Application Note

FESTO

Festo AX Motion Insights Pneumatic

GASA-MIP-CTR-*

This document describes how to set up AX Motion Insights Pneumatic from connectivity to asset onboarding and monitoring of pneumatic actuators.

Title ..... Festo AX Motion Insights Pneumatic
Version 1.60
Document no. 100677
Original ..... en
Author ..... Festo
Last saved 21.07.2025

General information:

This document is intended for qualified, trained and instructed professionals. The data provided in this document are no guaranteed specifications, in particular with regard to functionality, condition or quality in the legal sense. The information in this document is intended only as simple indications for the implementation of a specific, hypothetical application, and in no way as a substitute for the operating instructions of the respective manufacturers or the design and testing of the respective application by the user. The respective operating instructions for Festo products can be found under www.festo.com. The user of this document must ensure that each function described herein works properly in his application. The user remains solely responsible for his or her own use of this document, even by studying this document and using the information mentioned therein. This also applies to any software (in source code and/or object code) that is made available to the user as an appendix to this document.

Rights of use of the software:

If software is made available to the user as an appendix to this document, the user is granted a simple and unlimited right of use hereto. This right also includes the processing and distribution of the software to third parties in edited or unedited form. The User is not permitted to use the name "Festo" to endorse or promote products derived from the Software without express prior written permission.

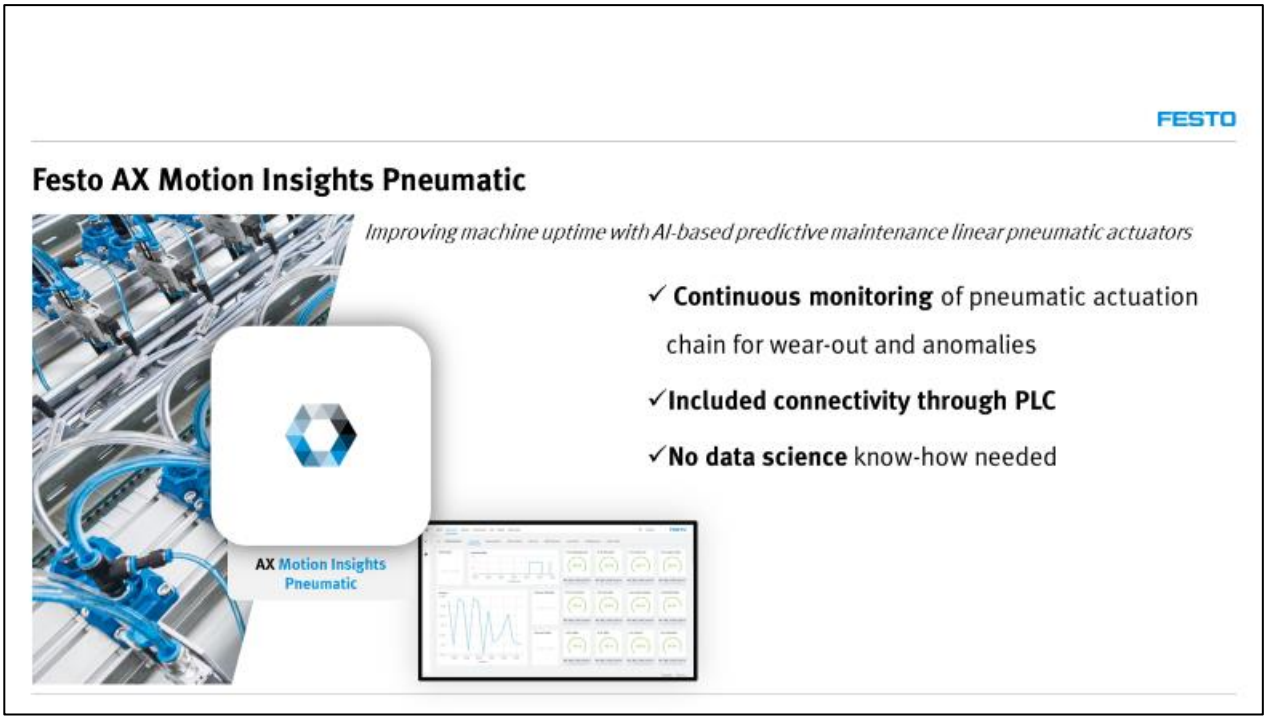
Software is provided to the user "as is". Festo does not assume any warranty or guarantee with regard to software. Festo's liability for damages of any kind arising from the use of the software is limited to intent and gross negligence.

Legal Notices:

Table of contents

1 Introduction

Festo AX Motion Insights Pneumatic (AX MIP) is an industrial app for continuous monitoring of pneumatic cylinders. It comes with a standardized AI model and a user interface as well as a connectivity adapter and PLC function blocks for data acquisition.



2 System Requirements

2.1 PLC

- Siemens S7 PLC (300/400 or 1200/1500 series)
  - Min. TIA V16 or S7 Classic
  - Ability to install function block into PLC
- Rockwell/Allen-Bradley RS-Logix
  - RSTUDIO up to version 20
  - RSTUDIO up to version 35
  - Ability to install function block into PLC
- Beckhoff TwinCAT3
  - Ability to install function block into PLC

2.2 Automation equipment

- 2x limit/reed switches on each cylinder
- Cylinder travel time must fit to this formula:
  - Travel time of cylinder **greater than** 10 times PLC cycle time

2.3 Computer hardware/runtime environment

2.3.1 Hardware

The Industrial App runs on industrial PCs, virtual machines (VM) or other devices and computing instances that meet the following hardware requirements:

- CPU: min. 4-core, x86-64bit (Core i5 or higher)
- HDD: 120 GB or more
- RAM: 8 GB or more
- 1x Ethernet network interface

2.3.2 Network

- Ethernet network access to all involved PLCs

For retrieval of the industrial app “AX Motion Insights Pneumatic” from Festo’s central container registry, temporary internet access is necessary. After installation, the internet access can be turned off.

2.3.3 Software / runtime environment

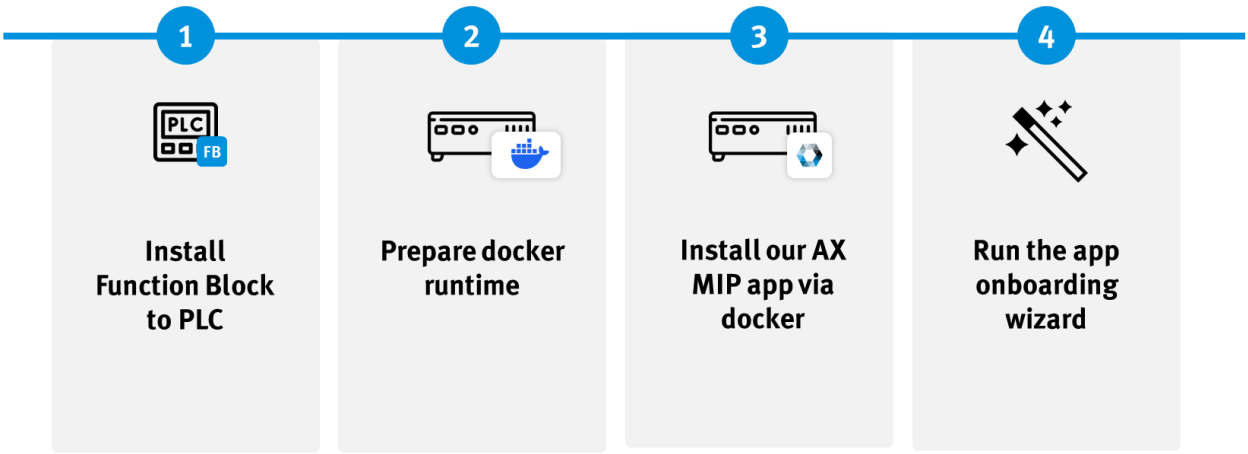
- Installed Docker runtime (OCI container)
- Support for Linux-Containers
- Docker-Compose v2.0
- WebUI: optimized for Webkit-based browsers and Firefox
- UI is optimized for a resolution of: 1024x768 or higher

2.4 Security/Intended Use

Festo AX Motion Insights Pneumatic (AX MIP) is an industrial app, provided as a set of docker containers, for continuous monitoring of pneumatic cylinders. Therefore, it gathers data from a function block inside a PLC via proprietary PLC protocols, converts and streams the data over MQTT, analyses the data regarding anomalies of the connected pneumatic actuator and persists the data and the results in a data storage (default a PostgreSQL database).
AX MIP is mainly designed to operate on shopfloor level on e.g. an edge computer inside an internal network with no permanent access to the public internet. If you choose distribute the Docker container of MIP on different hosting systems or to operate MIP (partly) in a public cloud, please ensure to secure all communication channels like the MQTT broker with methods of authentication like username/password or certificates. Furthermore, keep in mind to restrict the access to the ports of the system via an appropriate firewall configuration (open only necessary ports and filter IP addresses for the access.
AX MIP is a recommendation system, that gives maintenance engineers insights about the health of the connected pneumatic equipment. Therefore, AX MIP analysis data continuously by the use of algorithms from the field of machine learning. To ensure satisfying results, only data from the MIP function block should be analysed with AX MIP. Furthermore, it is not recommended to automate an intervention in the control system of the machine based on analysis results from AX MIP.

3 Installation and Commissioning

To setup the entire AX Motion Insights Pneumatic (AX MIP) industrial app, these steps have to be conducted:



3.1 Setup of connectivity – installing function blocks on PLCs

The installation of the MIP function block is described in detail separately for each supported PLC vendor. See Support Portal of Festo, also the function blocks can be downloaded there.

