CHEMICAL APPLICATION GUIDE

DISTILLATION COLUMNS

Improve Distillation Column Efficiency and Safety

Safely minimize energy consumption, meet product specs, and maintain high throughput with effective distillation instrumentation and control.

EMERSON

Industry Facts
You Need to Know

IMPROVE ENERGY EFFICIENCY AND YOUR BOTTOM LINE

- **It is estimated that roughly 40% of energy consumption is due to distillation columns**

  (Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Distillation Column Modeling Tools)

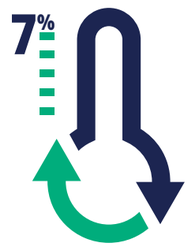
Approximately 40% of energy consumption is attributed to distillation columns.

- **Overprocessing or over-purifying to meet quality requirements can result in 7% production loss and use of as much as 12% excess steam**

  (Source: Energy Efficient and Always On-Spec. Emerson's Integrated Distillation Solution)

- **Unmanaged ambient temperature swings drive up to 7% excess energy consumption**

  (Source: LinkedIn article, "Are you minimizing energy usage in your distillation columns?" by Jackson Udy, PE)



Uncontrolled ambient temperature fluctuations can cause distillation columns to consume up to 7% more energy.

IMPROVE SEPARATION EFFICIENCY

- **It can take up to 8 hours to stabilize the distillation process after a column flooding event**

  (Source: Science Direct, Prediction of Flooding in Distillation Columns Using Machine Learning)

A column flooding event can take up to 8 hours to stabilize.

Boost Your Bottom Line
By Safely Balancing Separation Efficiency and Energy Use

Your primary distillation column objectives are to operate safely, minimize energy consumption, meet product quality targets and maximize throughput.

Quality measurements result in meeting your desired separation efficiency and reducing over-purifying, flooding or fouling. Additionally, better control will help improve safety.

Emerson has a comprehensive set of technologies to help you optimize your distillation processes. Better real-time, accurate data incorporated into your analytics software will allow the column to run much closer to optimal efficiency reducing energy usage and costs. At the same time this leads to a safer more reliable operation.

Poor measurements lead to:

- Inability to achieve desired separation efficiency
- Over-purification, wasting energy while meeting quality requirements
- Missed issues like tray damage, flooding, and fouling, causing unplanned shutdowns
- Failure to address unsafe operating conditions like excessive pressure, temperature, or level increases

APPLICATION CHALLENGES

Maximizing separation efficiency, reducing energy costs and enhancing safety is your goal. We can help you with these challenges, so you can optimize your distillation operation:

- **Optimize temperature & pressure profiles**
- **Gain reflux ratio and heating & cooling rate insights**
- **Understand feed & final product composition**
- **Visibility to flooding, weeping, and tray damage**
- **Improve mass and energy balance**
- **Improve safety**

The Value of Emerson's **Comprehensive Solutions**

Emerson's distillation solutions can help you keep products on-spec with advanced sensors, transmitters, and process control technology providing predictive diagnostics and optimized control for a more profitable and energy efficient distillation operation. Fully leveraging instrumentation, control, and automation technology supports achieving optimal distillation column efficiency and improves safety.

With Emerson's solutions you can:

Optimize temperature & pressure profiles

Enhance control and streamline pressure measurement throughout the column with Rosemount™ DP Electronic Remote Sensors (ERS) System, designed to boost response time and ensure optimal separation efficiency.

Monitor steam temperature and column temperature profile for optimal efficiency using Rosemount Temperature instrumentation.

Gain reflux ratio and heating & cooling rate insights

Monitor fluids and gases to optimize distillation and reduce energy usage of the reboiler and **optimize reflux rates** with Rosemount Vortex and DP Flow Meters.

Understand feed & final product composition

Improve monitoring of product composition to meet quality requirements while preventing costly over-purification using Rosemount Gas Chromatographs and analyzers.

Visibility to flooding, weeping, and tray damage

Monitor and ensure optimized separation and prevent column/tray flooding with Rosemount 3051S pressure transmitters featuring Statistical Process Monitoring and advanced diagnostics that can detect early column flooding and tray malfunctions.

Improve mass and energy balance

Get accurate data to improve mass balance across column with direct mass flow measurements entering and leaving the column with Micro Motion™ Coriolis meters.

Close mass balance gaps on columns with accurate and reliable measurements even in high pressure, temperature and corrosive environments with Flexim™ Non-Intrusive Ultrasonic Flow measurement.

