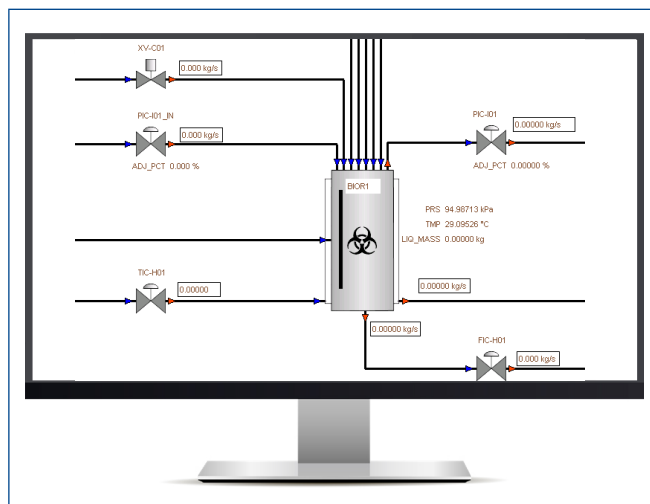


# DeltaV™ Mimic Process – Bioreactor

- Intuitive unit operation modeling
- Supports continuous, batch, semi-batch or any combination of reactor modes
- Accelerates control system testing, operator training, and technology transfer
- Matches product development lab data to the reaction kinetics
- Delivers analytical data through virtual experimentation to aid in process discovery and repeatability



## Introduction

DeltaV™ Mimic Process – Bioreactor is a rigorous first-principles, dynamic model of a bioreactor or fermenter designed for high-performance simulations for operator training, automation system testing, and operations and process improvement.

## Benefits

- **Intuitive unit operation modeling** – Mimic Process – Bioreactor comes with modeling infrastructure that makes the development of accurate models quick and easy. The default setup of the model is for the most sophisticated case of a bioreactor with mammalian cell cultures used today for most new biologics (highly complex proteins), but the equation parameters can be adjusted to model fermenters that use yeast cells (ethanol), fungal cells (antibiotics), and bacterial cells (simpler proteins).
- **Supports continuous, batch, semi-batch, or any combination of reactor modes** – Mimic Process – Bioreactor provides a dynamic model of a batch bioreactor or fermenter with or without an agitator and sparge and can also model continuous biological reactions including startup and shutdown. Reactor materials and heat transfer are completely configurable, supporting the use of single-use, glass, or stainless steel vessels.
- **Accelerates control system testing, operator training, and technology transfer** – Biological kinetics is orders of magnitude slower than chemical kinetics. Bioreactors and fermenter batches generally take days or weeks to complete. The use of speedup factors is an essential aspect of modeling these processes. Mimic Process – Bioreactor can run 1000 times real time so that a 10-day batch is completed in 15 minutes. Instead of waiting for days to see the effect of changes in operational, process, and control system conditions, the model provides complete batch profiles and scenarios in a matter of minutes.

- **Matches product development lab data to the reaction kinetics** – Many pharmaceutical manufacturers either have incomplete data or highly proprietary equations for kinetics. General purpose biological kinetic equations for the effect of operating conditions on cell growth rate and product formation rate enable the user to readily match existing profiles of cell and product formations without the use of proprietary kinetics.
- **Delivers analytical data through virtual experimentation to aid in process discovery and repeatability** – Besides testing configurations and training operators, Mimic Process can be used to do a design of experiments (DOE) and explore “what if” scenarios to track down the causes of variability. Process repeatability is a foremost concern for manufacturers in the beverage, food, and drug industries. If the bioreactor model matches the change with time of process inputs and process outputs, the model can be used to rapidly explore scenarios. By varying kinetic parameters, sequences, and setpoints, the correlations between process inputs and selected process outputs can be studied with data analytics. Principal component analysis (PCA) and Projection to Latent Structures (PLS) can be used to identify the major contributors to batch repeatability. These tools can potentially lead to the online diagnosis of bad batches.
- Dynamic media component mass balance calculation based upon feed streams, cell growth, reaction and utilization, mass transfer of dissolved gases, and evaporation or condensation.
- Dynamic mass transfer calculation for oxygen and carbon dioxide between bubbles, media, and cells, based upon concentrations, agitator, bioreactor pressure, and gas velocity, with optional user proprietary relationship overrides.
- Cell growth and product formation based upon Michaelis-Menten Kinetics with tunable rate factors and override factors for user proprietary data relationships or algorithms.
- pH and temperature kinetic effect based of the media and reaction to acid or base additions based upon the convenient cardinal model.
- Overlay stream inlet for inert gases injected in the vessel headspace for pressure control and to allow extraction of gas products. The Overlay gas vents through a vapor stream out.
- Sparge stream outlet with gas components from the Sparge dissolved and metabolized in the media or carried into the Overlay with exit on the vapor stream out.
- Agitation control for stirring the media with the appropriate effects for the mixing of the Sparge gasses and the principal reaction rate.
- Reaction speedup controls of 10 to 1000 times faster than real time.

## Product Description

DeltaV Mimic Process – Bioreactor was designed to help pinpoint operational, equipment, process, and control system problems, leading to a better understanding by operators and engineers.

The features designed for easy and effective use include:

- Dynamic mass balance calculation of cell culture media/ broth (liquid mass balance) based upon feed streams, drain streams, sparge, and evaporation and bubble effect.
- Dynamic mass balance calculation of Overhead (gas mass balance) based upon overlay stream, vent stream and evaporation and bubble from media effect.
- Dynamic energy balance calculation based upon media temperature, feed streams heat, cell metabolic heat, jacket heat transfer to bioreactor, and evaporation heat loss.

