



Asset Framework and PI System Explorer (PI Server 2024)

2024

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Welcome to PI System Explorer

Asset Framework (PI AF) enables you to use PI System Explorer to define a consistent representation of your assets and provide a structure for your data. For example, plant operators can view data associated with physical assets, such as equipment, devices, and processing units. With PI AF, you can identify the components or elements that make up a process, specify relationships between these objects, and organize them to help you find the information you need quickly and easily.

Get started with PI System Explorer

With Asset Framework (PI AF), you can represent assets and processes as PI AF objects and structure them to provide value to your business.

PI System Explorer (PSE) and PI Builder are the primary tools that you use to create and manage PI AF objects. Both tools include support for the following features:

- **Event frames**

With event frames, you can capture important process events and collect relevant data around them to help analyze why they occurred. See [Event frames in PI AF](#) for more information.

- **Asset analytics**

Integrated into PI System Explorer, you can use asset analytics to create calculations and set up conditional statements involving asset values. See the "[Asset analytics](#)" topic in the *Analytics and Notifications* publication for more information.

- **Notifications**

Integrated into PI System Explorer in PI AF 2016 R2, you can use notifications to create rules by which users can be alerted in real time to anomalous conditions in the system. See the "[Introduction to notifications](#)" topic in the *Analytics and Notifications* publication for more information.

How assets are represented in PI AF

PI Asset Framework (PI AF) enables you to build a representation of your equipment and processes that can give you tremendous insight into your data. In PI AF, the equipment and processes that you want to monitor are called assets. The PI AF representation of all your assets and processes together is called an asset model. The asset model organizes all your equipment into a structure that makes it easy to find information.

In the PI AF asset model, each piece of equipment is represented by an element. The associated data for an element is stored as attributes on the element. Attributes can hold simple values, representing fixed information, such as the diameter of a tank. An attribute can alternatively reference a PI point, a formula, a value from a relational database, a file, a photograph, and more. All relevant data about an asset is tied to the element representing that asset.

For example, suppose you have a pump with three associated pieces of data: the pressure (read from a PI point), the inlet temperature, and the outlet temperature. To model this in PI AF, you can create a PI AF element to represent the pump and then create three attributes to represent the associated data.

The following illustration shows how the data might look in PI AF. Although all the values are PI point values, the user never needs to know the names of the PI points. All the data is available directly on the element.



Name	Value
Head Pressure	92.1994592
Temperature Inlet	15 deg C
Temperature Outlet	16 deg C

Video

For information on assets and attributes, watch this video:

PI System Explorer

PI System Explorer provides a graphical user interface for creating, editing, and managing PI AF objects. Use PI System Explorer to create and manage your asset framework, including PI AF databases, elements, and templates.

Random and Ramp Soak interfaces removal

Starting with PI Server 2018 SP3, the Random and Ramp Soak interfaces are no longer installed by default with a new PI Data Archive installation. Optionally, you can install them by using separate install kits: the PI Interface for Ramp Soak Simulator Data and the PI Interface for Random Simulator Data. After installing these interfaces, follow the instruction provided by the interface install kits to create default PI points and then receive simulated data from these interfaces. For upgrades, previous versions of Random and Ramp Soak interfaces will remain and the default PI Points will continue to retrieve simulated data.

Prior to PI Server 2018 SP3, the following default PI points are created automatically with the PI Data Archive

install kit:

- BA:ACTIVE.1
- BA:CONC.1
- BA:LEVEL.1BA:PHASE.1
- BA:PHASE.1
- BA:TEMP.1
- CDEP158
- CDM158
- CDT158
- SINUSOID
- SINUSOIDU

PI System Explorer versions

On computers with a 64-bit operating system, both a 32-bit and a 64-bit version of PI System Explorer are available after a PI AF client installation. Beginning with PI AF 2017, the 32-bit version is labeled **PI System Explorer Legacy 32-bit**, whereas the 64-bit version is labeled simply **PI System Explorer**.

The legacy 32-bit version is available should you need to continue to use the legacy version of Notifications (prior to the 2016 R2 version) and its contact editor. This version of the contact editor is required to work with legacy delivery channels. For more information on notifications, see the "Notifications" topic.

Support for FIPS

Beginning with PI AF 2017 R2, PI AF supports Windows environments that enforce the use of U.S. Federal Information Processing Standards (FIPS) cryptographic algorithms. No additional configuration is required once the local security policy **System cryptography: Use FIPS compliant algorithms for encryption, hashing, and signing** has been enabled.

To be in compliance with FIPS, users who need to use passwords to link to external tables can only use PI AF 2017 R2 or later clients and servers. Furthermore, users cannot export data from a PI AF database that contains table passwords created with a PI AF 2017 R2 or later client and import those passwords to PI AF clients on older releases. For more information on linking to external table data references, see [Data references from outside the PI System](#).

Sign on with OpenID Connect (OIDC)

You can use claims-based authentication via Open ID Connect (OIDC) to sign on to PI System Explorer (PSE). OIDC uses an identity service to verify a user's identity and then grant access to AF client and Data Archive resources via access tokens. The AVEVA Identity Manager is the provided identity service for PI Server 2023.

Once you have successfully signed on with OIDC, the same access token is used to authenticate and gain access to other PI server resources. If a server does not use OIDC authentication, it defaults to Windows authentication.

When first opening PSE, the initially selected authentication mode is used for all default and implicit connections made during that session. To switch the authentication mode used to connect to a specific PI Server resource, you can use the Connect As command. See [Connect to a PI AF server](#), [Connect to Data Archive](#), and [Connect to a](#)

database on a different PI AF server.

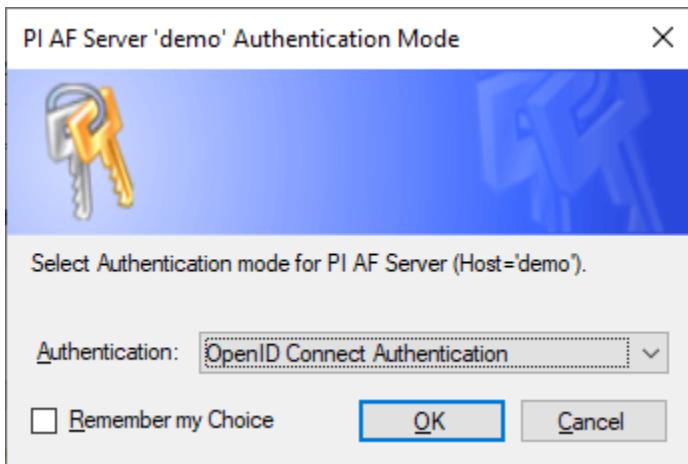
If OIDC is not enabled on a resource, Windows authentication is the default authentication mode.

Prerequisite

You must have created and assigned a user account to an Identity Server role, set permissions, and created a mapping.

1. Open PI System Explorer.

The **Authentication Mode** dialog opens.



2. Select the **Authentication** down arrow, then select **OpenID Connect Authentication**.

Note: If you selected **Windows authentication** to log on, PI System Explorer opens.

3. Optional: Select **Remember my Choice** in the **Authentication Mode** dialog to preserve your preferred authentication method, and bypass the dialog for future server connections.

4. Select **OK**.

The **AVEVA Identity Manager** browser window opens and then a second browser window opens and prompts for your sign-on credentials.

5. Enter your OIDC credentials (user name and password) in the browser window, then click **OK**.

6. In the AVEVA Identity Manager browser window, select **Yes/Allow** to enable sharing your identity.

The PI System Explorer window opens.

Note: User permissions are set up via role assignments in AVEVA Identity Manager.

7. Optional: To verify the authentication mode assigned to a user, select **File**, then select **Connections**.

The **Servers** dialog opens and lists server connections by user and authentication method: AIM (claims-based) or Windows.

Sign out of OpenID Connect

To initiate a single, automatic logout of all claims-based connections, you need to sign out of OpenID Connect (OIDC). When you use the Log out command to end a claims-based connection with a PI System server, the following actions take place:

- The user's claim-based session with the Identity service ends
- All connections to PI System servers associated with the same identity end
- The connection objects are cleared of all information related to the claims-based session including the access token
- You prevent your PI System data from being misused

Sign out of OIDC

- Select **File**, then select **Connections**.

The **Servers** dialog opens.

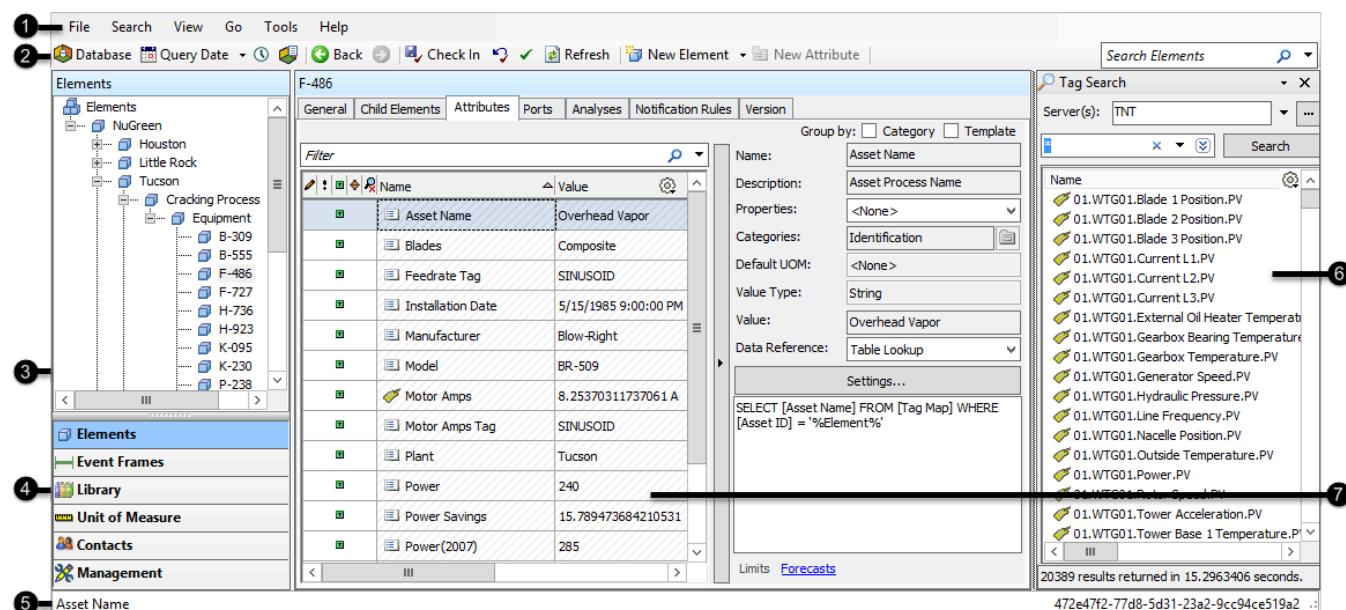
- Right-click one of the servers you connected to using OIDC, then select **Log out**.

The user is logged out of the Identity service, PSE, and all other PI System connections associated with the same identity. The Identity service's browser window opens and displays the **Logged Out** message.

- Close the Identity service's browser window.

PI System Explorer user interface components

The following illustration shows the major components of the PI System Explorer.



- Menu bar
- Toolbar
- Browser
- Navigator
- Status bar
- Palette
- Viewer

Videos

For information on PI System Explorer browser and navigator, watch this video:

For information on PI System Explorer palette and viewer, watch this video:

Feature suggestions

Beginning with PI AF 2017, you can make suggestions on features you would like to see added to the AVEVA™ PI System™. You can also review suggestions that other users have already submitted and vote for those you approve of. You can select from the following categories for your suggestion:

- Analytics and Calculations
- Asset Framework
- Data Archive
- Event Frames
- General
- Help/Documentation/Videos
- Installation
- Notifications
- PI Builder
- Security
- System Management

To provide feedback, you select **Help > Give Us Feedback** and click **Sign in**. You can type your feedback into the **Enter your idea** field, select an appropriate category, and provide additional details as needed.

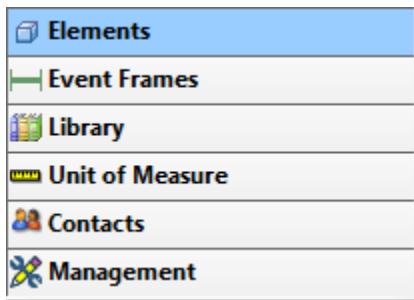
PI System Customer Experience Improvement Program

The **Customer Experience Feedback Option** on the **Help** menu enables you to participate in the telemetry program that collects anonymous usage data to improve the PI System and to prioritize new features. The collected data does not include business data or logic, but can include information such as IP addresses, host names, and names of PI System objects.

To participate in the telemetry program, you select **Yes, I would like to participate (Recommended)** and click **OK**.

PI System Explorer browser and navigator

The content of the PI System Explorer browser depends on which button is selected in the navigator. The default available objects in the navigator are elements, event frames, library objects, units of measure, and contacts. The management object is also displayed if the Management plug-in (which encompasses analyses and notification rules) is installed.



Note: If legacy notifications are installed on a PI AF client computer, MyPI and Notifications may also be displayed in the navigator.

You can move very quickly between browser objects in PI System Explorer with the following keyboard shortcuts. Notice also that different colors are displayed at the top of the browser and viewer to help distinguish between selected browser objects:

Shortcut	Browser
CTRL+1	Elements
CTRL+2	Event Frames
CTRL+3	Library
CTRL+4	Unit of Measure
CTRL+7	Contacts
CTRL+0	Management

Customize the navigator

To increase the space available on your screen for objects in the browser, change the buttons in the navigator to icons.

1. Right-click in the navigator and click **Navigation Pane Options**.
2. In the Navigation Pane Options window, clear the check box beside each component on the **Display Full Button** list.
3. Click **OK**.

The rows of button labels are replaced by a single row of icons.



4. Move your cursor over an icon to display its label.

PI System Explorer customization options

You can customize many aspects of PI System Explorer to suit your needs with **Tools > Options**.

General tab

You use the **General** tab to control display options for several features. You can control:

- Keystroke to open Check-In and Undo-Checkout windows. For more information, see [Check-in of database changes](#).
- Title bar appearance.
- Page size for browser objects. For more information, see [Configure browser page size](#).
- Number of queries returned in object searches. For more information, see [Search result paging](#).
- Unit of measure appearance for attributes. For more information, see [Show attribute values in source unit of](#)

measure.

- Display of attribute values to the units of measure that are mapped to a selected UOM group. When no UOM group is selected, attribute values are based on the default UOM defined in attribute templates or their source unit of measure (if **Use Source Unit-Of-Measure for attribute display** is selected). For more information, see [UOM groups](#).
- Display of excluded attributes. For more information, see [Excluded attribute property](#).
- Number of digits displayed for attribute values. For more information, see [Control the display of attribute and attribute template values](#).

Time Context tab

You use the **Time Context** tab to define the time or time range that PI System Explorer uses to display attribute values. For more information, see [Set time context for displayed attribute values](#).

Server Options tab

You use the **Server Options** tab to define how PI System Explorer should connect to a PI AF collective or Data Archive collective. For more information, see [Manage connection preferences for PI System Explorer](#).

Show attribute values in source unit of measure

For attributes that are defined by data references, you can have their values displayed in the units of measure that are defined by the data reference, rather than in the default units of measure that are established in attribute templates.

1. Select **Tools > Options**.
2. On the **General** tab, select **Use Source Unit-Of-Measure for attribute display**.
3. Click **Apply**.
4. Click **OK** to close the window.

Change the unit of measure for displayed attribute values

During your current session in PI System Explorer, you can change the unit of measure (UOM) that is displayed for an attribute value from its default or mapped value.

1. In the **Attributes** tab of the **Elements** or **Event Frames** viewer, right-click the value for an attribute and click **Change Display UOM**.
2. In the Select Display UOM window, select a new UOM for the value from the **Display UOMs** list.

Note: The list contains all UOM values in a class. <Default> is displayed beside the default UOM. If you have selected a UOM group in **Tools > Options** and the selected UOM group has a mapping for the attribute's default UOM, <Mapped> is displayed beside the mapped UOM.

3. Click **OK**.

Column display configuration

Property columns

Whenever data columns are displayed in the viewer or a search results window, you can customize which property columns you wish to view. At the far right of the window, you can click  and select additional column selections or clear default column selections.

Attribute columns

In viewer or search results windows for elements and event frames, you can also select attribute columns and display them as columns alongside the default property columns. An attribute column is identified by the | character.

Select attributes to display as viewer columns

For collections of **Elements**, **Element Searches**, **Event Frames Searches**, and **Transfer Searches**, you can select attributes to display as columns in the viewer, in addition to default properties. Note that you cannot add attributes from a **Transfer Searches** collection

1. In the navigator pane on the left, choose one of the following actions:
 - To select attributes for **Elements** and **Element Searches** collections, click **Elements** ().
 - To select attributes for **Event Frames Searches** and **Transfer Searches** collections, click **Event Frames** ()
2. In the browser, click the collection for which you want to select attributes.
3. At the far right of the viewer, click .
4. Click **Select Attributes**.
5. In the Select Attributes window, choose from the following options to select the attributes that you want displayed in the viewer:
 - a. Add attributes from a template:
 - i. Select the **Add Attributes from Template** option.
 - ii. Select a template from the list.
 - b. Add attributes from an element or event frame:
 - i. Select the **Add Attributes from Element/Event Frame** option.
 - ii. Choose from the following actions:
 - a. To search for an element or event frame, click  and enter criteria to locate attributes in the Element Search or Event Frame Search window.
 - b. To select an element or event frame from the browser tree, click  and select from the Element Browser or EventFrame Browser window.
 - i. Click **OK**.
 - c. Add other attributes:

- i. In the **Others** field, enter attribute names separated by a semicolon, or click  and enter criteria to locate attributes in the Attribute Search window.
 - ii. Click **Add**.
- Selected attributes are displayed in alphabetical order in the left-hand **Attributes** or **Attribute Templates** list. For added convenience, you can group them by category or template by selecting one of the **Group by** check boxes. You can also filter them if necessary with further search criteria.
6. From the **Attributes** or **Attribute Templates** list, select the attributes you want to display in the viewer.
 - a. Use standard Windows selection keystrokes (such as SHIFT+<click> and CTRL+<click>) to select contiguous and non-contiguous attributes in the list, as described in [Select multiple objects in the viewer](#).
 - b. Click  to move selected items or  to move all items to the right-hand **Attributes** list.
 7. Optional. Adjust the order that attributes will be displayed in viewer columns:

To ...	Do this ...
Move an attribute up the list	Select an attribute below the top row and click  .
Move an attribute down the list	Select an attribute above the bottom row and click  .
Remove an attribute from the list	Select an attribute and click  .
Remove all selected attributes	Click  .

8. Optional. You can add additional attributes as required, for example from another template. Repeat steps 5 to 7.
9. Click **OK** to complete the attribute selection.

The selected attributes are displayed as columns in the viewer.

10. Optional. You can control which selected attribute columns are displayed in the viewer:

To ...	Do this ...
Remove an attribute column	<ol style="list-style-type: none"> a. Click . b. Click Attribute Columns. c. Clear the attribute you want to remove.
Remove all attribute columns	<ol style="list-style-type: none"> a. Click . b. Clear Show Attribute Columns.

Select multiple objects in the viewer

In the viewer, use standard Windows mouse and keyboard combinations to select more than one object to complete operations such as copying, deleting, exporting, checking items in and out, as well as changing templates.

1. To select a group of contiguous objects in the viewer, click one object, move the cursor to the end of the group, press SHIFT and click the last object in the group.
2. To select non-contiguous objects, press the CTRL key as you click each object in the viewer.
3. To select all objects in the viewer, press CTRL+A. To deselect individual objects in the selection, press CTRL and click each object.

After selecting the objects, right-click and click the operation to perform on the context menu.

Object duplication

You can copy individual objects or multiple rows of objects and paste the information for those objects into a spreadsheet in a tab-separated format.

The **Copy** option is available on context menus throughout PI AF. The **Copy Path** and **Copy Cell** options are available where appropriate.

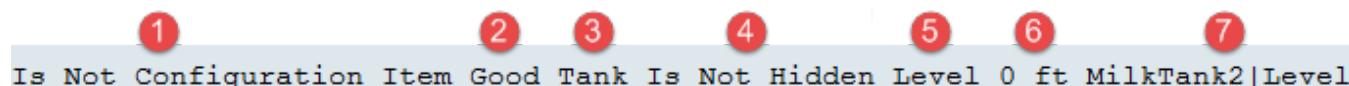
Note: When you drag and drop, the clipboard always contains the path information, which renders the data compatible with other client applications, such as PI ProcessBook.

Copy

In any PI AF browser, use **Copy** on a context menu to place the full path of the selected object on the clipboard:

\\Kaboom\\Chocolate Milk Tutorial\\ChocolateMilkModel\\MixFlow

In any viewer grid or list, use **Copy** to place the content of each displayed column in the selected row on the clipboard. If you select multiple PI AF rows, **Copy** places multiple data rows separated by a new line. In attributes lists, the copied data includes strings that correspond to the Configuration (✎), Quality (⌘), Template (☒), and Hidden (✖) column icons, in addition to other displayed columns:



1	2	3	4	5	6	7
Is Not Configuration Item	Good	Tank	Is Not Hidden	Level	0 ft	MilkTank2 Level
(1)						
(2)						
(3)						
(4)						
(5)			Name			
(6)				Value		
(7)					Path	

Copy Path

The **Copy Path** option places the full path for each selected object on the clipboard. If multiple PI AF objects are

selected, **Copy Path** places multiple paths separated by a new line:

```
\ABACUS-CURRENT\NuGreen\NuGreen\Houston\Cracking Process\Equipment\F-321\Model  
\ABACUS-CURRENT\NuGreen\NuGreen\Houston\Cracking Process\Equipment\F-321\Motor Amps
```

Copy Cell

In any viewer grid or list containing multiple columns, such as attributes, referenced elements, child event frames, and so on, the **Copy Cell** option places the contents of the selected cell on the clipboard.

Icons that indicate object states

PI System Explorer uses the following (mini) icons superimposed over object icons, such as attributes (), elements (), event frames (), and servers (), to indicate the current state of those objects. Such icons can also be combined to indicate multiple states: for example, uses the referenced and default icons to indicate the primary referenced element in an event frame, whereas uses the connected and default icons to indicate the default connected PI AF server.

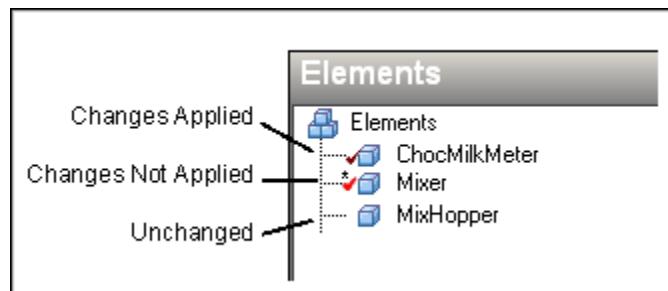
Icon	Object state
	Is changed, but not yet applied.
	Is checked out by you.
	Is checked out by a different user.
	Is available in multiple versions.
	Is a reference to another object.
	Is the default.
	Is disconnected, such as a collective member.
	Is connected, such as a PI AF server.
	Is a search.
	Is a template.
	Is arranged by category.

Icon	Object state
*	Is unsaved, such as a search.
!	Is unsupported, such as a server version.

Check-in of database changes

Whenever you make a change to an object, including whenever you create a new object, PI System Explorer checks that object out from the database. You need to save these changes in the database, although you can apply a change to a selected object by clicking ✓ in the toolbar and then check in your changes later.

- Unsaved changes are indicated by a red check mark ✘ icon.
- Changes that have been applied, but not saved to the database are indicated by a dark red check mark ✓ icon.



As you work, you can choose from these options to save your changes:

- Click **File > Check In**.
- On the toolbar, click **Check In**.
- In the browser, right-click an object and click **Check In** to save changes in the database for that object only.

The first two options allow you to save changes for all modified objects. The Check In window opens and displays objects that have been modified. You can select them all in or select some to check in, and allow others to remain checked out. Click **Session** to select objects modified only in the current session. You can still check in objects modified in other sessions.

Undo Check Out

If you decide not to save your changes, you can use the **File > Undo Check Out** option. In the Undo Check Out window, you clear any items in the list you *do* want to check in, and click **Undo Check Out**.

Undo Check Out for all users

Occasionally, you may be unable to modify a PI AF object because the element is checked out to another user. You see the following message types that inform you that an object is locked by a user:

- In notifications, when you attempt to stop, rename, delete, or otherwise change a notification, the error message *Notification 'Notification_name' with Unique ID 'ID' is locked by user Windows_account* is displayed.
- In PI AF, when you attempt to work with an object, the error message *AF Object Name 'Object_name' with UniqueID 'ID' is locked by user Windows_account* is displayed.

To undo the lock, a user who has the Admin permission on the object set to Allow can select **Show All Users** in the Undo Check Out window, select **All** and then click **Undo Check Out**. For more information, see [PI AF access rights](#).

Videos

For information on the check in/check out mechanism of a PI AF object, watch this video:

<https://www.youtube.com/embed/Pb8ZKxOaTsE?rel=0&controls=1>

For information on how to check in modifications to PI AF objects, watch this video:

<https://www.youtube.com/embed/Ky1ICZwwBqY?rel=0&controls=1>

For information on how to undo check out of PI AF objects, watch this video:

https://www.youtube.com/embed/OPSy_HbvAyY?rel=0&controls=1

Delete PI AF objects

You delete database objects (elements, event frames, and templates) from the [PI System Explorer browser](#). If the object references other objects, you can also select to delete the references, such as references between elements, event frames or event frames and elements. For more information on references, see [Element references in the asset hierarchy](#).

1. To delete a PI AF database object, click the **Element**, **Event Frame** or **Library** button in the navigator.

2. In the browser, navigate to the object you want to delete.
3. Right-click the object, then click **Delete**.
4. In the Delete window, you can delete objects that have references to other objects, as well as those that do not.
 - a. If the object has references to other objects...

To...	Do this...
Delete an object and all the references pointing to it without immediately checking in the changes.	Click Delete this object and all references to it. Check in is required to complete this action.
Delete the currently selected reference only without immediately checking in the changes.	Click Only delete this reference to the object. Check in is required to complete this action.
Delete the object permanently from your PI asset model.	Click Permanently delete; this action is irreversible. Caution: This option results in the immediate deletion of the object and its references from the database.

Caution: If the object is an event frame, selecting any of the options in the Delete window results in the immediate deletion of the event frame.

5. If the object does not have references to other objects...

Tip: By default, PI AF automatically deletes analyses and notifications that reference a deleted element. You can change this behavior by disabling the */EnablePropagationOfTargetDeletion* parameter in the PI AF Diagnostics utility. For more information, see [Deletion of elements](#).

6. Click **OK**.

Note: If you did not permanently delete the object, remember to click the **Check In** button to apply and save your changes to the database.

Keyboard shortcuts

PI System Explorer provides keyboard shortcuts for navigation and other tasks that require a mouse or other pointing device.

Shortcut	Action
CTRL+A	Selects all objects in the viewer.
CTRL+C	Copies the selected object to the clipboard.
CTRL+ALT+C	Copies the path of the selected object to the clipboard.
CTRL+V	Pastes the object on the clipboard to the viewer.
CTRL+X	Cuts (deletes) the selected object and copies it to the clipboard.

Shortcut	Action
DELETE	Deletes the selected object.
SHIFT+DELETE	Same as CTRL+X
INSERT	Adds a new object to the viewer or browser.
HOME	Selects the first row in the viewer, for example, the first row in a table of attributes.
END	Selects the last row in the viewer.
CTRL+HOME	Selects the first cell of the current page in the viewer.
CTRL+END	Selects the last cell of the current page in the viewer.
ALT+HOME	Selects the first page of objects in the viewer.
ALT+END	Selects the last page of objects in the viewer.
CTRL+PAGE UP	Selects the previous page of objects in the viewer.
CTRL+PAGE DOWN	Selects the next page of objects in the viewer.
CTRL+ENTER	If the viewer contains multiple pages of objects, displays the Select Page Number window.
ALT+ENTER	In the browser, displays the properties of the selected object.
SPACE or ENTER	Presses the currently selected button.
Left, Right, Up, and Down Arrows	Navigate objects in the viewer or browser.
F2	Edits the selected object on the viewer. For complex objects, displays the edit window for the object.
F4 or ALT+Up Arrow or ALT+Down Arrow	Displays the choices in the selected list box. For layered lists, displays the complete hierarchy of choices.
CTRL+1	Navigates to the Elements browser.
CTRL+2	Navigates to the Event Frames browser.

Shortcut	Action
CTRL+3	Navigates to the Library browser.
CTRL+4	Navigates to the Unit of Measure browser.
CTRL+5	Navigates to the MyPI browser.
CTRL+6	Navigates to the Notifications browser.
CTRL+7	Navigates to the Contacts browser.
CTRL+0	Navigates to the Analyses browser.

Change the language

You can change the language for PI System Explorer if the Language Packs feature has been installed. The language setting is per user locale, so if others want to use PI System Explorer on the same computer under a different login, they can use different language resources if available.

Prerequisite: At installation, your PI System administrator should have selected and installed the **Language Packs** feature.

1. Open PI System Explorer.
2. Click **View > Language Settings**.
The **PI Language Settings Tool** dialog opens.
3. On the Display Language tab, select a target language from the **Select a different language for your Windows user account** dropdown list, then click **OK**.
4. Quit and restart PI System Explorer.

The selected language displays in the PI System Explorer user interface.

Note: The language setting is account-specific, so users who sign on under a different account see the language selected for their account.

Valid characters in PI AF object names

PI AF has the following constraints on object names:

- Leading or trailing spaces are removed from names.
- Maximum name length is 259 characters.
- Blank names are not permitted.

You can use standard keyboard characters, with the following exceptions:

Object type	Invalid characters
Other than contacts	Control characters plus: * ? ; {} [] \ ``"
Contacts	Control characters plus: * ? ; [] \ "

PI time

You can use a special syntax, called PI time, to specify inputs for time stamps and time intervals. PI time uses specific abbreviations, which you combine to create time expressions.

PI time abbreviations

When specifying PI time, you can use specific abbreviations that represent time units and reference times.

Time-unit abbreviations

Abbreviation	Full version	Plural version	Corresponding time unit
s	second	seconds	Second
m	minute	minutes	Minute
h	hour	hours	Hour
d	day	days	Day
mo	month	months	Month
y	year	years	Year
w	week	weeks	Week

To specify time units, you can specify the abbreviation, the full version, or the plural version of the time unit, such as s, second, or seconds. You must include a valid value with any time unit. If specifying seconds, minutes, or hours, you can specify a fractional value, such as 1.25h. You cannot specify fractional values for other time units.

Reference-time abbreviations

Abbreviation	Full version	Corresponding reference time
*		Current time
t	today	00:00:00 (midnight) of the current day
y	yesterday	00:00:00 (midnight) of the previous day
The first three letters of the day of	sunday	00:00:00 (midnight) on the most

Abbreviation	Full version	Corresponding reference time
the week. For example: sun		recent Sunday
The first three letters of the month. For example: jun	june	00:00:00 (midnight) on the current day in June of the current year
dec DD	december DD	00:00:00 (midnight) on the <i>DD</i> th day of December in the current year
YYYY		00:00:00 (midnight) on the current day and month in year <i>YYYY</i>
M-D or M/D		00:00:00 (midnight) on the <i>D</i> th day of month <i>M</i> in the current year
DD		00:00:00 (midnight) on the <i>DD</i> th day of the current month

PI time expressions

PI time expressions can include fixed times, reference-time abbreviations, and time offsets. A time offset indicates the offset direction (either + or -) and the offset amount (a time-unit abbreviation with a value).

For example, PI time expressions can have the following structure:

Structure	Example
Fixed time only	24-aug-2012 09:50:00
Reference-time abbreviation only	t
Time offset only	+3h
Reference-time abbreviation with a time offset	t+3h

Include at most one time offset in an expression; including multiple time offsets can lead to unpredictable results.

Time-stamp specification

To specify inputs for time stamps, you can enter time expressions that contain:

- Fixed times

A fixed time always represents the same time, regardless of the current time.

Input	Meaning
23-aug-12 15:00:00	3:00 p.m. on August 23, 2012
25-sep-12	00:00:00 (midnight) on September 25, 2012

- Reference-time abbreviations

A reference-time abbreviation represents a time relative to the current time.

Input	Meaning
*	Current time (now)
3-1 or 3/1	00:00:00 (midnight) on March 1 of the current year
2011	00:00:00 (midnight) on the current month and day in the year 2011
25	00:00:00 (midnight) on the 25th of the current month
t	00:00:00 (midnight) on the current date (today)
y	00:00:00 (midnight) on the previous date (yesterday)
tue	00:00:00 (midnight) on the most recent Tuesday

- Reference-time abbreviations with a time offset

When included with a reference-time abbreviation, a time offset adds or subtracts from the specified time.

Input	Meaning
*-1h	One hour ago
t+8h	08:00:00 (8:00 a.m.) today
y-8h	16:00:00 (4:00 p.m.) the day before yesterday
mon+14.5h	14:30:00 (2:30 p.m.) last Monday
sat-1m	23:59:00 (11:59 p.m.) last Friday

- Time offsets

Entered alone, time offsets specify a time relative to an implied reference time. The implied reference time might be the current clock time or another time, depending on where you enter the expression.

Input	Meaning
-1d	One day before the current time
+6h	Six hours after the current time

Time-interval specification

Time-interval inputs define intervals for collecting or calculating values during a time period. For example, you might specify a 60-minute interval to compute an hourly average over a 12-hour period. To specify time-interval inputs, enter a valid value and time unit:

- Positive values define intervals that begin at the earlier time in the period and that finish at or before the later time in the period.

Start time	2:00:00
End time	3:15:00
Time interval	30m
Returned intervals	2:00:00 to 2:30:00 2:30:00 to 3:00:00

- Negative values define intervals that finish at the later time in the period and that begin at or after the earlier time in the period.

Start time	2:00:00
End time	3:15:00
Time interval	-30m
Returned intervals	2:15:00 to 2:45:00 2:45:00 to 3:15:00

Server and database connections

After a PI AF Client installation, an administrator needs to configure a PI AF server for general use. Configuration includes the following tasks:

- Connect to a PI AF server and set up a default.
- Set up PI AF identities.
- Map Windows user accounts to one or more PI AF identities.
- Select a default Data Archive, if one was not selected during PI AF Client installation.
- Create (or import) PI AF databases.
- Specify PI System Explorer connection preferences, if PI AF collectives are defined.
- Configure access permissions for identities to the PI AF Client server and databases. For more information, see [Security configuration in PI AF](#).

Video

For information on how to connect to and search an AVEVA™ PI System™, watch this video:

https://www.youtube.com/embed/_n3yLpjMhew?rel=0&controls=1

PI AF server connections

An administrator needs to select the PI AF servers to which to connect and establish the default. Additionally, an administrator needs to set up PI AF identities and mappings to PI AF servers.

Connect to a PI AF server

Use the Servers window to review PI AF server connections, connect to different servers as needed, and change the authentication mode used to connect to the PI AF server.

1. From the PI System Explorer menu bar, choose **File > Connections**.

In the Servers window, you see a list of known servers, identified by the following icons.

	A disconnected PI AF server in the Known Server Table
	A connected PI AF server
	The default connected PI AF server
	A Data Archive in the Known Server Table.
	The local default connected Data Archive
	A disconnected Data Archive collective
	A connected Data Archive collective

Note: The  icon and a warning indicates that the PI AF client is connected to an unsupported version of Data Archive, such as version 3.4.375 or 3.4.370. The PI AF client cannot connect to a Data Archive server that is running software earlier than version 3.4.370.

2. To connect to a PI AF server, choose from the following actions:

To ...	Do this ...
Connect to a different PI AF server	Select a server in the list and click Connect .
Connect to a server as a different user (for example, from a shared computer)	<ul style="list-style-type: none"> a. Right-click a server in the list and click Connect As. <ul style="list-style-type: none"> • If OIDC is not enabled, the Connect to PI AF servers window opens. Enter a Windows user account name and password. • If OIDC is enabled, the Authentication Mode dialog opens. Select the authentication mode you want to use for the connection: OpenID Connect or Windows. <ul style="list-style-type: none"> a. Click OK.
Connect to a server that is not displayed on the Known Servers Table	Click Add Asset Server . For more information, see Add a PI AF server to the connection list .
Set a default PI AF server	Right-click a connected PI AF server in the list and click Set as local default Asset Server . A  icon appears next to the default server.
Connect to a collective	<ul style="list-style-type: none"> a. Right-click a collective in the list. b. Choose one of the following actions: <ul style="list-style-type: none"> • To connect to the primary server in the collective, click Connect to Primary. • To connect to a specific collective member, click Connect to Collective Member, as described in Switch to a specific collective member.

3. Click **Close**.

Add a PI AF server to the connection list

If the PI AF server you want to connect to is not currently displayed on the Known Servers Table, you can add it in the PI AF Server Properties window.

1. In PI System Explorer, click **File > Connections**.
2. Click **Add Asset Server**.
3. In the PI AF Server Properties window, enter the PI AF server properties.
4. The **Name** field does not have to match the host name. After you connect to a PI AF server, you can change the server name by clicking **Rename** and entering a new name.

Caution: Renaming the PI AF server impacts all clients.

5. The **Account** field is typically not needed in normal installations and should be left blank.

By default, PI AF clients such as PI System Explorer attempt to use a Service Principle Name (SPN) registered by the PI AF server to establish a secure connection to the server. If an SPN cannot be created by the PI AF server, a secure connection can be established via Microsoft NTLM if the server is running under a system account, such as Network Service. In each case, the **Account** field is not needed and should be left blank.

If the PI AF server is run under a domain account, however, and an SPN is not successfully created by either the PI AF server or an administrator, the domain account of the server must be specified so that the PI AF client can securely identify the server.
 6. The default **Timeout** value of 300 seconds is acceptable in most cases. If you experience timeout errors as you work in PI System Explorer, increase the time in the **Timeout** box.
 7. Optional. **Aliases** are alternate names for the PI AF server which users can use to look for the server. When configured, PI AF server aliases are stored locally on the client only.
 8. Optional. The **Configure Active Directory** link is for setting up the notifications contacts list. This is a PI AF system administrator function.
 9. Click **Connect**.
-
- Note:** If an error message opens saying that you cannot connect to the PI AF server, you need to enter the domain account of the server in the **Account** field.
10. After a server is connected, you can click **Security** and set up security for the server. For more information, see the PI System Explorer topic [Security hierarchy](#).
 11. Click **OK**.

PI AF server properties

You manage the configuration of the currently connected PI AF server in the **PI AF Server Properties** window. The following tabs are available:

- **General**. For more information, see [View properties of the connected PI AF server](#).
- **Plug-Ins**. For more information, see [View installed plug-ins](#).
- **Libraries**. For more information, see [Review properties of loaded libraries](#).
- **Identities**. For more information, see [Manage identities in PI AF](#).
- **Mappings**. For more information, see [Manage mappings in PI AF](#).
- **Counts**. For more information, see [View PI AF server object counts](#).
- **RPC Metrics**. For more information, see [View RPC metrics](#).
- **Connections**. For more information, see [View PI AF server connections](#).

View properties of the connected PI AF server

On the **General** tab of the PI AF Server Properties window, review and modify settings for the currently connected PI AF server, such as:

- Server name, host name, and ID
- Default data server

- Server account
- Server version number
- Server port, timeout, and aliases

1. Click  on the PI System Explorer toolbar, or click **File > Server Properties**.
2. On the **General** tab of the PI AF Server Properties window, review the server information and modify as needed.
3. You can also choose from the following actions.

To ...	Do this ...
Rename the PI AF server	<ol style="list-style-type: none">a. Click Rename.b. In the New Name field of the New PI AF Server Name window, replace the current name with a new name.c. Click OK. <p>Caution: Renaming the PI AF server impacts all PI AF clients.</p>
Change the default data server	<ol style="list-style-type: none">a. Click the arrow next to the Default Data Server field.b. Select the data server to be invoked when you are using the %Server% substitution parameter for templated attributes that are tied to the PI point or PI point array data references.c. Click OK. <p>Note: To use the client's local default data server, select <Inherit local default Data Server>.</p>
Enter an alias	<ol style="list-style-type: none">a. Click .b. In the New Name field of the New Alias Name window, enter an alternate name that users can use to look for the PI AF server. Aliases are stored locally on the client.
Configure Active Directory access for contacts	See Configure Active Directory access for contacts.
View or modify security permissions of mapped user identities	<ol style="list-style-type: none">a. Click Security.b. In the Security Configuration window, review the permissions for the listed identities that have been configured for each server component. You can add and remove identities (as well as create new identities and mappings) as needed. For more information, see the PI System Explorer topic Configure security for a PI AF server.

4. Click **OK**.

Manage identities in PI AF

Use the **Identities** tab to review identities that are currently assigned to the PI AF server. You can also add, remove, and edit identities.

Note: Using permissions, you can restrict the identities and mappings visible on the **Identities** tab except for three built-in identities: Administrators, Owner, and World. Those identities are always visible. You can also use permissions to make identities editable or read only. For more information on granting permissions to PI AF identities, see the PI System Explorer topic [Security configuration in PI AF](#).

1. On the PI System Explorer toolbar, click .
2. In the PI AF Server Properties window, click the **Identities** tab.
3. Review the alphabetized list of identities. Click a column heading to change the sort order. Enabled identities are indicated as **True**, whereas disabled identities are grayed out and indicated as **False**. The built-in identities **Administrator** and **World** are read only.
4. You can choose from the following actions:

To ...	Do this ...
Disable an identity	<ol style="list-style-type: none">a. Double-click an enabled identity on the list.b. In the Identity Properties window, clear the Identity is Enabled checkbox.c. Click OK.
Enable an identity	<ol style="list-style-type: none">a. Double-click a disabled identity on the list.b. In the Identity Properties window, select the Identity is Enabled checkbox.c. Click OK.
Create a new identity	<ol style="list-style-type: none">a. Right-click and select New Identity.b. In the Identity Properties window, enter a name and description for the identity.c. Optional. Click the Mappings tab and click Add. For more information, see Add a mapping to an identity.
Manage security settings for identities	<ol style="list-style-type: none">a. Right-click a column title or below the list and click Security.b. In the Security Configuration window, you can review or modify permissions for a listed identity, as well as add or remove identities as needed. For more information, see the PI System Explorer topic Configure security for a PI AF server.

To ...	Do this ...
Delete an identity	<ul style="list-style-type: none"> a. Right-click an identity on the list and click Delete. b. In the Delete confirmation window, click Yes.
Rename an identity	<ul style="list-style-type: none"> a. Right-click an identity on the list and click Rename. b. Enter a new identity name. c. Right-click and click Check In to apply the change.

Manage mappings in PI AF

Use the **Mappings** tab to review mappings that are currently set up on the PI AF server. You can also add, remove, and edit mappings.

1. On the PI System Explorer toolbar, click .
2. In the PI AF Server Properties window, click the **Mappings** tab.
3. Review the alphabetized list of mappings. If necessary, scroll rightward to see mapped identities and Windows accounts.
4. You can choose from the following actions:

To ...	Do this ...
Modify the properties of a mapping	<ul style="list-style-type: none"> a. Double-click a mapping on the list. b. In the Mapping Properties window, you can edit the name and description as needed, as well as select a different identity from the Identity drop-down list. c. Click OK.
Create a new mapping	See Add a mapping to an identity and Map a role to a PI AF identity .
Delete a mapping for an identity	<ul style="list-style-type: none"> a. Right-click a mapping on the list and click Delete. b. In the Delete confirmation window, click Yes. <p>Note: If your user account is associated with the mapping you are deleting, a warning that you might be locked out is displayed.</p>
Rename a mapping	<ul style="list-style-type: none"> a. Right-click a mapping on the list and click Rename. b. Enter a new mapping name.

To ...	Do this ...
	c. Right-click and click Check In to apply the change.
Manage security settings for mappings	a. Right-click a column title or below the list and click Security . b. In the Security Configuration window, you can review or modify permissions for a listed identity, as well as add or remove identities as needed. For more information, see the PI System Explorer topic Configure security for a PI AF server .

Add a mapping to an identity

When you add a mapping for an identity, you need to specify the Windows account to be mapped and the name of the mapping. See [Map a role to a PI AF identity](#) if you are using OpenID Connect (OIDC) and want to map a role.

The security identifier (SID) for the account is generated automatically and cannot be changed while the mapping is being created.

1. Open the Mapping Properties window.
2. Select the **Windows** option.
3. In the **Account** field, enter one of the following object types:
 - User
 - Group
 - Built-in security principal
 - Service account
 - Computer name

You can also click  and enter search criteria in the Select User, Computer, Service Account, or Group window to select the object type, location, and name. The available search locations are the local computer hosting the connected PI AF server and active directory nodes that the user can access.

Note: You can also enter a SID directly in the Account field. When the entry is validated, a domain identifier is prepended if the account is a domain account. If the account is a local account on the AVEVA™ PI System™ host machine, the fully qualified domain name is prepended.

4. To validate your entry in the **Account** field, press Tab or click in another field.
The **Account SID** field displays the SID of the account, and the **Name** field defaults to displaying the account name.
5. In the **Name** field, modify the default account name as needed.
Text you enter in the **Description** field is displayed in the PI AF Server Properties window. Use this field to differentiate between mappings for any given identity (since in PI AF a single user can be mapped to multiple identities).
6. If an identity has not been selected already, select the identity you wish to associate with the mapping from

the Identity drop-down list.

