Advanced Instrumentation for Alkylation Units

A refiner's guide to enhancing safety and efficiency in acid alkylation units through measurement instrumentation.

EMERSON™

The Role of Alkylation in Refinery Operations

Modern refineries use alkylation units to produce high-octane components that enhance gasoline quality. This process combines light olefins, like propylene and butylene, with isobutane in the presence of a strong acid catalyst to create alkylates. Valued for their low vapor pressure and excellent anti-knock properties, alkylates significantly improve gasoline performance.

Operational Efficiency

Enhancing operational efficiency is crucial in these units, which start by precisely drying and purifying feedstocks like light olefins from the fluid catalytic cracking (FCC) units and isobutane to eliminate impurities. The reactor uses an acid catalyst to facilitate the reaction of these components to produce high-octane alkylates. The resulting mixture is then expertly separated through processes such as distillation and settling to isolate the alkylate product. The catalyst is regenerated and recycled to support the sustainability of the process. Finally, the refined alkylates are stored and blended with other refinery streams to create premium fuel formulations. Each step is crucial to ensuring the high efficiency and quality of the alkylation process.

Alkylation Units

Refineries utilize two main types of alkylation units: **sulfuric acid (SA)** and **hydrofluoric acid (HF)**. Both types aim to produce high-quality alkylates but differ significantly in their operational characteristics, beyond just the catalyst used.

The proceeding section of this eBook will address common challenges between the two acid alkylation processes. However, due to their distinct differences and safety considerations, separate sections are designated to discuss specific measurement instrumentation solutions in detail.

1 Tackling Common Alkylation Unit Challenges

Tackling Common Alkylation Unit Challenges

Those responsible for an alkylation unit in a refinery face several key challenges. These include:

- **Addressing safety concerns**
- **Ensuring operational efficiency**
- **Managing feedstock variability.**

Other challenges include maintaining equipment and adhering to environmental compliance standards. It is also essential to optimize processes, manage resources effectively, control corrosion, and implement advanced process control systems to ensure seamless operations.

Addressing Safety Concerns

One of the critical safety risks in alkylation units is the potential for leaks and vaporization of liquid isobutane and olefins, which are used as feedstock in these units. Since both isobutane and olefins are highly volatile hydrocarbons, they can readily transition from a liquid to a gaseous state when exposed to ambient conditions, especially if the leak occurs in a high-pressure system where the rapid depressurization facilitates vaporization, posing significant safety risks.

To address this safety concern, for either HF and SA alkylation units, the Rosemount™ 935 Open Path Combustible Gas Detector can be precisely calibrated to detect vaporized isobutane and olefins, making it ideal for large open areas that require fence-line protection. Additionally, the Rosemount™ 625IR Fixed Gas Detector can be strategically installed and calibrated near high-risk leak points within the units.

Placing the Rosemount™ 625IR or 925FGD Fixed Gas Detectors **(Figure 1)** near leak points like pipe elbows, valves, and pumps is crucial for safety, especially in older HF or SA alkylation units at higher risk for isobutane or olefin leaks.

FIGURE 1
The primary advantage of the Rosemount™ 625IR (left) over the Rosemount™ 925FGD (right) is its lifetime calibration and enhanced response time. Conversely, the Rosemount™ 925FGD offers comparable functionality while also featuring a Local Operator Interface (Transmitter) to accommodate users who prefer hands-on interaction.

To ensure safe and efficient operations, both gas detection and heat tracing in an alkylation unit collaborate to mitigate risks associated with temperature fluctuations and potential leaks. For these applications, where wired instrumentation is preferred, Emerson's Wireless 775 THUM Adapter is an excellent choice for retrofitting existing 2-, 3- or 4-wire HART® devices to wirelessly transmit measurement and diagnostic information. This adapter simplifies and reduces project implementation efforts, while also minimizing traffic in the area, contributing to a safer and more efficient operation.

Tackling Common Alkylation Unit Challenges

Ensuring Operational Efficiency

A primary criticality for safety and efficiency is managing the exothermic nature of the alkylation reaction. Emerson's Rosemount™ temperature and pressure transmitters provide crucial benefits to refiners by offering precise and reliable monitoring of these intense processes. For instance, the Rosemount™ 3051S Pressure Transmitter and the Rosemount™ 3144P Temperature Transmitter **(Figure 2)** deliver high-accuracy measurements that are essential for maintaining optimal reaction conditions and preventing overheating or pressure spikes that could lead to operational hazards.

These transmitters help operators closely monitor and control the process parameters in real-time, ensuring that the exothermic reactions remain within safe limits. The built-in diagnostics and robust design of Rosemount™ transmitters also allow for early detection of potential issues, facilitating predictive maintenance and reducing unplanned downtime. This not only enhances process efficiency but also significantly improves safety by minimizing the risk of incidents associated with uncontrolled exothermic reactions. By integrating Rosemount™ temperature and pressure transmitters, refiners can achieve safer, more reliable, and efficient alkylation units.

FIGURE 2
Rosemount™ 3051S Coplanar™ Pressure Transmitter (left) and Rosemount™ 3144P Temperature Transmitter (right).

To maximize yield and minimize the production of unwanted by-products, it is essential to maintain optimal operating conditions through continuous monitoring and adjustment of process parameters such as temperature, pressure, and flow rates. Ensuring operational efficiency allows the process to run smoothly and cost-effectively while producing high-quality alkylates.

Managing Feedstock Variability

Refineries often deal with variations in the composition of feedstock, which can affect the efficiency and output quality of the alkylation process. Engineers must frequently test and adjust the system to handle these changes effectively, ensuring consistent product quality and optimal performance.

To address the variation of feedstocks in SA and HF alkylation processes, Emerson offers a comprehensive suite of products designed for precise measurement and control. These solutions are critical in managing the complexities of different feedstocks to ensure optimal performance.

Tackling Common Alkylation Unit Challenges

Managing Feedstock Variability

Balancing Flows

To effectively manage feedstock variability, Emerson's Flexim™ PIOX™ S731 Series **(Figure 3)** is highly effective for evaluating the concentration and mass flow of corrosive materials in a non-intrusive manner. Its design allows for precise evaluation of fluid characteristics through sound velocity and temperature measurements, ensuring reliable assessments of mass flow, density, and concentration across various liquid qualities. This makes it ideal for consistent monitoring in fluctuating feedstock compositions, providing real-time process optimization and rapid anomaly detection.

The Flexim™ PIOX™ S731 Series is specifically designed for mass flow and concentration measurements, whereas the Flexim™ FLUXUS™ F Series flow meters are dedicated to measuring volumetric flow rates. Although both series employ non-intrusive designs to reduce the impact of acidic fluids which enhances safety and extends equipment lifespan. Additionally, they offer low installation costs and require near-zero maintenance.

The clamp-on design of Flexim™ meters facilitates quick installation and calibration without requiring process shutdowns or pipe modifications. Their ability to support pipe sizes from DN6 to DN6000 makes them versatile for various sections of alkylation units. By externally mounting these non-intrusive ultrasonic flow meters, the risk of leaks associated with intrusive sensors is eliminated. This improves safety for personnel and the environment by preventing exposure to hazardous chemicals and eliminating fugitive emissions, ensuring regulatory compliance.

To integrate these flow meters into a refinery's Safety Instrumented System (SIS), a structured approach ensures compatibility and reliability. This process begins with identifying key measurement points and selecting suitable Flexim models that can communicate with the SIS using protocols like HART®, Modbus®, or PROFIBUS®. Once connected to the SIS through the refinery's Distributed Control System (DCS) and Programmable Logic Controller (PLC), these meters are set up to interpret flow data and trigger necessary safety actions. Rigorous testing and validation confirm that the system adheres to safety integrity levels (SIL) and regulatory standards.