Improve safety

Monitor level to prevent overfill for added safety with Rosemount level instruments and **ensure the integrity of your piping systems** using Rosemount Corrosion monitoring solutions.

Safely minimize energy consumption, meet product specs, and maintain high throughput with effective distillation instrumentation and control.

Product **Solutions**

Emerson is a collaborative partner. Our team works along with you to meet your distillation column and separation goals.

On the next few pages, see how our product solutions have helped customers meet their distillation column goals:

- Optimizing Separation Efficiency
- Improving Quality
- Reducing Operations and Maintenance Costs
- Improving Safety

Let's start a conversation on how our team can work with you.

OPTIMIZING SEPARATION EFFICIENCY

IMPROVING QUALITY

REDUCING OPERATIONS & MAINTENANCE COSTS

IMPROVING SAFETY

GOAL: OPTIMIZING SEPARATION EFFICIENCY

Issues	Solutions	Featured Products
Improving mass and energy balance of the distillation column	Use direct mass flow measurement on inputs and outputs of the column	 **Micro Motion Coriolis Meters -** directly measures the mass flow of gas and liquid streams and liquid density allowing quick reaction to process changes, improved product quality control, and mass balance across the unit
Improving mass and energy balance of the distillation column when large line sizes, corrosive materials, or high temperatures are present	Use non-intrusive flow measurement solutions	 **Flexim FLUXUS F831 Permanent Flow Meter for Hazardous Areas -** non-intrusive meter for measuring process flows in extreme conditions including high process temperatures, pressures and corrosive environments
Ensuring uniform temperature profile across the column to maximize efficiency	Use high density multi-point temperature transmitter to simplify temperature monitoring	 **Rosemount 848T Temperature Transmitter -** - high density measurement technology allows for up to eight independently configurable RTD, thermocouple ohm, millivolt and 4-20ma inputs - cost effectively monitors the temperature profile of distillation columns for improved separation efficiency
		 **Rosemount 3144P Temperature Transmitter -** provides the highest accuracy transmitter and measurement redundancy for accurate temperature profile across the column even during changing ambient conditions which can have significant impact on column efficiency
Controlling column pressure, and differential pressure across trays to maximize separation efficiency and detect tray flooding	Use electronic remote sensors and pressure transmitter diagnostics to detect and prevent tray flooding	 **Rosemount 3051S Electronic Remote Sensor (ERS™) System -** - measure differential pressure to detect flooding, overpressure and excessive energy use - design uses two digitally linked sensors instead of impulse piping eliminating impulse piping issues and improving speed of response
		 **Rosemount 3051S Series Pressure Transmitter -** - combining the highest safety rated pressure transmitter in the industry with advanced diagnostics, the Rosemount 3051S Pressure Transmitter is used for measuring pressure across the column - critical measurement in optimizing distillation efficiency and maintaining safety within the column - features Statistical Process Monitoring and advanced diagnostics that can detect early column flooding and tray malfunctions

GOAL: IMPROVE QUALITY

Issues	Solutions	Featured Products
Lack of understanding of gas composition can lead to over-purification wasting energy or under-purification impacting quality	Use accurate gas analysis to monitor gas purity	 **Rosemount CT5800 Continuous Gas Analyzer -** - ideal for gas purity and quality applications, to ensure distillation efficiency and prevent over-purification - the Rosemount CT5800 uses a unique intra-pulse spectroscopic method that enables sub-parts-per-million analysis of up to 10 gases simultaneously in a single instrument, reducing cost of ownership, footprint and operational complexity - designed for industrial process applications requiring Class I, Division 2 hazardous area certification - combines Quantum Cascade Laser (QCL) and Tunable Diode Laser (TDL) technologies
		 **Rosemount X-STREAM Enhanced Continuous Gas Analyzers -** - ideal for gas purity and quality applications, to ensure distillation efficiency and prevent over-purification - multi-component and multi-method gas analysis combining non-dispersive infrared (NDIR), non-dispersive ultraviolet (NDUV) photometer, paramagnetic (pO2) detector, electrochemical hydrogen sulfide (eH2S), and electrochemical oxygen (eO2) cells, thermal conductivity (TCD) detector, as well as trace oxygen (tO2) and trace moisture (tH2O) sensors to deliver a cost-effective and reliable, precise measurement of more than 60 different gases
		 **Rosemount 470XA Gas Chromatograph -** - quickly measures overhead composition with field mounted capabilities adjacent to sampling source - this localized installation reduces operating cost while allowing closed loop control of product quality, reducing energy use and increasing product recovery

