WhitePaper

REFINING THE FUTURE

How smarter desalter operations drive efficiencies and sustainability?

BERTHOLD

Introduction

„If you cannot measure it, you cannot improve it." This insight from Lord Kelvin highlights a fundamental principle of industrial processes, especially in refining: accurate measurement is the cornerstone of any improvement. H. James Harrington expanded on this idea, stating, „Measurement is the first step that leads to control and, ultimately, to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. And if you can't control it, you can't improve it." Together, these perspectives emphasize that without precise measurement, efforts to refine and enhance processes remain fundamentally limited.

As the global energy landscape shifts towards greener alternatives and a hydrogen-based economy, the refining industry faces increasing pressure to improve efficiency and reduce its carbon footprint. Optimizing desalter operations is central to these goals. Effective management of this critical process can significantly boost refinery efficiency, lower energy consumption, and advance sustainability efforts (Bain et al., 2019).
Among all industrial processes, refineries top the list as the most energy-intensive of them all. In fact, in a typical 150,000 BPD refinery, 663 MW of energy is generally required, out of which approximately 217 MW is consumed by a crude distillation unit, accounting for more than one-third. The main purpose of this energy is heating crude oil to the 350°C to 400°C temperatures required for the separation of crude into its constituent fractions (Figure 1).

Fig.1 Based on capacity of 150,000 bpd / reference EIA, USA

Process	Consumption (MW)	Procent (%)
Atm. Distillation	**217.3**	**33%**
Vaccum Distillation	**100.6**	**15 %**
Visbreaking	0.9	0 %
Delayed Coking	23.5	4 %
FCC	**73.1**	**11 %**
Hydrocracking	18.3	3 %
Hydrotreating	**150.5**	**23 %**
Reforming	50.6	8 %
Alkylation	15.5	2 %
Ethers	2.5	0 %
Isomerization	7.3	1 %
Lube Oil	2.8	0 %
TOTAL	**662.9**	**100 %**

This is an enormously energy-intensive process, and inefficiencies, such as fouling in furnace tubes and heat exchangers, can lead to significant energy losses. Fouling reduces heat transfer efficiency, requiring more fuel to maintain essential process temperatures, which in turn raises operational costs and expands the refinery's carbon footprint. Addressing these waste sources is essential for refineries aiming to improve energy efficiency and enhance sustainability.
The desalter, one of the initial processing units in a refinery, plays a critical role in preparing crude oil for further processing. Its main purpose is to remove salts, minerals, and metals from crude oil before it enters this crude distillation unit. If not effectively removed, these contaminants can cause significant issues downstream, such as corrosion of equipment, fouling of heat exchangers and furnace tubes, and the deactivation of catalysts, all of which lead to increased operational costs, elevated energy consumption, and greater maintenance demands.

Desalters function through gravity separation, whereby fresh wash water is injected into the crude oil to dissolve salts and capture impurities. As the water mixes with the oil, it absorbs these contaminants, and the water droplets then coalesce and separate from the oil phase, adhering to Stokes' law of particle settling. For efficient desalter operation, it is essential that the water droplets have adequate residence time to settle out of the oil phase, making precise level control within the desalter vessel a key factor for optimal performance (Boughaba et al., 2020).

Optimize the desalter efficiency

Effective removal of salts, minerals, and metals in the desalter is essential to avoid major operational challenges. Salts, especially chlorides, are highly corrosive and can produce hydrochloric acid at high temperatures, leading to significant damage to refinery equipment. Such corrosion increases maintenance costs, raises the risk of unexpected equipment failures, and creates hazardous operational conditions. Furthermore, contaminants left in the crude can deposit on heat exchanger and furnace tube surfaces, forming insulating layers that hinder heat transfer efficiency and driveup fuel consumption. This not only raises operational costs but also increases greenhouse gas emissions.

Effective optimization of desalter operations translates directly into substantial cost savings by reducing catalyst poisoning in refinery processes. When contaminant metals, such as iron (Fe), are not adequately removed in the desalter, they accumulate downstream, poisoning catalysts in critical units like hydrocrackers and fluid catalytic crackers (FCCs). This contamination can necessitate costly catalyst replacements, potentially reaching $15-20 million annually for fresh catalyst alone, not accounting for additional operational costs due to reduced catalyst efficiency (Mani, V., 2024).

In addition to level control, several other factors influence desalter efficiency, including crude oil temperature, water injection volume, mix valve settings, grid voltages, and water outlet valve operation. The temperature of the crude oil is particularly important, as it affects both the viscosity of the oil-water mixture and the solubility of water in oil, both of which are critical for effective separation. The volume of water injected into the crude oil prior to the mix valve is also crucial: too little water may fail to dissolve all salts, while excessive water can overwhelm the desalter, reducing efficiency (Cahill, 2019).