Moreover, the Flexim™ PIOX™ S731, S831, and FLUXUS™ F-Series models are tailored to meet the stringent requirements of alkylation processes. Their certifications, including ATEX, IECEx, and FM, guarantee safe operation in hazardous environments, highlighting their suitability for these unit applications.

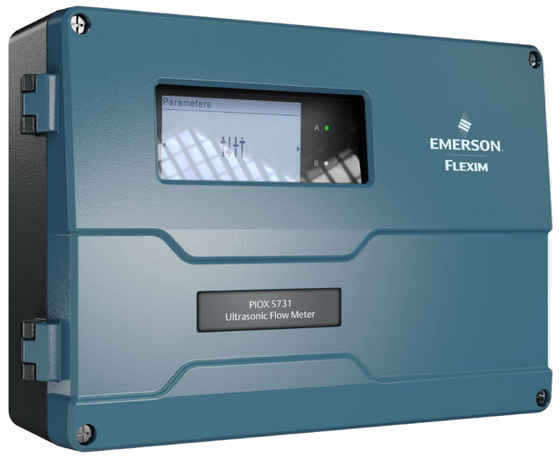


FIGURE 3
The Flexim™ PIOX™ S731 Non-Intrusive Ultrasonic Liquid Analyzer offers flow measurement accuracy up to ±1% of the measured value when installed correctly under optimal conditions. Additionally, its ability to precisely measure concentrations makes it invaluable for enhancing alkylation processes, with accuracy levels requiring application-specific settings and proper calibration.

Tackling Common Alkylation Unit Challenges

Managing Feedstock Variability

Balancing Flows

In various feed or recycle streams, such as the recycle liquid isobutane (iC4) streams, using the Rosemount™ 8800 Series Vortex Flow Meters **(Figure 4)** can offer significant benefits. These meters handle a wide range of flow rates, ensuring consistent monitoring and control amidst varying conditions. Precise measurement of the iC4 recycle stream boosts process control and optimization, leading to improved reaction efficiency and higher product yield. It also addresses challenges in the alkylation unit by contributing to operational safety and ensuring the process stays within safe limits.

The design of the Rosemount™ 8800, with no moving parts, minimizes wear and maintenance, making them ideal for handling corrosive and abrasive fluids. The ease of implementation is a key advantage when installing a Rosemount™ Vortex Meter in a refinery's SIS for alkylation processes.

FIGURE 4
Rosemount™ 8800 Series Vortex Flow Meters provide exceptional reliability due to their gasket-free, non-clog design, which eliminates potential leak points. This results in greater process availability and fewer unscheduled shutdowns. In addition, note that it's important to select materials like high-grade stainless steel or specialty alloys for durability to handle abrasive fluids.

To mass balance an alkylation unit, a Micro Motion™ Coriolis meter **(Figure 5)** is an excellent tool due to its ability to provide direct and accurate mass measurements on product streams. By deploying Micro Motion™ Coriolis Meters, refiners can achieve better control over production processes, reducing errors and enhancing product quality. The real-time mass flow data facilitated by Coriolis meters allows for immediate adjustments, leading to improved operational stability and reduced downtime. Incorporating Coriolis meters at key custody transfer points further ensures accurate accounting and financial transactions critical to refinery operations.

FIGURE 5
Micro Motion™ Coriolis Flow Meters provide industry-leading liquid mass flow accuracy, ranging from ±0.1% to ±0.05%, with unmatched flow and density measurement performance. They do not require compensations due to changes in process conditions or fluids.

Tackling Common Alkylation Unit Challenges

Ensuring Reliability

Predictive Maintenance

Implementing predictive maintenance and regular calibration of monitoring instruments also plays a crucial role in ensuring accurate and reliable performance in SA and HF alkylation units. Emerson's **Smart Meter Verification** (SMV, Figure 6) and **Advanced Meter Verification** (AMV, Figure 7) software significantly enhance predictive maintenance and regular calibration of flow instruments in alkylation units.

FIGURE 6
The SMV technology can be used to continuously verify the performance and integrity of Emerson's Coriolis Flow Meters. Even though the Micro Motion™ ELITE™ Coriolis Flow Meters are available in Hastelloy C-22, titanium, and tantalum to resist corrosion, the SMV diagnostic software also offers the capability to detect corrosion and/or potential abrasion wear within the meter.

SMV utilizes advanced diagnostics to continuously monitor the health and performance of Micro Motion™ and Rosemount™ flow meters in real-time, enabling early detection of sensor drift or build-up that can compromise measurement accuracy. This proactive approach allows for timely maintenance interventions, reducing unplanned downtime, and extending the lifespan of the instruments.

Similarly, AMV utilizes advanced algorithms and diagnostics to evaluate the accuracy and integrity of flow measurements without interrupting the process. This non-invasive verification ensures that flow meters remain correctly calibrated and reliable, even in the harsh and corrosive environments typical of HF and SA alkylation units.

Together, SMV and AMV enhance operational efficiency by providing continuous insights into flow meter performance, supporting timely maintenance interventions, and ensuring process safety while minimizing maintenance costs.

FIGURE 7
Advanced Meter Verification allows you to check the health of Emerson's Flexim™ FLUXUS™ flow measurements in depth directly at the measurement point without the need for process interruption.

Tackling Common Alkylation Unit Challenges

Ensuring Reliability

Corrosion Monitoring

The corrosive nature of materials involved in an acid alkylation process necessitates regular monitoring for signs of wear and proactive maintenance of affected components to prevent leaks and equipment failures.

For lower temperature applications (up to 120 °C/250 °F) commonly encountered in most alkylation unit areas, the Rosemount Wireless ET210 Corrosion and Erosion Transmitter **(Figure 8)** employs specially designed low-power EMAT technology to measure metal thickness through external corrosion protection coatings. Each transmitter is mounted to the exterior of pipes or vessels using an integral magnet, eliminating the need for direct contact with hazardous process fluids.

Corrosion monitoring serves as a prime example of addressing critical challenges in alkylation units through advanced remote monitoring. By collecting and processing data on an analytic platform, necessary actions can be enabled more effectively than by attempting to solve open loop challenges using a control platform.

Analytic platforms, such as Emerson Plantweb Insight™, are tailored for open loop field applications, whereas control platforms are better suited for closed-loop and logic state applications.

FIGURE 8
The Rosemount™ Wireless ET210 Corrosion and Erosion Monitoring System is non-intrusive and battery-powered, enabling easy and rapid magnetic installation. It provides reliable and accurate wall thickness data through a WirelessHART® network to the associated software, assisting in making informed decisions about pipe maintenance and replacement.

Tackling Common Alkylation Unit Challenges

Ensuring Reliability

Advanced Remote Monitoring

Industries may refer to advanced remote monitoring in various ways, including IIoT (Industrial Internet of Things) or data collection networks, among others. Beyond corrosion monitoring, other open-loop application challenges in alkylation units can be addressed with advanced remote monitoring, including pressure relief valves (PRVs), safety showers, motor-operated valves (MOVs), pumps, heat exchangers, steam traps, heat tracing, and gas detection.

An additional incentive to expand advanced remote monitoring is related to occupational safety, which is taken very seriously in any operation. Especially for acid alkylation units, the aim is to elevate safety by reducing the need for manual rounds, thus keeping operators out of hazardous areas as much as possible. However, open loop applications may hinder these safety goals when intensive manual rounds are required to inspect and collect data from various assets and equipment.

Even though alkylation units do not operate under extremely high pressure, PRVs are vital in protecting personnel and assets from unexpected system overpressure by routing harmful gases through a connected flare system. Real-time identification of malfunctioning PRVs is crucial for mitigating root causes, as leakage due to improper valve seating can allow harmful gases to pass undetected.

The installation of Rosemount™ 708 Non-Intrusive Acoustic Transmitters on PRV outlets provides a solution by detecting mechanical vibrations from fluid passages and sending this data to Emerson's Plantweb Insight™ PRV App for actionable alerts **(Figure 9)**.