3.1.1 Siemens Step7

https://www.festo.com/de/de/support-portal-specific/?query=Motion+Insights+Pneumatic&groupId=18&productName=Motion+Insights+Pneumatic&documentId=671016

3.1.2 Siemens TIA Portal

https://www.festo.com/de/de/support-portal-specific/?query=Motion+Insights+Pneumatic&groupId=18&productName=Motion+Insights+Pneumatic&documentId=671017

3.1.3 Rockwell Studio 5000 Logix Designer

https://www.festo.com/de/de/support-portal-specific/?query=Motion+Insights+Pneumatic&groupId=18&productName=Motion+Insights+Pneumatic&documentId=671019

3.1.4 Beckhoff TwinCat3

https://www.festo.com/de/de/support-portal-specific/?query=Motion+Insights+Pneumatic&groupId=18&productName=Motion+Insights+Pneumatic&documentId=671018

3.2 Installation and setup of AX MIP containers

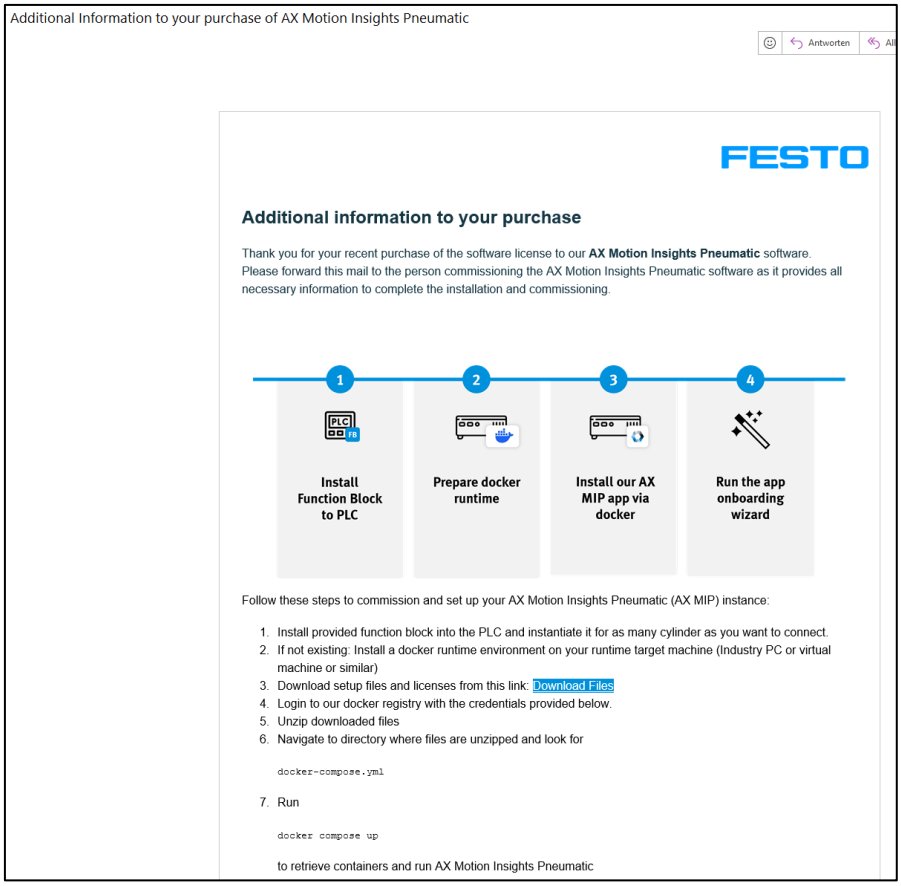
To learn more about “Container Applications” please refer to a google search and possible resources (last checked: Feb 2024):

Title	Author	URL
“Docker overview”	docker.com	https://docs.docker.com/get-started/overview/
„Docker 101 Tutorial“	docker.com	https://www.docker.com/101-tutorial/
„Introduction to Docker containers“	Microsoft Learn	https://learn.microsoft.com/en-us/training/modules/intro-to-docker-containers/
„Using tar archives to install offline“	docker.com	https://docs.docker.com/reference/cli/docker/image/save/ https://docs.docker.com/reference/cli/docker/image/load/

The tutorials also explain on how to install a docker runtime on your preferred environment.

3.2.1 Provisioning of relevant information after purchase

After purchase an email is sent to the purchasing entity that includes all relevant information to fulfill the installation. The email looks like this:



The email contains brief step-by-step instructions and links to all relevant document and most important setup and license files (“Download files” Link). Through this link a .zip is provided. It includes the following files:

Filename	Description
.env	File containing all relevant environment variables for the AX MIP instance, such as version, host name information, credentials. Besides other it is used by the docker-compose.yml to setup all containers accordingly. **Note:** Depending on local file explorer settings, this file might be hidden. Modifications to this file should only be made by knowledgeable persons.
docker-compose.yml	The docker-compose.yml file is a configuration file used in Docker to define and manage multi-container applications. It is used to specify the services, networks, and volumes required for AX MIP to run. The docker-compose.yml, defines the different containers in the AX MIP installation, their dependencies, and the configuration options for each container. **Note:** Modifications to this file should only be made by knowledgeable persons.

‹uuid›-‹package›-‹nr›.lic	License file for each purchased AX MIP license. The number of .lic files in that package is equal to the number of licenses purchased through Festo online sales channel. The content of the license has to be copied to activate the license in one specific instance of AX MIP.
mosquitto.conf	File containing the configuration for the external facing MQTT broker that can be used to ingest data to Festo AX MIP. Additionally this MQTT broker can also be used to subscribe to the results of MIP. **Note:** Modifications to this file should only be made by knowledgeable persons.

3.2.2 Pre-Requisites to install and run AX MIP

AX MIP is provided as "docker container application". To run AX MIP, e.g. on an Industry PC, "Docker" must be installed on the device/OS. Please refer to the provided information in chapter 0 or search for preferred and up-to-date installation instructions. This part is not covered in this application note.

It is highly recommended to also know about command line interaction, such as Bash or Windows PowerShell.

For installation, the target device must be connected to the internet (to get the containers). After that, the internet connection can be disconnected again.

3.2.3 Retrieve container from Festo's container registry

Upon purchase you receive an email with instructions and credentials to access our public container registry and retrieve ("download") AX MIP containers.

The address of Festo AX's container registry is:

festoaxregistry.azurecr.io

3.2.4 Authenticate / Login to registry

To authenticate to our registry a login command has to be executed. This authenticates the client to our public Festo AX container registry and allows for pulling of repositories and their stored container(s).

Insert on command line/terminal:

```
docker login -u <user> -p <password> festoaxregistry.azurecr.io
```

The credentials to `<user>` and `<password>` are automatically sent after purchase of AX MIP through our online sales channel, e.g. Festo App World. If not available to reader of this document, get in contact with the people that performed the purchase through our online sales channel.

➔ **Note**

- **In case you can not access this registry, check the firewall settings according to** https://learn.microsoft.com/en-us/azure/container-registry/container-registry-firewall-access-rules

3.2.5 Start with docker compose file

The docker compose file is also attached to the after sales email and is the central setup file to retrieve all containers and set them up in the correct order and configuration. It is configured as an easy-to-use setup. It can be edited and adjusted to individual needs. Note: Modifications to this file should only be made by knowledgeable persons.

Open up a command interface and navigate to the directory where the `docker-compose.yml` is stored.

To start the application enter the following command. Upon first execution or after version changes in the docker compose file, the containers are retrieved from the central repository and installed locally.

Insert on command line/terminal:

```
docker compose up
```

To stop the container from running again, enter the following command:

Insert on command line/terminal:

```
docker compose down
```

3.2.6 Version update

If there is a new version released, the update procedure only needs a `docker compose down`, change of the version tag at the beginning of the `.env` file and run `docker compose up` again like described in 3.2.5:

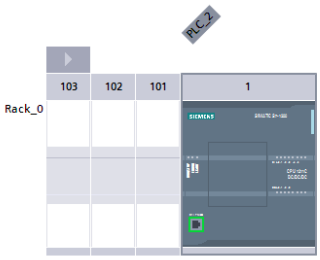
```
##BEGIN OF COMMON SECTION
# Version of the Containerset
VERSION=xx.y.zz
```

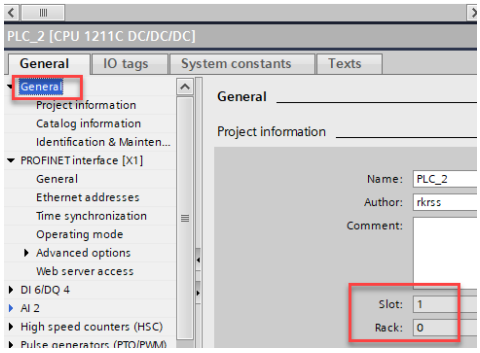
3.3 Running AX MIP Connect Wizard

To establish the connection to AX MIP, some settings must be configured. Browse to `<ip-address>:8007` on your AX MIP installation and follow the instructions of the wizard.