GOAL: REDUCING OPERATIONS & MAINTENANCE COSTS

Issues	Solutions	Featured Products
Inaccurate column, boiler drum, and reboiler level measurements when fluid properties are changing increases maintenance and operating cost	Utilize level measurement technologies that are immune to fluid property changes such as guided wave radar	 **Rosemount 5300 Level Transmitter - Guided Wave Radar -** - accurately measures tower levels, reflux drum and reboiler level regardless of fluid density and viscosity, even in extreme process conditions - dynamic vapor compensation ensures accurate level measurement in boiler drum level applications
		 **Rosemount CMB Level Chamber -** - critical when level measurement requires the measurement to be isolated from the process - the use of a preassembled chamber reduces cost and improves on safety and reliability of the measurement
Ensure accurate flow measurement of process streams to reduce operations costs	Leverage fit for purpose technologies such as Vortex and Mulitvariable DP flow on steam, Annubar for larger line sizes, and Integrated flow meter technology to reduce complexity	 **Rosemount 8800 MultiVariable Vortex Flow Meter -** - the all-welded non-clogging design provides reliable flow readings without the need for impulse lines where high accuracy is not required such as reflux and steam - increases energy efficiency by more accurately monitoring steam usage - multi-variable capability with integral temperature sensor and external pressure transmitter input for P&T compensation
		 **Rosemount 9295 Process Flow Meter -** - simplify DP flow meter installation with a fully assembled spool section with conditioning orifice technology to reduce straight run - all-welded design eliminates potential leak points; ruggedized isolation valves improve process safety
		 **Rosemount 3051S MultiVariable™ Transmitter, Rosemount 3051SFC Compact Orifice Flow Meter, and Rosemount 3051SFA Annubar™ Flow Meter -** measures differential pressure, static pressure and process temperature to perform fully compensated mass and energy flow calculations allowing tighter control of critical process parameters

GOAL: REDUCING OPERATIONS & MAINTENANCE COSTS, CONTINUED

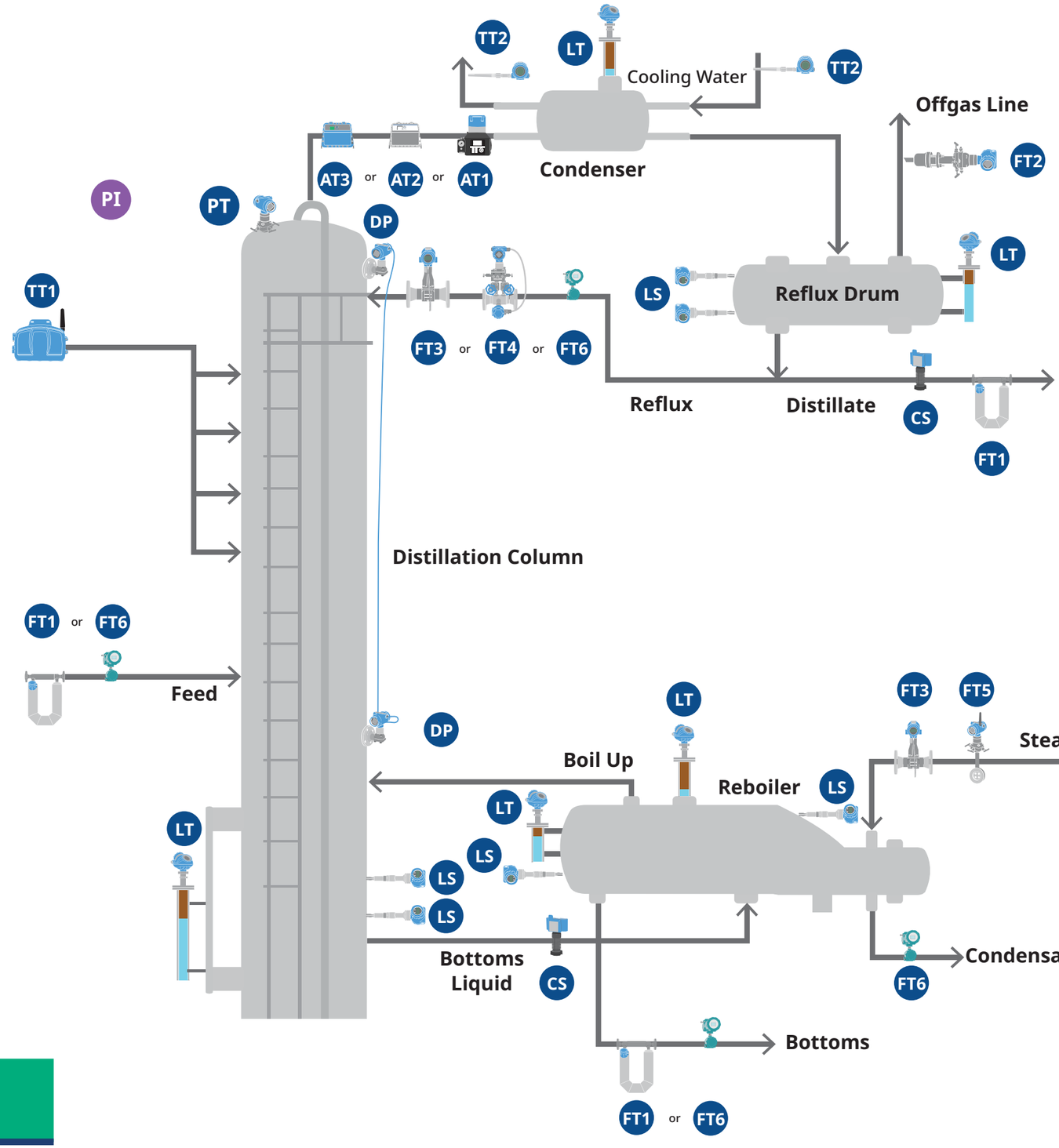
Issues	Solutions	Featured Products
Simplify and lower the cost of additional temperature monitoring points	Leverage non-intrusive temperature measurements and simplify thermowell design and selection	 **Rosemount X-well™ Technology -** simple clamp on temperature measurement with no pipe penetrations enables quick and efficient addition of process temperature measurements for improved monitoring of thermal efficiency
		 **Rosemount Thermowell Design Accelerator -** significantly reduces the complexity and engineering hours required to design thermowells