7. Click **OK**.

Map a role to a PI AF identity

You can create a mapping from a PI AF identity to an Identity provider (IdP) role. A role represents a group of users with similar job functions and access permissions. Roles are stored and managed by the Identity provider service. The AVEVA Identity Manager is the provided identity service for PI Server 2023.

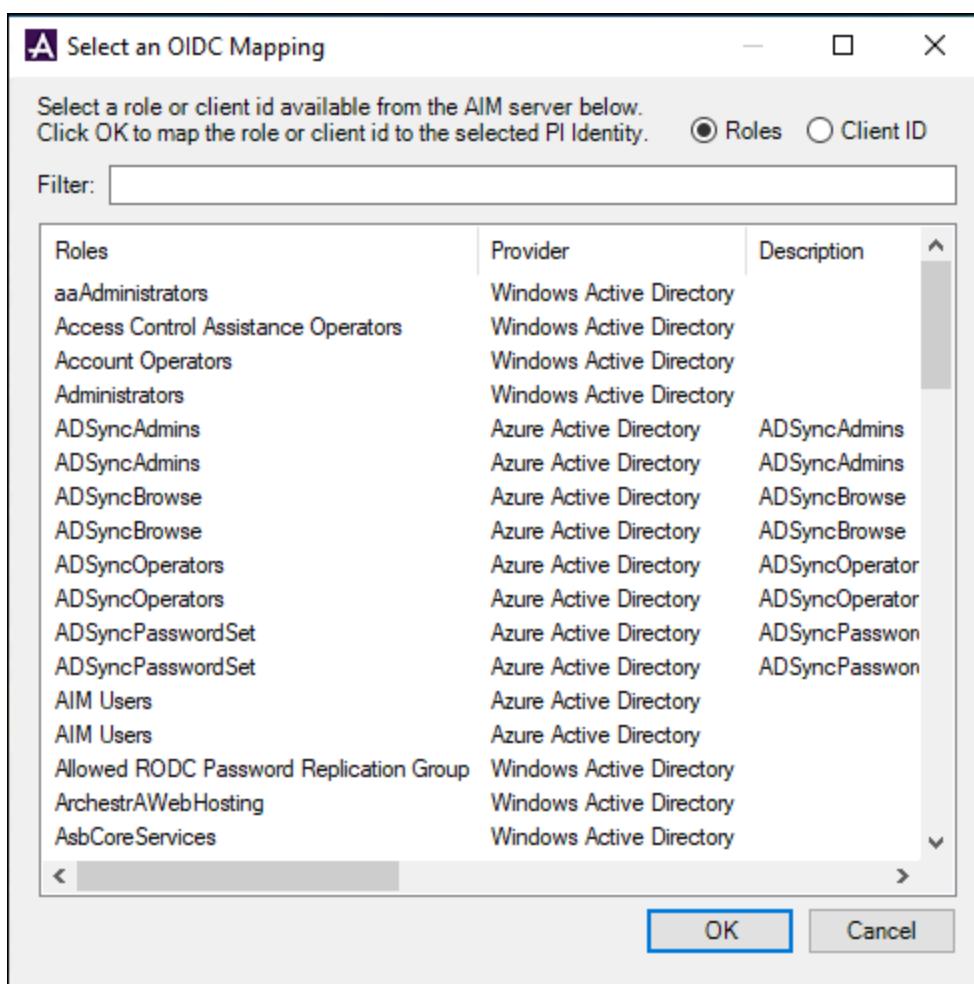
A PI AF identity represents a set of access permissions on the AF server for a Windows user or group. Role members that are mapped to a PI AF identity inherit the same access permissions as the PI AF identity, such as access to an element collection or objects. See [PI AF identities and mappings](#) for more information.

Prerequisite

OIDC authentication must be enabled.

1. Open PI System Explorer.
2. If this is the first time you are opening PI System Explorer, select the OIDC authentication option and [sign in with your OIDC credentials](#).
3. Select **File**, then select **Connections**.
The **Servers** dialog opens.
4. Select the **Properties** button.
The **PI AF Server Properties** dialog opens.
5. Select the **Mappings** tab.
6. Right-click in the dialog and select **New Mapping**.
The **Security Mapping Properties** dialog opens.
7. Select the **OpenID Connect** option.

Note: If the user has signed on with OIDC, the **OpenID Connect** option is selected by default.
8. Select the **Role** magnifying button.
The **Select an OIDC Mapping** dialog opens.



9. Select the **Roles** or **Client ID** option to filter the list box by Identity provider roles or client ID names.
10. In the list box, select the role or client ID you want to map to the PI AF identity, then select **OK**.
Note: The roles listed in the **Select a Role** dialog depends on the identity provider. Roles are created and configured on the identity server.
11. The role, role ID, and name are added to the **Security Mapping Properties** dialog.
12. In the **Security Mapping Properties** dialog, select the **Identity** down arrow, then select the PI AF identity you want to map to the role.
13. Select **OK**.

The role is now mapped to the PI AF identity in PI System Explorer. Users assigned to the role inherit the same access permissions to AF resources as the PI AF identity.

View PI AF server object counts

You can view object counts for the PI AF server to which you are currently connected, such as the number of databases, elements, element templates, event frames, and so on.

1. In PI System Explorer, click **File > Server Properties**.
2. In the PI AF Server Properties window, click the **Counts** tab.

View RPC metrics

You can view remote procedure call (RPC) metrics for the current server connection. The **RPC Metrics** page displays performance data about RPC calls by name, including the number of calls and call duration.

Note: Only users with administrator privileges can view the **RPC Metrics** page. Beginning with PI AF 2018 SP2, only certain column headers on the RPC Metrics page are visible.

1. On the PI System Explorer toolbar, click .
2. In the PI AF Server Properties window, click the **RPC Metrics** tab.
3. You can view, sort, and copy data on the RPC Metrics page:
 - To sort data by a particular column heading such as Calls or Total Duration, click the column heading.
 - To copy one row of connection data, right-click the row and then click **Copy**.
 - To copy all connection data, right-click the row, click **Select All** and then click **Copy**.
4. Review information about each call as needed. You can expand the width of the columns as needed.
5. The RPC Metrics page displays the following information:

Column Title	Explanation
RPC Name	The name of the client process executed by the server
Calls	The number of total calls for the individual RPC since the server was last started
Total Duration	The total length of all the calls to the server from a particular client
Per Call	The average length of each call
Calls (Delta)	A count of the number of calls since the list was last displayed or refreshed
Duration (Delta)	The total length of the calls to each RPC since the list was last displayed or refreshed
Per Call (Delta)	The average length of the calls to each RPC that occurred since the list was last displayed or refreshed
Calls (Client)	The number of calls to each RPC that was made by the client retrieving the RPC metrics
Duration (Client)	The length of the RPC call made by the client retrieving the RPC metrics
Per Call (Client)	The average length of the calls to each RPC that was made by the client retrieving the RPC metrics

Column Title	Explanation
Retries	The number of times the client process has been attempted

Note: Use the **Refresh** button to update the RPC Metrics page with the latest RPC call data.

View PI AF server connections

You can view, sort, and copy details about PI AF server connections on the **Connections** page.

Note: Only users with administrator privileges can view information on the Connections page.

1. On the PI System Explorer toolbar, click .
2. In the PI AF Server Properties window, click the **Connections** tab.
The Connections page opens.
3. You can view, sort, and copy data on the Connections page:
 - To sort data by a particular column heading such as a start or end time, click the column heading.
 - To copy one row of connection data, right-click the row and then click **Copy**.
 - To copy all connection data, right-click the row, click **Select All** and then click **Copy**.
4. The Connections page displays the following information:

Column Title	Explanation
Username	The name of the user or service connected to the server
Client Host	The host's IPv6 address
Client Port	The port that they're connecting from
Authentication	Type of authentication protocol used to establish the connection. There are three types of authentication: <ul style="list-style-type: none"> • None: An anonymous connection that occurs when a client first attempts a connection • NTLM: A Windows connection • OAuth 2.0: An OpenID Connect (OIDC) connection
Start Time	Time connection began
End Time	Time connection ended

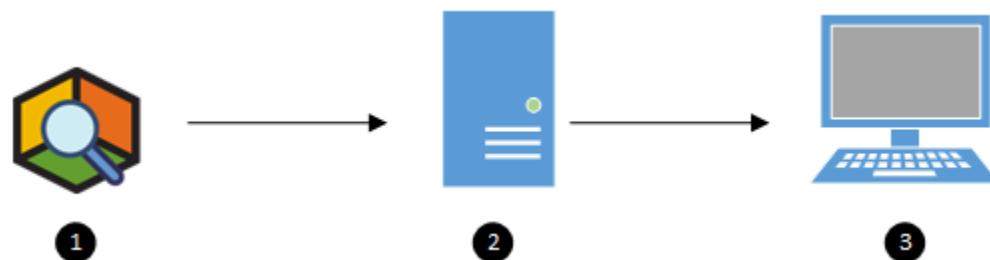
Note: Use the **Refresh** button to update the Connections page with the most current information.

5. To move quickly through a defined number of records, click the **Previous** or **Next** button. To change paging settings, see [Search result paging](#).

Data Archive connections

You can set the default Data Archive, also called the default data server, at the PI AF server and PI AF database level. Setting the default data server points PI System Explorer to the location of PI point data references. By default, any database without a default data server set inherits the PI AF server's default data server.

The %Server% substitution parameter resolves to the default data server. See [Find the default Data Archive server](#) for more information. The following diagram shows the order that the default data server gets resolved using the %Server% substitution parameter:



- 1. Current AF database
 - 2. PI AF server
 - 3. Local client machine
1. PI AF checks to see if the current PI AF database's default Data Archive is specified. If specified, PI AF looks there for stored templated attributes that are tied to PI point or PI point array data references. See [View or edit properties of PI AF databases](#) for more information.
 2. If one is not specified for the current database, it resolves to the PI AF server's default Data Archive setting. See [View properties of the connected PI AF server](#) for more information.
 3. If none is specified at the PI system level, it resolves to the local default Data Archive.

You can view the default data server for the database and PI AF server using the following methods:

- Use the Database Properties window to view and set the default PI AF server for the database.
- Use the PI AF Servers Properties window to view and set the default Data Archive server for the system.

Note: If the default Data Archive is not specified on the PI AF server or PI AF database, it can resolve to a different Data Archive for different client machines depending on their configuration.

Connect to Data Archive

Use the Servers window to review Data Archive known server connections, connect to different servers as needed, and change the authentication mode used to connect if OpenID Connect (OIDC) is enabled.

1. Click **File > Connections**.

In the Servers window, a list of known servers is displayed in the Known Server Table (KST). Each of the following icons indicate the type of server and its current connection:

	A disconnected PI AF server in the Known Server
--	---

	Table
	A connected PI AF server
	The default connected PI AF server
	A Data Archive in the Known Server Table
	The default connected Data Archive
	A disconnected Data Archive collective
	A connected Data Archive collective

Note: A warning icon () beside a server indicates that Data Archive is running an unsupported version, such as version 3.4.375 or 3.4.370. The PI AF client cannot connect to a Data Archive server that is running software earlier than version 3.4.370.

- To connect to a Data Archive, choose from the following actions:

To ...	Do this ...
Connect to a different Data Archive	Select a server in the list and click Connect .
Connect to a server as a different user (for example, from a shared computer) or change the authentication mode used to access the server	<p>a. Right-click a server in the list and click Connect As.</p> <ul style="list-style-type: none"> i. If OIDC is not enabled, the Connect to PI Data Archive server window opens. Enter a Windows user account name and password. ii. If OIDC is enabled, the Authentication Mode dialog opens. Select the authentication mode you want to use for the connection: OpenID Connect or Windows. <p>b. Click OK.</p>
Connect to a server that is not displayed on the Known Servers Table	Click Add Data Server . For more information, see Add PI Data Archive servers to connected server lists .
Set a local default Data Archive	Right-click a server in the list and click Set as local default Data Server . An  icon appears next to the local default data server.

- Click **Close**.

Data Archive connection problems

Windows Authentication only uses identity mappings and does not utilize trusts defined with windows credentials for authentication or any other trusts that may be configured. When connecting to Data Archive,

error messages might appear if there is no PI mapping configured and one of the following conditions exists:

- You are using a PI username and password to login to Data Archive.
- You are using the default user with a blank password to login to Data Archive.

These errors occur because PI AF 2012 and later has more stringent security settings than earlier versions of PI AF. Clients that connect to Data Archive through PI AF 2012 and later are subject to the following behaviors:

- The default behavior for connections is to not prompt the user for an explicit login unless the **Allow login prompt** setting is configured. This setting controls what happens when Data Archive authentication fails. If the **Allow login prompt** setting is enabled, a window opens prompting the user for a username and password. If the setting is off, an error message is displayed. The setting is specific to each client computer. For more information, see [Configure clients to allow explicit login prompts](#).
- Default user connections are no longer supported.

To resolve error conditions, configure PI mappings for users connecting to Data Archive. For more information, see the PI System Management Tools topic [Identities, Users, and Groups](#).

PI Data Archive connection error messages

Error Message	Connect Failure Conditions
Insufficient privilege to access Data Archive. No Access - Secure Object Default User connections to Data Archive are currently enabled from this client but are not supported from PI AF.	Default User connections are enabled in PI SDK.
Insufficient privilege to access Data Archive. No supported authentication methods are enabled. No Access - Secure Object Default User connections to Data Archive are currently enabled from this client but are not supported from PI AF.	Default User connections are the only authentication method enabled in PI SDK.
Insufficient privilege to access Data Archive. No Access - Secure Object The explicit login prompt is not configured on this computer and therefore not allowed.	Explicit logins setting was not set in registry.

Configure clients to allow explicit login prompts

If all configured protocols fail, use the PI SDK Utility to allow a login prompt to be displayed.

1. Open **PISDKUtility** from the Windows Start menu.

2. Click **Connections > Options**.
3. In the Connection Options window, select the **Allow login prompt (if all configured protocols fail)** check box.
4. Click **OK**.
5. Click **File > Exit PISDKUtility**.

Review digital state sets on a Data Archive

You use the **State Sets** tab in the PI Data Archive Properties window to review the digital state sets on a specific Data Archive and compare them to existing enumeration sets in the current PI AF database. You can also export digital state sets from the Data Archive to create enumeration sets.

1. Click **File > Connections**.
2. In the Servers window, select a connected Data Archive.
3. Choose one of the following actions.
 - Right-click and click **Properties**.
 - In the taskbar, click **Properties**.
4. In the PI Data Archive Properties window, click the **State Sets** tab.

In addition to the digital state sets available on the selected Data Archive, the window displays matching enumeration sets in the current PI AF database and how many differences exist between them.

5. Choose from the following actions.

To...	Do this...
Review differences between a digital state set and its equivalent enumeration set in the current database	See Review differences between digital state sets and enumerations sets .
Export digital state sets on a Data Archive to the current database	See Create enumeration sets from digital state sets .
Refresh the list of digital state sets	Right-click the grid and click Refresh .

6. To close the PI Data Archive Properties window, click **OK**.

Review differences between digital state sets and enumerations sets

On the **State Sets** tab in the PI Data Archive Properties window, review the differences between a digital state set on a selected Data Archive and its equivalent enumeration set in the current PI AF database.

1. In the PI Data Archive Properties window, select a digital state set where the Conflicts column indicates that a number of states are different.

A grid opens with a list of conflicts.

 - If a **Digital State Name** and an **Enumeration Value Name** are different, both are displayed in boldface text.
 - If a digital state name does not exist in an enumeration set, the **Enumeration Value Name** is displayed in boldface text and the **Digital State Name** is blank.

- If an enumeration value name does not exist in a digital state set, the **Digital State Name** is displayed in boldface text and the **Enumeration Value Name** is blank.
 - If a digital state value does not exist in a digital state set but does exist in the enumeration set, the **Value** and the **Enumeration Value Name** are displayed in boldface text and the **Digital State Name** is blank.
2. Review other digital state set conflicts as needed.
 3. Click **OK**.

Create enumeration sets from digital state sets

In PI System Explorer, select the AF database you wish to create the enumeration sets in.

You can export digital state sets from a Data Archive server into the current PI AF database to create enumeration sets.

1. In PI System Explorer, click **File > Connections**.
The Servers window opens.
2. In the **Name** column, select the Data Archive server that contains the digital state set, then click **Properties**.
The PI Data Archive Properties window opens.
3. In the PI Data Archive Properties window, select the **State Sets** tab, then choose from the following actions.

To...	Do this...
Create one or more enumeration sets from digital state sets on the selected Data Archive	<ol style="list-style-type: none">a. Use standard Windows selection keystrokes (such as SHIFT+<click> and CTRL+<click>) to select contiguous and non-contiguous digital state sets in the list, where the Enumeration Set cell is empty and the Conflicts column displays <i>EnumerationSet 'EnumName' not found</i>.b. Right-click and select Create Enumeration Set from State Set.c. In the Create EnumerationSets window, click Yes.
Create enumeration sets from all digital state sets on the selected Data Archive	<ol style="list-style-type: none">a. Right-click and select Select All.b. Right-click and select Create Enumeration Set from State Set.c. In the Create EnumerationSets window, click Yes. <p>Enumeration sets that already exist are ignored, but those that do not exist are created.</p>

4. Click **OK**.
5. To exit the Servers window, click **Close**.
6. Check in your changes.

Add PI Data Archive servers to connected server lists

If the Data Archive server you want to connect to is not currently displayed on the Known Servers Table, add it in the PI Data Archive Properties window.

1. Click **File > Connections**.
2. In the Servers window , click **Add Data Server**.
3. In the PI Data Archive Properties window, enter properties as needed.
4. Optional. You can change the default name in the **Name** field:
 - a. Click **Rename**.
 - b. In the **New Name** field in the New PI Data Archive Name window, enter a name for the new Data Archive. The name does not need to match the host name.
 - c. Click **OK**.
5. Enter the host name in the **Host** field. You can enter:
 - A fully qualified domain name.
 - A server name.
 - An IP address. An IPv6 address must be enclosed in brackets [].
6. Unless your particular application requires a different port, accept the default value in the **Port** field.

Note: You can modify the host name and port only when disconnected from the server.

7. The default values for the **Connection Timeout** and **Data Timeout** fields are acceptable in most cases. If you experience connection timeouts when connecting to Data Archive from PI System Explorer, increase the time in the **Connection Timeout** field. If you experience timeout errors while accessing Data Archive data, increase the time in the **Data Timeout** field.
8. Optional. Enter an alias name in the **Aliases** field.
Aliases are alternate names that can be used for Data Archive. Data Archive aliases are stored locally on the client only.
9. Click **Connect** to connect to Data Archive.
Note: The **ID**, **Time Zone** and **Version** fields are not editable. **ID** is the Data Archive ID, **Time Zone** is the local time zone of the Data Archive and **Version** is the Data Archive version.

-
10. Click **OK**.

View buffering status for connected Data Archive servers

If PI Buffer Subsystem 4.3 or later is installed and running, you can view the buffer status of a connected Data Archive server.

1. Click **File > Connections**.

In the Servers window, each Data Archive server for which a connection is configured displays a buffering status in the **Buffer Status** column.

Note: PI Buffer Subsystem versions 3.4.380 and earlier display a status of **Unknown**.

2. To view more details and manage buffering for a specific Data Archive, click **Buffering Manager** to open the Buffering Manager tool.

Note: You can also open Buffering Manager from the PI System Explorer **Tools** menu.

PI AF database connections

PI AF stores the asset framework objects (elements, templates, and so on) in PI AF databases. You can have multiple databases in PI AF, although you can connect to only one at a time. You typically work with PI AF databases in PI System Explorer or in PI Builder. When you start PI System Explorer for the first time, it connects to the default PI AF database. If no databases are defined, PI System Explorer prompts you to create a new database.

Note: The **Configuration** database is used by PI AF clients, such as PI Web API, as they interact with PI AF. Do not use this database for your own application data.

Videos

For information on how to create PI AF databases, watch this video:

<https://www.youtube.com/embed/P7Zopif-j-c?rel=0&controls=1>

For information on how to work with multiple PI AF databases, watch this video:

<https://www.youtube.com/embed/CN0R7cW3BUc?rel=0&controls=1>

For information on the configuration database, watch this video:

<https://www.youtube.com/embed/bfTnAeSinmo?rel=0&controls=1>

Create PI AF databases

You can create an empty PI AF database with no pre-configured content, or you can load a library that has been saved on a connected PI AF server.

1. Choose one of the following actions:
 - Press Ctrl+O.

- On the PI System Explorer toolbar, click  Database.
 - Click File > Database.
2. From the **Asset server** drop-down list in the Select Database window, select a connected server on which you have administrator access rights to create a database. Alternatively, click  and select a server from the PI AF Servers window.
 3. Click **New Database**.
 4. In the Database Properties window, enter a unique name in the **Name** field.
 5. Optional. Enter a description in the **Description** field.
 6. Choose from the following actions:

To ...	Do this ...
Create a new database with no configured content	Leave the Load Library field (if displayed) set to <None>.
Create a database with configured objects from a saved library	Select a library from the Load Library drop-down list. For more information, see PI AF saved libraries .
Create extended properties	See Storage of application-specific information .
Set up access permissions for the new database	See Configure security for a single PI AF database .

7. Click **OK**.

The new database is added to the **Database** list in the Select Database window.

View or edit properties of PI AF databases

Use the Database Properties window to check how many objects exist in each collection type in a PI AF database, set the default data server, and review or add extended properties and access permissions.

1. On the PI System Explorer toolbar, click  Database.
2. In the Select Database window, right-click a database and click **Properties**.
3. In the Database Properties window, choose from the following actions:

To ...	Do this ...
Review the number of objects in the database	Click the Counts tab.
Review or modify the database name and description	On the General tab, make changes as needed in the Name and Description fields.
Review or modify extended properties	<ol style="list-style-type: none"> a. On the General tab, click Extended Properties. b. In the Extended Properties window, make changes as needed in the Name and Value fields. To create a new property, click New Extended Property. For more information, see Create extended properties.

To ...	Do this ...
Review or modify database security	<ul style="list-style-type: none"> a. On the General tab, click Security. b. In the Security Configuration window, make changes as needed. For more information, see Configure security for a single PI AF database.
Review the properties of the connected server	<ul style="list-style-type: none"> a. On the General tab, click . b. In the PI AF Server Properties window, review properties on the General tab, as described in View properties of the connected PI AF server.
Change the default data server	<ul style="list-style-type: none"> a. Click the arrow next to the Default Data Server field. b. Select the data server to be invoked when you are using the %Server% substitution parameter for templated attributes that are tied to the PI point or PI point array data references. c. Click OK. <p>Note: To use the PI AF Server's default data server, select <Inherit from PI AF Server>.</p>
Load a saved library	<ul style="list-style-type: none"> a. On the General tab, select a saved library from the Load Library list. For more information on saved libraries, see PI AF saved libraries. b. Click Apply.

4. Click **OK**.

Connect to a database on a different PI AF server

Use the PI AF Servers window to locate and connect to the PI AF server that contains the database you want to work with. If OpenID Connect (OIDC) is enabled, you can also change the authentication mode used to connect to the database.

1. In the Select Database window, click .
2. In the PI AF Servers window, review the list of servers. Note that the default database on each connected server is also displayed.
3. Choose from the following actions.

To ...	Do this ...
Select the server where the database is located	Double-click on a connected () server. The PI AF Servers window closes and the selected server is displayed in the Asset server field.
Check the properties of a server	Select a server and click Properties .

To ...	Do this ...
Connect to a server	Right-click a server that is not connected () and click Connect .
Connect to a server as a different user (for example, from a shared computer) or change the authentication mode used to access the server	<p>a. Right-click a server that is not connected and click Connect As.</p> <p>i. If OIDC is not enabled, the Connect to PI AF servers window opens. Enter a Windows user account name and password.</p> <p>ii. If OIDC is enabled, the Authentication Mode dialog opens. Select the authentication mode you want to use for the connection: OpenID Connect or Windows.</p> <p>b. Click OK.</p>
Review access permissions for a connected server	<p>a. Right-click a connected server and click Security.</p> <p>b. In the Security Configuration window, check the settings for the listed identities, as needed.</p> <p>Note: If you have administrative privileges on the server, you can also modify the security configuration. See Configure security for new PI AF databases.</p>

Set the default database

The default database is displayed when PI System Explorer opens for the first time. After the first time you run PI System Explorer, it will display whatever database was open when you last closed PI System Explorer.

1. On the PI System Explorer toolbar, click  .
2. In the Select Database window, right-click a database and click **Set as Default Database**. A check mark icon () is displayed over the database icon that is now the default.
3. Click **OK**.

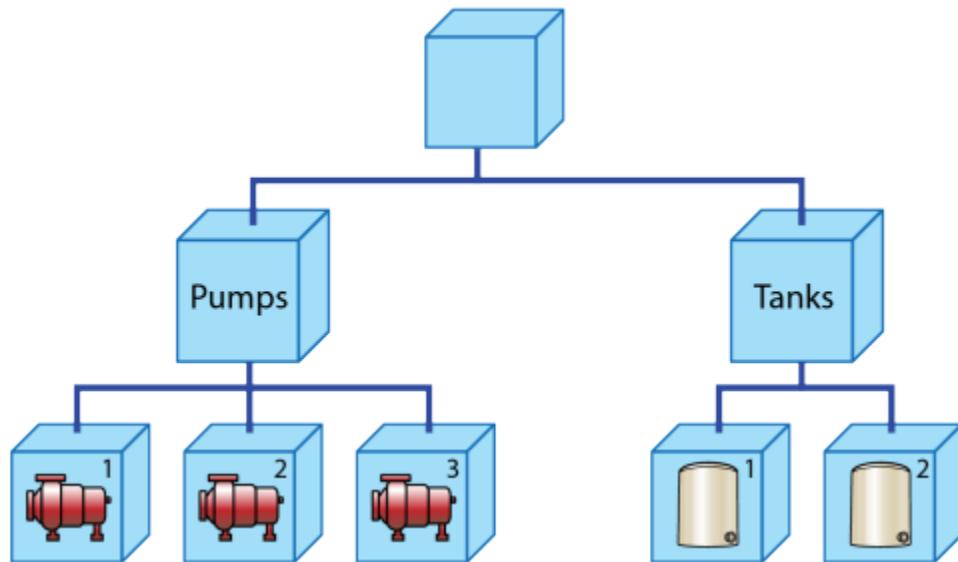
The structure of PI AF asset models

PI AF objects are organized in a tree structure, similar to the file structure on a Windows computer. In Windows, rather than having thousands of files on your desktop, you typically group files under folders. The same concept applies to PI AF elements. Organizing elements into hierarchies makes navigation of the elements easier, and it also provides insights into how the elements relate to one another.

When you create an asset model, you need to decide on a structure that makes it easy for users to find the different assets. Consider who your users are and what they will be looking for. For example, maintenance engineers might want to use PI System Explorer to find and record maintenance information. For this audience you might want to group assets by equipment type.

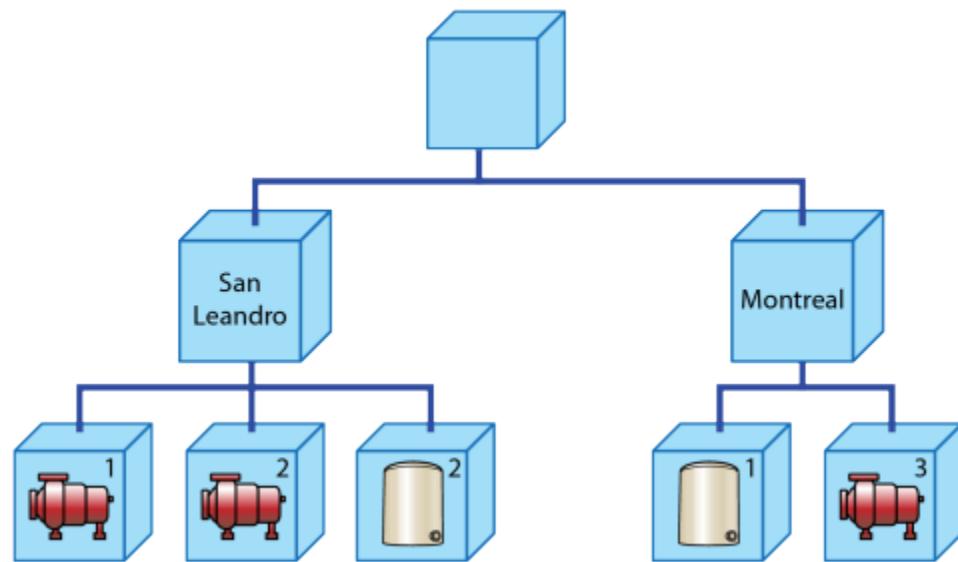
For example, if you had three pump elements, you might create an element called Pumps and then place all the pump elements beneath it. If you had two elements representing tanks, you might put them all under a Tanks element.

Asset model organized by equipment type



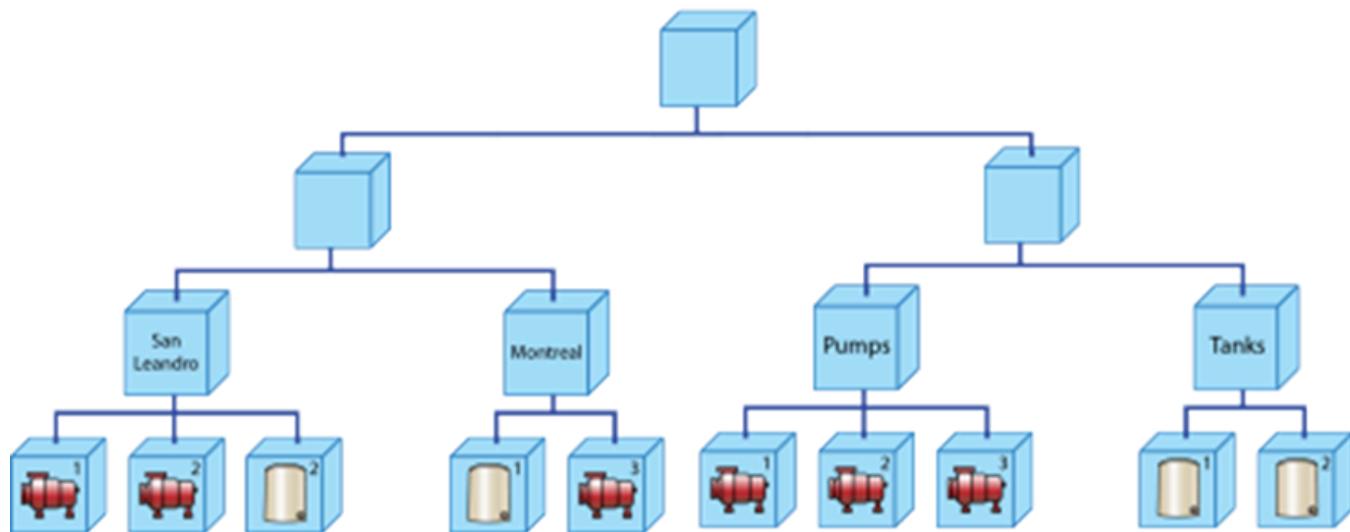
On the other hand, if you have multiple plants in different locations, that same maintenance engineer might want to see all the equipment located at his own plant. The following illustration shows the same elements organized by plant.

Asset model organized by location



You are not restricted to only one organizational strategy. You can use an *element reference* to include the same asset in more than one place in the tree. For example, you could choose to organize by equipment type and by plant as well. In the following illustration, the hierarchy includes the geographical tree and the equipment tree side by side.

Mixed asset model



You could alternatively nest the equipment organization under the geographical organization.

Note: Limit the depth of your asset hierarchies to 10 levels or less to maintain the performance and interpretability of your asset data.

Rename databases

You can change the name of a PI AF database as needed.

1. On the PI System Explorer toolbar, click Database.
2. In the Select Database window, right-click a database and click **Rename**.
3. Enter a valid name for the database. For rules on object names, see [Valid characters in PI AF object names](#).
4. Click **OK**.

Search for PI AF databases

To locate a specific PI AF database on a selected PI AF server, use the Search feature.

1. On the PI System Explorer toolbar, click Database.
2. In the Select Database window, begin typing the name of a database in the **Databases** field.
The **Search** icon changes to the **Searching** icon . Results filter corresponding to how many letters you type.
3. Select a database in the list and click **OK**.
The window closes, and you will be working in the selected database.
4. To return to the full list of available databases, press **ESC**.
The window closes.

Refresh the list of databases

When other users add databases to the PI AF server, those databases might not be displayed until you refresh.

1. On the PI System Explorer toolbar, click  Database.
2. In the Select Database window, right-click in the list of databases and click Refresh.

Database deletion

When you delete a database, all information contained within that database is removed. Before you delete a database, therefore, ensure that you have selected the database that you want to delete.

Caution: You cannot undo a deletion. However, you can recover data by restoring your last SQL Server backup.

Manage the known servers table (KST)

The known servers table (KST) contains a list of Data Archive servers and AF servers used by client applications for connections. Previously, AF servers were stored in a file, while PI Data Archives were stored in the Windows registry. Starting with PI AF Client 2024, AF SDK applications now store the entire KST in local files instead of the registry.

During an upgrade, a migration tool automatically transfers registry-based KST entries to the new file-based KST. However, PI SDK applications still rely on the registry-based KST, so any new Data Archives added after the upgrade may need to be manually updated with multiple tools to ensure system-wide availability.

For more details on KST access methods, see [KST access methods in PI Server products](#). For management and migration steps, see [Overview of changes to the known servers table \(KST\)](#) and [Migrate KST using PI Server tools](#).

Overview of changes to the known servers table (KST)

This topic provides an overview of the changes to the known servers table (KST) for PI AF Client 2024. It also explains how to ensure your servers are properly recognized across both AF SDK-based and PI SDK-based applications.

Note: The new file-based KST is located at **C:\ProgramData\OSisoft\AF\PIDataArchiveKST.config**. Manual editing of the file is discouraged.

- **During upgrade to PI AF Client 2024:**

When you upgrade to PI AF Client 2024, any existing PI Servers in the registry-based KST are replicated to the new file-based KST for AF SDK applications.

- **Post-upgrade considerations:**

After the initial replication during upgrade, the registry-based KST and file-based KST are not automatically synchronized. Therefore, any new servers added after the upgrade must be manually added to both the AF SDK and PI SDK environments to ensure full accessibility.

For more information, see [Migrate the KST using PI Server tools](#).

- **Adding new Data Archives:**

- **AF SDK-based tools:** Adding a new Data Archive through the Connection dialog in an AF SDK-based PI

Client (for example, PI DataLink) makes the server visible in other AF SDK tools, such as PI System Explorer and PI Web API.

- **PI SDK-based tools:** Adding a new Data Archive through an AF SDK-based PI Client does not make it visible in PI SDK-based tools (for example, PI Buffering Manager). In this case, the server must be added separately to the registry-based KST to ensure it is available in those tools.

For details on KST access methods, see [KST access methods in PI Server products](#).

Migrate the known servers table (KST) using PI Server tools

An AVEVA PI System 2024 installation includes the known server table (KST) migration tool as part of the PI AF Client 2024 deployment. This utility carries out the migration of registry-based KST entries to a file-based system.

When the tool is executed, it first checks if a valid (non-empty) KST configuration file already exists. If such a file is detected, the tool exits without migrating, and also issues a warning to prevent accidental overwriting of the existing file. However, if you need to force a migration—for instance, updating the KST file with current entries from the PI SDK KST in the Windows registry—the tool can be called manually with the **/forceoverwrite** command-line switch. In this scenario, the tool will clear all entries in the existing KST file and repopulate it with the entries from the Windows registry.

To start the KST tool, see [Open the KST migration tool](#).

Command-line switches

The KST migration tool offers several command-line switches to customize its behavior during the migration process. This table includes a list of available switches and important notes on their usage.

Switch	Usage
/SuppressUI	Hides the console window during the tool's execution. This switch is useful for running the tool silently as part of an automated script.
/ForceOverwrite	Forces the migration process even if a KST file already exists. The existing KST file will be renamed, and a new file containing the migrated content will replace it. This is especially important when ensuring that the latest configurations are applied.
/OutputFile	Specifies the file path where the migrated content will be written. This switch is particularly useful for testing purposes, allowing users to verify the migrated content before committing to the migration. However, note that the PI AF SDK cannot recognize KST files located outside its default configuration folders.
?, /help	Displays the help message, listing all available switches and their descriptions.

Code examples of command-line switches for the KST migration tool

Below are examples of how to use the KST migration tool with different command-line switches.

Code example: Basic migration using the KST migration tool

This command performs the migration without displaying the console window and overwrites the existing KST file.

```
KSTMigrationTool.exe/SuppressUI/ForceOverwrite
```

Code example: How to output migrated content to a file

This command performs the migration and outputs the migrated content to the specified file path. This can be useful for validation purposes.

```
KSTMigrationTool.exe/OutputFile:C:\path\to\output\KST_migrated.txt
```

Additional considerations

- **Testing before migration:** It is recommended to use the **/OutputFile** switch to validate the migrated KST content before committing to the migration process. This helps ensure that the migration will not disrupt your PI Server configurations.
- **AF SDK compatibility:** Keep in mind that KST files created or moved to locations outside of the common configuration folders may not be recognized by the AF SDK. Always verify that the migrated KST file is in a proper location after testing.
- **Automated deployments:** The **/SuppressUI** switch is particularly useful for automated deployments or when integrating the migration tool into larger scripts, allowing for seamless background execution.

Open the KST migration tool

To open the KST migration tool, follow these steps:

1. Open the Command Prompt: Search for cmd in the **Start** menu or press **Win + R**, type cmd, and press **Enter**.
2. Navigate to the tool's directory: cd C:\Program Files\PIPC\AF.
3. Execute the tool with the desired command-line switch.
For example: KSTMigrationTool.exe/SuppressUI/OutputFile:C:\path\to\output.txt
4. To view available options, run: KSTMigrationTool.exe/?

Note: If the tool is in the system's path, it can be run from any directory by simply typing KSTMigrationTool.exe followed by the desired command-line switches.

KST migration tool: Command-line switches

Switch	Usage
/SuppressUI	Hides the console window during the tool's execution. This switch is useful for running the tool silently as part of an automated script.
/ForceOverwrite	Forces the migration process even if a KST file already exists. The existing KST file will be renamed, and a new file containing the migrated content will replace it. This is especially important when ensuring that the latest configurations are applied.
/OutputFile	Specifies the file path where the migrated content will be written. This switch is particularly useful for testing purposes, allowing users to verify the migrated content before committing to the migration. However, note that the PI AF SDK cannot recognize KST files located outside its default configuration folders.
?, /help	Displays the help message, listing all available switches and their descriptions.

Known servers table (KST) access methods in PI System products

The known servers table (KST) stores information about Data Archive servers and AF Servers required for connections by various PI Server products. Depending on whether the product is PI SDK-based or AF SDK-based, the KST is stored in different locations: In a local file or in the Windows registry.

The tables below categorize PI Server products based on their KST access methods, highlighting which products use a file-based KST and which rely on the Windows registry.

Note: Starting with PI AF Client 2024, AF SDK-based products read the Data Archive portion of the KST from a local file instead of the Windows registry. This change introduces a more modern approach to configuration management, where settings are stored in easily accessed files. To take advantage of this new behavior, it is necessary to upgrade to PI AF Client 2024 or later.

PI System products that use the file-based KST (AF SDK-Based)

The following products read the Data Archive portion of the KST from a local file when PI AF Client 2024 or later is installed.

PI Server products	Description
PI Asset Framework (AF) Client	Allows applications to interact with PI Asset Framework, and access its data structures and configurations to support comprehensive asset management and analytical tasks.
PI Web API	The PI Web API is a RESTful service in the Developer Technologies suite, designed to provide cross-platform web and mobile programmatic interfaces to the PI System.
PI Vision	Web-based tool that allows users to create and interact with visual displays of PI System data. Users can build custom dashboards, trends, and charts to visualize real-time data from PI Server, aiding in process monitoring and decision-making.
PI DataLink	Excel add-in that allows users to pull data from the PI System into Microsoft Excel. It provides functions to query and display time-series data, making it easier to perform analysis and generate reports using Excel's tools.
PowerShell Tools for the PI System	Delivers a set of PowerShell commands designed for scripting and automating routine tasks within the PI System, enhancing operational efficiency through automation.

PI System products that use the Windows registry-based KST (PI SDK-Based)

The following products read the Data Archive portion of the KST from the Windows registry. These products are PI SDK-based, using a method of configuration storage that directly interacts with the operating system's registry.

PI Server products	Description
PI Buffering Manager	Manages buffering to ensure continuous and reliable data delivery to the PI Data Archive, especially important in networked environments.
PI Collective Manager	Manages PI Server Collectives, which are groups of PI Servers configured to ensure high availability and load balancing of data access and storage.
PI Module Database Builder (MDB)	A tool for creating and managing the PI Module Database, which organizes and categorizes PI System elements for easier management and retrieval.
PI ProcessBook (Retired)	A desktop application used to create graphical displays

PI Server products	Description
	and trends of PI System data. It allows users to design custom visualizations for monitoring and analyzing process data. Note that PI ProcessBook is a legacy product, with many users now migrating to PI Vision for similar functionality.
PI Software Development Kit (PI SDK Utility)	Provides a collection of programming tools and libraries that enable the development of custom applications integrated with the PI System, offering flexibility in creating tailored solutions for specific engineering challenges.
PI System Management Tools (PI SMT)	A comprehensive toolset for configuring, managing, and monitoring the PI System, supporting efficient system administration and operational oversight.

PI AF and Data Archive collective connections

An administrator needs to configure connection preferences if a PI AF collective or Data Archive collective is being set up.

Manage connection preferences for PI System Explorer

Use the **Server Options** window to define how PI System Explorer should connect to a PI AF collective or Data Archive collective, whether login prompts are allowed, and if you want servers to be added to the Known Servers Table automatically.

1. In PI System Explorer, choose **Tools > Options > Server Options**.
2. In the **PI AF Server Connection Settings in PI System Explorer** section, define how PI System Explorer should connect to the PI AF server:

Setting	Description
Connection preference	<p>Use this preference to influence the selection of a collective member when a connection is made to a PI AF collective.</p> <ul style="list-style-type: none"> • Prefer Primary PI System Explorer attempts to connect with the primary server in the collective, and if it is not available, uses the individual priority settings of the collective member to influence selection of the server connection. This is the default setting. • Require Primary

Setting	Description
	<p>PI System Explorer is required to connect with the primary server in the collective. If the primary server is not available, the connection fails.</p> <ul style="list-style-type: none"> Any <p>PI System Explorer can connect with any available member of the collective, and uses the individual priority settings of the collective member to influence selection of the server connection.</p>
Server name resolution behavior	<p>Use this preference to inform PI System Explorer what action to perform when it attempts to communicate with one or more PI AF servers that are not in the Known Servers Table.</p> <ul style="list-style-type: none"> Auto Add <p>Adds a server to the Known Servers Table automatically if the computer name is valid and PI System Explorer can find the server's computer name on the network.</p> <ul style="list-style-type: none"> Auto Add If Resolvable <p>Adds a server to the Known Servers Table only when the server name is successfully resolved by a DNS server.</p> <ul style="list-style-type: none"> Do Not Auto Add <p>Makes no attempt to find a server if it cannot be found in the existing collective.</p>
Allow login prompt	<p>Select this option if you want a login prompt to appear when a connection to the server fails because of a security exception.</p>

3. In the **PI Data Archive Connection Settings in PI System Explorer** section, define how PI System Explorer should connect to Data Archive:

Setting	Description
Connection preference	<p>This preference is used to influence the selection of a collective member when a connection is made to a Data Archive collective.</p> <ul style="list-style-type: none"> Prefer Primary <p>PI System Explorer attempts to connect with the primary server in the collective, and if it is not available, uses the individual priority settings of the collective member to influence selection of</p>

Setting	Description
	<p>the server connection. This is the default setting.</p> <ul style="list-style-type: none"> • Require Primary PI System Explorer is required to connect with the primary server in the collective. If the primary server is not available, the connection fails. • Any PI System Explorer can connect with any available member of the collective, and uses the individual priority settings of the collective member to influence selection of the server connection.
Server name resolution behavior	<p>Use this preference to inform PI System Explorer what action to perform when it attempts to communicate with one or more PI Data Archive servers that are not in the Known Servers Table.</p> <ul style="list-style-type: none"> • Auto Add Adds a server to the Known Servers Table automatically if the computer name is valid and PI System Explorer can find the server's computer name on the network. • Auto Add If Resolvable Adds a server to the Known Servers Table only when the server name is successfully resolved by a DNS server. • Do Not Auto Add Makes no attempt to find a server if it cannot be found in the existing collective.

4. In **Protocols** in the **PI Data Archive Connection Settings** section, set the authentication protocols and the order in which they are used when connections are attempted to known servers.
PI System Explorer attempts to connect using the first protocol listed. If the first attempt fails, it continues attempting to connect using the other protocol in the list (if selected). If attempts using all protocols fail and **Allow login prompt** is selected, the **PI Data Archive Login** window is displayed.
 - a. To establish the order used when connecting to a server, use the arrows button to move protocols.
 - b. Select the **Allow login prompt** option if you want a login prompt to be displayed when a connection to the server fails because of a security exception.
5. Click **OK**.