Example of using Siemens S7 connection:

- Add a name for the PLC as ID to recognize the machine etc. later on in AX.
- The rack and slot information of the PLC details are taken from TIA Portal:



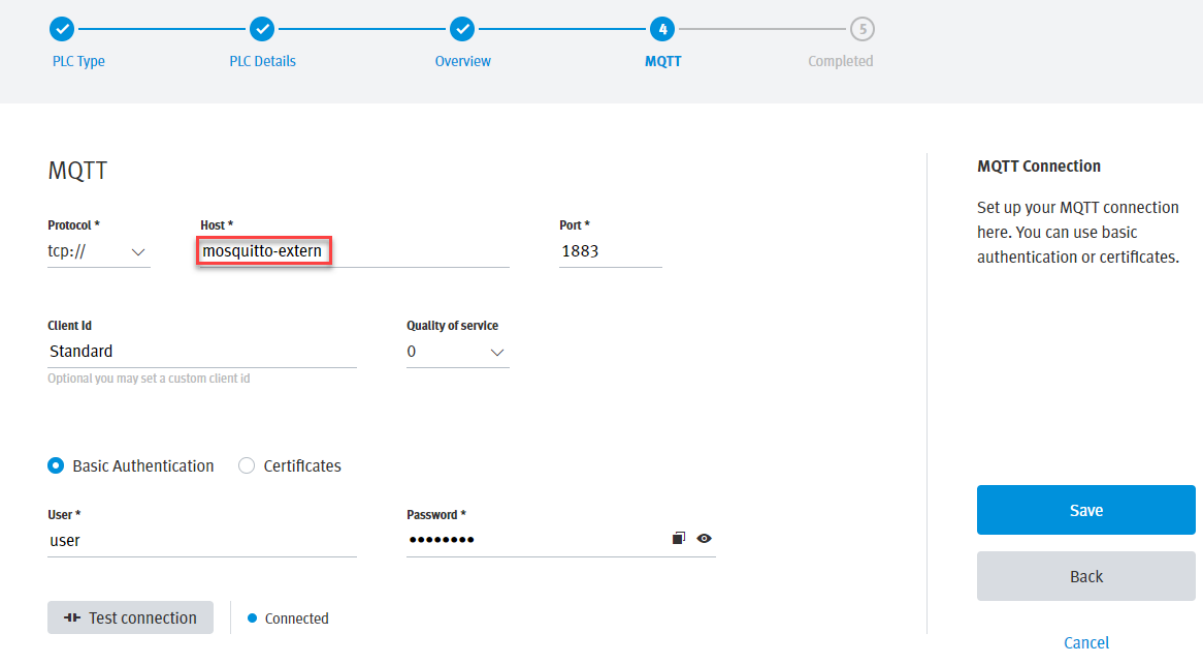


- To add the data blocks that have been created in TIA, click the “+” icon.
- Either single values or ranges to scan can be entered for the DBs.
- The polling interval should be assigned according to the cycle time of the cylinder to be monitored. E.g. if the cylinder moves every 5s, the polling interval can be down to 1s.

➔ **Note**

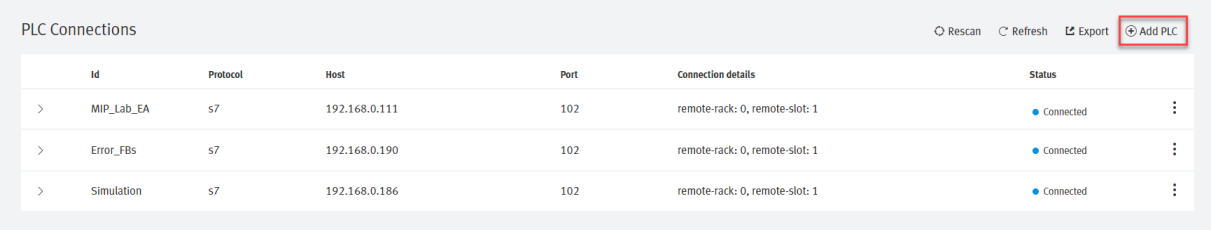
- **Configuration and settings are slightly different with other PLC connections like Beckhoff or Rockwell.**

- For the MQTT connection a broker, which is part of the docker-compose.yml, can be used with standard settings:



- user/PW: the broker is configured to allow anonymous connections, so you can define user and password by your own. Changes can be made in the mosquitto.conf file and/or by adding a password file: [Authentication methods | Eclipse Mosquitto]

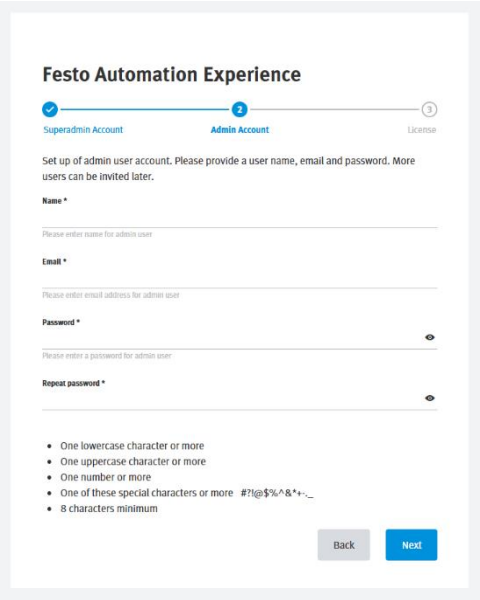
3.3.1 Adding more than one PLC connection



3.4 Initial Setup: user creation and license activation

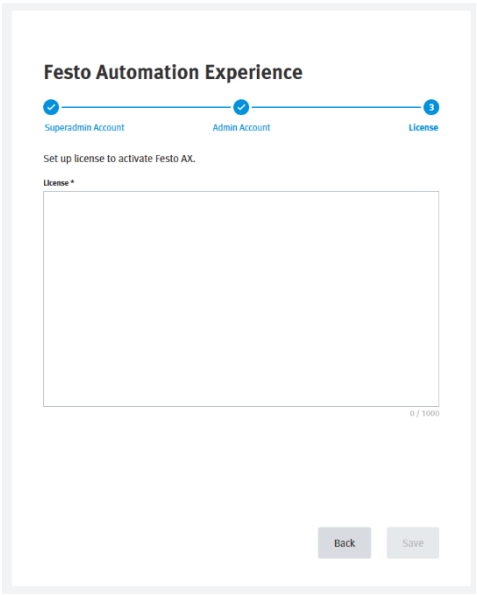
To further work in the main application browse to `<ip-address>` without any additional port information (it uses standard http port 80).

During startup, you will be asked to create initial user accounts for Superadmin and Admin:



In the next step you will be asked for a license key. License keys are provided as files through the after sales email that redirects to the setup package of files.

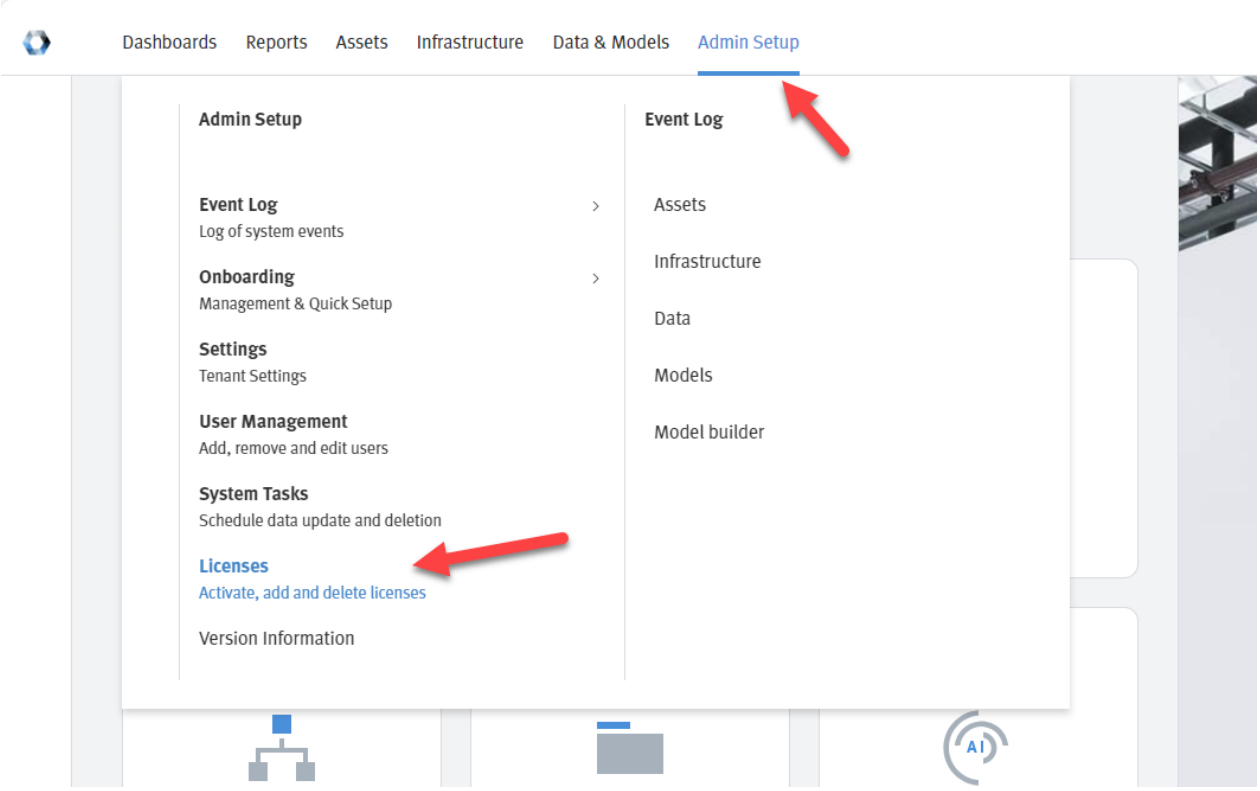
The license files (.lic) include the license key string that is needed to activate a license in one AX MIP instance. Therefore paste the content of your license file (*.lic) into the form:



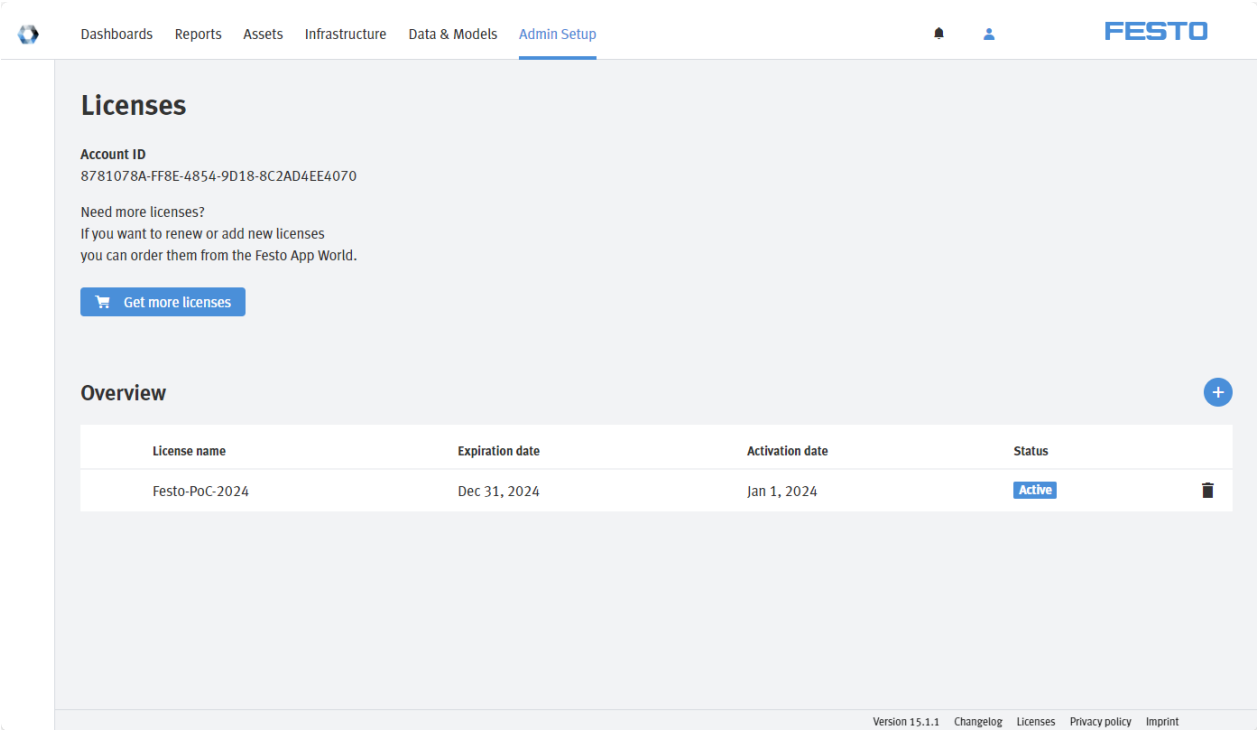
Further licenses can be added later according chapter 3.5.

3.5 Additional licenses

To activate further licenses, please navigate to “Admin Setup” › “Licenses”

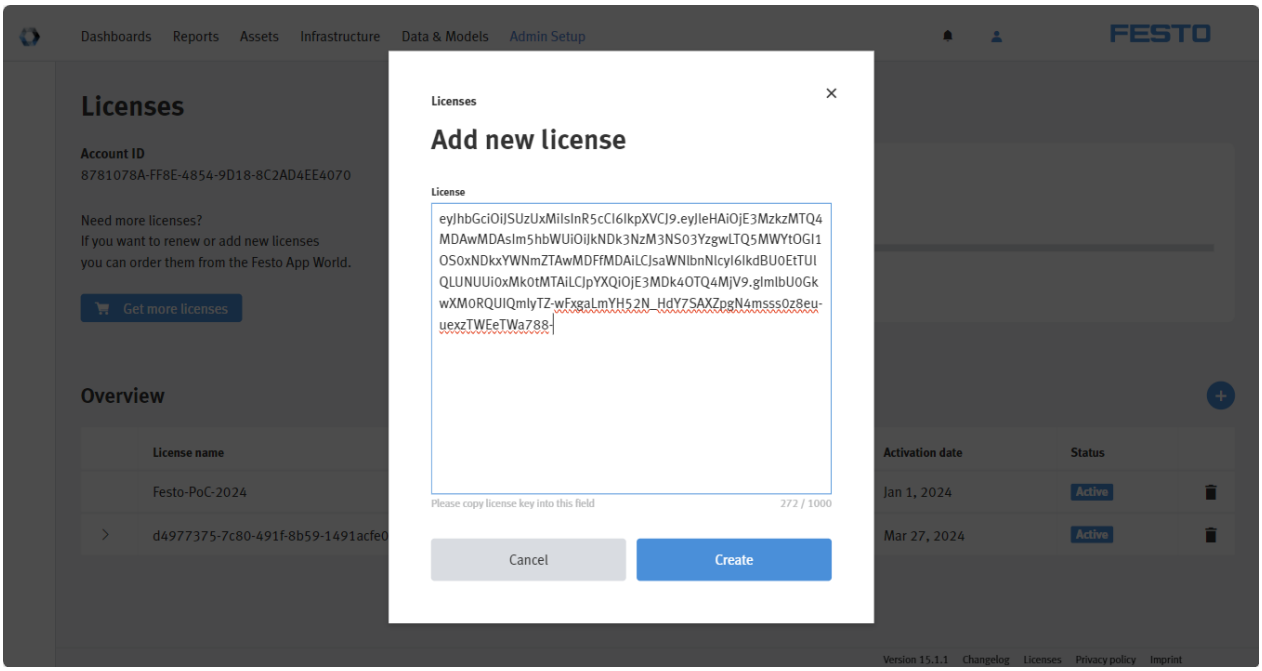


You will be in the license overview page:

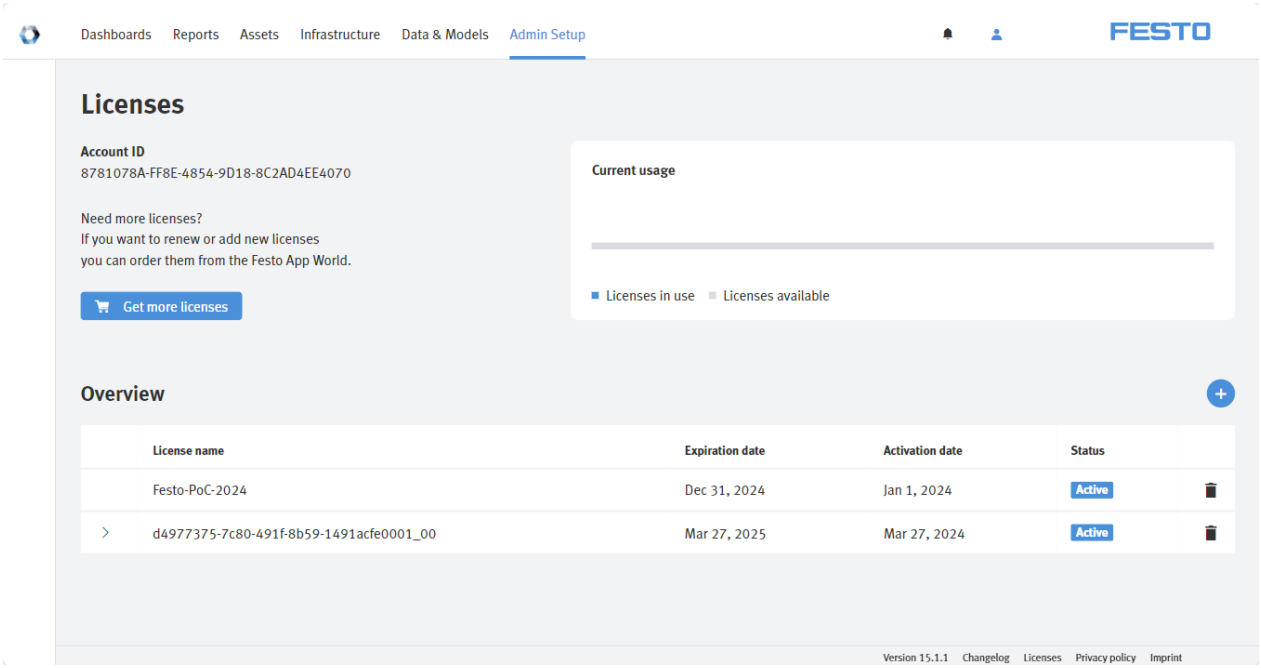


This gives you an overview of the already activated licenses. Furthermore, once assets are onboarded, you will also see the number of already onboarded assets (and the number of licenses left).

By clicking on the (+) button, one can add new licenses to the instance. Therefor paste the content of one your license files (*.lic) into the form:



The license is then added to the instance. Further assets can be onboarded then!



4 Onboarding of Assets

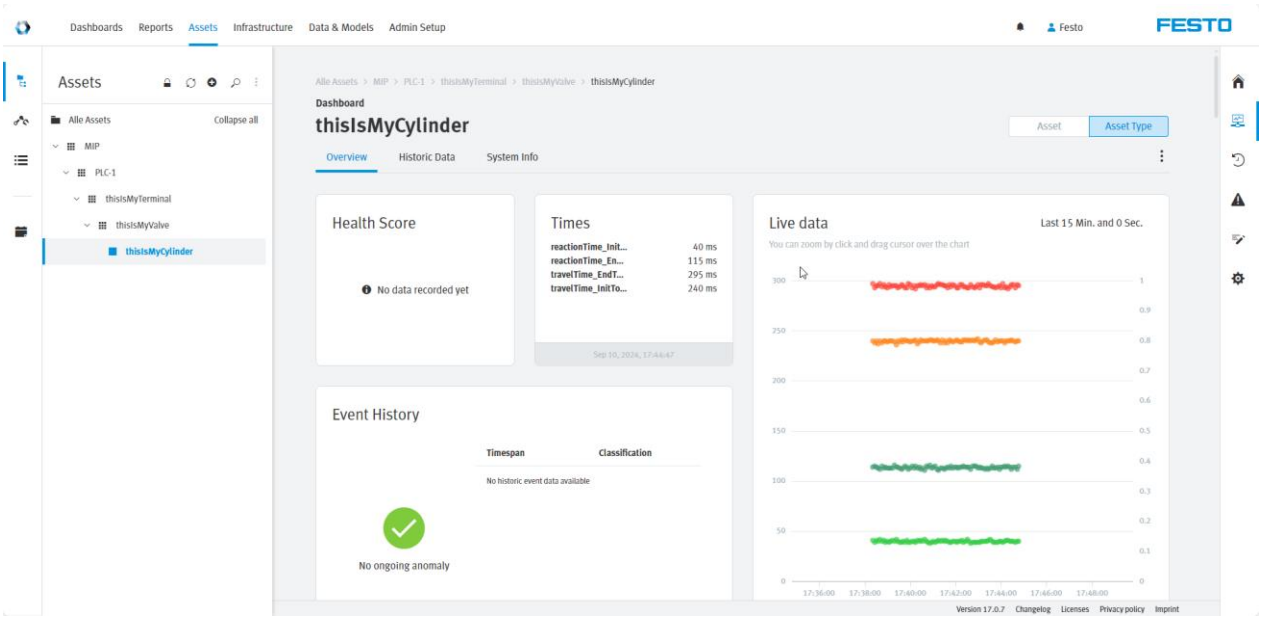
4.1 Automatic Onboarding

Once the connectivity with the PLC function block is set up and the connectivity wizard is completed to set up the connection to the PLC(s), AX MIP Connector scans the PLC for existing assets (identified by data blocks).

