## NOT ALL SPHERES ARE CREATED EQUAL

That's the lesson that producers have learned in the Permian basin. Traditionally, options for sand separators have been limited to using either low storage and flow-sensitive vertical cyclonics, or low efficiency generic spheres to manage sand. Functional differences in technology, design, innovation, and quality of material may not be apparent on the surface but ultimately impacts overall production in addition to bottom-line. Making it crucial for decision makers to understand the differences between separator technologies and how to manage produced sand most effectively.

## VERTICAL SAND SEPARATOR DESIGN COMPARISON

Vertical cyclonic sand separators are some of the most common separators used in flowback operations due to their cost and high pressure rating. These factors make them easy to deploy in many different applications to remove sand and protect downstream equipment. However, a vertical separator has several disadvantages which make them a poor choice for sand separator selection, including:

1. Low overall separation efficiency of sand
2. Low storage capacity of sand
3. High fugitive gas emissions release during dumping
4. 'Turndown' at low gas rates resulting in decreased efficiency

Detailed modeling from Computational Fluid Dynamics (CFD) simulations is used to showcase the steady flow patterns which develop in the Sandtinel spherical separator and a vertical cyclone during operation. These CFD models are used at a typical flowback operating condition from the US Permian basin to estimate the efficiency of the two separator designs at one selected scenario. Simulations are also used to estimate the difference in fugitive emissions release. Sandtinel spherical separators outperform vertical cyclonics on each of these metrics.

Real field data is reviewed from three different applications in different basins, including the Delaware, Haynesville, and Permian basins, where a Sandtinel Defender went head to head against a vertical cyclonic sand separator. An abridged table of results is shown below.

| PARAMETER | TRIAL #1 | TRIAL #2 | TRIAL #3 |
|---|---|---|---|
| Basin | Delaware | Haynesville | Permian |
| Sandtinel device | G2-S Defender | G2 Defender | G2-S Defender |
| Vertical cyclone | 10K cyclonic | 10K cyclonic<br>5800 VSKO | FMC cyclone |
| Sand rate | 210 lb./hr. | 80 lb./day | 20 – 200 lb./day |
| Sand capture | 54% (cyclone)<br>91% (Sandtinel)<br>92% (both) | 58% (U/S cyclone)<br>>99% (Sandtinel)<br>3% (D/S cyclone) | 97% (Sandtinel)<br>39% (FMC low flow)<br>81% (FMC high flow) |
| Test duration | 5-10 days | 10 days | 6 days |

Computer modeling and field data collection show that generic vertical cyclonic separators are unreliable, have low efficiency, and do not adequately protect downstream equipment from sand. Sandtinel spherical sand separators are a better option for sand removal along every metric studied and in every basin where they have been deployed.

# PERFORMANCE METRICS

There are several metrics by which one may evaluate the performance of a sand separator. One challenging aspect of evaluating sand separator performance is that much of the separator's operation is opaque, or hidden to casual inspection. In practice, separators are usually recognized only when they are performing badly, and even then the available data can be quite sparse.

The best available data has been compiled for this report to compare key performance indicators.

1. Separation efficiency: The primary function of a sand separator is to remove sand; all other considerations are ultimately secondary. Separation efficiency typically varies based on a well's operating conditions (flow rates, temperature, pressure, oil content, oil thickness, etc.) and sand conditions (sand size, sand quantity, sand crushability, sand density, etc.). A typical sand separator will have a maximum separation efficiency at ideal conditions, and efficiency will drop off as the conditions change to become harder.

   *Sandtinel provides a guarantee of 95% separation efficiency for 150 micron (100 mesh) sand while operating within a specified flow envelope.*

2. Sand storage capacity: After separating sand, a sand separator needs to retain it prior to dumping. Virtually every sand separator on the market works in batch mode, meaning that it collects sand prior to being manually dumped to a larger collection basin or tank. Batch dumps require operator time and usually entail the release of fugitive emissions (below); unnecessary dumps also fill the collection basin with water which needs to be disposed of. Therefore it is desirable to have as high a storage capacity as possible so that separators do not need to be dumped very frequently.

   *Sandtinel separators typically use a "Sand Lock" system to enhance storage capacity. They can generally hold between 200 – 600 lb efficiently before the efficiency starts to be affected. The maximum possible storage in a 48" Sandtinel sphere is approximately 2,000 lb, although they should generally be dumped prior to that.*

3. Fugitive emissions: When performing a manual dump operation from a sand separator, some gas release is usually seen along with the collected sand slurry. This gas will typically be either vented to atmosphere or flared. It is preferable to keep these so-called 'fugitive' emissions as low as possible.

   *Sandtinel sees some of the lowest fugitive emissions of any sand separator on the market. The Vapor Lock design philosophy isolates the gas in the upper hemisphere away from the sand drain port. Sandtinel typically sees less than 50% of the emissions during a dump compared to competing separator designs, and potentially down to 2% of typical, depending on the operating condition.*

4. Ease of sand removal: Sand that has been collected in a sand separator needs to be dumped to a larger collection tank. To reduce production downtime and operator time requirements, it is preferable if it is a very simple process to remove accumulated sand from the sand separator.

