



Statistical Process Control (SPC) Solution Features & Templates

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1 Features

1.1 Multiple Input Options

1.1.1 Automatic Data Input with Machine Integration

Arcstone's arc.quire module offers the ability to connect to multiple different types of hardware components. Connection is made using any industry standard communication protocols for OT/IT data exchange (e.g., OPC UA, Modbus, MQTT, Profibus, TCP/IP, etc.). The full list of options for connection methods and protocols are listed in the table below.

Integration Option	Description	Apply to
Open communication protocols	Machine is open for connection through industry standard protocols such as OPC, MODBUS, MQTT, Profibus, FINS, etc.	Any equipment with open I/O port (Ethernet, RS232, RS485) and has available documentation for supported protocols
Log file/output file	Process machine output file or log file that contains production data	Any machine that supports file-based loggings, CNC machines that support DPRINT command
Use external remote I/O module or IoT box (will incur additional hardware cost for the I/O module or IoT box)	Tap on available I/O channels (analogue or digital) of the machine and map it with machine data point (status, count, etc.)	Machines with available I/O channels and I/O map drawing/documentations
Integration with available HMI connected with the machine	In case where machine has limited I/O port that is already used for the HMI, integration can be done with the HMI instead to pull machine data collected and displayed on the HMI	Any HMI that is open to integration through the above methods

Table 1.1.1 Available machine integration options

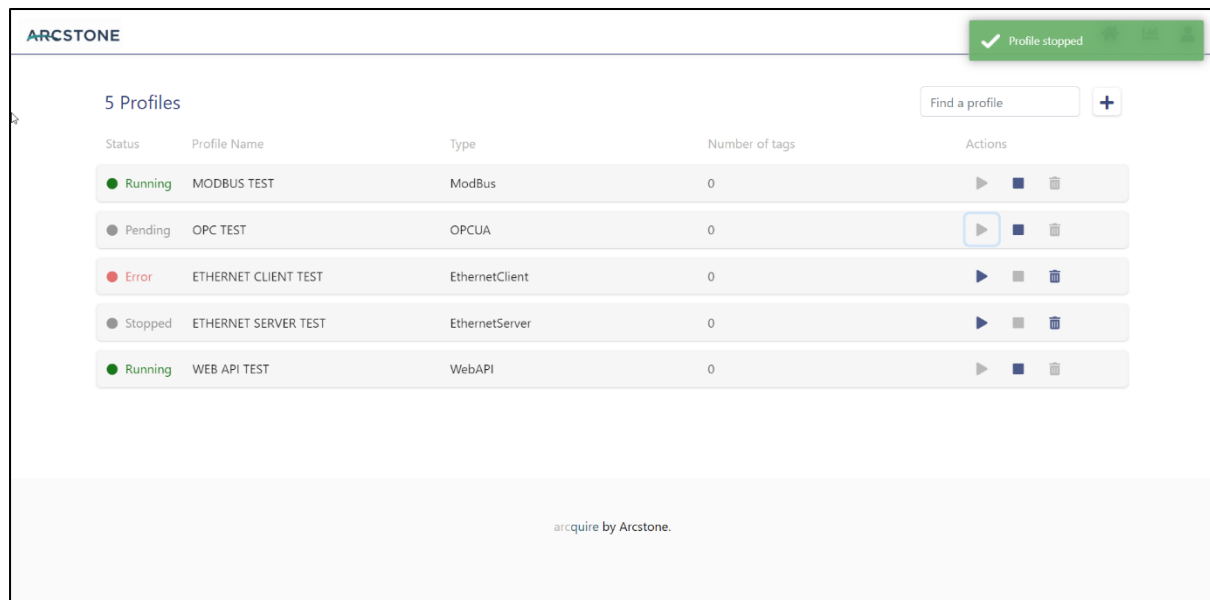


Figure 1.1.1 arc.quire configuration

In the case where the machines do not support such data exchange methods, an external IoT box or remote I/O modules can be used to map individual I/O signals, be it digital or analogue,

available from the machine circuit board to act as a middleman transferring machine data to arc.quire.

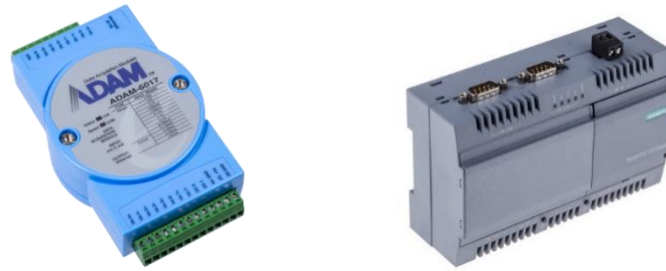


Figure 1.1.2 Common external I/O devices

Data collected from machines and hardware components will be streamed into a data processing engine for contextualization before being used as input for the SPC analytic module.

1.1.2 Automatic Data Input with 3rd Party Software System Integration

Arcstone's arc.flow module can connect and integrate with 3rd Party Software Systems. The list of standard integration methods supported by Arcstone is listed below. Integration done outside of this may require additional development and implementation effort.

Method	Description	Requirement
RESTApi	Done through HTTP/HTTPS protocol (recommended).	API documentation
SOAP Web Service	Done through HTTP/HTTPS protocol	WSDL files
Shared Database Operation	Data exchanged is done through shared database. Support standard SQL-based databases (MS SQL, MySQL, PostgreSQL, Oracle, etc.).	Read-access account Database schema and documentation
File exchange	Done through FTP/SFTP/network sharing.	File format and data structure FTP server/network drive access

Table 1.1.2 Supported integration methods

Integration events will trigger arc.flow profiles that can be flexibly configured to receive data and perform follow up actions. Similar to data coming from machines and hardware components, this data can be further processed/contextualized before being used as input for the SPC analytic module.

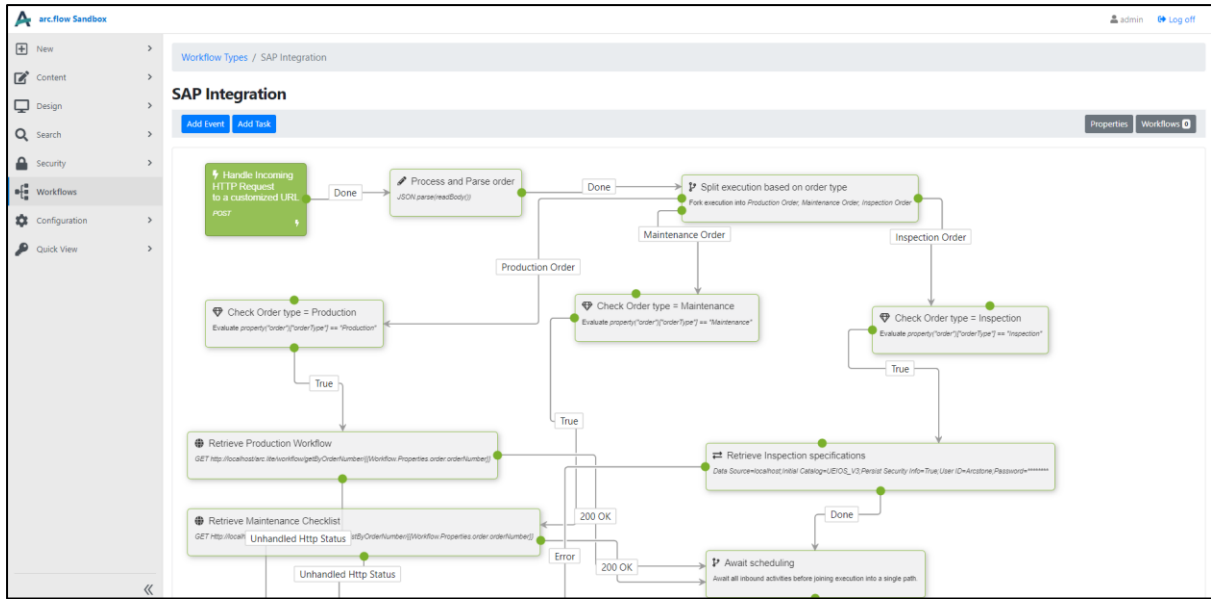


Figure 1.1.3 Sample arc.flow integration profile

1.1.3 Manual Data Input with Advanced Digital Checklists

Arcstone's Workstation module provides a unified interface to capture production related information, complimenting automatically captured data from machine integration with manual inputs and checks where needed.

