Measurement Instrumentation for the Biotech and Pharmaceutical Industries

EMERSON™

Demand for pharmaceuticals and biotechnology products is on a continuous rise, fueled by factors such as emergence of scalable, personalized medicine, advancements in developing novel treatments, and the growing global population. The emphasis on personalized medicine is projected to drive significant growth between 2023 and 2030. Additionally, the growing global population has challenged life science manufacturers to expedite drug development and market release as seen by the approval of 71 novel treatments and vaccines in 2023 by the United States Food and Drug Administration (U.S. FDA) for various cancers and hard-to-treat diseases compared to only 45 approved in 2022. Moreover, many producers are expanding to new regions to mitigate risks associated with supply chain disruptions.

Whether the driver is speed, new market opportunities, or regionalizing production, these trends highlight the importance of integrating advanced measurement instrumentation to ensure quality, control costs, and improve operational efficiency while navigating the accelerating biotech and pharmaceutical industries.

This eBook examines various steps in the drug manufacturing process looking at the role instrumentation has in driving pipeline acceleration, flexible manufacturing, operational integrity, real-time release, and sustainable operations.

Drug Manufacturing Process

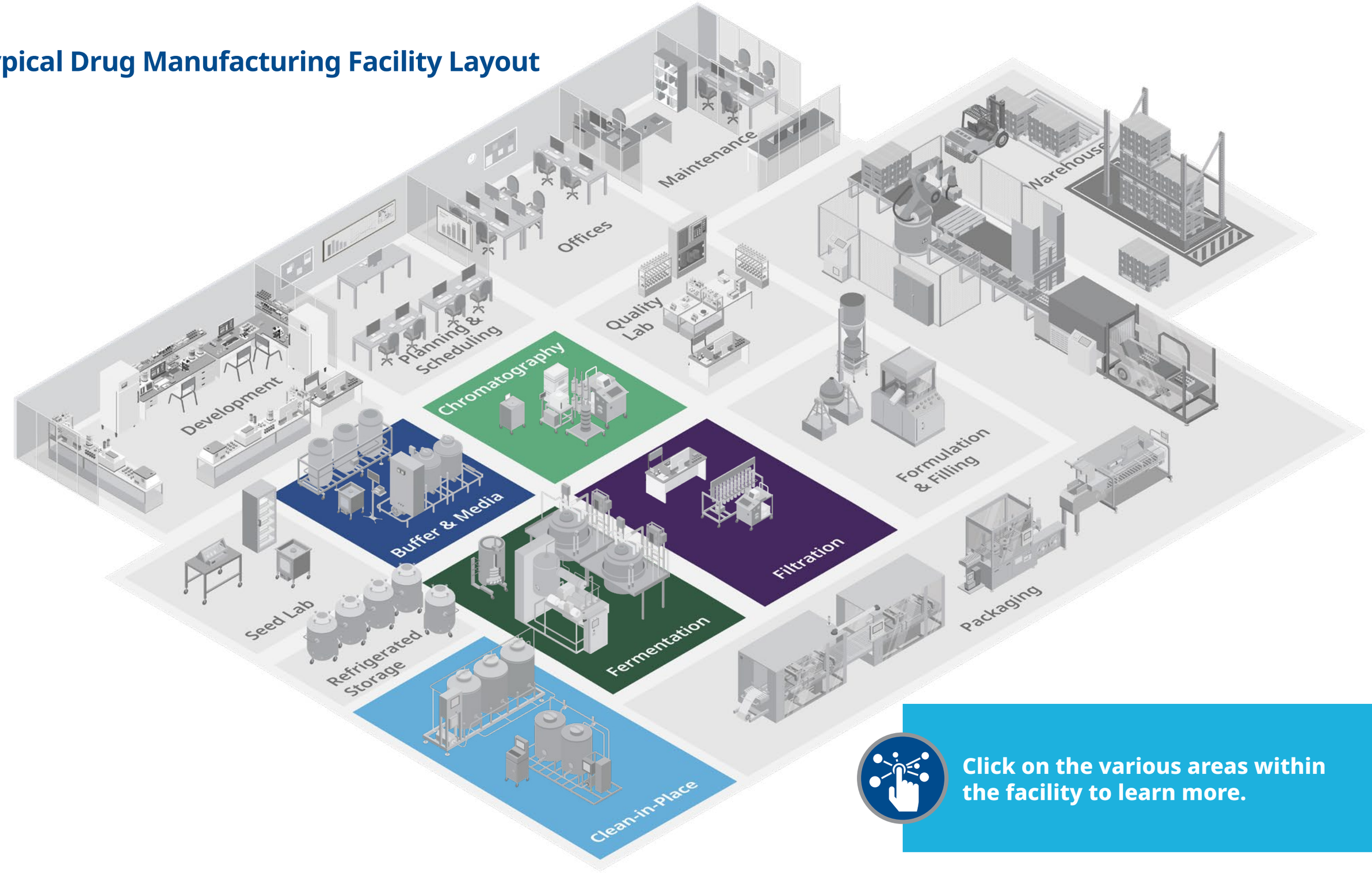
Life sciences products can be chemically synthesized drugs or very complex biopharmaceuticals. Biopharmaceuticals are typically made in smaller batches although continuous (bio)processing techniques are gaining favor because they deliver advantages related to speed, quality, and operational flexibility. Some of the processes are refinements of natural sources such as plant extracts, while others are complex biologicals produced though cell culture.

Biological drug manufacturing is generally classified as Upstream Processes (USP) and Downstream Processes (DSP). Manufacturers design their processes in a ballroom setup to use their fleet of bioreactors and vessels optimally, with sequences and schedules created and refined to minimize the amount of equipment changeover and setup time. With more flexibility also comes the need for rigorous control systems. Manufacturing campaigns are planned to follow this approach to maximize production by minimizing downtime. Whatever the specific process, manufacturing steps are outlined in highly detailed recipes following current good manufacturing practices (cGMP), and individually audited by the relevant regulatory authority, such as the U.S. FDA.

In addition to manufacturing, life sciences facilities typically have infrastructure that includes internal utilities to produce steam, compressed air, and water for injection (WFI), plus clean-in-place (CIP) and sterilize-in-place (SIP) systems for equipment sanitation.

During the chemistry, manufacturing, and controls (CMC) process the critical quality attributes (CQAs) are established which drive the critical process parameters (CPPs). Process variables must be specified in the critical process parameters (CPPs) to reflect practical tolerances and ensure on-spec batches. These CPPs follow the critical quality attributes (CQAs) established during the chemistry, manufacturing, and controls (CMC) process. Since the variety of variables measured can cover a wide range, it is important to select the right instruments with the appropriate accuracy and repeatability to gather the data of the CPPs. Temperature, pH, density, dissolved oxygen, level, and pressure are typical parameters that are critical for characterizing the process.

Typical Drug Manufacturing Facility Layout



Click on the various areas within the facility to learn more.

Industry Challenges

Life sciences manufacturing challenges include significant initial investment in product development, the difficulty of making modifications due to validation and expensive raw materials.

Required product development investments during CMC are significant, with many iterations typically required to create optimal formulations and recipes. Once product development is done at a small scale, it must be ramped up to pilot and then full production, and approaches that work on a small scale often must be modified for larger volumes, adding to costs.

As with any manufacturing process, modifications are often required to reach scale. This is particularly difficult for life sciences manufacturers because initial approaches are validated by regulators and process changes require extensive documentation, and in most cases, must be re-validated. Process Analytical Technology (PAT) initiatives can help ease this procedure, but it still is, and will remain, very difficult to change life sciences manufacturing processes.

Raw material sourcing presents another issue as many of these ingredients must be produced by life sciences manufacturers, adding to their cost. Careful handling of these raw materials is often also required, both in shipping, and in storage prior to use.

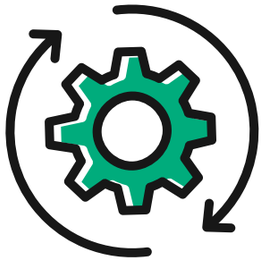
Industry Drivers

To address these and other challenges and to take advantage of emerging opportunities many life sciences manufacturers seek to make gains in five key areas: pipeline acceleration, flexible manufacturing, operational integrity, real-time release, and sustainable operations. These industry drivers are central to successful long-term market adaptation and are influenced in many ways by how and where measurement instrumentation is applied in the production processes.