Pilot-operated PRVs can be monitored with the Rosemount™ 708 Acoustic options and built-in differential pressure transmitters from Emerson's Anderson Greenwood PRVs. For PRVs with bellows to prevent back pressure and fugitive emissions, Emerson's Crosby PRVs with innovative new diaphragm and Rosemount Wireless Pressure Transmitters are recommended for monitoring potential breakages and harmful gas emissions.

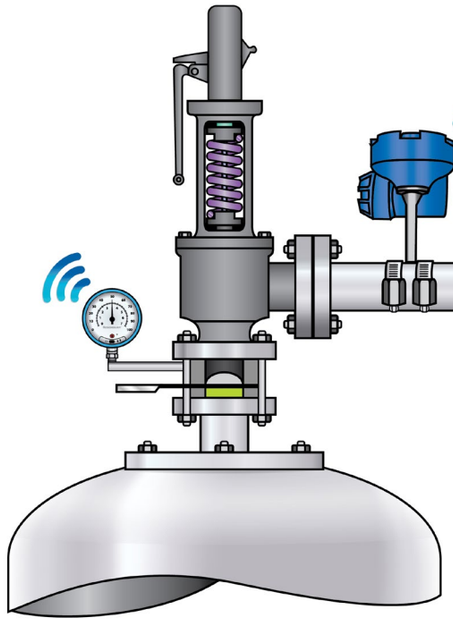


FIGURE 9

The Rosemount™ 708 Wireless Acoustic Transmitter monitors PRVs by using ultrasonic acoustic detection to transmit data on the magnitude of vibration and temperature as fluid flows through the discharge pipe. This information, including device status, is sent via the Wireless HART® network. The Plantweb Insight™ software provides real-time data and actionable alerts, enhancing safety by eliminating the need for manual inspections.

Tackling Common Alkylation Unit Challenges

Ensuring Reliability

Advanced Remote Monitoring

In alkylation units, routine safety and operational inspections are crucial, particularly in sections where acids are managed. Within these high risk areas, safety showers and eye wash stations are strategically located. Yet, traditional safety showers and eyewash stations equipped with beacon lights and sirens often fail to provide precise location pinpointing. Hardwiring these stations to control rooms can be impractical, particularly for portable units. Additionally, radio communications have proven ineffective during emergencies.

To address these issues, Emerson offers the GoSwitch connected to Rosemount™ 702 Discrete Input WirelessHART® Transmitters. This system monitors manual valves and sends alerts to Plantweb Insight™ for continuous supervision, ensuring reliable and effective emergency response.

In addition, MOVs installed on large alkylation unit assets like vessels, which usually require manual operation, can benefit from the Rosemount™ 802 Wireless Multi Discrete I/O Transmitter **(Figure 10)**. The Rosemount 802 offers multi-channel input/output configurations for remote interface, start-stop commands, and status monitoring, reducing the need for operator presence in hazardous areas.

FIGURE 10
The Rosemount™ 802 Wireless Multi Discrete Transmitter is rated for hazardous locations, environmentally protected, and can be powered by either the Emerson 701P SmartPower™ Module or an external 10-30VDC power source.

Furthermore, creating and upholding advanced process control systems to automate operations, monitor performance, and promptly address deviations from standard operating conditions is essential for ensuring optimal efficiency and safety. Emerson offers a range of solutions tailored to process level and differential pressure (DP) level measurement in SA and HF alkylation processes, which are critical for enhancing decision-making and operational reliability.

The Rosemount™ 3051S Electronic Remote Sensor (ERS)™ System **(Figure 11)** is designed for high-precision DP level measurement, eliminating the need for long capillary lines and associated maintenance issues. This significantly improves reliability and reduces potential leak points in highly corrosive environments. The electronic remote sensors are resistant to the aggressive chemical nature of SA and HF, ensuring consistent and accurate readings crucial for maintaining optimal process conditions.

The enhanced response time and stability of the Rosemount™ 3051S ERS provides real-time data to quickly detect and address deviations, ensuring the process operates within safe and efficient parameters. Additionally, this innovative device supports advanced diagnostics, enabling proactive maintenance and early detection of issues, ultimately enhancing operational safety, reducing downtime, and driving overall efficiency in alkylation units.

FIGURE 11
The Rosemount™ 3051S Electronic Remote Sensor (ERS)™ System provides DP Level measurements with a faster response time than traditional systems. To further improve resistance to corrosive environments, specify capillary and direct mount hardware with Alloy C-27.

Tackling Common Alkylation Unit Challenges

Ensuring Reliability

Advanced Remote Monitoring

For level measurement, the Rosemount™ 5300 Guided Wave Radar Level Transmitter **(Figure 12)** delivers accurate readings despite the challenging conditions posed by aggressive chemicals. These instruments can promptly detect and respond to deviations from normal operating conditions, enabling refinery operators to make informed decisions swiftly and maintain optimal process performance.

FIGURE 12
Standardizing the Rosemount™ 5300 Guided Wave Radar Level Transmitter with an Alloy 400 probe and a high-pressure seal for HF alkylation applications is a strategic decision aimed at ensuring material compatibility, safety, operational efficiency, and reliable measurements.

For SA alkylation applications, probe materials such as 316L stainless steel, Hastelloy, or other specialized alloys may be more appropriate to ensure long-term durability and resistance to sulfuric acid corrosion. Although, high-pressure seals are crucial in both HF and SA alkylation units.

Reducing Environmental Impact

Maintaining Compliance

Meeting stringent environmental regulations related to emissions, waste disposal, and the handling of hazardous materials is also essential. Engineers must implement and maintain systems to monitor and control pollutants, ensuring compliance with laws and minimizing the environmental impact of refinery operations. Specifically, neutralization systems used to neutralize acid by-products can release acid gases like sulfur dioxide (SO_2) from SA units and HF gases from HF units.

For environmental compliance, Emerson's Rosemount™ CT5400 Continuous Gas Analyzer **(Figure 13)** can detect both SO_2 and HF and offers hot/wet gas analysis capability to effectively monitor low levels of these components and other water-miscible pollutants. The hot/wet approach also eliminates the need for a chiller, simplifying emissions monitoring and reducing maintenance and operational costs.

Utilizing Quantum Cascade Laser (QCL) and Tunable Diode Laser (TDL) technologies, the Rosemount CT5400 provides high precision and sensitivity for measuring several gases simultaneously down to ultra low ppm levels in real time. This helps support continuous emissions monitoring and compliance with environmental regulations while reducing costs.

