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Products & CTDMO Services

Data Sheet

Bio4C ProcessPad™ Software

Visualizations, Analytics, and Process Monitoring for Data-Driven Decisions

Pharmaceutical and biopharmaceutical processes are complex and highly variable in nature. This can result in inconsistent and sometimes unpredictable process outcomes.

To manage complexity and better understand causes of variability, in-depth knowledge and thorough understanding of the process and the various factors affecting process performance are critical. This makes knowledge management and process monitoring an indispensable part of process improvement efforts for any drug manufacturer.

Bio4C ProcessPad™ software is a data collection, visualization, and analytics platform that enables bioprocess monitoring, lifecycle management, reporting, investigations, and continued process verification (CPV).

Intelligently combining process data from disparate data sources generated during batch execution into a single, contextual, integrated data source, Bio4C ProcessPad™ software ensures process information is current, complete, and accessible throughout the product lifecycle.

Dashboard

Batch Profiles

Events on Profiles

Key Benefits

- Intuitive browser-based interface
- Automatically aggregate data from various sources into a single source of validated, analysis-ready, data
- Enhanced process understanding with out-of-the-box data visualizations
- Streamlined regulatory reporting with automated and templated reports
- Improve process robustness and reduce the risk of batch failure with real-time MVDA process monitoring tunnel
- Seamless tech transfer from process development to large-scale GMP manufacturing
- Data is democratized for global teams, CMOs, and suppliers with ready access to data, analytics, and visualizations
- Automate and simplify CPV
- Designed to facilitate regulatory compliance and audit readiness

Access to an Aggregated and Contextualized Single Source of Data

Browser-based Access to all Process Data

- Intuitive and easy to learn and use
- Web-based platform means no software to download, install, update, or manage
- Provides access to straightforward analysis tools and visualizations to dispersed teams

Validated Source of Data

Aggregated, single source of validated data ensures data are current, complete, and contextual throughout the product lifecycle.

- Secure sharing of data, reports, and visualizations across global teams
- Common access to data between CMOs and sponsors for enhanced knowledge sharing and collaboration

Process Data Integration

Bio4C ProcessPad™ software's data connection tool can acquire, automatically assemble complex and multidimensional data into analysis-ready format, and analyze data from:

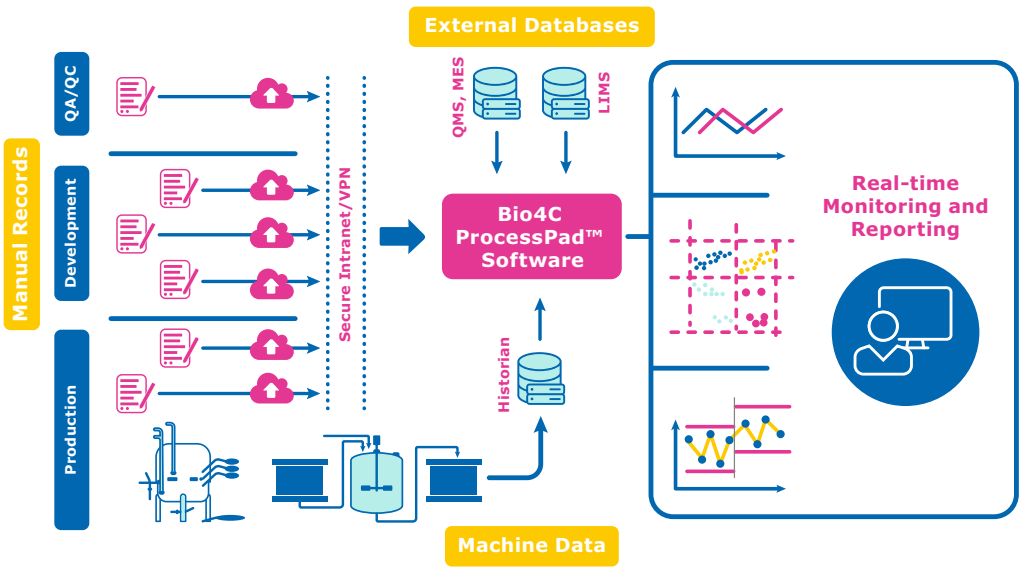
- Batch records
- Quality control results
- Any standard database such as SQL-Server, MySQL, and Oracle
- ERP (Enterprise Resource Planning software)
- MES (Manufacturing Execution System)
- QMS (Quality Management System)
- Data historians
- Paper-based, manual records
- Validated spreadsheets
- Third-party application's web-services

Data can be collected from manual paper records via Bio4C ProcessPad™ software's configurable web forms that are specifically designed to capture batch process or sample test data and various other kinds of data such as:

- Time-based observations
- End-point performance data
- Textual observations and events
- Qualitative batch attributes (e.g., column re-pack details, resin lot ID)
- Assay results
- Assay background (reference assay, calibration or system suitability details)
- Stability sample results
- Qualitative assay attributes (e.g., test instrument ID, internal reference lot ID)

While doing so, the assembly engine keeps intact the relationships that exist between batches, unit operations, and parameters. The data capture web form design is flexible to enable on-the-fly addition of any number of parameters by the system user without the need of any special IT skills and expertise.

