recommend against firetube coating.

CONCLUSIONS

While it clearly deviates from the paradigms of the past, fired oilfield vessels should be designed with the firetubes in oil. With no water to deposit scales or cause corrosion, the firetube life should be extended indefinitely. The only culprits left are over-firing, flat faced firetube flange leaks, and proper attention to routine stack gas analysis and burner jet sizing will prevent this!

For the sake of safety, each burner assembly should have a flame arrestor. And with the limitless electronics we have today, there is no question about the usefulness of a Bacharach Stack Gas Analyzer, a low-low vessel level switch, and/or fire eye that can ESD the treater, stop the burner, and potentially save the treater just in case there is a failure and a fire.



ABOUT BREAKTHROUGH ENGENUITY AND ITS OWNER/INVENTOR

Bill Ball is the founder and owner of Breakthrough Engenuity LLC. He has a distinguished history of oilfield separation system designs, and a comprehensive list of related patents. Bill's hands-on oilfield experience and career portfolio make him one of the industry's leading separation authorities today. After his university studies he launched his career in a 1,000,000 b/d waterflood operation where he was responsible for the evaluation and performance improvement of all surface facilities. He joined NACE and SPE. He sent most of his work days crawling through the process equipment of the day, making improvements wherever possible.

This hands-on experience was the foundation Bill needed to improve, develop, and advance the technologies necessary to improve process equipment efficiencies across the board. In the early years Bill learned what works, and what doesn't! In the decades since his accumulated separation knowledge and experience led to his ten patents, each of which speaks for itself.

The result is a unique approach; one where, "Engineering meets ingenuity!"

Bill's efforts continue to innovate improvements like the patent pending combination free water knockout- heater treater in one vessel. It's called "KOTREAT®". Each new KOTREAT® eliminates the time and expense of installing two more traditional and separate vessels; the FWKO followed by a heater treater, combining the two vessels into one. Through this unique approach and the use of more efficient internals, KOTREAT® has become another industry game changer.

Another example of ingenious innovation is the MorOil™ system. MorOil™ is a patent pending system designed to condense the valuable C4+ hydrocarbon liquids from produced natural gas streams to generate a larger produced oil stream with added cash flow without the need for compression or chilling.

These are just a few of Breakthrough Engenuity's unique oil industry contributions.

Today, Breakthrough Engenuity is one of the industry's leading low-cost engineering and vessel design firms. We specialize developing designs for the industry's most efficient high and low pressure, two and three-phase heated and unheated separators, as well as providing general engineering services geared to specialty subjects like:

- *Optimized tank battery design.*
- *Natural gas handling to optimize income and liquids recovery.*
- *Correct and proper line sizing avoiding turbulence, erosion-corrosion, and eliminating the mixing energies that can create severe emulsion issues.*
- *Specialty vessel internals designed to maximize separation performance.*
- *Recommendations for the optimized application of oilfield chemicals 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 cash flow to operators and efficiency to their operations. We're a full service engineering firm. We pledge to meet and exceed every client expectation.

CONTACT US

If all else fails, or if you just have a question, don't hesitate to call Bill Ball at Breakthrough Engenuity for assistance. You can reach Bill at the office at 918-298-6841, or on his cell phone at 918-231-9698.