The following sections of the eBook examine the role instrumentation has in media and buffer preparation, fermentation, chromatography, filtration, and utilities, as it relates to the pursuit of each of these five industry drivers.

Pipeline Acceleration

- **Faster** new product introductions / tech transfer
- **Flexible** processes and recipes
- **Modular** building blocks
- **Consolidated** lifecycle data

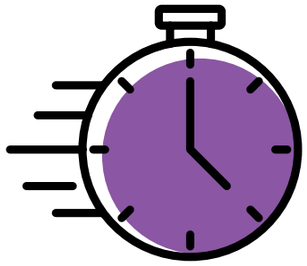


Flexible Manufacturing

- **Fast** change over
- **Seamless** orchestration of equipment, people, materials
- **Integrated** control strategy definition and execution

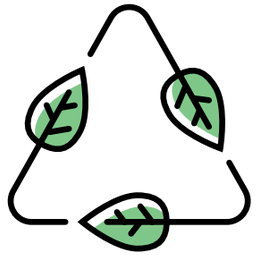
Operational Integrity

- **Shorter** production set-up
- **Reliable** equipment monitoring
- **Predictive** asset management
- **Adaptive** operator training
- **Optimized** facility scheduling



Real-Time Release

- **Consolidated** "control tower" views
- **Integrated** in-line testing
- **Live** exception resolution
- **Improved** quality attribute control
- **Easy** process analysis



Sustainable Operations

- **Reduced** waste
- **Optimized** energy usage
- **Improved** environmental responsibility

Buffer and Media Preparation

Just as reactor vessels and tanks provide the physical environment for manufacturing, media and buffer solutions provide the chemical environment to support growth (USP) and purification (DSP) steps through the pipeline, as well as operational integrity for more routine production. The ability to produce these solutions reliably provides the required flexible manufacturing capabilities as producers move from campaign to campaign.

Creating ideal conditions to promote cell growth and protein synthesis depends on providing an environment rich in nutrients to support target cell lines, with optimal culture pH and cellular osmotic pressure. Generally, media solutions contain a mix of carbohydrates, amino acids, vitamins, minerals, growth factors and hormones to sustain optimal growth. Buffers maintain the stability of pH and other attributes of the solution to ensure target protein stability, but they are often exchanged in preparation for the next purification step or to eliminate salinity from excess elution buffers in chromatography.

Within the full range of pharmaceutical manufacturing processes, media and buffer preparation tend to be at the preparative end of the spectrum, depending primarily on blending and mixing actions, rather than chemical reactions or fermentation. Nonetheless, they must deliver the required attributes, batch to batch. Typically, media and buffer vessels can contain between 50 to 20,000 liters. It is crucial to maintain quality across the full range of volumes.

Creating consistent solutions depends on controlling a wide range of variables, requiring many types of instrumentation:

- Mass flow meters to monitor the weight of ingredient components
- Mass flow meters for total amount of WFI
- Level for the overall volume
- Temperature of media/buffer solutions
- Pressure within the mixing vessel
- Mixing time with agitation speed
- pH verification and other liquid analytical checks at critical points in the mixing vessel

Buffer and Media Preparation

Micro Motion H-Series Hygienic Coriolis Flow and Density Meters with Micro Motion 5700 Field-Mount Transmitter

Micro Motion Hygienic G-Series Coriolis Flow and Density Meters with Micro Motion 1600 Compact Transmitter

Rosemount 3051 Electronic Remote Sensor (ERS) System

Rosemount 644 Temperature Transmitter

Rosemount 5408 Level Transmitter Non-Contacting Radar

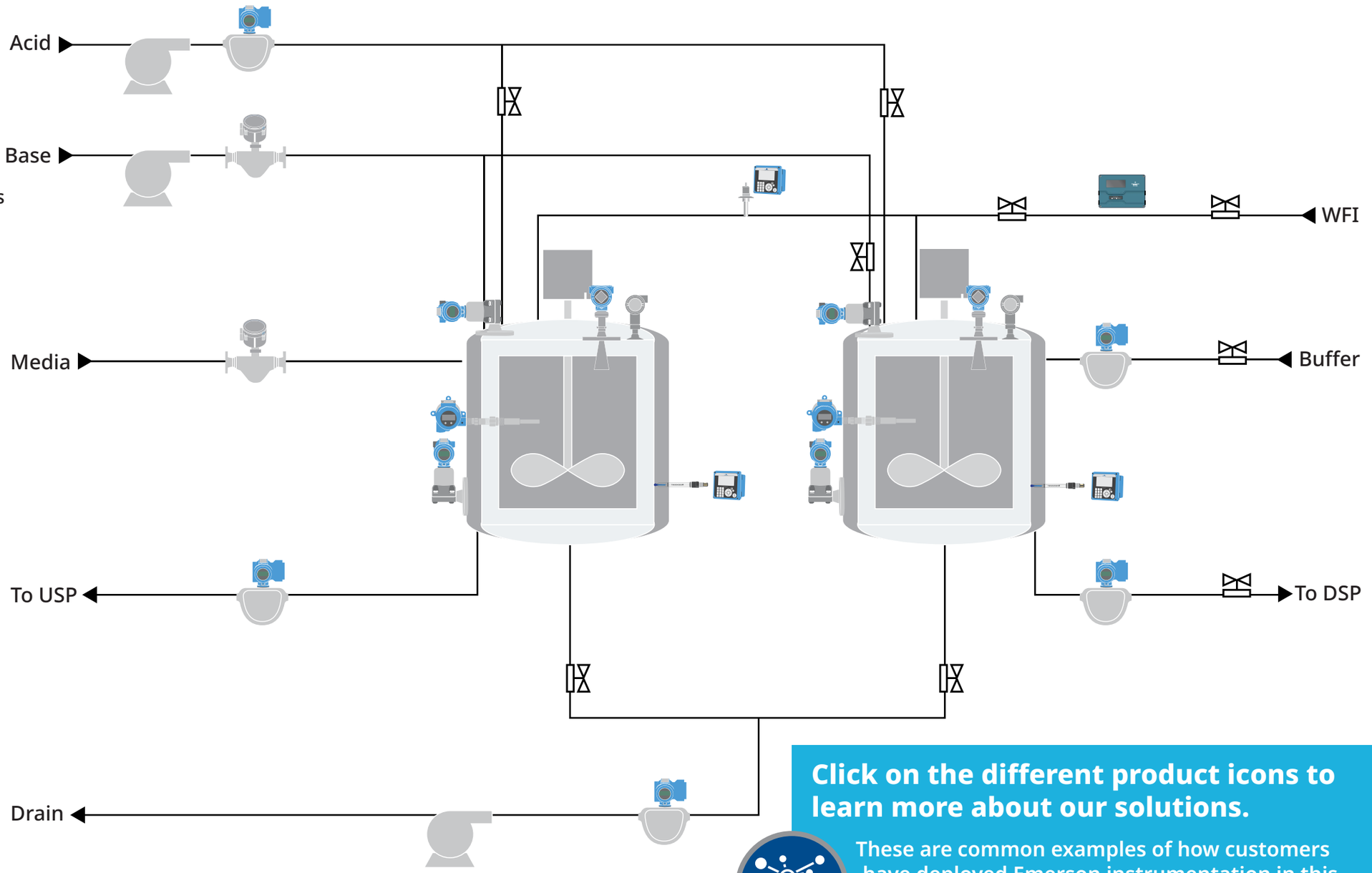
Rosemount 3051HT Pressure Transmitter

Flexim FLUXUS F731 Ultrasonic Flow Meters

Rosemount Hx338+ Steam Sterilizable & Autoclavable pH Sensor

Rosemount 1058 Dual Channel Transmitter

Rosemount 403 Conductivity Sensor



Click on the different product icons to learn more about our solutions.

These are common examples of how customers have deployed Emerson instrumentation in this application. Connect to an expert to learn more.