Process Data Integration



Knowledge Management and Compliance

21 CFR Part 11

Bio4C ProcessPad™ software facilitates 21 CFR Part 11 compliance by meeting applicable requirements including unique usernames and passwords, timestamped audit trails, and secure storage of all records.

Aligned with 21 CFR Part 11, our software undergoes stringent internal validation and has a mature software development life cycle (SDLC) and quality software development practices.

Knowledge Management and Reporting

Using an aggregated and contextualized single source of truth for data, Bio4C ProcessPad™ software enables good record keeping and data management, simplifies knowledge transfer, supports reporting such as annual product quality reviews (APQR) and process summary reports, improves the quality of decision making on the plant floor and corrective and preventative action (CAPA) identification.

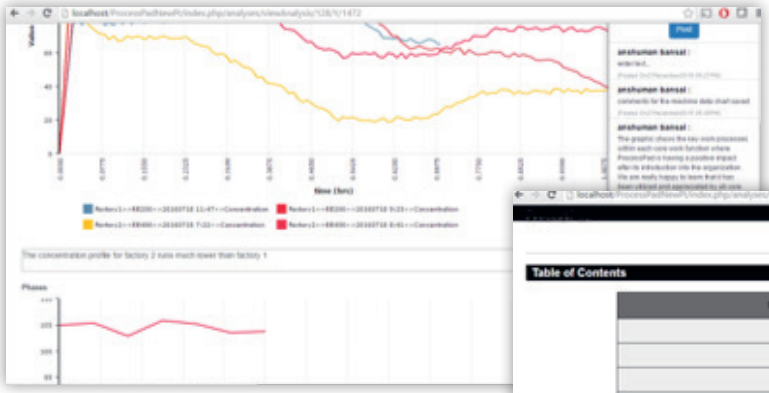
Reporting Capabilities

Standard Reporting

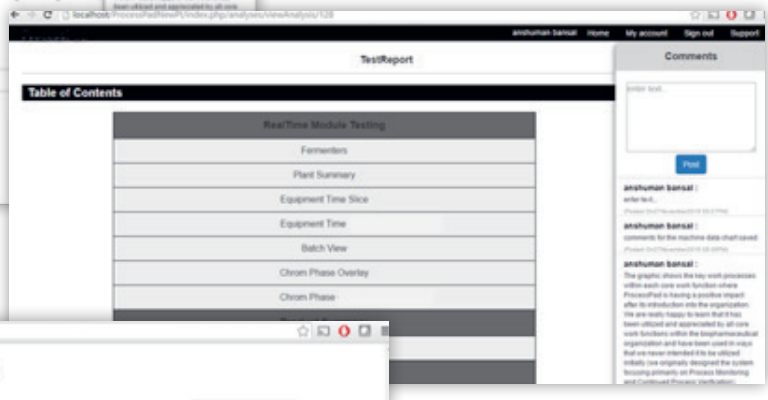
Scientists and process engineers can create and save templates for reports built with any of the data available in Bio4C ProcessPad™ software. Reports can be generated on-demand or scheduled on a daily, weekly, or monthly basis. They can easily be shared with relevant stakeholders. Some built-in, adaptable, report templates include:

- Process summary report
- Manufacturing campaign report
- Batch summary and run excursion reports
- Plant equipment utilization report
- Ad hoc reports in support of root cause analysis