Switch collective members

When you connect to a PI AF collective, PI AF automatically connects you to the collective member with the highest priority (lowest number). You can switch the connection to the next member in the collective list. The next member in the list is determined by members' assigned priority.

1. In PI System Explorer, click **File > Connections**.
2. Right-click the collective and click **Switch Collective Member**.

Switch to a specific collective member

When you connect to a PI AF collective, you are automatically connected to the collective member with the highest priority (lowest number). You can switch to a specific member of the collective.

1. In PI System Explorer, select **File > Connections**.
2. Right-click the collective and click **Connect to Collective Member**.
3. In the Choose Collective Member window, select the collective member from the **Collective Member** list to which you want to connect.
4. Click **OK**.

You are now connected to the selected collective member.

Database import and export

You can export a database from PI System Explorer in XML and then restore it from that XML file by importing it back to PI AF.

To export the database without having to manage XML files, you export the database as a library, as described in [Save databases as libraries](#).

Videos

For information on how to import and export databases with PI System Explorer, watch this video:

For information on how to import and export databases with import and export utilities, watch this video:

Export a database to XML

This procedure archives PI AF databases into an XML file that you can later restore.

Note: You can also export PI AF objects from a command line utility. See [AFExport utility](#).

1. Click **File > Export to File**.
2. In the Export to File window, select desired export options ([XML export options](#)).
3. Click **OK**.

PI System Explorer exports the current database into an XML file.

XML export options

The **Export to File** window contains the following export options.

Export option	Result
Include All Referenced Objects	Causes dependent references to be exported, as detailed in the All Referenced Objects table. Use this option to facilitate moving objects between different PI AF databases.
Include Security Settings	Causes the security settings of individual objects to be exported. This option increases the amount of time required for the export and subsequent import operations. You must have Administrative privileges to import objects that have the security setting specified.
Flatten XML	Exports hierarchical objects in a flat format. Exporting in a flat style can make editing in some tools simpler. Hierarchical objects that will be exported flat are attributes, attribute templates, elements, and event frames.
Simplify Configuration Strings	Removes Data Archive and tag identifiers from configuration strings for PI point data references. Additionally, substitution parameters will be resolved. Note: This option slows the export process because it requires evaluation of the saved configuration strings.
Include Default Values	Includes the default values assigned to objects. Without this option, a property that has not been changed from its default setting is not included in the output. This saves considerable space and time when you are exporting large amounts of data.
Include Unique IDs	Includes the unique ID of each object in the export. By including this option, you can rename existing items during an import to the same database. Unless rename is required, it is more efficient to leave this option turned off.
Library Objects Only	Limits the database export to include only library objects (templates, enumeration sets, reference types, tables, table connections, categories, and UOM databases).
Include Event Frames, Transfers, and Cases	Exports event frames, transfers, and cases.

All Referenced Objects

The following table lists the objects that are exported when you select **Include All Referenced Objects**.

XML object type	Included reference
AFAnalysis	AFAnalysisCategories referenced AFAnalysisTemplate in Template AFELEMENTTemplate in CaseTemplate AFELEMENT in Target AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFAnalysisTemplate	AFAnalysisCategories referenced AFELEMENTTemplate in CaseTemplate AFELEMENT in Target AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFAttribute	Referenced AFEnumerationSets in ValueTypeQualifier when not from template
AFAttributeTemplate	Referenced AFEnumerationSets in ValueTypeQualifier
AFCase	AFELEMENTCategories referenced AFEnumerationSets referenced in attributes without templates All child AFELEMENTs All AFConnections (not just those added or removed)
AFContact	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFDatabase	UOMDatabase AFContacts referenced

	<p>AFNotificationContactTemplates referenced</p> <p>AFSecurityIdentities (if Include Security Settings is also selected)</p>
AFEElement and AFModel	<p>AFEElementTemplate in <i>Template</i></p> <p>AFEElementCategories referenced</p> <p>AFEnumerationSets referenced in attributes without templates</p> <p>AFReferenceTypes to referenced children</p> <p>Same as above for all child elements</p> <p>AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)</p>
AFEElementTemplate	<p>Base AFEElementTemplates</p> <p>AFEElementTemplates referenced in AFPort.AllowedElementTemplate</p> <p>AFReferenceTypes that specifically reference this template</p> <p>AFEElementCategories referenced</p> <p>AFEnumerationSets referenced in attribute templates</p> <p>AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)</p>
AFEnumerationSet	<p>AllReferences adds AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)</p>
AEEventFrame	<p>AFEElementTemplate in <i>Template</i></p> <p>AFEElementCategories referenced</p> <p>AFEnumerationSets referenced in attributes without templates</p> <p>AFReferenceType from parents</p> <p>AFEElements referenced including full hierarchy of their parent root elements</p>

	Child event frames referenced
	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFModelAnalysis	AFAnalysisCategories referenced
	AFEElementTemplate in Template
	AFEElementTemplate in CaseTemplate
	AFEElement in Target
	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFNotificationTemplate	AFNotificationContacts
	AFAnalysisTemplate
	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFNotification	AFNotificationTemplate in Template
	AFNotificationContacts
	AFAnalysis
	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFNotificationContact	AFNotificationContactTemplate
	Child AFNotificationContacts
	AFContact referenced
AFNotificationContactTemplate	Child AFNotificationContactTemplates
	AFContacts referenced
	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFDeliveryFormat	DeliveryChannel

AFNotificationRule	AFNotificationRuleTemplate AFNotificationContactTemplate (via Subscribers) Child AFNotificationContacts AFContact AFDeliveryFormat
AFNotificationRuleSubscriber	AFNotificationContactTemplate Child AFNotificationContacts AFContact
AFNotificationRuleTemplate	AFNotificationContactTemplate (via Subscribers) Child AFNotificationContacts AFContact AFDeliveryFormat
AFReferenceType	AFReferenceTypeCategories referenced AFElementTemplates from AllowedParentElementTemplate and AllowedChildElementTemplate AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFSecurityIdentity	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFSecurityMapping	AFSecurityIdentity mapped to AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFTable	AFTableConnection AFTableCategories referenced AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)

AFTableConnection	AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)
AFTransfer	<p>AFEElementTemplate in Template</p> <p>AFEElementCategories referenced</p> <p>AFEnumerationSets referenced in attributes without templates</p> <p>AFEElements referenced in Source and Destination including full hierarchy of their parent root elements</p>
UOMClass	<p>UOMClass for exported class and classes referenced by UOMs in UOMClass. For example, when the Area class is exported, the Length class is included because Length UOMs are referenced by many Area UOMs.</p> <p>Note: UOMClass export does not include security settings, which are only exported with UOMDatabase.</p> <p>UOMGroup (if any of the UOMs in the exported or referenced classes have an assigned UOMGroup).</p> <p>UOM for all UOMs belonging to the exported UOMClass.</p>
UOMDatabase	<p>AFSecurityIdentities from SecurityAccessControl (if Include Security Settings is also selected)</p> <p>UOMGroup. Group mappings are defined under each UOM.</p> <p>UOMClass</p> <p>UOM</p>

File format for export and restore

The Import/Export XML format is described in a schema file located in the **PIPC\AF** installation directory, **OSIsoft.AF.xsd**.

Many of the AF Objects support an operation attribute in the XML that allows for deletion. Similarly, you can execute the **Auto Point Config** option selectively on elements using this same technique.

Example

```
...
<AFEElement operation="delete"> <Name>ElementToDelete</Name> </AFEElement>
```

...

Elements and Attributes can be imported using a flat list, in which the relative path of the element or attribute is included in the name field. Example:

```
...
<AFEElement> <Name>RootElement</Name> ... </AFEElement>
<AFEElement> <Name>RootElement\ChildElement1<\Name> ... </AFEElement>
<AFEElement> <Name>RootElement\ChildElement2<\Name> ... </AFEElement>
...
```

Restore databases from exported XML files

You can restore a database that has been exported to XML by importing objects from the XML file.

You can also import PI AF objects with a command line utility. See [AFImport utility](#).

Avoid the **Allow Update** option when importing objects with duplicate names, such as event frames, into an empty PI AF database. Otherwise, problems can occur. However, you may then receive a message that objects, such as units of measure, already exist on the PI AF server. The import does not attempt to make any changes to existing objects, which means that if there are differences between objects' properties in the XML file and the destination system, they are not resolved.

1. Click **File > Import from File**.
2. In the Import from File window, select the XML file that contains the data and select the appropriate options.

Import option	Description
Allow Create	Allows new objects to be created. If you want to update existing items, clear this option to prevent accidental creation of new objects.
Allow Update	Allows existing objects to be updated. If you only want to add new items, clear this option to prevent existing objects from being accidentally overwritten.
Automatic Check In	Allows the import operation to automatically check in objects as the import proceeds. This reduces the maximum memory requirements of the operation. Use this option when you are importing a large number of objects.
Create or Update PI Points	Causes any attributes with a PI point configuration specified in the XML file to be updated if they already exist, or created if they do not exist. This option invokes the appropriate Data Reference CreateConfig option, which creates or updates PI points, as well as resolving their substitution parameters and setting server and point IDs. The performance of the import operation is negatively affected when this option is selected. Note: PI points are not created unless the Tag

Import option	Description
	Creation check box is selected in the PI Point Data Reference window.
Preserve Unique IDs	<p>Retains any unique IDs that exist in the source XML. This option is only valid when the Allow Create and Automatic Check In options are also selected. The performance of the import operation is negatively affected when this option is selected. There is no guarantee that PI AF will preserve unique IDs of attributes derived from templates because unique IDs of such attributes are generated based on the template's unique ID.</p> <p>Note: Because PI AF servers maintain a cache of rowids to <i>ids</i>, the import with Preserve Unique IDs option affects load-balanced PI AF servers differently from non-load balanced PI AF servers. In a non-load balanced scenario, removed items will cause the cache of rowids to <i>ids</i> to be updated. However, in a load-balanced scenario, the non-connected server will need to be restarted to have the cache updated after items are removed, and before the import with Preserve Unique IDs option is used to restore items to the same system.</p>
Disable New Analyses and Notifications	When enabled (the default), any new analyses or notifications that are created by the import are disabled by the import, regardless of the value of the Enabled property on the analysis or notification. The Status settings in the XML for existing analyses and notifications are ignored and they are not modified when the option is selected.

Export of library objects to another database

You can export library objects (templates, formulas, UOM, and so on) from one database into another.

PI AF saved libraries

A PI AF saved library provides a collection of application- or domain-specific objects that you can import into a PI AF database. Saved libraries typically include categories, element templates, enumeration sets, reference types, tables, as well as the unit-of-measure database, which is always included. You also have the option to include other objects, such as elements and notifications.

Note: Libraries are stored as XML files in the PI AF SQL Server database (PIFD), where they are easily accessible to other users. By contrast, the **Export to File** option enables you to export an entire database of objects as an

XML file to your computer or network. The exported file can be imported to a different server altogether.

Save databases as libraries

You save database objects as a library when you wish to make those objects available for import to a different database on the PI AF server.

1. Click **File > Save as Library**.
2. In the Save Database as Library window, enter a name in the **Library Name** field. The library name does not need to be unique if you plan to overwrite an existing library.
3. Optional. Enter a description of the library content in the **Description** field.
4. To replace an existing library, select the **Replace existing Library without prompting** check box.
5. To include objects such as elements and notifications in the library, select the **Include non-library objects** check box.
6. Click **OK**.

Load database libraries

You load a database library from a set of libraries that have been previously saved in the PI AF database.

1. Click  **Database**.
2. In the Select Database window, select the database into which you want to load a library, and click **OK**.
3. Click **File > Load Library**.
4. In the Load Library into Database window, select a library from the list and click **OK**.

The objects in the loaded library populate the current database. To confirm how many objects are loaded, view the **Count** tab in the Database Properties window, as described in [View or edit properties of PI AF databases](#).

Review properties of loaded libraries

You view the properties of libraries that have been loaded on the PI AF server in the PI AF Server Properties window. You can change a library name and description.

1. Click **File > Server Properties**.
2. In the PI AF Server Properties window, click the **Libraries** tab.
The libraries that are currently installed are listed.
3. Right-click the library you want to review and click **Properties**.
4. Optional. In the Library Properties window, you can change the library name and description as needed.
5. Click **OK**.

AFExport utility

The AFExport utility is a command line application that you can use to archive PI AF databases into an XML format that you can restore later. Use this utility to archive elements, templates, event frames, transfers, and other objects from a PI AF database. You can also export collections of PI AF objects from the PI System Explorer. See [Export a database to XML](#).

The **AFExport.exe** utility is located in the **\PIPC\AF** folder.

To run the PI AF Export utility you open a command window and navigate to the **\PIPC\AF** folder. Use the following syntax: AFExport .exe and choose from the parameters listed in [AFExport utility parameters](#). To display all parameters, type: AFExport /?

Guidelines for exporting collections

You should follow these guidelines as you prepare to export a collection:

- Specify collections by their PI AF SDK property name, followed by "[]".
- Identify individual members of a collection by placing their name within the brackets.
- If no collection name is specified, the default child collection for that location in the path is assumed.
- The default child collection of a PI AF server is **Databases**.
- The default child collection of a database is **Elements**.
- The default child collection of an element is **Elements**.
- The default child collection of UOM database is **UOM**.
- A vertical bar (|) indicates an attributes or attribute templates collection.

AFExport utility parameters

The AFExport utility supports the following parameters.

Parameter	Short form	Description
<i>Path</i> Additional details and examples follow this table.		Path to the object that you wish to export. Typically of the form: <code>\afserver\database</code> . Use <code>'.'</code> to export the default database. See Sample export paths .
<code>/File:string</code>	<code>/F</code>	Specify an output file. If not specified, then the output is streamed to the console.
<code>/StartTime:string</code>	<code>/T</code>	Specify a start time to cause event frames, transfers, and cases to be exported that are between the start and end times specified.

Parameter	Short form	Description
<i>/EndTime:string</i>	<i>/E</i>	Specify an end time when exporting event frames, transfers, and cases.
<i>/AllReferences[-]</i>	<i>/A</i>	Export any referenced object from the specified PI AF object. This parameter cannot be used with the <i>No References</i> parameter.
<i>/NoReferences[-]</i>	<i>/N</i>	Do not export any referenced objects, including child objects. This parameter cannot be used with the <i>All References</i> parameter.
<i>/DefaultValues[-]</i>	<i>/D</i>	When this parameter is not specified, then properties that are set to the default values are not exported, resulting in a substantially smaller export file. Importing a file without default values over existing objects may result in values not being reset to their defaults.
<i>/Library[-]</i>	<i>/L</i>	Export only the library objects from a database. Library objects include all categories, templates, enumeration sets, reference types, and tables.
<i>/Security[-]</i>	<i>/Y</i>	Export security information. Exporting security information will increase both export time and subsequent import times.
<i>/SimplifiedConfigStrings[-]</i>	<i>/Sc</i>	Export configuration strings for attribute templates or attributes derived from attribute templates without substituting parameters and do not export UniqueIDs or point identifiers in the configuration strings.
<i>/UniqueIDs[-]</i>	<i>/U</i>	Export unique IDs of all objects. This allows the renaming of objects when imported back into the same database. This parameter increases the size of the output file and may

Parameter	Short form	Description
		increase the amount of time required to import.
<i>/Silent[-]</i>	<i>/S</i>	Silent mode. Prevents informational messages from being displayed. If no output file is specified, this option is automatically chosen.
<i>/Summary[-]</i>	<i>/M</i>	Summary mode. Output only minimal information on progress. This parameter is not valid with the <i>Silent</i> mode or if no output file is specified.
<i>/User:string</i>	<i>/user</i>	Use to specify a different Windows user account to connect to the PI AF server.
<i>/Password:string</i>	<i>/pw</i>	If a user name is specified, specify the network credentials password.
<i>/Version</i>	<i>/V</i>	Use to display version information. All other parameters are ignored.
<i>/Flat[-]</i>	<i>/flat</i>	Export hierarchical object in a flat format. Exporting in a flat style can make editing in some tools simpler. Hierarchical objects that will be exported flat are attributes, attribute templates, elements, and event frames.
<i>/Paste[-]</i>	<i>/Pa</i>	Paste operation behaves as a typical copy/paste.
<i>/?, /help</i>		Prints the contents of this table.
<i>@file</i>		Use the specified file to provide additional input arguments. The file should contain one argument per line. Comment lines start with the # character.

Sample export paths

The following table contains sample syntax to export different database components.

To export ...	Use this syntax ...
The default database	.
The database MyDatabase on the default PI AF server	\.\.\MyDatabase
The element MyElement in the database MyDatabase on the PI AF server named MyAFServer	\MyAFServer\MyDatabase\MyElement
All element templates in the database MyDatabase	\.\.\MyDatabase\ElementTemplates[]
Element template T1 in the database MyDatabase	\.\.\MyDatabase\ElementTemplates[T1]
All enumeration sets in the MyAFServer default database	\MyAFServer\.\.\EnumerationSets[]
All attributes of MyChildElement in the MyAFServer default database	\MyAFServer\MyElement\MyChildElement\Attributes[]
The UOM database (UOMDatabase is case sensitive)	\.\.\UOMDatabase
All tables in the MyAFServer default database	\MyAFServer\.\.\Tables[]

AFImport utility

The **AFImport** utility is a command line application that you can use to restore PI AF objects into a database. You can also use **Import from File** in PI System Explorer to restore database objects. See [Restore databases from exported XML files](#).

The **AFImport.exe** utility is located in the **\PIPC\AF** folder.

To run the **AFImport** utility, you open a command window and navigate to the **\PIPC\AF** folder. Use the following syntax: **AFImport.exe** and choose from the parameters listed in [AFImport utility parameters](#). To display all parameters, type:

```
AFImport /?
```

Syntax Example #1

To import database objects from an XML file into a PI AF database and create or update PI point configuration for newly created elements, enter:

```
AFImport "\AFServer\database" /File:"C:\Filename.xml" /P
```

Note: Using the **/P (/CreateUpdatePIPoints)** parameter may significantly impact import performance.

Syntax Example #2

To import database objects from an XML file into a PI AF database and disable the validation of configuration string settings for data references and delivery channels, enter:

```
AFImport "\AFServer\database" /File:"C:\Filename.xml" /D
```

Note: Use the `/D (/DisableConfigStringValidation)` parameter to improve the speed of an import operation. Keep in mind that using this parameter bypasses looking up PI points, which corrects or adds server IDs and point IDs to configuration strings.

Syntax Example #3

To import database objects from an XML file into a sub-element under a PI AF database, enter:

```
AFImport "\\\AFServer\database\element" /File:"C:\Filename.xml"
```

AFImport utility parameters

The AFImport utility supports the following parameters.

Parameter	Short form	Description
<code>Path</code>		Path to the object into which you want to import. Typically of the form: <code>\\\afserver\database</code> . Use <code>'.'</code> to import into the default database.
<code>/File:string</code>	<code>/F</code>	Specify an input file. If not specified, the import operation reads from the standard input.
<code>/AutoCheckIn[-]</code>	<code>/A</code>	Automatically check in changes during an import operation. Default value: True
<code>/Create[-]</code>	<code>/C</code>	Allow import operation to create new objects. Default value: True
<code>/Update[-]</code>	<code>/U</code>	Allow import operation to update existing objects. Default value: True
<code>/CreateCategories[-]</code>	<code>/CC</code>	Create categories that do not exist but are referenced by objects in the input. Default value: True
<code>/CreateUpdatePIPoints[-]</code>	<code>/P</code>	Create or update PI point configuration for newly created elements. This option can significantly affect import performance.
<code>/PreserveUniqueIDs[-]</code>	<code>/Pid</code>	Retain unique IDs that exist in the source XML. This option is only valid when <code>/Create</code> and <code>/AutoCheckIn</code> are also specified.

Parameter	Short form	Description
		<p>This option can significantly affect import performance.</p> <p>There is no guarantee that PI AF will preserve unique IDs of attributes derived from templates because unique IDs of such attributes are generated based on the template's unique ID.</p> <hr/> <p>Note: Because PI AF servers maintain a cache of rowids to ids, the import with Preserve Unique IDs option affects load-balanced PI AF servers differently from non-load balanced PI AF servers. In a non-load balanced scenario, removed items will cause the cache of rowids to ids to be updated. However, in a load-balanced scenario, the non-connected server will need to be restarted to have the cache updated after items are removed, and before the import with Preserve Unique IDs option is used to restore items to the same system.</p>
<i>/DisableNewAnalysesNotifications</i> [-]	<i>/DN</i>	New analyses and notifications are created in a disabled state. Existing analyses and notifications in the destination database are not affected.
<i>/DisableConfigStringValidation</i> [-]	<i>/D</i>	Disable the validation of configuration string settings for data references and delivery channels, which can improve the speed of the import operation. However, this will bypass looking up PI points, which corrects or adds server IDs and point IDs to configuration strings.
<i>/GenerateUniqueNames</i> [-]	<i>/G</i>	Generate unique names for objects when an object with the same name already exists.
<i>/Paste</i> [-]	<i>/Pa</i>	Paste operation behaves as if this is

Parameter	Short form	Description
		a copy/paste process. Depending on where the data is imported, this affects whether a new name is generated.
<i>/ContinueOnError</i>	<i>/CE</i>	Specify the behavior of the import process when a recoverable error occurs. The three options available are Yes, No, and Prompt. The default value is Prompt, unless running silently in which case the default will be to cancel the import process.
<i>/Silent[-]</i>	<i>/S</i>	Silent mode. Prevent informational messages from being displayed.
<i>/Summary[-]</i>	<i>/M</i>	Summary mode. Output only minimal information on progress.
<i>/User:string</i>	<i>/user</i>	Use to specify a different Windows user account to connect to the PI AF server.
<i>/Password:string</i>	<i>/pw</i>	If a user name is specified, specify the network credentials password.
<i>/Version</i>	<i>/V</i>	Display version information. All other parameters are ignored.
<i>@file</i>		Read response file for more options. The response file contains one parameter per line. Comment lines start with the # character.

Retrieval of asset information

PI System Explorer provides a variety of methods that you can use to locate and review the assets in your PI AF database, including a browser, search windows, trends to verify formulas and calculations, and version management. You can also review time series data for attributes that contain or reference such data.

Asset browsing

You use the PI System Explorer browser to display asset objects in the PI AF database. The browser displays the following assets, depending on the asset type that you have selected in the navigator pane:

- **Elements**

Displays element assets and element searches in a tree format. You can control how many elements are displayed per page.

- **Event Frames**

Displays event frame and transfer search collections. Because asset models can comprise thousands of event frames or transfers, these objects are not displayed in a hierarchy in the browser. Instead, each has a search collection in the browser. Recent searches are also listed under the search collection.

- **Library**

Displays object collections for **Templates** (for elements, event frames, models, and transfers), **Enumeration Sets**, **Reference Types**, **Tables**, **Table Connections**, and **Categories** (for analyses, attributes, elements, notification rules, reference types, and tables). To see all the objects of a particular type, you expand the collection for that type.

- **Unit of Measure**

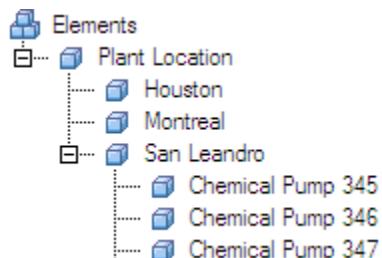
Displays all UOM classes in the Unit of Measure database. When you select a class, UOMs belonging to that class are listed in both the viewer and the conversion calculator.

- **Contacts**

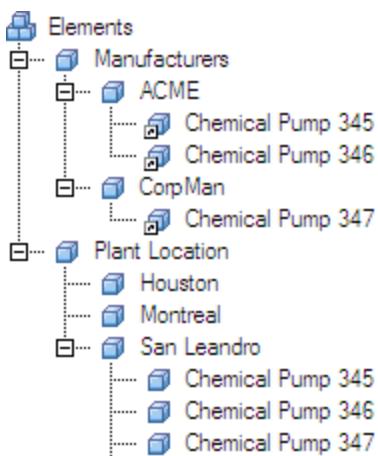
Displays a list of contact searches, escalation teams, groups, and stand-alone delivery endpoints for use with notifications.

Element browsing

Elements are displayed as a tree in the browser. The structure of the element tree is different for each organization. The asset model designer chooses structure that is relevant to the users in the organization. In the following illustration elements are organized by plant location. If you were in charge of all the equipment for a particular plant, then such a model might make sense for you. A different model might be more useful for someone with a different role.



The element tree can include different sub trees that provide different context for the same assets. This allows users to find elements in the context that makes the most sense for the task at hand. For example, in addition to the organization by plant location shown above, you might also have an organization by equipment manufacturer, as shown in the following illustration.



The elements representing the pumps appear in both the Manufacturers and the Plant Location hierarchies. In the Manufacturer hierarchy, the pump elements are not new separate elements, rather they are references to the elements that already existed in the Plant Location tree. To indicate that they are element references, they are represented by the referenced element icon .

Configure browser page size

The PI System Explorer browser is paged. This means that it displays a certain number of objects at a time. If more objects exist, PI System Explorer displays them in another page. When this happens, you see  <Previous> and  <Next> in the browser.

By default, the maximum number of objects displayed in the browser is 1000. You can change that number.

1. In PI System Explorer, select **Tools > Options**.
2. On the **General** tab, type the maximum number of objects that can be displayed in the browser in the **Maximum Tree Branch Page Size** field.
3. Click **OK**.

Open additional browser windows

Occasionally, you may find it convenient to open additional browser windows. For example, you can have the Unit of Measure database displayed in one browser instance while creating a new template in the Library browser.

1. In the navigator pane, right-click the item you want to open in another window.
2. Select **Open in New Window**.
3. To move between windows, click the PI System Explorer icon in the Windows taskbar and select the thumbnail of the window you want.

Asset and asset data searches

PI System Explorer provides a variety of options for finding assets, asset data, and PI points.

- Find data for a specific piece of equipment. For example: PI point data, calculation results, maintenance information, and so on. For example, you can use PI System Explorer to find information about a specific tank at a specific plant.
- Find all equipment with specified attribute values or value ranges. For example, get a list of all tanks with temperature greater than 200 °F.

Quick search

You can use the quick search box at the right end of the PI System Explorer toolbar to find elements, event frames, element templates, or UOM (unit of measure) types.

1. Make a selection in the navigator pane to set the context for quick search.
For example, select **Event Frames** to set quick search to search for event frames.
2. In the quick search box, select a search constraint from **Actions ▾**, enter search criteria, and press Enter.
Search results are displayed in the viewer, as well as in the browser.

Note: Search results that are displayed in the browser remain there for easy access in the event you need them again. You can right-click and delete them from the browser; they are also removed when you exit PI System Explorer. You can right-click and save them to keep them until you delete them.

Search result paging

When you are searching large numbers of elements or event frames, you can use the **Set Maximum Query Size** option to return quick search results back in manageable chunks. This is called *paging*. Change the **Set Maximum Query Size** value to the number of objects you want to see in the search results at one time. If the search returns a greater number of objects than the **Set Maximum Query Size** value specifies, the results are paged.

For example, if the **Set Maximum Query Size** value is 100,000 the PI AF server attempts to find 100,000 matching objects before returning the results. You probably would not want to wait for the server to find that many matches, nor would you want to see that many matches in a single page of search results. If you change **Set Maximum Query Size** to 100, the PI AF server would send you the results after each 100 matches, and you would see 100 objects at a time in the search results.

Search result rules

- Only search results for elements, transfers, and event frames are paged.
- The **Set Maximum Query Size** setting applies only to quick searches of elements, transfers, or event frames. If you are searching other objects, the search ignores the **Set Maximum Query Size** value.
- In search windows, the **Results per Page** value overrides the **Set Maximum Query Size** value.

Maximum query sizes

A system default controls the number of objects that can be returned by a search query. Users can override the system default by specifying a different value in Element Search, Attribute Search, Event Frame Search, and Transfer Search windows.

System default

You set the **Maximum Query Size** option in **Tools > Options**. This sets the default value for PI System Explorer.

Custom sizes

You can override the system default for a specific search by setting a custom value for **Maximum results**. For event frames, you specify a custom value in the **Results per Page** field.

Searches on a specified date

You can conduct a search in PI System Explorer at a specified time and date, by entering that time setting for **Query Date**. PI System Explorer also displays object versions for that date. See [Query Date and PI System Explorer time](#) for information on what objects are affected by **Query Date**.

In addition, you can set a time or time range that applies only to displayed attribute values and leaves in place the **Query Date** setting. To do this, establish a time context in the Set Time Context window, as described in [Set time context for displayed attribute values](#).

Search for PI points

Use the Tag Search window to retrieve PI points that match your search query criteria. In PI AF and PI Builder 2017 or later versions, you can create a search query based on both PI point attributes and PI point values.

Note: To create PI point data references directly from PI points retrieved from a PI point search, select **View > Palette > Tag Search**. For more information, see [Create direct PI point data references from Tag Search results](#).

1. In the navigator pane, click **Elements**.
2. Select **Search > Tag Search**.
3. In the Tag Search window, select the Data Archive computers on which you want to search.

To add or change Data Archive computers, choose from the following actions:

- Click ▾ next to the **Server(s)** field and click a Data Archive on the list.
- Click and double-click on the Data Archive you wish to add from the list in the PI Data Archives window.
- To remove a selected Data Archive, select the server name in the **Server(s)** field, right-click and click **Delete**.

Servers are added in alphabetical order to the existing selection. You can add multiple selections from either list.

4. You create a PI point search query in the text box next to the Search button. A search query comprises a filter name, which can be a text string, a PI point attribute (defaults to tag) or a PI point value (for example, Value), an operator (defaults to :=), and a query filter (defaults to *, or all PI points). For a full description of the syntax of a PI point query, see [Syntax for PI point searches](#).

Examples of attribute queries are:

- sin*
- tag:=sin*

- tag:<>sin* datatype:float
- step:0 AND pointsource:L
- tag:<>sin* AND PointType:Float64

Examples of value queries (which you can combine with attribute queries) are:

- Value:>1000
- tag:<>sin* AND Value:>10
- PointType:Int32 AND Value:>10
- PointSource:L AND Annotated:1 AND TimeStamp:t
- creationdate:>y-1d AND future:true AND timestamp:<*

By default, PI AF searches for point names that start with the query string (meaning that the Starts With filter is already selected).

Note: Queries that contain a query filter name (such as name:*sine*), search tag attributes only. In previous versions of PI AF, queries that contained a query filter name would search the descriptor attribute as well as the specified query filter, unless the descriptor attribute was actually specified as part of the query filter.

To build a search query, choose from the following actions.

To ...	Do this ...
Clear previously selected criteria	Click Reset . All queries are cleared, as well as the Include Description in Search filter.
Include point descriptions in a query	a. Click  . b. Click Add Criteria or press ALT+C. c. Select Include Description in Search and set the value to True .
Type a query directly in the search text box	a. Type the first character of the query. b. Select from the list of matching point attributes and values, or continue typing a point attribute or value manually. c. Enter the criteria to be matched.

To ...	Do this ...
Include common PI point attributes in a query	<p>a. Click .</p> <p>b. Enter criteria in any of the following fields:</p> <ul style="list-style-type: none"> a. Name (alias for tag attribute) b. Point Source c. Data Type (alias for pointtype attribute) d. Point Class (alias for ptclassname attribute) <p>c. To enter criteria for engineering units and description, click Add Criteria or press ALT+C. Then click Engineering Units and/or Description.</p> <p>Criteria are appended to the string in the search text box, separated by a space.</p> <p>Note: The search query returns only PI points that match all criteria.</p>
Include PI point values in a query	<p>a. Click .</p> <p>b. Click Add Criteria or press ALT+C.</p> <p>c. Click any of the following criteria:</p> <ul style="list-style-type: none"> a. Value b. TimeStamp c. IsGood d. Annotated e. Substituted f. Questionable <p>a. Enter criteria in the fields you have selected, as required. Note that you can select a comparison operator for Value and TimeStamp criteria.</p> <p>Criteria are appended to the string in the search query text box, separated by a space.</p> <p>Note: The search query returns only PI points that match all criteria.</p>
Clear an existing query, or remove a criterion from the expanded search area	Click x.
Use a previous query	<p>a. Click ▼.</p> <p>b. Click Recent Searches.</p>

To ...	Do this ...
	c. Select the existing query from the list.
Filter point names by contents, exact match, or ending	a. Click ▾. b. Click the appropriate filter: a. Contains b. Exact Match c. Ends With

5. Click **Search** to retrieve the points that match into the results table.
6. Choose from the following actions.

To ...	Do this ...
Review time series data	Right-click a PI point and click Time Series Data . For more information, see View time series data .
Create a trend	Right-click a PI point and click Trend . For more information, see Create trends .
Add a PI point to an existing trend	Right-click a PI point and click Add to Trend .
Review current PI point values, time stamps, and attributes	Right-click a PI point and click Properties .
Create a PI point data reference	For search results displayed in the palette only. Drag a PI point onto the Attributes grid. For more information, see Create direct PI point data references from Tag Search results .
Change the columns in the results table	Click  and clear the columns that you want to remove.
Add attribute columns to the results table	a. Right-click a column heading and click Add Column . b. In the Select Point Attributes window, select the point attributes to be added. c. Click OK .
Restore original columns in the results table	Right-click a column heading and click Restore Original Columns .

7. Click **OK**.

The results are displayed in the viewer. Each search is temporarily listed in the browser with a **Tag Search Results** label. To differentiate between searches, you can change a label by right-clicking and clicking **Rename**.

Syntax for PI point searches

Refer to the following sections for details on the syntax for building PI point queries in PI AF and PI Builder. For complete details on PI point query syntax, see “[PIPoint Query Syntax Overview](#)” in PI System Explorer Help > AF SDK Reference > Overview, or refer to [PI Point Query Syntax Overview](#).

Condition filters

To build a PI point query, enter one or more *AND* condition filters that you can also combine with an *OR* condition as needed. Each *AND* condition contains one or more queries, separated by a space or *AND*. A query consists of a query filter name, an operator, and the query filter. This enables you to specify multiple conditions with a single query, as shown in the following example:

```
(tag:<>sin* AND PointType:Float64) OR (tag:="*Tank*" AND DataType:=Int32)
```

Note: You can only use parentheses between *OR* conditions.

You can only reference a filter name once per *AND* condition of the query string. For example, `PointId:>5 AND PointId:<10` generates an error, whereas `PointType:=Int32 OR PointType:=Float32` is valid.

For maximum efficiency, build your query so that you eliminate most items from the retrieved results with your first condition filters.

Query filter names

When querying based on PI point attributes, the query filter name is a PI point attribute name or alias. Common aliases are:

Alias name	Attribute name
Name	Tag
DataType	PointType
Description	Descriptor
PointClass	PtClassName

Starting in PI AF 2017, you can query based on values, in addition to querying PI points based on attribute. However, you cannot use the *OR* condition to query a PI point value. For example, you would generate an error if you were to enter the following queries:

- `IsGood:false OR Annotated:true`
- `PointType:Float AND Value:>10` because `PointType:Float` is implicitly translated to '`PointType:=Float16 OR PointType:=Float32 OR PointType:=Float64`'
- `PointType:Int AND Value:>10` because `PointType:Int` is implicitly translated to '`PointType:=Int16 OR PointType:=Int32`'
- `sin* AND Value:>10` because `sin*` is implicitly translated to '`tag:=sin* OR Descriptor:=sin*`' if the default filter setting for **Include Description in Search** is selected. To be valid, you would need to clear the **Include Description in Search** filter.

Wildcard characters

You can use the following special characters in a PI point query.

Special character	Description	Example
*	Substitute any number of unspecified characters	sin* Returns all PI points that have names starting with "sin", for example, sinusoid and sinusoidu.
?	Substitute a single unspecified character	CD?158 Returns all PI points that have names starting with "CD", followed by any single character, followed by "158" (for example, CD1158, CDA158, and so on).
: or :=	When searching for all PI points with a specific attribute value (other than name), separates the attribute and the value you are searching for. Note When searching for a PI point name that contains a colon, enclose the name in double quotation marks, or precede the colon with a backslash.	pointsource:R Returns all PI points that have the <i>pointsource</i> value R. "ba:temp.1" ba\temp.1 Either of the above examples returns the PI point named ba:temp.1.
'' or '''	Delimiters for search strings containing spaces or special characters	'*Owner Change*' or **Owner Change** Returns all PI points that have names containing Owner Change. "ba:temp.?" Returns all PI points that have names starting with ba:temp. and ending with any single character.

Note: Results of the examples above assume you are using the default search option, which searches for PI point names that start with your search string.

Operators

The following table lists the operators that you can use in an *AND* condition.

Operator	Description	Example
=	The <i>EQUALS</i> operator.	Tag:Tank* or Tag:=Tank*
<>	The <i>NOT EQUALS</i> operator.	PointType:<>Int32
<	The <i>LESS THAN</i> operator.	Descriptor:<M
<=	The <i>LESS THAN OR EQUAL</i> operator.	Tag:<=Tank
>	The <i>GREATER THAN</i> operator.	Tag:>Tank
>=	The <i>GREATER THAN OR EQUAL</i> operator.	Tag:>=Tank

In PI point value queries with a String data type, you cannot use the following operators: <, <=, >, or >=. Furthermore, when boolean values are expected (as with *Substituted*, *Questionable*, *Annotated*, and *IsGood* point value queries), you can only use the = and <> operators.

Syntax restrictions

- You cannot query future point attributes, such as `creationdate:>y-1d AND future:true`, on Data Archive servers older than 3.4.395.
- You cannot query security point attributes, such as *PtSecurity* and *DataSecurity*, on Data Archive servers older than 3.4.380.

Manage search results

PI System Explorer displays all search results in the browser where you can save them in a searches collection for reuse, rename them, or edit the criteria. All unsaved search results are indicated by an asterisk.

Note: All unsaved search results are deleted when you exit PI System Explorer.

1. Optional. To work from a list of search results in the viewer rather than in the browser, choose from the following actions:

To ...	Do this ...
Manage an element or attribute search	<ol style="list-style-type: none"> In the navigator, click Elements. In the browser, click the Element Searches collection.
Manage an event frame search	<ol style="list-style-type: none"> In the navigator, click Event Frames. In the browser, click the Event Frame Searches collection.
Manage a transfer search	<ol style="list-style-type: none"> In the navigator, click Event Frames. In the browser, click the Transfer Searches collection.

2. Select a search and choose from the following actions:

To ...	Do this ...
Save a search result	Right-click an unsaved search result name and click Save .
Rename a search result	a. Right-click a search result name and click Rename . b. Type a new search result name.
Copy a search result	Right-click the search result name and click Copy .
Edit criteria for a search result	a. Right-click a search result name and click Properties . (In the viewer, you can also double-click a search result name.) b. Modify search criteria as needed and click OK .
Delete a search result	a. Right-click a search result name and click Delete . b. Click Yes in the Delete confirmation window.
Rearrange event frame or transfer search results	In the browser only: a. Right-click an event frame or transfer search result name and click Arrange By . b. Select from the following options: a. Arrange By Name b. Arrange By End Time c. Arrange By Start Time d. Arrange By Category e. Arrange By Template
Display the full path to elements or event frames	In the viewer only: a. Right-click on the column header (or below the search results grid). b. Click Show Full Paths .

Search for elements

Use the Element Search window to retrieve element data that matches your search criteria.

- In the navigator pane, click **Elements**.
- Choose from the following actions:
 - From the PI System Explorer menu, select **Search > Element Search**.
 - In the browser, right-click the **Element Searches** root node and select **New Search**.

3. Set the **Element Search** window to find the desired element or elements in the PI AF database.

Note: If you enter values for multiple criteria, the search returns only those elements that match all the specified criteria.

4. From the Actions ▾ list, select the type of filter to apply: **Contains**, **Exact Match**, **Starts With**, or **Ends With**.
 5. Choose from the following actions:

To ...	Do this ...
Type one or more filter conditions directly into the Enter element criteria field	<ul style="list-style-type: none"> Use the : or := operator to select elements that match a name, description, template, and category. Use special characters as needed. For more information, see Special characters in name searches. Enclose strings that contain spaces or special characters with the " character. Separate filter conditions with a whitespace, for example: Category:"Processing Plants" Name:Cracking <p>Beginning with PI AF 2018 SP2, you can use OR conditions when typing directly. For example:</p> <ul style="list-style-type: none"> "Name:'ElementName' (Attribute1:>5 OR Attribute2:<2)" "Description:'TestDescription' OR Name:'TestName'"
Filter elements under Criteria	Enter values in the following fields as needed. Click Add Criteria to enter criteria for additional fields.

- **Name**

Enter the name of the element to retrieve, based on the filter type. You can enter special characters to match part of a name. See Special characters in name searches.

- **Element Search Root**

Enter the element that you want to use as the root or base level for the element search. Type the exact name or click  to open the **Element Browser** window, where you can view the element hierarchy and select an element. You cannot include wildcard characters in the entered name. If you do not specify an element, you set the main level of the element hierarchy as the root.

Depending on your PI AF hierarchy, specifying an element in the **Element Search Root** field can improve search performance.

- **All Descendants**

Select **True** to retrieve any sub-element in the hierarchy that matches the specified criteria. Select **False** to retrieve only root-level elements that match the specified criteria.

- **Template**

Select the template that retrieved elements must be based on. After you select a template, you can add criteria to find elements by attribute value.

- **Category**

Select the category that retrieved elements must match.

- **Attribute Value**

You can specify up to three conditions for an attribute value. For each condition, specify an attribute name, operator, and attribute value, such as Temperature >= 98.

- In versions prior to PI AF 2018, only available when you specify a template.
- In PI AF 2018 and later versions, you can specify attribute values without needing to specify a template.

- **Description**

Enter a string (of up to 440 characters) that retrieved elements must match.

- **Element Type**

Select the type that retrieved elements must match.

- **Is Annotated**

(PI AF 2017 or later versions.) Set to True to retrieve only elements that have annotations. Set to False to retrieve only elements that do not have annotations.

- **Creation Date**

(PI AF 2017 or later versions.) Select an operator and enter a date or a PI time abbreviation (>= *-30d is the default) to retrieve elements that were created in the specified period. You can also click  to select a date in the Date and Time Picker window. You can select Creation Date a second time and filter the search for results between two values (< *+1d is the default).

- **Modify Date**

(PI AF 2017 or later versions.) Select an operator and enter a date or a PI time abbreviation (>= *-30d is the default) to retrieve elements that were modified in the specified period. You can also click  to select a date in the Date and Time Picker window. You can select Modify Date a second time and filter the search for results between two values (< *+1d is the default).

Note: An element's modify date is updated whenever an annotation or child element is added, as well as when a change to its configuration is checked into the database.

Most template changes, or any modification to an attribute value that is not a configuration item, will not affect an element's modify date.

- **Results per Page**

Enter the maximum number of elements to show on a single page of the search results.

6. Optional. Specify how you want results to be displayed in the Results table.

To ...	Do this ...
Group by template	Select the Template check box.
Group by category	Select the Category check box.
Change column selections	a. Right-click the column heading in the Results table or the white space below.

To ...	Do this ...
	<p>b. Click Column Visibility.</p> <p>c. Select or clear column selections as needed.</p>
Display attributes as columns	<p>a. Click  and click Select Attributes.</p> <p>b. In the Select Attributes window, use standard Windows keystrokes to highlight contiguous (SHIFT+<click>) or non-contiguous (CTRL+<click>) attributes.</p> <p>c. Click .</p> <p>d. Click OK.</p>
Display full paths of elements	<p>a. Right-click the column heading in the Results table or the white space below.</p> <p>b. Click Show Full Paths.</p>
Conceal full paths of elements	<p>a. Right-click the column heading in the Results table or the white space below.</p> <p>b. Click Hide Full Paths.</p>

7. Select any of the results you want to use and click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

8. Select any of the results you want to use and click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Configure search conditions for attribute values when a template is specified

Before you configure search conditions, you should be aware of the following:

- Unindexed attributes can take a significant amount of time to evaluate, particularly if they are configured with a data reference.
- You cannot search for attributes with Object or Array value types.

You can restrict your search based on the value of an attribute. After you specify a template (required in versions prior to PI AF 2018), use the **Attribute Value** field to configure up to three conditions that the search must match regarding an attribute value.

1. Click  (**Display attribute choices**) and select an attribute from the list of possible attribute categories:

Option	Description
attribute a	Indexed attributes, including configuration attributes.
Configuration Attributes ▾	Configuration attributes that are not indexed.
Other Attributes ▾	Non-configuration attributes that are not indexed.

2. Click \geq , and select a mathematical operator from the list.
 - For attribute value types Single and Double, queries do not support the In operator.
 - For attribute value types String, Boolean, and Int64, queries do not support the following operators:
 - < (less than)
 - > (greater than)
 - <= (less than or equal to)
 - >= (greater than or equal to)
3. Enter a value in the units specified by the default UOM in the attribute template.

Note: For indexed attributes that store String value types, the search only uses the first 40 characters of the entered value.

Configure search conditions for attribute values when no template is specified

Before you configure search conditions, you should be aware of the following:

- When no template is selected, all attributes are searched, including those used in templates.
- When no template is selected, wildcard characters should not be used in the **Attribute Value** field.
- Unindexed attributes can take a significant amount of time to evaluate, particularly if they are configured with a data reference.
- You cannot search for attributes with Object or Array value types.

When using a PI AF 2018 or later client and connected to a PI AF 2018 or later server, you can restrict your search based on the value of an attribute, without first having to specify a template. Use the **Attribute Value** field to configure up to three conditions that the search must match regarding an attribute value.