Fermentation

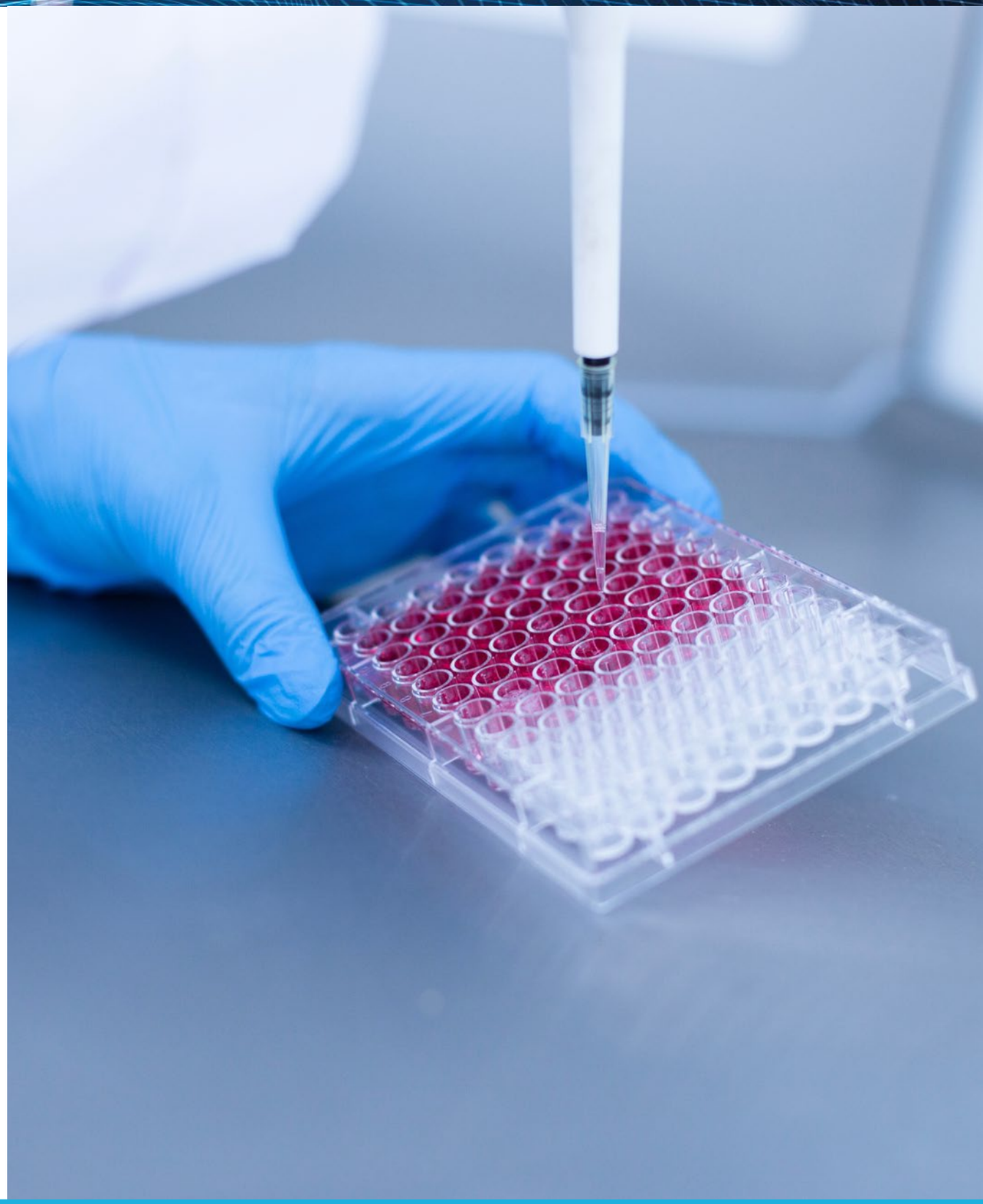
The effective use of a bioreactor as a pharmaceutical manufacturing technique has increased the range of new products enormously. Cell culture is now used to produce antibiotics, recombinant protein vaccines, and monoclonal antibodies and even nucleic acids such as mRNA. These capabilities have driven much faster development of new offerings in the pipeline, along with operational integrity built on sophisticated process control.

Enticing microorganisms to synthesize desirable endogenous molecules requires ideal conditions for the active cells to do their work, including temperature, pH, dissolved oxygen, and availability of nutrients.

The process measurement and devices used can be highly complex, requiring measurement and control of many crucial elements, including:

- Liquid analytics for pH, dissolved oxygen, trace minerals, etc.
- Air flow for nitrogen, oxygen, carbon dioxide, etc.
- Metabolite monitoring for glutamate, lactate, ammonium, etc.
- Total cell density (TCD) and viable cell density (VCD) monitoring
- Temperature, steam flow, pressure, density, mixing speed, and other process variable monitoring

Once the microbes have done their work, it is necessary to determine the best way to separate what has been produced, and to then purify the desired elements. This can require all manner of separation methods, including filtration, chromatography, and others as necessary to isolate the target protein.



Fermentation

Micro Motion H-Series Hygienic Coriolis Flow and Density Meters with Micro Motion 5700 Field-Mount Transmitter

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Rosemount 3051 Electronic Remote Sensor (ERS) System

Rosemount 8800 Series Vortex Flow Meters

Rosemount 644 Temperature Transmitter

Rosemount 5408 Level Transmitter Non-Contacting Radar

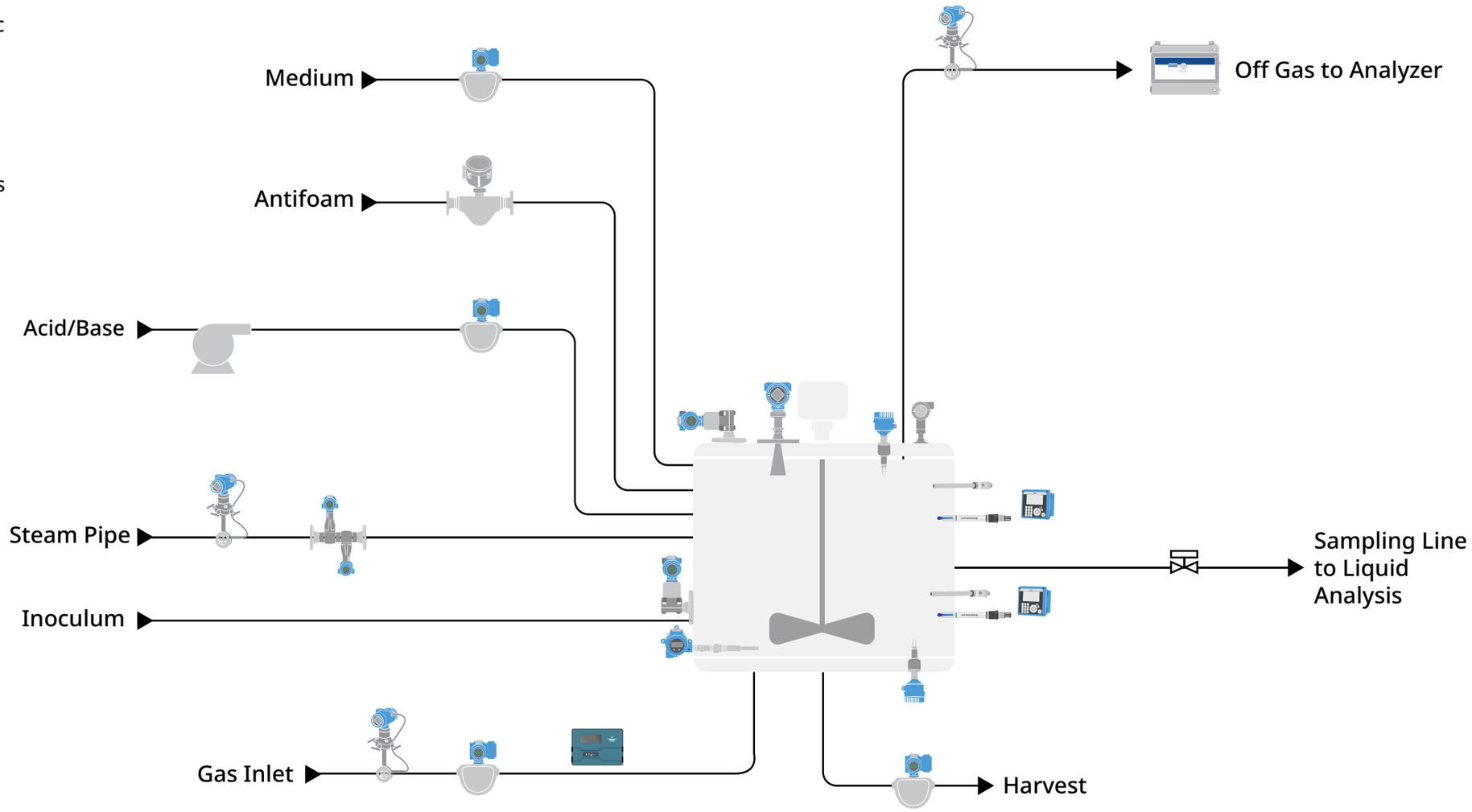
Rosemount 3051SFC Compact Orifice Flow Meter