⇨ **AX MIP onboards newly found assets automatically to the application!**

These new assets will be shown besides the already onboarded assets in the asset hierarchy (under “Assets”) according to their structure

“PLC Name” › “Valve Terminal ID” › Valve ID › “Cylinder ID”/Asset name.

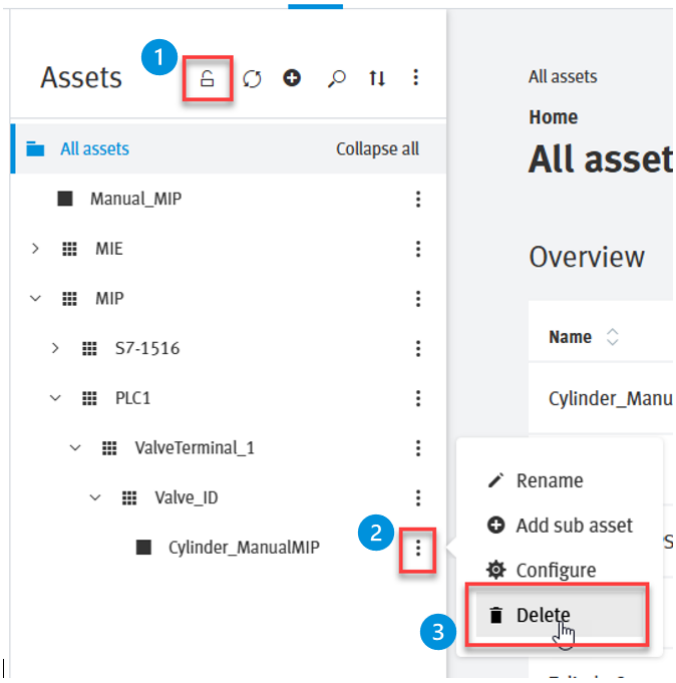


4.2 Manual offboarding / deletion of assets

In case there are assets, that you don’t need to monitor anymore, they have to be deleted in the AX MIP UI manually. Make sure, that you also deactivate the according function block on the PLC or at least the connection in the MIP Connector (see 3.1, exclude the corresponding DB number), otherwise the asset will be auto-onboarded again.

Turn on edit mode of the asset tree, then delete the assets via right click on the context menu of each assets bottom up.

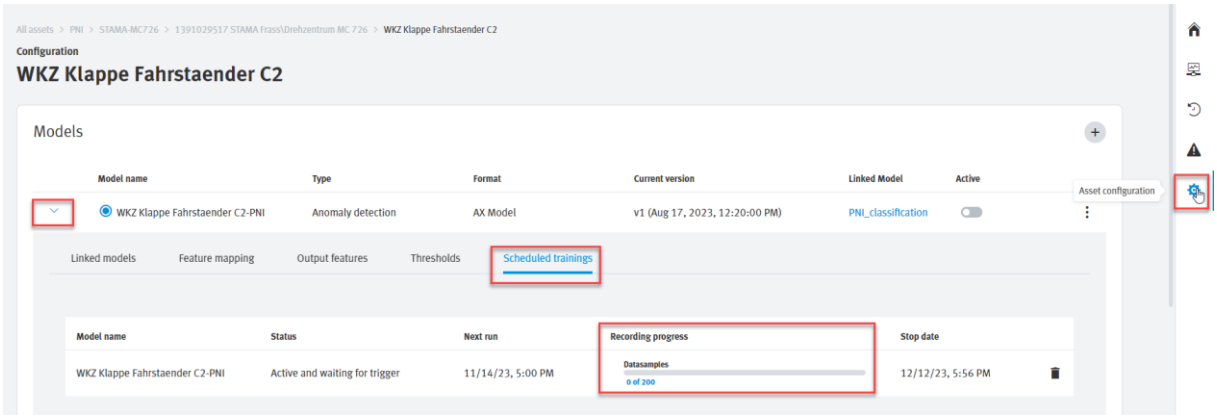
By deleting the assets, the according license will be released then.



4.3 Model-Finetuning / Initial Training

Before the anomaly detection is active, a first initial training has to be finished. Therefore a scheduled training is configured by default. You can check the progress in the asset settings.

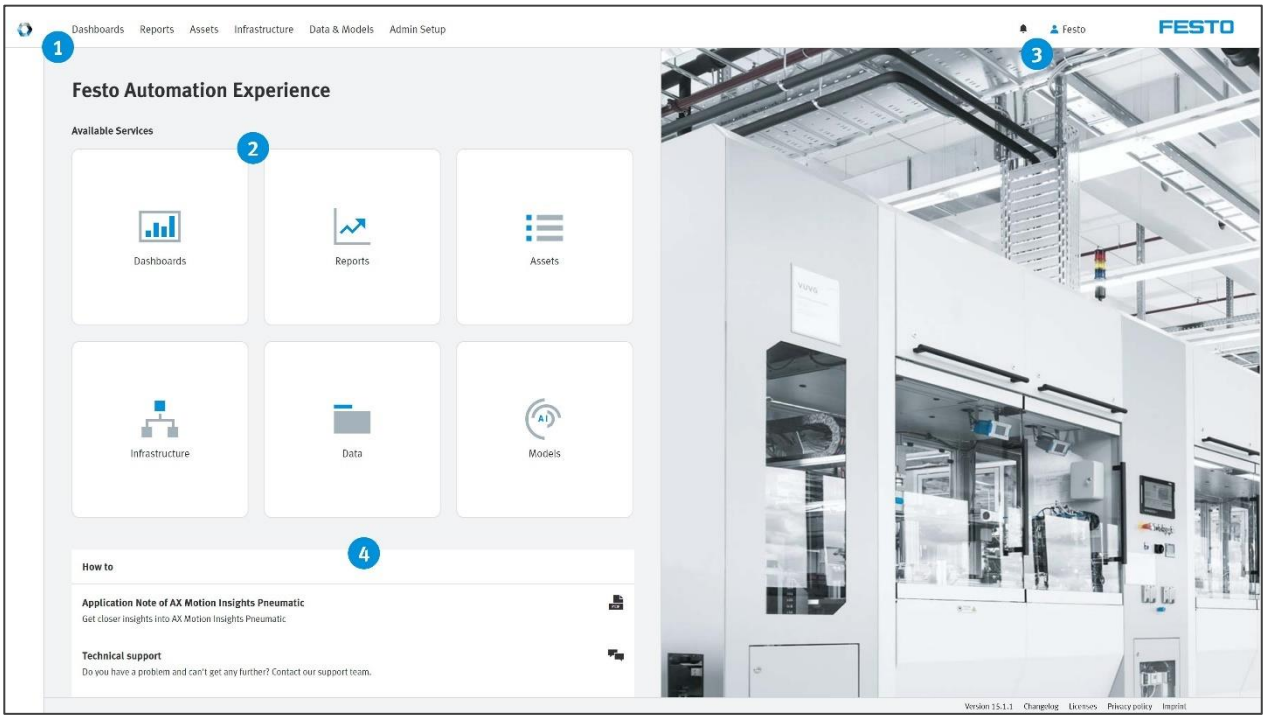
AX MIP needs at least 300 “good” cycles for initialization. “Good” means, the cylinder must be in a good condition working in its usual behavior. This is the “baseline” for the ongoing anomaly detection.



5 When the application is running

5.1 UI Walkthrough

After logging into the application, the user is greeted with the app's start screen. As user with the role "ADMIN", the start screen looks as following:



5.1.1 Main Menu (1)

On the top you'll find the main menu starting from the left, that will bring you to the sub sections of the app. It includes:

Menu point	Description	Remark
Dashboards	Access to build customized dashboards from a selection of widgets with the data coming from onboarded assets with their data points/features.	Only users with ADMIN role
Reports	Access to reports to get dedicated views on events and data in retrospective. First report is "Hierarchical Report" to gain overview of anomalies that have occurred in a specific time range.	All users
Assets	Access to all onboarded assets (here: pneumatic cylinders) with their dedicated dashboards for each asset for live view on the asset state. An asset tree allows for easy navigation in hierarchical structure.	All users
Infrastructure	Expert setting screen to adjust inbound and outbound MQTT broker and other settings.	Only users with ADMIN role
Data&Models	Expert setting screen to work with data sets and trigger new trainings on models.	Only users with ADMIN role
Admin Setup	Access to event log, onboarding settings, general tenant settings, user management and system settings. Furthermore access to license settings to activate new licenses and gain overview about existing license setting.	Only users with ADMIN role

5.1.2 Quick Access Buttons (2)

The buttons copy the functionality from the main menu for fast access.