1. From the **Add Criteria** list, select **Attribute Value**.
2. In **Attribute Value**, enter the name of the attribute to retrieve.
3. Click \geq , and select a mathematical operator from the list.
4. Enter a value. If the value type is Enumeration Set or Guid, you also need to append as `Enumeration_Set` or as `Guid` to the search query displayed in the **Enter element criteria** field.

For example, to search for assets with a Health Status attribute value of Error, you would enter the following as the **Attribute Value** criteria:

To complete the search query, you would append the name of the Health Status enumeration set to the string already displayed in the **Enter element criteria** field:

```
as 'Health Status'
```

The completed search query in the **Enter element criteria** field would look as follows:



Keep in mind the following guidelines when appending to search queries:

- Append **As String** or **As Numeric** whenever the value type of an attribute does not match what the query search value appears to be.
- For example, if the value type of an attribute were *String* and the search value were *55* (which looks like a numeric), you would need to append **As String** to the query.
- Use uppercase and lowercase combinations when you append to search queries: **As String**, **as string**, and **as STRING** are all equivalents.
- Use either ' or " to enclose enumeration sets and strings that contain space characters.

Special characters in name searches

When searching for objects by name, such as element names, event frame names, or attribute names (when associated with a template), you can use special characters:

Special character	Purpose
*	Substitute any number of unspecified characters.
?	Substitute a single unspecified character.
[xyz]	Specify a set of characters (x, y, or z) to match.
[!xyz]	Specify a set of characters (x, y, or z) to preclude a match.
\	Ignore the subsequent special character and interpret as its actual character.
[first-last]	Specify a range of characters (from <i>first</i> to <i>last</i>) to match. For example, a[a-c] matches aa, ab, or ac, but does not match ad or abc.

Search for attributes on elements

You can search for an attribute or group of attributes. You may want to locate a particular attribute, for example, to configure a formula data reference or to assign it as a value to another attribute. (To search for a specific attribute value, choose an attribute value as search criteria for an element search.)

1. In the navigator pane, click **Elements**.
2. Choose from the following actions:

- From the PI System Explorer menu, select **Search > Attribute Search**.
 - In the browser, right-click the **Element Searches** collection and select **New Attribute Search**.
3. Set the Attribute Search window to find the desired attributes in the PI AF database:
- a. Under **Where**, set the fields to restrict attributes retrieved:
 - a. **Attribute name**

Enter the name of the attribute to retrieve. You can enter special characters to match part of a name. See Special characters in name searches.
 - b. **Attribute description**

Enter a string (of up to 440 characters) that retrieved attributes must match.
 - c. **Attribute category**

Select the category that retrieved attributes must match.
 - d. **Attribute value type**

Select the type of value that the retrieved attributes must store.
 - e. **Maximum results**

Enter the maximum number of matching attributes to retrieve.
 - b. In the **Element Criteria** area, set the fields to restrict the elements searched for matching attributes:
 - a. **Search Root**

Enter the element that you want to use as the root or base level for the attribute search. Type the exact name or click **Browse** to open the Element Browser window, where you can view the element hierarchy and select an element. You cannot include wildcard characters in the entered name. If you do not specify an element, you set the main level of the element hierarchy as the root. Depending on your PI AF hierarchy, specifying an element in the **Search Root** field can improve search performance.

Select the **Search Sub-Elements** check box to search the entered root and any sub-elements. Clear this check box to search only the entered root.
 - b. **Name**

Enter the name of the elements in which you want to search for attributes. You can enter special characters to match part of a name. See Special characters in name searches.
 - c. **Description**

Enter a string (of up to 440 characters) to retrieve only those elements that match.
 - d. **Category**

Select the category of the elements in which you want to search for attributes.
 - e. **Template**

Select the template of the elements in which you want to search for attributes.
 - f. **Type**

Select the type of the elements in which you want to search for attributes.
- If you specify values for multiple settings, the search returns only those attributes that match all the specified settings.
4. Click **Search** to retrieve the matching attributes into the **Search results** table.
- Alternatively, use the element tree under **Search results** to browse for attributes under particular elements, and then select the attributes to add them to the **Search results** table.

Remember that the attributes available by searching and the attributes available by browsing the element hierarchy depend on the configuration properties of the attributes.

5. Select items in the search results list and click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Search for event frames

Use the Event Frame Search window to retrieve event frame data that matches your search criteria.

1. In the navigator pane, click **Event Frames**.
 2. Choose from the following actions:
 - From the PI System Explorer menu, select **Search > Event Frame Search**.
 - In the browser, right-click the **Event Frame Searches** collection and select **New Search**.
 3. Set the **Event Frame Search** window to find the desired event frame or event frames in the PI AF database.
- Note:** If you specify values for multiple criteria, the search returns only those event frames that match all the specified criteria.
4. From the **Actions** list, select the type of filter to apply: **Contains**, **Exact Match**, **Starts With**, or **Ends With**.
 5. Choose from the following actions:

To ...	Do this ...
Type one or more filter conditions directly into the Enter Event Frame Criteria field	<ul style="list-style-type: none">• Use the : or := operator to select elements that match a name, description, template, primary element name, or category.• Use special characters as needed. For more information, see Special characters in name searches.• Enclose strings that contain spaces or special characters with the " character.• Separate filter conditions with a whitespace, for example: Category:"Processing Plants" Name:Cracking Beginning with PI AF 2018 SP2, you can use OR conditions when typing directly. For example:<ul style="list-style-type: none">• "Name:'EventFrameName' (Attribute1:>5 OR Attribute2:<2)"• "Description:'TestDescription' OR Name:'TestName'"
Filter event frames under Criteria	Enter values in the following fields as needed. Click Add Criteria to enter criteria for additional fields.

- **Search**

Select the method you want to use to specify when the desired event frames occurred. The window shows the appropriate fields for the selected method.

For example, select **Active Between** to specify a start time and end time, and find event frames active any time during that period. Select **Starting After** to specify only a start time, and find event frames that start after that time.

- **In Progress**

If available, select this check box to further restrict matching event frames to those that have not yet finished.

- **Search start**

A PI time expression that specifies the start of the time period used to search for event frames.

- **Search end**

A PI time expression that specifies the end of the time period used to search for event frames.

Optional. From the list next to this field, select a defined time to automatically fill in the **Search start** and **Search end** fields.

- **All Descendants**

Select this check box to search all levels of the event frame hierarchy below the specified root for matching event frames.

- **Name**

Enter the name of the event frame to retrieve, based on the filter type. You can enter special characters to match part of a name. See [Special characters in name searches](#).

- **Element Name**

Enter a PI AF element that must be the parent of any retrieved event frames. You can enter special characters to match part of a name. See [Special characters in name searches](#).

- **Category**

Select the category that retrieved event frames must match.

- **Results per Page**

Enter the maximum number of event frames to show on a single page of the search results.

- **Template**

Select the template that retrieved event frames must be based on. After you select a template, you can add criteria to find elements by attribute value.

- **Analysis Name**

Enter the name of the analysis that retrieved event frames were generated from. You can use wildcards as needed.

- **Attribute Value**

You can specify up to three conditions for an attribute value. For each condition, specify an attribute name, operator, and attribute value, such as Temperature >= 98.

- In versions prior to PI AF 2018, only available when you specify a template. For more details, see [Configure search conditions for attribute values when a template is specified](#)
- In PI AF 2018 and later versions, you can specify attribute values without needing to specify a template. For more details, see [Configure search conditions for attribute values when no template is specified](#).

- **Duration**

Select an operator and enter a value, which can include a PI time abbreviation. For example, select >= and enter 1d to retrieve events that last at least one day. You can select **Duration** a second time and filter the search for results between two values. For example, select <= and enter 2d to retrieve events that lasted between one and two days.

- **Event Frame Search Root**

Enter the event frame that you want to use as the root or base level for the event frame search. Type the exact name or click **Browse** to open the Event Frame Browser window, where you can view the event frame hierarchy and select an event frame. You cannot include wildcard characters in the entered name. If you do not specify an event frame, you set the main level of the event frame hierarchy as the root. Depending on the complexity of your PI AF hierarchy, specifying an event frame in the **Event Frame Search Root** field can improve search performance.

- **Can Be Acknowledged**

(PI AF 2016 or later versions.) Set to True to retrieve event frames that can be acknowledged. The ability to acknowledge event frames is determined in the template on which the event frame is based.

- **Is Acknowledged**

(PI AF 2016 or later versions.) Set to True to retrieve event frames that have been acknowledged. Set to **False** to retrieve only event frames that have not been acknowledged.

- **Is Annotated**

(PI AF 2016 or later versions.) Set to True to retrieve only event frames that have annotations. Set to **False** to retrieve only event frames that do not have annotations.

- **Severity**

(PI AF 2016 or later versions.) Select an operator and select a severity setting from the list. For example, select >= **Minor** to retrieve event frames that have at least a Minor severity setting. You can select **Severity** a second time and filter the search for results between two severity settings. For example, select <= **Critical** to retrieve event frames that have Minor, Major and Critical severity settings.

- **Creation Date**

(PI AF 2017 or later versions.) Select an operator and enter a date or a PI time abbreviation ($\geq *-30d$ is the default) to retrieve event frames that were created in the specified period. You can also click  to select a date in the Date and Time Picker window. You can select **Creation Date** a second time and filter the search for results between two values ($< *+1d$ is the default).

- **Modify Date**

(PI AF 2017 or later versions.) Select an operator and enter a date or a PI time abbreviation ($\geq *-30d$ is the default) to retrieve event frames that were modified in the specified period. You can also click  to select a date in the Date and Time Picker window. You can select **Modify Date** a second time and filter the search for results between two values ($< *+1d$ is the default).

Note: An event frame's modify date is updated whenever a capture value, an annotation, or a child event frame is added, as well as when a change to its configuration is checked into the database. Most template changes, or any modification to an attribute value that is not a configuration item, will not affect an event frame's modify date.

6. Optional. Specify how you want results to be displayed in the **Results** table.

To ...	Do this ...
Group by template	Select the Template check box.
Group by category	Select the Category check box.
Change column selections	<ol style="list-style-type: none"> Right-click the column heading in the Results table or white space below. Click Column Visibility. Select or clear column selections as needed.
Display attributes as columns	<ol style="list-style-type: none"> Click  and click Select Attributes. In the Select Attributes window, use standard Windows keystrokes to highlight contiguous (SHIFT+<click>) or non-contiguous (CTRL+<click>) attributes. Click . Click OK.
Display full paths of event frames	<ol style="list-style-type: none"> Right-click the column heading in the Results table or white space below. Click Show Full Paths.
Conceal full paths of event frames	<ol style="list-style-type: none"> Right-click the column heading in the Results table or white space below. Click Hide Full Paths.

7. Click **Search** to retrieve the matching event frames into the Results table.

8. Click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Search for attributes on event frames

Use the Event Frame Attribute Search window to retrieve event frame attribute data that matches your search criteria.

1. In the navigator pane, click **Event Frames**.
2. Choose from the following actions:
 - From the PI System Explorer menu, select **Search > Event Frame Attribute Search**.
 - In the browser, right-click the **Event Frame Searches** collection and select **New Attribute Search**.
3. Set the Event Frame Attribute Search window to find the desired attributes in the PI AF database:

Under **Where**, set the fields to restrict attributes retrieved:

- a. **Attribute name**

Enter the name of the attribute to retrieve. You can enter special characters to match part of a name.

[See Special characters in name searches.](#)

b. **Attribute description**

Enter a string (of up to 440 characters) that retrieved attributes must match.

c. **Attribute category**

Select the category that retrieved attributes must match.

d. **Attribute value type**

Select the type of value that the retrieved attributes must store.

e. **Maximum results**

Enter the maximum number of matching attributes to retrieve.

4. In the **Event Frame Criteria** area, set the fields to restrict the search to matching attributes:

- **Search**

Choose criteria to find transfers that overlap the time period specified by **Search start** and **Search end**.

- **Search start / Search end**

Choose or enter start and end times for the search time period.

- **Search Root**

Enter the event frame to use as the root or base level for the attribute search. Type the exact name or click **Browse**  to open the Event Frame Browser window, where you can view the hierarchy and select an event frame. You cannot include wildcard characters in the entered name. If you do not specify an event frame, the root is set to the main level of the hierarchy. Depending on the complexity of your PI AF hierarchy, specifying search root can improve search performance.

Select the **Search Sub-Event Frames** check box to search the entered root and its children. Clear this check box to search only the entered root.

- **Name**

Enter the name of the event frames you want to search for attributes. You can enter special characters to match part of a name. See [Special characters in name searches](#).

- **Description**

Enter a description string of up to 440 characters to retrieve only those elements that match.

- **Duration**

Enter minimum and maximum duration values to limit the attribute search to event frames whose duration is within these limits.

- **Category**

Select the category of the event frames you want to search for attributes.

- **Template**

Select the template of the event frames you want to search for attributes.

If you specify values for multiple settings, the search returns only those attributes that match all the specified settings.

5. Click **Search** to retrieve the matching attributes into the **Search results** table.

You can limit the results further to list only those attributes that match the text entered into the **Search results** field.

6. Select items in the search results list and click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Search for transfers

Use the Transfer Search Criteria window to retrieve transfer data that matches your search criteria.

1. In the navigator pane, click **Event Frames**.
2. Choose from the following actions:
 - From the PI System Explorer menu, select **Search > Transfer Search**.
 - In the browser, right-click the **Transfer Searches** collection and select **New Search**.
3. Set the Transfer Search Criteria window to find the desired transfers in the PI AF database:
 - **Search**
Choose criteria to find transfers that overlap the time period specified by **Search start** and **Search end**.
 - **Search start / Search end**
Choose or enter start and end times for the search time period.
 - **Name**
Enter the name of the transfers you want to search for. You can enter special characters to match part of a name. See [Special characters in name searches](#).
 - **Description**
Enter a description string of up to 440 characters to retrieve only those transfers that match.
 - **Source**
Enter or click  to open the Element Browser window, where you can view the element hierarchy and select the source element for transfers you want to include in the search. Click the **Any** button to reset to the default <Any>.
 - **Destination**
Enter or click  to open the Element Browser window, where you can view the element hierarchy and select the destination element for transfers you want to include in the search. Click the **Any** button to reset to the default <Any>.
 - **Template**
Select the template of the transfers you want to search for.
 - **Maximum results**
Enter the maximum number of matching transfers to retrieve.
If you specify values for multiple settings, the search returns only those transfers that match all the specified settings.
4. Click **Search** to retrieve the matching transfers into the **Search results** table.
You can limit the results further to list only those transfers that match the text entered into the **Search results** field.
5. Click **OK**.
The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Search for attributes on transfers

Use the Transfer Attribute Search window to retrieve transfer attribute data that matches your search criteria.

1. In the navigator pane, click **Event Frames**.
2. Choose from the following actions:
 - From the PI System Explorer menu, select **Search > Transfer Attribute Search**.
 - In the browser, right-click the **Transfer Searches** collection and select **New Attribute Search**.
3. Set the Transfer Attribute Search window to find the desired attributes in the PI AF database:
 - a. Under Where, set the fields to restrict attributes retrieved:

Attribute name

Enter the name of the attribute to retrieve. You can enter special characters to match part of a name. See [Special characters in name searches](#).

Attribute description

Enter a string (of up to 440 characters) that retrieved attributes must match.

Attribute category

Select the category that retrieved attributes must match.

Attribute value type

Select the type of value that the retrieved attributes must store.

Maximum results

Enter the maximum number of matching attributes to retrieve.

- b. In the **Transfer Criteria** area, set the fields to restrict the attribute search to transfers matching the specified criteria:

Search

Choose criteria to find transfers that overlap the time period specified by **Search start** and **Search end**.

Search start / Search end

Choose or enter start and end times for the search time period.

Name

Enter the name of the transfers you want to search for attributes. You can enter special characters to match part of a name. See [Special characters in name searches](#).

Description

Enter a description string of up to 440 characters to retrieve only those attributes that match.

Source

Enter or browse to and select the source element for transfers whose attributes you want to include in the search.

Destination

Enter or browse to and select the destination element for transfers whose attributes you want to include in the search.

Template

Select the template of the transfers you want to search for attributes.

Category

Select the category of the transfers you want to search for attributes.

If you specify values for multiple settings, the search returns only those attributes that match all the specified settings.

4. Click **Search** to retrieve the matching attributes into the **Search results** table.

You can limit the results further to list only those attributes that match the text entered into the **Search results** field.

5. Click **OK**.

The results are displayed in the viewer and in the browser tree. For more information on working with search results, see [Manage search results](#).

Trends in PI System Explorer

While browsing elements in PI System Explorer, you can quickly create simple trends to verify the formulas, calculations, and other measurements you are building within PI AF. For example, while you are designing a PI AF formula, you might want to see what the results look like over the last several hours. Or, if you are creating PI point attributes that involve summaries, it could be useful to see what those look like over recent hours.

You can add the PI AF attributes or PI points of interest to a trend; one way of adding them is to drag and drop them onto the trend. You can then explore the data by adjusting the duration and the start and stop times of the trend.

After you have created the trend, it remains available in the Trend window even when you are using other features within PI System Explorer. You can add or remove traces to the trend at any point. You can also right-click the trend cursor and select commands from a context menu.

You can also see a trend of an attribute when you view its time series data (by right-clicking an attribute and clicking **Time Series Data**). The trend is automatically shown at the bottom of the Time Series Data window.

Create trends

Use visualization tools, such as AVEVA PI Vision, PI ProcessBook, and PI WebParts, to create and save trends that you plan to use more than once.

To verify formulas, calculations, and other measurements in PI AF, create a trend.

1. From the PI System Explorer menu, select **View > Show Trend**.
2. In the Trend window, choose from the following actions.

To ...	Do this ...
Add an attribute to the trend	<ol style="list-style-type: none">Click Add Attributes.In the Attribute Search window, specify search parameters in the Attribute Name, Attribute Category, and other fields to find the attribute of interest.Expand the element hierarchy in the Search results area and select the attribute.

To ...	Do this ...
	<p>d. Click OK.</p> <p>The Trend window displays a trend showing how that attribute has varied over the past hour (1 hour is the default duration).</p>
Adjust the duration	Specify times in the Start Time and End Time fields.
Add a PI point to the trend	<p>a. Click Add PI Points.</p> <p>b. In the Tag Search window, search for the PI point you want to see and select it in the results.</p> <p>c. Click OK.</p> <p>The PI point is added to the trend.</p>
Adjust which traces are visible on the trend	Click Traces and clear the check box of attributes or points you do not want to see.

3. Add any further PI AF attributes and PI points for which you want to view data.

The traces in the Trend window persist until you close the window.

You can drag attributes and PI points from other search results and drop them on the trend to add them.

Alternatively, you can right-click an attribute or point and click **Add to Trend**.

Version management for equipment and processes

When you need to make an equipment change, such as swapping out a broken pump for a similar pump, you can continue to use the existing element to represent the new pump. However, to indicate that a change has occurred, it is a good idea to create a new version of the element. That way you have a record of the change to the equipment that the element represents.

Similarly, you might need to create versions of a table. For example, strapping tables of tanks are updated periodically to match the changing physical characteristics of the tank. By versioning the table, you will be able to use the table as it was configured at the time of the data collection.

PI System Explorer allows you to create multiple versions of elements, models, and tables.

You can also indicate an element, model, or table is not in service past a specific date by selecting that date as its *obsolete* date.

Videos

For an overview of version management, watch this video:

For information on how to create versions of elements and tables, watch this video:

Create versions for elements or models

Whenever a new version is created, a check-in occurs on the element or model.

Create a new version when you need to keep track of changes to an asset.

1. In the navigator, click **Elements**.
2. in the Elements browser, choose from the following actions.
 - Right-click the element or model you want to version and click **Create Version**.
 - Click the element or model you want to version. In the viewer, select the **Version** tab and click **New**

Version.

3. In the Create Version window, enter an **Effective Date** for the version or click  to select a date.
PI System Explorer creates a new version.
4. Optional. In the **Comment** field, enter information on the new version.
5. Click **OK**.

To indicate that more than one version exists, the icon in the browser changes to  for an element or  for a model.

Create table versions

Whenever a new version is created, a check-in occurs on the table.

Create a new version when you need to keep track of changes to a table.

1. In the navigator, click **Library**.
2. In the Library browser, choose from the following actions.
 - Right-click the table you want to version and click **Create Version**.
 - Click the table you want to version. In the viewer, select the **Version** tab and click **New Version**.
3. In the Create Version window, enter an **Effective Date** for the version or click  to select a date.
PI System Explorer creates a new version.
4. Optional. In the **Comment** field, enter information on the new version.
5. Click **OK**.

To indicate that more than one version of the table exists, the icon in the browser changes to .

Compare two versions

You can compare two versions of an element, model, or table that has more than one version.

1. Choose from the following actions.

To...	Do this...
Compare table versions	<ol style="list-style-type: none">a. In the navigator, click Library.b. In the Library browser, select a table that displays the  icon.
Compare element or model versions	<ol style="list-style-type: none">a. In the navigator, click Elements.b. In the Elements browser, select an element that displays the  icon, or a model that displays the  icon.

2. In the viewer, select the **Version** tab and click **Show History**.
3. In the Show History window, select two versions in the left panel from the list of all existing versions.

The right panel uses colored change bars to indicate the differences between the versions:

- Red means that the item was present in the older version and is not present in the newer version.
- Green means the item is present in the newer version but was not present in the older version.
- Yellow means that the item changed between the older and newer version.

4. To exit, click **Close**.

Display of different object versions and obsolete objects

By default, PI System Explorer shows the latest versions of elements, models, and tables (even if those versions are in the future). It also excludes earlier versions and all objects that have an **Obsolete** date specified (even if that date is in the future). As a result, when you specify an **Obsolete** date for an object and check it in, it immediately disappears from PI System Explorer.

You can, however, find and view an obsolete object, or a particular version of an object, by setting **Query Date** to a fixed time at which the object or version is current. To display an element that became effective January 1, 2010 and obsolete on January 1, 2011, for example, set **Query Date** to any time between those two dates.

Video

For information on how to display different versions, watch this video:

Query Date and PI System Explorer time

Query Date determines the time values PI System Explorer uses to:

- Find and display attribute values.
- Identify current versions of objects to display and include in search results.

At the default **Query Date** setting, **Set to Latest**, PI System Explorer finds and displays the most current data for attribute values. You can override the **Query Date** to view values for a different time with **Set Time Context**. See [Set time context for displayed attribute values](#).

Set to Latest also causes PI System Explorer to use the latest versions of objects, even if those versions are in the future, and excludes any object with an **Obsolete** date, even if that date is in the future.

You can change **Query Date** to specify a fixed date and time:

- The date and time picker lets you choose a specific date and time setting.
- The selections **Set to Now** and **Set to Today** each use the current time to establish a fixed date and time. For example, if you choose **Set to Now** on Monday, then on Wednesday **Query Date** will still be set to Monday.

How Query Date affects PI System Explorer

What is affected	Query Date is Set to Latest	Query Date is a fixed date and time
All PI System Explorer objects	PI System Explorer uses the latest versions, even if those versions are in the future; it excludes any object with an obsolete date, even if that date is in the future.	PI System Explorer uses versions of objects that are in effect at that time.
Element, model, and table versions in search	PI System Explorer returns the latest versions, even if those versions are in the future.	PI System Explorer returns the versions that are in effect at that time.
Relative times in searches	PI System Explorer defines the current time (*) as the time of the search.	PI System Explorer defines the current time (*) as the time specified by the Query Date.
PI data	PI data is returned at its latest snapshot value.	PI data returned is the value for the timestamp specified by the Query Date.

Show specific dates and times

When you set the query date to a specific date and time, it remains constant at that date and time until you change it again.

1. On the PI System Explorer tool bar, click the **Query Date** button.
2. In the Date and Time Picker window, choose the date and time that you want. If you want to set the query date to the current date and time, click the **Set to Now** button.

Note: When you choose **Set to Now** as the query date, you are setting the query date to a specific date and time; this is a constant value. This is not the same as setting the query date to always be the current time. For that, you should choose the **Set to Latest** option.

3. Click **OK**.

Video

For information on how to set a specific query date, watch this video:

Time context for attribute values

The time or time range that PI System Explorer uses to display attribute values is determined by values you set in the Set Time Context window.

By default, PI System Explorer displays the latest values for attributes based on the current time. The Query Date reflects PI System Explorer's time setting (see [Query Date and PI System Explorer time](#)). You can view attribute values for a different time, however, by specifying a new time in the Set Time Context window.

The time and time range settings in the Set Time Context window apply only to displayed attribute values. Query Date continues to apply to all other PI System Explorer objects.

Set time context for displayed attribute values

You use Set Time Context to specify a different time or time range for displayed attribute values. Changes to time context settings are applied to all attribute values in your AF database. After updating the time context, changes are shown on the Attributes tab of each element.

1. On the PI System Explorer toolbar, click .

Alternatively, click **Tools > Options** and select the **Time Context** tab.

2. In the Set Time Context window, select one of the following options.

Enter time values for an option directly, or click  to select a date and time. You can also click  to construct a time expression, such as *-1d.

Option	Description
Query Date Time	Displays the current setting for Query Date (defaults to Latest Available). You can specify a different date time setting for Query Date, to enable PI System Explorer to evaluate which versions of objects to retrieve from the PI AF database.
Alternative Time	Displays the time context for data retrieval after applying the current Query Date setting. The default is the current time (*), but you can enter a new time context to use for displayed attribute values.
Time Range	Enter Start and End times to specify a new time range to use for displayed attributed values that require a time range.

3. Optional. Click **Set as Default** to register the current settings as the default time context, or click **Restore Default** to restore the time context for **Query Date Time** to Latest Available.
4. Click **Apply** to see your changes and **OK** to keep them.

The revised time context settings are displayed in the PI System Explorer title bar.

View time series data

PI System Explorer can display time series data for attributes that contain or reference such data. This allows you to preview how your data reference configurations will work with your collected data in other PI client tools, such as PI ProcessBook, AVEVA PI Vision, PI DataLink and PI WebParts.

Note: Some attribute configurations do not support this type of data. See [Restrictions on viewing time series data](#).

1. Right-click on the attribute in the viewer and click **Time Series Data**.
2. In the Time Series Data window, choose the tab representing the type of data you want to see:
 - **Archive**
For PI points. Shows the archived values within the specified time. Settings include [Boundary type](#) and [Filter expression](#).
 - **Sampled**
Returns evenly-spaced, interpolated values over a regular interval. You can include a [Filter expression](#).
 - **Plot**
Retrieves values over the specified time range suitable for plotting over the specified number of intervals. Typically, the intervals represent pixels and you would use this feature to represent the screen width available for the plot.
 - **Summary**
Displays summary [Statistics](#) for attribute values that support this feature. You can specify [Weighting](#).
 - **Data Pipe**
Enables you to monitor and display data changes within attributes. For attributes that support future

data, you can specify how the data pipe returns data with the [Event horizon mode](#) and Offset properties. For historical tags, Event Horizon Mode has no effect.

Boundary type

Specify a boundary type to determine how the searches for data values are handled near the start and end times of the value range:

- **Inside (default)**

Returns values at start and end times, if they exist, or the nearest values occurring within the range.

- **Outside**

Returns the closest values occurring immediately outside the range.

- **Interpolated**

Returns interpolated values at start and end times.

Filter expression

Add a filter expression to filter event values using a mathematical expression, eliminating data for which the expression evaluates as false. For example, the simple filter expression:

```
'.' < 70
```

Note: Be sure to place filter expressions within two straight apostrophe symbols (Unicode character 'APOSTROPHE' (U+0027)).

would remove all values over 70 from the calculation. You can also use any valid PI performance equation in the filter expression to build more complex expressions to remove atypical peaks in data values, for example.

Expression variables are limited to attributes or PI points which originate from a single Data Archive. Attributes which resolve to a static value (no data reference configured), are also acceptable. See [Indirect PI point references](#) for a complete description of possible reference syntax.

Attribute variable examples

Filter expression	What it does
'.'	Reference to the attribute being queried.
'Level'	Reference to the attribute Level at the same attribute hierarchy level in the element or event frame.
'..'	Reference to the parent attribute of the attribute being queried. Only valid for nested child attributes.
'. HighLimit'	Reference to the child attribute HighLimit of the attribute being queried.
' Temperature'	Reference to the Temperature attribute at the top hierarchy level in the current element or event frame.

Filter expression	What it does
'\\MyPIServer\sinusoid'	Absolute path to a PI point. It must be in the same Data Archive as the current queried attribute.
'\\myAFServer\myDatabase\myElement myAttribute'	Absolute path to a PI AF attribute.
'\myRootElement myAttribute'	Database relative path to a PI AF attribute.

PI point variable examples

Filter expression	What it does
'.'	Reference to the PI point being queried.
'sinusoid'	Reference to the PI point sinusoid in the same Data Archive.
sinusoid	

Statistics

The **Summary** tab provides the following statistics for attributes that support such statistics:

- **Percent Good**

Displays the percentage of time for which good values are returned over the total time range. Good values are event values determined to be valid and not in an error state.

- **Average**

Computes the average of values during the interval.

- **Minimum**

Returns the minimum value during the interval.

- **Maximum**

Returns the maximum value during the interval.

- **Range**

Computes the maximum value minus the minimum value during the interval.

- **Standard deviation**

Computes the standard deviation of values during the interval.

- **Population standard deviation**

Computes the population standard deviation of values during the interval.

- **Count**

Returns the number of values stored during the interval.

Weighting

The **Summary** tab allows you to select the Weighting for the statistical calculations:

- **Time-weighted**

Default. Weights each event value by the length of time over which it applies.

- **Time-weighted continuous**

Time-weights values, but does all interpolation between values as if the values represent continuous data, (standard interpolation) regardless of whether the attribute is stepped.

- **Time-weighted discrete**

Time-weights values, but does all interpolation between values as if the values represent discrete, unrelated values (stair step plot) regardless of the attribute is stepped.

- **Event-weighted**

Weights each event equally. This method requires at least one event in a time range (two events for standard deviation calculations). By default, events at the boundary of the calculation are handled as follows:

- use events at both boundaries when there is only one calculation interval
- include events at start time in multiple intervals and the intervals are in ascending time order
- include events at the end time in multiple intervals and the intervals are in descending time order

- **Event-weighted - Exclude Earliest Event**

EventWeighted, except that the event at the start time (earliest time) of an interval is not used in that interval.

- **Event-weighted - Exclude Most Recent Event:**

EventWeighted, except that the event at the end time (most recent time) of an interval is not used in that interval.

- **Event-weighted - Include Both Ends:**

Events at both ends of the interval boundaries are included in the event-weighted calculation.

Event horizon mode

Event horizon mode controls when events for attributes that support future data are returned in the PI AF data pipe. Possible values are described in the following table.

Value	Description
End of Stream	Events are returned as they are created, without regard to the current time.
Time Offset	Events are only returned after they cross the relative time offset into the future from now. For example, with a time offset of zero, future tag data changes are not returned until their timestamp is less than or equal to the current time.

Value	Description
Time Offset with Outside Event	<p>Events are only returned if they occur before the relative time offset into the future, or they are the next event that would cross this time horizon.</p> <p>For example, with a time offset of one hour, future tag data changes are not returned until their time stamp is less than or equal to the current time plus one hour, or they are the next known event after the one hour time horizon. This mode is useful for trending data into the future.</p>

Restrictions on viewing time series data

PI point data reference configuration types

Although many configurations are possible with PI point data references, support differs for each data function. PI point data references can be grouped into the following types for time method configurations:

- **Simply configured PI point**

All data functions are supported and there is no additional configuration. Time method is Automatic, Interpolated, or AtOrBefore.

- **Archive retrieval of specified PI point**

Only functions in the interpolated values group (listed in the following table) are supported. Time method is Before, Exact, AtOrAfter, or After.

- **Relative time PI point**

Simply configured PI point with relative time configured. Time method is Automatic, Interpolated, or AtOrBefore.

- **Time range only**

Time method is not supported.

- **Time range with relative time**

Time method is TimeRange or TimeRangeOverride.

The following table details which data functions are supported by the PI point data reference configurations listed above. These restrictions also apply to other client tools, such as PI DataLink, PI Vision, PI ProcessBook and PI WebParts.

Data function	Simply configured	Archive retrieval	Relative time	Time range only	Time range with relative time
InterpolatedValue	✓	✓	✓	✗	✓
InterpolatedValues	✓	✓	✓	✗	✓

Data function	Simply configured	Archive retrieval	Relative time	Time range only	Time range with relative time
InterpolatedValuesAtTimes	✓	✓	✓	✗	✓
RecordedValue	✓	✗	✓	✗	✗
RecordedValues	✓	✗	✓	✗	✗
RecordedValuesAtTimes	✓	✗	✓	✗	✗
RecordedValuesByCount	✓	✗	✓	✗	✗
Async	✓	✗	✓	✗	✗
PlotValues	✓	✗	✓	✗	✗
Summary	✓	✗	✓	✗	✗
Summaries	✓	✗	✓	✗	✗
FilteredSummaries	✓	✗	✗	✗	✗
UpdateValue	✓	✗	✓	✗	✗
UpdateValues	✓	✗	✓	✗	✗
Annotations	✓	✓	✓	✗	✗
Filters	✓	✗	✗	✗	✗
AFDataPipe	✓	✗	✗	✗	✗

Non-PI point data reference configuration types

Non-PI point data references can be grouped into the following types for time method configurations:

- No data reference
Data reference is set to None.
- Calculation-based data reference with time-series inputs

Calculation-based data references with time-series inputs, such as Analysis, Formula, String Builder, Table Lookup, and URI Builder support the base data functions. However, filtering and annotations functions are not supported. Calculation-based data references use recorded values of their inputs to generate

timestamps for their own recorded values. If calculation-based data references contain no time-series inputs, they behave like the No-data-reference configuration type, except that they cannot be written to.

Note: Table Lookup data references that are configured with a time column, as described in [Table provided time series data](#), support the same data functions as the configuration type: Custom data reference generating its own time-series data.

- Custom calculation-based data reference

Custom calculation-based data references are required to "opt-in" to gain access to base data functions.

- Custom data reference generating its own time-series data

Custom data references that generate their own time-series data require code to be implemented for each data function call.

The following table details which data functions are supported by the non-PI point data reference configurations listed above. These restrictions also apply to other client tools, such as PI DataLink, PI Vision, PI ProcessBook and PI WebParts.

Data function	No data reference	Calculation-based data reference with time-series inputs	Custom calculation-based data reference	Custom data reference with its own time-series data
InterpolatedValue	✓	✓	OptIn ¹	Code ²
InterpolatedValues	✓	✓	OptIn ¹	Code ²
InterpolatedValuesAtTimes	✓	✓	OptIn ¹	Code ²
RecordedValue	✓	✓	OptIn ¹	Code ²
RecordedValues	✓	✓	OptIn ¹	Code ²
RecordedValuesAtTimes	✓	✓	OptIn ¹	Code ²
RecordedValuesByCount	✓	✓	OptIn ¹	Code ²
Async	✓	✓	OptIn ¹	Code ²
PlotValues	✓	✓	OptIn ¹	Code ²
Summary	✓	✓	OptIn ¹	Code ²
Summaries	✓	✓	OptIn ¹	Code ²
FilteredSummaries	✗	✗	✗	Code ²
UpdateValue	✓	✗	✗	Code ²

Data function	No data reference	Calculation-based data reference with time-series inputs	Custom calculation-based data reference	Custom data reference with its own time-series data
UpdateValues	✓	✗	✗	Code ²
Annotations	✗	✗	✗	Code ²
Filters	✗	✗	✗	Code ²
AFDataPipe	✓	✓	OptIn ¹	Code ²

¹ Indicates that a custom data reference can be written with one method to declare which attributes it uses as inputs, and another method that transforms inputs to outputs. With input support, the AF SDK uses these methods to emulate the others, using a time series generated from input data.

² Indicates that code is needed for each method, if the time series comes from the system of record that is being connected to.

Organization of asset models in PI AF

The goal of your asset model organization is to make assets easy to find for your users. The main method of organization is the element tree. PI AF elements are organized in a tree structure. Individual elements can be organized and regrouped within the tree, without limitations. If you are just getting started with PI AF, then start by creating the element hierarchy.

You can additionally organize through categories to speed up and simplify browsing and searching information. Think of categories as labels that you can apply to PI AF objects. Each object can have multiple categories.

Note: You can also organize assets within a process. See [Process models in PI AF](#).

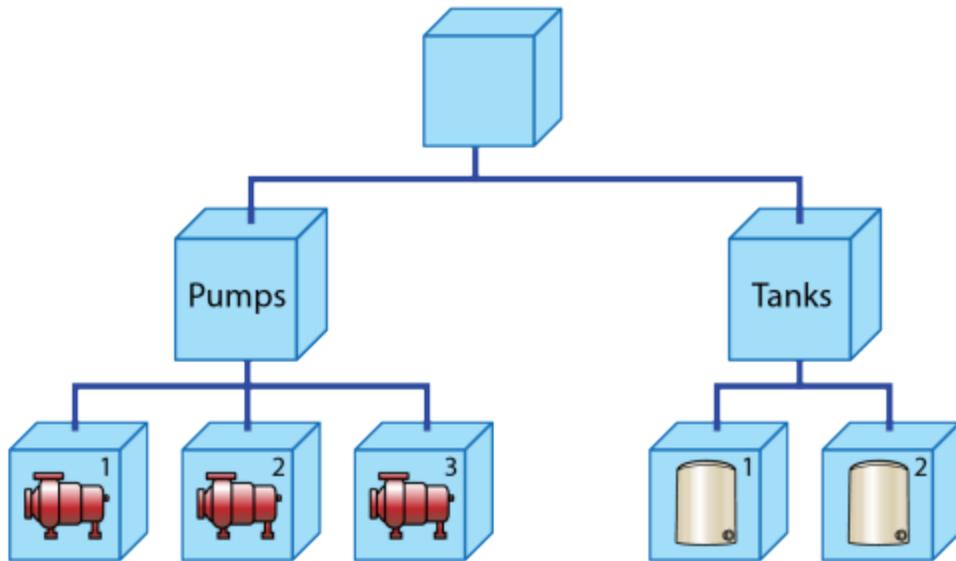
The structure of PI AF asset models

PI AF objects are organized in a tree structure, similar to the file structure on a Windows computer. In Windows, rather than having thousands of files on your desktop, you typically group files under folders. The same concept applies to PI AF elements. Organizing elements into hierarchies makes navigation of the elements easier, and it also provides insights into how the elements relate to one another.

When you create an asset model, you need to decide on a structure that makes it easy for users to find the different assets. Consider who your users are and what they will be looking for. For example, maintenance engineers might want to use PI System Explorer to find and record maintenance information. For this audience you might want to group assets by equipment type.

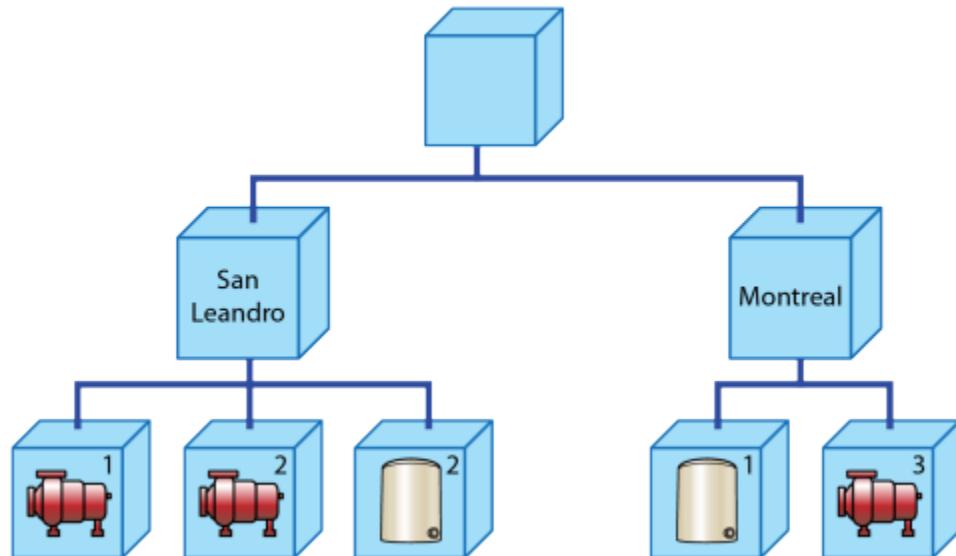
For example, if you had three pump elements, you might create an element called Pumps and then place all the pump elements beneath it. If you had two elements representing tanks, you might put them all under a Tanks element.

Asset model organized by equipment type



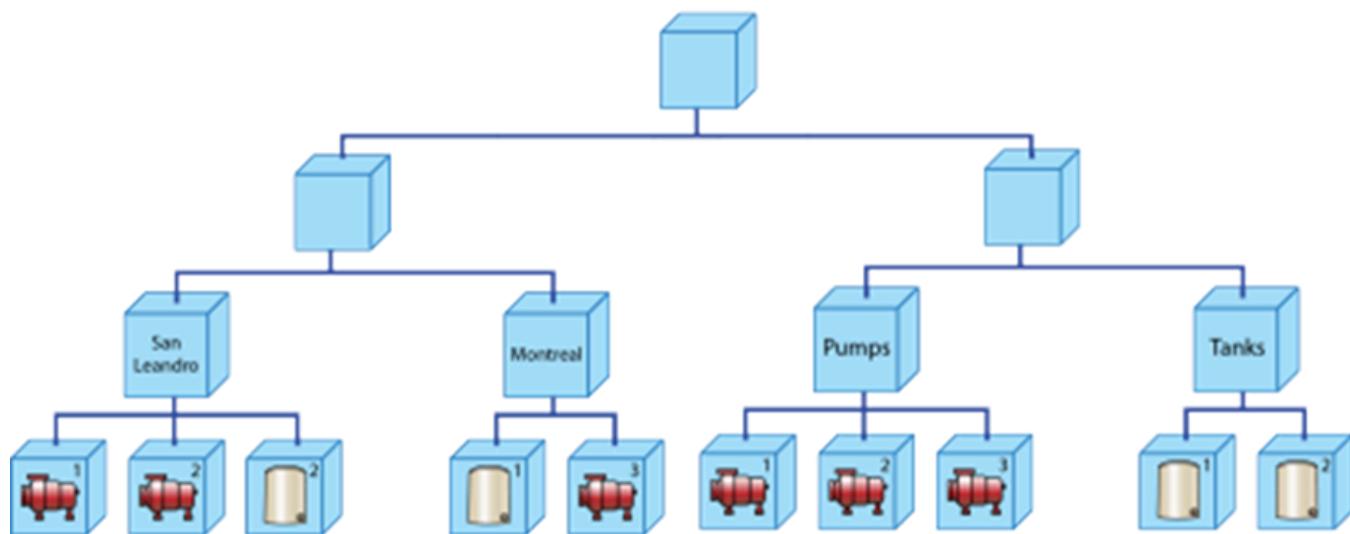
On the other hand, if you have multiple plants in different locations, that same maintenance engineer might want to see all the equipment located at his own plant. The following illustration shows the same elements organized by plant.

Asset model organized by location



You are not restricted to only one organizational strategy. You can use an *element reference* to include the same asset in more than one place in the tree. For example, you could choose to organize by equipment type and by plant as well. In the following illustration, the hierarchy includes the geographical tree and the equipment tree side by side.

Mixed asset model



You could alternatively nest the equipment organization under the geographical organization.

Note: Limit the depth of your asset hierarchies to 10 levels or less to maintain the performance and interpretability of your asset data.

The design of PI AF asset hierarchies

The goal is to create an asset (element) hierarchy that is going to make sense to the people who need to use it. If you have different types of users, then you might need more than one tree structure.

If you are just getting started, do not try to do everything at once. Create a hierarchy for a subset of your assets. For example, you might start by modeling all your tanks, or alternatively, your equipment in a single plant, or your equipment from a particular manufacturer. Another approach would be to create a hierarchy for a particular type of user.

Gather information:

- What assets will be included in the tree? In other words, what types of equipment do you want to model?
- Who is going to need to find assets in this tree? Maintenance engineers? Process control engineers? Operators? For each type of user, what tasks will they need to perform?
- What assets are important to each user and what types of information will they need? Consider asking a few representative users of each type about what data they need to access and how. This should inform your organizational strategy.

Again, start small. You might start with one type of user. For example, suppose maintenance engineers need to use the model. If you have several plants, each with a group of maintenance engineers responsible for the equipment at that plant, then you should probably include a tree that organizes equipment by plant.

From there, you might ask some maintenance engineers how they would want to access the equipment information. Perhaps they usually look for assets by equipment type but sometimes they need to search by manufacturer. You could create parallel trees, one organized by equipment type and another by manufacturer. Each asset would then appear in each tree. Or you could organize the tree by equipment type and then use categories to label each asset by manufacturer.

After you create the hierarchy for a type of user, you might have a few of them try it out for a period of time, then take their feedback to improve the hierarchy. You can always change a hierarchy.

Note: When thinking about users, remember that the element hierarchy might also be exposed in certain PI client applications. Consider the users of those applications as well. For example, AVEVA PI Vision exposes the tree for users searching for related assets. In AVEVA PI Vision, related assets are elements built from the same template.

Videos

For information on how to create elements, watch this video:

For information on how to build element hierarchies, watch this video:

Element references in the asset hierarchy

You can use element references to add the same element to your element hierarchy more than once, as described in [The structure of PI AF asset models](#). When you create a reference to an existing element, you essentially create a placeholder in the hierarchy that points back to the referenced element. This allows users to find the element in all the relevant contexts, but it does not create a copy of the element. The exact behavior depends on the reference type.