The mix valve is essential in atomizing water droplets within crude oil, ensuring they are sized optimally for effective separation. Proper management of grid voltages is critical to facilitate the coalescence of water droplets, while the water outlet valve must be precisely controlled to maintain the appropriate water level and maximize residence time. All these factors require careful control to ensure the desalter operates efficiently, minimizing fouling, corrosion, and energy consumption. (Mani, V. 2024).

The ability to monitor the rag layer in real-time is crucial for optimizing desalter performance. The rag layer, which is formed as an emulsion of oil, water, solids, and surfactants, presents a significant challenge to effective oil-water separation. If left unchecked, its growth can reduce the effective separation volume within the desalter, shorten residence time, and ultimately lower operational efficiency. This results in higher levels of contaminants in the desalted crude and increases the risk of fouling and corrosion in downstream equipment. Accurate measurement of the rag layer's thickness and position allows operators to take timely corrective actions, such as adjusting chemical treatments, demulsifier injection, or washwater, to prevent emulsion buildup. Without precise monitoring, refineries are forced to rely on estimates, which can lead to inefficiencies, increased maintenance costs, and compromised equipment reliability.

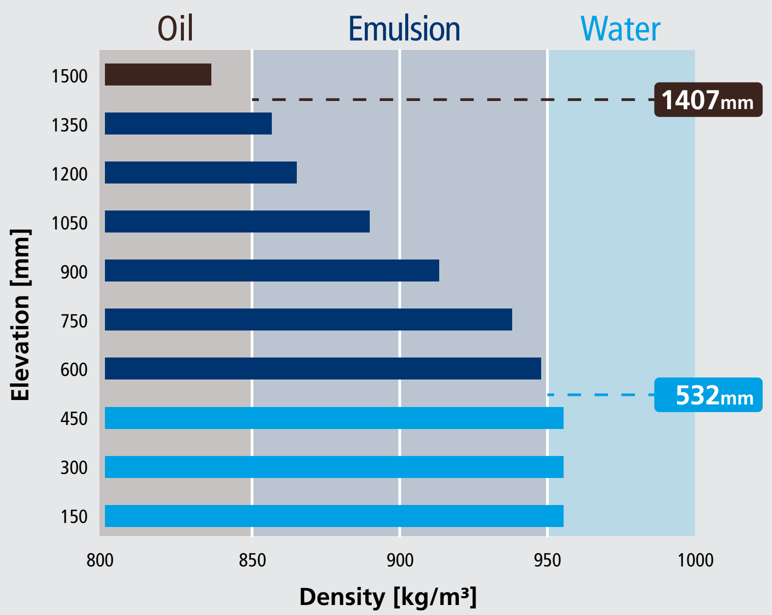
Fig.2 Berthold's EmulsionSENS mounted outside a desalter

Density profiles in operation

When operating correctly, a desalter should exhibit a clear transition from 100% water at the bottom of the vessel to 100% oil at the top. This transition is reflected in density readings, which smoothly decrease from bottom to top. However, when a desalter loses coalescence, a rag layer, a mixture of water, oil, surfactants, and solids, can form on top of the water, disrupting this transition. The presence of a rag layer reduces the desalter's efficiency by diminishing The tables and corresponding graphs below illustrate the differences in density profiles during normal operation versus when a rag layer is present.

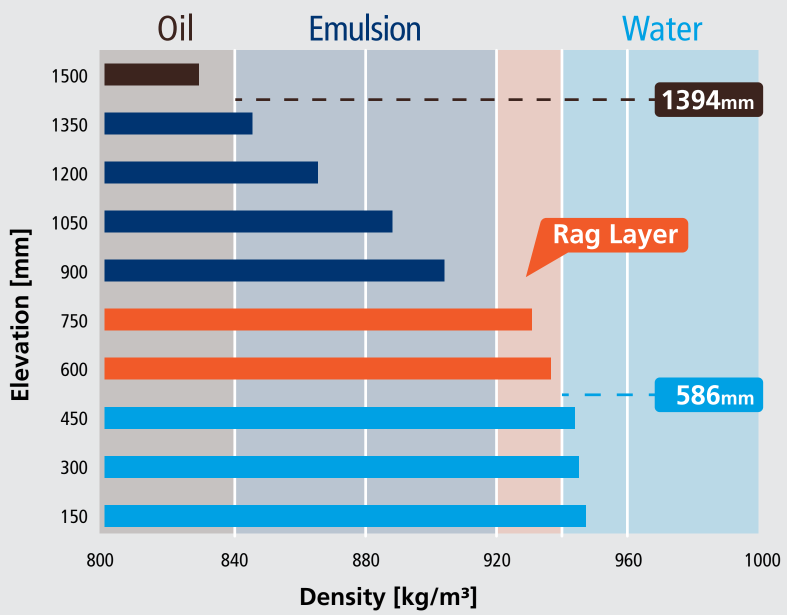
Elevation [mm]	Density [kg/m³]
1500	835.7
1350	856.5
1200	864.8
1050	889.6
900	913.6
750	938.5
600	948.2
450	955.5
300	955.1
150	955.7