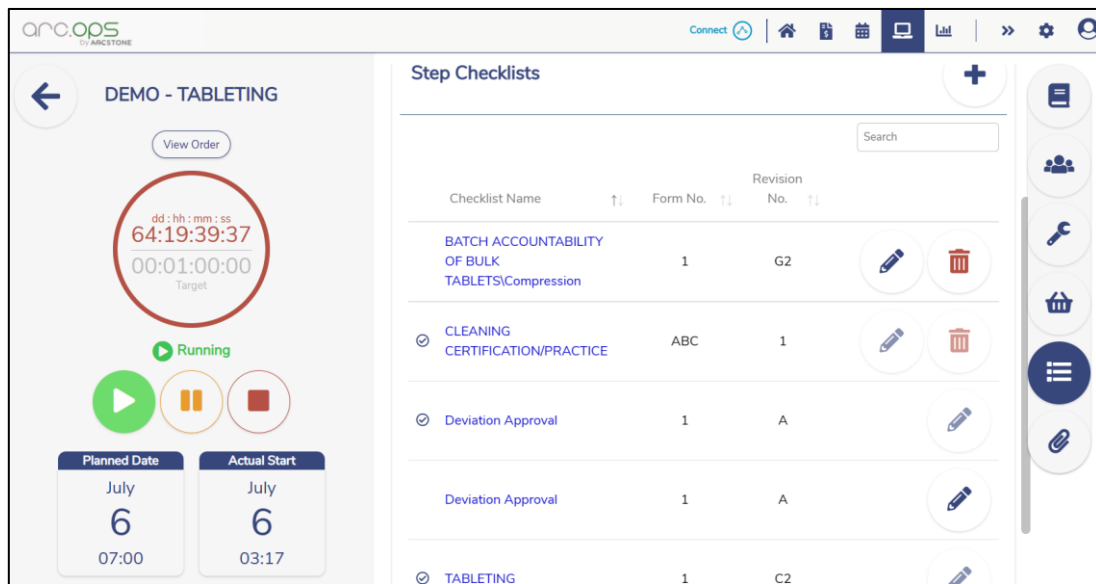


Figure 1.1.4 Workstation Interface

The workstation allows for:

1. **Timing information to be tracked.** Actual timing may be compared with target timing which may be automatically calculated based on cycle time, production quantity or other factors
2. **Flow control.** This ensures that production steps are executed in the right order (which can be specified in a workflow). Checks may also be enforced to make sure valid data is captured or certain parameters are met before the next step is allowed to be proceed. Alerts may automatically be triggered if such prerequisite conditions fail.

3. **Operator Instructions.** Documentation, videos and images may be displayed to provide step-by-step guidance to an operator completing a production step
4. **Personnel access control.** Ensure that only the qualified personnel can work on each production step. More granular control can be invoked for Quality control sign-offs.
5. **Equipment control.** Ensure only valid equipment with appropriate calibration is used
6. **Resource tracking.** Scan barcodes/QR-codes or RFIDs to track raw material used finished good produced.

In conjunction with the above, Arcstone incorporates an advanced checklist module into the workstation. Arcstone's FDA 21 CFR 11 compliant digital checklists provide a fully configurable way to manage and capture production data. Checklists provide:

- **Complete audit trail** of any data added or changed within a checklist, along with personnel name, date & time stamp
- **The ability to auto-populate checklist** fields from connected equipment or system.
- **The ability to automatically perform calculations** on previously entered values, or data captured elsewhere in the system
- **Configurable conditional logic** to enforce values on certain checklist fields. Automatically trigger warnings or halt production where pre-requisite conditions are not met.

Figure 1.1.5 Checklist Overview

Checklists are configurable with a variety of controls such as text fields, drop down controls, images, attachments etc. The checklist builder provides an intuitive interface to populate these controls and customize the layout. Options exist to include images, attachments, and a variety of custom controls such as text fields, multi-select menus, signature fields and more.

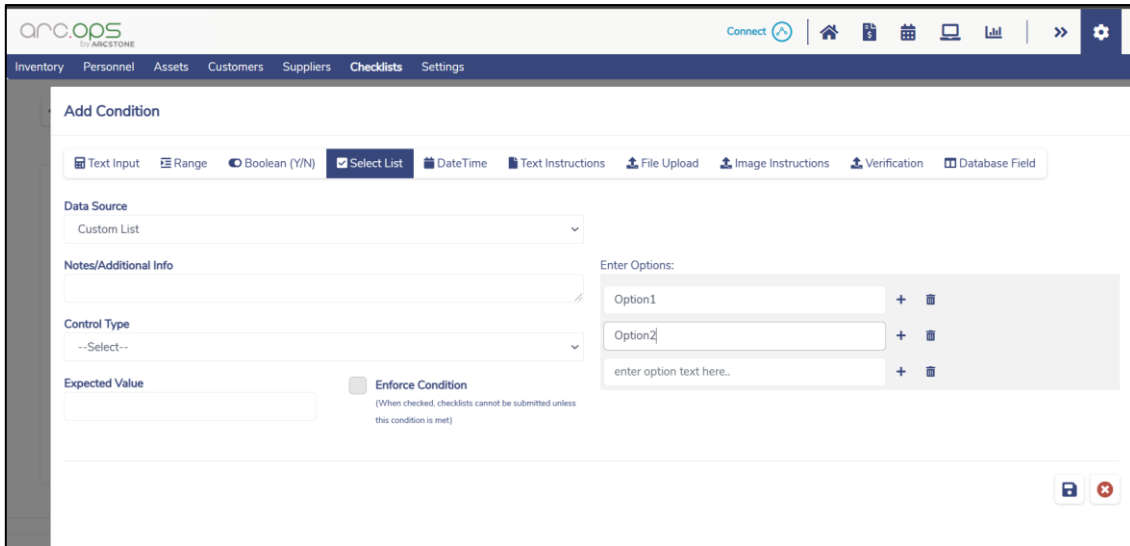


Figure 1.1.6 Option to add in checklist controls

The advanced digital checklist can be applied to capture data related to:

- 1) Incoming inspection
- 2) In-process quality control
- 3) Out-process quality control

Captured data can subsequently be used as input for the SPC analytic module.

1.1.4 Manual Data Input with File Upload

arc.flow comes with in-built file processing task that can be used within an automation flow to retrieve, read and process content from various file formats, including excel and csv. Files can be accessed through FTP, FTPS or network drive connection. As such, typical file outputs from various CMM, inspection machines/systems can be easily read and feed into the SPC analytic module.

