Key Vessel Specs

"Where Engineering Meets Ingenuity"

Buying oilfield equipment demands attention to details, because, just as in project management, the devil is in the details. And, there are many important details.

Oilfield equipment is not generic. Manufacturers tend to develop their own "standards" in an effort to trim costs and avoid costly customization. However, most of today's manufacturers' "standards" were developed before the shale oil boom when process conditions were completely different. This spells trouble for today's producers!

The shale oil boom ushered in a new era in the oil industry. Long laterals and multi-staged frac jobs resulted is huge IP conditions not seen in past decades in the domestic oil patch. New wells produce much higher volumes of oil and gas than the industry was used to before.

Additionally, higher IP rates tend to fall off rapidly, drastically altering the process conditions. Equipment sized for prolific IP conditions are suddenly immensely oversized for the declining flaw rates. And end users still trust manufacturers to decide on appropriate vessel designs. Some even look to vessel manufacturers to design their entire process facilities.

In decades gone by this made sense. Major equipment manufacturers had their own R&D groups. They sought ways to improve every faction of their business. But, in 1985, all of that changed when the industry entered a 23 year long period of decline. As operators trimmed staffing all equipment manufacturers followed suit. R&D came to an end. And for the most part the "brain trust" of the industry was lost. The result is that advances in technology stopped, and competitive pressures forced manufactures to remove more and more of the design advances of the past. By the time the 23 year-long "bust" cycle was over, very few manufacturers had any staff who knew what had been lost, or why it existed in the first place.

Concurrently, producers and the industry brain-trust consulting firms experienced the same reductions and loss of decades old vessel design knowledge. The newer generations no longer had mentors to point them in the right direction. So, they had little choice but to turn elsewhere, and who better to absorb design responsibility than the equipment manufacturers?

The harsh reality is that in the process vessel design field it takes decades of sustained growth for any firm to build a meaningful knowledge base of what to do and how to best do it. After 23 years of down-cycle, the boom of 2008 only lasted months, and returned to "bust" for a few years. Then the shale oil "boom" lasted less than five years … still not enough time to ramp up R&D again. So here we are in another down cycle, still lacking in vessel and facility design expertise.

This reality returns the burden of vessel design specifications responsibility back onto the end-user producers who MUST make new and old equipment alike work like it should.

FOCUS ON KEY COMPONENTS

All pressure vessels have key components that either enhance or deter their functions. They are:

1. *Inlet momentum absorber/flow diverters.*
2. *Wave breaking/fluid redistribution baffles.*

3. *Sand withdrawal systems ("sand pans").*
4. *Proper interface levels tuned to vessel size and function.*
5. *Mist eliminators (aka demisters).*
6. *Oil Buckets in three-phase separators.*

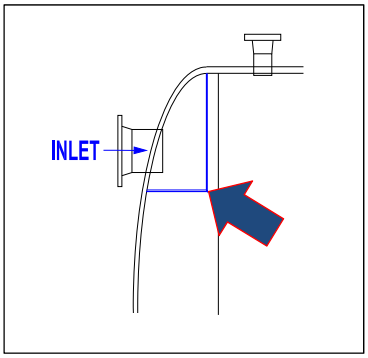
Let's look at each of these in some detail.

INLET MOMENTUM ABSORBER/FLOW DIVERTERS

Properly designed separation equipment must have a device that absorbs inflowing fluid momentum to minimize associated mixing energy in the confined space within the separator. Inflowing fluid flow should also be redirected to move liquids into the liquid portion of the separator, and gas into the gas portion above, both as gently as possible to avoid unnecessary mixing. When this is accomplished properly the capacity of any separator increases dramatically; sometimes up to 6-8 times! Conversely, when this is not done properly, mixing energies dominate and fluids remain dispersed in one another where separation should occur. This can reduce vessel capacity and separation efficiency by the same factors.

So, specifying an efficient momentum absorber/inlet diverter can make a huge difference in performance, while avoiding the issue can cost the end user for the life of the vessel!

This begs the question, "How does an end user specify an efficient inlet momentum absorber/inlet diverter? What does it look like compared to the ones commonly installed by so many manufacturers?"