Rosemount 2100 Series Vibrating Fork Liquid Level Switch

Rosemount 3051HT Pressure Transmitter

Flexim FLUXUS G731 CA Ultrasonic Flow Meters

Rosemount Hx438 Steam Sterilizable Dissolved Oxygen



Rosemount 403 Conductivity Sensor

Rosemount Hx338+ Steam Sterilizable & Autoclavable pH Sensor

Rosemount 1058 Dual Channel Transmitter

Rosemount™ X-STREAM Enhanced XEGP Continuous Gas Analyzer

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Chromatography

Biological molecules of interest are created through protein synthesis along with all the normal proteins and organelles typically found in cells. In some cases, these byproducts may be useful in other applications, or they may be cell debris and considered contaminants. In either case, the target proteins must be liberated, separated and purified from the cell broth. Depending on the physical properties of the specific molecular entities, chromatographic methods offer a range of possibilities: :

- Ion exchange based on charge or the isoelectric points of proteins
- Gel permeation, gel filtration, size exclusion, or molecular sieve based on molecular size
- Affinity, based on a specific binding interaction between an immobilized ligand and its binding partner
- Mixed mode chromatography using both hydrophobic interactions as well as electrostatic charge

Effective chromatographic separation depends on controlling a wide range of variables, requiring many types of measurements:

- Mass flow to monitor product, buffer, alkali, and water for injection (WFI) flows
- Conductivity to verify changes in salinity of the elution buffer
- Spectroscopic detection of molecules coming off the column
- Temperature of solutions
- Pressure within the separation columns
- Mass flow of final product streams
- pH verification and other liquid analytical checks at critical points throughout the unit
- And others, depending on the exact nature of the process

Chromatography

Micro Motion H-Series Hygienic Coriolis Flow and Density Meters with Micro Motion 5700 Field-Mount Transmitter

Micro Motion Hygienic G-Series Coriolis Flow and Density Meters with Micro Motion 1600 Compact Transmitter

Rosemount 3051SFC Compact Orifice Flow Meter

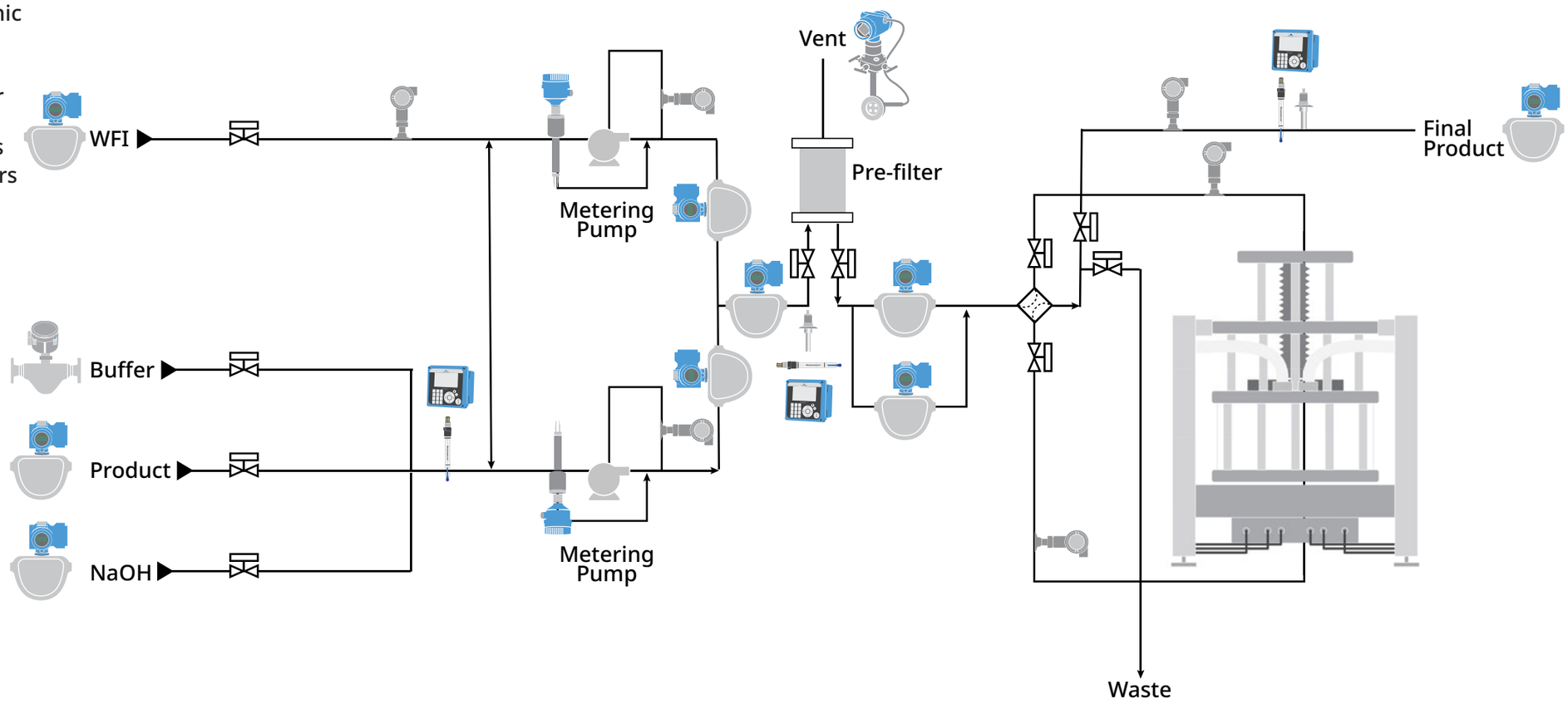
Rosemount 2100 Series Vibrating Fork Liquid Level Switch

Rosemount 3051HT Pressure Transmitter

Rosemount Hx338+ Steam Sterilizable & Autoclavable pH Sensor

Rosemount 403 Conductivity Sensor

Rosemount 1058 Dual Channel Transmitter



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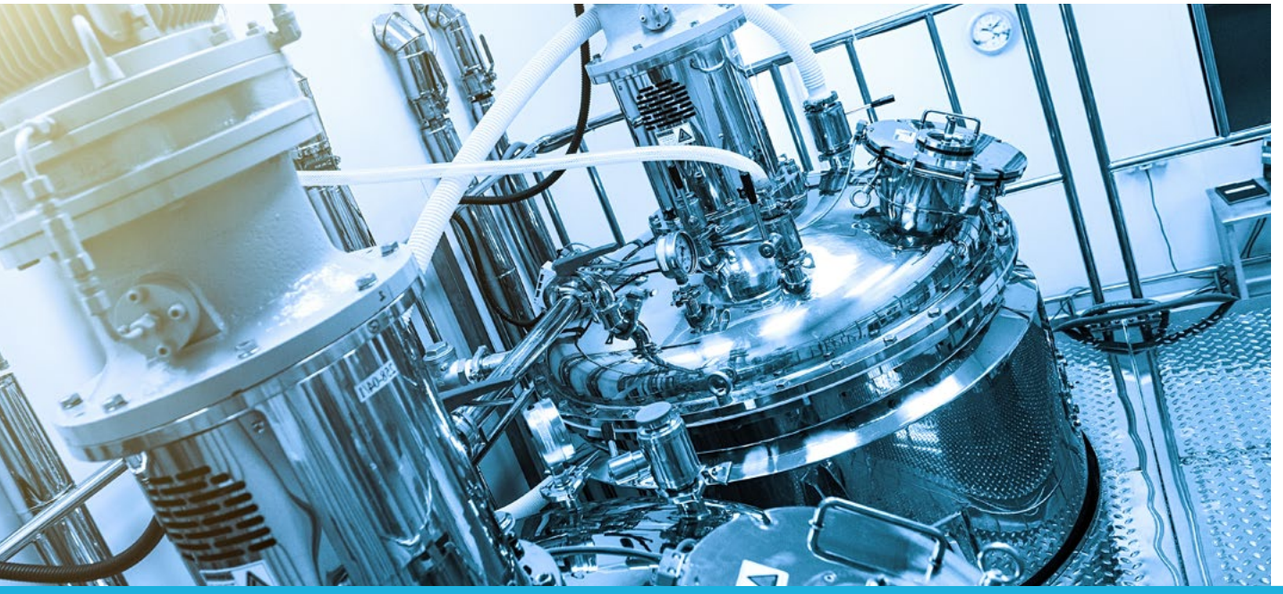
Filtration

Filtration has a strong presence in various parts of the DSP manufacturing of biopharmaceutical drugs. There are two main membrane filtration modes which can use either microfiltration or ultrafiltration membranes. Direct flow filtration (DFF), also known as dead-end filtration, is a traditional method for removing solid contaminants from a liquid product. DFF applies the feed stream perpendicular to the membrane face and attempts to pass the entire volume of liquid through the membrane.