5.1.3 Notifications and User Profile (3)

The bell icon gives you access to the notification dialog. Here users will be notified about two types of events:

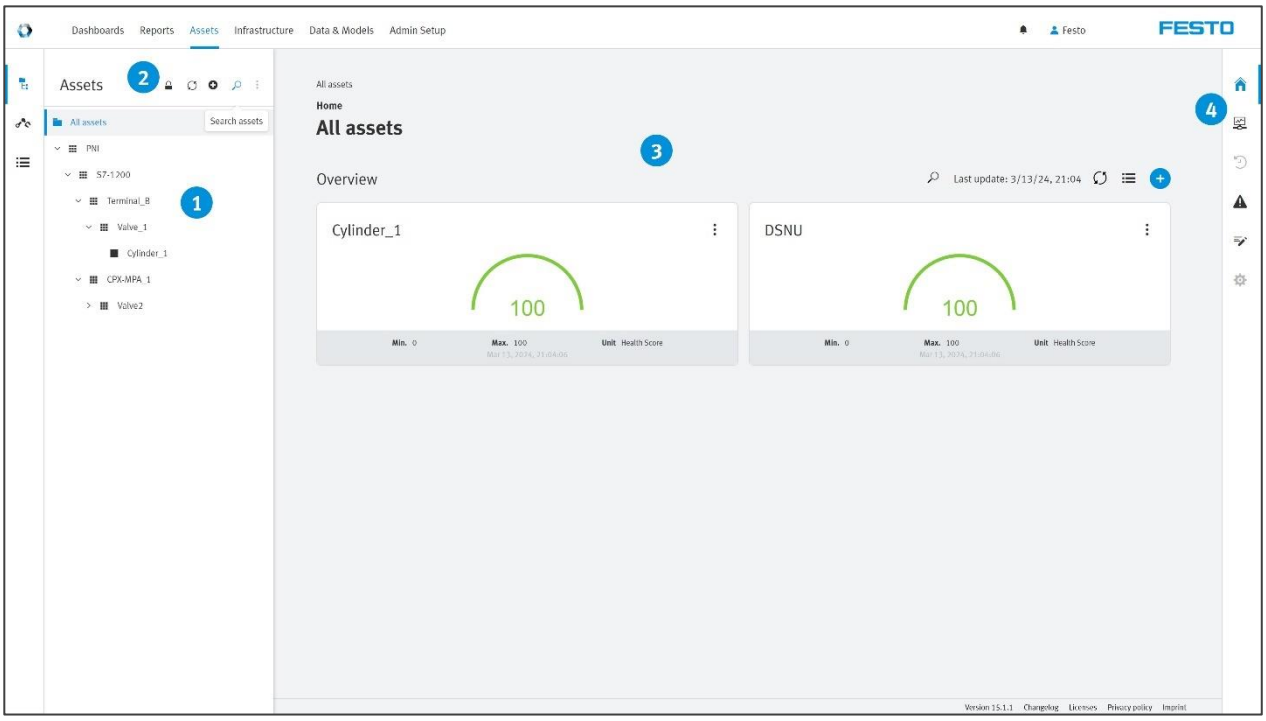
1. Anomaly events
2. Onboarding events

Anomaly events: All anomaly events that occur on the onboarded assets are being triggered as a notification and shown here for direct access.

Onboarding events: Once a new asset has been onboarded to the application, a notification is triggered and shown here. This is especially helpful in the onboarding process.

5.2 Asset Dashboard Walkthrough

Clicking on “Assets” guides you to the assets section that represents one of the core parts of the application. This section gives you structured access to the live data for all onboarded assets.



5.2.1 Asset Tree (1)

The asset tree represents the hierarchical structure of your monitored machine or subsystem. Its branche’s root is the PLC that has been onboarded. Further down the nodes mirror the configuration that has been done in the function block in the PLC.

“PLC Name” › “Valve Terminal ID” › Valve ID › “Cylinder ID”/Asset name

Clicking on the asset name will bring you to the detail screen for the asset.

5.2.2 Asset Tree Controls (2)

These buttons allow you to turn on the edit mode for the asset tree (to modify it), to reload its structure (can be helpful in onboarding phase), to create new assets or to search for a specific one (helpful in scenarios with many assets).

5.2.3 Asset Main Screen (3)

The main screen section displays the respective sub menu content that is selected through the sub menu on the right side. For example: it contains the dashboard section for an asset when “Dashboard” is selected on the right side.

5.2.4 Asset Tree Controls (4)

The sub menu on the right side controls section to show for the asset selected by the asset tree.

	Home Screen for the asset. Contains an overview including the current health score for the asset (or group of assets when a node is selected in the tree).
	**The dashboard for the asset.** There is two sections: the general dashboard that is derived from the asset’s asset type and a dashboard for the individual asset. The latter can be designed individually by the user. The first one gives a great overview and already contains a lot of information about the current state of the asset as well as a look back for a certain time period.
	Access to historic data of the asset. Further offers to export the data selection as csv or to create a new data set in AX from it to train a model with it.
	Event log for an asset. Here all events for the asset, such as anomalies, are collected.
	Upon anomalies, annotation can be added to an event to use in future events.
	Model overview for an asset. Allows for fine tuning of a model and to schedule new trainings, e.g. after component replacement. Expert section.

5.3 Inviting New Users

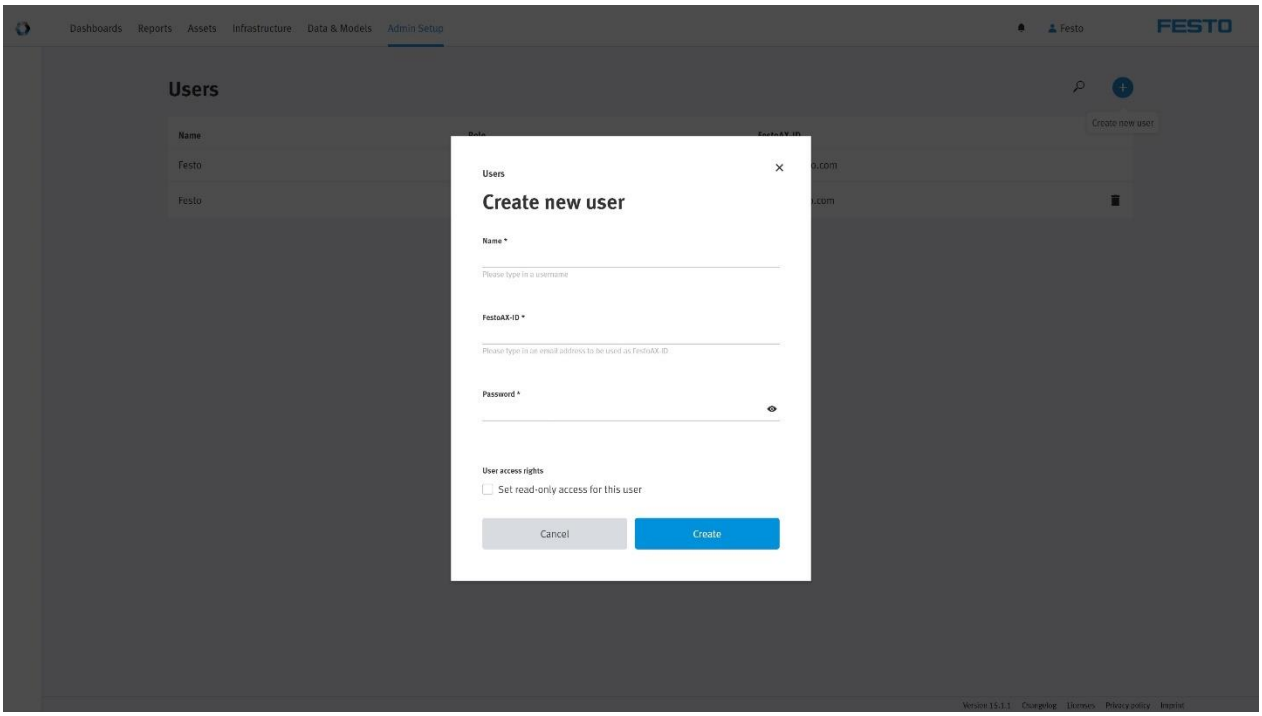
User with role “ADMIN” can invite new users. There is currently no logical limit to users added to the application. New users are added through the “Users” screen. It is reached through

Admin Setup › User Settings › (+) *New User*

Three things are needed for a new user:

- Name: a non-unique name to label the user
- FestoAX-ID: E-Mail address to uniquely identify user (also used for login)
- Password: The password to authenticate the user.

The new user can be set to “read-only”. This allows for accounts that can only view the data but not make amendments.