Reference types

When you add an element reference to an element hierarchy the exact relationship between the referenced element and the element to which you add it depends on the type of reference. PI AF provides three system-defined reference types:

- Parent-Child
- Composition
- Weak Reference

You can also create your own custom reference types, as described in [Creation of custom reference types](#) and [Child templates](#).

Videos

For a 5-minute tutorial on how to use reference types, watch this video:

For more information on how to use reference types, watch these longer videos:

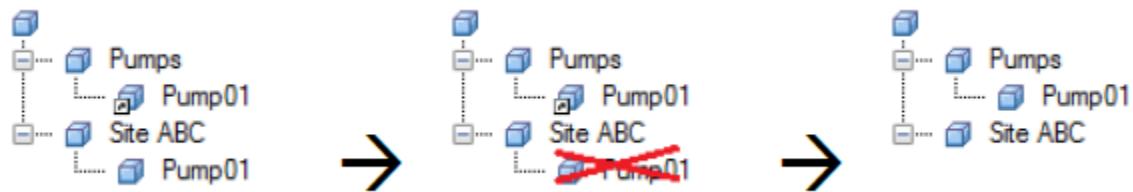
For information on how to build custom reference types, watch this video:

For the conclusion of the reference type example, watch this video:

Parent-Child reference type

The default reference type is parent-child. The reference type is strong since it allows the child element to have many parents and exist as long as it has one or more strongly related parents. When the last parent element of the child is deleted, the child itself is deleted. Use the parent-child reference type when you want the child element to exist as long as it has a strong reference to at least one parent, but you do not want the child element to be treated as a single unit with the parent element.

Effect of a deleted parent-child reference when that parent-child reference type exists elsewhere



Example

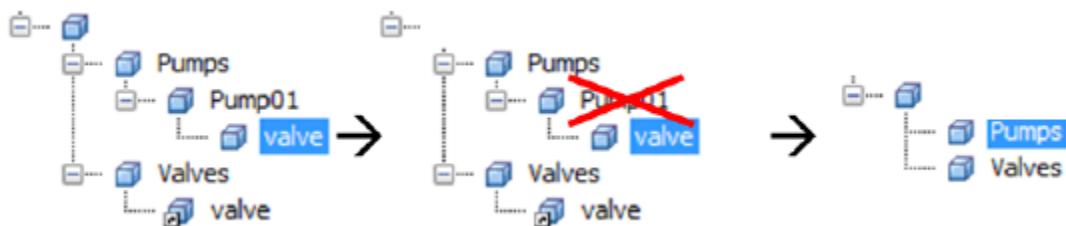
A meter belongs to a company and is attached to a building. You would use a parent-child reference between the Company element and the child Meter element, and another parent-child reference between the Building element and the child Meter element. If the reference between the Meter and the Building element is deleted, the Meter element continues to exist because it has a parent-child reference to the Company element. However, if the child Meter element is also deleted from the Company element, it no longer exists because all parent-child references have been removed.

Composition reference type

A reference type with a reference strength of composition means that the child element is really a part of the parent and does not exist without the parent. If you delete a parent element that has a child element that is

compositionally referenced, you delete the child element also.

Effect of a deleted parent element on elements with a composition reference type



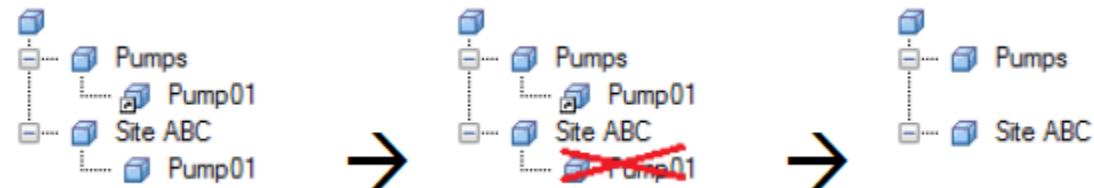
Example

Use a composition reference when the two objects in the relationship are considered one item. For example, a meter might be composed of two sensors, and so you would use a composition reference between the Meter element and each of its two child Sensor elements. When you delete the Meter element, the child Sensor elements are also automatically deleted.

Weak reference type

Use a weak reference between two elements when you want to create a relationship between two elements but you do not want that relationship to control the lifetime of the child element. For example, you may want to organize your meters into groups, but if all strong references to the meter are removed, then you want it to automatically be removed from the grouping. In this case, you would use a weak reference between the group parent element and the child meter element.

Effect of a deleted strong element on an element with a weak reference type



Example

A child element with a weak reference is deleted as soon as no more strong references exist. You may find this useful if you want one view of your assets to be the master view. For example, in the above illustration the master view might be the Site ABC view and contain elements with strong parent-child reference types. Other views, such as Pumps, reference elements with a weak reference type. If the strong Pump01 element in the master Site ABC view is deleted, the weak-referenced Pump01 element in the Pumps view is deleted automatically.

Create single element references

You create a single element reference to establish a hierarchical relationship between two elements.

1. In the Elements browser, click the element that you want to reference and drag it to the appropriate parent

element.

2. In the Choose Reference Type window, select the reference type.

If you are not sure what reference type you want, you probably want the default reference type, parent-child. See [Reference types](#) for more information.

3. Click **OK**.

The referenced elements are displayed in the browser. The referenced element icon  indicates that they are references.

Video

For additional information on how to create an element reference type, watch this video:

Create multiple element references

You create multiple element references to establish a relationship between an element and other elements in the hierarchy.

1. In the Elements browser, right-click an element and click **New > Add Element Reference**.

Note that you can also select an element and drag it to the parent.

2. In the Add Element(s) window, click the **Find Multiple Elements** button.

3. In the Element Search window, select search criteria to locate the desired elements and click the **Search** button.

The search results field shows the results of your search.

4. Select the elements that you want to reference and click **OK**.

5. In the Add Elements window, select the reference type. If you are not sure what reference type you want, you probably want the default reference type, parent-child. See [Reference types](#) for more information.

6. Click **OK**.

The referenced elements are displayed in the browser. The referenced element icon  indicates that they are references.

Locate other references to the same element

A single element can be referenced in multiple places in a hierarchy. You can find all the elements in the hierarchy that contain the element or a reference to the element.

1. Select the element in the Elements browser.

2. In the **General** tab, click the **Parents** link.

The element's parents are displayed in the Parents of *Element* window.

3. Click **Close**.

Change reference types

You can change the reference type of a child element and event frame that has at least one parent in the hierarchy and is not at the root level of the hierarchy (where the reference type must be parent-child).

1. Choose from the following actions:

To ...	Do this ...
Change a child element reference type	<ol style="list-style-type: none">In the navigator, select Elements.In the browser, expand the Elements tree and locate the child element with more than one parent.Right-click the child element and click Convert > Change Reference Type.
Change a child event frame reference type	<ol style="list-style-type: none">In the navigator, select Event Frames.In the browser, expand the Event Frames tree and locate the child event frame with more than one parent.Right-click the child event frame and click Convert > Change Reference Type.

2. In the Change Reference Type window, select a parent from the **Parent** list.
3. Select a new reference type from the **New Reference Type** list. Only valid reference types for the selected parent are available.
4. To establish the selected parent as the primary parent (when the selected reference type is valid), select the **Primary Parent** check box.

Note: To be valid, the selected reference type must be strong and no composition references can be defined for the element or event frame.

5. Click **OK**.

Creation of custom reference types

Custom reference types are easy to create. Each custom reference type must be based on one of the three pre-defined reference types. Through the use of custom reference types, you can create rules that allow PI AF to guide users when they create new elements. See [Child templates](#) for information on creating template references.

Create custom reference types

Custom reference types are created in child templates. You can also create them to define your own hierarchy of elements using a more specific relation. Custom reference types must be based on one of the pre-defined reference types.

Note: You can create reference types more quickly in the Element Templates collection using referenced templates, as described in [Create child template references](#).

1. In the Library browser, right-click the **Reference Types** collection and select **New Reference Type**.
2. In the **Name** field, enter a name for the reference type.
3. In the **Child Name** and **Parent Name** fields, enter names for the child and parent.
4. Optional. In the **Categories** field, click  and select one or more categories to which the reference type belongs from the Categorize window. You can also enter one or more reference type categories directly, separated by a semicolon.
5. In the **Reference Strength** field, select **Strong**, **Weak**, or **Composition** from the list. See [Reference types](#) for definitions of reference type strengths.
6. In the **Allowed Parent Element Template** and **Allowed Child Element Template** fields, select a template to which the reference type parent and child belong from the list.

Categorization of objects

PI System Explorer allows you to organize objects into categories. Categories are essentially object groups that you define yourself. Their purpose is to help you find objects more easily. When you search for an object, you can use the category as a filter to reduce the list of results. Define as many categories as you like. Objects can belong to multiple categories.

For example, suppose you have a set of elements representing tanks. Half of the tanks are manufactured by ACME company, and the other half are manufactured by EMCA company. To locate tanks by manufacturer, create an ACME category and an EMCA category.

Each object type has its own categories. You cannot apply categories from one object type to an object of another type. For example, you cannot apply an element category to a table. PI AF supports the following category types:

- Analysis
- Attribute
- Element
- Notification Rule

- Reference Type
- Table

Videos

For information on how to create categories, watch this video:

For information on how to assign categories, watch this video:

For information on how to group by category, watch this video:

Create new categories

Create categories for specific object types. Alternatively, use PI Builder to create multiple categories in an Excel worksheet.

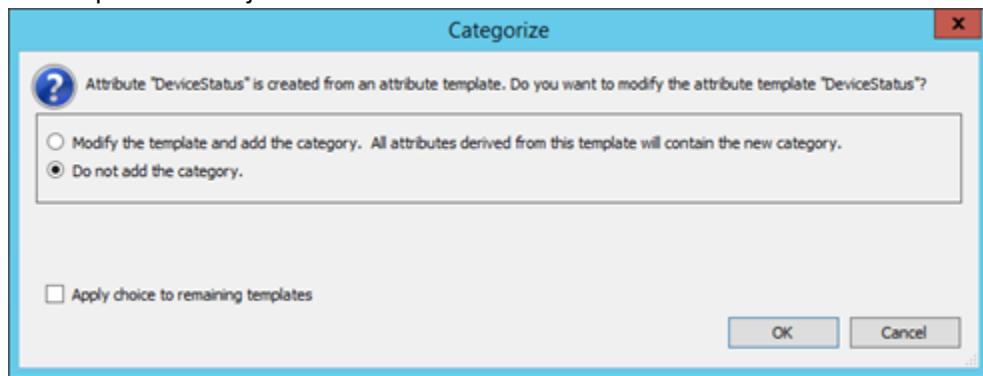
1. In the navigator, click **Library**.
2. In the Library browser, under **Categories**, right-click on the category object type and select **New Category**.
3. In the *Object_Type* Category Properties window, enter a name for the category in the **Name** field.
4. Optional. Enter a description of the category in the **Description** field.
5. Click **OK**.
6. Optional. Click the **Security** link if you wish to set up custom access permissions to the category beyond those already established at the server, database, or collection level. For more information, see [Configure security for objects](#).

Assign objects to categories

Assign objects to the categories that you have created for each category type.

1. In the viewer, use standard Windows keystrokes to highlight contiguous (SHIFT+<click>) or non-contiguous (CTRL+<click>) objects that you want to categorize.
2. Right-click and select **Categorize**.
3. In the Categorize window, select the category or categories to assign to the selected objects.
 - a. If the category you need is not listed, click the **New Category** button.
 - b. In the Attribute Categories Properties window, create the new category and click **OK**.
4. Click **OK**. The categories are applied and are displayed in the **Categories** field in the configuration panel for each object.

- a. If any selected objects are created from templates, you can modify the template or not add the category to that particular object.



Choose one of the following options:

- a. Click **Modify the template and add the category** to modify all attributes derived from the template with the category.
- b. Click **Do not add the category** to prevent the category from being assigned to the object.
- b. To apply the option to other selected attributes that are derived from templates, select the **Apply choice to remaining templates** check box.
- c. Click **OK**.

Representation of assets in PI AF

Each physical object that you include in your model is represented by a PI AF element. Physical objects are typically pieces of equipment, such as pumps or tanks. To associate data with an element, you create attributes on the element. Attributes can hold simple values representing fixed information, such as the diameter of a tank. An attribute can alternatively reference a PI point, a formula, a value from an external relational database, and more.

Templates

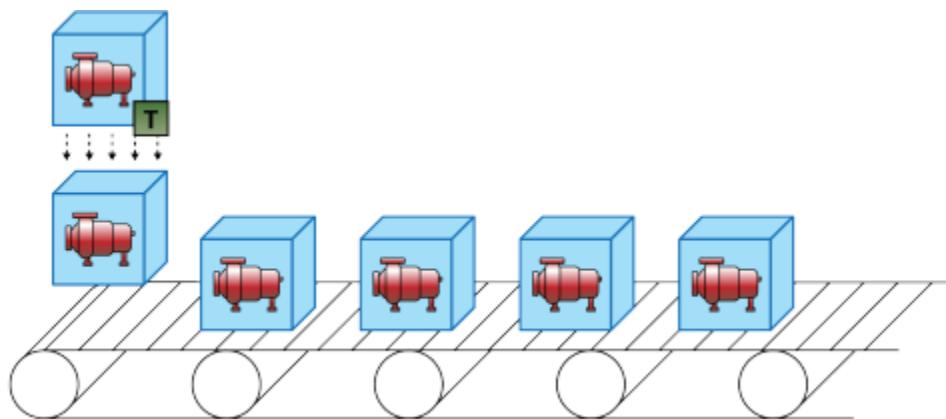
You can create each element individually, but it is recommended to base individual elements on an asset template that represents the type of equipment. Element templates enable you to:

- Configure the template once; no need to individually configure each element based on the template.
- Update element structure across all elements belonging to the template.
- Maintain consistency in the asset model.
- Enable powerful features in PI AF client applications.

Asset representation with templates

PI AF allows you to base similar objects on a single template. Templates essentially define a set of base attributes for all the objects that use that template. Create the template once and you can create as many elements based on the template as needed. If you make a change to a template, the change is automatically reflected in all the elements that use that template.

For example, suppose you have 100 pumps with the same three attributes. You can create a template for one pump and then base all the other pumps on that one template. The attributes in the template are automatically created for you in the pumps that are based on that template.



Now, suppose you need to make a change to the pump objects. You simply make the change in the template, and PI AF automatically propagates the change to all the pump objects that are based on that template. Templates are a powerful tool, not only for creating new objects, but for keeping existing objects consistent and up to date.

A further advantage is that visualization tools can provide special features for objects based on templates. For example, suppose you build a trend for a pump based on a template. A visualization tool might let you swap or add in any other pump that is based on the same template. Assets based on the same template are sometimes called *related assets*.

Note: You can also create templates for event frames, transfers, models, and notifications.

Template strategy

In almost every case, it is best to base your elements on templates. You not only save time but also ensure that you have consistent definition across all of the elements based on that template. Any changes that you make to an element template are propagated to every element that is based on that template. A single template modification can alter hundreds of elements. This allows you to make changes to your model in a single place; you don't need to update every element.

You do not have to plan and create all your templates at once. A good approach is to start by modeling a single type of asset. Create a template for the asset type. Decide what data, calculations, and other properties you need to store for that type of asset. Each of these items requires an attribute template.

Base templates

Template usage can be very broad or very specific. A template can define a specific type of measurement device, such as a brand-name instrument, or it can be a broad-use template specifying a particular role, such as a liquid mass meter. Depending on how broadly you define the template, you might find that the list of attributes is slightly different for different subsets of assets. In this situation, consider using a base template (for more information, see [Base and derived templates](#)). The alternative is to use a different template for each asset subset.

Extensions

You can also set up element templates to include attributes (as well as ports) that are not defined or maintained by the template (for more information, see [Extensions](#)). You can add simple, asset-specific attributes without the need to add them on all instances of the template.

Note: Categories, analyses and notifications are not affected by whether the **Allow Extensions** check box is enabled.

Element templates

An element template is a model of an asset type that saves you time and promotes consistency. Element templates make creating displays, notifications, calculations, and analytics much simpler because equipment of the same type can share the same implementation. Typically, you create a base template that represents a type of equipment, such as a tank or pump and assign common attributes to that asset. Then, you create one or more derived templates based on the base template and assign additional attributes to each asset subset.

You can easily create elements based on a derived template because most of the element configuration is defined in the template.

When you change an element template, those changes propagate to all elements derived from it.

Deleting an element template deletes any notification or analysis templates that target it.

Note that:

- An element derived from a template gets its *initial* definition of categories from the template. An element's attributes and ports are derived from its template.
- If the template allows extensions, then a derived element can contain ports and attributes that are not defined in the template.
- Element templates can specify the allowed parent and child references (Parent Reference Types and Child Reference Types) for an element created from the template. This restricts the allowed relationships between elements in the hierarchy.
- An element cannot be derived directly from a **Base Template Only** template.

Video

For information on how to create element templates, watch this video:

Default attribute

The default attribute is an attribute that is most representative of the element. For example, if a user were to reference a tank, perhaps Level would be the single best attribute to use. For an electrical meter, the best attribute to use could be Voltage. The attribute must be at the top level of the attribute hierarchy of the element.

Notifications and asset analytics can take advantage of the default attribute to simplify some tasks. For example, if you were to create a comparison between two electrical meters, and had not specified which attributes to compare, the comparison would be performed using the Voltage attribute of the meters because you had made Voltage the default attribute.

Base and derived templates

A base template is best used when you are modeling elements that share most attributes, but have a few attributes that differ. A base template passes on all its attributes (as well as ports and analyses) to any derived templates that are created from it. When you later create an element from such templates, that element contains not only every attribute (as well as ports and analyses) from the base template, but also from the derived template.

Base template only (BTO) templates

To ensure certain templates are not used directly to create objects, you can assign the **Base Template Only** (BTO) property to a new template. Just like other base templates, a BTO template can be as broad or specific as needed and then used to create a derived template. When an instance of an object is created, it is based on the derived template, not the BTO template. Any modifications to a BTO template also alter its derived templates. The BTO property can be assigned to element, model, transfer, and event frame templates.

Note: A checkmark next to the **Base Template Only** check box on the **General** page of the Template Properties window indicates the template is a BTO template.

Base template example

Suppose you have a set of tanks, some with two valves and some with one valve: you can create an element template for the one-valve models, and use that as the base template for the derived template that you create for the two-valve models. When you create objects based on the two-valve model, they inherit all the attributes from the one-valve model, as well as any additional attributes defined for the two-valve model.

Derived templates

You define derived templates from a base template. You can designate a derived template after creating a base template using the following method:

- Right-click a base template in the Library browser, then click **New > New Derived Template**.
- The new template is immediately added to the Library browser with the new name **BaseTemplate_Derived1**.

You can modify the definition, including the name, as described in [Create element templates](#).

Override of base-template attribute values

Situations may exist where you need to use attribute template values in a derived template that suppress or override attribute template values inherited from their base template. Consider the following situations:

- Different substitution patterns are needed for PI points on the same type of asset (such as trucks with a common set of measurements, but truck manufacturer A uses a different PI point naming pattern than manufacturer B).
- Some assets employ direct measurement for an attribute PI point, whereas others may need that attribute value to be calculated. Similarly, an attribute value may be calculated for both types of assets, but the calculation is slightly different between the two.
- Different default UOMs or categories are needed for the same attribute, based on a template.
- Not all attribute templates in a derived template are applicable (for example, some meters may only need three of the five attributes in a generic base *Meter* template).

You override base template attribute values by creating an attribute template with exactly the same name in the derived template. You can then modify properties as needed.

You can also prevent an attribute template that has been inherited from a base template from being visible to users or a client application, such as AVEVA PI Vision, by creating an attribute template of the same name in the derived template and selecting **Excluded** as its **Properties** setting. For more information, see [Excluded attribute property](#).

Template inheritance

By default, element templates are arranged by name in the Library browser. To determine the relationship that exists between templates, you might prefer to arrange them by template inheritance instead. You can right-click the **Element Templates** collection and click **Arrange By > Arrange By Template Inheritance**. Expand templates with  beside them to reveal derived templates.

Extensions

You can allow some attributes to be defined in the element itself, independent of the template. To do this you configure the template to allow extensions. Attributes that are created as extensions do not change when the template changes.

Note: If you have a template that allows extensions and you later change it to disallow extensions, no new extended element attributes can be added to elements based on that template. However, all existing extended element attributes remain.

Extensions permit flexibility in cases where assets are similar in many areas, but a number of small variations exist. For example, suppose you build a template for a specific model of a car. All the cars of this model have the same core set of features: four tires, a steering wheel, and so on. However, one car may have a spoiler while the other car may not. One might have air conditioning, while another does not. Extensions are intended to handle this type of variation.

When extensions are enabled, you can base all the elements on a template, while adding additional information to each element as required. However, if you have multiple elements that are very similar to the template definition, but all require the same extra attributes, a base template might be a better approach than allowing extensions.

Note: Categories, analyses and notifications are not affected by whether the **Allow Extensions** check box is enabled.

Naming patterns

Naming pattern substitution parameters

When you define naming patterns for element, event frame, transfer, and model templates, you can use the substitution parameters described in the following table. These naming pattern shortcuts are available in addition to the substitution parameters that are listed in the **Naming Pattern** field when you click .

Parameter name	Substitution
Description parameters	
%DESCRIPTION:path%	The object's description represented by the path to the object. If the path is not specified, the description of the current object is used.
%\ELEMENTDESCRIPTION%	The description of the object's root element, or the description of the primary referenced element of the object's root event frame.
%.. \ELEMENTDESCRIPTION%	The description of the object's parent element, or the description of the primary referenced element of the object's parent event frame. Use .. notation, such as %.. .. \ELEMENTDESCRIPTION%, to retrieve further ancestors.
%\EVENTFRAMEDESCRIPTION%	The description of the object's root event frame.

Parameter name	Substitution
%..\\EVENTFRAMEDESCRIPTION%	The description of the object's parent event frame. Use ..\\ notation, such as %..\\..\\EVENTFRAMEDESCRIPTION%, to retrieve further ancestors.
ID parameters	
%ANALYSISID%	The ID of the object's analysis.
%ATTRIBUTEID%	The ID of the object's attribute or attribute template.
%/ATTRIBUTEID%	The ID of the object's root attribute or attribute template.
%..//ATTRIBUTEID%	The ID of the object's parent attribute or attribute template. Use ..// notation, such as %..//..//ATTRIBUTE%, to retrieve further ancestors.
%DATABASEID%	The ID of the object's PI AF database.
%ELEMENTID%	The ID of the object's element, or the ID of the primary referenced element of the object's event frame.
%\\ELEMENTID%	The ID of the object's root element, or the ID of the primary referenced element of the object's root event frame. Use ..\\ notation, such as %..\\..\\ELEMENTID%, to retrieve further ancestors.
%..\\ELEMENTID%	The ID of the object's parent element, or the ID of the primary referenced element of the object's parent event frame.
%EVENTFRAMEID%	The ID of the object's event frame.
%\\EVENTFRAMEID%	The ID of the object's root event frame.
%..\\EVENTFRAMEID%	The ID of the object's parent event frame. Use ..\\ notation, such as %..\\..\\EVENTFRAMEID%, to retrieve further ancestors.
%ID:path%	The object's ID represented by the path to the object. If the path is not specified, the ID of the current object is used.
%MODELID%	The ID of the object's PI AF model.
%SYSTEMID%	The ID of the object's PI AF server.

Parameter name	Substitution
%TRANSFERID%	The ID of the object's PI AF transfer.
Name parameters	
%ANALYSIS%	The name of the object's analysis.
%DATABASE%	The name of the object's PI AF database.
%\ELEMENT%	The name of the object's root element, or the name of the primary referenced element of the object's root event frame.
%.. \ELEMENT%	The name of the object's parent element, or the name of the primary referenced element of the object's parent event frame. Use ..\ notation, such as %.. \ELEMENT%, to retrieve further ancestors.
%\EVENTFRAME%	The name of the object's root event frame.
%.. \EVENTFRAME%	The name of the object's parent event frame. Use ..\ notation, such as %.. \EVENTFRAME%, to retrieve further ancestors.
%NAME:path%	The object's name represented by the path to the object. If the path is not specified, null is returned since it references the name of the current object.
%SYSTEM%	The name of the object's PI AF server.
%\TEMPLATE%	The name of the root template of the object's element or event frame.
%.. \TEMPLATE%	The name of the parent template of the object's element or event frame. Use ..\ notation, such as %.. \TEMPLATE%, to retrieve further ancestors.
Path parameters	
%ELEMENTPATH%	The path of the base element, the element of an attribute, or the primary referenced element of an event frame.
%.. \ELEMENTPATH%	The path of the object's parent element, or the path of the primary referenced element of the object's parent event frame. Use ..\ notation, such as %.. \ELEMENTPATH%, to retrieve further ancestors.
%EVENTFRAMEPATH%	The path of the event frame or the element of an attribute of an event frame.

Parameter name	Substitution
%..\\EVENTFRAMEPATH%	The path of the object's parent event frame. Use ..\\ notation, such as %..\\%EVENTFRAMEPATH%, to retrieve further ancestors.
Time parameters	
<p>Note: You can specify a format string with all time substitutions. The format string is separated from the substitution name by a colon. For example, %TIME:d% uses the short date pattern, whereas %UTCTIME:yyyy/MM/dd HH:mm:ss.fff% specifies the format in full.</p>	
%ENDTIME:yyyy-MM-dd HH:mm:ss.fff%	The current local end time of the object using the specified formatting. If no formatting is specified, the default formatting is used. The formatting uses standard format strings supported by the <code>DateTime.ToString</code> method, as described in Format strings for time substitution parameters .
%UTCENDTIME:yyyy-MM-dd HH:mm:ss.fff%	The current Coordinated Universal Time (UTC) end time of the object using the specified formatting. If no formatting is specified, the default formatting is used. The formatting uses standard format strings supported by the <code>DateTime.ToString</code> method, as described in Format strings for time substitution parameters .

Create element templates

Create and configure an element template to ensure consistent definitions for elements in your asset structure.

1. In the Library browser, right-click the **Element Templates** collection and click **New Template**.
2. Adjust and assign settings on tabs to configure the element template. PI System Explorer provides defaults for all required settings, but you can configure settings yourself. The settings include:

Option	Description
Base Template	You can base the template on an existing template. Select the base template from the list. For more information on base templates, see Base and derived templates .
Type	You can base the template on an element type. Select the element type from the list. For more information on element types, see Element types in models .
Categories	Optional. You can organize objects by grouping them into categories. To browse available categories or to create a new category, click  . See Categorization

Option	Description
	of objects.
Default Attribute	Optional. Select a default attribute from the drop-down list. See Default attribute .
Naming Pattern	<p>Optional. You can enter a text string, or click  to choose from the following substitution parameters to define a naming pattern.</p> <ul style="list-style-type: none"> • %TIME:yyyy-MM-dd HH:mm:ss.fff% The current local time of the object using the specified formatting. If no formatting is specified, the default formatting is used. The formatting uses standard format strings supported by the <code>DateTime.ToString</code> method, as described in Format strings for time substitution parameters. • %UTCTIME:yyyy-MM-dd HH:mm:ss.fff% The current Coordinated Universal Time (UTC) time of the object using the specified formatting. If no formatting is specified, the default formatting is used. • %TEMPLATE% The name of the object's template. • %@Attribute% The value of the object's attribute, represented by the path. You can also use other naming pattern substitution parameters. For example, if you want an element path included in the naming pattern, enter <code>%ELEMENTPATH%</code> as a substitution parameter. For a complete list of naming pattern substitution parameters, see Naming patterns. Each element derived from the template will have a unique, identifiable name. To ensure that new elements created from the template have an incremental number, enter <code>*</code> at the end of any pattern you enter here. If left blank, PI System Explorer uses the element template Name field and adds an asterisk to add an incremental number as needed. Some substitution parameters may not be applied when a derived element is created. To

Option	Description
	<p>ensure a derived element's name fully reflects the naming pattern, right-click the element and click Reevaluate Naming Pattern.</p> <p>Note: The name generated by the naming pattern must be less than the maximum name length of 260 characters.</p>
Allow Extensions	<p>Select this checkbox to enable additional attributes (as well as ports) to be defined for an element, beyond those defined in its template. See Extensions.</p> <p>Note: Categories, analyses and notifications are not affected by whether the Allow Extensions check box is enabled.</p>
Base Template Only	<p>Select this checkbox to assign the Base Template Only (BTO) property to an element template. Elements cannot be derived directly from BTO templates. For more information, see Base and derived templates.</p>
Extended Properties	<p>This link is an advanced feature. For more information, see Storage of application-specific information.</p>
Location	<p>Click this link if you wish to set up location attribute traits for the element. However, you can also set them on an attribute if you prefer. Note that you can only assign one set of location attributes per element. For more information, see Attribute traits.</p>
Security	<p>Click this link if you wish to set up custom access permissions to the element template beyond those already established at the server and database level. For more information, see Configure security for objects.</p>

3. Use the **Attribute Templates** tab to create an attribute template for each property or data item for the template. See [Create attribute templates](#).
4. If you are creating a model, use the **Ports** tab to specify ports, which define end-points for connections between elements within a model. See [Process models in PI AF](#).
5. Optional. Use the **Analysis Templates** tab to create an analysis template for the element template. For more information, choose from the following:
 - To create an expression analysis template, see [Create an expression analysis template](#).
 - To create a roll up analysis template, see [Create a rollup analysis template](#).
 - To create an event frame generation analysis template, see [Create an event frame generation analysis](#)

template.

- To create an SQC analysis template, see Create an SQC analysis template.
6. Optional. Use the **Notification Rule Templates** tab to select or create a notification rule template for the element template. For more information, see Create a notification rule template.
7. To save your work, press CTRL+S or click **Check In**.

Find template references

Locate where a template is used in PI System Explorer.

1. In the Library browser, choose from the following options:
 - To locate an element template, expand **Templates > Element Templates** and select a template.
 - To locate an event frame template, expand **Templates > Event Frame Templates** and select a template.
2. Choose from the following options:

To find ...	Do this ...
Derived templates	Click Derived Templates . The Find Derived Templates for <i>Element_Template</i> window displays all element templates that have the selected element template as their base template. The list also includes element templates that are indirectly derived from the selected template, through multiple templates.
Elements created from the template	Click Elements . The Find Elements for <i>Element_Template</i> window displays all elements, models, transfers, and event frames that have been created directly from the selected element template. Note: To display the full path to elements, right-click on the column header (or below the search results grid) and click Show Full Paths .
Elements derived from the template	Click Derived Elements . The Find Derived Elements for <i>Element_Template</i> window displays all elements, models, transfers, and event frames that have been created from the selected element template, as well as from any template that is derived from it. Note: To display the full path to derived elements, right-click on the column header (or below the search results grid) and click Show Full Paths .
Referenced parent templates	Click Referenced Parent Templates .

To find ...	Do this ...
	The Find Referenced Parent Templates for <i>Element_Template</i> window displays element templates that have specifically been linked to this element template as a parent through a reference type. The list of templates includes those that indirectly have been linked through template inheritance.
Referenced child templates	Click Referenced Child Templates . The Find Referenced Child Templates for <i>Element_Template</i> window displays element templates that have specifically been linked to this element template as a child through a reference type. The list of templates includes those that indirectly have been linked through template inheritance.
Event frames created from the template	Click Event Frames . The Find Event Frames for <i>Event_Frame_Template</i> window displays all event frames that have been created directly from the selected event frame template. Note: To display the full path to event frames, right-click on the column header (or below the search results grid) and click Show Full Paths .
Event frames derived from the template	Click Derived Event Frames . The Find Derived Event Frames for <i>Event_Frame_Template</i> window displays all event frames that have been created from the selected template, as well as from any template that is derived from it. Note: To display the full path to derived event frames, right-click on the column header (or below the search results grid) and click Show Full Paths .

Define templates for other objects

In addition to element templates, you can create base templates for event frames, models, and transfers. After a base template is designed, you can create derived templates from it and then assign additional attributes as needed. You then create instances of the object by basing them on the derived template. To learn more, see [Base and derived templates](#).

1. In the navigator, click **Library**.

2. In the Library browser, open **Templates** to display the following object collections:

- **Element Templates**
- **Event Frame Templates**
- **Model Templates**
- **Transfer Templates**

3. Right-click an object collection and select **New Template**.

The new template displays the following tabs:

- **General**
- **Attribute Templates**
- **Ports** (not available for event frame templates)

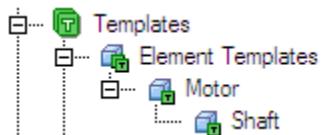
Note: To ensure certain templates are not used directly to create objects, you can assign the **Base Template Only** (BTO) property to a new template. BTO templates can be used to create derived templates. When an instance of an object is created, it is based on the derived template, not the BTO template.

4. Fill in these tabs just as you would for an element template. See [Create element templates](#).

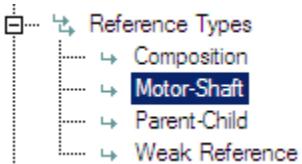
5. To save your work, press CTRL-S or click **Check In**.

Child templates

In some cases, you might want to create a template that has one or more child templates. For example, suppose you have a template representing a motor and you want a separate template for the shaft. You want the shaft template to be a child of the motor template. You cannot directly create a child template in the same way that you would create a child element. Instead, you create a new referenced template below the Motor template.



This also creates a new reference type in the Reference Types collection.



Now, suppose you create an element based on the Motor template. PI System Explorer does not automatically create the child element, Shaft. However, when you manually create a child element on the motor element, the Motor-Shaft reference type is added to the list of reference types and the Shaft template appears in the Element Template list.

Create child template references

Create a child template reference when you need to establish parent-child relationships between two element templates.

1. In the Library browser, right-click the template to which you want to add the child template reference and click **New > New Referenced Template**.
2. In the **Set Referenced Element Template Name** window, type a name for the child template, and click **OK**. This creates a child template in the **Templates** collection and a new reference type in the **Reference Types** collection.
3. Optional. To define a reference type other than strong parent-child, select the **Edit reference type** check box.
 - a. In the Reference Type Properties window, select the desired reference strength from the **Reference Strength** list.
 - b. Click **Check In**.
 - c. Click **OK** to close the window.
4. Complete the element template definition, as described in [Create element templates](#).

Asset representation with elements

In your asset model, elements represent physical objects, such as pumps or tanks. Each element has associated attributes that store properties and data for that element. Typically, you base each element on a template. For example, you would base each pump element on a pump template.

Create elements based on a template

Use the element templates that you have defined to create elements in your asset hierarchy.

1. In the Elements browser, right-click the collection of elements or an individual element and click **New Element**.
2. In the **Choose Element Template** window, select an element template in the **Element Template** field.
3. In the **Add child element using the reference type** field, select a reference type from the list of available types.

The available reference types depend on the selected element template and what reference types are defined in the database. If you are not sure what reference type to use, select the default reference type, parent-child.
4. Click **OK**.

Property tabs for the new element are displayed in the viewer. Because the element is based on a template, most fields on the **General** tab are read-only (with gray or hash-pattern shading).
5. In the **Name** and **Description** fields, type a name and description for the element.
6. Optional. Perform the following actions as needed.
 - Click the **Extended Properties** link to create properties for client applications such as PI ProcessBook and PI WebParts. For more information, see [Storage of application-specific information](#).
 - Click the **Location** link to set up location attribute traits for the element. For more information, see [Set location attribute traits](#).
 - Click the **Annotations** link to enter a note for the element. For more information, see [Element annotations](#).
 - Click the **Security** link to set up custom access permissions for the element. For more information, see [PI](#)

[AF object security.](#)

7. Optional. Click the **Attributes** tab to review the attributes defined by the template. You cannot add new attributes unless the template allows extensions.
8. Optional. Click the **Notification Rules** tab to review any notification rules defined by the template. You cannot add new notification rules unless the template allows extensions.
9. To save your work, press CTRL+S or click **Check In**.

Create elements not based on a template

Although you can create elements that are not based on a template, it is strongly recommended to base your elements on templates to take advantage of powerful template-based features available in client applications. You can use the Convert to Template feature, as described in [Convert elements to element templates](#).

1. In the Elements browser, right-click the collection of elements or an individual element and click **New Element**.
2. In the **Choose Element Template** window, select a reference type in the **Add child element using the reference type** field.

The available reference types depend on the element template and what reference types are defined in the database. If you are not sure what reference type to use, you probably want the default reference type, parent-child.

3. In the **Element Template** field, click **<None>**.
4. Click **OK**.

Property tabs for the new element are displayed in the viewer.

- Use the **General** tab to perform the basic element configuration.
 - The **Child Elements** tab is mainly used to view existing child elements on an existing element. You can optionally create new child elements directly from this tab.
 - Use the **Attributes** tab to create an attribute for each property or data item.
 - Use the **Ports** tab only if you are modeling a process.
 - Use the **Analyses** tab to select an analysis for the element.
 - Use the **Notification Rules** tab to select a notification rule for the element.
 - Use the **Version** tab to add version information for the element.
5. Optional. Perform the following actions as needed.
 - Click the **Extended Properties** link to create properties for client applications such as PI ProcessBook and PI WebParts. For more information, see [Storage of application-specific information](#).
 - Click the **Annotations** link to enter a note for the element. For more information, see [Element annotations](#).
 - Click the **Security** link to set up custom access permissions for the element. For more information, see [PI AF object security](#).
 6. To save your work, press CTRL-S or click **Check In**.

Find where an element is used

Use the **Find** links on the **General** tab for a selected element to locate where and how it is used in the asset model.

1. Select an element in the Elements browser.
2. Choose from the following options:

To find ...	Do this ...
Parent elements	Click the Parents link. The Parents of <i>Element</i> window opens.
Child elements	<ol style="list-style-type: none">a. Click the Children link.b. In the Element Search window, enter element name text in the search field. To refine your search, you can enter additional criteria in the Criteria section.c. Click Search. <p>Matching elements are displayed in the Results section.</p>
Event frames connected to the element	Click the Event Frames link. <ul style="list-style-type: none">• If a match is found, the Find Event Frames for <i>Element</i> displays a list of all event frames that reference the element.• If no match is found, a <i>No Event Frames Found</i> message is displayed.

Deletion of elements

When you delete an element, PI AF automatically deletes the notifications and analyses that target that element. If you wish to repurpose a notification attached to an element that you plan to remove, ensure you do so before you remove the element.

Alternatively, you can change the default behavior so that PI AF does not automatically delete notifications and analyses when you delete the targeted element.

You use the **afdiag** command line utility with the */EnablePropagationOfTargetDeletion* parameter, as described in [AFDiag utility parameters](#):

```
afdiag /EnablePropagationOfTargetDeletion-
```

Be aware that disabling the setting can cause problems, such as:

- Notifications are left open (and remain active)
- New notifications are not created
- Expected emails are not sent

Attribute-value reset to original properties

When you have created elements based on templates in a test environment and later want to transfer your work to a production environment, you can reset all attributes for an element to the original properties as defined by a template. You can right-click an attribute for an element and click **Reset to Template**.

For example, suppose you configure a PI AF attribute to use the name of Data Archive as part of the attribute's configuration in a test environment. You might want this to reflect the new name for Data Archive when you transfer your work to a production environment.

Convert elements to element templates

You should create elements that are based on templates. If you created elements and attributes and did not originally base them on a template, you can later convert them to a template.

1. In the navigator, click **Elements**.
2. In the Elements browser, locate the element that you want to convert to a template.
3. Right-click the element and click **Convert > Convert to Template**.

A template named **ElementNameTemplate** is created and displayed in the **Template** field on the **General** tab.

4. Optional. To rename the template, click **Library** in the navigator.
 - a. In the Library browser, locate the new template in the **Element Templates** branch.
 - b. Right-click the template and click **Rename**.
 - c. Modify the default name as needed. The new name must be unique across all templates.

Change element templates

Exercise caution when you change an element template, since there can be unintended consequences. For example, attributes could be deleted if they were defined by the old template and are not present in the new template. Be sure that attributes with the same name in both the old and new template have the same data type.

You can change the template on which an existing element is based, or add a template to an element that is not currently based on a template.

1. In the navigator, click **Elements**.
2. In the Elements browser, right-click the element that you want to change and click **Convert > Change Template**.
3. In the Choose Element Template window, select a template from the **Element Template** list.
 - Optional. To display only templates in a specific category, select a category from the **Templates of category** list.
4. Click **OK**.

Storage of application-specific information

Extended properties are properties that other applications define on PI AF objects. For example, PI WebParts stores Icon and URL in a PI AF element's extended properties. Applications typically make use of the information stored in the Extended Properties window programmatically with AF SDK.

An **Extended Properties** link is displayed on the **General** tab of many object types in PI System Explorer. This link can be used to configure one or more additional properties for an object.

Note: Users do not need to use this advanced PI AF feature.

Create extended properties

In general, client applications such as PI WebParts and PI ProcessBook use the Extended Properties feature to write properties, and users do not need to use this advanced feature.

1. Click the **Extended Properties** link.
2. In the Extended Properties window, choose from the following actions:
 - To create the first extended property, click the **New Extended Property** link.
 - To create an additional extended property, right-click in the **Name** column and select **New Extended Property**.
3. In the **Name** field, delete the default text and enter the extended property name.
4. Click in the **Value** field and choose from the following options:
 - Enter a string. To visualize the text you are entering, press F2 and type in the Text Visualizer window.
 - Click  and select from the list of **Basic Types**, **Array Types**, and **Objects**.
 - If you choose an object such as **Attribute** or **Element**, click  and locate the desired object.
 - If you choose **File**, click  and select **Upload** to locate the desired file.
5. Click **Close**.

Association of data with PI AF assets

To associate data with an asset, you create attributes on the element that represents that asset.

Attributes can hold simple values that represent fixed information, such as the diameter of a tank. They can also hold values from PI points, be derived from formulas, or hold data from outside the PI System through the use of PI AF tables.

Enumeration sets

If you need an attribute to hold only predefined values, you can use an enumeration set. An enumeration set maps an ordered set of user-defined constant values to a set of strings. You can use the strings to provide brief, descriptive text to use within your PI AF model.

Videos

For information on how to create element attributes, watch this video:

For information on how to create child attributes, watch this video:

Attribute templates

Attribute templates are associated with element templates. Just as an element template represents a type of asset, an attribute template represents a type of data configuration. When you create an instance of the element template, that element contains an attribute for each attribute template. These attributes inherit all properties configured on the attribute template.

Rather than create attributes on each element, create attribute templates in an element template. Whenever you create elements based on that template, PI AF automatically creates the attributes for you. You still need to give each attribute a value.

Modification of attribute descriptions created from attribute templates

Beginning with 2017 R2, you can modify the descriptions of attributes that are created from a template. You may find this helpful when differentiating between attributes that use the same attribute template. For example, in a series of pumps, each pump has a Flowrate attribute with a PI point data reference. The template description for Flowrate is simply Pump flowrate. To make that description unique for each instance of the pump, you could use PI Builder to load the *descriptor* attribute for each pump flowrate PI point and incorporate that value into each Flowrate description, thereby customizing it.

To modify descriptions created from an attribute template, you must use a PI AF client and server that are running PI AF 2017 R2 or later. Older clients that connect to a PI AF server running 2017 R2 or later continue to see only the description from the attribute template.

Note: Because extra memory is used to store descriptions for attributes that have been overridden, loading them into client applications can take a little longer.

Video

For information on how to create attribute templates, watch this video:

Attribute properties

You need to set up the properties for each element attribute. After you assign properties in an attribute template, users can only modify the **Exclude** property on individual attributes.

Configuration Item attribute property

You assign the **Configuration Item** property to an attribute that represents inherent properties of an asset. Any attribute that has a constant value can be a configuration item. Because the attribute value of a configuration item is presumed to be constant, PI System Explorer automatically checks out the attribute when you change the attribute value. To commit the change, you need to check it in. In PI System Explorer, configuration attributes are marked with a pencil icon (✎).

Attributes with values that change, such as PI point data references, or formula data references, should not be configuration attributes. When you change the value of a non-configuration attribute, PI System Explorer does not check out the attribute. For example, suppose you have an element representing a tank. The element has the following attributes:

- ✎ manufacturer
- ✎ photo (file)
- ✎ serial number
- ✎ maximum temperature rating
- ✎ maximum volume
- temperature (PI point data reference)
- volume (PI point data reference)

The first five attributes would typically be configuration items, since these values will not change unless you change the equipment. The last two attributes would not be configuration items, since the values change all the time.

Excluded attribute property

You exclude an attribute in situations where not all attributes in an element template apply. For example, suppose you have five attribute templates defined in an element template named Meter, which you use to create elements representing several different types of meter in use at your facility. In some kinds of meter (meterA), only three attributes from the Meter template are applicable, whereas in the remainder (meterB) all five attributes apply. In meters of type A, you should select the **Excluded** property for the two attributes that are inapplicable. For all practical purposes, those two attributes “seem” nonexistent to most PI AF client applications since searches retrieve the digital state value *No Result*.

Note: An excluded attribute cannot be used to return elements and event frames that are referenced by an excluded attribute value.

When the **Excluded** property is assigned in an attribute template, the property is indicated by  beside the attribute name if the **Show Excluded Attributes** option is enabled. Attributes that are derived from that template appear on an element **Attributes** tab with  in the Template column and **Excluded** in the Value column. You can toggle the display of such attributes with the **Hide Excluded Attributes** and **Show Excluded Attributes** command on the **Attributes** tab context menu. Note that when **Show Excluded Attributes** is enabled, users can change the **Excluded** property setting for an attribute from the setting it is assigned in an attribute template. See [Create attribute templates](#) for instructions on how to exclude an attribute.