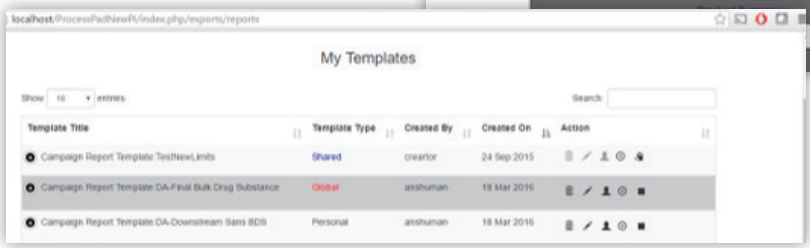
Collect Report Review Comments



Collect Notes & Analysis in a Single Report



Templates



Advanced Reporting

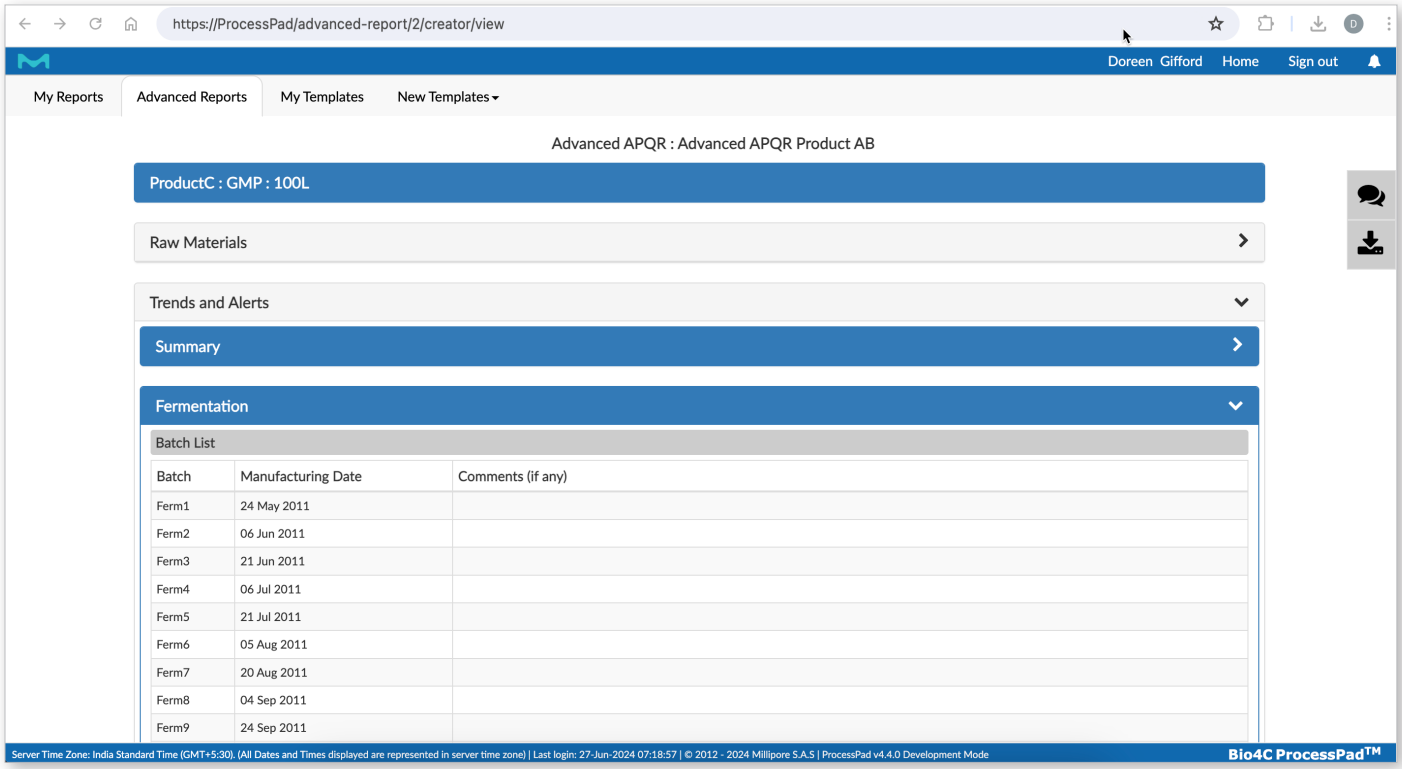
Bio4C ProcessPad™ software offers an Advanced Reporting Module for Continuous Process Verification (CPV) and Annual Product Quality Review (APQR) reporting workflows which provides an approval workflow, enables collaborative sharing of reports, and report customization. Data from real-time and offline modules can be integrated into a report which can then be collaboratively edited and sent to an approval workflow all within Bio4C ProcessPad™ software. By providing a complete solution for a CPV program and integrating it with an APQR program, Bio4C ProcessPad™ software frees resources from repetitive tasks and enhances overall productivity.

Bio4C ProcessPad™ software empowers users to generate detailed reports that include real-time monitoring data, historical trend analyses, and crucial compliance documentation. For CPV and APQR, Bio4C ProcessPad™ software streamlines reporting workflows, while adhering to regulatory standards. Bio4C ProcessPad™ software allows authorized users to customize the report template to their specific needs. Different data types (for example, a control chart or QC data) from multiple sources can be easily brought into the report template through export, text-rich editor, and import from the application itself. A unified approval workflow for CPV and APQR reports provided by Bio4C ProcessPad™ software enables collaborative editing and reviews. Throughout a report's review and approval process an audit trail is created and when approved, e-signatures are captured to facilitate compliance with 21 CFR Part 11. The approved document is available for QA audits or process improvement.

Report Sharing and Collaboration

Using Bio4C ProcessPad™ software, reports can be shared with the relevant people with a simple click. This immediate access to shared data sets is helpful for collaborations where only limited data sets need to be shared.

Global teams, CMOs and sponsors can easily share data and reports avoiding time-consuming manual efforts, errors, rework, potential supply chain and quality or compliance problems, and project delays.