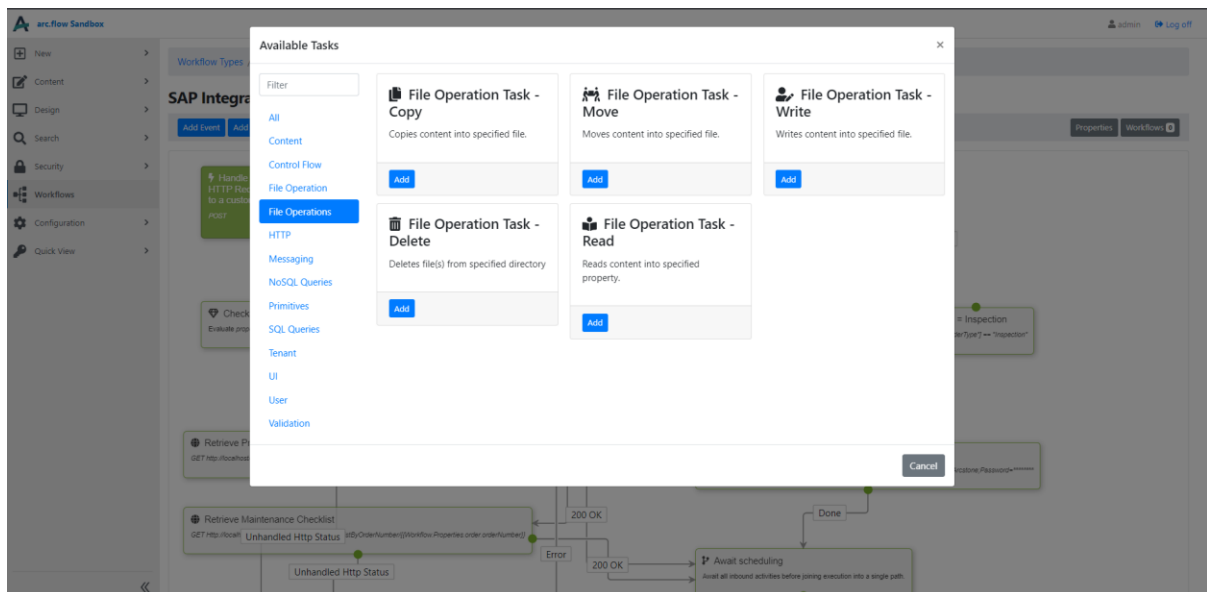


Figure 1.1.7 arc.flow in-built file operations

1.2 Flexible Data Processing, Transformation & Storage

1.2.1 Configurable Logic Flow

arc.flow comes with multiple in-built logic functions and scripting capabilities to support flexible data handling and processing. Some of these include:

- 1) Logic gate functions (if/else, looping, parallel task execution)
- 2) Javascript scripting function
- 3) Mathematical and Statistical functions

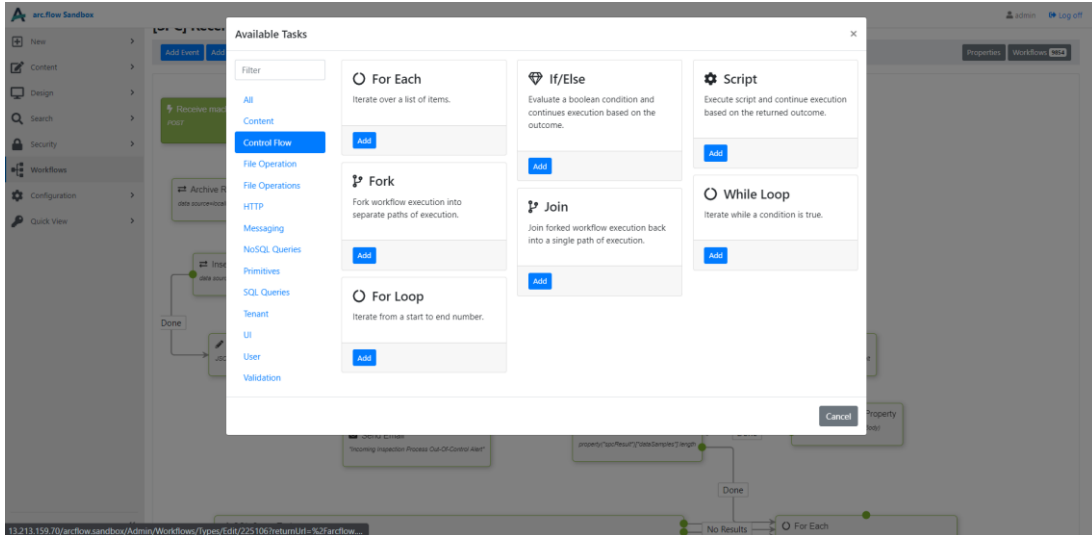


Figure 1.2.1 arc.flow in-built logic operations

This allow for comprehensive data standardization, normalization and cross-process analysis, empowering the SPC engine further.

1.2.2 Extendable Capabilities with External Analytic Engines

arc.flow comes with in-built HTTP capability that allows for communication with open RESTApi of external services and analytics engines. This makes sure the solution is open to integration and can be scaled up and extended as needed. In certain use cases, arc.flow task lists can be extended to include more out-of-the-box modules and features to integrate with external services as well. For instance, if there are analytic libraries that come packaged as .NET dlls, arc.flow tasks can be built to expose the dlls' functions for usage within a configuration profile.

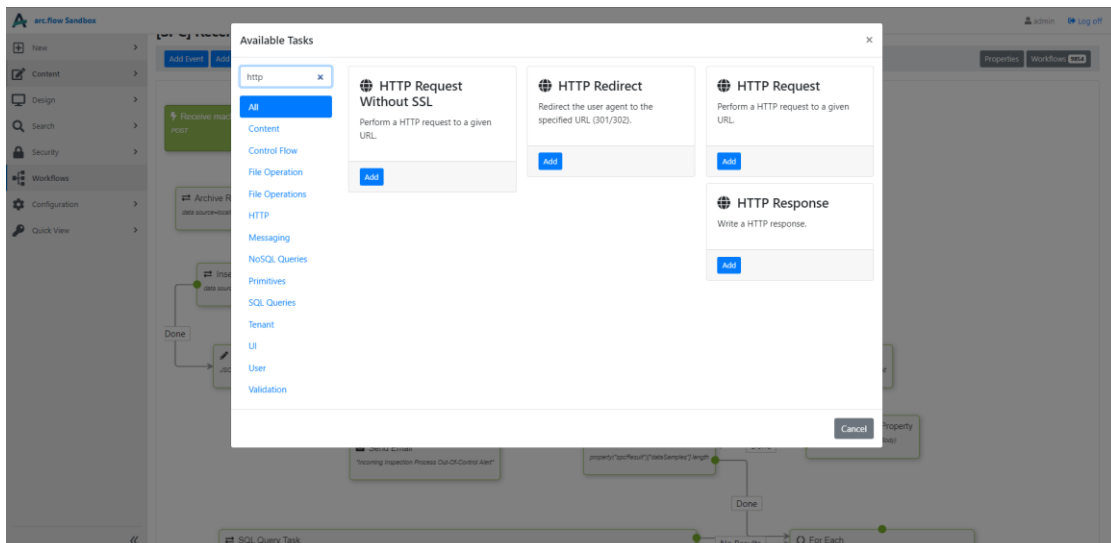


Figure 1.2.2 arc.flow in-built HTTP/HTTPS operations

1.2.3 Compatible with Multiple Storage Formats

Input raw data, processed data and SPC result can be saved into multiple different storage formats. Storage with common databases are available out of the box, such as MongoDB, MS SQL, MySQL, PostgreSQL, and any other database that supports Open Database Connection (ODBC). Additionally, arc.flow also supports file storage.