Tangential flow filtration (TFF), also known as crossflow filtration, orients the feed stream in such a way that it passes parallel to the membrane face. When analyzing a TFF application, the filtrate or permeate is the liquid that passes through the filter, and the retentate is material that does not pass through. Usually this contains the target protein, and the ultrafiltration membrane is selected to not allow these proteins to pass through, but when using microfiltration membranes, fractions of dilute protein mixtures can also be separated from one another.



The uses of DFF are:

- Clarification of cell broth through depth filtration
- Bioburden reduction between different DSP steps to enhance performance (0.45µm)
- Viral filtration when using nanofiltration membranes ranging from 0.1µm to 0.001µm
- Sterile filtration using sterilizing grade membranes rated at 0.2µm

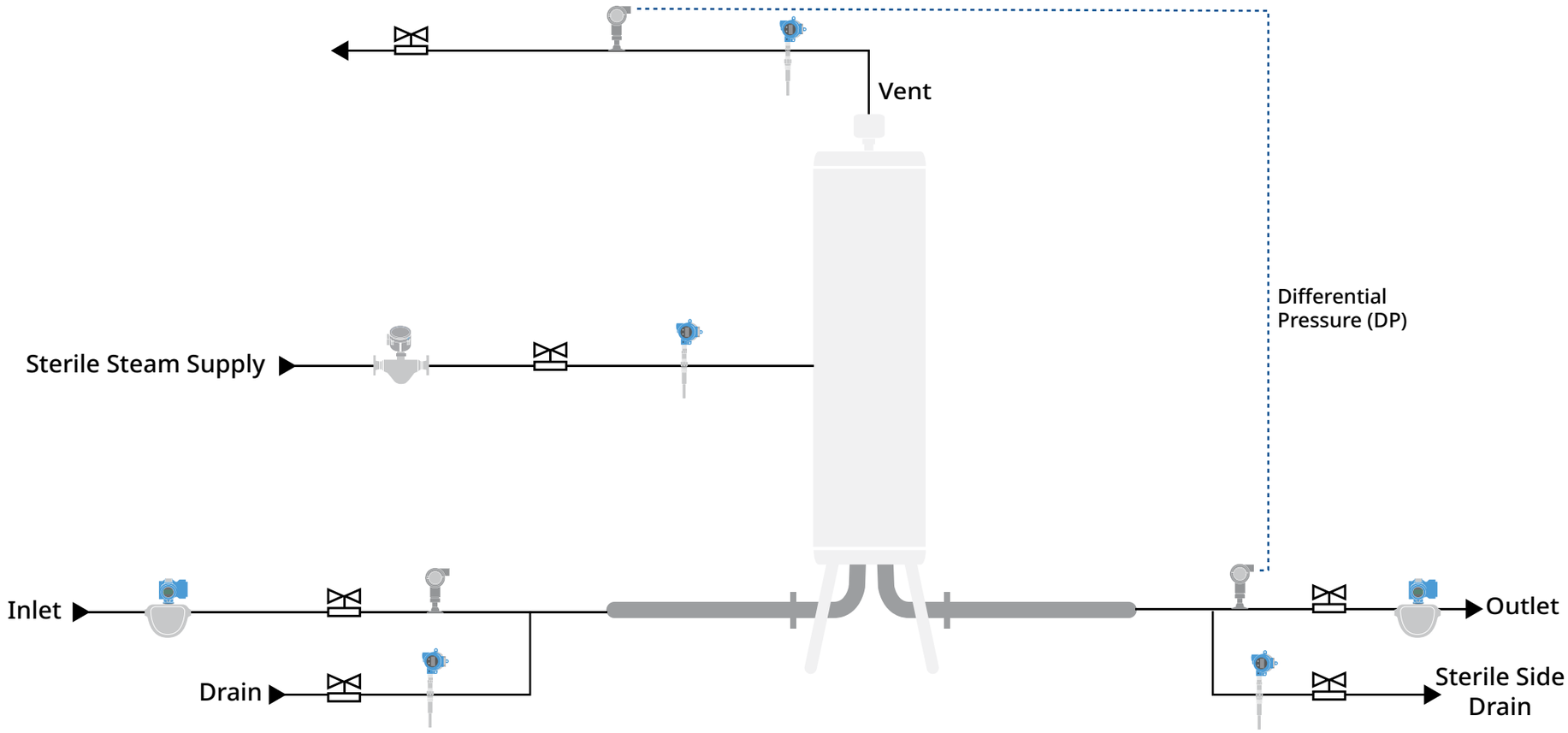
The uses of TFF are:

- Diafiltration or buffer exchange to eliminate certain buffers or prepare the cell culture broth for next DSP steps
- Concentrating and desalinating after certain DSP steps
- Depyrogenating of water, buffers and media solutions
- Concentrating prior to chromatography to increase performance or prior to formulation and filling

Whatever the approach, effective filtration depends on controlling multiple variables:

- Flow rate determined by differential pressure (DP) for DFF and transmembrane pressure (TMP) for TFF
- Tank conditions, including solution pH, conductivity, temperature, level, and agitation
- Solution turbidity and overall product concentration

Direct Flow Filtration



Micro Motion H-Series Hygienic Coriolis Flow and Density Meters with Micro Motion 5700 Field-Mount Transmitter

Micro Motion Hygienic G-Series Coriolis Flow and Density Meters with Micro Motion 1600 Compact Transmitter

Rosemount 644 Temperature Transmitter

Rosemount 3051HT Pressure Transmitter

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Tangential Flow Filtration

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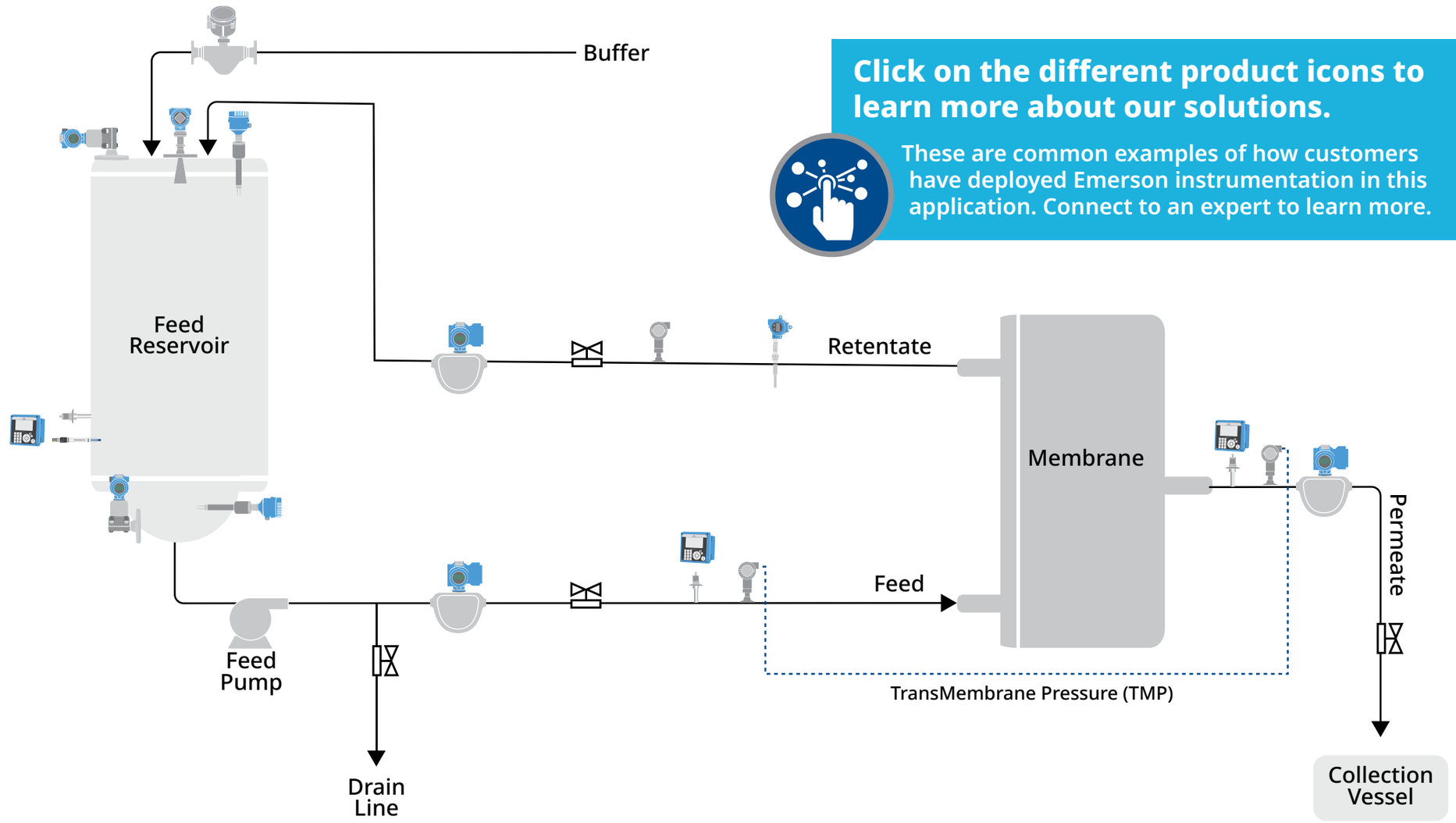
Rosemount 2100 Series Vibrating Fork Liquid Level Switch