Subsections Summary and Fermentation in the Trends and Alerts Section

Batch Data Analytics

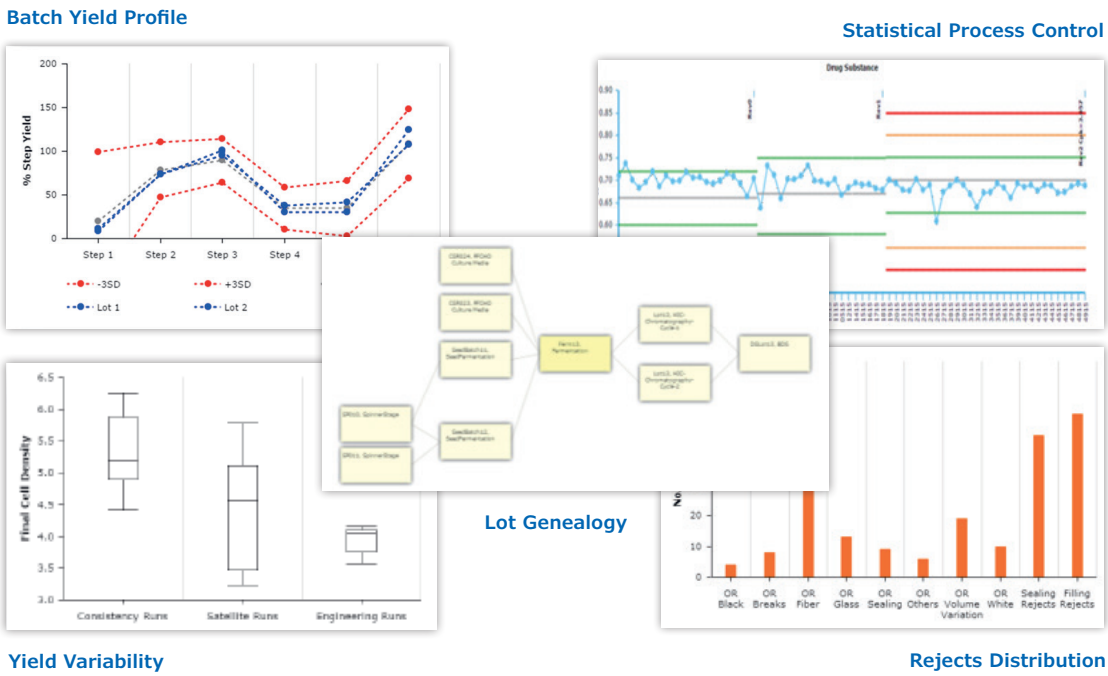
The batch data analytics in Bio4C ProcessPad™ software specifically cater to the analysis needs of batch manufacturing processes that involve quantitative (e.g., process parameters) as well as qualitative data (e.g., events and textual information). In the design of these visualizations, focus is given to displaying events and textual information related to a batch.

Analysis types

Lot Genealogy helps investigators instantly find feed/raw materials, intermediates, or finished products corresponding to a defective lot	Overlay intra and inter batch time series data to compare batch profiles within processing times
Align unit operations on a timeline to correlate execution time context with the process event under investigation	Perform correlations and regressions on process parameters for inter or intra unit operations
Trend batch data on control charts for statistical process control to better understand process variability and to perform CPV	For inter and intra products and process analyses, create ad hoc data groups to perform statistical comparison of groups to identify significant differences

These analysis types provide rich context and display in one window all the information required to draw useful conclusions about the process and the product. The browser-based, on-demand visualizations and analytics are easily accessible and essential for:

- Root cause investigations
- Process monitoring and trending
- Tracing and tracking of buffer/media and product batches
- Outlier batch detection
- Cell culture profiles comparison and trend analysis
- Process capability assessment



Multivariate Data Analysis (MVDA)

Bio4C ProcessPad™ software offers comprehensive MVDA capabilities, providing an effective way to monitor the performance of an ongoing process and enable proactive control measures in near real time. Through PCA, historical data can be used to build a Process Monitoring Tunnel that helps predict the future state of a batch with early fault detection, process improvement, and greater operational efficiency.

Principal Component Analysis (PCA)

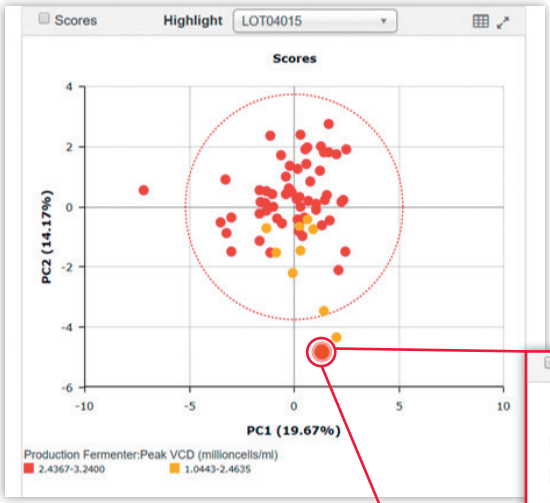
Bio4C ProcessPad™ software provides several applications for PCA analysis including PCA for outlier batch detection, and 2 types of process monitoring tunnels: a batch progression model, and a time series progression model.