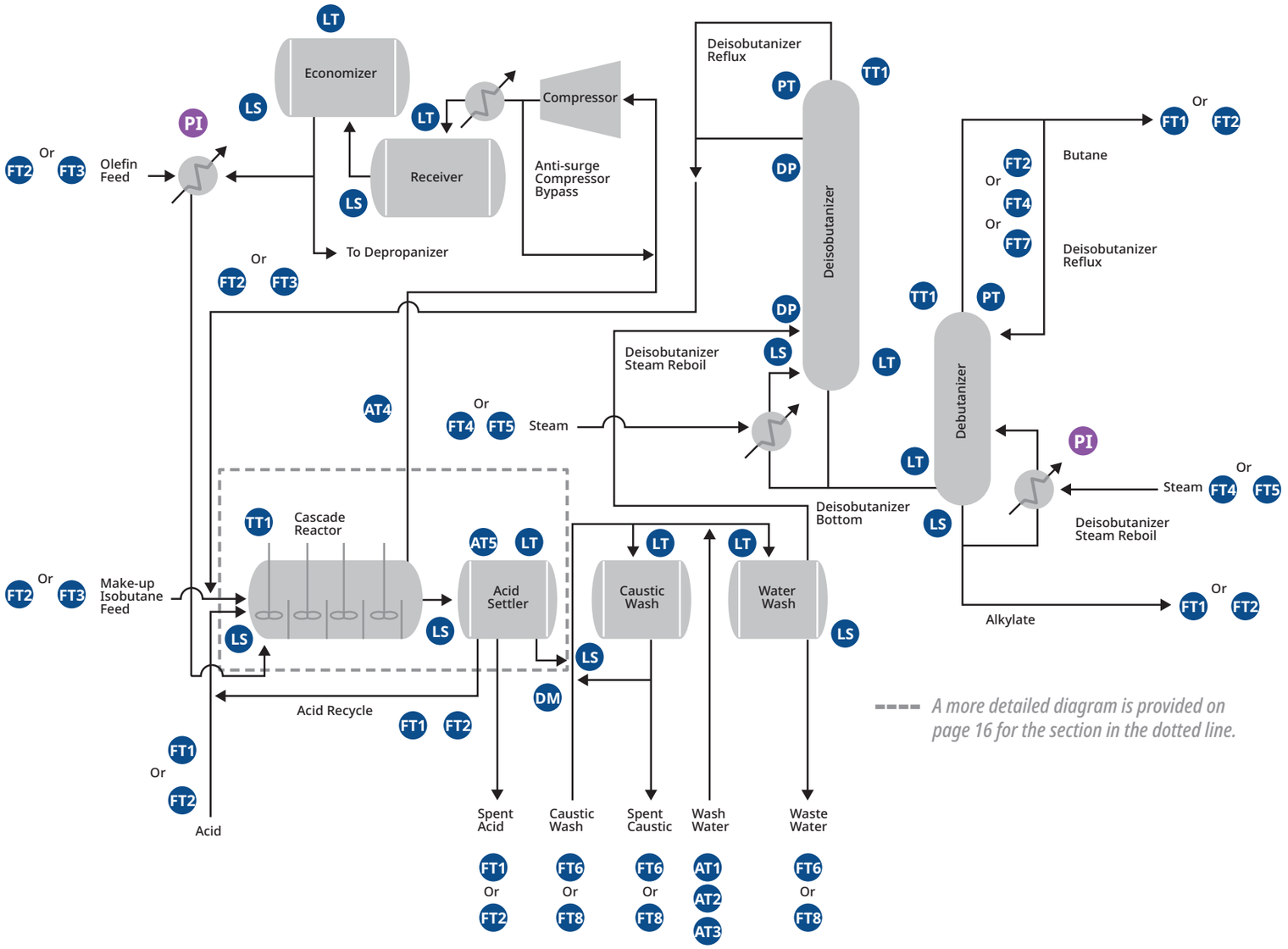
FIGURE 13
The Rosemount™ CT5400 Continuous Gas Analyzer is the world's first purpose-built hybrid process gas analyzer that combines QCL and TDL technologies. It is specifically designed to boost performance and cut costs, particularly in continuous emissions monitoring applications.

With the ability to analyze gas both hot / wet and cold / dry, the rack-mount Rosemount™ CT5400 analyzer integrates seamlessly into existing plant infrastructure without the need for expensive consumables or extensive maintenance.

2 Sulfuric Acid Alkylation Process

Sulfuric Acid Alkylation Process

The diagram shown below **(Figure 14)** highlights a general overview of Emerson's advanced measurement instrumentation designed to address the specific needs and challenges of SA alkylation.



A more detailed diagram is provided on page 16 for the section in the dotted line.

FIGURE 14

A simplified process flow diagram of a sulfuric acid alkylation process. Depending on the turndown and pressure drop requirements, measuring fresh, interstage, and spent acid accurately can also be done with the Rosemount™ Magnetic Meters.


AT1 Rosemount 3900 General Purpose pH/ORP Sensor


AT2 Rosemount 400 Conductivity Sensor


AT3 Rosemount 56 Dual-Channel Transmitter


AT4 Rosemount 700XA Gas Chromatograph


DM Micro Motion Fork Density Meter


DP Rosemount 3051S ERS Differential Pressure Level


FT1 Micro Motion ELITE Coriolis Flow Meter


FT2 Flexim FLUXUS F831 Permanent Flow Meter


FT3 Rosemount 8800 Quad Vortex Flow Meter


FT4 Rosemount 8800 Single MultiVariable Flow Meter


FT5 Rosemount 3051S DP Flow Meter with 1595 Conditioning Orifice Plate


FT6 Rosemount 8705 Flanged Magnetic Flow Meter Sensor


FT7 Rosemount 9295 Process Flow Meter


FT8 Flexim FLUXUS F731 Non-Intrusive Ultrasonic Liquid Flow Meter


LS Rosemount 2140 Vibrating Fork Level Detector


AT5 Flexim FLUXUS S731 Non-Intrusive Ultrasonic Liquid Analyzer


TT1 Rosemount 848T Wireless Temperature Transmitter


LT Rosemount 5300 Guided Wave Radar Level Transmitter


PT Rosemount 3051S Pressure Transmitter

PI Plantweb Insight Analytics Software

Sulfuric Acid Alkylation Process

Process Control

Monitoring Acid Concentration

Frequent acid regeneration is a significant challenge in an SA alkylation unit due to the degradation of SA over time, which makes maintaining target acid concentration levels critical for both safety and economic reasons. If the concentration is too high, it becomes excessively costly, whereas if it is too low, it could lead to a hazardous situation known as acid runaway. Acid runaway is a scenario where the reactions become uncontrollable, the acid is rapidly consumed, and operational shutdowns are required.

The challenge in monitoring acid concentration is exacerbated by the fact that lab sampling is not a continuous process, requiring a higher margin of safety to account for potential fluctuations. While magnetic flow meters (mag meters) can be utilized to monitor interstage acid flows, they do not measure acid concentration, leaving a gap in the continuous monitoring needed to ensure optimal and safe operational conditions.

Since Micro Motion™ Coriolis flow meters **(Figure 15)** measure both flow rate and density, they can be used to correlate density to acid strength to provide continuous measurements between lab titrations.

Installing Coriolis meters on the interstage acid lines allows for ongoing monitoring throughout the process. An issue in the first or second reactor might take hours to be detected in the final settler, but changes in density offer early problem detection. Additionally, placing a Coriolis meter on the fresh acid line can trigger an alarm if there is an accidental switch in the feed tank, such as from fresh acid to spent or swing tanks.

FIGURE 15
The Micro Motion™ ELITE™ CMF200 and ELITE™ CMF300 are recommended for monitoring the interstage and spent acid strength.

Sulfuric Acid Alkylation Process

Process Control

Monitoring Acid Concentration

Another important issue to consider when monitoring acid concentration is that some hydrocarbons unavoidably remain mixed with the acids in the settlers, as shown in **Figure 16**, and the monitoring of the acid/hydrocarbon (HC) ratio is frequently overlooked in the Contactor reactors. This is likely due to the ineffectiveness of traditional methods, which involve using a ratio glass.

The ratio glass often becomes obstructed or difficult to read, leading operators to abandon its use. However, maintaining the correct acid/HC ratio is crucial. A low acid/HC ratio causes the emulsion to shift from an acid-continuous phase to an HC-continuous phase, resulting in a decreased reactive surface area and a consequent decline in product quality. Conversely, a high acid/HC ratio leads to an increase in competitive reactions, thereby reducing selectivity.