GOAL: IMPROVING SAFETY

Issues	Solutions	Featured Products
Prevent safety incidents associated with vessel overfills	Use accurate point level detection for high level alarms in the safety system to minimize overfills	 **Rosemount 2140 Level Detector – Vibrating Fork -** - level switches are a critical component in the use of safety loops, as well as overfill protection on the column, reflux drum and reboiler - features automated proof testing software that simplifies SIS loop integrity testing
Inadequate insight into corrosion rates risks pipe and vessel damage resulting in loss of containment or premature replacement	Take advantage of wireless real-time corrosion monitoring solutions	 **Rosemount Wireless Permasense ET310C Corrosion Transmitter -** wireless corrosion monitoring enables real-time detection of pipe and vessel wall thickness reductions that can negatively impact equipment life and lead to loss of containment
		Plantweb Insight™ Non-Intrusive Corrosion Application - dashboards display real-time corrosion trends providing insight into any potential process conditions that may be shortening the life of piping and vessels as well as providing more predictability as to the life of those assets
Accurately detect the presence of an unwanted fire without nuisance alarms due to false sources such as lightning, welding, or similar phenomena	Multi-IR flame detectors identify hydrocarbon and hydrogen fires, as well as a host of other challenging fuel types	 **Rosemount 975 Flame Detector -** - accurately detects hydrocarbon and hydrogen-based fuel or gas fires at long distances with a high immunity to false alarms - fast responding flame detectors are key to an effective fire protection system
Detect hydrocarbon gases before they can create dangerous situations	Quickly detect combustible gases in open air, ducts or other enclosed spaces, or by using a sample draw system for containers or pipes with Infrared (IR) gas detectors	 **Rosemount 625IR Fixed Gas Detector -** - provides ultra-fast response times using optical absorption detection technology, the gas detector transmits infrared light through a sapphire lens and reflects light back again to determine gas concentration - built-in environmental compensation and a 15 year warranty on the infrared (IR) source - a host of accessories are available to simplify routine function checks, installation in a sample draw system, and more

Emerson can help you optimize your distillation processes. By integrating more accurate, real-time data into your analytics software, the column can operate closer to its optimal efficiency, reducing energy consumption and costs. This also results in a safer, more reliable operation.