Bio4C ProcessPad™ software's intuitive parameter selection and data pre-processing user interface (specifically programmed for the bioprocess industry) help you build PCA models with just a few clicks, considerably reducing the time from data to insights.

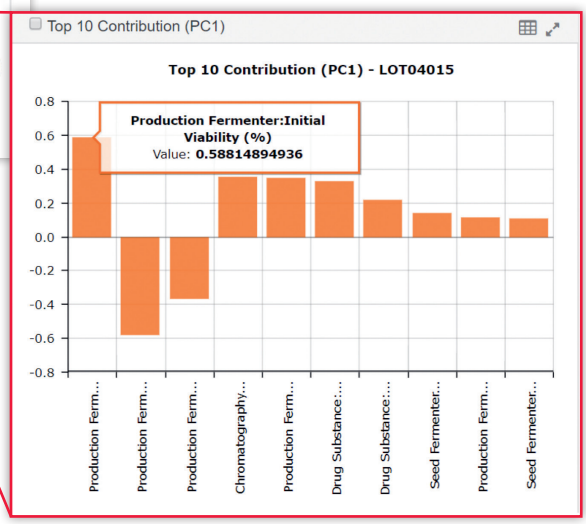
Bio4C ProcessPad™ software will automatically plot PCA charts including:

- **Scores Plot:** scores of the first two principal components (PC1 and PC2) and highlights the amount of variation each principal component captures from the data
- **Loadings Plot:** shows which variable has the strongest influence on a principal component
- **Contributions Plot:** top 10 contributing parameters to PC1 and PC2
- **Hotelling's T^2 Plot:** plots the Hotelling's T2 statistic for all batches
- **Scree Plot:** displays how much variation is captured by each principal component