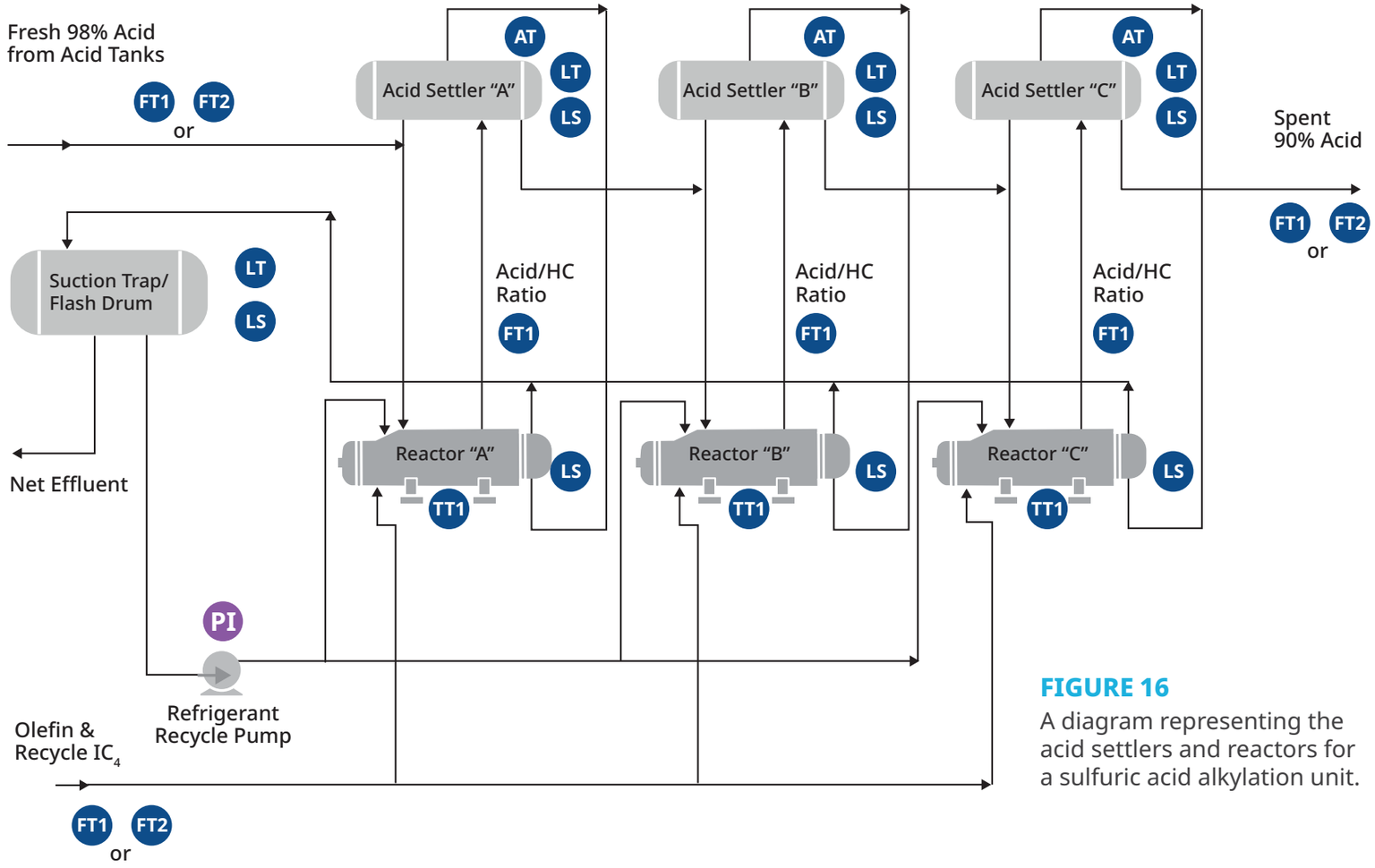


FIGURE 16
A diagram representing the acid settlers and reactors for a sulfuric acid alkylation unit.

FT1 Micro Motion ELITE Coriolis Flow and Density Meter

FT2 Flexim FLUXUS F831 Permanent Flow Meter

AT Flexim FLUXUS S731 Non-Intrusive Ultrasonic Liquid Analyzer

LS Rosemount 2140 Vibrating Fork Level Detector

LT Rosemount 5300 Guided Wave Radar Level Transmitter

TT1 Rosemount 848T Wireless Temperature Transmitter

PI Plantweb Insight Analytics Software

Sulfuric Acid Alkylation Process

Process Control

Monitoring Acid Concentration

Installing a Micro Motion™ ELITE™ CMF100 **(Figure 17)** or a Micro Motion™ Density Meter alongside the existing ratio glass enables online density measurement, providing real-time data to maintain the correct acid/HC ratio. It should be noted that while the Coriolis meter does not monitor emulsion tightness, the ratio glass can still be maintained for this purpose.

Ultimately, utilizing Micro Motion™ Coriolis meters in an SA alkylation unit offers significant advantages in terms of product quality and process efficiency. The ability to monitor acid strength in real time enables operators to make precise operational adjustments, ensuring that acid purity remains within normal limits. This results in consistently higher quality alkylate, which is a more valuable gasoline blending feedstock for the refinery.

Additionally, maintaining proper acid purity minimizes side reactions that can produce hydrocarbons, which might otherwise overload the effluent treating system and cause corrosion in equipment and piping. By reducing these risks, Coriolis meters help prevent costly unit downtime and loss of production, further enhancing the economic performance and reliability of the alkylation process.

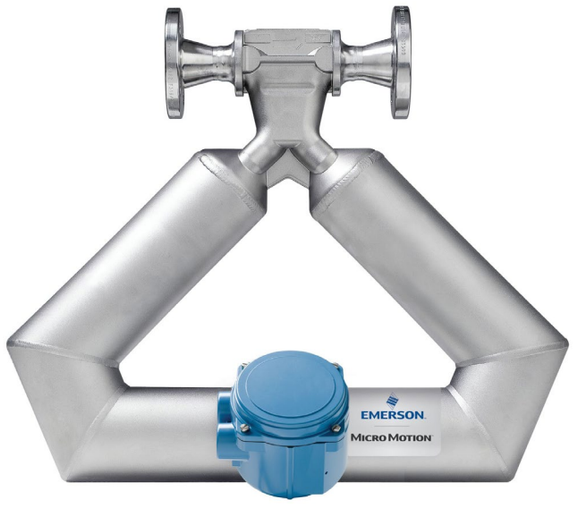


FIGURE 17
The Micro Motion™ ELITE™ CMF100 is recommended for monitoring acid to hydrocarbon ratio control.

3 Hydrofluoric Acid Alkylation Process

Hydrofluoric Acid Alkylation Process

Emerson's state-of-the-art measurement instrumentation also addresses multiple critical challenges in an HF alkylation unit, ensuring enhanced safety and operational efficiency. A simplified process flow diagram is shown in **Figure 18**.