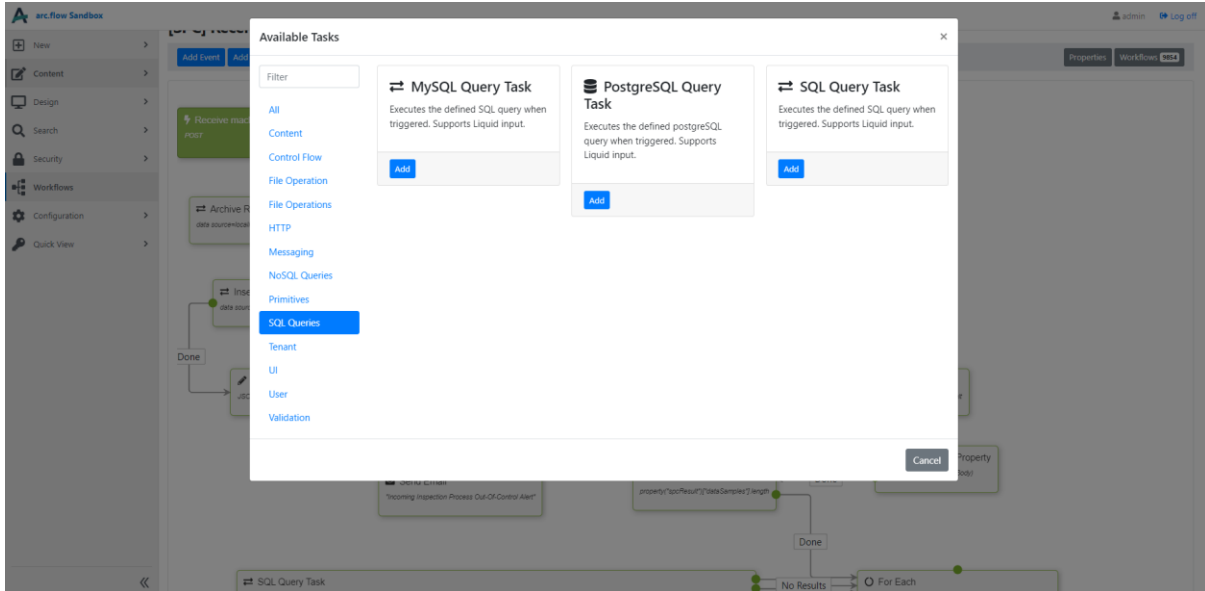


Figure 1.2.3 arc.flow in-built database operations

1.3 Modular & Comprehensive SPC Engine

1.3.1 Discrete Data Control Charts

The following control charts are supported:

- 1) u Chart: Attribute control chart for number of defects per unit
- 2) c Chart: Attribute control chart for total number of defects
- 3) p Chart: Attribute control chart for percentage of defectives
- 4) np Chart: Attribute control chart for number of defectives

1.3.2 Continuous Data Control Charts

The following control charts are supported:

- 1) X-MR/I-MR Chart: variable control chart for continuous data with sample size = 1
- 2) Xbar-R Chart: variable control chart for continuous data with sample size from 2 to 9
- 3) Xbar-S Chart: variable control chart for continuous data with sample size larger than 9

1.3.3 Open API

The above analysis can be run through open RESTAPI endpoints that allow any external parties to consume and perform SPC analysis. The result is returned in real-time for any follow up actions.