Rosemount 3051HT Pressure Transmitter

Rosemount Hx338+ Steam Sterilizable & Autoclavable pH Sensor

Rosemount 1058 Dual Channel Transmitter

Rosemount 403 Conductivity Sensor



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Clean-in-Place

Life sciences facilities depend on the same utilities that most process manufacturers require, such as compressed air and steam. However, life sciences facilities have a longer list of utilities and require a higher degree of regulatory compliance, and hence sophistication. For life sciences manufacturers, regulatory compliance can extend beyond products to utilities, because in some cases these utilities may directly affect production quality, as described below.

For example, steam systems in life sciences plants are used for SIP applications, so the temperature must be maintained above a suitable threshold for a certain amount of time in order to validate the SIP cycle. Similarly, there are situations where compressed air may come into contact with products and must therefore be sterile, requiring extensive filtration to remove any potential pathogens and oil residue. While it may be desirable to treat the entire distribution system this way, it may be more practical to include additional filtration at critical process points.

WFI is a component of most life sciences manufacturing processes, and some cleaning operations. Small facilities might buy WFI from an outside supplier, but most have internal production capabilities. These WFI systems use either a distillation or reverse osmosis process, combined with sterile filtration to remove most mineral content, bioburden, pyrogens and potential pathogens.

CIP and SIP systems are used on a daily basis in most facilities. For decades now, automated cleaning processes have been validated when applied to equipment designed for this method. Systems are installed in most facilities, either fixed or mobile, to handle production equipment.

There is often a wide range of scales in terms of piping systems and vessel sizes, so cleaning systems must be designed accordingly.

Generally, CIP systems follow a sequence of alkali (base) cleaner followed by an acid rinse, and then water to neutralize the equipment for the next campaign. Validation calls for verifying flow rates necessary to create sufficient turbulence, along with spray projection from tank washing nozzles to cover all interior surfaces as required.

These steps must be combined with temperature readings and liquid analytics, normally conductivity, to show that all solutions have sufficient heat and chemical concentration to perform the required decontamination. Validation may also require swab tests of biological indicator strips to prove compliance.

Ensuring the efficacy of CIP processes for a biomanufacturing facility requires precise measurement and control. Without the right systems in place, managing the sequencing of pipes and vessels for cleaning while optimizing production can become a scheduling challenge.

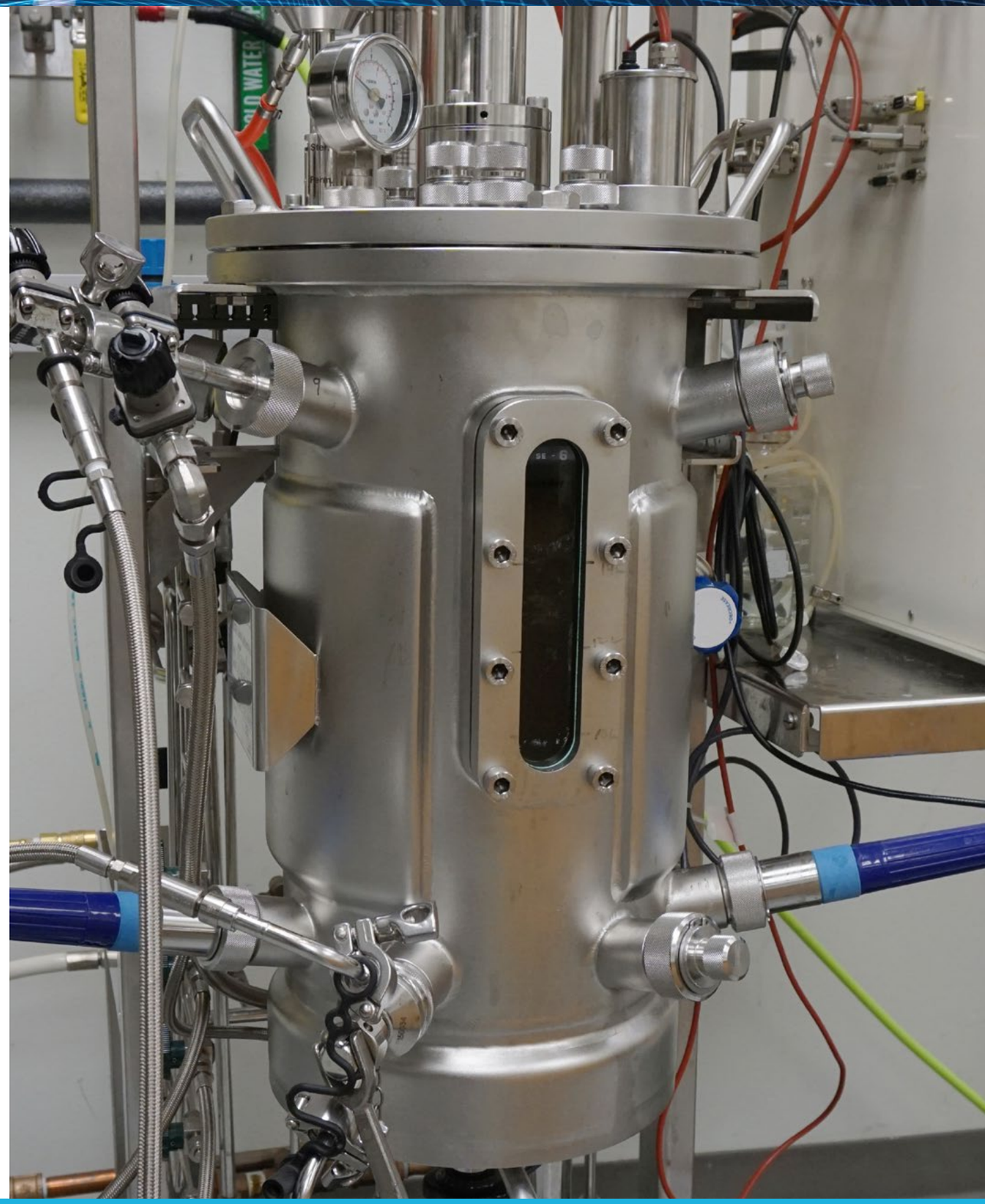
Effective CIP sequences require two groups of instruments supporting the cleaning processes. The first group measures the mechanical action of the solutions:

- Flow meters to ensure sufficient liquid velocity in the piping to generate turbulence, while covering all surfaces and displacing air
- Pressure transmitters at strategic points to verify cleaning action, along with sufficient pressure to drive tank cleaning nozzles and spray balls
- Tank level transmitters to ensure sufficient quantities of each solution
- Temperature sensors to validate required sterilization

The second group measures chemical composition of the solutions:

- Conductivity to verify acidity and alkalinity of cleaning solutions
- Depending on the nature of the contaminants, turbidity monitoring may be necessary
- Conductivity or pH to verify neutrality of final rinsing solutions

Emerson's intelligent devices and control systems provide a regulatory-compliant solution that increases efficiency and improves safety by reducing cross-contamination, while offering greater assurance of product quality.