Alternatively, you can clear the **Show Excluded Attributes** option in **Tools > Options** to hide excluded attributes everywhere in PI System Explorer. When attributes are hidden, the *Excluded attributes are hidden* message is displayed on the **Attributes** tab.

Hidden attribute property

A hidden attribute is one that cannot be retrieved in searches from PI AF client applications such as AVEVA PI Vision. This property is useful if an attribute is being used to hold an intermediate result, such as a table lookup result that can then be retrieved by a PI point data reference, or is being used solely to populate a PI point name in a substitution parameter.

It can also be useful to set an attribute property to **Hidden** in a template when configuration has not been fully completed in the element itself. For example, elements are being created from a template with a PI point data reference, but because some instrumentation is missing, PI points do not yet exist for all the elements. By setting the attributes for the missing instrumentation to **Hidden**, a PI AF client application is prevented from obtaining an error result from a search.

When the **Hidden** property is assigned to an attribute in an attribute template, the property is indicated by  in the Hidden column beside the attribute name. The same icon is displayed next to the attribute name on the **Attributes** tab when the template is assigned to an element.

Indexed attribute property

You index an attribute to optimize it for fast search results and fast value retrieval. Indexes only improve performance for attributes whose values are stored in the PI AF database. This means that you do not gain any benefit from indexing attributes that obtain their values from data references, as is the case with PI points and linked tables. For event frames, however, when attribute values are captured they are written to the PI AF server and as a result can benefit from indexing.

Note: Only the first 40 characters of indexed attributes with a **String** value type are used in searches.

When you index an attribute, both the attribute and the attribute value are returned more quickly in a search. However, indexed attributes increase the table size in your PI AF database and they create some CPU load on the SQL server. Indexed attributes are marked with the  icon.

You typically index an attribute that you think users are likely to search for frequently. For example, if you know that you want to locate assets by searching for a serial number, you should index the serial number attribute.

Manual Data Entry attribute property

You flag an attribute for manual data entry to enable client applications (such as AVEVA PI Vision and PI Manual Logger) to guide users to enter data for that attribute.

To determine which attributes have this property, add a Manual Data Entry column to an attribute grid in the **Elements** viewer, where attributes with this property display as *True*.

Attribute traits

Attribute traits identify commonly held characteristics or related behaviors of a parent attribute. PI AF supports attribute traits for limit conditions, forecasted values, geolocation information, reason codes, asset health, and analysis start triggers. Users and client applications like AVEVA PI Vision can then find, display, and analyze such related attributes more effectively.

To set and access attribute traits, both the PI AF client and server need to be running PI AF 2016 or later.

Limit attribute traits

You use limit attribute traits to identify the expected range of a process variable or a measurement attribute. Limit attribute traits are often set elsewhere (for example, on a control system), or represent inherent properties of the parent attribute, such as temperature. A typical usage would be to set up conditions for an alarm. AVEVA PI Vision, for example, uses most limit attributes as input when configuring multi-state behavior for a visual alarm.

Limit attribute traits are child attributes of the measurement they describe and have the same value type and UOM as the parent. The only exception is when the value of a limit attribute trait is obtained from a data reference, in which case the source UOM of a defined data reference can be different. You can also only set limit attribute traits for parent attributes that are numeric. Note that you can only assign a specific limit attribute trait once to a parent attribute.

The following limit traits are defined:

Limit attribute trait	Description
Minimum	Indicates the very lowest possible measurement value or process output.
LoLo	Indicates a very low measurement value or process output, typically an abnormal one that initiates an alarm.
Lo	Indicates a low measurement value or process output, typically one that initiates a warning.
Target	Indicates the aimed-for measurement value or process output.
Hi	Indicates a high measurement value or process output, typically one that initiates a warning.
HiHi	Indicates a very high measurement value or process output, typically an abnormal one that initiates an alarm.
Maximum	Indicates the very highest possible measurement value or process output.

Video

For information on how to set limit attribute traits, watch this video:

Forecast attribute traits

In general, you use forecast attribute traits as predicted values to compare with the actual value of the parent attribute. Typically, such attribute traits represent future PI points but that is not a requirement. Client applications can very easily relate these attributes and trend them together.

Forecast attribute traits are child attributes of the attribute they describe and have the same value type and UOM as the parent. The only exception is when the value of a forecast attribute trait is obtained from a data reference, in which case the source UOM of a defined data reference can be different. You can also create forecast attribute traits for parent attributes that are of any value type. Note that you can have multiple forecast attribute traits defined for a parent attribute.

Location attribute traits

You use location attributes to define longitude, latitude, and altitude information for an asset. You can use this information to identify the location of the asset on a map.

You can create location attribute traits on an element, an event frame, a model, or on their child attributes. However, you can create only one of each attribute trait per element, event frame, or model. The UOM for the latitude and longitude attribute traits should be degree (the default) or at least an angle, whereas the altitude attribute trait can be meter (the default) or another UOM in the Length class. The value type for all location attribute traits must be numeric (double).

Reason attribute traits

You use reason attribute traits on event frames and transfers to enable users to select a reason code for excursions, downtime, and other events. You can set a single reason attribute trait on an event frame or transfer template or an event frame or transfer instance. The reason attribute trait must be an enumeration set that is previously defined, or a system enumeration set delivered with PI AF.

Health attribute traits

You use health attribute traits on elements and models to enable users to set a numeric health score and a health status (for example, healthy, out of service, in maintenance, warning, or error). The **HealthStatus** attribute trait uses values from the **Health Status** enumeration set, which is delivered with PI AF. Administrators can modify the **Health Status** enumeration set as required.

Analysis start-trigger attribute traits

When users configure analytics to generate event frames, they can optionally elect to store the name of the start trigger in the value of an attribute (string) and mark that attribute with the analysis start trigger trait. This enables clients like AVEVA PI Vision to indicate the start trigger that created that particular event frame. For more information, see Event frame generation analyses.

Set limit attribute traits

Set up to seven limit traits for an attribute template or an element attribute to enable users to define the expected range of a process variable or a measurement.

1. Choose from the following actions:

To set a limit trait for an ...	Do this ...
Attribute template	a. In the Library browser, select an element template. b. In the viewer, click the Attribute Templates tab.
Element attribute	a. In the Elements browser, select an element. b. In the viewer, click the Attributes tab.

2. Select the attribute for which you want to set one or more limit traits.
3. Choose one of the following actions:
 - Right-click and click **Limits**.
 - At the bottom of the configuration area, click the **Limits** link.
4. In the Limits window, select the check box beside the limit trait you want to set.
5. In **Attribute**, choose one of the following actions:
 - Leave the default attribute name as is.
 - Replace the default attribute name with a revised name of your choice.
 - If a child attribute already exists that you want to assign to the limit trait, select it from the drop-down list.

Note: Limit attribute traits that have already been defined are displayed in bold typeface.

6. Choose from the following actions:

To set a ...	Do this ...
Value for the limit trait	In Value , enter a limit value.
Value for the limit trait from a data reference	<p>a. In Data Reference, select a data reference type.</p> <p>b. In Settings, click  to configure the data reference.</p> <p>Note: The source UOM of a data reference can be different from that of the parent attribute.</p> <p>c. Click OK to close the data reference window.</p> <p>The result of the evaluated data reference is displayed.</p>

7. Repeat steps 4 to 6 to set values for other limit traits.
8. Click **OK** when your list of limit traits for the selected parent attribute is complete.

Set forecast attribute traits

Set one or more forecast traits for an attribute template or an element attribute to enable users and client applications to compare predicted values with actual values and plot a trend.

1. Choose from the following actions:

To set a forecast trait for an ...	Do this ...
Attribute template	<p>a. In the Library browser, select an element template.</p> <p>b. In the viewer, click the Attribute Templates tab.</p>
Element attribute	<p>a. In the Elements browser, select an element.</p> <p>b. In the viewer, click the Attributes tab.</p>

2. Select the attribute for which you want to set one or more forecast traits.
3. Choose one of the following actions:
 - Right-click and click **Forecasts**.
 - At the bottom of the configuration area, click the **Forecasts** link.
4. In the Forecasts window, click the **New Forecast** button or link.
5. In **Attribute**, choose one of the following actions:
 - Leave the default attribute name as is.
 - Replace the default attribute name with a revised name of your choice.
 - If a child attribute already exists that you want to assign to the forecast trait, select it from the drop-down list.

Note: Forecast attribute traits that have already been defined are displayed in bold typeface.

6. Choose from the following actions:

To set a ...	Do this ...
Value for the forecast trait	In Value , enter a forecast value.
Value from a data reference	<p>a. In Data Reference, select a data reference type.</p> <p>b. In Settings, click  to configure the data reference.</p> <p>Note: The source UOM of a data reference can be different from that of the parent attribute.</p> <p>c. Click OK to close the data reference window.</p> <p>The result of the evaluated data reference is displayed.</p>

7. You can set as many forecasted values as necessary. Repeat steps 4 to 6.
8. Click **OK** when your list of forecast attributes for the selected parent attribute is complete.

Set location attribute traits

You can only set one set of location attribute traits per element, model, or event frame.

Set one or more location traits on an element or event frame template or on an element or event frame to enable users to identify the location of an asset on a map. You can also set a location for a model.

1. Choose from the following actions:

To set a location trait on ...	Do this ...
Element or model template	<p>a. In the Library browser, select an element or model template.</p> <p>b. Choose one of the following actions:</p> <ul style="list-style-type: none"> a. Right-click and click Location. b. On the General tab, click the Location link.
Event frame template	<p>a. In the Library browser, select an event frame template.</p> <p>b. Choose one of the following actions:</p> <ul style="list-style-type: none"> a. Right-click and click Location. b. On the General tab, click the Location link.
Element or model	<p>a. In the Elements browser, select an element or model.</p> <p>b. Choose one of the following actions:</p> <ul style="list-style-type: none"> a. Right-click and click Location. b. On the General tab, click the Location link.
Event frame	<p>a. In the Event Frames browser, select an event</p>

To set a location trait on ...	Do this ...
	<p>frame.</p> <p>b. Choose one of the following actions:</p> <ul style="list-style-type: none"> a. Right-click and click Location. b. On the General tab, click the Location link.

Note: You can also configure location traits as a child attribute template to an existing attribute template, or as a child attribute to an existing attribute: 1) On a template, right-click an attribute template and click **Location of Element/Event Frame/Model Template**, and 2) On an element, event frame, or model, right-click an attribute and click **Location of Element/Event Frame/Model**.

2. In the Location window, select the check box beside the trait you want to apply, or select the check box in the column header to select all traits.
3. In **Attribute**, choose one of the following actions:
 - Leave the default attribute name as is. The default attribute name displays the path relative to the element.
 - Replace the default attribute name with a name of your choice. Ensure that the full path to the element is retained.
 - If a child attribute already exists that you want to assign to the location trait, select it from the list.

Note: Location attribute traits that have already been defined are displayed in bold typeface.

4. Choose from the following actions:

To set a ...	Do this ...
Value for the location trait	In Value , enter a location value.
Value from a data reference	<p>a. In Data Reference, select a data reference type.</p> <p>b. In Settings, click  to configure the data reference.</p> <p>c. Click OK to close the data reference window.</p> <p>The result of the evaluated data reference is displayed.</p>

5. Click **OK** when your list of location attributes for the selected element is complete.

Set reason attribute traits

You can only set one reason attribute trait per event frame or transfer.

Use reason attribute traits on event frames and transfers to enable users to select a reason code for excursions, downtime, and other events.

1. To designate an attribute as a reason attribute trait for an event frame or transfer, choose from the following actions:

To set a reason attribute trait for ...	Do this ...
Event frame template	<ul style="list-style-type: none"> a. In the Library browser, select an event frame template. b. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click and click Reason. b. On the General tab, click the Reason link.
Transfer template	<ul style="list-style-type: none"> a. In the Library browser, select a transfer template. b. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click and click Reason. b. On the General tab, click the Reason link.
Event frame	<ul style="list-style-type: none"> a. In the Event Frames browser, select an event frame. b. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click and click Reason. b. On the General tab, click the Reason link.
Transfer	<ul style="list-style-type: none"> a. In the Event Frames browser, select a transfer. b. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click and click Reason. b. On the General tab, click the Reason link.
Attribute template for an event frame template	<ul style="list-style-type: none"> a. In the Library browser, select an event frame template. b. Click the Attribute Templates tab. c. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click an existing attribute template and click Reason for Event Frame Template. b. Click New Attribute Template, right-click and click Reason for Event Frame Template.
Attribute template for a transfer template	<ul style="list-style-type: none"> a. In the Library browser, select a transfer template. b. Click the Attribute Templates tab. c. Choose one of the following actions: <ul style="list-style-type: none"> a. Right-click an existing attribute template and click Reason for Transfer Template. b. Click New Attribute Template, right-click and click Reason for Transfer Template.
Event frame or transfer attribute	If the Allow Extensions check box has been selected

To set a reason attribute trait for ...	Do this ...
	<p>for an event frame or a transfer template, and no attribute template has previously been designated as a reason attribute trait, you can either create a new attribute and establish it as the reason attribute trait, or choose an existing attribute.</p> <ol style="list-style-type: none"> In the Event Frames or Transfer browser, select an event frame or transfer. Click the Attributes tab. Choose one of the following actions: <ol style="list-style-type: none"> Right-click an existing attribute and click Reason for Event Frame or Reason for Transfer. Right-click below the attribute table and click Reason for Event Frame or Reason for Transfer.

2. In the Reason window, select the check box beside the Reason trait you want to apply.
3. In **Attribute**, choose one of the following actions:
 - Leave the default attribute name as **Reason**.
 - If an attribute already exists that you want to designate as the reason trait, select it from the list.

Note: Reason traits that have already been defined are displayed in bold typeface.

4. Choose from the following actions:

To set a ...	Do this ...
Default value for the reason trait	<ol style="list-style-type: none"> a. In Value Type, select Enumeration Value > Enumeration Sets and select an enumeration set to use for the reason trait. The default is the built-in System enumeration set. b. In Default Value, select the default reason trait value from the selected enumeration set.
Default value from a data reference Note: The data reference must be to a digital states tag.	<ol style="list-style-type: none"> a. In Data Reference, select a data reference type. b. In Settings, click  to configure the data reference. c. Click OK to close the data reference window. The result of the evaluated data reference is displayed.

5. Click **OK** when the assignment of a default reason trait for the selected event frame or transfer is complete.

Set health attribute traits

You can only set one set of health attribute traits per element or model.

Set health attribute traits for an element template or for an element to enable users to establish the health of an asset. You can also set health attribute traits for a model template or model.

1. Choose from the following actions:

To set a health trait for ...	Do this ...
Element or model template	<ol style="list-style-type: none">In the Library browser, select an element or model template.Choose one of the following actions:<ol style="list-style-type: none">Right-click and click Health.On the General tab, click the Health link.
Element or model	<ol style="list-style-type: none">In the Elements browser, select an element or model.Choose one of the following actions:<ol style="list-style-type: none">Right-click and click Health.On the General tab, click the Health link.
Attribute template	<ol style="list-style-type: none">In the Library browser, select an element or model template.In the viewer, click the Attribute Templates tab.Choose one of the following actions:<ol style="list-style-type: none">Right-click under the grid and click Health of Element Template.Click New Attribute Template and from the Properties list, select Health > HealthScore or Health > HealthStatus. Then assign values, as described in step 4.
Attribute	<ol style="list-style-type: none">In the Elements browser, select an element or model.In the viewer, click the Attributes tab.Choose one of the following actions:<ol style="list-style-type: none">Right-click under the grid and click Health of Element.Click New Attribute and from the Properties list, select Health > HealthScore or Health > HealthStatus. Then assign values, as described in step 4.

Note: You can also configure health traits as a child attribute template to an existing attribute template, or as a child attribute to an existing attribute by right-clicking and clicking **Properties**. From the **Properties** list,

select **Health > HealthScore** or **Health > HealthStatus**. Then assign values, as described in step 4.

2. In the Health window, select the check box beside the trait you want to apply, or select the check box in the column header to select all traits.
3. In the **Attribute** column of the Health window, choose one of the following actions:
 - Leave the default attribute name as is. The default attribute name displays the path relative to the element.
 - Replace the default attribute name with a name of your choice. Ensure that the full path to the element is retained.
 - If a child attribute already exists that you want to assign to the health trait, select it from the list.

Note: Health attribute traits that have already been defined are displayed in bold typeface.

4. Choose from the following actions:

To set a ...	Do this ...
Value for the HealthScore trait	In Default Value (for a template) or Value (for an element), enter a numeric value.
Value for the HealthStatus trait	In Default Value , select a Health Status enumeration value: <ul style="list-style-type: none">• Healthy• Out of Service• In Maintenance• Warning• Error• Other Health Status enumeration set values added by an administrator
Value from a data reference	a. In Data Reference , select a data reference type. b. In Settings , click  to configure the data reference. c. Click OK to close the data reference window. The result of the evaluated data reference is displayed.

5. Click **OK** when your list of health attributes for the selected element (or model) is complete.

Control the display of attribute and attribute template values

Prior to PI AF 2018, PI System Explorer rendered numeric data types in displays with high levels of precision. For example, the Single and Double data types have a precision of seven and fifteen respectively. Such high levels of precision are not always useful in real-time situations, or for PI AF client products: for example, a temperature gauge may only display a precision of three digits, so process engineers are unlikely to require a greater degree of precision for mathematical calculations.

Beginning with PI AF 2018, the **Use DisplayDigits for Attribute and Attribute Template values** system option is

enabled and ensures that the default setting of the **DisplayDigits** property is used to display attribute values: -5, or a total of five digits overall. This is the same default setting used for PI points on Data Archive.

When creating attribute templates, you can now control the number of digits you want to see for individual attributes in the **Display Digits** field:

- You can enter a negative number up to -20 to indicate the total number of digits to display.
- You can enter a positive number up to 10 to indicate the number of digits after the decimal point to display, including trailing zeros.

When you are editing an attribute value, the actual number is displayed rather than the truncated number established by the **Display Digits** field.

For attributes that are not based on a template, the precision of PI point data references is obtained from the PI point itself.

Note: On upgrades, existing attributes configured with a PI Point data reference are not updated to obtain their **DisplayDigits** value from the PI point: they are set to -5.

Create attribute templates

Use attribute templates to create a standard set of attributes that are associated with element, event frame, model, and transfer templates.

1. In the Library browser, select a template.
2. To create a new attribute template, choose one of the following actions:
 - On the toolbar, click **New Attribute Template**.
 - Right-click the template in the browser and click **New > New Attribute Template**.
3. In the **Name** and **Description** fields, enter a unique name and a description for the attribute template.

Note: When you need to search for an attribute, you can search on up to 440 characters of a description.

4. Set the configuration fields, as needed.

Field	Description
Properties	Select one or more of the following properties, as needed. <ul style="list-style-type: none">• Configuration Item• Excluded• Hidden• Indexed• Manual Data Entry For more information on these properties, see Attribute properties . You can set up the current attribute template to be a location attribute trait for a parent object. Select one of:

Field	Description
	<ul style="list-style-type: none"> • Location > Longitude • Location > Latitude • Location > Altitude <p>When the parent object is an event frame or transfer, you can set up the current attribute template to be a reason attribute trait. For more information, see Set reason attribute traits.</p> <p>When the parent object is an element or model, you can set up the current attribute template to be an asset health attribute trait. For more information, see Set health attribute traits.</p> <p>Note: When you configure a child attribute template, you can also select limit and forecast attribute traits, depending on the value type of the parent attribute template. For more information, see Attribute traits.</p>
Categories	<p>Click  and select one or more previously defined categories from the Categories window. You can also create a new category. For more information, see Categorization of objects.</p>
Default UOM	<p>Select a UOM from the list. For more information on UOMs, see Units of measure in PI AF.</p> <p>Note: Although a user can change the UOM that is displayed for an attribute in PI System Explorer, the UOM that is defined in the template does not change.</p>

5. Configure the type of value that the attribute holds.

- For attributes with constant values, set the attribute **Value Type**. Constant attribute values can be numbers, strings, files, date-times, Boolean, URLs, arrays, and more. For more information, see [Define constant values for attribute templates](#).

Note: Do not set a default UOM for integer value types if searches by client applications, such as AVEVA PI Vision, will be performed on the value or a UOM conversion is involved. For example, an integer value type with a default UOM is not compatible with the UOM groups feature introduced in PI AF 2017 R2. Use the **Single** or **Double** value type instead.

Note: While allowed, the **Anything** value type is not recommended. When the value type is unspecified, many client applications may have difficulty working with that attribute. For example, PI OLEDB Enterprise, PI ProcessBook, and AVEVA PI Vision would all have reduced capability with such attributes, such as the inability to trend a value numerically. Furthermore, standard PI AF features such as automatic UOM conversion, formulas, and analytics cannot function with attributes that have no value type.

- For PI point values, PI point arrays, formulas, and table data (including data from relational databases), click **Settings** to configure a data reference. For more information, see [Configuration of data references](#).

6. Optional. Enter a default value for the attribute in the **Default Value** field.
 7. Optional. When the **Use DisplayDigits for Attribute and Attribute Template values** system option is selected, you can override the default DisplayDigits property value of -5 and specify the number of digits to display in the **Display Digits** field. Only numeric values in the **Value** field are affected.
 - Enter a negative number up to -20 to indicate the total number of digits to display.
 - Enter a positive number up to 10 to indicate the number of digits after the decimal point to display, including trailing zeros.
- For more information, see [Control the display of attribute and attribute template values](#) and [PI System Explorer customization options](#).
8. To save your work, press CTRL-S or click **Check In**.

When you create an attribute based on the template, you need to set the value:

- For constant values, add the value to the attribute directly.
- For data references, you need to create the instance of the data reference. To do this, right-click on the element in the browser and choose **Create or Update Data Reference**. For more information, see [Attribute-value updates from PI point data references](#).

Note: The way you configure an attribute can sometimes restrict how the data can be viewed in client applications, such as PI ProcessBook or AVEVA PI Vision. See [Restrictions on viewing time series data](#) for more information.

PI AF data types

The following table contains definitions of the data types in use in PI AF.

Data type	Data Archive equivalent	Description	Range
Boolean	None	A data type that tracks true or false conditions	True or False A Boolean attribute can be stored into a PI point of type String and any of the Integer tags, but Digital is the preferred representation.
Byte	None	An 8-bit unsigned data type	0 to 255 These values can be represented in a larger PI data type such as Int16. However, if Data Archive contains data outside the byte range, an error is returned when retrieved through PI AF.

Data type	Data Archive equivalent	Description	Range
DateTime	Timestamp	Date and time stored internally in 64 bits	<ul style="list-style-type: none"> If stored in Data Archive: 1 Jan 1970 to 19 Jan 2038, with a precision of 15 microseconds If not stored in Data Archive: 1 Jan 0001 to 31 Dec 9999, with a precision of 100 nanoseconds
Double	Float64	A 64-bit floating point number	±5.0e-324 to ±1.7e308, 15 digits of precision
GUID	None	A unique 128-bit data type used for the global identification of objects	00000000-0000-0000-0000-000000000000 to ffffffffffffff-ffff-ffff-ffff-ffffffffffff The above values can be represented as a String PI data type.
Int16	Int16	A 16-bit signed integer	-32,768 to 32,767 The PI AF Int16 data type is not equivalent to the Data Archive Int16 data type. In Data Archive, the Int16 data type only supports positive integers.
Int32	Int32	A 32-bit signed integer	-2,147,483,648 to 2,147,483,647
Int64	None	A 64-bit signed integer	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807 There is no equivalent of an Int64 in Data Archive. For non-numerical representations (such as an ID number), a string may be used. For numerical representations, Float64 provides some

Data type	Data Archive equivalent	Description	Range
			equivalence but will be subject to rounding issues with very large (positive or negative) numbers.
Single	Float32	A 32-bit floating point number	±1.5e-45 to ±3.4e38, 7 digits of precision
String	String	A sequence of multiple characters	Data Archive strings limited to 976 characters, and are not unicode

Define constant values for attribute templates

You can assign constant values directly on an attribute template. Although you cannot set actual attribute values in attribute templates, you can define default values.

1. In the viewer, use the **Value Type** field to select the data type of the attribute.

There are four groups of value types:

- **Basic Types**

A data type supported by PI AF, as described in [PI AF data types](#).

- **Array Types**

An array contains any of the Basic types as elements.

- **Enumeration Sets**

An enumeration set is a list of user-defined constant values. You typically use an enumeration set to define a list of predefined values for an attribute template. When you configure attributes based on that template, you can select a value from the list. Use the **Enumeration Sets** option to select any of the enumeration sets that have already been created in your PI AF database.

- **Objects**

An object can be another PI AF attribute, element, or an operating system file.

2. Click in the **Default Value** field.

The format of the **Default Value** field changes according to the **Value Type**.

3. Configure the value for the attribute, as described in the appropriate procedure for the attribute data type.

Configure values for Basic data types

After you have set **Value Type** to one of the Basic data types, you can define the attribute's value.

1. Click in the **Default Value** field.

The format of the field changes according to the value type. See [PI AF data types](#).

2. Enter the attribute's value in the **Default Value** field.

PI System Explorer resolves the data you enter and when you check in your changes, it sends the resulting

value to PI AF. For example, for **DateTime**, it sends the resulting date and time.

Examples

If the value type is **DateTime**, you can type the time in any string format that is supported by PI AF (including PI Time formats) or the .NET DateTime object. Some examples of valid entries:

```
*-5d  
May 12, 2009  
07 06 2010 10:00:00 AM  
09 14 2008 14:00:00
```

To create an attribute with a link as a value, select the value type **String** and enter the URL as the attribute value. Strings that are recognized as absolute URL paths will be displayed as a link. For example, strings starting with *http://*, *ftp://*, *file://* and *www.* are recognized as links, whereas strings starting with *C:*, and *abc.com* are not. In PI System Explorer, links appear underlined and have an associated tooltip.

Configure values for Array data types

After you have set **Value Type** to one of the Array data types, you can define the attribute's value.

1. Click in the **Default Value** field.
2. Click  beside the **Default Value** field.
3. In the Array window, define your array.

The **Default Value** field is set to the appropriate format for the data type you selected for your array elements. See [PI AF data types](#).

4. Click **OK**.

PI System Explorer resolves the data you have entered and when you check in your changes, it sends the resulting array values to PI AF.

Configure Enumeration Set values

When you select an enumeration set for the **Value Type**, you can pick the value for an attribute from that set's predefined list of constant values. For more information on enumeration sets, see [Enumeration sets in PI AF](#).

1. Click in the **Default Value** field.
The **Default Value** field becomes a drop-down with values from the selected enumeration set.
2. Select a value from the list of predefined constants.

When you check in your changes, PI System Explorer sends the resulting value to PI AF.

Configure values for Object data types

After you have set **Value Type** to one of the Object data types, you then define the attribute's value.

1. Click in the **Default Value** field.
The action button beside the field changes according to the selected value type.

Value Type	Action
<Anything>	<p>While allowed, the Anything value type is not recommended.</p> <p>Note: When the value type is unspecified, many client applications may have difficulty working with that attribute. For example, PI OLEDB Enterprise, PI ProcessBook, and AVEVA PI Vision would all have reduced capability with such attributes, such as the inability to trend a value numerically. Furthermore, standard PI AF features such as automatic UOM conversion, Formulas, and Analytics cannot function with attributes that have no value type.</p>
Attribute	<p>Click  to open the Attribute Search window. Enter search criteria, as described in Search for attributes on elements.</p>
Element	<p>Click  to open the Element Browser window, where you can locate and select an element.</p>
File	<p>Click  and select Upload. Locate and select a file in the Open window. For acceptable types of attachment files, see /FileExtensions in AFDiag utility parameters.</p> <p>Caution: Before you upload a file, run an anti-virus check and ensure that the file size does not exceed your storage space. Some file types can pose a security risk, and a warning message will be displayed, asking if you are sure you want to continue. The list of file types that PI System Explorer considers unsafe can change. As a guideline, look at Microsoft's list of file types blocked by Outlook.</p>

2. Click **OK**.

When you check in your changes, PI System Explorer sends the resulting value to PI AF.

Add attribute extensions to template-based elements

The **Allow Extensions** check box on the **General** tab for the element template upon which the attribute is based must be checked.

In some situations, you might want to add another attribute to an existing element. If the element is based on a template that allows extensions, you can define additional attributes in the element itself independently of the template.

1. In the Elements browser, select the element to which an attribute will be added.

2. Choose from the following actions.

- In the toolbar, click **New Attribute**.
- Right-click the element in the browser and click **New > New Attribute**.
- Select the **Attributes** tab in the viewer, right-click and click **New Attribute** from the context menu.

3. In the **Name** and **Description** fields, enter a unique name and a description for the attribute template.

Note: When you need to search for an attribute, you can search on up to 440 characters of a description.

4. Configure the type of value that the attribute holds:

- For attributes with constant values, set the attribute **Value Type**. This setting determines what you can enter in the **Value** field.

Constant attribute values can be numbers, strings, files, date-times, Boolean, URLs, arrays, and more.

Note: While allowed, the **Anything** value type is not recommended. When the value type is unspecified, many client applications may have difficulty working with that attribute. For example, PI OLEDB Enterprise, PI ProcessBook, and AVEVA PI Vision would all have reduced capability with such attributes, such as the inability to trend a value numerically. Furthermore, standard PI AF features such as automatic UOM conversion, formulas, and analytics cannot function with attributes that have no value type.

Optional. Enter or modify the default value for the attribute in the **Value** field.

- For formulas, PI point values, PI point arrays, and table data (including data from relational databases) click **Settings** to configure a data reference.

See [Configuration of data references](#) for information about configuring different types of data reference.

5. Set other configuration fields, as needed.

Field	Description
Properties	Select one or more of the following properties, as needed. <ul style="list-style-type: none">• Configuration Item• Excluded• Hidden• Indexed• Manual Data Entry For more information, see Attribute properties .
Categories	Click  and select one or more previously defined categories from the Categories window. You can also create a new category. For more information, see Categorization of objects .
Default UOM	Select a UOM from the drop-down list. For more information, see Units of measure in PI AF . Note: You can change the UOM that is displayed for the attribute in PI System Explorer; however, the UOM defined in the template is not changed.

6. To save your work, press CTRL-S or click **Check In**.

Enumeration sets in PI AF

You typically use enumeration sets to establish predefined values for attribute templates. When you configure element attributes based on those templates, you can then have users select those values from pre-populated lists rather than typing values manually. This helps ensure you have consistent nomenclature throughout your database.

Hierarchical enumeration values

Beginning with PI AF 2017 R2, you can nest enumeration values in a hierarchy. This can be very helpful when you create a predefined set of reason attribute traits. You can create as many levels as you need. Each level is designated by the | character, which you can either enter manually or by right-clicking a row and clicking **New Child Enumeration Value**.

Hierarchical enumeration set example

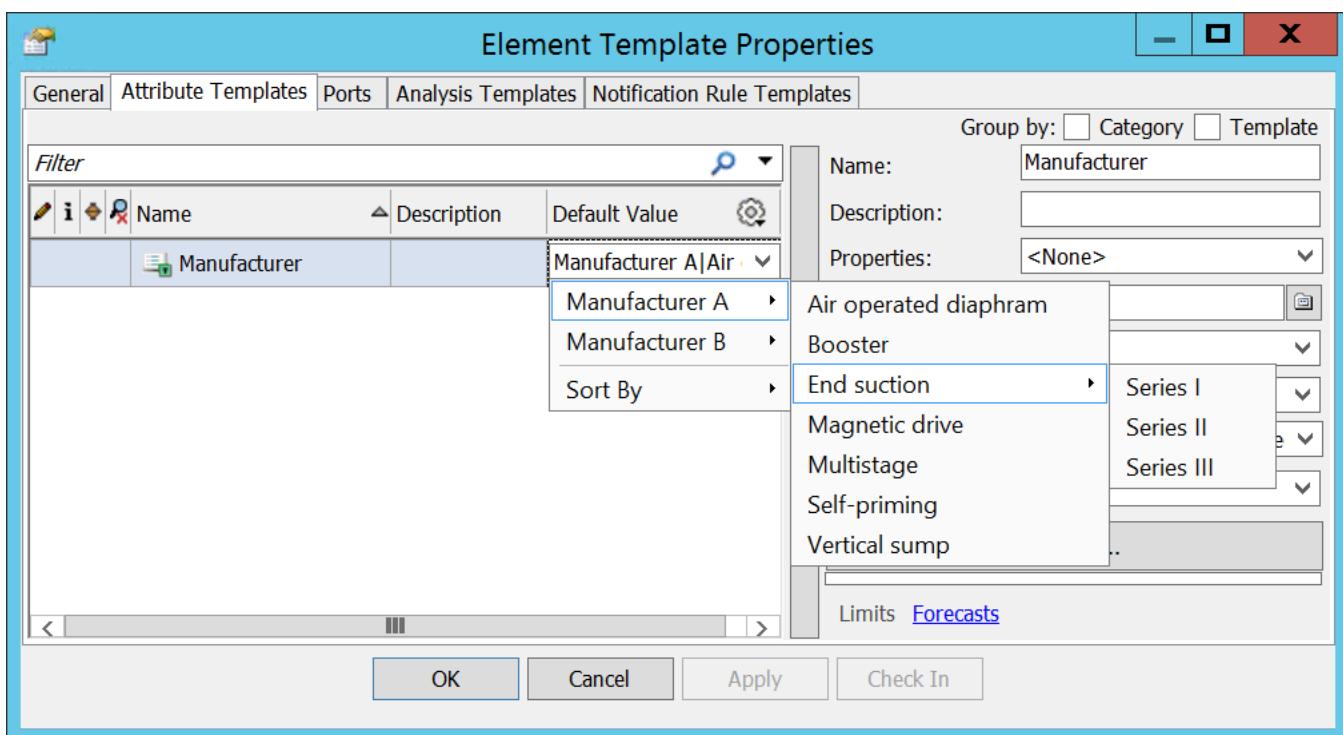
Suppose you have an enumeration set of pump manufacturers, with child enumeration values for pump types. Within each pump type you could also create child enumeration values for different models.

Sample hierarchy of enumeration values

Pump Manufacturer			
General			
Name:		Pump Manufacturer	
Description:			
<input type="checkbox"/> Hexadecimal		Security	
Value	Name	Description	
0	Manufacturer A		
5	Manufacturer A Air operated diaph...		
10	Manufacturer A Booster		
15	Manufacturer A End suction		
16	Manufacturer A End suction Series I	Temp under 80° c or 176° F	
17	Manufacturer A End suction Series II	Hot water pump temp under 120° c or 248° F	
18	Manufacturer A End suction Series III	Chemical pump temp under 120° c or 248° F	
20	Manufacturer A Magnetic drive		
25	Manufacturer A Multistage		
30	Manufacturer A Self-priming		
35	Manufacturer A Vertical sump		
40	Manufacturer B		
45	Manufacturer B Chopper		
50	Manufacturer B Dry pit		
55	Manufacturer B Grinder		
60	Manufacturer B Vertical well		

When you configure the Pump attribute template, you can simply select the Pump Manufacturer enumeration set as the **Value Type**, and thereby enable users to select predefined pump types and model numbers.

Sample enumeration set in attribute template



Sort order

Beginning with PI AF 2017 R2, wherever predefined values defined by enumeration sets are displayed, users can select **Sort By > Sort By Name** to sort those values by name, or **Sort By > Sort By Value** to sort by enumeration set value.

Video

For information on how to create enumeration sets, watch this video:

Manage enumeration sets

Beginning with PI AF 2018 SP2, you can export digital state sets from a Data Archive to create enumeration sets. For more information, see [Review digital state sets on a Data Archive](#).

You use enumeration sets in attribute templates whenever you want to be able to select from lists of predefined values when you are defining element attributes. You also use enumeration sets to create reason attribute traits for event frames and transfers.

1. In the navigator, click **Library**.
2. Choose from the following actions.

To ...	Do this ...
Create a new enumeration set	<ol style="list-style-type: none">a. Choose one of the following actions.<ol style="list-style-type: none">a. On the toolbar, click New Enumeration Set.b. In the browser, right-click the Enumeration Sets collection and click New Enumeration Set.b. In the Name field, enter a unique name for the enumeration set.c. Optional. In the Description field, enter a description for the enumeration set.d. Optional. To use hexadecimal values, select the Hexadecimal check box.e. Optional. If you want to configure access permissions for the new enumeration set that are different from those inherited from the

To ...	Do this ...
	<p>Enumeration Sets collection, click the Security link. For more information, see Configure security for objects.</p>
Create a new enumeration value	<p>a. Choose one of the following actions.</p> <ul style="list-style-type: none">a. In the browser, click an existing enumeration set. In the viewer, right-click in any Value field and click New Enumeration Value.b. In the browser, right-click an existing enumeration set and click New Enumeration Value. <p>The value is a unique numeric value associated with the enumeration and provides a quicker, less memory-intensive representation of an enumeration's value.</p> <ul style="list-style-type: none">b. In the Value field of the Enumeration Value Properties window, either enter a unique number manually, or click to increase or lower the value.c. In the Name field, enter a unique string that describes the condition or state being represented. This string is used as the displayed value when an enumeration set is selected as the value type for an attribute.d. Optional. In the Description field, enter a description for the enumeration value.
Create a new child enumeration value in Enumeration Value Properties window	<ul style="list-style-type: none">a. In the browser, click an existing enumeration set.b. In the viewer, right-click an existing value to which you want to add a child enumeration value, and click New Child Enumeration Value.c. In the Enumeration Value Properties window, verify that the value selected in the Parent field is correct. Otherwise, select a different parent from the list.d. In the Value field, either enter a unique number manually, or click to increase or lower the value.e. In the Name field, enter a unique string that describes the condition or state being represented. This string is used as the displayed value when an enumeration set is selected as

To ...	Do this ...
	<p>the value type for an attribute.</p> <p>f. Optional. In the Description field, enter a description for the enumeration value.</p>
Create a new child enumeration value manually	<p>a. In the browser, click an existing enumeration set.</p> <p>b. In the viewer, click an empty row and enter a unique number manually in the Value field.</p> <p>c. In the Name field:</p> <ul style="list-style-type: none"> i. Enter the original enumeration value for which you want to create a child value. ii. Enter a character. iii. Enter a unique string that represents the child enumeration value. <p>d. Optional. In the Description field, enter a description for the child enumeration value.</p>
Rename an enumeration value	<p>a. In the browser, click an existing enumeration set.</p> <p>b. In the viewer, right-click the existing value that you want to rename and click Properties.</p> <p>c. In the Name field of the Enumeration Value Properties window, revise the name string as needed but ensure it remains unique. If the name is being used as a parent enumeration value, note that the name change will update the parent portion of all child enumeration value strings.</p>
Renumber enumeration values	See Renumber enumeration values .
Delete an enumeration value	<p>a. In the browser, click an existing enumeration set.</p> <p>b. In the viewer, right-click the existing value that you want to delete and click Delete.</p> <p>c. Click Yes in response to the Delete warning. Note that you will invalidate objects where the value is currently being used.</p>

3. On the toolbar, click **Check In**.

Renumber enumeration values

You can renumber an enumeration set although you will invalidate objects where the value is currently being

used.

1. Right-click anywhere in a field and select **Renumber Enumeration Values**.

The Change Enumeration Value confirmation window explains that you will invalidate objects already using the existing enumeration set.

2. To continue, click **Yes**.

3. In the **Starting Values** field of the Renumber window, click to increase or lower the value.

4. In the **Increment by** field, click to select an increment value.

If you select a row before renumbering, renumbering starts at the selected row, with this row getting the starting value and each subsequent row getting the next value of increment. Only the selected row and following rows are changed during a renumber action. If renumbering does not start at the topmost row, a possibility of the generated values being identical to the values above the selected row exists. The following error message is displayed:

Attempting to change the enumeration values would overlap previous enumeration values prior to the selected row.

Configuration of data references

You can configure an attribute or attribute template to obtain a value from a specified source. This configuration is called a data reference. Attributes that include them are called data reference attributes. You create a data reference for the following sources:

- **PI point**

Produces a value from a PI point, or the summary, or other operation on the point value, depending on how you configure it.

- **PI point array**

Produces a single value from an array of PI points.

- **Formula**

Produces a value from a calculation result. The calculation itself can include attributes, as well as other data reference attributes.

- **String builder**

Produces a string value from text-manipulation functions and substitution parameters.

- **Table lookup**

Produces a value from:

- Internal table
- Imported value from an external (non-PI) table
- Linked value in an external table

- **URI builder**

Produces a dynamic link for attributes from attribute values and substitution parameters. You can use the attribute in a notification or in a client application, such as AVEVA PI Vision.

Attribute configuration strings in PI System Explorer

An attribute configuration string describes a data reference. The syntax of a configuration string depends on the type of data reference.

The configuration string for String Builder data references can contain substitution parameters. For attribute templates, any configuration string can contain substitution parameters. See [List of PI AF substitution parameters](#).

In PI System Explorer, when you select an attribute with a data reference, the configuration string appears in the text box below the **Settings** button. You edit configuration strings directly in the text box.

The following table contains examples of configuration strings for different types of data references:

Type of data reference	Sample configuration string
Formula	=Density;V=Volume;[D*V]
	A=Attribute3;[A*3];UOM=cm
PI Point	\MyP IDataArchiveServer\sinusoid
	\192.168.0.255\ChocMilkMeter;TimeMethod=TimeRange;RelativeTime=-1h;TimeRangeMethod=Total;ReadOnly=False
PI Point Array	\MyP IDataArchiveServer\Point.1 Point.2 Point.3
String Builder	"%Attribute% value is";'Attribute1';
Table Lookup	SELECT Density FROM [Material Specifications] WHERE MaterialID = @Product
URI Builder	https://MyDataServer.int:443/Vision/#Displays/215915/Mine-Truck-10-Brake-Temp?Asset=\System%\Database%\Element%&StartTime=03%2F21%2F201609:26:00&EndTime=&Mode=kiosk

Configuration strings for PI point data references

The attribute configuration string for PI point data references must contain the path to the point. The string can also contain parameters that specify the value that the data reference returns. If specified in an attribute template, the string can contain parameters that specify the point to create. In the string, you separate the parameters with semi-colons.

Examples

- Simple reference to a point on a Data Archive server called MyPIDataArchiveServer:
`\MyPIDataArchiveServer\sinusoid`
- Configuration string referencing the same point, but with a time retrieval specification and specified units of measure:
`\MyPIDataArchiveServer\sinusoid;TimeMethod=ExactTime;UOM=°C`
- Configuration string referencing the same point, but returning a total of point values over a time range:
`\MyPIDataArchiveServer\sinusoid;TimeMethod=NotSupported;
TimeRangeMethod=Total;RateConversion=day`
- Configuration string from an attribute template, using substitution parameters:
`\%Server%\%Element%.%Attribute%`
- Same configuration string, but with tag creation enabled and point configuration specified:
`\%Server%\%Element%.%Attribute%;ptclassname=classic;pointtype=Float32; engunits=m3/
s;location1=1;location2=30;location4=1;location5=1;pointsource=R`

Data reference parameters that specify values to return

Configuration strings for PI point data references can include optional parameters that specify the value that the data reference returns. The following table lists available parameters:

Parameter	Syntax	Example	Default
<i>TimeMethod</i>	<code>TimeMethod=time_method</code> where <i>time_method</i> is one of: <ul style="list-style-type: none"> After AtOrAfter Before AtOrBefore Automatic ExactTime Interpolated NotSupported TimeRange TimeRangeOverride 	<code>TimeMethod=Automatic</code>	Automatic
<i>RelativeTime</i>	<code>RelativeTime=[*] + - integer time_unit</code> where <i>time_unit</i> is one of:	<code>RelativeTime=-1h</code>	N/A

Parameter	Syntax	Example	Default
	<ul style="list-style-type: none"> • y • M • d • h • m • s 		
<i>TimeRangeMethod</i>	<p><code>TimeRangeMethod=method_name</code> where <i>method_name</i> is one of</p> <ul style="list-style-type: none"> • Average • Count • Delta • EndTime • Maximum • Minimum • PopulationStandardDeviation • Range • StandardDeviation • StartTime • Total 	<code>TimeRangeMethod=Total</code>	<code>EndTime</code>
<i>TimeRangeMinPercentGood</i> ¹	<code>TimeRangeMinPercentGood=percentage</code>		80
<i>CalculationBasis</i> ¹	<p><code>CalculationBasis=calculation_basis</code> where <i>calculation_basis</i> is one of:</p> <ul style="list-style-type: none"> • EventWeighted • EventWeightedExcludeEarliestEvent • EventWeightedExcludeMostRecentEvent • EventWeightedInclude 		TimeWeighted

Parameter	Syntax	Example	Default
	deBothEnds • TimeWeighted • TimeWeightedContinuous • TimeWeightedDiscrete		
RateConversion ²	RateConversion= <i>uom</i> where <i>uom</i> is a defined unit of measure	RateConversion=minute	day
UOM	UOM= <i>uom</i> where <i>uom</i> is a defined unit of measure	UOM=°C	Attribute's Default UOM
ReadOnly	ReadOnly= <i>boolean</i> where <i>boolean</i> is one of: • true • false	ReadOnly=false	true

¹ Used when specifying *TimeRangeMethod*.