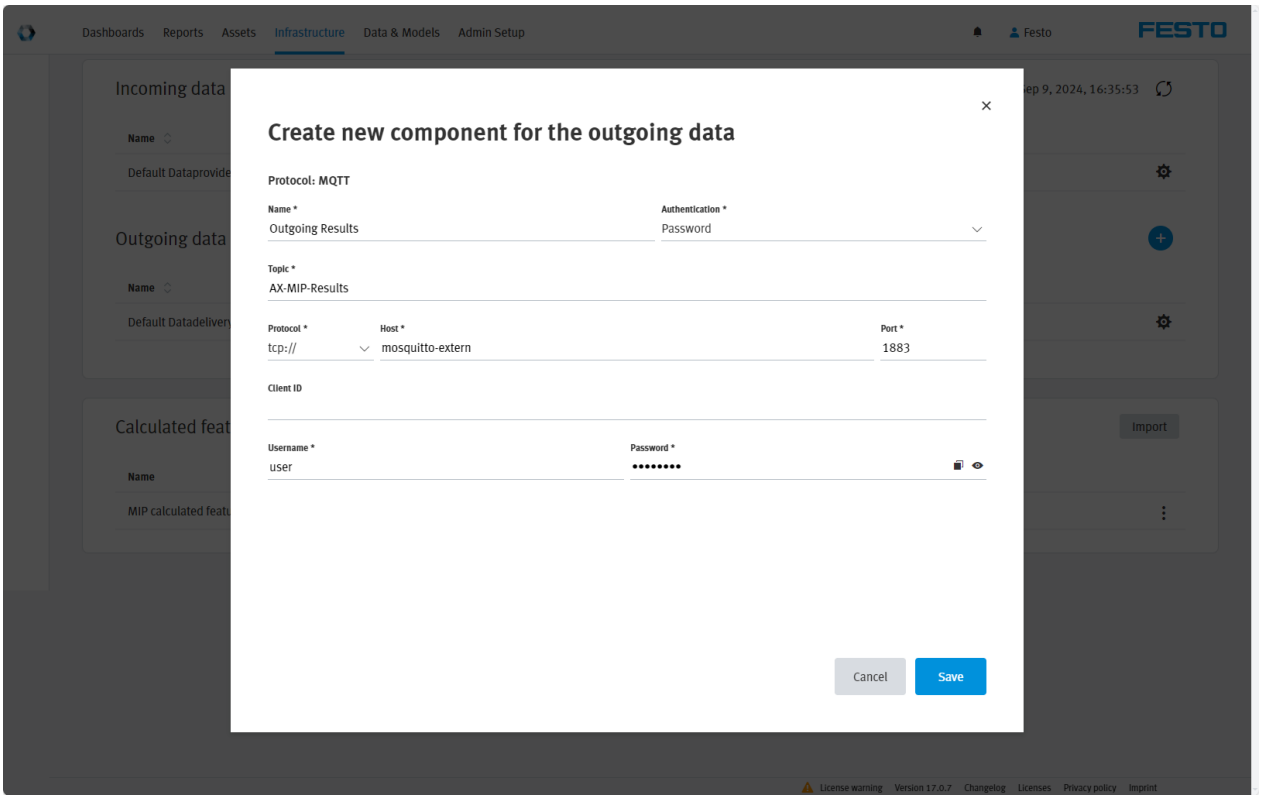


5.4 Outbound MQTT Data Delivery

To use model results like anomaly score or anomaly event in 3rd party systems, an outbound connection via MQTT can be configured. It is reached through

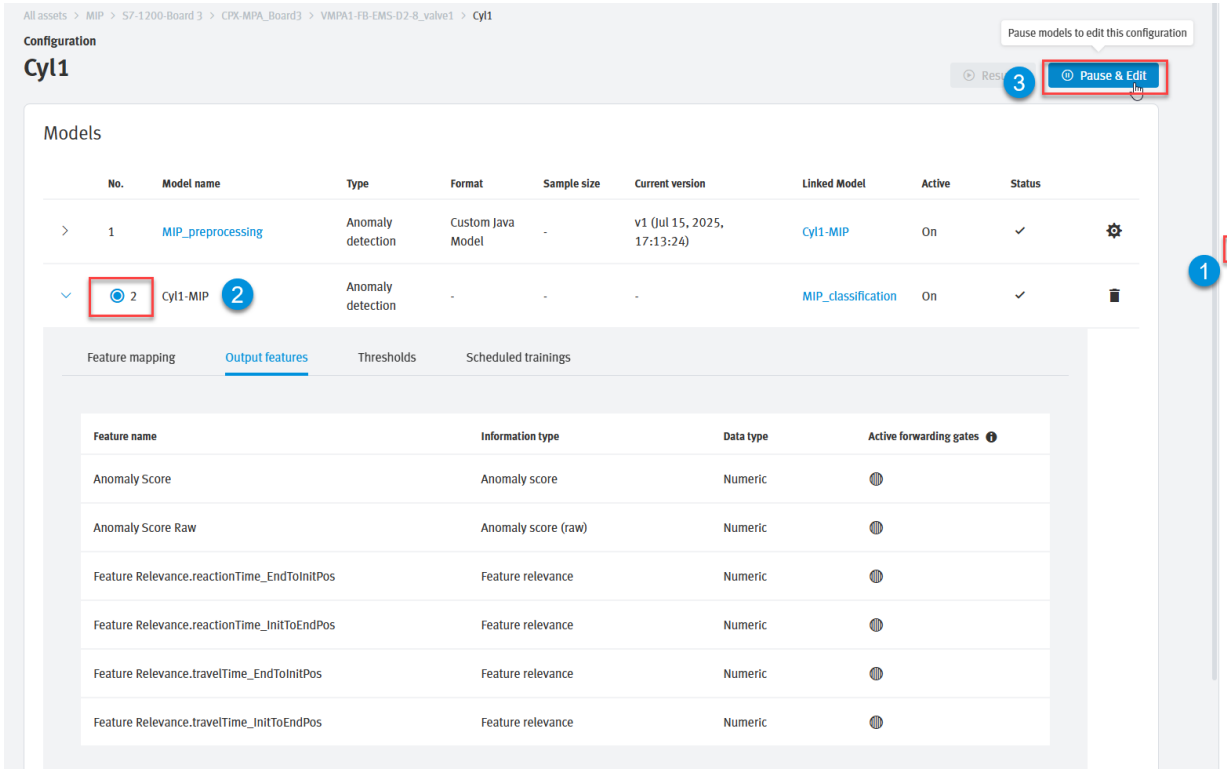
Infrastructure › Field › Outgoing data › Default Datadelivery › (+) *New Component*

The same broker like for the incoming data, which is part of the docker-compose.yml, can be used:

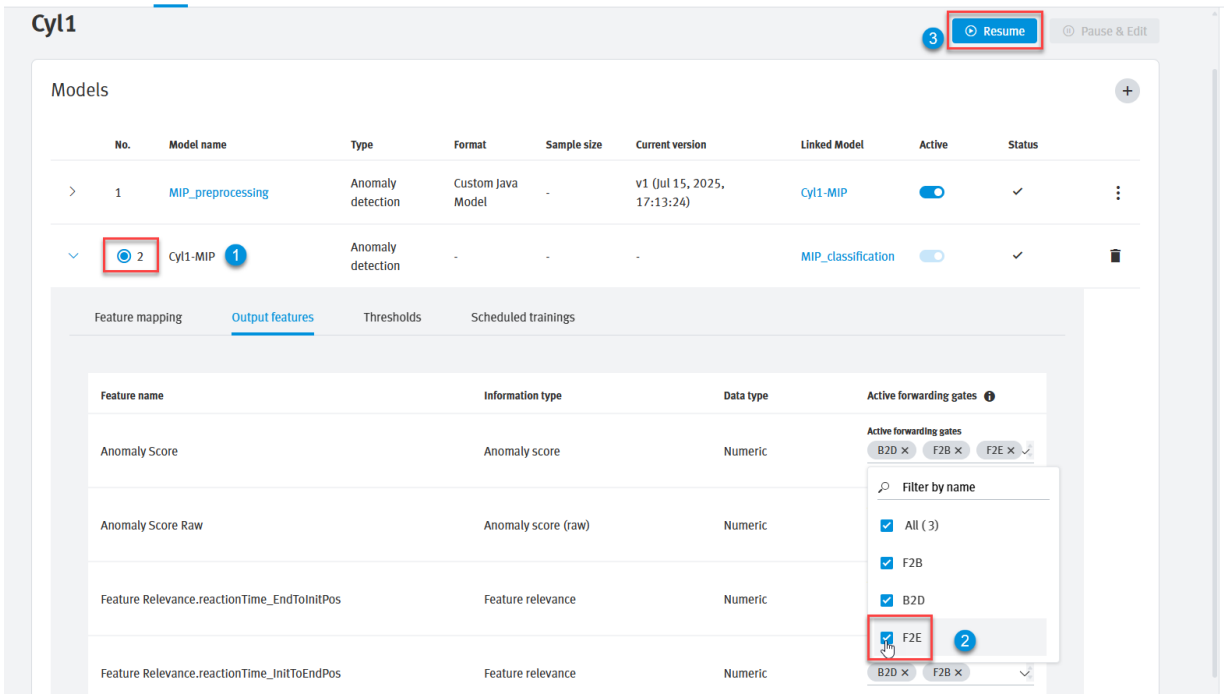


To get results being sent out, the “Field to External (F2E)” forwarding gate has to be activated for the features needed:

- For the according asset, choose the settings and pause the anomaly detection model:



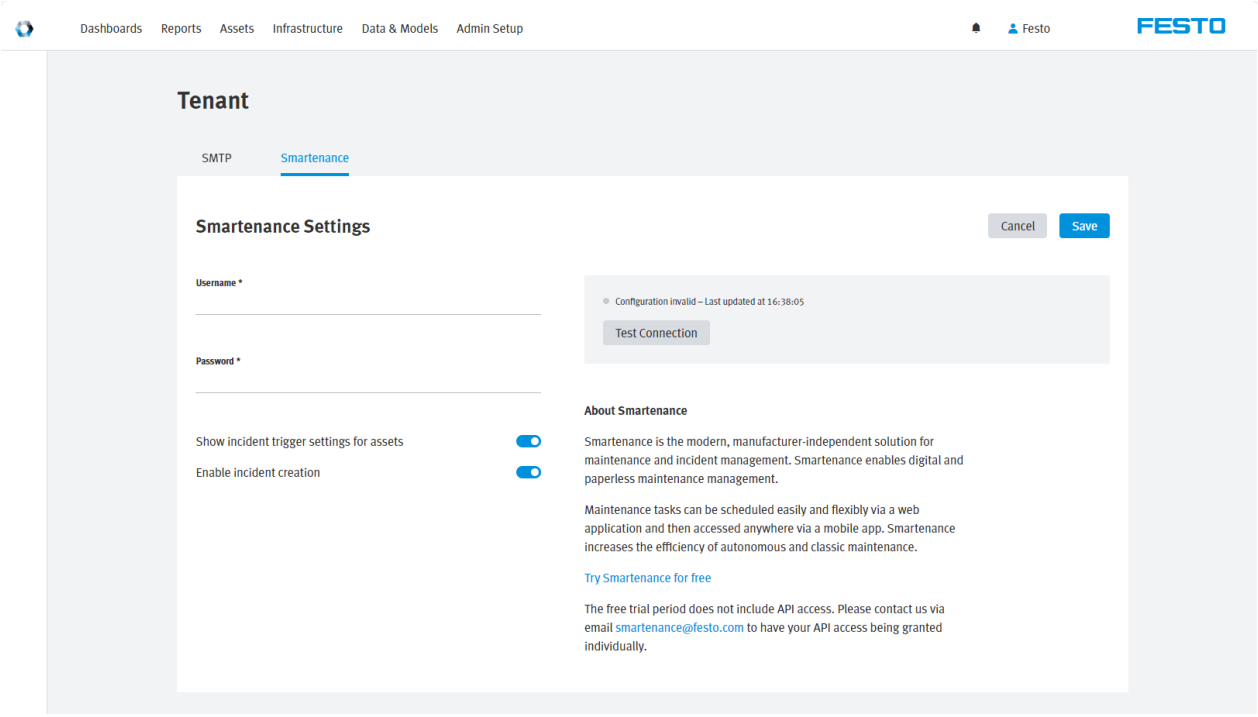
- After pausing the model, the forwarding gates can be adjusted and the anomaly detection model can be resumed:



5.5 Connecting Festo AX Smartenance

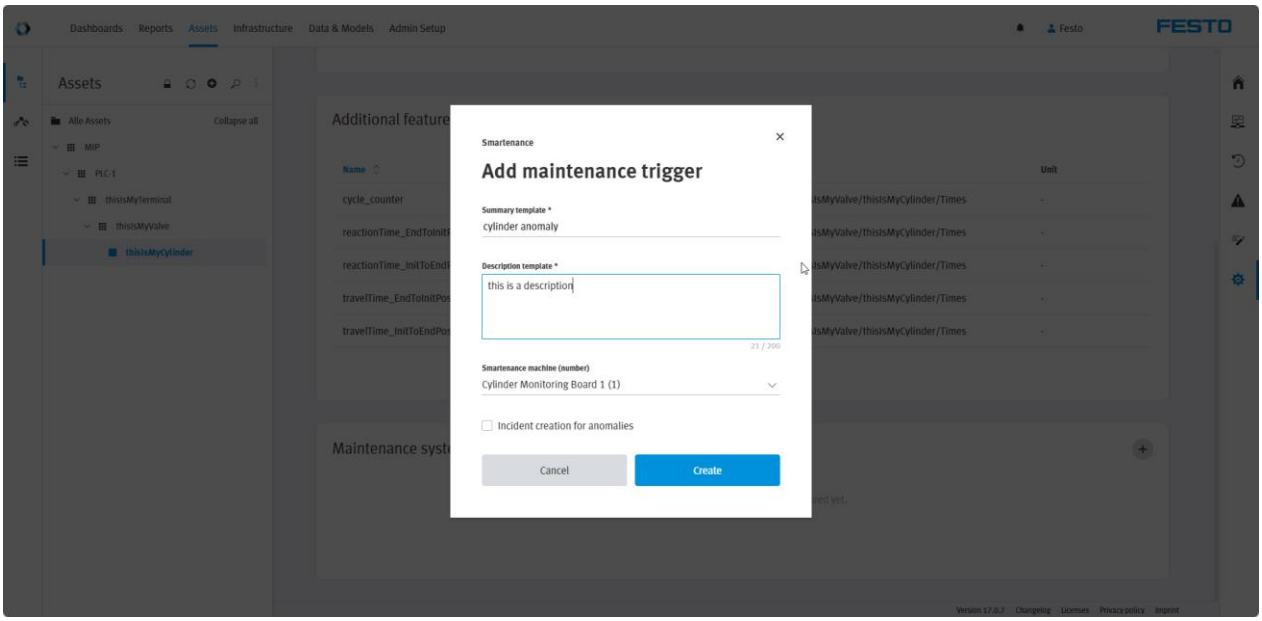
To be able to trigger incidents for specific assets, a premium account for Festo AX Smartenance is needed. Then the API credentials to connect both systems can be added in Festo AX Motion Insights Pneumatic here:

Admin Setup › Settings › Smartenance



After establishing the connection, each asset can be configured to trigger an according incident in Smartenance:

Asset Tree Controls › Asset configuration › Maintenance system triggers › (+) *Add maintenance trigger*



5.6 Deletion of data

Recorded data is deleted by 90 days as a default deletion task. This can be changed by adding a new task and deleting the existing default task:

Admin Setup › System Tasks

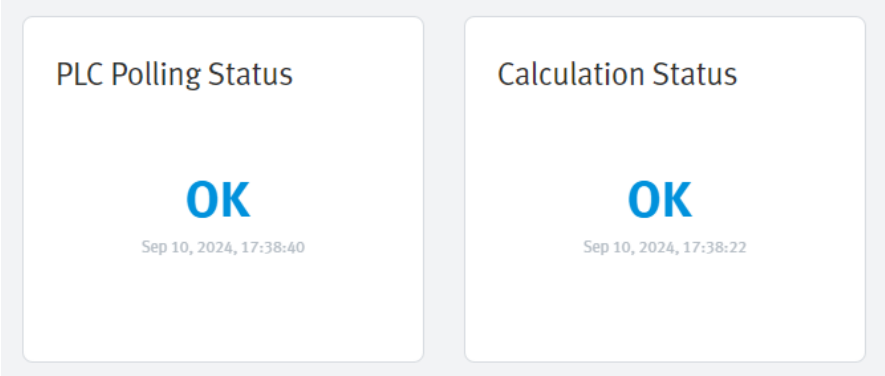
5.7 Debugging: System Info / Status

In case of any unexpected behaviour, the status of connectivity etc. can be checked in the MIP connector as well as in the System Info tab of each asset dashboard.

MIP Connector:

Data Block	Cylinder Id	Valve Id	Valve Terminal Id	Polling Status
1	thisIsMyCylinder	thisIsMyValve	thisIsMyTerminal	✓ HEALTHY

Asset Dashboard:



PLC Polling Status

The polling status is determined by comparing the actual polling rate with the target rate, taking into account a delta value. If there is a deviation, the status is classified as UNHEALTHY.

State in MIP Connector	**Description**
IN CALCULATION	During the “IN CALCULATION” state, it is determined whether the polling is HEALTHY by counting the individual transmissions from the PLC to MQTT.
HEALTHY	The "HEALTHY" state of the polling status is achieved when the transmissions between the PLC and MQTT fall within the specified delta range. In this state, the actual polling rate closely matches the target polling rate, indicating a healthy polling rate.
UNHEALTHY	The "UNHEALTHY" state of the polling status occurs when the transmissions deviate from the specified delta range, indicating an unstable polling rate.
State in asset dashboard	
OK	Is mapped to the "HEALTHY" status in the MIP Connector, but it only changes when the state transitions from another state.
ERROR	Is mapped to the "UNHEALTHY" status in the MIP Connector, but it only changes when the state transitions from another state.

Calculation Status

The "Calculation Status" indicates whether the travel times can be calculated correctly. If the calculation cannot be performed after 8 timestamp value changes, it is assumed that the timestamps are not in the correct order, and the timing is considered to be incorrect.

State in asset dashboard	Description
OK	If the travel times can be calculated, the status is classified as “OK”
ERROR	otherwise “ERROR”

6 Frequently Asked Questions

- **How many cycles do I need to fine-tune the model initially?**

300 cycles of the cylinder are needed to fine-tune the model. These cycles should include all possible variants of the cylinder (e.g. different weights).

- **What actuators does AX Motion Insights Pneumatic work for?**

It works for linear pneumatic actuators with two limit switches attached (to detect end position). So:

- Piston rod cylinders
- Rodless cylinders
- Clamp cylinders
- Pneumatic Grippers

Generally it works for all linear actuators, for which this formula is true:

Travel time actuator	***GREATER THAN***	**ten times PLC cycle time**

- **Can I install Motion Insights to an existing installation or do all the actuators have to be new at start up?**

Motion Insights can be installed on existing, running installations as well as new ones. Cylinders should be in good condition and running optimally. It is great to onboard cylinders especially after a recent maintenance.

- **What happens to the monitoring when an actuator is replaced by a new one?**

You need to retrain the AI for 300 cycles to re-establish norms.

- **Does AX Motion Insights Pneumatic work with non-Festo cylinders?**

Yes it does. Generally all pneumatic cylinders that fulfill the criterias defined above.

- **My PLC vendor is not yet officially supported by AX MIP. What can I do?**

Festo updates the support for other PLCs continuously. Generally all modern PLCs can be added with slightly more individual effort (lacking the plug'n'play approach described in this document). Please get in contact with Festo through your contact person to discuss individual challenges.

- **I have specific questions. How can I get in contact?**

Get in contact with your Festo contact person or through https://www.festo.com/contact

- **I also have other motion components, e.g. electrical axis. Can I monitor them as well?**

A standardized AX Industrial App for e-axis-monitoring is also available, Motion Insights Electric. Generally the Festo AX Industrial Intelligence suite can be used to tackle various challenges. Find out more here: https://www.festo.com/ax

- **The machine is running but I don't see any data or anomaly score calculated. What is the reason?**

There's different reason why no anomaly score is calculated and no data received although everything seems to be set up correctly and machine is running.

- Check for the parameter "ENABLE" in the function block. This must be set to **true**!
- Check for the parameter "bAutomaticMode" in the function block. Only data is taken into account that is generated while this parameter is set to **true**!
- The machine might be running but are the monitored cylinders moving?
- Is everything wired correctly with the function block?

- **Can I use limit switches with N/C (normally closed) contacts?**

Generally yes, but the signals have to be inverted in the PLC before connecting to the function block. The function block expects N/O (normally open) contacts.