Clean-in-Place

Rosemount 8721
Hygienic Magnetic Flow Meter

Micro Motion Hygienic G-Series
Coriolis Flow and Density Meters
with Micro Motion 1600
Compact Transmitter

Rosemount 3051 Electronic
Remote Sensor (ERS) System

Rosemount 644
Temperature Transmitter

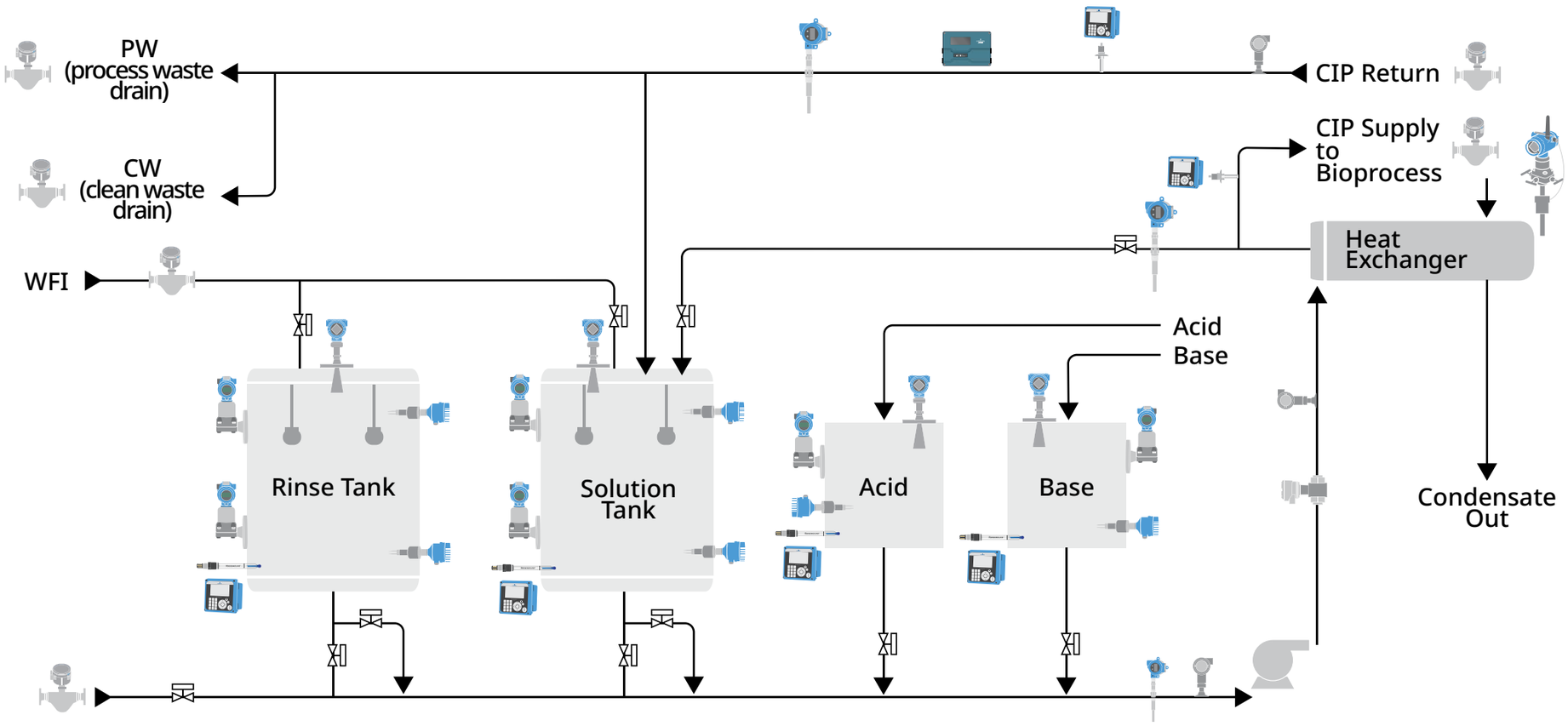
Rosemount 5408
Level Transmitter
Non-Contacting Radar

Rosemount 3051SFA
Annubar Flow Meter

Rosemount 2100 Series
Vibrating Fork
Liquid Level Switch

Rosemount 3051HT
Pressure Transmitter

Flexim FLUXUS F731
Ultrasonic Flow Meters



Rosemount Hx338+ Steam
Sterilizable & Autoclavable
pH Sensor

Rosemount 1058
Dual Channel Transmitter

Rosemount 403
Conductivity Sensor

Click on the different product icons to learn more about our solutions.

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Digital Transformation

Digital transformation in life sciences is no longer a “nice to have” but a “need to have.” With the pace of new drug development, the speed to market increasing, and large volumes as well as personalized medicine, and everything in between, digitization is critical to success. BioPhorum’s Digital Plant Maturity Model is one well known industry assessment tool to evaluate the current state of a facility’s digital maturity and establish a potential roadmap to meet future goals (Figure 1).

Returning to the five critical industry drivers:

- Pipeline acceleration
- Flexible manufacturing
- Operational integrity
- Real-time release
- Sustainable operations

These all depend on sophisticated instrumentation, smart devices, and up-to-date control systems. Emerson’s comprehensive solutions can help life sciences producers at any level navigate their digital transformation journey, while staying competitive along the way. Our digital ecosystem enables cloud integration of diverse operational systems at scale, and it allows devices to become part of smart database systems, and our advanced technology helps engineers and operators visualize issues ahead of time. Wherever your company is in its digital transformation journey, Emerson’s expertise can help increase efficiency and profits.

FIVE LEVELS OF DIGITAL PLANT MATURITY MODEL

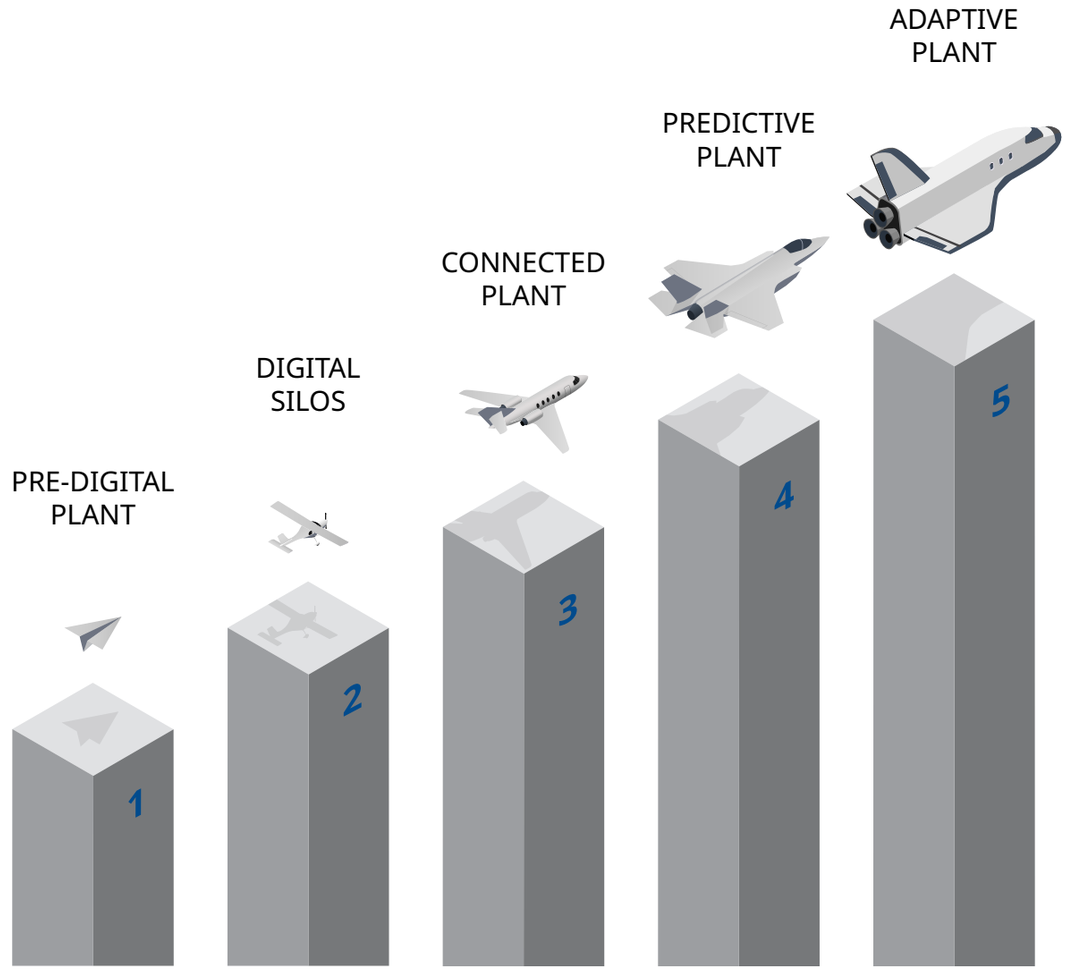

FIGURE 1

Digitization is changing the way life sciences manufacturers measure success.