   *Sandtinel's dump is a very fast operation, and usually takes between 30 seconds and 2 minutes to complete, depending on the accumulated sand. It consists of turning three valves, and can either be done in one single drain, or in multiple shorter staggered drains. There is zero exposure to operators as the sand is dumped to a collection tank.*

5. Turndown: Some sand separators have a 'sweet spot' or 'goldilocks zone' at elevated flow rates where they perform best. This target flow rate needs to be maintained to provide high efficiency sand removal, and performance will start to drop as the velocity reduces later in a well's lifespan. This phenomenon is called 'turndown,' and it is preferable if sand separators do not have a large turndown window so that they do not unduly dictate how a well can be managed.

   *Sandtinel sand separators do not experience any notable turndown. They typically perform just as well at very low velocity as they do at higher velocities.*

6. Pressure range: Sand separators usually work better when they are placed as close as possible to the wellhead. Operating on the high pressure side slows down the flow and increases the separation efficiency, and more importantly also protects the choke valve. Therefore, it is preferable for a sand separator to be have a high pressure rating.

   *Sandtinel typically provides 48" spherical separators rated up to 5,000 psi, and also has a 44" spherical separator rated up to 10,000 psi.*

7. Cost: Sand separators are only one piece of equipment in a flowback, and must pay for themselves in erosional reduction on the remainder of the system. Lower cost is preferable for sand separators to enhance the value proposition of the device. Similarly, wearable or sacrificial elements like filters are also undesirable, as they require operator time to change out along with the new parts needed.

   *Sandtinel offers a range of sand separators to meet any requirement, from large 96" Generals for facilities and group well testing, to smaller 36" separators suitable for small projects. Accurate sizing and predictive modeling ensure that customers never overpay for the sand removal they need. Sandtinel has no sacrificial internal elements or filters.*

Sandtinel has several different separator designs in its fleet, this report will be considering the 48" G2-S Sandtinel Defender, a robust design for many operating conditions.

# CONCLUSIONS

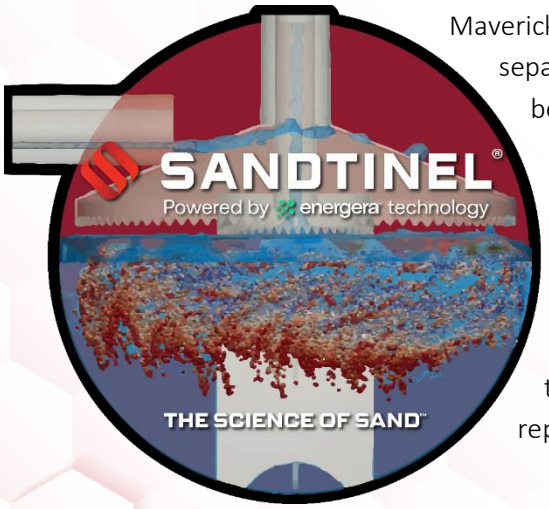
Overall, Sandtinel spherical separators have several key advantages over generic vertical cyclonic separators (regardless of the exact manufacturer):

- Higher overall sand removal efficiency, from 50-80% up to 90%-100% removal
- Larger storage capacity of sand, up to 600 lb. or more (based on velocity of the flow)
- Dramatically reduced fugitive emissions from the bottom drain during dump operations, of up to 98% reduction or more (depending on the conditions and dump duration)
- A reduction or elimination of 'turndown,' which is a loss of sand separation efficiency which develops in vertical cyclones at low flow rates

Detailed results from three different field trials in different basins (the Delaware, Haynesville, and Permian) confirm that the Sandtinel G2/G2-S Defender has a significantly higher separation efficiency compared to a typical vertical cyclonic sand separator.

There are some novel 'advanced' cyclone devices introduced in recent years (such as the TetraTech Sandstorm-Q or the Enercorp Sahara) which have significant improvements compared to a generic vertical cyclone. This report only covers the comparison of the Sandtinel against a typical vertical cyclonic separator, which will be similar to the design discussed in Section 2. These advanced cyclonic separators are not covered by this report, although many of the same factors (storage capacity, fugitive emissions, etc.) may apply to them. Sandtinel is currently gathering performance data compared to these more advanced units as of writing (Oct 2021) and will report on any findings in the future.

Overall, a Sandtinel separator is a significantly more effective sand removal device than the simple generic cyclones which have dominated the market for years. A Sandtinel sphere can remove more sand and hold it more effectively, while releasing lower emissions during the dump process, compared to a vertical cyclonic. In particular, the introduction of the 44" 10K Sandtinel G4-S2 Maverick provides a high-pressure option for sand separation where previously only a vertical shell would be able to be used to protect upstream chokes.




Sandtinel can provide CFD simulations, performance estimates, emissions comparisons, and more upon request for specified operating conditions. Advanced Sandtinel units are also available to tackle tougher challenges, including the Maverick and General lineup, whereas this report only discussed the G2 Defender series.