Scores Plot



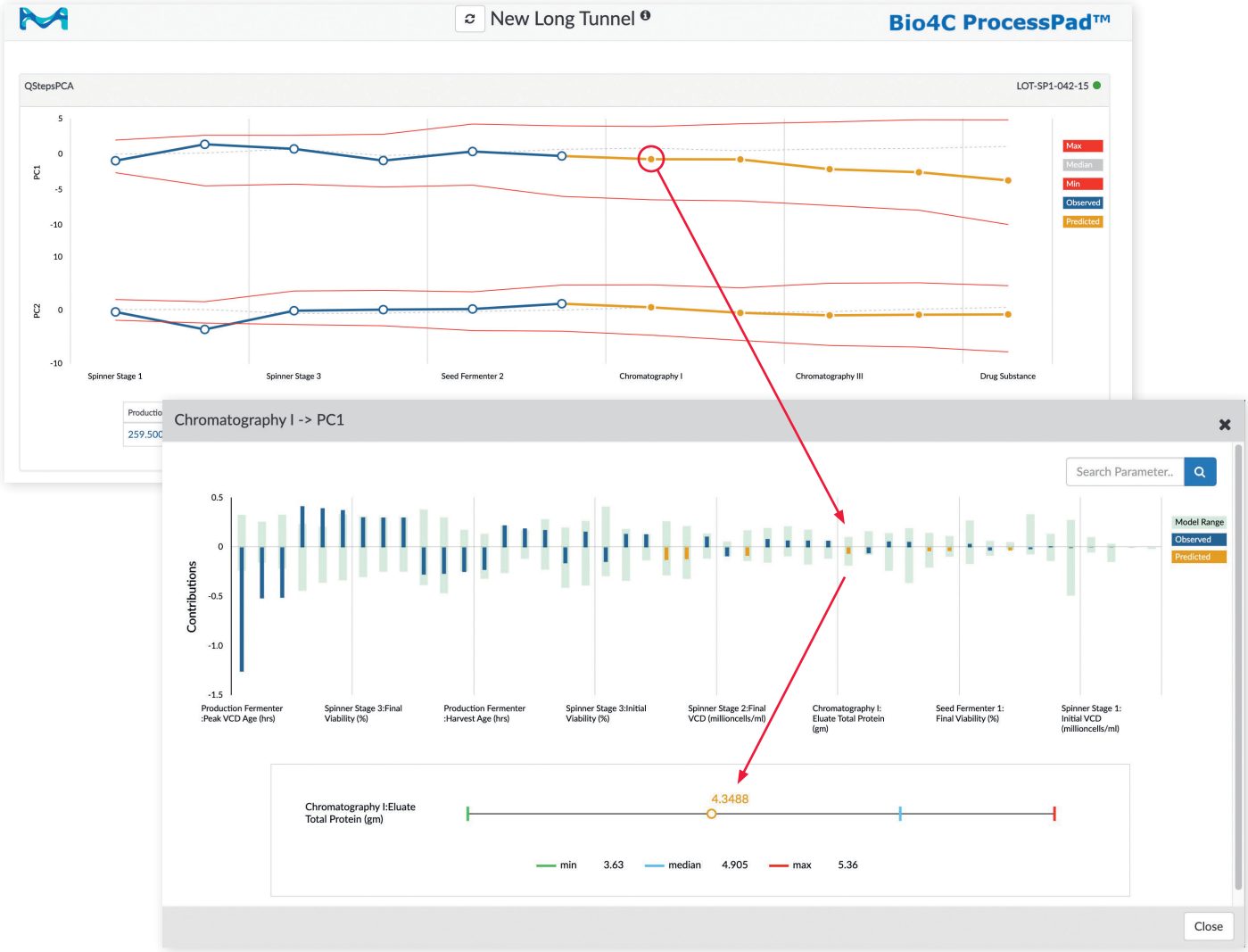
Contributions Plot



Batch Progression Model

With Bio4C ProcessPad™ software, process engineers can create a single batch profile chart with monitoring ranges derived from PCA models created using batches which have the desired parameter values at the various stages of the manufacturing process. When plotted as a process profile for all stages, the multivariate score ranges produce a “process monitoring tunnel” that represents a single metric or control chart condensed from several parameters (key and critical process parameters) of a multistage process.

Process engineers can know not only the current state of the process for a batch in execution but also see an estimate of upcoming stages in the process. The batch progression model allows scientists and engineers to query which parameters are currently contributing the most to the process’s state and which parameters are estimated to contribute the most in upcoming processing steps. Users can drill down to the parameter level to see the estimated values of the process parameters.



Batch Progression Model

Time Series Model

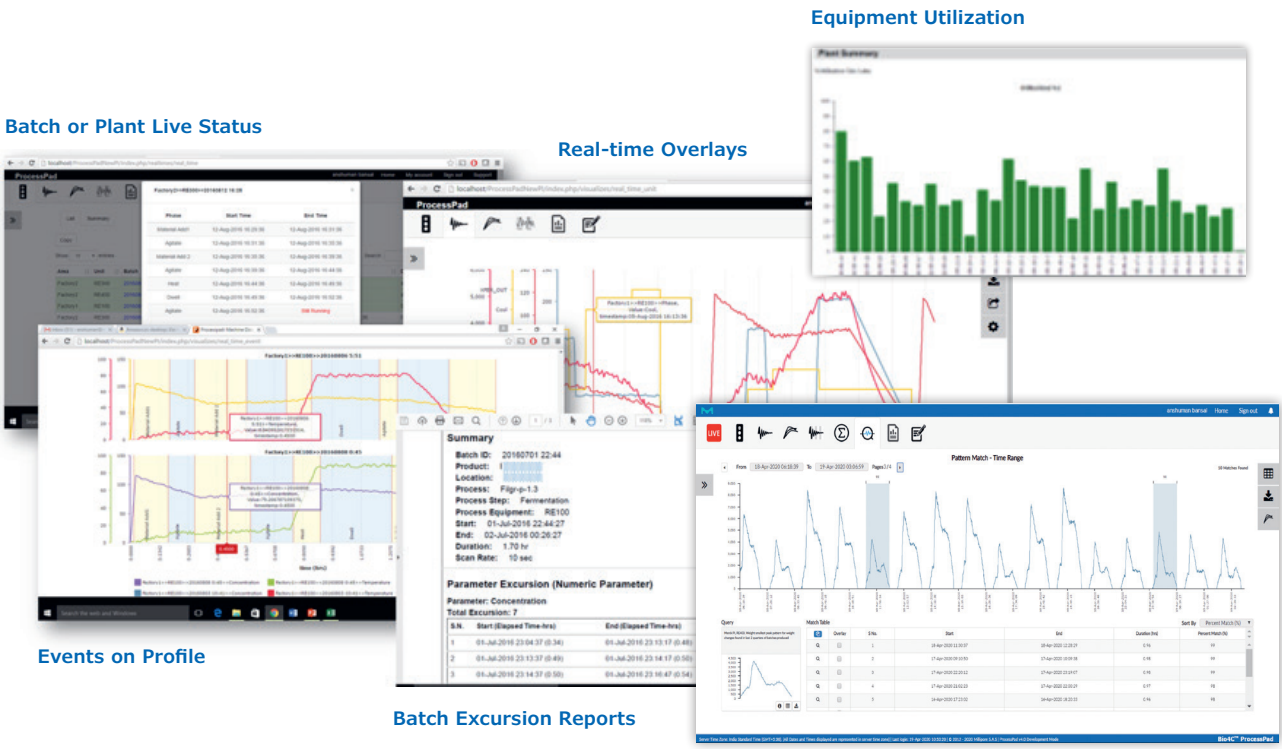
Bio4C ProcessPad™ software offers a guided parameter selection and data pre-processing interface to build a Process Monitoring Tunnel through a PCA-based time series model that describes the evolution of batch processes over time. The Process Monitoring Tunnel enables near real-time monitoring of batch processes, allowing for early detection of deviations and prompt intervention to prevent quality issues or product failures. The models can also be used to optimize batch performance by identifying opportunities for process improvement. The model is built using parameters selected from historical batches running the same process.