Fig.3 Graphic „Density profiles under normal conditions"



Elevation [mm]	Density [kg/m³]
1500	830.2
1350	846.5
1200	866.2
1050	889.6
900	908.5
750	929.6
600	932.6
450	944.3
300	945.4
150	948.3

Fig.4 Graphic „Density profiles with rag layer"



Unveiling the invisible: the EmulsionSENS advantage

Berthold's EmulsionSENS is not only theoretically advantageous; real-world refinery operations demonstrate its genuine benefits. The ability to accurately assess and control desalter performance results in substantial improvements in operational efficiency and sustainability. By maintaining optimal water levels and precisely managing transition zones, refineries can reduce energy consumption, prevent fouling, and extend the lifespan of critical equipment. As highlighted in the case study from Veolia at a Southeast Asia refinery, traditional measurement technologies, such as capacitance probes, have limitations in accurately detecting both the interface between water and oil and the rag layer when present. Capacitance-based instruments rely on differences in dielectric properties to differentiate between oil and water phases. However, they struggle in the presence of emulsified layers, where the mixture of oil, water, and solids disrupts the dielectric contrast, making it difficult to reliably detect the boundary between the rag layer and the water. Consequently, capacitance probes may provide a steady reading even as the rag layer grows, failing to alert operators to changes in the desalter's internal conditions.

In contrast, more advanced technologies like Berthold's EmulsionSENS, which measure density at various elevations, are better suited for this application. These systems provide accurate, real-time data on both water levels and rag layer positioning, a capability critical for effective desalter management. By offering precise measurements, they enable refineries to optimize separation efficiency, minimize fouling risks, and enhance overall process stability. (Mani, V. 2024)
The EmulsionSENS system is highly effective in detecting not only the interface between oil and water within the desalter but also in accurately monitoring the mud layer at the bottom of the vessel. This dual capability is essential for implementing an optimized mud washing program, which ensures the periodic removal of accumulated solids before they can impair the desalter's performance. By effectively reducing the concentration of solids, the mud washing process helps prevent the formation of emulsions that could disrupt oil-water separation. Emulsions take up critical volume, diminishing residence time and compromising separation efficiency.

With real-time data from EmulsionSENS, refineries can adjust mud washing frequency by monitoring the effectiveness. Increased mud washing frequency plus introducing solids wetting agents, achieving up to 50-60% solids removal efficiency, as demonstrated in a Southeast Asian refinery case study by Veolia. This consistent removal of solids prevents downstream fouling of heat exchangers, which often results from solids carryover. In this case, the optimized mud wash process, along with wetting agents, reduced wash durations significantly – from up to 70 minutes to less than 30 minutes – while also preventing the heat exchanger fouling issues that can arise when solid-laden emulsions pass through. This improvement helps maintain high thermal efficiency in heat exchangers, thereby reducing the need for additional fuel and operational costs. (Mani, V. 2024)

A major European refinery, which had been struggling with iron (Fe) contamination being carried downstream to their FCCU, praised the EmulsionSENS system, stating, ‚Perfect design and excellent results. It works like a dream! Many, many thanks to everyone for staying focused and making it happen. Goodbye, iron!!!' This enthusiastic feedback underscores the critical importance of accurate management and measurement in refining processes, as they have a direct impact on operational efficiency and reliability. A user highlighted the long-term benefits of using EmulsionSENS technology, stating: "Both desalters are operating in auto-control as usual. The low-level operation helps us remove particulates containing iron, which can poison our Resid FCC catalyst." This testimony underscores how maintaining optimal levels and properly controlling the desalter's operation can significantly improve refinery performance, reduce corrosion, and prevent catalyst degradation. Another satisfied user commented, "The levels in our desalters are the best thing we've done for that unit in a long time," emphasizing the operational improvements enabled by automatic control. This ensures the desalter operates within the ideal range, preventing both excessively high and low levels. It highlights the importance of precise monitoring and control in the desalter unit, which has a profound impact on refinery performance by enhancing separation efficiency, reducing fouling, and lowering maintenance costs.

Revolutionizing desalter operations

The push for green energy and sustainability presents both a challenge and an opportunity for the refining industry. To stay competitive in a resource-constrained world while meeting global environmental targets, refiners must prioritize energy efficiency and reduce their carbon footprint. A key strategy for achieving this is optimizing the operation of critical units like the desalter. Fouling in heater tubes and heat exchangers – often resulting from suboptimal desalter performance – can significantly reduce efficiency in crude oil refineries. By enhancing performance through effective level control, temperature management, and the use of advanced technologies like Berthold's EmulsionSENS, refineries can significantly mitigate these inefficiencies and move toward more sustainable operations.