² Used only when *TimeRangeMethod=Total*.

Data reference parameters that specify PI point to create

In attribute templates that specify new PI points, configuration strings for PI point data references include parameters that specify the type of point to create. Point creation parameters consist of a point attribute and value. To specify a new PI point, attribute templates must include the *pointtype* attribute as a parameter; other attributes are optional.

- Create a PI point of type Float64 and use default settings for the rest of the point configuration:
`\%Server%\%Element%.%Attribute%;pointtype=Float64`
- Create a PI point that sets the point attributes shown in the following table:

Point attribute	Setting
<i>ptclassname</i>	classic
<i>pointtype</i>	Float32
<i>pointsource</i>	R

Point attribute	Setting
<i>location4</i>	1
<i>location5</i>	2
<i>span</i>	200
<i>zero</i>	1100

```
\%Server%\Element%.Attribute%;ptclassname=classic;pointtype=Float32;
location4=1;location5=2;pointsource=R;span=200;zero=1100
```

Path syntax for references to other attributes

To reference other attributes, you use paths that locate attributes on the server, database, and elements in which they reside.

- Use an absolute path to specify the actual server, database, and element where an attribute is located. For example:

```
\MyP IDataArchive\MyAFDatabase\MyElement|Attribute1
```

- Use a relative path to identify an attribute based on its name and its place in the hierarchy of elements and attributes. For example:

```
..\Element2|Attribute1
```

Components of a path

A path is comprised of parts, with each part representing an object or list of objects. Each part of the path is typically separated as follows: by a single backslash (\), with the following exceptions:

- PI AF attributes and PI AF attribute templates are preceded by the pipe character (|).
- The Data Archive is preceded by two backslashes (\ \).

You can specify a Data Archive and a database by name or by globally unique identifier (GUID). A GUID is a unique 128-bit number produced by Windows to identify a particular component, application, file, or database entry. GUIDs must be specified within curly brackets ({ and }). For example:

```
\{5c64c379-c182-4f35-8d30-78d8c2f84502}\{5c64c379-c182-4f35-8d30-78d8c2f84503}
```

If you specify both the name and GUID, separate them with a semicolon (;). The first one specified takes precedence in the search, so in the following example, the GUID takes precedence:

```
\{5c64c379-c182-4f35-8d30-78d8c2f84502};MySystem\{5c64c379-c182-4f35-8d30-78d8c2f84503};My Database
```

Path syntax for Data Archive computers

To indicate a fully qualified path from the Data Archive, start the path with two backslashes (\ \) followed by the Data Archive.

To indicate the current system, start a relative path with two backslashes followed by a period (\ \.). For example,

to reference a database called Database2 in the current system, type:

```
\.\Database2
```

To specify a collection of PI Data Archives, use the following format:

```
\\\PIDataArchives[MyPIDataArchiveName]
```

Path syntax for PI AF databases

The PI AF database follows the Data Archive specification.

You can start a relative path with a single backslash (\) to indicate the current database. For example, the following paths reference objects in the current database:

```
\Element2
```

```
\Tables[MyTable]
```

Note: You can access non-database objects external to the PI System. You must identify the collection, as demonstrated by the following example:

```
\\\MySystem\Contacts[JSmith]
```

Syntax for relative paths

Use a double period (..) to indicate the parent object. The following example references Attribute1 of Element2 that is in the current database:

```
..\Element2|Attribute1
```

The single period (.) represents the current object. You can use it to create a relative path from the current object.

- When the current object is a PI AF attribute, a single period followed by a backslash (\) represents the owning PI AF element. For example:

```
.\|Attribute1
```

- A single period followed by a vertical bar (.|) references a child PI AF attribute, for example:

```
.|Attribute1|Attribute2
```

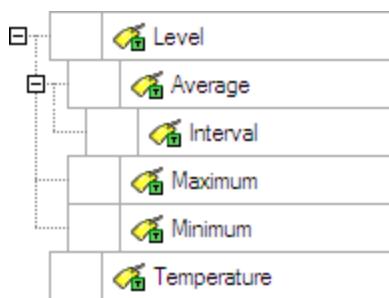
- When the current object is a PI AF element, a relative path is created from the database, for example:

```
\Element1\Element2|Attribute1
```

Examples of references to attributes of the same element

To reference an attribute that belongs to the same element, you can:

- Identify the attribute relative to its top-level ancestor attribute.
- Identify the attribute relative to the current attribute (the attribute for which you are configuring the data reference).



The following examples refer to the above illustration.

Type of reference	To reference this attribute	From this attribute	Type
Parent attribute	Level	Average	Level or ..
Grandparent attribute	Level	Interval	Level or
Parent attribute	Average	Interval	Level Average or ..
Sibling attribute	Average	Minimum	Level Average or Average
Child attribute	Average	Level	Level Average or . Average
Grandchild attribute	Interval	Level	Level Average Inter- val or . Average Interval
Top level attribute	Temperature	Any attribute	Temperature

Full path from top-level ancestor

To reference any attribute from another attribute belonging to the same element, you can specify that attribute's entire path from the element. Start the path with the pipe symbol (|) and use the pipe symbol to separate attribute levels.

In the above illustration, the top-level ancestor of the Interval attribute is Level. To reference the Interval attribute from any other attribute of the same element, type:

```
|Level|Average|Interval
```

To reference any top-level attribute from any other attribute of the same element, type the pipe symbol followed by the attribute name. For example, to reference the Level attribute from anywhere, type:

```
|Level
```

To reference the Temperature attribute from anywhere, type:

```
|Temperature
```

Sibling attributes

To specify a sibling, simply use the name of the sibling attribute. No other notation is usually required, but because the PI Point data reference requires some attribute path characters to differentiate this reference from a PI Point reference, use the full attribute path from the element.

In the illustration shown above, the Maximum and Minimum attributes are siblings. To reference the Maximum attribute when configuring the Minimum attribute, you would type:

```
Maximum
```

Parent and grandparent attributes

You use two periods (..) to move up the attribute hierarchy. For example, to specify the parent attribute, you would use:

```
..
```

You can use this notation to move up the attribute's ancestor elements. For example, to reference the grandparent attribute, you would use:

```
...|..
```

In the illustration shown above, to reference the Level attribute from the Average attribute, type:

```
..
```

Because Level is the top-level parent attribute, you could type instead:

```
|Level
```

You cannot use this notation to reference the Temperature attribute from the Average attribute, because Average is not a descendent of Temperature. Furthermore, you cannot use this notation to reference the Average attribute from the Interval attribute, because Average is not at the top level of the attribute hierarchy.

To reference the Level attribute from the Interval attribute, type:

```
...|..
```

You cannot use this notation to reference the Maximum attribute from the Interval attribute, because the Interval attribute is not a descendant of the Maximum attribute. In this case, you need to use a complete path:

```
|Level|Maximum
```

Similarly, to reference the Temperature attribute from the Interval attribute, use

```
|Temperature
```

Descendant attributes

To reference a child attribute, you use a period (.), which indicates "this attribute", followed by a path.

In the illustration shown above, to reference the Average attribute from the Level attribute, type:

```
. | Average
```

To reference the Interval attribute from the Level attribute, type:

```
. | Average | Interval
```

You cannot use this notation to reference the Interval attribute from the Temperature attribute, because the Interval attribute is not a descendant of the Temperature attribute. In this case, you need to use a full path:

```
| Level | Average | Interval
```

Examples of references to attributes of different elements

You can reference attributes that belong to different elements in the following ways:

- Directly from the top of the element hierarchy in the database.
- Specify the parent element of the target attribute using a relative path.

Attributes relative to database

To reference an attribute based on a path relative to the root of the PI AF database, specify the entire element and attributes path from the database. Start the path with a backslash (\), and use the backslash to separate element levels. Precede the attribute with the pipe symbol (|). For example:

```
\Reactors\React1|pressure
```

This example assumes that the Reactors element is at the top level of the element hierarchy. You can always use this notation to reference an attribute relative to the top level of elements in the database.

For example, suppose you have the element hierarchy shown in the following illustration:



Assume you want to reference an attribute called pressure, belonging to the NewTank element. You can type:

```
\Tanks\Tank1\NewTank|pressure
```

If you want to represent a child attribute of pressure called temp, the reference is:

```
\Tanks\Tank1\NewTank|pressure|temp
```

Attributes relative to containing element

You can reference attributes relative to the containing element of the attribute that you are configuring. Use backslashes (\) to move down the element hierarchy and .. to move up the element hierarchy.

In the above illustration, each element (Tank1, Tank2, Tank3, and NewTank) has a pressure attribute:

These examples demonstrate the syntax to:

- Reference a sibling element:

To refer to the Tank2 attribute pressure from Tank1, type:

```
..\Tank2|pressure
```

- Reference a parent element:

To refer to the Tank1 attribute pressure from NewTank, type:

```
..\|pressure
```

- Reference a child element:

To refer to the NewTank attribute pressure from Tank1, type:

```
.\NewTank|pressure
```

Path syntax for dynamic objects

Paths to dynamic objects are also supported. To create a PI point array attribute with Sinusoid and Sinusoidu values, for example:

```
PI Point Array.\piserver2\sinusoid|sinusoidu
```

If a path is to a PI point, a dynamic attribute is created. To create an attribute with the data reference configured to read values from the PI point Sinusoid, for example:

```
\piserver2\sinusoid
```

Path syntax for collection types

Each parent object has a default collection type. For example, a Data Archive has a default collection of databases, and a PI AF database has a default collection of elements.

Use a single period enclosed in square brackets ([.]) to represent the default object of the parent object. The following example refers to Element1 of the default database in the current system:

```
\\.\\Databases[.]\\Element1
```

Path syntax for filters

A collection filter starts with the at sign (@) followed by the filter name. Supported filters are: @Category, @Description, @Index, @Name, @ReferenceType, @Template, @Trait, @Type, and @UOM.

You must enclose the filter specification in square brackets ([and]).

You can also specify multiple filters; they are evaluated in the order specified. For example:

```
\MySystem\MyDatabase\\Elements[@Template=Tank][@Category=Tutorial]|Attributes[@Category=Tutorial]
```

Category filter example

The following example returns the Volume attribute from all elements in the category, Tutorial, that belong to the database called MyDatabase:

```
\MySystem\\Databases[MyDatabase]\\Elements[@Category=Tutorial]|Volume
```

Type filter example

The following example returns the attributes of Element1 that are of Int32 type:

```
\Element1|Attributes[@Type=System.Int32]
```

Unit of measure filter example

The following example returns the attributes of Element1 that have meters as their unit of measure:

```
\Element1|Attributes[@UOM=meter]
```

Index filter example

Use the index filter `[@Index=int]` or `[int]` to specify the position of the matched object to return (the first item is at index position 1). The index filter must be the last filter specified. The following example returns the third database in the collection of PI AF databases in the current system:

```
\\Systems[MySystem]\Databases[@Index=3]
```

Beginning with PI AF 2017, you can use a negative number for an index from the end of the collection (for example -1 indicates the last item, -2 indicates the penultimate item).

```
\Element#1\Elements[@Name=Tank*][@Index=-3]
```

The index filter name is optional if another filter is specified before the index filter. For example:

```
\Element#1\Elements[@Name=Tank*][3]
```

Wildcard characters in Name filters

You can place a wildcard asterisk (*) character in the name of any object to match zero or more characters.

Note: To match a literal asterisk, use a preceding backslash (*).

Examples

```
\\MySystem\MyDatabase\[@Name=E*]  
\MySystem\MyDatabase\Elements[@Name=E*][@Index=3]
```

Substitution parameters in data references

Substitution parameters are variables that you place in attribute templates for data references such as PI point, String Builder, and URI Builder. PI AF resolves the substitution parameters when it creates the data reference for an attribute based on that template. For example, you can use substitution parameters:

- To configure a PI point data reference template to use names for tags based on element names built from that template.
- To use the value of a different attribute in the configuration of a PI point property value.

Videos

For information on how to use substitution parameters in templates, watch this video:

For information on how to use substitution parameters as you create PI points, watch this video:

Symbols used in substitution parameters

Use the symbols in the following table to build a substitution parameter.

Symbol	Description	Examples
%...%	Considers the expression as a substitution parameter.	%Element% %Attribute%
.	Current element or attribute. Use .\ to navigate down from current element. Use ./ to navigate to child attributes of the current attribute.	%. ChildElement/Attribute%
..	Navigates a level up.	%. .. Element% %. Attribute%
\	Separates components of a path, except attributes.	%. Element%
/	Separates attributes in a path.	%. Attribute%
@	<p>References the value of the object instead of its name.</p> <p>Note: Only PI point data references use attribute value substitution syntax. Other data references, such as formula, table lookup, and String Builder have a simpler syntax for referencing attribute values.</p>	<ul style="list-style-type: none"> Attribute value at same level as attribute: %@Attribute% Attribute value at root level of same element: %@/Attribute% Attribute value at parent attribute level: %@.. Attribute% Attribute value at parent element level: %@.. /Attribute% Attribute value of child attribute of same element: %@. Attribute% Attribute value of child element attribute: %@. ChildElement ChildOfChild Attribute% Attribute value of primary element of event frame: %@. Elements[.] Attribute%

Name substitutions

When you use a name substitution, PI AF performs a direct substitution of the substitution parameter for whatever that particular parameter represents.

The table in [List of PI AF substitution parameters](#) lists the available substitution parameters and what they represent. For example, `%Element%` is a substitution parameter that represents the element name. After you create an element based on that template, you tell PI AF to create the data reference ([Attribute-value updates from PI point data references](#)). When PI AF creates the reference, it substitutes the current element name wherever the configuration says `%Element%`.

Suppose you have a data reference template that references the PI point name:

`%Element%_TT`

You create an element named Tank1 that is based on that template. The attribute data reference points to a PI point named:

`Tank1_TT`

References to attribute values

When configuring a PI point data reference attribute, you can use substitution parameters to reference the value of another attribute. You can use attribute value references to specify a value in the **Relative Time** field or in the point attribute configuration for automatically-generated PI points. The syntax is:

`%@AttributeName%`

where *AttributeName* is the name of the attribute. The @ indicates to substitute the value of the indicated attribute, rather than its name. To reference an attribute that is not a sibling of the current attribute, use the syntax described in [Indirect PI point references](#) to define the path to the desired attribute.

PI AF does not update the attribute value over time. When a substitution is used in the tag name, the value is resolved only at the time the data reference is loaded. If a substitution parameter is used to define point attributes, PI AF uses the value of the attribute at the exact time that you created or updated the data reference (see [Attribute-value updates from PI point data references](#) for more information). This value is a constant. PI AF does not evaluate that attribute value again, unless you update the data reference.

Note: The exception to this rule is a value substitution for the **Relative Time**, which is evaluated on every value call to the PI point data reference (see [Create ranges of configurable durations](#)).

List of PI AF substitution parameters

PI AF interprets numerous types of substitution parameters. The following tables are grouped by type:

- Name
- Time
- ID
- Description
- Path
- Environment variable

Name substitution parameters

The following table lists the name substitution parameters that supports.

Parameter name	Substitution
%@path%	The value of the object's attribute or attribute template, represented by the path.
%Analysis%	Name of analysis, if obtainable from the context.
%Attribute%	Name of the object's attribute or attribute template.
%/Attribute%	Name of the root attribute or attribute template that holds this data reference.
%.. /Attribute%	Name of the parent attribute or attribute template that holds this data reference.
%Database%	Name of the PI AF database in which the attribute resides.
%Destination%	Name of the destination element for the transfer in which the attribute resides.
%Element%	Name of the element in which the attribute resides. For event frames, this refers to the name of the primary-referenced element.
%\Element%	Name of the root element in which the attribute resides.
%.. \Element%	Name of the parent element of the element in which the attribute resides. To retrieve further ancestors, use the .. \ notation, such as %.. \.. \Element%.
%EventFrame%	Name of the event frame in which the attribute resides.
%\EventFrame%	Name of the root event frame in which the attribute resides.
%.. \EventFrame%	Name of the parent event frame of the event frame in which the attribute resides. To retrieve further ancestors, use the .. \ notation, such as %.. \.. \EventFrame%.
%Model%	Name of the model, if obtainable from the context.
%Name:path%	Name of the object represented by the path to the object. If the path is not specified, null is returned

Parameter name	Substitution
	since the name of the current object is being referenced.
%Server%	<p>Name of the default Data Archive. It first resolves to the current PI AF database's default Data Archive if one is specified; otherwise, it resolves to the PI AF server's default Data Archive if one is specified. If one is not specified there, it resolves to the local default Data Archive.</p> <p>Note: If the default Data Archive is not specified on the PI AF server or PI AF database, it can resolve to a different Data Archive for different client machines depending on their configuration.</p>
%Source%	Name of the source element for the transfer in which the attribute resides.
%System%	Name of the PI AF server or collective where the attribute resides.
%Template%	Name of the template on which the element or event frame is based. For example, if you created element Valve101 from a template called Valve, then the substitute text would be Valve.
%\Template%	Name of the root template on which the element or event frame is based.
%..\Template%	Name of the parent template on which the element or event frame is based. To retrieve further ancestors, use the ..\ notation, such as %.\\.\\Template%.
%Transfer%	Name of the transfer in which the attribute resides.

Time substitution parameters

PI AF supports substitution parameters that specify a particular time and time zone, depending on the context. Optionally, you can augment these supported parameters by including a format string that specifies the format of the time string. See [Format strings for time substitution parameters](#).

The following table lists the time substitution parameters that supports.

Parameter name	Substitution
%Duration%	Time span between the start time and end time, if it can be obtained from the time context. In open event frames, obtains the time span from start time to the current time. The time span uses a different format

Parameter name	Substitution
	<p>from other time substitution parameters.</p> <ul style="list-style-type: none"> You can use standard formats such as "c" (constant), "g" (general, short), or "G" (general, long), for example: <code>%Duration:c%</code>. For more information, see the MSDN article Standard TimeSpan Format Strings. You can also use a custom time span format, as described in the MSDN article Custom TimeSpan Format Strings. <p>Note that you need to define the symbols that separate days from hours, and so on with a string literal. For example, <code>%Duration:d\.\hh\:\mm\:\ss%</code> defines a period (.) as the separator between days and hours, and a colon (:) as the separator between hours, minutes, and seconds.</p>
%EndTime%	Local end time, if obtainable from the time context. For event frame-based objects that do not have an end time yet specified, the result is an empty string.
%StartTime%	Local start time, if obtainable from the time context.
%Time%	Local time, if obtainable from the time context.
%UtcEndTime%	Coordinated universal (UTC) end time, if it can be obtained from the time context. For event frame-based objects that do not have an end time yet specified, the result is an empty string.
%UtcStartTime%	Coordinated universal (UTC) start time, if it can be obtained from the time context.
%UtcTime%	Coordinated universal (UTC) time, if it can be obtained from the time context.

ID substitution parameters

The following table lists the ID substitution parameters that supports.

Parameter name	Substitution
%AnalysisId%	ID of the analysis with which the attribute is associated.
%AttributelId%	ID of the attribute that holds this data reference.

Parameter name	Substitution
%/ <i>AttributelId</i> %	ID of the root attribute or root attribute template in which the attribute resides.
%../ <i>AttributelId</i> %	ID of the parent attribute or parent attribute template in which the attribute resides. Further ancestors can be retrieved by using the .. / notation, such as %..../ <i>AttributelId</i> %.
% <i>DatabaselId</i> %	ID of the database in which the attribute resides.
% <i>ElementlId</i> %	ID of the element in which the attribute resides. For event frames, this refers to the ID of the primary referenced element.
%\ <i>ElementlId</i> %	ID of the root element in which the attribute resides. For event frames, this refers to the ID of the primary referenced element of the root event frame in which the attribute resides.
%..\ <i>ElementlId</i> %	ID of the parent element in which the attribute resides. For event frames, this refers to the ID of the primary referenced element of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the .. \ notation, such as %..\\..\ <i>ElementlId</i> %.
% <i>EventFrameId</i> %	ID of the event frame in which the attribute resides.
%\ <i>EventFrameId</i> %	ID of the root event frame in which the attribute resides.
%..\ <i>EventFrameId</i> %	ID of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the .. \ notation, such as %..\\..\ <i>EventFrameId</i> %.
% <i>Id:path</i> %	ID of the object represented by the path to the object. If the path is not specified, the ID of the current object is used. .
% <i>ModelId</i> %	ID of the model in which the attribute resides.
% <i>SystemId</i> %	ID of the PI AF server in which the attribute resides.
% <i>TransferId</i> %	ID of the transfer in which the attribute resides.

Description substitution parameters

The following table lists the description substitution parameters that supports.

Parameter name	Substitution
<code>%Description:path%</code>	Description of the attribute represented by the path to the attribute. If the path is not specified, the description of the current attribute is used.
<code>%/Description%</code>	Description of the root attribute or root attribute template in which the attribute resides.
<code>%../Description%</code>	Description of the parent attribute or parent attribute template in which the attribute resides. Further ancestors can be retrieved by using the .. / notation, such as <code>%../../Description%</code> .
<code>%ElementDescription%</code>	Description of the element in which the attribute resides. For event frames, this refers to the description of the primary referenced element of the event frame in which the attribute resides.
<code>%\ElementDescription%</code>	Description of the root element where the attribute resides. For event frames, this refers to the description of the primary referenced element of the root event frame in which the attribute resides.
<code>%..\'ElementDescription%</code>	Description of the parent element in which the attribute resides. For event frames, this refers to the description of the primary referenced element of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the .. \' notation, such as <code>%..\'..\'ElementDescription%</code> .
<code>%EventFrameDescription%</code>	Description of the event frame in which the attribute resides.
<code>%\EventFrameDescription%</code>	Description of the root event frame in which the attribute resides.
<code>%..\'EventFrameDescription%</code>	Description of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the .. \' notation, such as <code>%..\'..\'EventFrameDescription%</code> .

Path substitution parameters

Path substitutions cannot generally be used to create references to other attributes, because they contain

backslash characters. The Path substitution parameters are most useful with String Builder data references when you construct paths for output into strings. The path that is produced does not include the PI AF server or database.

The following table lists the path substitution parameters that supports.

Parameter name	Substitution
<code>%ElementPath%</code>	Path of the base element, the element of an attribute, or the primary referenced element of an event frame.
<code>%..\\ElementPath%</code>	Path of the parent element in which the attribute resides. For event frames, this refers to the path of the primary referenced element of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the ..\ notation, such as <code>%..\\..\\ElementPath%</code> .
<code>%EventFramePath%</code>	Path of the event frame, or the element of an attribute of an event frame.
<code>%..\\EventFramePath%</code>	Path of the parent event frame in which the attribute resides. Further ancestors can be retrieved by using the ..\ notation, such as <code>%..\\..\\EventFramePath%</code> .

Environment variable parameter

The following table lists the environment variable parameter that supports.

Parameter name	Substitution
<code>%Environment Variable%</code>	Value of the matching system-environment variable. For example, <code>%COMPUTERNAME%</code> is replaced with the name of the computer on which the data reference is executing.

Format strings for time substitution parameters

In time substitution parameters, you can include a format string that specifies the format of the time string.

Standard date and time format

Use any standard format string supported by the `DateTime.ToString` method, described in the MSDN article [Standard Date and Time Format Strings](#). In the specification of the time substitution parameter, separate the substitution and the format string with a colon. For example, `%TIME:d%` specifies the local time in a short-date pattern.

The following table provides an abbreviated description of `DateTime` format strings:

Format specifier	Description	Example
d	Short date pattern	6/15/2009 (en-US) 15/06/2009 (fr-FR) 2009/06/15 (ja-JP)
D	Long date pattern	Monday, June 15, 2009 (en-US) Montag, 15. Juni 2009 (de-DE)
f	Full date/time pattern (short time)	Monday, June 15, 2009 1:45 PM (en-US)
F	Full date/time pattern (long time)	Monday, June 15, 2009 1:45:30 PM (en-US)
g	General date/time pattern (short time)	6/15/2009 1:45 PM (en-US) 15/06/2009 13:45 (es-ES) 2009/6/15 13:45 (zh-CN)
G	General date/time pattern (long time)	6/15/2009 1:45:30 PM (en-US) 15/06/2009 13:45:30 (es-ES) 2009/6/15 13:45:30 (zh-CN)
M, m	Month/day pattern	June 15 (en-US)
O, o	Round-trip date/time pattern	2009-06-15T13:45:30.0000000-07:00
R, r	RFC1123 pattern	Mon, 15 Jun 2009 20:45:30 GMT
s	Sortable date/time pattern	2009-06-15T13:45:30
t	Short time pattern	1:45 PM (en-US)
T	Long time pattern	1:45:30 PM (en-US)
u	Universal sortable date/time pattern	2009-06-15 20:45:30Z
U	Universal full date/time pattern	Monday, June 15, 2009 8:45:30 PM (en-US)
Y, y	Year month pattern	June, 2009 (en-US)
Any other single character	Unknown specifier	

Custom date and time format

You can also construct custom patterns in the date and time format string, using time specifiers described in the

MSDN article [Custom Date and Time Format Strings](#). For example, `%TIME:yyyy/MM/dd HH:mm:ss.fffffff%` produces output similar to 2015/03/31 09:28:03.843512.

Find the default Data Archive server

You can now specify the Data Archive, also referred to as the default data server, for the PI system and PI AF database. By default, PI AF databases inherit the PI AF server's local default data server.

Note: The `%Server%` parameter defines the default Data Archive. It first resolves to the current PI AF database's default Data Archive if one is specified; otherwise, it resolves to the PI AF server's default Data Archive. If one is not specified there, it resolves to the local default Data Archive. If the default Data Archive is not specified on the PI AF server or PI AF database, it can resolve to a different Data Archive configured for each one depending on the different client machines' settings.

Choose from the following actions:

To ...	Do this ...
View the default data server for the current database	<ol style="list-style-type: none">1. On the PI System Explorer toolbar, click  Database.2. In the Select Database window, click Database Properties.3. Locate the Default Data Server field on the General page to view the default data server.4. Click OK twice.
View the default data server settings for the system	<ol style="list-style-type: none">1. Click  on the PI System Explorer toolbar, or click File > Server Properties.2. Locate the Default Data Server field on the General page to see the default data server for the PI system.3. Click OK.
View the name of the default data server	<ol style="list-style-type: none">1. From the PI System Explorer menu bar, choose File > Connections.2. Locate the  icon to identify the default Data Archive data server.3. Click Close.

PI point data references

A PI point data reference is a reference from a PI AF attribute to a PI point. The value of the data reference attribute can be the same as the point value, or it can be the result of a calculation based on point values. You can create a PI point data reference for:

- An element attribute or an element attribute template
- A transfer attribute or a transfer attribute template
- An event frame attribute or an event frame attribute template

A PI point data reference for an attribute template has additional features. When you create a PI point data reference in an attribute template, you can:

- Automatically create tags referenced by attributes based on the template.
- Create a naming scheme for attributes based on the template so that attributes built from it have unique names that conform to a consistent structure.

To reference the PI point, you use a direct or an indirect reference. There are two quick methods to create a direct reference, whereas you need to use the PI Point Data Reference window to create a more complex direct reference or an indirect reference.

Videos

For information on how to set up PI point data references, watch this video:

For information on UOMs in PI point data references, watch this video:

Direct PI point references

In the configuration string, a direct point reference uses two backslashes (\\) to reference a PI point on a Data Archive. For example, the following configuration string references the *sinusoid* point on a Data Archive called MyPIServer:

```
\MyPIServer\sinusoid
```

For attribute templates, you can also use substitution parameters in the reference. For example, the following configuration string references the *sinusoid* point on the default Data Archive of the PI AF database for the attribute:

```
\%Server%\sinusoid
```

For more information on substitution parameters, see [Substitution parameters in data references](#).

Indirect PI point references

You can configure a PI point data reference to point at another attribute. The referenced attribute must itself be a PI point data reference. This is called an *indirect reference* to whatever PI point the target attribute references. It makes sense to reference by attribute when you need multiple attributes that each use data from the same PI point.

For example, suppose you have an attribute called Level that references a PI point registering a tank level. You want three child attributes to hold the daily average, minimum, and maximum tank levels. If you configure the three child attributes to reference the Level attribute, you can later change the Level attribute to reference a different point and you do not have to reconfigure child attributes. Used in combination with templates, this significantly reduces the amount of configuration required per element instance.



Relative paths

To reference another attribute, the configuration string uses a *relative path*. The relative path identifies a data reference attribute based on its name and its place in the hierarchy of elements and attributes. For the PI point data reference, the path must include an attribute path designation (| or ..) in the configuration string so that it is distinguished from a PI point reference.

The following table shows typical configurations for indirect references:

Object	Syntax	Example
Top level attribute of same element	topLevelAttribute	See "Full path from top-level ancestor" in Examples of references to attributes of the same element .
Parent attribute	..	See "Parents and grandparent attributes" in Examples of references to attributes of the same element .
Child attribute	. childAttribute	See "Descendant attributes" in Examples of references to attributes of the same element .
Sibling attribute (when not a top level attribute)	.. siblingAttribute	See "Sibling attributes" in Examples of references to attributes of the same element .
From event frame to primary element	. \Elements[.] Attribute	See Data references to attributes in the primary referenced element .
From event frame to attribute of parent element	. \Elements[.] \.. \ Attribute	See "Examples that use relative paths" in Data references to attributes in other elements .
From event frame to attribute of child element	. \Elements[.] \ChildElementName Attribute	See "Examples that use relative paths" in Data references to attributes in other elements .
Database path	\TopLevelElement myAttribute	See "Attributes relative to database" in Examples of references to attributes of different

Object	Syntax	Example
		elements.
Full path	\myServer\myDatabase\myElement myAttribute	See Path syntax for references to other attributes .

Create direct PI point data references from Tag Search results

You can drag a PI point from Tag Search results in the palette to set the name, description (if the PI point has a descriptor), and type of a PI point data reference. If the engineering units property of the PI point matches an existing unit of measure, including case, the **Default UOM** field is also set.

1. To configure a PI point data reference:
 - In the Elements browser, select the desired element.
 - In an element template, select the desired element template in the Library browser.
2. In the **Attribute or Attribute Templates** tab, select the attribute.
3. Select **View > Palette > Tag Search**, or press CTRL+SHIFT+8.
4. In the Tag Search window, create a search query to retrieve the PI points you want to use as data references. For more information on searching for PI points, see [Search for PI points](#) and [Syntax for PI point searches](#).
5. Do one of the following:
 - To create a new attribute, drag a PI point from search results onto the **Attributes** grid. A new attribute configured as a data reference based on the PI point is added to the grid.
 - To configure an existing attribute, select the attribute in the viewer and drag a PI point from search results to the attribute **Settings** field to configure the attribute as a data reference based on the PI point.
6. Click **Check In** to save the data reference.

Configure direct or indirect PI point data references

Use the PI Point Data Reference window to configure PI point data references on element attributes.

1. From the **Attributes** tab in the viewer, select an attribute.
2. In the attribute configuration section, select **PI Point** from the **Data Reference** list.
3. Click **Settings**.

Note: You can click in the **Settings** field and enter a tag name to create a direct PI point data reference in `\serverName\tagname` format. PI System Explorer retrieves the tag name from the default Data Archive. For example, if you enter `sinusoid`, the PI point data reference displays `\yourDefaultDataArchive\sinusoid`.

4. In the PI Point Data Reference window, choose from the following actions to create the data reference.

To ...	Do this ...
Create a direct PI point data reference	a. Leave the default server, or choose a different Data Archive from the Data server list.

To ...	Do this ...
	<p>Note: If the desired Data Archive does not appear in the list, click  and select a Data Archive from the PI Data Archives window.</p> <p>b. In the Tag name field, type the point name, or click  to search for a point on the selected Data Archive.</p> <p>Tip: You can enter a substitution parameter instead of the tag name. If you are creating a reference in an attribute template, you can use substitution parameters in both the Data server and Tag name fields. See List of PI AF substitution parameters.</p>
Create an indirect PI point data reference	<p>a. Choose the Attribute option.</p> <p>b. Type a relative path to the attribute, or choose one from the drop-down list of attributes that have PI Point data references.</p> <p>To type in a path, use the syntax described in Indirect PI point references. The attribute that is referenced must also have a PI point data reference.</p>

5. Optional. Specify the units that the referenced PI point uses. See [Unit of measure considerations](#).

Note: For time weighted totals on referenced PI Point data reference attributes, ensure that you select a UOM from the **Source Units** list that matches the UOM of the source attribute. Even if the default source units appear to match the UOM of the source attribute, do not select <Default> but instead select the appropriate hardcoded UOM from the list.

6. In the **Value retrieval methods** section, specify how the attribute gets its value. For example, the attribute value could be the same as the point value, or it could be a result of a calculation on the point value. See [Configuration of retrieval methods for attribute values](#).
7. Use the **Read Only** check box to specify whether you want PI AF to write the attribute value back to the source point. By default, PI AF does not write data to the referenced PI point (the **Read Only** check box is checked). See [PI point value updates from a data reference](#).

References to attribute values

When configuring a PI point data reference attribute, you can use substitution parameters to reference the value of another attribute. You can use attribute value references to specify a value in the **Relative Time** field or in the point attribute configuration for automatically-generated PI points. The syntax is:

`%@AttributeName%`

where *AttributeName* is the name of the attribute. The @ indicates to substitute the value of the indicated attribute, rather than its name. To reference an attribute that is not a sibling of the current attribute, use the syntax described in [Indirect PI point references](#) to define the path to the desired attribute.

PI AF does not update the attribute value over time. When a substitution is used in the tag name, the value is resolved only at the time the data reference is loaded. If a substitution parameter is used to define point attributes, PI AF uses the value of the attribute at the exact time that you created or updated the data reference (see [Attribute-value updates from PI point data references](#) for more information). This value is a constant. PI AF does not evaluate that attribute value again, unless you update the data reference.

Note: The exception to this rule is a value substitution for the **Relative Time**, which is evaluated on every value call to the PI point data reference (see [Create ranges of configurable durations](#)).

Unit of measure considerations

When you define a PI point data reference you can optionally specify the units that the referenced PI point uses. If possible, PI AF automatically changes the attribute type to a value type that is compatible with the specified units.

However, if the attribute is defined by an attribute template, PI AF cannot change the type. Instead, PI AF attempts to convert the value to the template's value type. If PI AF cannot convert the value, it generates an error.

Configuration of retrieval methods for attribute values

Client applications request attribute values for a specific time or for a time range. For example, in PI ProcessBook, the display can optionally provide a time range context (a time range symbol, such as a trend, must be present on the display to enable reception of a time range). You typically configure the data reference to expect either a time or a time range. The attribute value will then be either:

- The value of the point at a specific time. See [Configure value retrieval by time](#).
- The result of a calculation on the point's values over a time range. See [Configure value retrieval by time range](#). For example, the attribute value could be the average of the point values over an hour.

Videos

For information on how to retrieve aggregate values in PI point data references, watch this video:

For information on how to retrieve a single value in a PI point data reference, offset by a time period, watch this video:

Relative time

Relative time expressions are some number of a number of days (*d*), hours (*h*), minutes (*m*), or seconds (*s*), specified with either a leading plus sign (+) or a leading minus sign (-). The **Relative time** field in the PI Point Data Reference window shifts the time context by the specified offset. For example, if a client requests an attribute value at the current time where the relative time expression is -8*h*, PI AF returns data from eight hours before the current time.

Fractional times are supported. For example, use -1.5*d* to indicate one and one-half days.

Relative time expressions can contain only one operator, either + or -. For example, the following is *not*

supported:

-1d+1h

The following are all valid relative times:

+1d
-24h
-3.25m
+24s

Time retrieval options

The following table describes the available options for the By Time value-retrieval method in the PI Point Data Reference window.

Option	Description
After	Returns the first recorded value after the time requested by the client application.
At or After	Returns a recorded value at the time requested by the client application. If no value exists at the specified time, returns the next recorded value.
At or Before	Returns a recorded value at the time requested by the client application. If no value exists at the specified time, returns the previous recorded value.
Automatic	A continuous point (step attribute = 0) is treated as Interpolated, whereas a discrete point (step attribute = 1) is treated as At or Before.
Before	Returns the first recorded value before the time requested by the client application.
Exact Time	Returns a recorded value at the time requested by the client application. If no recorded value exists at that time, an error is returned.
Interpolated	Returns an interpolated value for the time requested by the client application. Discrete points (step attribute = 1) carry the previous value forward.
Not Supported	Used in time range calculations only. If the client application sends a time instead of a time range, PI AF returns an error message as the attribute value.
Time Range	Used in time range calculations only. Creates a default time range to use if the client application sends a time instead of a time range. If you choose this option, you must type a PI relative time expression in the Relative Time field. See Create default time ranges for element

Option	Description
	attributes for details.
Time Range Override	Used in time range calculations only. Specifies a time range that always overrides the time range supplied by the client application. You can specify: <ul style="list-style-type: none"> A fixed duration, as described in Create ranges of configurable durations. A dynamically calculated duration, as described in Configure dynamic time range calculations.

Range retrieval options

The following table describes the available options for the By Time Range value-retrieval method in the PI Point Data Reference window.

Option	Description
Average	Returns the average value over the time range.
Count	Returns the event count over the time range, when Calculation Basis is set to Event Weighted . Returns the sum of event time duration over the time range, when Calculation Basis is set to any of the time weighted options.
Delta	Returns the difference in value from the end of the time range to the start of the time range.
End Time	Returns the value at the end of the time range.
Maximum	Returns the maximum value over the time range. Note: The timestamp value displays the time that the maximum value occurred.
Minimum	Returns the minimum value over the time range. Note: The timestamp value displays the time that the minimum value occurred.
Population Standard Deviation	Returns the population standard deviation over the time range.
Range	Returns the range of values over the time range (Maximum-Minimum)
Standard Deviation	Returns the standard deviation over the time range.

Option	Description
Start Time	Returns the value at the start time of the time range.
Total	Returns a totalization over the time range.

Configure value retrieval by time

A client application request for an attribute value includes a time. Specify how to interpret that time to retrieve values for the attribute.

1. Select an option from the **By Time** list. The default option is **Automatic**. For more information, see [Time retrieval options](#).
 2. Optional. If an attribute is configured to return the value at a specific time, you can configure a time delay from the time requested. This can be useful when you are creating dead-time delayed attributes.
In the **Relative Time** field, type the relative time of the delay. Use a PI relative time expression, as described in [Relative time](#).
-
- Note:** You can also use substitution parameters to read the relative time from the value of another attribute, as described in [References to attribute values](#).
3. Select an option from the **By Time Range** list. The default option is **End Time**. For more information, see [Range retrieval options](#).
 4. Click **OK**.

Configure value retrieval by time range

If you want the attribute value to be the result of a summary calculation over a time range, configure the value retrieval by time range.

1. Select an option from the **By Time** list. The default option is **Automatic**. For more information, see [Time retrieval options](#).
2. Select an option from the **By Time Range** list. The default option is **End Time**. For more information, see [Range retrieval options](#).
3. If the **Calculation Basis** list is enabled, select one of the following options.

Note: If you select one of the time weighted options for a totalization, source units convert to a rate. Select a unit of time from the list next to the **Source Units** field.

Option	Description
Event Weighted	Evaluates values with equal weighting for each event. No interpolation is done. At least one event must be within the time range to perform a successful calculation. Two events are required for standard deviation. In handling events at the boundary of the calculation, PI AF uses the following rules:

Option	Description
	<ul style="list-style-type: none"> Events at both boundaries are used when there is only one calculation interval. Events at start time are included when multiple intervals exist and the intervals are in ascending time order. Events at the end time are included when multiple intervals exist and the intervals are in descending time order.
Event Weighted Exclude Most Recent Event	Behaves the same as Event Weighted , except in the handling of events at the boundary of summary intervals in a multiple intervals calculation. Use this option to prevent events at the intervals boundary from being double count at both intervals. With this option, events at the end time (most recent time) of an interval are not used in that interval.
Event Weighted Exclude Earliest Event	Similar to the Event Weighted Exclude Most Recent Event option. Events at the start time (earliest time) of an interval are not used in that interval.
Event Weighted Include Both Ends	Events at both ends of the interval boundaries are included in the event-weighted calculation.
Time Weighted	Weights the values in the calculation by the time over which they apply. Interpolation is based on the <i>step</i> attribute of the point. Interpolated events are generated at the boundaries if necessary.
Time Weighted Continuous	Applies weighting as in Time Weighted , but does all interpolation between values as if they represent continuous data (standard interpolation), regardless of the <i>step</i> attribute of the point.
Time Weighted Discrete	Applies weighting as in Time Weighted but does interpolation between values as if they represent discrete, unrelated values (stair-step plot), regardless of the <i>step</i> attribute of the point.

- In the **Min percent good** field, enter a value between 0 and 100. This is a percentage representing the minimal amount of time a value must be good before a summary value is returned. For time weighted calculations, the percentage is based on time. For event weighted calculations, the percent is based on event count.
- Click **OK**.

Create ranges of configurable durations

To guarantee that time ranges are always of the same length, configure time range overrides.

1. From the **By Time** list, select **Time Range Override**.
2. In the **Relative Time** field, type a PI relative time expression, as described in [Relative time](#).

PI AF creates a time range based on the end time supplied by the client application and the offset defined by the relative time.

Note: You can use substitution parameters to read the relative time from the value of another attribute, as described in [References to attribute values](#). If you do this, PI AF evaluates the referenced attribute value at the time of each data request.

Example

To create a one-hour rolling average, you would use the following settings:

- From the **By Time** list, select **Time Range Override**.
- In the **Relative Time** box, type -1h.
- From the **By Time Range** list, select **Average**.

With this configuration, the data reference always computes a 1-hour average, even when the client application specifies a different time range.

Create default time ranges for element attributes

You can create a default time range for element attributes. A default time range is a time range that PI AF uses when a client application provides a specific time, rather than a time range.

Note: Event frame and transfer attributes treat time ranges differently, as described in [Time ranges for event frames and transfers](#).

1. In the PI Point Data Reference (or PI Point Array Data Reference) window, use the following value retrieval settings:
 - a. From the **By Time** list, select **Time Range**.
 - b. In the **Relative Time** field, type a PI relative time expression, as described in [Relative time](#).

Note: You can also use substitution parameters to read the relative time from the value of another attribute, as described in [References to attribute values](#).

PI AF creates a time range based on the time specified by the client application and the offset defined by the relative time.

Example

A totalization meter requires a time range in order to deliver a totaled value. If the client application sends a specific time, you want to create a one-hour time range that ends in the specified time. To do that, you would use these settings:

1. From the **By Time** list, select **Time Range**.
2. In the **Relative Time** field, type:
-1h
3. From the **By Time Range** list, select **Total**.

Note: For a 24-hour totalizer you would set a relative time of -24h or -1d.

Configure dynamic time range calculations

Use a PI AF attribute to calculate the time range based on variable factors. You can use the attribute value to determine the time range dynamically. The attribute values must be valid PI relative times, as described in [Relative time](#).

1. Configure an attribute to generate the PI relative times. The attribute might reference an enumeration set containing PI relative times, or it might construct PI relative times based on a calculation.
2. Configure the PI point data reference.
 - a. From the **By Time** list, select **Time Range Override**.
 - b. In the **Relative Time** field, type: %@AttributeName%
where **AttributeName** is the name of the attribute that generates the PI relative time values.
 - a. From the **By Time Range** list, select a calculation method.

With this configuration, the data reference uses the calculated relative time as a time offset that determines the time range.

See [Example variable end time](#) to step through an example.

Example variable end time

This example creates a data reference with a variable end time.

1. Create an enumeration set, MyEnumSet, that contains these three values:

-30m
-1h
-2h

General		
Name:	MyEnumSet	
Description:		
<input type="checkbox"/> Hexadecimal		
	Value	Name
	0	-30m
	1	-1h
	2	-2h
*		

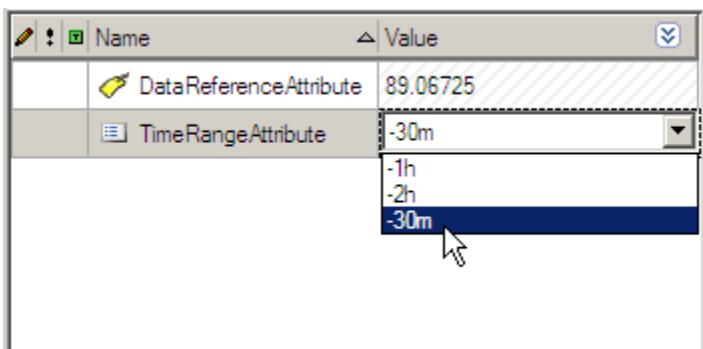
Note: Values must be valid relative time expressions, as described in [Relative time](#).

2. Create an attribute, called TimeRangeAttribute, that references the MyEnumSet enumeration set.

You specify the enumeration set when configuring the attribute. From the **Value Type** list, select **Enumeration Sets > MyEnumSet**.

3. Create another attribute, called DataReferenceAttribute with a configured PI point data reference:
 - For the PI point, choose any point that has a numeric value.
In this example, we will use the sinusoid point on a Data Archive named PISRV1.
 - From the **By Time** list, select **Time Range Override**.
 - In the **Relative Time** box, type: %@TimeRangeAttribute%
 - From the **By Time Range** list, select **Average**.

The TimeRangeAttribute attribute lets you choose the time interval for the calculation.