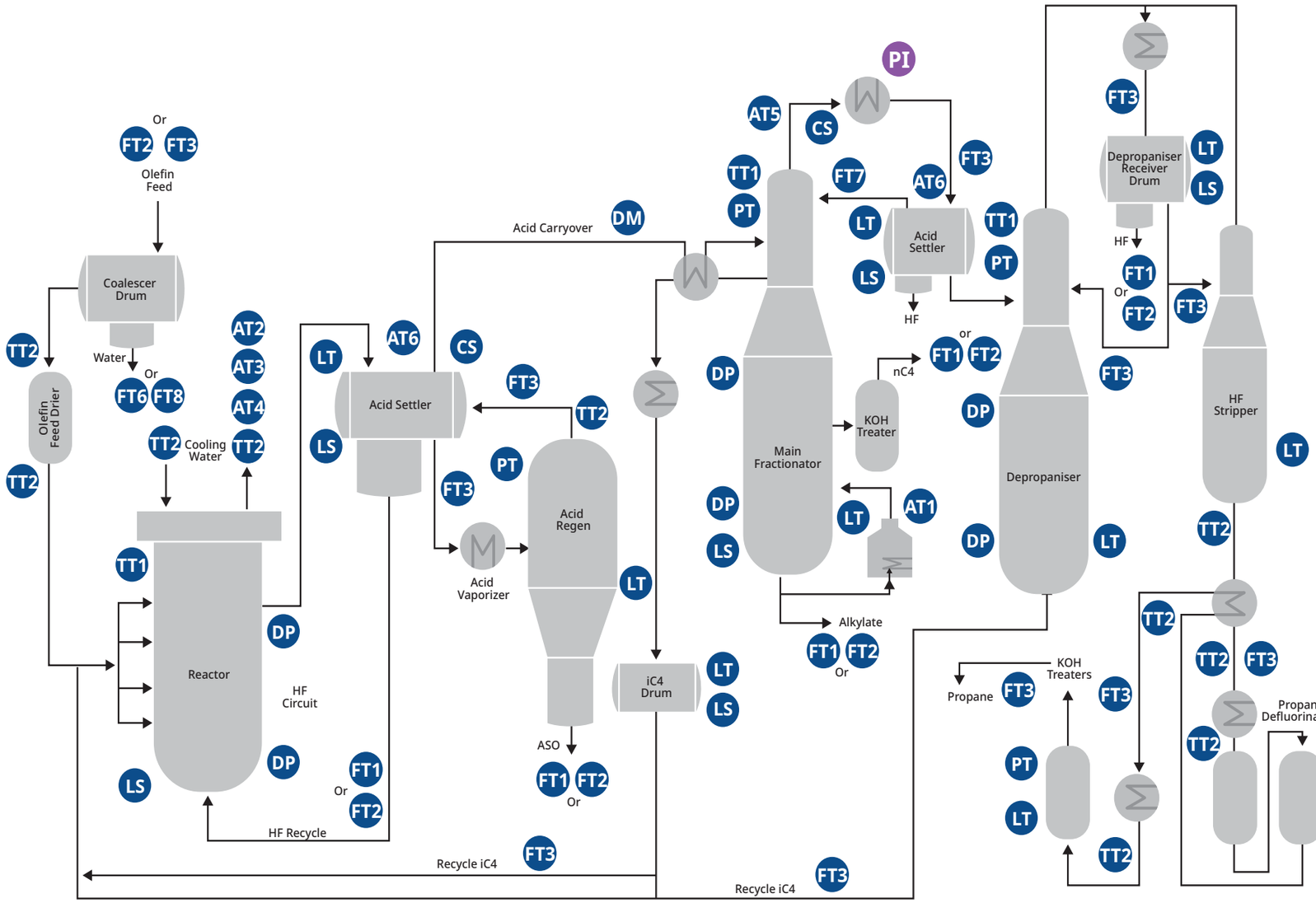


FIGURE 18
Basic Hydrofluoric Acid Alkylation Unit Diagram.

- AT1 — Rosemount 6888A In Situ Oxygen Analyzer and Rosemount OCX 8800 Oxygen and Combustibles Transmitter
- AT2 — Rosemount 3900 General Purpose pH/ORP Sensor
- AT3 — Rosemount 400 Conductivity Sensor
- AT4 — Rosemount 56 Dual-Channel Transmitter
- AT5 — Rosemount 700XA Gas Chromatograph
- DM — Micro Motion Fork Density Meter
- DP — Rosemount 3051S ERS Differential Pressure Level
- FT1 — Micro Motion ELITE Coriolis Flow Meter
- FT2 — Flexim FLUXUS F831 Permanent Flow Meter
- FT3 — Rosemount 8800 Quad Vortex Flow Meter
- FT4 — Rosemount 8800 Single MultiVariable Flow Meter
- FT5 — Rosemount 3051S DP Flow Meter with 1595 Conditioning Orifice Plate
- FT6 — Rosemount 8705 Flanged Magnetic Flow Meter Sensor
- FT7 — Rosemount 9295 Process Flow Meter
- FT8 — Flexim FLUXUS F731 Non-Intrusive Ultrasonic Liquid Flow Meter
- LS — Rosemount 2140 Vibrating Fork Level Detector
- AT6 — Flexim FLUXUS S731 Non-Intrusive Ultrasonic Liquid Analyzer
- TT1 — Rosemount 848T Wireless Temperature Transmitter
- TT2 — Rosemount 3144P Temperature Transmitter
- LT — Rosemount 5300 Guided Wave Radar Level Transmitter
- PT — Rosemount 3051S Pressure Transmitter
- PI — Plantweb Insight Analytics Software

Hydrofluoric Acid Alkylation Process

Ensuring Safety

The petroleum refining industry has increasingly prioritized the safe use of HF in refineries. This focus has led the American Petroleum Institute (API) to issue safety guidelines for HF alkylation units, detailed in API RP-751. To address potential safety concerns, advancements have been made in flow meter technology selection.

Minimizing HF Leak Risks

Existing orifice meters may pose risks due to the high number of potential HF leak points from threaded connections. For this reason, the Rosemount™ 8800 Vortex Flow Meter is a notable option for replacing traditional orifice installations. It features an isolated sensor design to seal the process and all-welded bodies that enable online maintenance and sensor verification. Its robust design minimizes HF leak risks and ensures precise control. The Critical Process Safety Valve enhances safety by verifying that the sensor cavity is free of process fluid before removal, eliminating the need for bypass lines. Additionally, the meter is available in various corrosion-resistant materials, such as nickel alloys. Furthermore, the Rosemount™ Quad Vortex Flow Meter **(Figure 19)** is specifically designed to enhance safety and stands out with its four independent sensors, providing continuous accurate measurements and redundancy to ensure reliability.

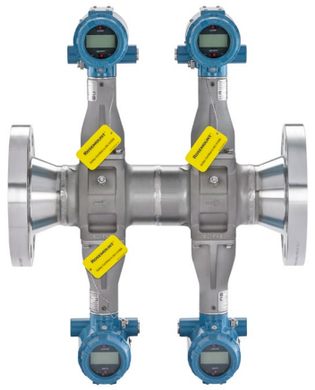
Operational Stability

The primary task of a Polymer Surge Drum is to collect heavier polymeric by-products that are formed as side reactions in the HF alkylation process. To monitor the outlet of this drum, the Rosemount™ 242 Flow Through Toroidal Conductivity Sensor or the Rosemount™ 228 Toroidal Conductivity Sensor are both excellent choices. Both sensors are designed to withstand the harsh conditions and corrosive environments common in such applications, providing reliable and robust measurements.

The non-contact nature of toroidal (inductive) conductivity sensors eliminates direct contact between the sensing element and the process fluid. This design reduces the risk of sensor fouling, coating, and degradation, leading to more consistent and reliable measurements.

FIGURE 19

Emerson's Rosemount™ Quad Vortex Flow Meter is certified for safety instrumented functions (SIFs), up to SIL 3. It is frequently utilized in SIS loop applications, where equipment is required to meet the highest reliability standards while reducing or eliminating unscheduled shutdowns.



The Rosemount 242 offers additional benefits with its flow-through design, ideal for continuous monitoring and integration into existing pipelines. Meanwhile, the Rosemount 228 provides versatility and durability with its adaptable installation options. Employing either of these sensors ensures accurate, real-time conductivity measurements, helping to control polymer content and maintain operational stability.

Furthermore, the Rosemount™ 372 HF Resistant pH Sensor, shown in **Figure 20**, is specifically designed to withstand the highly corrosive environment typical of an HF alkylation unit. This sensor provides accurate and reliable pH measurements, crucial for monitoring and optimizing the alkylation process. Proper pH control helps resist corrosion, ensures process efficiency, and maintains product quality. When integrated with the polymer surge drum, the sensor helps detect the build-up of acidic by-products or heavy polymers, enabling timely interventions to prevent system disruptions.