## Configuration

Mimic Process – Bioreactor is based upon the Vessel Process Object and incorporates the Bioreaction parameters as an extension of that object. Other unit operations, such as valves, pumps, or compressors, can be added to replicate the actual plant physical design.

In addition to flexibility in modeling of mammalian, yeast, fungal, and bacterial cells, options exists to interface external calculations of maximum specific growth rate or maximum specific product formation rate or any of the contributing individual rate factors associated with an operating condition (pH, temperature, inhibiting or limiting component concentrations). The model will predict the concentrations of dissolved gases, sugars (glucose), amino acids (glutamine), inducers, inhibitors (ammonia and

lactate), precursors, live cells, dead cells, and product in the broth of fermenters and the media of bioreactors.

Configuration parameters available for the Bioreactor allow the user to make the model function close to the actual plant bioreactor and include:

- Physical characteristics – dimensions, number of inlet and outlets, and elevations.
- Heat source type, characteristics, and links to heat instrumentation source tags in Mimic IO models.
- Agitator type, characteristics, and links to agitator control tags in Mimic IO models.
- Component set composition and kinetic effect of components.
- Kinetics parameters for each rate factor with user ability to override with proprietary data or algorithms.

### Online Kinetics Tuning

At the center of the Mimic Process – Bioreactor is the cell growth and product formation based upon Michaelis-Menten and Cardinal Kinetics. Factor contributors and environmental factors are tunable on-line, while the Bioreactor model is running, for each rate factor in the Kinetics tab of the BIOR Kinetics tuning window.

| Parameter   | MIN          | MAX           | OPTIMAL       | BIAS         | GAIN         | Calculated   |
|-------------|--------------|---------------|---------------|--------------|--------------|--------------|
| Temperature | 5.0000000000 | 45.0000000000 | 37.0000000000 | 0.0000000000 | 1.0000000000 | 0.9999999966 |
| pH          | 6.0000000000 | 8.0000000000  | 7.0000000000  | 0.0000000000 | 1.0000000000 | 0.9999976296 |

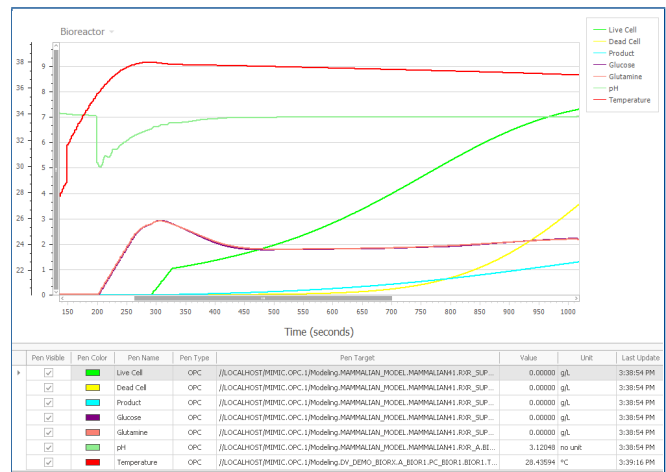
| Component    | INHIBIT        | LIMIT        | BIAS         | GAIN         | Inhibition   | Limitation   | Calculated   |
|--------------|----------------|--------------|--------------|--------------|--------------|--------------|--------------|
| OXYGEN       | 0.0200000000   | 0.0002000000 | 0.1500000000 | 1.0000000000 | 0.9084912678 | 0.9096970116 | 0.9764427965 |
| AMMONIA      | 0.1000000000   | 0.0000000000 | 0.0000000000 | 1.0000000000 | 0.917972673  | 1.0000000000 | 0.917972673  |
| LACTIC ACID  | 0.2000000000   | 0.0000000000 | 0.0000000000 | 1.0000000000 | 0.9249580015 | 1.0000000000 | 0.9249580015 |
| GLUCOSE_AQ   | 100.0000000000 | 0.2000000000 | 0.0000000000 | 1.0000000000 | 0.9802533458 | 0.9096838732 | 0.8917206604 |
| GLUTAMINE_AQ | 100.0000000000 | 0.2000000000 | 0.0000000000 | 1.0000000000 | 0.9797573605 | 0.9117421254 | 0.8932860680 |

Overall: 0.0132069370      Rate: 0.0698735037

Bioreactor Kinetics tuning window.

### Bioreactor View

The run time Bioreactor view provides real-time trends and profiles of the main reactor variables, delivering a deep insight into the object performance. The set of strip charts contains views for: inlet/outlet flow rates of the vessel, pressure/temperature and vapor fraction in the reactor, vapor and liquid holdup and composition changes, reaction rate constants and reaction rates, net production and consumption, cell growth, and reactor jacket and agitator performance (if applicable).



Bioreactor run time view.

### Product Support

Mimic Product Support is delivered through Guardian™. Guardian is Emerson's digital platform for addressing the end-to-end lifecycle needs of automation & control software and asset performance management solutions. The Guardian digital experience enables users to quickly connect to product support; securely manage subscriptions; get intuitive views into system health; and explore additional software and services that propel performance.

## Ordering Information

DeltaV Mimic is licensed on a Flexible Subscription Unit (FSU) basis. An FSU is a currency that can be used to access any Mimic feature licensed on an FSU basis, with each feature requiring its own number of FSUs. The FSU subscription is offered in one-year, three-year, and five-year terms. To purchase, extend, or expand a license, please contact your Emerson Sales Representative.

## Related Products

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- DeltaV Mimic Foundation
- DeltaV Mimic Test Bench
- DeltaV Mimic Train
- DeltaV Mimic Simulated I/O Drivers
- DeltaV Mimic Synchronize
- DeltaV Mimic Aspen HYSYS Link
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