Bio4C ProcessPad™ software is capable of handling complex, non-linear batch processes with time-varying dynamics, and can capture the interactions between process variables that may affect product quality. It also allows for the inclusion of prior knowledge about the process, such as process specifications and constraints, which can be used to set alerts and control limits.

Machine Data Analytics

Bio4C ProcessPad™ software-RT module provides direct web-based access to streaming data from process equipment for real-time machine and batch data analysis. Process engineers have easy access to data to perform routine monitoring of batch profiles or process troubleshooting. Visualizations for machine data include:

- **Golden Tunnel Live View** – golden tunnel dashboard
- **Plant View** – gives the status of equipment based on a time period
- **Equipment View** – visualizes current trends of any equipment of interest
- **Batch View** – provides overlay of parameters for various batches
- **Batch Event** – view all batch events with parameter profiles
- **Run Reports** – generate templated excursion report or ad hoc reports for a batch
- **Create a Batch Event** – user entry forms for creating batch events
- **Cell Culture Profiles Comparison and Trend Analysis**
- **Process Capability Assessment**
- **Pattern Match View** – allows user to match any time-series pattern against historical data



All the machine data analytics are designed to minimize the time from issue discovery to insights, for faster root cause investigations and CAPA implementation. For process engineers, Bio4C ProcessPad™ software-RT simplifies and streamlines the following tasks:

- Live plant, machine, or batch status
- Determine current stage or phase of the process batch
- Tabular access to execution stats like batch start time, end times, and duration
- Compute and compare equipment utilization for overall equipment efficiency (OEE) estimations
- Find process tags within or across equipment to overlay or compare parameter values within the time period of a non-conformance event or investigation
- Overlay current and historical batch profiles on a common timescale for easy comparison and benchmarking
- In real-time extract data within batch phases and compare phase data across batches
- Correlate streaming parameters
- Align multiple batch events to compare and troubleshoot batch differences due to operational shifts in scheduled batch events
- Generate batch excursion reports on both quantitative (e.g. pH, concentration, DO) and non-numeric qualitative parameters (e.g. operators, phases, events)
- Search matching anomaly or process patterns historically for quick resolution of observed deviation from routine process parameter profiles

Stability Trending

The Bio4C ProcessPad™ software Stab module enables drug development and manufacturing engineers and scientists to capture and trend drug stability data or to perform shelf-life estimation without exporting data or using an additional external system. The stability module's data capture forms duplicate the in-process test/assay data capture format to ensure no additional training for lab and QA personnel entering, verifying, and approving data.

The stability management console supports specification limits management and tracks both quantitative and qualitative specifications. Users can flag protocol events, addendums, or method changes for better correlation of data and quick compilation of protocol data, events, or addendums throughout the entire lifecycle of the protocol execution.

The stability module also provides advanced statistics for estimating shelf life under long-term storage conditions. All the shelf-life estimation models designed for batch poolability conform to statistical approaches outlined in **ICH-Q1E (Appendix B2.2)**