The ability to accurately measure and manage the water/transition zone, oil/transition zone interfaces, and mud levels is essential for optimizing the desalter's efficiency. Berthold's EmulsionSENS technology offers this capability, enabling real-time monitoring and precise control, which translates into significant advantages for refinery operations. By adopting these advanced technologies and best practices, refiners can position themselves for long-term success in an increasingly competitive and environmentally conscious industry. Installing EmulsionSENS not only enhances refinery performance and reduces maintenance costs but also supports sustainability efforts by lowering energy consumption and minimizing environmental impact.

As the refining industry navigates the transition to a greener, more sustainable future, optimizing desalters becomes a critical pillar in this journey. Through precise measurement, data-driven management, and advanced technologies, refineries can position themselves to meet the evolving demands of the energy landscape. Embracing these innovations not only ensures their continued competitiveness but also contributes to the global movement toward energy efficiency and environmental stewardship. As H. James Harrington aptly put it, "Measurement is the first step that leads to control and eventually to improvement." Through accurate measurement, effective control, and a commitment to continuous improvement, refineries can thrive, both profitability and a positive environmental impact.

Takeaway statements

1. **Increased refinery performance:** The implementation of advanced technologies like Berthold's EmulsionSENS enables real-time monitoring and precise control of the desalter, significantly enhancing refinery performance. By optimizing critical operations such as interface and mud level monitoring, the system prevents fouling in heat exchangers and improves separation efficiency, leading to higher throughput and consistent product quality.
2. **Reduced operational costs and sustainability:** Through effective desalter optimization, refineries achieve substantial cost savings by reducing energy consumption, maintenance requirements, and catalyst replacement expenses. These improvements not only enhance profitability but also align with sustainability goals by lowering greenhouse gas emissions and minimizing environmental impact, thereby supporting the transition to a greener energy future.

References

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COMMITTED TO TECHNOLOGICAL LEADERSHIP

Outstanding long-term stability

A reliable measurement is vital for the efficient operation of a process and is therefore our highest priority. Due to various patented technologies, Berthold's detectors operate consistently, irrespective of even large variations in ambient temperature or degradation caused by aging. The result: many years of operation without the need for recalibration or maintenance and a measurement that you can rely on!

Protected against X-Ray interference (XIP, RID)

Every Berthold detector features our X-ray Interference Protection (XIP), allowing the system to detect interference radiation, like weld inspections (NDT), and freeze the output before false readings are transmitted. By using Berthold's unique Co-60 rod sources in combination with our patented RID (Radiation Interference Discrimination) function, it is even possible to continue the measurement even while NDT is being performed. Berthold's detectors are not affected in any way by the excessive radiation and automatically return to normal operation after the interference has ceased.

Gas Property Compensation (GPC)

Gas property fluctuations in large vessels can greatly impact the output level value. Berthold compensates for such effects by using a second detector positioned at the top of the vessel which continuously monitors the gas phase. The gas property compensation (GPC) feature of Berthold's systems uses the gas density signal to compensate the level signal for accurate and reliable process control. It reduces the risk of errors or failures, and helps customers achieve better efficiency, safety and reliability.

ALARA – As Low As Reasonable Achievable

Berthold's SuperSENS detector with its large scintillation crystal is the most sensitive detector on the market. Due to their excellent efficiency, our detectors can be operated with low source activities, providing safe handling and major cost savings. In fact, Berthold detectors can even be retrofitted on existing measurements using original sources too weak for other detectors.

SIL 2 / SIL 3 certified

The SENSseries LB 480 detectors are certified for use in SIL 2 and, with homogenous redundancy, in SIL 3 applications. The certificate covers all measurement applications, from high-level or low-level alarms to continuous level and density measurement.

[SIL 2] [SIL 3] [EX]

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Berthold Technologies stands for excellent know-how, high quality and superior reliability. The customer is always the focus of our solution. We know our business!
Using our varied product portfolio, our enormous specialized knowledge and extensive experience, we develop suitable solutions together with our customers for new, individual measurement tasks in a wide variety of industries and applications. Berthold Technologies is specialized in radiometric process measurements for over 75 years. This is our core competence with state-of-the-art and innovative products and solutions covering a vast range of industries and applications.

We are here for you – worldwide!
The engineers and service technicians from Berthold Technologies are wherever you need them. Our global network assures you fast and above all competent and skilled assistance in case of help needed. No matter where you are, our highly qualified experts are willing and ready to assist you in a timely manner with the best possible solution for you, even in the most challenging applications.

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