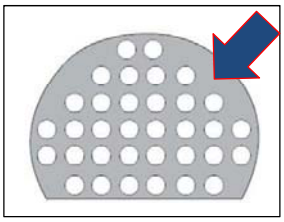


To answer this question we need to see what is considered normal. The normal inlet diverter is a simple "L" shaped plate as seen here in blue in the figure at the right. It is open on the sides, and welded into the inlet head. Inlet fluids impinge on the vertical plate which absorbs the momentum of these fluids and redirects them out both sides. In high GOR conditions the impact of the fluids creates a fine fog-like mist. The impact of liquid and gasses on the perpendicular surface causes droplet shearing and mist generation, reduces effective particle sizes, and creates the mixing of the three fluids (oil, water, and gas). Since mixing is the opposite of separation, the most common of all inlet diverters is a very poor choice.

Specifying an effective inlet diverter/momentum absorber takes some effort. Many other superior designs exist. The producer's facility engineers should study this subject, or get recommendations from experts in the field, and then specify the one that they believe works best for them.

WAVE BREAKING/REDISTRIBUTION BAFFLES

For 100 years vessel designers have realized the value of stopping waves before they propagate throughout the length of horizontal separators. These experts also understood the realities of how converging flow reduces separation capacities, and the value of repeated fluid wave breaking redistribution baffles like the one pictured here at the right can slow flow velocities allowing for rapid Stokes' Law separation in dynamic conditions and ballistic flow paths.

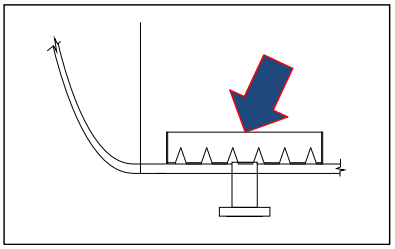


Cutting corners in this area can mean the loss of uniform cross sectional flow, fluid acceleration, and diminished separation efficiency.

However, competitive pressures can drive manufacturers to reduce costs, particularly in times when the market is shrinking. So properly designed wave breaker baffles, perforated to accomplish desired uniform fluid redistribution throughout the entire cross section of a vessel, are sometimes left unperforated, or deleted altogether. The result is a significant reduction in overall separation capacity and efficiency.

Savvy end user facility engineers will design and specify perforated wave breakers, or call on experts who can do this for them. Properly designed and strategically located they maximize separation and improve performance by at least a factor of 3-5.

SAND REMOVAL SYSTEMS



Historically sand accumulation in domestic onshore USA separation systems has been a non-issue, at least for the most part, while offshore and internationally it has been commonplace. But, with the advent of the so-called "shale oil boom", sand, particularly frac sand, has become an issue that needs to be reckoned with. Fortunately, sand removal systems were perfected in the 1960s using inverted "sand pans" with dedicated outlet nozzles, sometimes augmented with sand jet systems to fluidize otherwise compacted sand for ease of removal.

Today's facility engineers can find references to these designs in any number of SPE articles and texts like Arnold and Stewart's "Surface Production Equipment".

PROPER INTERFACE LEVELS

Designers should always specify the desired interface levels. These levels are usually set dependent on the fluid ratios. For instance, a two phase separator designed to process very large quantities of gas with very small quantities of liquids may have a very low liquid-gas interface to maximize the vessel vapor space (and vapor retention time). However, in an application where the gas volume is small and the liquid volume is high, the opposite may be true. A so-called "manufacturer's standard" separator may work in one case but not the other, or in neither!

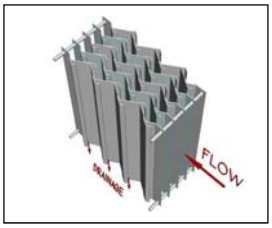
Since only the end user really has a clue about expected fluid flows, the end user needs to shoulder the responsibility of communicating the desired interface levels to the manufacturer rather than assuming that the manufacturer is all knowing.

MIST ELIMINATORS/DEMISTERS

These systems may be also be referred to as "demisters". Their function is to interrupt the direct outflow of liquid containing vapors, and to collect as much of the liquid as possible so it stays in

the separator rather than being carried out with the gas. This is done because the gas is often sold to a third party as it exits the separator, and any oil that leaves with the gas then becomes the property of the gas buyer. Since liquid hydrocarbons have a significantly higher value than vapor phase hydrocarbons, the producer benefits economically by installing mist eliminators/demisters.