Stability Profiles

Shelf-life Prediction

Protocol Reporting

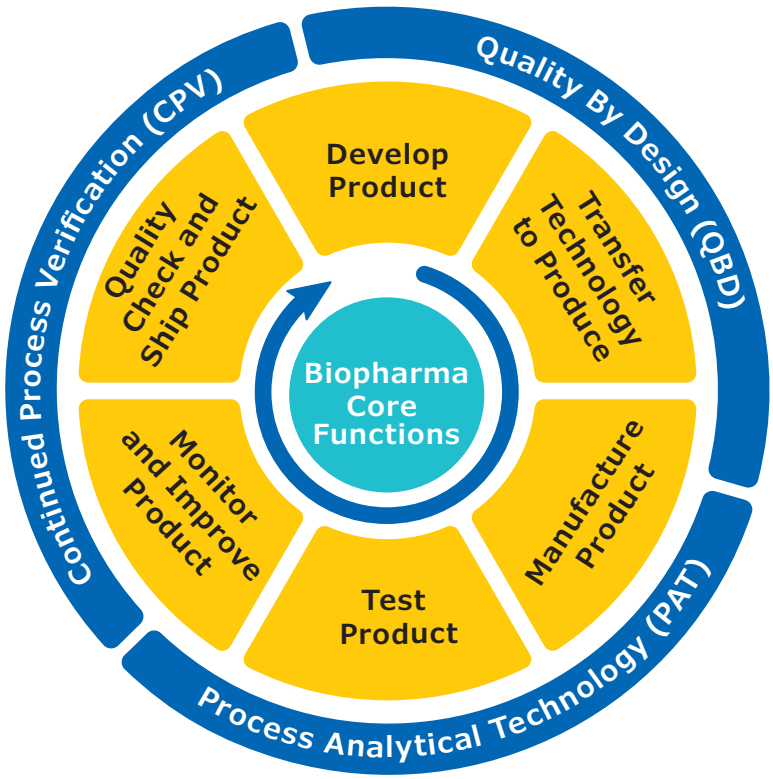
Process Lifecycle Management

Bio4C ProcessPad™ software allows scientists and engineers to collect process development data and leverage it throughout the entire lifecycle for effective knowledge transfer during process characterization through scale-up to large scale GMP manufacturing.

Core process functions create and consume process data in similar ways with similar underlying metadata and context. Bio4C ProcessPad™ software helps manage and serve contextual process information throughout the lifecycle of Quality by Design (QbD), Process Analytical Technology (PAT) and Continued Process Verification (CPV).

- Efficiently capture all development, scale-up, and commercial process execution data in a single platform
- Easily manage specification or control limit history
- Utilize historical data for investigations and process improvement
- Simplify the tech transfer process
- Instant access to the latest version of process map/ genealogy (CQAs, CPPs, sampling plans)

Bio4C ProcessPad™ software provides a platform to capture, modify, and track your critical process parameters (CPPs) or critical to quality attributes (CQAs). Over the lifecycle of the product, users can monitor the process's evolution with full traceability of critical to quality parameters and control limits applied to CPPs or CQAs. Using Bio4C ProcessPad™ software, users track, compare and build reports on process development and manufacturing datasets making tech transfer easy and making historical process knowledge available during commercial manufacturing. Scientists and engineers can build discussion forums around development and manufacturing data reports to collect and archive subject matter expert process knowledge for later search and retrieval (even if a subject matter expert leaves the organization – the knowledge remains with you).



Continued Process Verification

The Food and Drug Administration (FDA) guidance on continued process verification (CPV) and the EU GMP Annex 15 requirements for ongoing process verification direct pharmaceutical and biopharmaceutical manufacturers to ensure that their processes remain in a continual state of control (a validated state) during the lifecycle of the product so that the strength, quality, and purity of the final drug product is maintained.

In the absence of a structured process data management tool, more than 80% of time is spent on hunting for data leaving only 20% of time on quality analysis. Bio4C ProcessPad™ software automates many steps involved in CPV and offers a one-click solution for statistical trending of data (control charts, X-bar and R charts, correlation charts, box plots, etc.), campaign reports, and annual product quality review (APQR).

Bio4C ProcessPad™ software provides the data integration, data analysis, data sharing across the manufacturing network and end-to-end data management throughout the process validation lifecycle that successful CPV requires.

- Single source of all process data (online machine streaming and offline batch record entries)
- Statistical process control and process capability
- Control limit management
- Lot traceability and genealogy
- Pre-configured trending rules to aid process monitoring
- Correlations across process steps for quick troubleshooting
- Real-time out of trend email alerts
- Process analysis tools to aid investigations and process troubleshooting
- Validated reporting

Specifications/System Requirements

Hardware and Software Requirements for Bio4C ProcessPad™ Software Base Server	
Hardware/Software	**Specification**
Processor	2.0 GHz or above
Installed Memory (RAM)	>32 GB (64 GB recommended)
Hard Disk Space	>500 GB
Operating System	Windows® Server 2012R2 Standard or above

Hardware and Software Requirements for Bio4C ProcessPad™ Software (Client-PC Requirements)	
Hardware/Software	**Specification**
Processor	1.6 GHz or above
Installed Memory (RAM)	>4 GB
Web-Browser	Google Chrome™ (version 70 or above)

Bio4C ProcessPad™ Software Services

Service Offerings

- Installation/deployment services
- Validation package
- Validation services
- Software training

Benefits

- Facilitates regulatory compliance
- Enable smooth, successful, and efficient software platform implementation and integration
- Increase software platform usability and adoption
- Training to ensure that your team can operate and troubleshoot the software
- Focus your attention on your core business

BioContinuum™ Platform

Converge, Intensify and Evolve. Together.

An expanding environment of advanced processing, software, automation and analytic technologies, unlocking the potential of Bioprocessing 4.0 and empowering biomanufacturers to achieve greater speed, flexibility and quality.

For additional information

please visit **SigmaAldrich.com/data-analytics**

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