Your Life Sciences Instrumentation Partner

Global infrastructure

Since life sciences manufacturers can be anywhere in the world, and many have facilities located in multiple countries, an instrumentation and automation partner must be able to service users on any continent and time zone. Emerson has engineering and manufacturing offices throughout the world, allowing it to support customers with a high degree of responsiveness and expertise, regardless of their location.

Proven products and technologies

Emerson also has the widest range of process instrumentation of any manufacturer, for the measurement of many process variables, including but not limited to flow, pressure, level, temperature, and others.

This expansive offering means that life sciences manufacturers can rely on Emerson to fill all their instrumentation needs, simplifying selection, purchasing, stocking, installation, and maintenance. Compatibility is also eased, both when connecting to instrumentation networks, and to host systems, such as those used for control and monitoring or asset management.

Decades of experience

Emerson has the life sciences industry experience needed to handle the most challenging applications, and it continues to learn more about the industry, while developing new technologies dedicated to the needs of the life sciences manufacturers.

Flow Measurement

Micro Motion™ H-Series Hygienic Coriolis Flow and Density Meters with Micro Motion™ 5700 Field-Mount Transmitter

- Ensure product consistency and quality with superior density measurement
- Enable fast product change-over with self-draining design and superior temperature stability
- Choose from options including highly polished 316L stainless steel with a surface finish up to 15 Ra
- Capture valuable process data with the 5700 on board data historian

Micro Motion™ Hygienic G-Series Coriolis Flow and Density Meters with Micro Motion™ 1600 Compact Transmitter

- Ultra-compact, lightweight sensor design enables installation flexibility
- Easy installation, integration, and remote monitoring with trusted Micro Motion electronics and advanced diagnostics
- Power over Ethernet reduces wiring complexity with the 1600 Transmitter
- Cleanable, self-draining design
- Laser-etched tagging for sterile applications and longevity in demanding environments

Rosemount™ 8721 Hygienic Magnetic Flow Meter

- All-welded meter body for hygienic and reliable performance
- Contact surfaces are constructed of FDA-approved materials designed in accordance with 3A standards
- Available with a variety of sanitary process connections with easily accessed process gaskets to facilitate efficient inspection and maintenance

Flexim FLUXUS® F731 Ultrasonic Flow Meters

- Non-intrusive flow measurement without touching the medium
- 1% accuracy for liquid flow with 0.15% repeatability
- Perfectly suitable for ultra-pure media and non-critical applications
- Standard temperature range up to 130°C – SIP safe

Flow Measurement

Rosemount™ 8800 Series Vortex Flow Meters

- Complete 316 SST wetted material
- Multivariable option with integrated temperature sensor to compensate for changes in steam density
- SIL-rated and single, dual and quad meter configurations for critical measurements
- All-welded, no crevice and gasketfree design avoids clogging or particulate build-up
- Isolated sensor prevents process contamination

Rosemount™ 3051SFC Compact Orifice Flow Meter

- Built with either a compact orifice plate, a patented 4-hole conditioning plate, this flow meter provides measurements for process control and general purpose monitoring
- Perfect for tight piping arrangements or skid mounted applications
- Available in line sizes up to 12 in. (300 mm), this flow meter is designed for gas, liquid and steam service and operates well in harsh process conditions
- Offered with multiple communication protocols including *Wireless*HART® which allows 100% battery operated measurement

Rosemount™ 3051SFA Annubar™ Flow Meter

- Superior measurement accuracy over a wide flow range
- T-shape Annubar design features very low permanent pressure loss
- SIL 2/3 certified to IEC 61508
- Arrives fully configured, leak-tested and ready to install right out of the box for fast installation

Flexim FLUXUS® G731 CA Ultrasonic Flow Meters

- Non-intrusive flow measurement without touching the medium
- 2% accuracy for gas flow with 0.15% repeatability
- Perfectly suitable for pure air and gases and non-critical applications
- Very high turndown ration enables leak monitoring

Level Measurement

Rosemount™ 5408 Level Transmitter Non-Contacting Radar

- Robust, reliable measurement with 26 GHz FMCW Fast Sweep Technology and advanced echo logics
- Unaffected by changing process conditions for trouble-free operations
- Unique data historian with 7-day echo curve and alerts
- Signal quality metrics for predictive maintenance

Rosemount™ 2100 Series Vibrating Fork Liquid Level Switch

- Flexible measurement: Top or side mounted with choice of switch outputs
- No moving parts, needs no calibration and virtually unaffected by changing process conditions
- Fast drip fork design to ensure cleanability
- Selectable switch delay prevents false trips in turbulent applications
- Visible Heartbeat LED shows device status, magnetic test point for simple functional test

Rosemount™ 3051 Electronic Remote Sensor (ERS) System

- Best-in-class performance and measurement with 15-year stability
- Flexible digital DP architecture eliminates impulse piping and mechanical repeaters for higher reliability and accuracy, up to <0.5%
- Uses a single two-wire 4-20 mA loop with pre-programmed and synchronized DP calculation
- Up to 5 times faster response time than traditional systems
- SIL 2/3 certified to IEC 61508

Liquid Analysis Measurement

Rosemount™ 403 Conductivity Sensor

- Available with 1-1/2” and 2” sanitary flange connections
- USP Class VI and 21CRF177 Compliance for all wetted plastics and elastomers
- All wetted surfaces have a 16 microinch (0.4 micrometer) Ra finish
- Steam sterilizable up to 275°F (135°C)

Rosemount™ Hx438 Steam Sterilizable Dissolved Oxygen

- Tolerates repeated steam sterilization
- Sensor response practically independent of flow
- Fast response time
- Capitalizes on industry-standard PG13.5 process connection

Rosemount™ Hx338+ Steam Sterilizable & Autoclavable pH Sensor

- Protection against batch cross-contamination with pre-pressurized reference
- Measures accurately after many SIP cycles at 286°F (140°C)
- Installs easily with quick disconnects from cable-to-sensor
- Requires minimal servicing and maintenance

Rosemount™ 1058 Dual Channel Transmitter

- Each sensor channel is independently configurable to support a wide selection of digital or analog liquid analysis sensors
- Predictive pH sensor health diagnostics let you know when your pH sensor is nearing the end of its life
- IP66/Type 4X rated engineered polymer enclosure with universal mounting options provides confident and easy installation indoors or outdoors

Pressure and Temperature Measurement

Rosemount™ 3051HT Pressure Transmitter

- Best in class reference accuracy is .065% of span
- Up to 7-year stability ensures the Rosemount 3051HT delivers precise and repeatable pressure measurements in tough applications
- Batch-to-batch repeatability tested to ensure pressure measurements will stay within specification even after being subjected to routine, high temperature cleanings
- Multiple industry certifications available to ensure quality and application reliability

Rosemount™ 644 Temperature Transmitter

- Achieve highly accurate temperature measurements by utilizing transmitter-sensor matching
- Prevent inaccurate readings or loss of measurement through customizable advanced diagnostics and dual sensor functionality
- Available in a variety of housing material options suitable for use in many different applications

Gas Analysis Measurement

Rosemount™ X-STREAM Enhanced XEGP Continuous Gas Analyzer

- CO_2 gas purity measurement with a full range of 0-100% CO_2 and a suppressed range of 98-100% CO_2
- Measures up to five components simultaneously in various combinations such as NDIR/UV photometer, paramagnetic and electrochemical O_2, thermal conductivity, and moisture sensors
- Response time (T90) is <30 seconds from zero to span or sample

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