1.3.4 Sample control charts

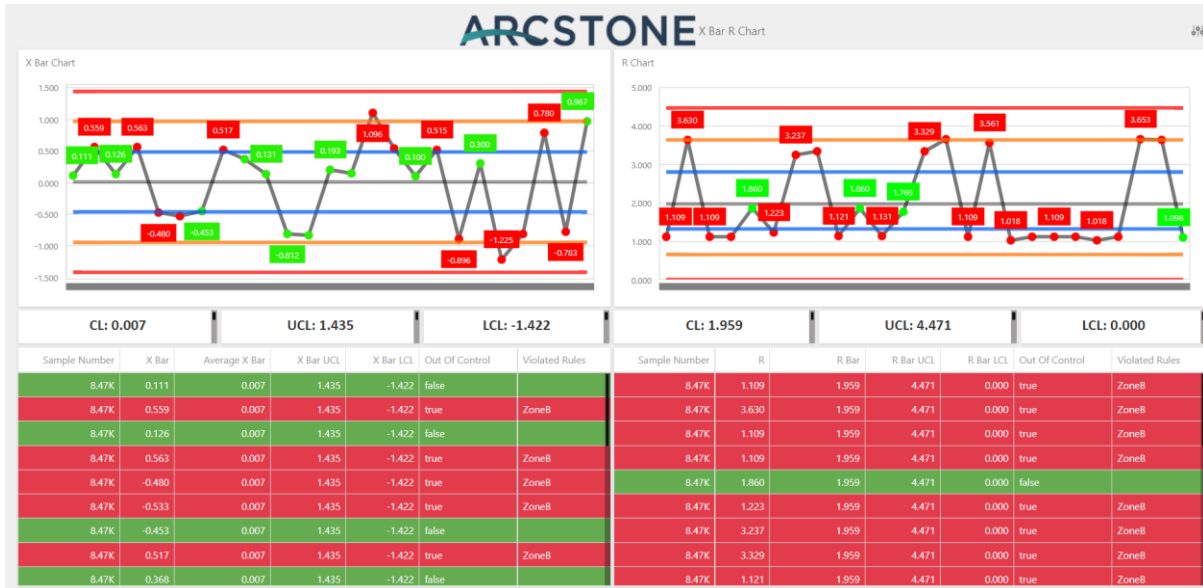


Figure 1.3.1 Sample Xbar-R Chart

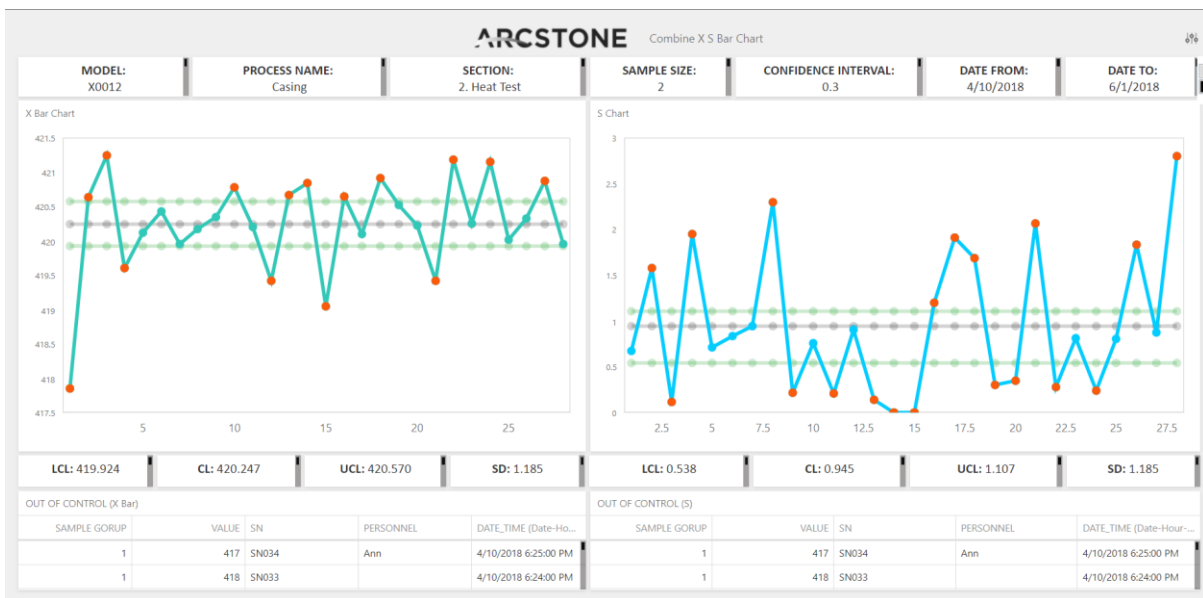


Figure 1.3.2 Sample Xbar-S Chart

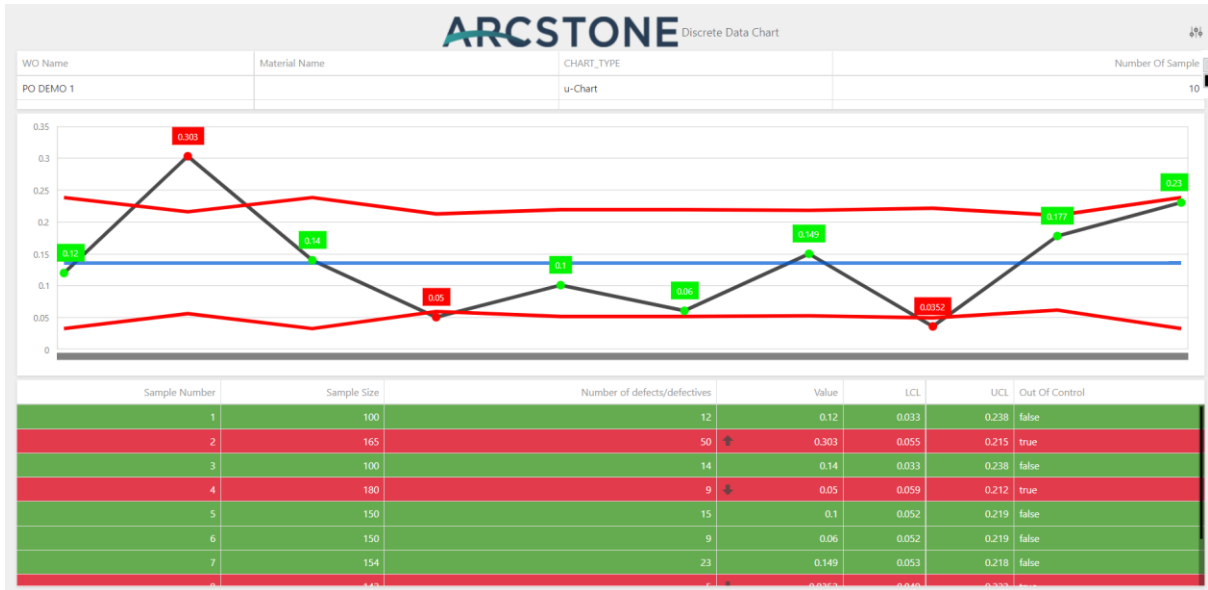


Figure 1.3.3 Sample u Chart

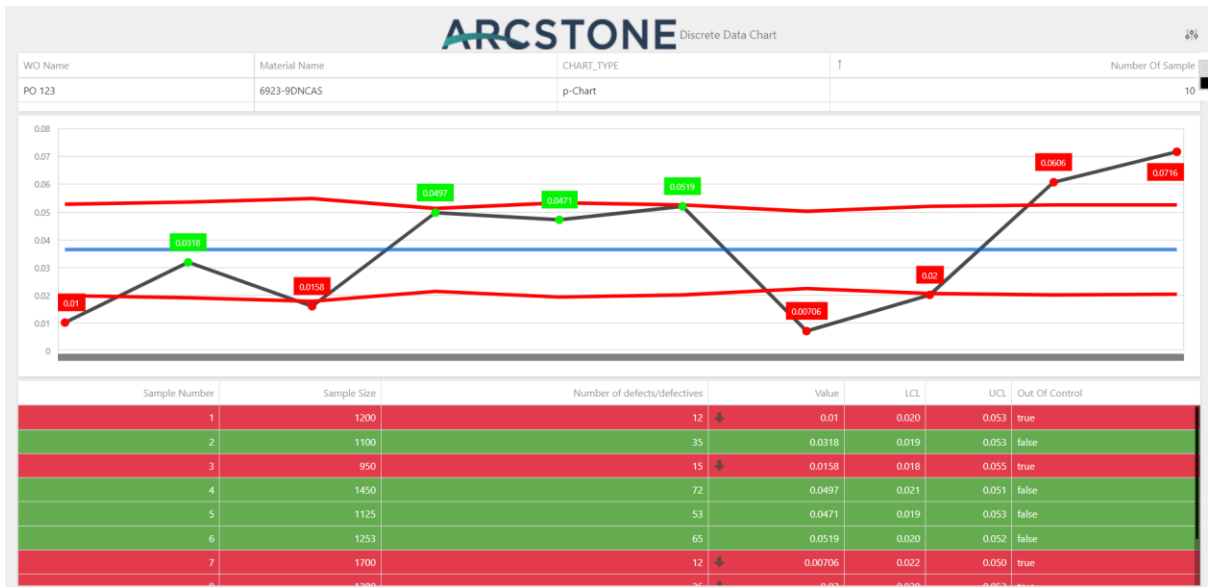


Figure 1.3.4 Sample p Chart

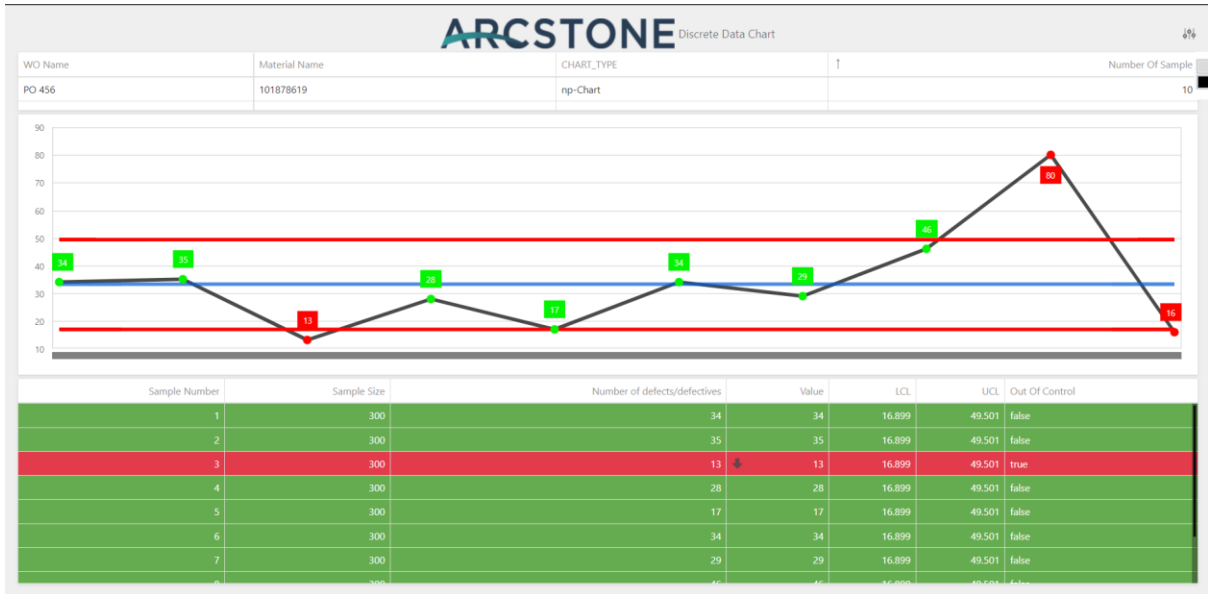


Figure 1.3.5 Sample np Chart

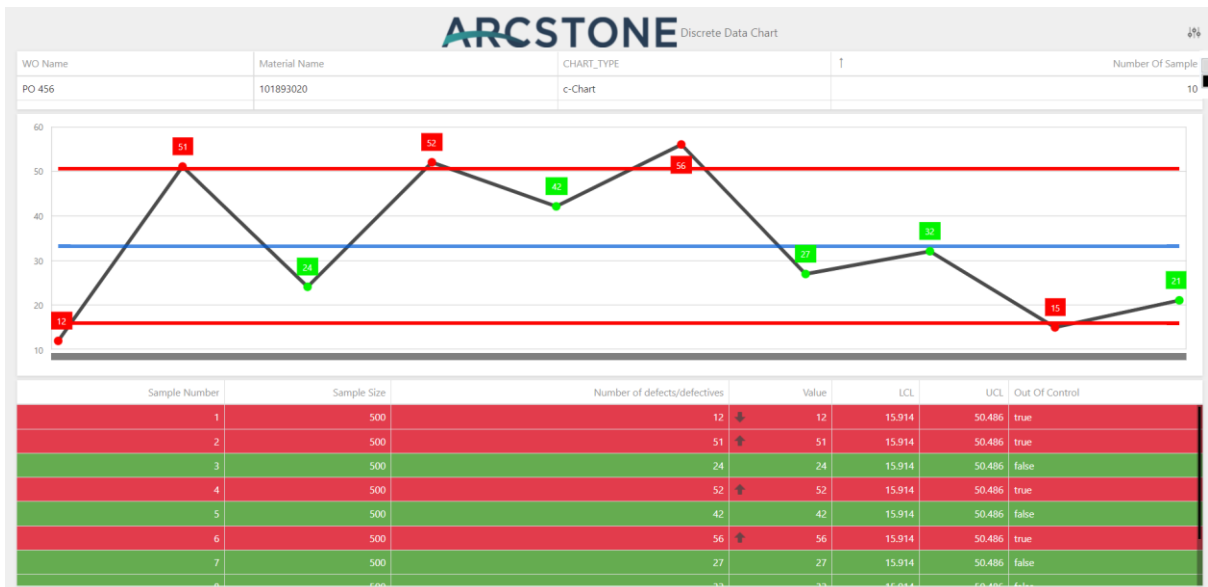


Figure 1.3.6 Sample c Chart

1.4 Flexible Visualization & Reporting

1.4.1 Dashboard Designer

The Dashboard Designer provides a very intuitive drag-and-drop method for building dashboards suited for different users and different viewing needs, from operators