- **PI** Plantweb Insight Analytics Software
- **AT1** Rosemount 470XA Gas Chromatograph
- **AT2** Rosemount CT5800 Continuous Gas Analyzer
- **AT3** Rosemount X-STREAM Enhanced Continuous Gas Analyzer
- **DP** Rosemount 3051S ERS System
- **LT** Rosemount 5300 Guided Wave Radar
- **PT** Rosemount 3051S Pressure Transmitter
- **LS** Rosemount 2140 Switch Vibrating Fork
- **FT1** Micro Motion ELITE Coriolis Flow Meter
- **FT2** Rosemount 3051SFA Annubar Flow Meter
- **FT3** Rosemount 8800 MultiVariable Flow Meter
- **FT4** Rosemount 9295 Process Flow Meter
- **FT5** Rosemount 3051S DP Flow Meter with 1595 Conditioning Orifice Plate
- **FT6** Flexim FLUXUS F831 Permanent Flow Meter
- **TT1** Rosemount 848T Wireless Temperature Transmitter
- **TT2** Rosemount 3144P Temperature Transmitter
- **CS** Rosemount Wireless Permasense ET310C Corrosion and Erosion Monitoring System



Please contact your Emerson sales representative to discuss solutions to meet your goals.

Case **Study**

OXEA Reduces Maintenance and Unit Operating Costs with Improved Distillation Column Level Measurement

Results

- Improved unit efficiency by 10%
- Higher throughput and longer production cycles
- Reduced maintenance time by 40% & replacement costs by 40%
- Reduced spares

CUSTOMER

OXEA Produktions GmbH & Co. KG, Marl, Germany. OXEA is a world leader in Oxo chemicals, producing more than 70 Oxo intermediates and Oxo derivatives for customers in a wide range of industries and end market applications.

APPLICATION

DP level measurement and control in a distillation column with acetates

CHALLENGE

OXEA distills acetates in the production of various esters for a variety of end market applications. At the Marl plant, accurate level control was difficult due to the harsh process conditions of 200 mbar static pressure, 120 °C temperature, and a differential pressure of 170 mbar.

"We were having trouble with level measurement failures," said Herr Andreas Busch-Ahlschläger, I&C Engineer. "The harsh process conditions caused frequent seal failures, which required us to shut down the column and completely replace the balanced system."

"We have reduced our maintenance time on this unit by nearly 40%, and have longer production cycles with fewer shutdowns and startups due to maintenance issues. We have also been able to raise the upper limit of the level measurement, (which) has made our unit more efficient."

Herr Andreas
Busch-Ahlschläger I&C Engineer

In addition to seal failures, OXEA was having trouble with capillaries being damaged each time a new system was installed, causing further shutdowns and system replacements.

"We typically refill and restart the column every two to three weeks based on demand," said Busch Ahlschläger. "And we were able to meet customer demand in spite of the unscheduled shutdowns. But startups and shutdowns are expensive, and our operating costs were higher than they should be."

OXEA was also looking for a more accurate level measurement without the ambient temperature effects on long capillary runs, which were exacerbated by changes in seasons, to improve level control and reduce the cost of operation. The plant also wanted to reduce maintenance time and measurement system replacement costs.

SOLUTION

OXEA installed the Rosemount™ 3051S Electronic Remote Sensor (ERS)™ System with one diaphragm seal on the tank wall and one in-line sensor directly connected to the process. This solution eliminates all capillaries in the system, which significantly reduced maintenance costs, spares and measurement errors. The upper seal was eliminated from the harsh process by the in-line sensor, reducing installation costs as well as eliminating seal failures at that measurement point.

Capillary failures and measurement errors due to ambient temperature changes were completely eliminated with replacement of the upper seal and an electronic remote sensor placed on the lower measurement point. Mechanical improvements were made to the seal with a change in seal vendor (and therefore method of welding, material, etc.), and failures due to corrosion have been significantly reduced.

The Rosemount 3051S ERS System then relays the DP between the upper sensor and lower sensor to the DCS to determine the level within the tank. The Rosemount 3051S ERS System performed at a higher accuracy with much higher reliability than the traditional balanced-design system.

"This solution was much easier to install," said Herr Busch-Ahlschläger. "It is much easier to maintain, and does not require a complete system replacement when one component, like the seal, needs to be replaced. And when the upper sensor needs to be replaced (due to the highly corrosive environment), we don't have to shut down the column."

Installation time is reduced, ongoing maintenance is significantly reduced, replacement costs are much lower (the whole system does not need to be replaced), spare parts are reduced, and distillation unit operating costs are significantly lower.

The Rosemount 3051ERS System improves both accuracy and reliability of the level measurement on the distillation column, while cutting response time by 90%.

Measurement Instrumentation

The broadest range of measurement and analytical technologies for the chemical industry.

To learn more about Emerson's solutions for the chemical industry

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