Hydrofluoric Acid Alkylation Process

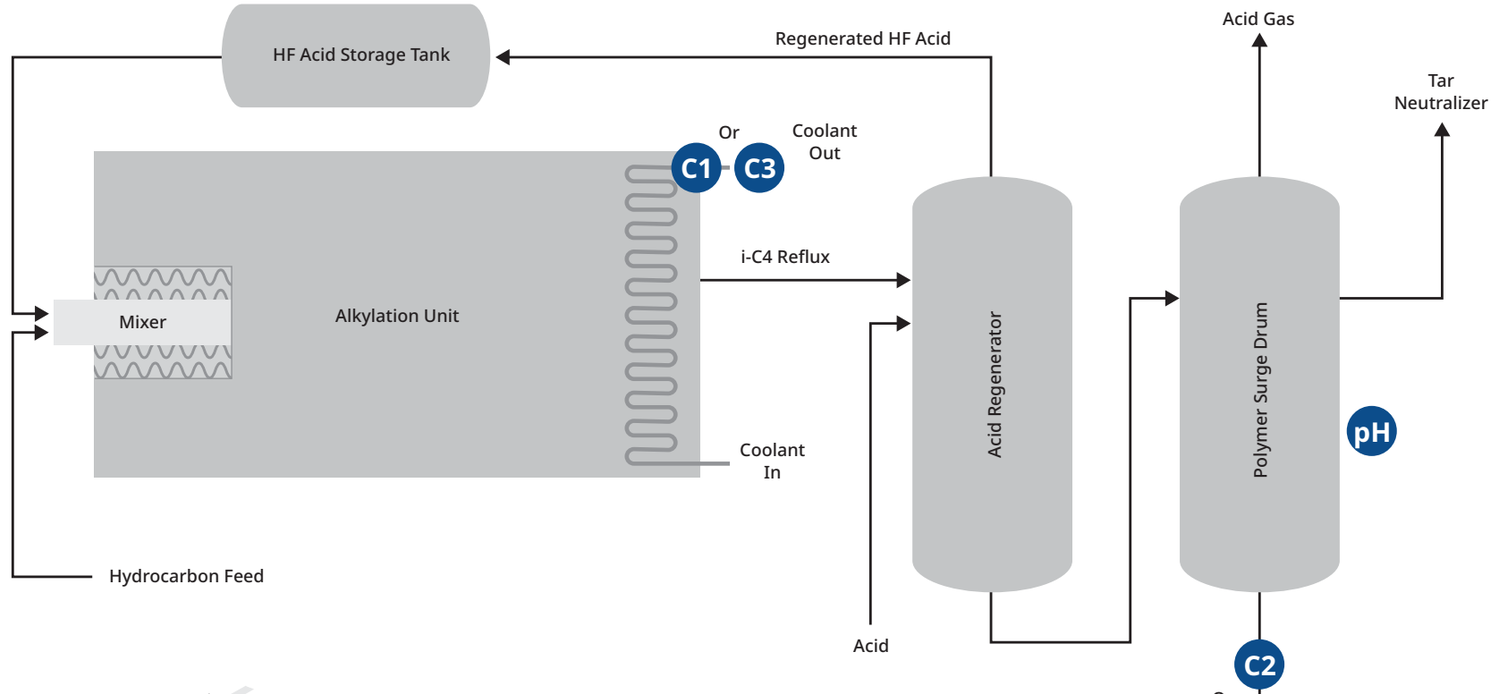
Ensuring Safety

Operational Stability

To detect cooling coil leaks in an HF alkylation unit, selecting the right conductivity sensor depends on the specific needs of sensitivity, accuracy, and environmental resistance.

The Rosemount™ 228 Toroidal Conductivity Sensor is well-suited for highly corrosive environments where fouling is a significant concern. Its robust design and lower maintenance needs make it an excellent choice for long-term reliability. However, it may not offer the same level of sensitivity as contacting sensors.

Conversely, if precise and high-sensitivity measurements are required to detect very small leaks, the Rosemount™ 400 Contacting Conductivity Sensor might be more appropriate. Its contacting design typically provides higher sensitivity and accuracy, which is crucial for early leak detection. Choosing between these options involves balancing the need for sensitivity with the operational demands of a highly corrosive environment.



C1 Rosemount 400 Contacting Conductivity Sensor

C2 Rosemount 242 Flow Through Toroidal Conductivity Sensor

C3 Rosemount 228 Toroidal Conductivity Sensor

pH Rosemount 372 HF Resistant pH Sensor

FIGURE 20

Notable conductivity and pH measurement points in an HF alkylation unit. Both the Rosemount™ 400 Contacting Conductivity Sensor and the Rosemount™ 228 Toroidal Conductivity Sensor are compatible with transmitters like the Rosemount™ 1058 General Purpose and 5081 Explosion Proof models. This combination ensures precise data capture, real-time monitoring, enhanced process control, and compliance with safety standards.

Hydrofluoric Acid Alkylation Process

Ensuring Safety

Corrosion & Erosion Monitoring

To specifically address the extensive corrosion and erosion risks posed by HF alkylation, the recommended placement of the Emerson's Rosemount™ Wireless Corrosion Monitoring Sensors is shown in **Figure 21**.

Potential monitoring locations encompass the entire HF cycle around the reactor and the overheads system, where acid condensation can lead to corrosion of piping and other equipment.

Special attention is also required in the acid regeneration section and downstream post-treatment equipment. Typically, an installation includes around 30 monitoring points, each equipped with 2 to 4 sensors. These systems are engineered to be robust in industrial environments and monitor critical areas, including some high-temperature zones of the alkylation unit where free HF is present or other regions where phase changes might occur.