on the shopfloor to upper management overseeing the entire factory or enterprise. It consists of a wide range of widgets with full configurability over the layout and data representations, including Pareto chart, box-and-whisker chart, histogram and more.

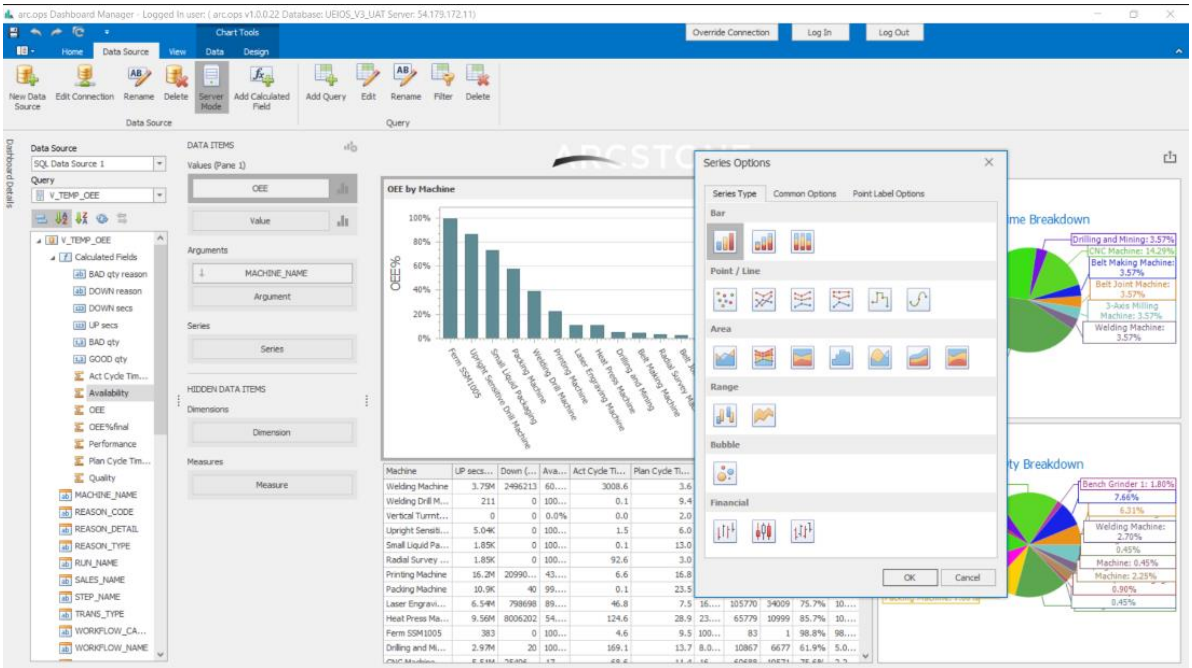


Figure 1.4.1 Dashboard Designer Charting Options

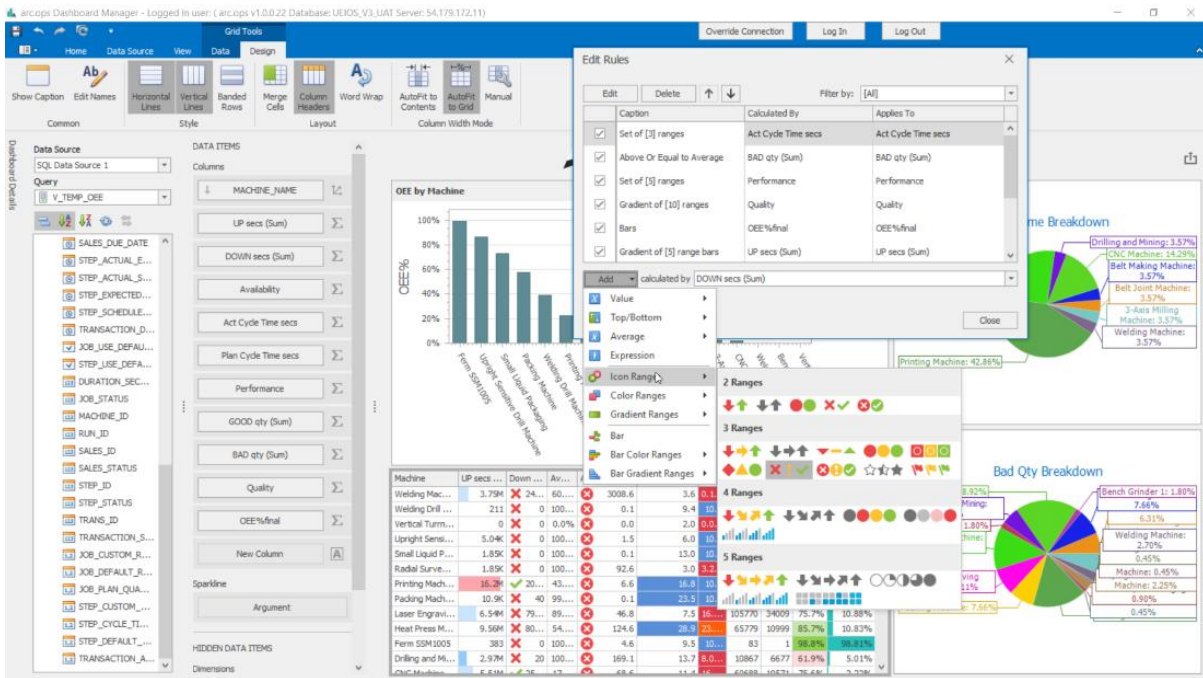


Figure 1.4.2 Dashboard Widget Additional Settings

The finished dashboard can be viewed through web browsers and are hence easily accessible by any devices. Filtering, sorting, as well as drilling down of charts for details are also available as built-in elements for quick and efficient data searching.