Demisters come in many forms and types. Wire mesh, resembling a 'Brillo" pad, are the least expensive and generally considered to be the most efficient. However, since they are also excellent filters, they tend to plug with paraffin, iron sulfide, or other fines that may collect on the face and inside the mesh itself. And, when undersized, they flood, entirely defeating their proposed function. When used in a clean gas service, properly specified wire mesh may be a superior application. Wire mesh drains well when gas flows through it horizontally, but when gas flows up through a horizontal mesh pad the pad tends to flood, causing serious carryover. Also, while mist eliminators sometimes prevent hydrocarbon liquid carryover in separators adding thousands of dollars' worth of hydrocarbon liquids over a vessel's life, manufacturers may delete them for the sake of cost. When specified, some manufacturers may install undersized units, placing them in the horizontal position in small "gas boots" to meet a poorly defined specification.

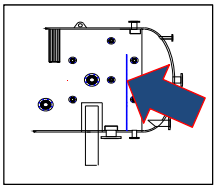


For this reason alternate demister designs were developed as the industry learned its lessons about wire mesh. In the 1930s parallel plates were developed. These were more costly, and over time also had a tendency to collect solids and eventually plug. In the 1950s corrugated plates were engineered to alter flow directions and change flow velocities. This long-term "self-cleaning" system, known as the "serpentine vane" or "chevron plate" design, has proven to be both valuable in minimizing plugging and as effective as wire mesh in both the short term and in the long term. Additionally, these plates offer a real boost to liquid-liquid separation, and are therefore often extended vertically both through the gas phase and the oil phase in three phase separators.

So, the savvy facility engineer should be careful to specify exactly what he wants. Industry experts are here to assist as needed. The savvy facility engineer is careful to specify the orientation, configuration, and size of every demister.

OIL BUCKETS

Three phase separators always have a dedicated oil container, or "bucket". When the oil bucket is located between the head seams it occupies a considerable fraction of the oil layer area, defeating oil retention time and sacrificing water-oil separation efficiency in the mix. While this is a common design, it should be avoided except in cases where oil throughput volumes are very small compared to water throughput volumes. When the oil-to-water ratio is low, using the oil bucket design adds water retention time and can improve effluent water quality. In that that case (only) oil remains in the vessel so long that retention time is a non –issue.



In the remainder of cases the oil compartment should be located as far away from the inlet as possible. This is often accomplished by specifying a vertical oil spillover baffle near the rear head seam. It resembles the blue baffle highlighted by the arrow in the graphic at the right.

The savvy facilities engineer will specify the oil holding capacity of his oil bucket, the spillover height from the vessel ID, and whether or not it is to have a gasketed and sealed manway for access from the water section into to oil bucket section.

MORE SPECIFICATIONS

Clearly, there are many more vessel details each facility engineer should specify. Specify flange types, ASME Code manufacturing, valve sizes, skids if desired, piping to skid edge when considered advantageous, compliance with ANSI B31.3 and 16.5 in all cases, manways with blinds and davits, Flexataulic gaskets, cad plated bolts and nuts, and so on. The better your specs, the more likely it is that the vessel you purchase will perform as expected.

One final note. The vessels you specify will be in service for the next 15-30 years or more. When you weigh the cost the savings of eliminating internals against the income generated by maximizing separation (generating more stock tank barrels of oil over the life of the vessel), it's likely that you'll be able to justify the time to create a full-blown vessel specification.

See our article titled "Vessel Sizing" for more guidelines in making certain the vessel you purchase will actually process your fluids. If you need help, call us!

ABOUT BREAKTHROUGH ENGENUITY'S 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 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 many 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 separate vessels. And, through the use of highly efficient internals, KOTREAT® is a game changer when it comes to performance.
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 new producer stream of cash flow in the form of saleable, highly valued NGLs.

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

Today, Breakthrough Engenuity is one of the industry's leading low-cost engineering and 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:

- *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 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.