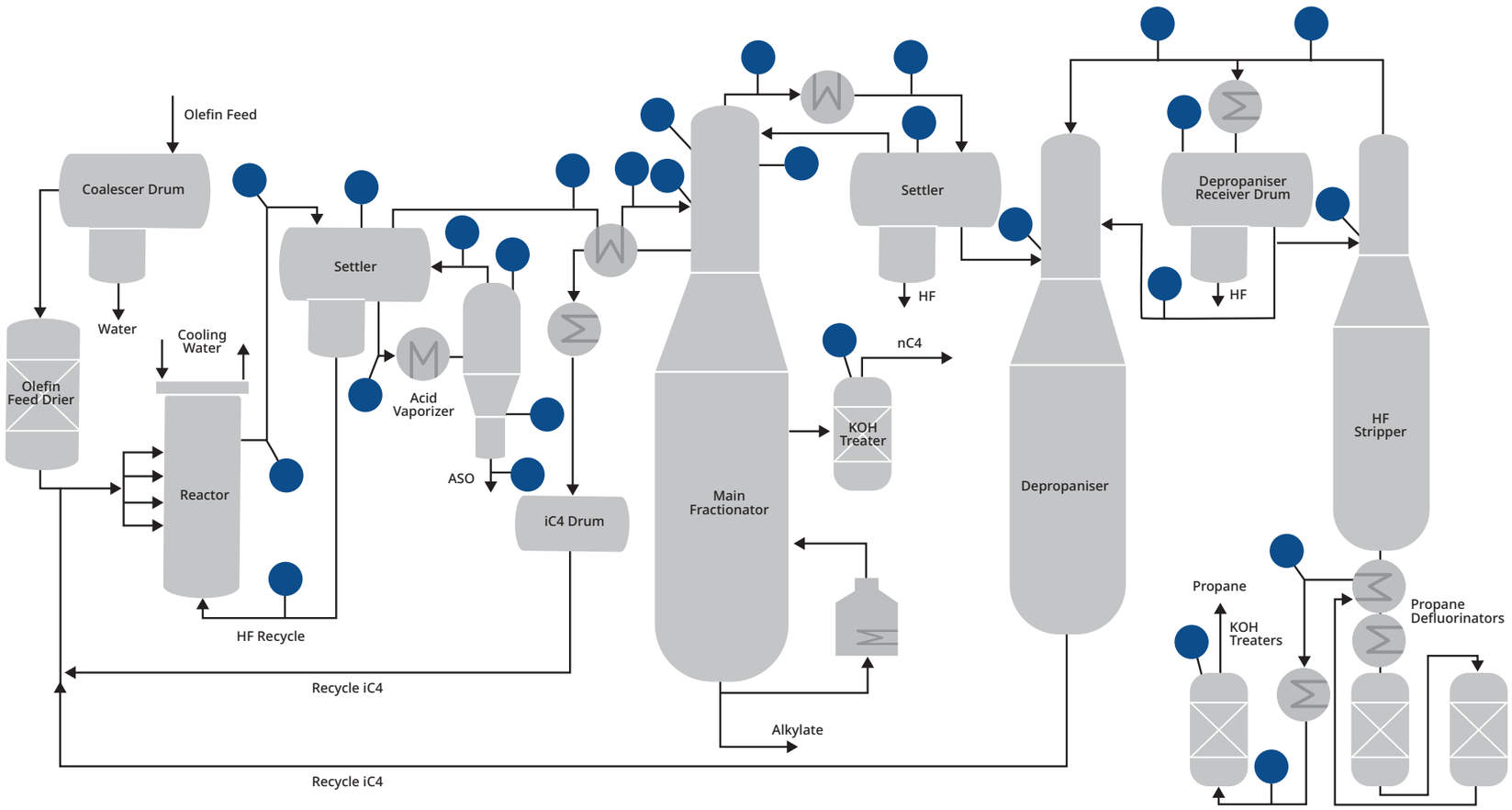


FIGURE 21
An outline of corrosion and erosion monitoring locations for HF alkylation.

Hydrofluoric Acid Alkylation Process

Asset Health Monitoring

Pump Health Monitoring

The common threats to pump health in an HF alkylation process are identified in **Figure 22**. Due to these operational issues, Emerson's wireless solutions for pump health monitoring are exceedingly beneficial for this application, primarily due to their ability to enhance both operational efficiency and safety.

By implementing wireless monitoring, operators can remotely track the health and performance of pumps without the need for regular manual rounds in hazardous areas. This significantly limits Health, Safety, Security, and Environmental (HSSE) exposure, reducing the risk of accidents and potential harm to personnel.

Automated wireless solutions ensure continuous real-time data collection and analysis, enabling predictive maintenance to preemptively address potential failures. Consequently, this minimizes downtime, extends the lifespan of critical equipment, and optimizes the overall reliability and productivity of the HF alkylation unit.

RESTRICTION
A restriction of the pump's suction can result in cavitation of the pump. Root causes can include a plugged suction strainer, loss of level in the suction drum or a possible valve issue.

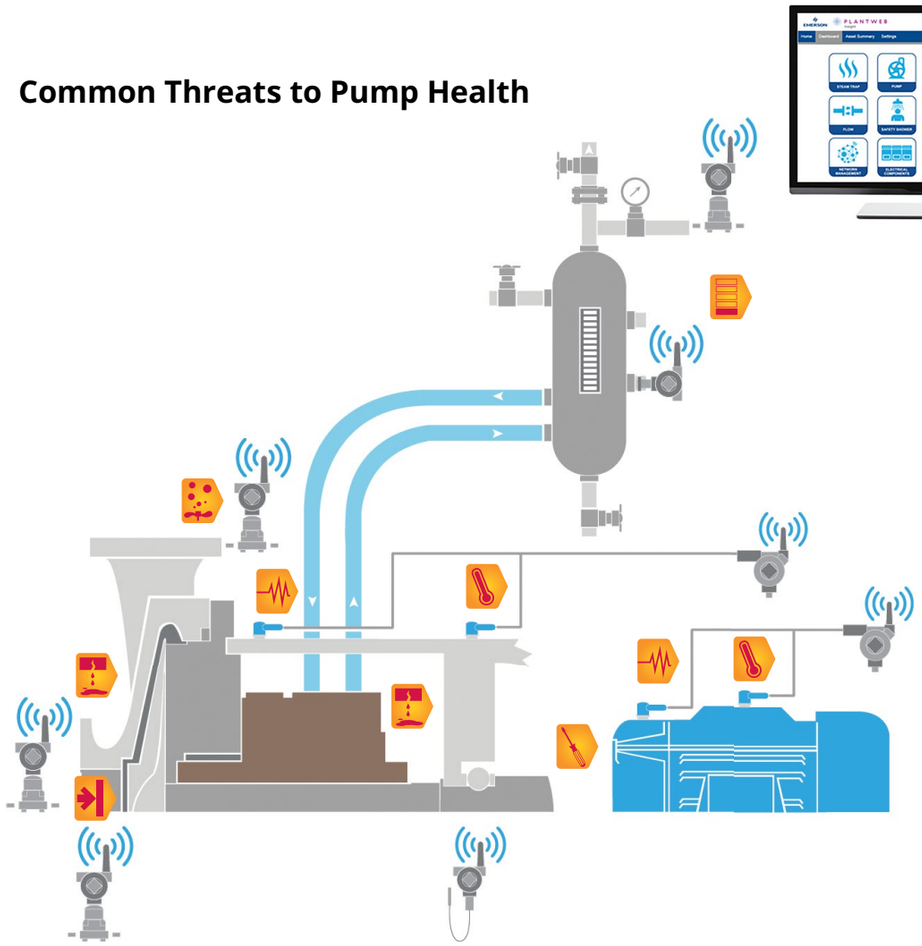
CAVITATION
As liquid pressure falls below its vapor pressure, bubbles form and implode on impellers and interior surfaces, damaging pump internals, disrupting flow and leading to seal failure.

LEAKAGE
Leaks caused by mechanical failures can be catastrophic. Early detection of abnormal conditions such as cavitation, pressure imbalance or excess vibration can help avoid leaks and their consequences.

LEVEL
Inadequate monitoring of Auxiliary Seal Flush levels can result in missed low level conditions, indicating a loss of flush or high level conditions, indicating mechanical seal leakage and eventual flaring.

VIBRATION
Several detectable root causes for vibration can damage seals or internals and cause pump failure.

Common Threats to Pump Health



TEMPERATURE RISK
Blocked-in discharge can result in fluid stagnation, causing a spike in temperature. This can also result in cavitation, damaging pump internals and seal failure. Inadequate monitoring of standby pump temperature can result in damage when a cold pump is put into hot service.

INSTALLATION
Improper installation can lead to shaft misalignment, excessive vibration leading to pump damage and possible failure.

FIGURE 22
Common Threats to Pump Health (left) and the Plantweb Insight™ Pump application (top right) offers comprehensive monitoring for HF alkylation pumps, utilizing machine learning models and analytics to display real-time status and alerts. It detects issues such as cavitation, plugged strainers, early bearing and gear wear, and imminent seal leaks, enabling a shift from reactive to predictive maintenance strategies.

Optimizing Alkylation Processes

In the dynamic field of alkylation, Emerson offers a comprehensive portfolio of measurement instrumentation meticulously designed to promote unparalleled safety, reliability, flexibility, and process optimization for both SA and HF alkylation processes.

Emerson's state-of-the-art instrumentation—including advanced flow meters and innovative pressure and temperature sensors—plays a crucial role in ensuring alkylation units operate within optimal parameters. By providing accurate, real-time data, our instruments enhance operational safety, minimize the risk of acid leaks and hazardous incidents, and ensure compliance with stringent industry standards.

Reliability is at the core of Emerson's offerings. Our instruments are engineered to withstand the harsh conditions typical of acid alkylation environments, ensuring continuous and dependable performance. This reliability not only reduces downtime but also extends the lifespan of critical assets, contributing to overall operational excellence.

Moreover, process optimization is deeply embedded in Emerson's approach. By leveraging sophisticated measurement technologies, we enable refineries to achieve greater efficiency, higher product quality, and optimized resource utilization. Our solutions empower operators to make data-driven decisions, enhancing productivity and economic performance. As the industry continues to evolve, Emerson remains committed to providing innovative solutions that drive operational excellence.

Emerson.com/Alkylation

Emerson.com/MeasurementInstrumentation

Monitoring Corrosion in Hydrofluoric Acid Alkylation Units

Case Study: How A Large Refinery Improved Reliability and Safety in HF Alkylation Unit

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