In terms of data manipulation, the designer comes with an expression editor allowing for complex calculations or formatting to be done over the data pulled from the data sources.

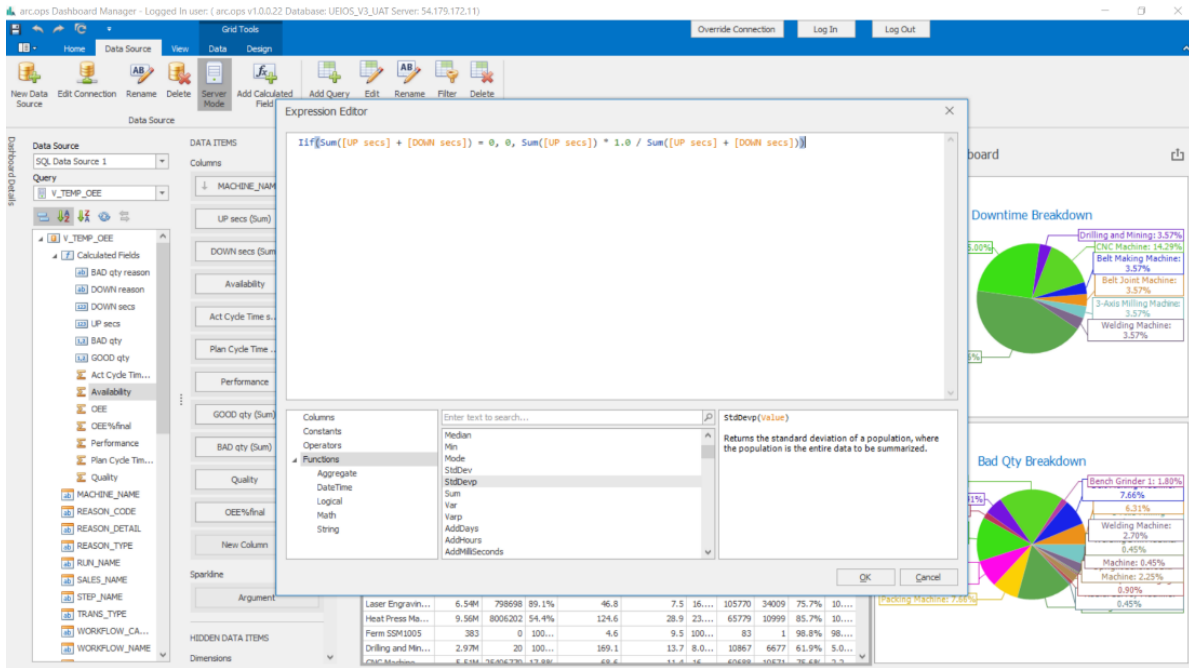


Figure 1.4.3 Dashboard Designer Expression Editor

As for data source configuration, the dashboard designer supports a wide range of commonly used databases. In case where the data source is not readily accessible, there are also options for simple API calls as well as CSV ingestions.

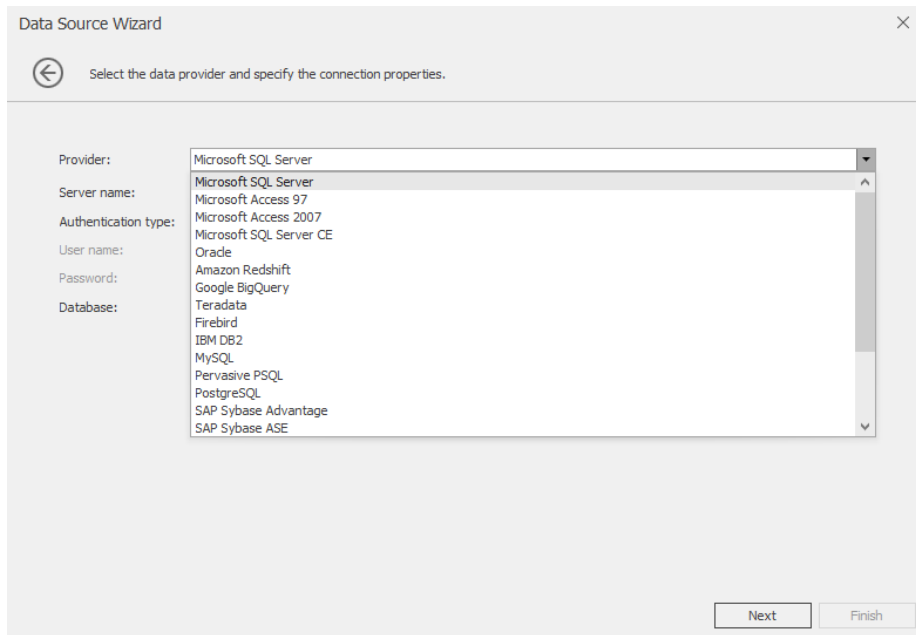


Figure 1.4.4 Dashboard Designer Data Source selection (Database)

For the SPC solution, the Dashboard Designer will be used to visualize SPC related data, including raw SPC data, SPC analysis result and plotting of the different control charts. Built dashboards will also be able to display and highlight issues detected within the analysis, including rule violations, out of control values and anomalies.

1.4.2 Report Designer

The Report Designer allows for consolidation of data captured from multiple sources and combining it into a drag-and-drop designer platform that is end-user-configurable and easy

to use. At the same time, it allows for additional analysis of the raw data using built-in formula editor, with an array of available algorithms for data processing and transformation. Any built report can be automatically generated and archived/emailed to relevant parties in multiple formats (picture, PDF, HTML, DOCS, XLSX, etc.).

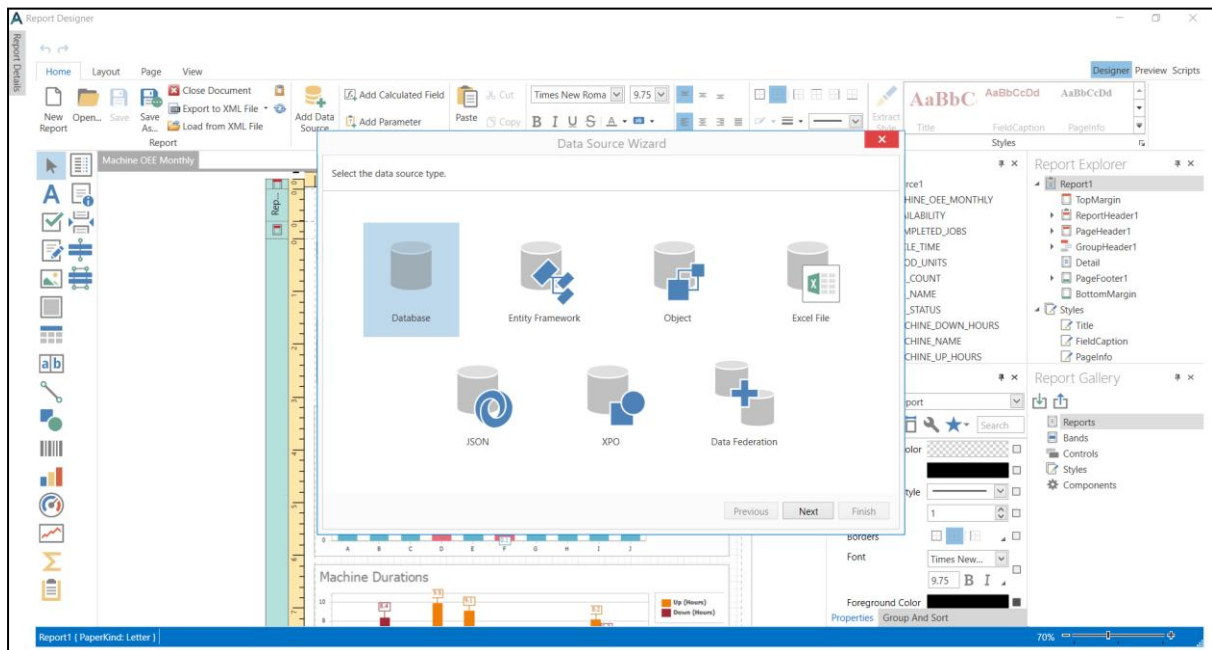


Figure 1.4.5 Report Designer Options for data source

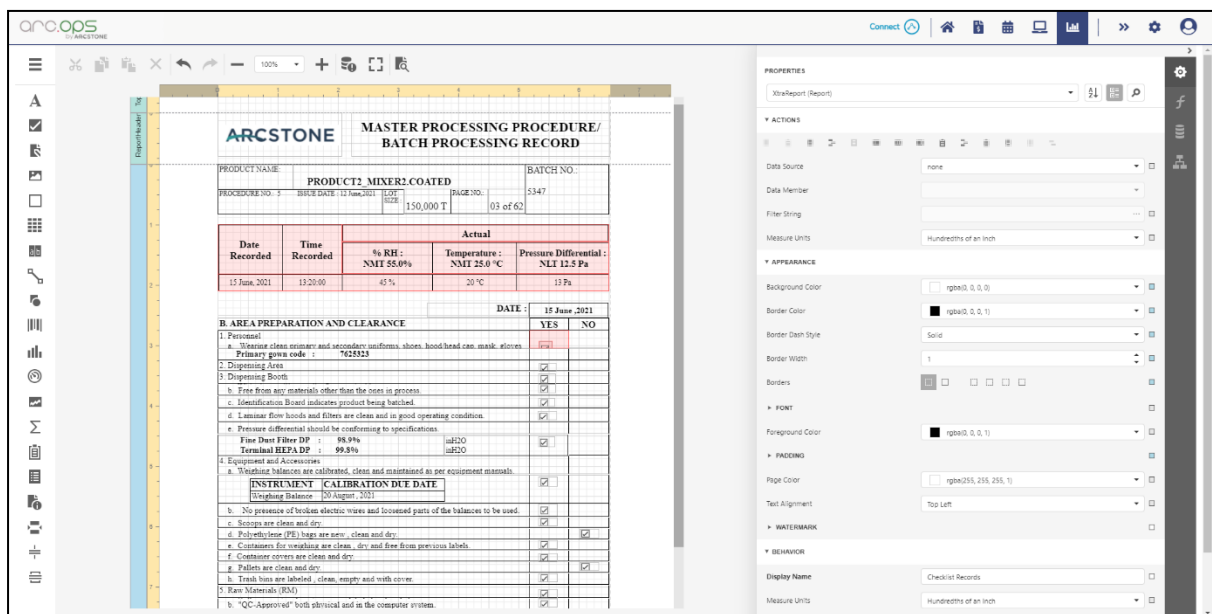


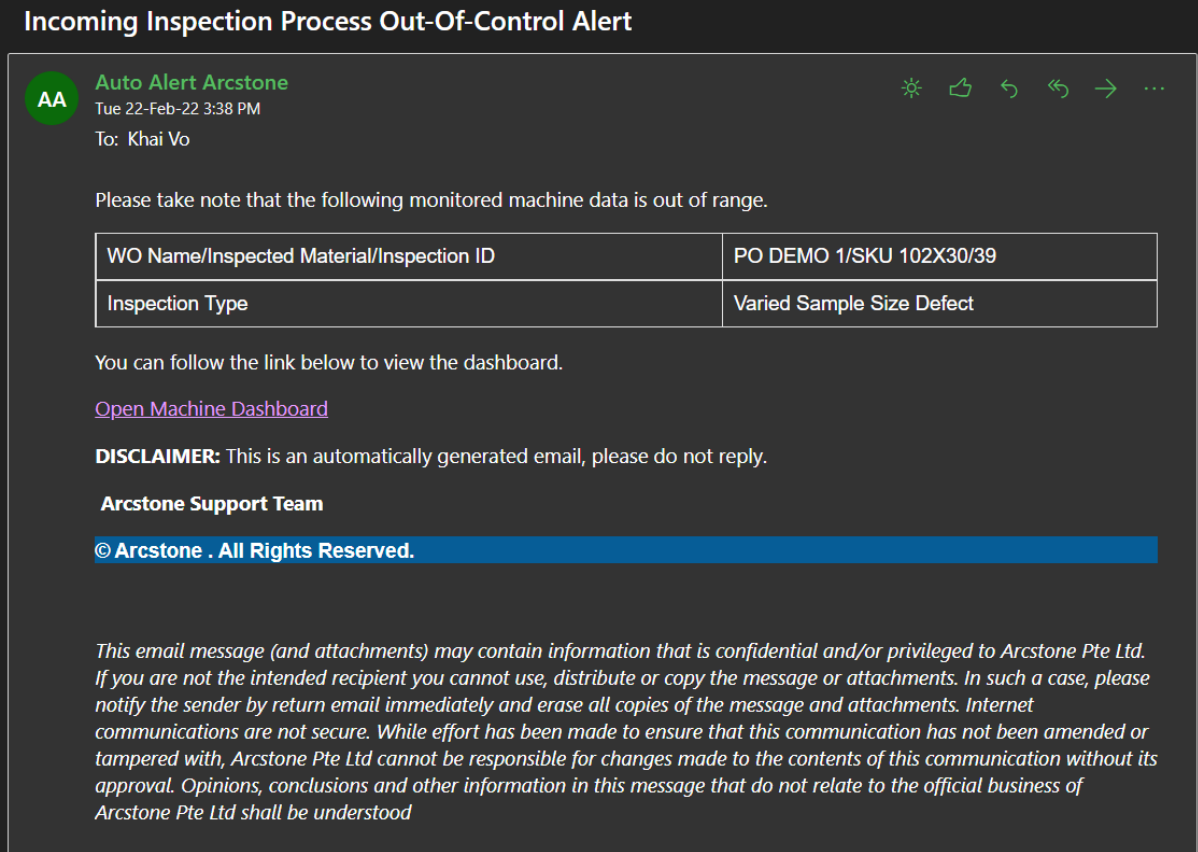
Figure 1.4.6 Highly configurable report designing interface

For the SPC solution, the Report Designer will be used to generate SPC related reports from the SPC analysis result. Report can be automatically generated, emailed out or archived.

1.5 Flexile Output Handling

1.5.1 Real-time Alarms & Alerts

Real-time alarms and alerts can be configured to trigger based on SPC analysis result. arc.flow comes with in-built alarm/alert features including in-app notification, email sending, SMS sending, Whatsapp/Slack/Telegram notification that can be configured as part of the automation flow.



Incoming Inspection Process Out-Of-Control Alert

AA Auto Alert Arcstone
Tue 22-Feb-22 3:38 PM
To: Khai Vo

Please take note that the following monitored machine data is out of range.

WO Name/Inspected Material/Inspection ID	PO DEMO 1/SKU 102X30/39
Inspection Type	Varied Sample Size Defect

You can follow the link below to view the dashboard.
[Open Machine Dashboard](#)

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Figure 1.5.1 Sample Email alert for SPC out-of-control result

1.5.2 Integration with External Services

Leveraging arc.flow's extensive capability to integrate with external services through open APIs/open integration channels, SPC analysis result can be posted to or used to trigger events/commands in external systems, such as triggering a Rework process in the MES, triggering a Maintenance Order in the Equipment Maintenance System, or trigger a rerun in the inspection machine.