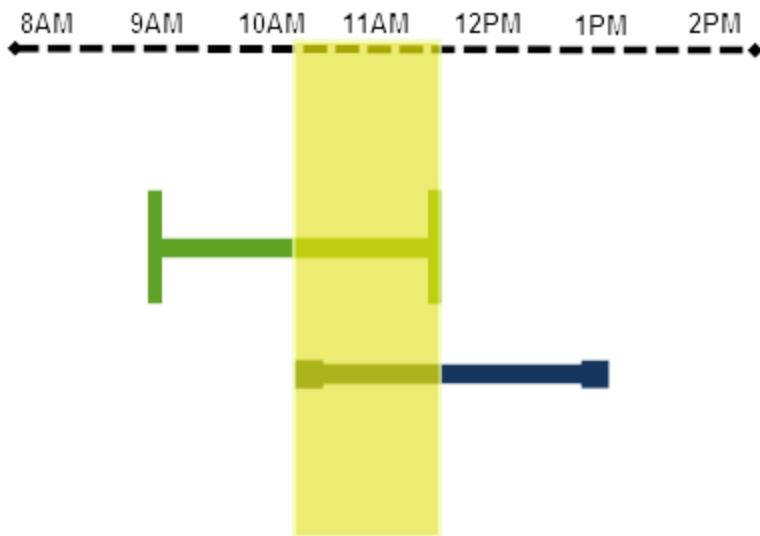


Time ranges for event frames and transfers

Event frames and transfers, by their nature, have a time range associated with them. When a calling application requests a value from an attribute, the value returned depends on the data reference and its configuration:

- When the calling application supplies no time context, PI AF calculates the attribute value using the time range of the event frame or transfer. For example, if an attribute contains a PI point configured with a time range summary option, the summary will be performed over the time range of the event frame or transfer.
- If an attribute contains a PI point configured with only the default time option, PI AF returns the value of the point at the end time of the event frame.
- When the calling application supplies a single timestamp, PI AF returns the value at the specified time, even if the time is outside the time range of the event frame or transfer.
- If the calling application supplies a time range, PI AF uses the intersection of the supplied time range and the time range of the event frame. If there is no intersection, a "No Data" event is returned.
- The shaded area in the following figure represents the intersection between an event frame time range and a requested time range. For attributes that contain a PI point configured with a time range summary option, the summary is performed over this intersection. If the attribute contains a PI point configured with only the default time option, the value at the start time of the intersection is returned.

Intersection between event frame time range and requested time range



PI point value updates from a data reference

An attribute with a PI point data reference can write a value to a PI point. In the PI Point Data Reference configuration window, the **Read only** check box determines whether the attribute can write data to the referenced PI point. By default, the check box is selected (Read only = True), meaning that the PI AF attribute cannot change the value of the PI point.

In rare cases, you might want to write the attribute value back to the point value. For example, if the attribute value is the result of a calculation or analysis, you can update the PI point with the result of that analysis. In this case, you would clear the **Read only** check box to allow the attribute to write its value to the point.

Note: Applications that use the AF SDK **UpdateValue** method, such as the PI Analysis Service, can write data to the PI point regardless of whether the **Read only** check box is selected or not.

Attribute-value updates from PI point data references

When you create an attribute based on a template with a data reference, PI AF does not automatically create the PI point data references associated with that element. To create the data references, you must right-click the element in the Elements (or Event Frames) browser and click **Create or Update Data Reference**. PI AF replaces all substitution parameters with the corresponding values at that moment, and creates and locks in the data reference.

Data reference lock-in

When a data reference is locked in, changes to the attribute template no longer affect instances of the attribute. Substitution parameters are also no longer evaluated. However, the following fields are exceptions:

- An attribute value reference is entered in the **Relative Time** field, as noted in [References to attribute values](#).
- Any point attribute change made in the Tag Creation Settings window.

For example, if a point attribute change is made or a point attribute is defined by substitution parameters, the data reference of derived attributes will still be affected whenever you right-click an element and click **Create or Update Data Reference**.

Data reference reset

After an attribute value has been locked in, you can use the **Reset to Template** feature to reset an element to its template's original properties, as described in [Attribute-value reset to original properties](#).

Attribute indicators for updates of PI point data references

PI System Explorer employs distinctive visual indicators for attributes that support the **Create or Update Data Reference** option. A visual indicator is also displayed when an attribute no longer appears to be configured correctly, such as after a server or a tag name has been changed.

The following visual indicators for the **Create or Update Data Reference** option are available:

Icon	Description	Column
	The attribute is associated with a template that contains point creation rules. Use the Create or Update PI Point option to create the tag configuration based on the template. Additionally, the point name and ID is resolved.	Configuration Item Indicator column ()
	Specifies if an attribute's data reference configuration differs from what is stored in the specified data server. This can occur when a point is renamed, when an attribute's data reference is tied to a PI point without a value (floating) or when the underlying PI Data Archive is replaced. Use the Create or Update PI Point option to update the configuration.	Configuration Item Indicator column ()
	The data reference has returned a system digital state rather than a typical value from the source. An example is when a PI point has been created, but doesn't have any data.	Quality Indicator column ()
	The value returned from the data reference has a bad quality. An example is when a PI point has been created, but it does not yet	Quality Indicator column ()

Icon	Description	Column
	have any data.	
	<p>The attribute is a configuration item. See Configuration Item attribute property for more information.</p> <p>Note: The Create or Update Data Reference option is not applicable for configuration item attributes.</p>	Configuration Item Indicator column (

When you review element attributes on the **Attributes** tab, the first entry in the column at left of a data reference attribute's name indicates whether you can run the **Create or Update Data Reference** option. You initiate the **Create or Update Data Reference** option by right-clicking an element or an attribute and clicking **Create or Update PI Point**.

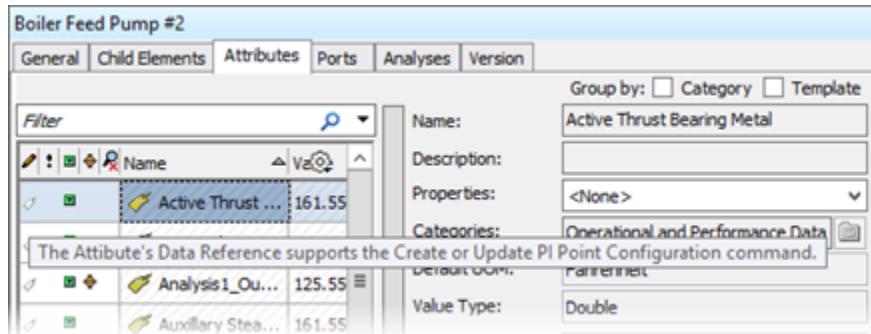
The **Create or Update Data Reference** operation updates a PI point data reference with any changes that have occurred to the PI point; substitution parameters are resolved, and server and point IDs are updated. If the PI point does not yet exist, and the configuration contains a point creation option, it is created.

Attribute update example

When you see the indicator displayed for an attribute, you can update its configuration by right-clicking and clicking **Create or Update PI Point**.

Note: The icon does not determine beforehand if any changes to the tag or its configuration will occur.

Attribute indicator with tooltip



As the tooltip shown above indicates, when you update the configuration, point name substitution rules are resolved and the point ID is stored into the attribute's metadata. This results in faster subsequent initialization.

Note: You can use the **Column List** button to add columns to or remove columns from the Attributes window.

Configure creation of PI points

In an attribute template, you can configure a PI point data reference to create PI points.

1. In the Library browser, select an element template.

2. Click the **Attribute Templates** tab.
3. Add a new attribute template to the element template, as described in [Create attribute templates](#).
4. From the **Data Reference** list, select **PI Point**.
5. Click **Settings**.
6. In the **Tag name** field in the PI Point Data Reference window, set up the PI point names for the generated points. Use substitution parameters to enable PI AF to build point names for the points it generates.
 - a. Click  to select name substitution and related attribute values from a context menu. For more information on name substitution values, see [List of PI AF substitution parameters](#).

Note: If the attribute value substitution is a string that contains spaces, you must surround the entire tag name in double quotes. Concatenate the entire string first, then substitute the value into the tag name portion of the string with String Builder.

For example:

"\\%Server%\\%Element%.%ID%.%@ConcatStringName%;pointtype=String"

- b. Select the **Tag Creation** check box.
- c. Click .
- d. In the Tag Creation Settings window, specify a point class and point type in the **Point Class** and **Point Type** fields. For more information on PI point classes and attributes, see [Point classes and attributes](#).
- e. Default attribute values are displayed for the selected point class. You can edit the default PI point attributes, or you can click **Import** to import PI point attribute values from an existing point that you locate in the Tag Search window.
7. To preview how the selected substitution parameters resolve, click the **Select example instance** link in the **Preview** section.
8. In the Find Derived Elements for *Element_Template* window, select a sample element.
9. Click **OK**.
The **ConfigString** and **Value** fields display the resolution of the substitution parameters you selected, as well as the tag creation settings.
10. To save your work, press CTRL-S or click **Check In**.
11. Create a new element based on your element template and click on the **Attributes** tab.
12. Right-click the PI point data reference attribute and click **Create or Update Data Reference**.
13. To save your work, press CTRL-S or click **Check In**.

All the points that the new elements reference are created. This only works because the elements were based on a template and the attribute template for the data reference uses the Tag Creation option.

After the PI points are created, it might take some time before values are written into Data Archive by the specified interface. Until then, the values are displayed as **Pt. Created**.

Edit PI point properties

Edit a PI point property when you need to provide more information on a PI point than default tag property values. For example, it can be helpful to provide a descriptor for a PI point that is created as output from an analysis.

1. In the Elements browser, locate the element that contains the PI point you want to edit.
2. Click the **Attributes** tab and select the attribute with the **PI Point** data reference.
3. Click **Settings**.
4. In the PI Point Data Reference window, click .
5. In the PI Point Properties window, choose from the following actions:

To ...	Do this ...
Edit a property value	<ol style="list-style-type: none">a. Click the Value field beside a property.b. Enter a revised value.
Restore an edited value to Data Archive default	<ol style="list-style-type: none">a. Click the Value field beside an edited property.b. Click  and select Restore default value.

6. Click **OK**.

Preview substitution parameters in PI point data references

Preview how substitution parameters resolve as you configure a PI point data reference in an attribute template.

1. In the Library browser, select an element template.
2. Click the **Attribute Templates** tab.
3. Add a new attribute template to the element template, as described in [Create attribute templates](#).
4. From the **Data Reference** list, select **PI Point**.
5. Click **Settings**.
Default substitution values are displayed in the **Tag name** field.
6. Use substitution parameters to enable PI AF to build point names automatically for the points it generates.
Click  to select name substitution and related attribute values from a context menu. For more information on name substitution values, see [List of PI AF substitution parameters](#).
7. To preview how the selected substitution parameters resolve, click the **Select example instance** link in the **Preview** section.
8. In the Find Derived Elements for *Element_Template* window, select a sample element.
9. Click **OK**.
The **ConfigString** and **Value** fields display the resolution of the substitution parameters you selected, as well as any tag creation settings and value retrieval methods (if selected).
10. Choose one of the following actions:
 - To confirm the PI point data reference configuration, click **OK**.
 - To change configuration settings, click **Cancel** and start over by clicking **Settings**.

PI point array data references

You use the PI point array data reference to link attributes of elements to arrays of PI points for either reading or writing their values. Each tag name specified corresponds to a single entry in the array. Configure the PI point

array data reference as you would the PI point data reference, with the exception of the **Tag Names** field in the PI Point Array Data Reference window.

Video

For information on how to set up PI point array data references, watch this video:

Create PI point array data references

Create a PI point array data reference to link attributes of elements to arrays of PI points for either reading or writing their values.

1. To configure a PI point array data reference:
 - In the Elements browser, select the desired element.
 - In an element template, select the desired element template in the Library browser.
2. In the **Attribute** or **Attribute Templates** tab, select the attribute.
3. In the attribute configuration panel, choose **PI Point Array** from the **Data Reference** list.
4. Click the **Settings** button.
5. In the PI Point Data Array Reference window, leave the default server, or choose a different Data Archive from the **Data server** list.

Note: If the desired Data Archive does not appear in the list, click  and select a Data Archive from the PI Data Archives window.

6. In the **Tag name** field, choose from the following actions:
 - To enter PI points directly, enter point names separated by the pipe symbol (|). For example:
CDM158|CDT158|SINUSOID
 - To search for PI points, click  and enter search criteria in the Tag Search window. Select multiple PI points on the selected Data Archive.

7. Optional. Specify the units that the referenced PI points use. See [Unit of measure considerations](#).
8. In the **Value retrieval methods** section, specify how the attribute gets its value. For example, the attribute value could be the same as the point values, or it could be a result of a calculation on the point values. See [Configuration of retrieval methods for attribute values](#).
9. Use the **Read Only** check box to specify whether you want PI AF to write the attribute value back to the source points. By default, PI AF does not write data to the referenced PI points (the **Read Only** check box is checked). See [PI point value updates from a data reference](#).

Formula data references

You use formula data references to create custom calculations based on other element attributes. Calculations can be a single formula or a sequence of calculations. Formula data references can have multiple input attributes.

Videos

For information on how to create formula data references, watch this video:

For information on UOMs in formula data references, watch this video:

Formula data reference operators

You can use the following operators in formula data references (in order of precedence):

Operator	Precedence
Parenthesis	9 (calculated first)
Unary Minus	8
^	7
* / mod	6
+ -	5
< > <= >= == <>	4
NOT	3
AND	2
OR	1 (calculated last)

You cannot use the assignment operator = at the beginning of any formula.

Note: Formula data reference syntax uses == (two equals signs) to indicate equality and = (single equals sign) for

assignment. Analytics (and performance equation) syntax uses = to indicate equality and := for assignment.

Compound operators

You can choose **If-Then-Else**, a compound operator with operands used as follows:

If expr0 Then expr1 Else expr2

where *expr0*, *expr1*, and *expr2* are expressions. If *expr0* is true, the value of *expr1* is returned; otherwise, the value of *expr2* is returned.

Formula example

This sample formula calculates the daily average cost of reagent per tonne processed, as shown in the **Value** field for **Grinding Media** in the following mineral processing illustration:

```
A=.|Addition (Daily Total);B=.|Unit Cost;C=Tonnage (Past 24 Hours);[if C ==0 then
digstate("No Data") else A*B/C]
```

Sample formula data reference

Line 1						
		General	Child Elements	Attributes	Ports	Analyses
		Notification Rules	Version			
<i>Filter</i>						
	Name	Value	Time St...	Description	Unit Of Measure	Data Reference
⊕	Grinding Media	1.50028962510637 US\$/t	10/26/2...	Cost of Reagent per Tonne Processed (Dail...	US Dollar per tonne	Formula
⊕	Supplier Phone Number	555-111-1234	1/1/197...	Contact Info for Supplier	<None>	Table Lookup
⊕	Unit Cost	B	1.5 US\$	Cost per Unit of Reagent	US Dollar	Table Lookup
⊕	Grinding Media Addition	5.91122824793745 kg	10/26/2...	Reagent Added to Process	kilogram	PI Point
⊕	Addition (Daily Total)	A	8235.72598081772 kg	Reagent Added to Process (Daily Total)	kilogram	PI Point
⊕	Target	1 kg/t	1/1/197...	Reagent Consumption Target	kilogram per tonne	Table Lookup
⊕	Lime	0.27432676570096 US\$/t	10/26/2...	Cost of Reagent per Tonne Processed (Dail...	US Dollar per tonne	Formula
⊕	Operating Work Index	No Data	1/1/197...	Energy Input for Particle Size Reduction	kWh per ton	PI Point
⊕	Feed Size (F80)	5.25818735823215 in	10/26/2...	Grinding Feed Size (80th Percentile Size)	inch	PI Point
⊕	Product Size (P80)	78.4700347615732 µm	10/26/2...	Grinding Product Size (80th Percentile Size)	µm	PI Point
⊕	Throughput (Past Hour Average)	347.941885315025 t/h	10/26/2...	Hourly Average Throughput	tons per hour	PI Point
⊕	Availability	100 %	10/26/2...	Past 12 Hour Average	percent	PI Point
⊕	Recycled Water Ratio	66.3047868581947 %	10/26/2...	Percentage of Recycled Water	percent	PI Point
⊕	Status	OK	10/26/2...	Process Status	<None>	PI Point
⊕	Throughput	344.125814047259 t/h	10/26/2...	Process Throughput	tons per hour	PI Point
⊕	Shift Supervisor	Joe B.	9/29/20...	Shift Supervisor of Current Crew	<None>	Table Lookup
⊕	Crew	A	9/29/20...	The Rotating Production Crew on Shift	<None>	PI Point
⊕	Tonnage (Past 24 Hours)	C	8234.1361057874 t	Total Daily Tonnage	tonne	PI Point
⊕	Water Use	811.897012298679 m3/h	10/26/2...	Total Water Use	cubic meter per hour	PI Point

Formula data reference functions

PI AF supports the following functions in a formula data reference. For information on analyses expression functions, see Expression functions reference.

Function	Description
<code>abs(X)</code>	Absolute value of X.
<code>acos(X)</code>	Arc cosine of X.
<code>asin(X)</code>	Arc sine of X.
<code>atan(X)</code>	Arc tangent of X.
<code>badval(x)</code>	Returns 1 if the value has a bad status, has a floating point value of not a number (NaN), or is not a numeric value, otherwise returns 0.
<code>ceiling(X)</code>	Smallest integer not less than X.
<code>cos(X)</code>	Cosine of X.
<code>cosh(X)</code>	Hyperbolic cosine of X.
<code>cot(X)</code>	Cotangent of X.
<code>coth(X)</code>	Hyperbolic cotangent of X.
<code>csc(X)</code>	Cosecant of X.
<code>csch(X)</code>	Hyperbolic cosecant of X.
<code>digstate()</code>	Returns a system digital state value. <ul style="list-style-type: none"> If successful, the system digital state is returned as a system enumeration value. For PI AF Client versions older than 2.4, the value is returned as a PI SDK digital state, because the system enumeration value set did not exist. If unsuccessful, the value is returned as a string. In both cases, the <code>AFValue.IsGood</code> flag is set to false, and the attribute is flagged in the Attributes Viewer with the  icon.
<code>e()</code>	Value of the natural logarithm base.
<code>exp(X)</code>	Natural logarithm base e raised to power of X.
<code>floor(X)</code>	Largest integer not greater than X.
<code>ln(X)</code>	Natural logarithm of X.
<code>log(X)</code>	Logarithm of X using base 10.
<code>logbase(X,Y)</code>	Logarithm of X using base Y.

Function	Description
max(X,Y)	Greater of X and Y.
min(X,Y)	Lesser of X and Y.
normalrnd(X,Y)	Random number that maps the normal distribution curve. X is the mean and Y is the standard deviation.
pi()	Value of pi.
poisson(X)	Random number that maps the Poisson distribution. X is the mean.
pow(X,Y)	X raised to the power of Y.
rand()	Uniform random number. The values can be between 0 and less than 1.0
rand(X,Y)	Uniform random number. The values can be between X-Y/2 and less than X+Y/2.
remainder(X,Y)	Returns the remainder resulting from the division of X by Y.
round(X)	X rounded to the nearest whole number.
roundfrac(X,Y)	X rounded to the number of fractional digits specified by Y. Y is an integer number.
sec(X)	Secant of X.
sech(X)	Hyperbolic secant of X.
sign(X)	Returns 1 if X is greater than zero and -1 if X is less than zero.
sin(X)	Sine of X.
sinh(X)	Hyperbolic sine of X.
sqrt(X)	Square root of X.
tan(X)	Tangent of X.
tanh(X)	Hyperbolic tangent of X.

Units of measure in formula data references

When working with formulas and units of measure, you need to configure the equation inputs and the output with the correct UOM:

- For the attributes in the equation, use the UOM that the formula expects (NOT the units the attribute is already in).
- For the calculation result, specify the UOM in which you want the result to appear. This must be consistent with the UOMs for your inputs (attribute values).

Example of UOM in a formula data reference

Consider the following formula configuration for converting volume and density into mass:

```
V=Volume;UOM=L;D=Density;UOM=kg/L;[V*D];UOM=kg
```

The units of measure for the inputs and outputs are consistent: ($L \cdot kg/L = kg$). This formula works on any input attributes or output attributes, regardless of the attribute's unit of measure, as long as they have a unit of measure of the correct class specified.

Configure formula data references

The formula data reference does not support strings or other non-numeric value types.

Create formula data references to perform custom calculations.

1. Choose one of the following actions.
 - In the Elements browser, select the desired element.
 - In an element template, select the desired element template in the Library browser.
2. In the **Attribute** or **Attribute Templates** tab, select the attribute.
3. From the **Data Reference** drop-down list, choose **Formula**.
4. Click the **Settings** button to open the Formula Data Reference configuration window.
5. If your equation requires an attribute value, click  to add it as a parameter ([Define parameters for formula data references](#)).
6. Select the **Default Values Allowed** check box to enable PI AF to use attribute default values in the calculation. Default values are specified on the attribute template. If you clear the check box, the calculation fails when the data for one or more attributes is not available.
7. Click  to begin defining the equation. For more information, see [Define equations for formula data references](#).
8. In the **Unit of Measure** field, specify the unit of measure the result of the formula or calculation sequence will produce, as described in [Units of measure in formula data references](#).
9. In the **Minimum** field, enter an appropriate value for the minimum returned value. If the calculated value is less than this minimum, the data reference returns the minimum value you specify. If there is no minimum value for this calculation, leave the **Minimum** box blank.
10. In the **Maximum** field, enter an appropriate value for the maximum returned value. If the calculated value is greater than this maximum, the data reference returns the maximum value you specify. If there is no maximum value for this calculation, leave the **Maximum** box blank.
- Note:** Select the **Stepped** check box for the value to be stepped when plotted.
11. Click **Evaluate** to test the data reference. The value returned by the calculation sequence appears in the adjacent box. When the formula data reference is configured under a template attribute, the calculation uses

the default values for the template attributes. When the configuration is done under an element attribute the actual data is used for the calculation.

12. Click **OK**.
13. Configure the rest of the attribute settings as you would for any other attribute.

Define parameters for formula data references

When equations require attribute values, add those attributes as parameters in the Formula Configuration window.

1. Click  next to the **Parameters** field.

Note: You can alternatively click in an empty row and enter a variable (a - z).

2. In the Parameter Configuration window, select a variable from the **Variable** menu.
The number of variables available is limited to 26 chars (from A to Z).
3. Select the attribute that the variable represents.
 - Choose the attribute from the **Attribute** menu. All sibling attributes with supported value types are listed.
 - If the attribute that you want is not in the menu, choose **Other**. A new field called **Attribute** appears in the window. Click  to pick your attribute from the tree. Alternatively, type in the path to the attribute of interest. Examples of some attribute paths are listed.
4. Select the desired unit of measure for the attribute. Note that this is not the UOM of the attribute but rather the UOM that your formula requires from this input, as described in [Units of measure in formula data references](#).

For example, if your input attribute has a UOM of Celsius but your equation requires Fahrenheit, you would select Fahrenheit in this field.

Define equations for formula data references

Define equations for use in formula data references.

1. To add a new formula row, click  next to the **Equations** field.

You can also click in the text area and type in an equation.

2. Type an equation directly or build your equation from a list of available variables, operators, functions, and substitution parameters. Click  to choose from the following actions:

To ...	Do this ...
Enter a variable	Click Variables and click a letter on the alphabetized list.
Enter an operator	Click Operators and click an operator on the list. Valid operators are listed in Formula data reference operators .

To ...	Do this ...
Enter a function	Click Functions and click a function on the list. Valid functions are listed in Formula data reference functions .
Enter a substitution parameter	Click Substitution Parameters and click a time substitution parameter. For elements and transfers, only <code>%Time%</code> is available, but for event frames you can select from <code>%StartTime%</code> , <code>%EndTime%</code> , <code>%UtcTime%</code> , <code>%UtcStartTime%</code> , <code>%UtcEndTime%</code> , and <code>%Duration%</code> . For more information on these parameters, see List of PI AF substitution parameters . Numbers are converted to a double, time spans to a duration in seconds, and timestamps to UTC seconds.

3. To add another row to the formula, click and continue the formula. Repeat as needed until you have completed the formula.
4. To change the formula, choose from the following actions:

To ...	Do this ...
Remove the selected equation from the calculation sequence	Select the row you wish to remove and click .
Remove all equations from the calculation sequence	Click .
Move an equation up or down in the calculation sequence	Select the row to be moved and click or .

String Builder data references

The **String Builder** data reference enables you to apply string manipulation functions, such as concatenation, to an attribute's values, and output a reformatted string. This is useful when you need to obtain a string or numeric value type from other element attributes. String Builder data references do not perform Unit of Measure conversions or calculations. When you use the **String Builder** data reference in a template, value substitution takes place at run time.

Expression syntax

Observe the following rules as you build an expression:

- You can construct an expression on a single line, using semicolons to separate its terms.
- You can also place each term on its own line, which eliminates the semicolons and makes the expression structure more apparent.

- Enclose substitution parameters in double quotes so that their result is treated as a literal string.
- You can include any keyboard character in a double-quoted string, for example, dashes, backslashes, colons, semicolons, and so on. To include the double-quote character in a string, type two consecutive double-quote characters within the string, for example, """t""e""s""t"" produces "t"e"s"t".
- You can include single-quoted attribute paths to display the value of the referenced attribute in the result.
- You should avoid the use of unquoted strings because you may get haphazard results.

Attribute references in String Builder

To reference other attributes, you use the syntax in the following table.

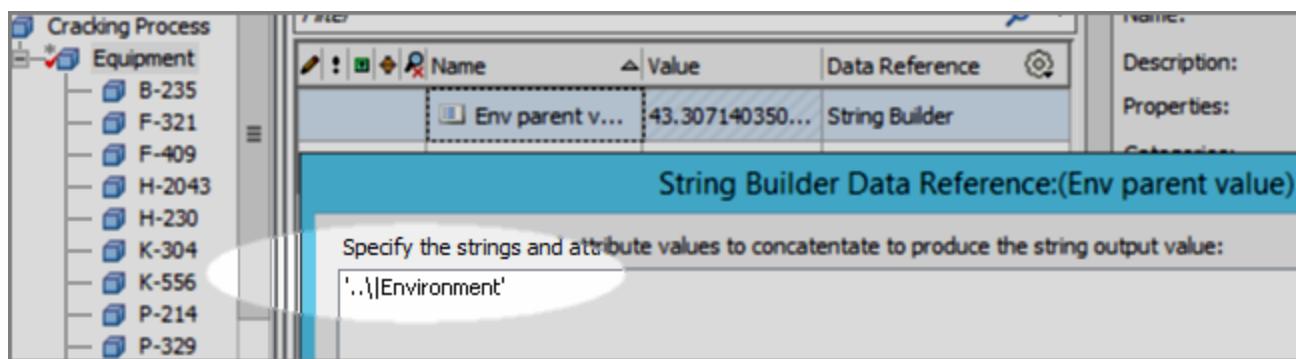
Object	Syntax
Sibling attribute	<i>siblingAttribute</i>
Top level attribute of same element	<i>/topLevelAttribute</i>
Parent attribute	..
Parent element attribute	..\\ <i>myAttribute</i>
Child attribute	.\\ <i>childAttribute</i>
From event frame to primary element	.\\ <i>Elements[.]</i> \\ <i>myAttribute</i>
Database relative path	\\ <i>TopLevelElement</i> \\ <i>myAttribute</i>
Full path	\\\\ <i>myServer</i> \\\\ <i>myDatabase</i> \\\\ <i>myElement</i> \\\\ <i>myAttribute</i>

Examples

Suppose you want to retrieve the Environment PI point value from the Cracking Process parent element:

The screenshot shows the software interface for managing industrial assets. On the left, the 'Elements' tree view shows a hierarchy: Elements > NuGreen > Houston > Cracking Process. The 'Cracking Process' element is selected. On the right, the 'Cracking Process' details view is displayed, containing tabs for General, Child Elements, Attributes, Ports, Analyses, and Version. The 'Attributes' tab is active, showing a table with two rows. The first row has a 'Name' column value of 'Energy Savin...' and a 'Value' column value of '2'. The second row has a 'Name' column value of 'Environment' and a 'Value' column value of '43.307140350...'. A 'Data Reference' column indicates 'Table Lookup' for the first row and 'PI Point' for the second.

In the child element Equipment, you would use the syntax ..*myAttribute* and enter '..\\|Environment' in the String Builder Data Reference window:



A value similar to the following is displayed in the **Value** field: **43.3071403505214**.

Function implementation in String Builder

In String Builder, you can use several text manipulation functions, as well as the *Format* function.

Text extraction and case manipulation

You can use functions to manipulate the case of a string and to extract certain sections.

The syntax for text manipulation functions in String Builder is described in the following table:

<i>Left(string, length)</i>	Returns a string that contains the specified number of characters (<i>length</i>) from the left of the input (<i>string</i>). Example: <code>Left("Temperature", 4)</code> returns <i>Temp</i>
<i>Right(string, length)</i>	Returns a string that contains the specified number of characters (<i>length</i>) from the right of the input (<i>string</i>). Example: <code>Right("GasTemp", 4)</code> returns <i>Temp</i>
<i>Mid(string, start, [length])</i>	<i>length</i> is optional. Returns a sub-string from the specified position (<i>start</i>) of the input (<i>string</i>). When number of characters (<i>length</i>) is included, returns the specified number of characters. Example: <code>Mid("GasPressure", 4, 8)</code> returns <i>Pressure</i>
<i>UCase(string)</i>	Converts <i>string</i> to uppercase. Example: <code>UCase("Temperature")</code> returns <i>TEMPERATURE</i>
<i>LCase(string)</i>	Converts <i>string</i> to lowercase. Example: <code>LCase("TEMPERATURE")</code> returns <i>temperature</i>
<i>Trim(string)</i>	Removes blanks on both sides of <i>string</i> . Example: <code>Trim(" Temperature ")</code> returns <i>Temperature</i>

<i>RTrim(string)</i>	Removes trailing blanks from <i>string</i> . Example: RTrim(" Temperature ") returns "Temperature"
<i>LTrim(string)</i>	Removes leading blanks from <i>string</i> . Example: LTrim(" Temperature ") returns "Temperature"
<i>Replace(string1, string2, string3)</i>	The function searches <i>string1</i> for <i>string2</i> , then replaces <i>string2</i> with <i>string3</i> . Example: Replace("Temperature", "Temp", "External Temp") returns "External Temperature"

You can also nest text manipulation functions.

- For example, for an attribute named GasPressure, you can use the *Mid* function in combination with the *UCase* function to return the following expression: *GASPR*

```
Mid(UCase("%Attribute%"), 1, 5);
```
- Alternatively, for the same attribute, you can use the *Mid* function in combination with the *LCase* function to return the following expression: *pressure*

```
Mid(LCase("%Attribute%"), 4, 8);
```

Beginning with PI AF 2018, you can nest functions in any position, not the first position only. In the following examples, all functions return the expression: *a2c*

```
Replace(Mid("abc",1,3),"b","2");
Replace("abc",Mid("abc",2,1),"2");
Replace("abc","b",Mid("123",2,1));
```

Format function

The *Format* function enables you to convert real numbers, integers, and time stamps to a string according to the format and optional culture specification.

Note: Unlike other string functions, the syntax of **Format(DateTime, ...)** follows C# syntax.

The syntax for Function implementation in String Builder is described in the following table:

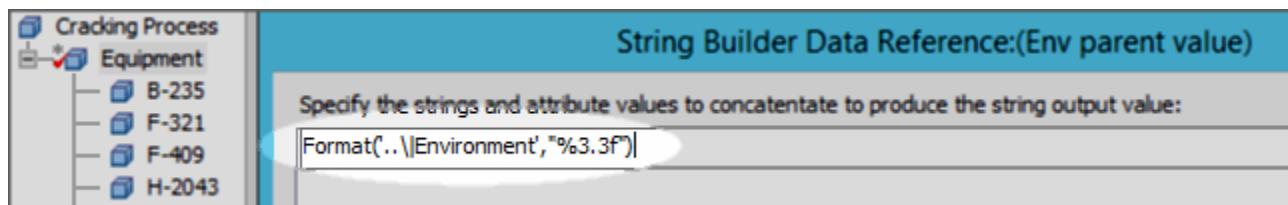
Real numbers	<i>Format(real, format)</i> <i>Format (real, format, culture)</i>	Format follows Performance Equation (PE) style syntax, such as "%0.3f", where the number before the decimal indicates the minimum total number of characters to output, pre-padding with blanks, and the number after the decimal indicates the number of digits to display after the decimal point. Culture is optionally specified using an Internet Engineering Task Force
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		(IETF) language tag, such as "en", "en-US", "de", which specifies the language and optional culture and regions.
Integer numbers	<i>Format(integer, format)</i> <i>Format(integer, format, culture)</i>	Format follows PE style syntax, such as "%4d", where the number indicates the minimum total number of characters to output, pre-padding with blanks as necessary. Culture is optionally specified using an IETF language tag, such as "en", "en-US", "de", which specifies the language and optional culture and regions.
Time stamps	<i>Format(datetime, format)</i> <i>Format(datetime, format, culture)</i>	Format follows C# <i>DateTime.ToString(format)</i> syntax, and can be either a pre-defined syntax, or a custom syntax. <i>DateTime</i> format uses invariant culture settings. To display dates and times for a specific culture, add an IETF language tag, such as "fr-FR" and "fr-CA", as described in the MSDN article Table of Language Culture Names, Codes, and ISO Values Method . For more information on date and time formats, see Format strings for time substitution parameters .
Arrays	<i>Format(array, delimiter)</i> <i>Format(array, delimiter, format)</i> <i>Format(array, delimiter, format, culture)</i>	Delimiter uses white space " " as the default delimiter, unless another delimiter character is specified. In addition, <i>format</i> and <i>culture</i> can optionally be specified, using the same syntax as real and integer numbers above. For example, the following String Builder data reference to an array (with values 11.12, 15.98, and 99.154) that specifies a "-" delimiter, a "%3.3.f", and a "Fr-fr" culture: <i>Format('..\ TestArray','-</i>

		" , "%3.3f" , "Fr-fr"); produces a value of 11,120-15,980-99,154.
New line	<code>NewLine()</code>	Ensures that a new line is displayed in the output value. For example, when <code>a;Newline();b</code> ; is entered, the output value is displayed as: <code>a</code> <code>b</code>

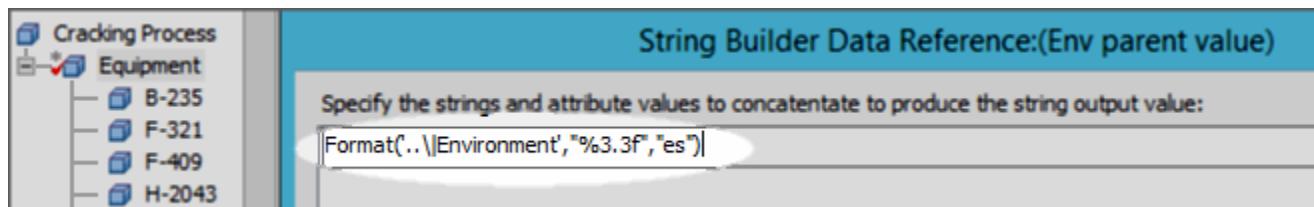
Numeric format example

Suppose you want to format the Environment PI point value that you have already retrieved from the Cracking Process parent element. In the String Builder Data Reference window, you would select the row that contains the string expression, click  and select **Functions > Format(Real, "%3.3f")** to modify the expression:



The **Value** field changes from `43.3071403505214` to `43.307`.

To change the cultural value from the US default to a Spanish culture format, you would select **Functions > Format(Real, "%3.3f", "en-US")** and change the "`en-US`" string to "`es`":



The **Value** field changes from `43.307` to `43,307`.

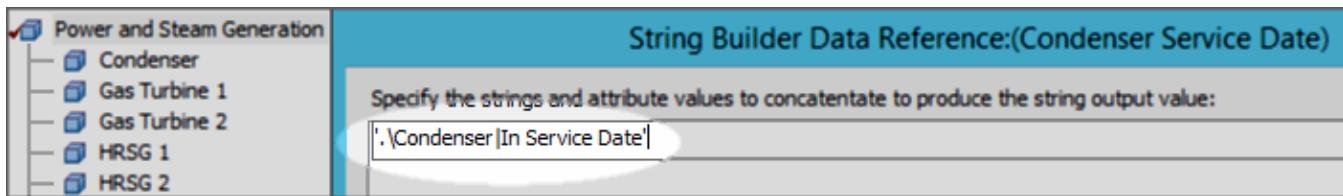
Note: Be sure the data type you specify matches the attribute data type. You would encounter errors, for example, if you specify "`%3.2f`" for an integer type attribute value or "`%3d`" for a floating point attribute value.

Date time format example

Suppose you want to retrieve and format the In Service Date value from the Condenser child element:

<input checked="" type="checkbox"/> Power and Steam Generation	<input type="checkbox"/> Condenser Temp...	49.0549621582031 °C	PI Point
<input type="checkbox"/> Condenser	<input type="checkbox"/> Condenser Vacuum	701.738464355469 mmHg	PI Point
<input type="checkbox"/> Gas Turbine 1	<input type="checkbox"/> In Service Date	2/25/2009 12:00:00 AM	<None>
<input type="checkbox"/> Gas Turbine 2	<input type="checkbox"/> Last Service Date	2/25/2011 12:00:00 AM	<None>
<input type="checkbox"/> HRSG 1			
<input type="checkbox"/> HRSG 2			

In the parent element Power and Steam Generation, you would create an attribute named Condenser Service Date. Use the syntax `.\childElement\Attribute`, and enter '`.\Condenser|In Service Date`' in the String Builder Data Reference window:



The In Service Date value is retrieved and displayed in the **Value** field: **2/25/2009 12:00:00 AM**.

To change the format from the US default to Universal full date in German culture format, you would alter the expression to read `Format(.\\Condenser|In Service Date, "U", "de")`. The Condenser Service Date attribute value format is converted accordingly:

*	Power and Steam Generation	Auxiliary Power	101.634834289551 MW	PI Point
	Condenser	Condenser Service Date	Mittwoch, 25. Februar 2009 08:00:00	String Builder
	Gas Turbine 1	Demandated Water Outlet	149.1422242E302.9C	DT Point
	Gas Turbine 2			

Create String Builder data references

When a String Builder data reference is used in a template, value substitution takes place at run time.

Create a String Builder data reference when you need to apply string manipulation functions, such as concatenation, to an attribute value and output a reformatted string.

1. Choose one of the following actions:
 - In the Elements browser, select the desired element.
 - In the Event Frames browser, select the desired event frame.
 - In an element template, select the desired element template in the Library browser.
2. In the **Attribute or Attribute Templates** tab, select the attribute.
3. In the attribute configuration panel, choose **String Builder** from the **Data Reference** list.
4. Click **Settings**.
5. In the String Builder Data Reference window, click
6. In the highlighted row, press F2 or click and select from the following options:

Option	Description
Literals	A text string between double quotation marks: "Sample"
Attribute Values	A list of other attributes for the selected element or element template. Note that attributes must appear in single quotes.
Related Attribute Values	A list of the following attribute references: <ul style="list-style-type: none"> • '<code>\<Server>\<Database>\<Element> \<Attribute></code>

Option	Description
	<ul style="list-style-type: none"> • '.' • '\\.\<Database>\<Element> <Attribute>' • '\<Root Element> <Attribute>' • '.\<Child Element> <Attribute>' • '..\ <Primary Parent Attribute>' • '..\<Sibling Element> <Attribute>' <p>You can also select Search to enter search criteria in the Attribute Search window.</p>
Substitution Parameters	A list of 20 commonly used substitution parameters. For more information, see List of PI AF substitution parameters .
Functions	A list of the following functions: <ul style="list-style-type: none"> • Left(string, length) • Right(string, length) • Mid(string, length) • Mid(string, start, length) • UCase(string) • LCase(string) • Trim(string) • RTrim(string) • LTrim(string) • Replace(string, string, string) • Format(Real, "%3.3f") • Format(Real "%3.3f", "en-US") • Format(DateTime, "yyyy-MM-dd HH:mm:ss") • Format(DateTime, "yyyy-MM-dd HH:mm:ss", "en-US") • Format(Array, Separator) • NewLine()

7. Build your expression further. You can either type a semicolon (;) and continue in the same row, or click  to continue on another row. You can use the following icons to manipulate the expression:

To ...	Do this ...
Append a new string	Click  .
Remove a string	Select a row and click  .

To ...	Do this ...
Remove all strings	Click  .
Move a string up a row	Select a row below the top row and click  .
Move a string down a row	Select a row above the bottom row and click  .

As you build the string expression, you can preview the result of the expression in the **Value** field.

- When the string expression is complete, click **OK**.

Examples

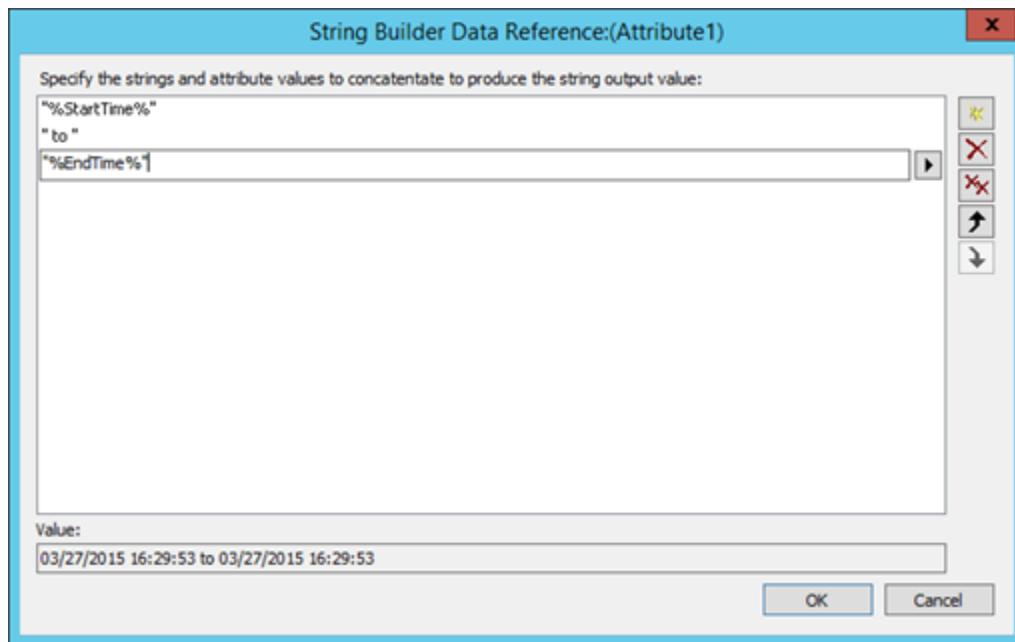
- You can enter the following substitution parameters in a single row to concatenate a pathname string. For example:

```
"%Database%" ; "\;" ; "%Element%" ; " | " ; "%Attribute%" ;
```

- This data reference would produce output similar to: *DB26\WX12000/pressure*.

- You can build an expression in separate rows to show the duration of an event. For example:

- Click , press F2 and select **Substitution Parameters > "%StartTime%"**.
- Click  and type the characters: " to "
- Click , press F2 and select **Substitution Parameters > "%EndTime%"**.
- The **Value** field shows a date and time interval:



For more examples, see [Function implementation in String Builder](#).

Table lookup data references

You can configure an attribute to obtain its value from a PI AF table. You can define the PI AF table entirely in PI AF, or you can link to or import from a data source outside the PI System (such as a Microsoft SQL table).

Important: We do not recommend using Excel files for linked tables. See the KB article: [Do not link AF tables to Excel files.](#)

Table lookup

The table lookup data reference is intended to be a simple table lookup. It uses Microsoft's .NET *System.Data.DataTable.Select* method, and follows the filter expression rules of that method. Note that not all its features are implemented in PI AF. For example, a table lookup data reference does not include functionality such as column functions and parent/child relation referencing.

Note: The table lookup data reference is not optimized to treat data in an external table as a time series and query for it. For optimal performance, such data should be stored in PI tags on a Data Archive.

Table lookup methodology

You begin by creating a table profile in the Library browser, where you establish general settings for the time zone and cache interval for refreshing data, as well as definitions of table columns and connections to data sources outside the PI System if you are linking to or importing external data.

If you are linking to external data sources, consider creating reusable table connection profiles in the Library browser, as described in [Create reusable table connections](#).

Videos

For information on how to create internal tables for table lookup data references, watch this video:

For information on how to configure table lookup data references, watch this video:

Create PI AF tables

You create a table profile so that attributes can obtain their values from an internal or external table.

1. In the Library browser, right-click the **Tables** collection and click **New Table**.
2. In the **General** tab, enter a **Name** and **Description** for the table.
3. Optional. Assign one or more categories to the table. Enter table category names directly, separated by a colon, or click  and select them from the Categorize window.
4. Decide how DateTime values should be stored in the table. By setting the value for the table overall, you need not specify it every time you create a table lookup data reference.
 - a. In the **Time Zone** field, select a time zone from the list.
 - b. Select or clear the **Convert To Local** check box. Choose from the following options:
 - To convert DateTime values to the local time, select the **Convert To Local** check box.
 - To display DateTime values in the time zone selected in the **Time Zone** field, clear the **Convert To Local** check box.

Note: When a client application queries the table, the time zone in which DateTime values are displayed depends on whether the **Convert To Local** check box is selected. PI System Explorer uses this setting to determine the precise DateTimeKind to use in a Microsoft .NET data table, as described in [Conversion settings for time zones](#).

5. In the **Cache Interval** field, enter the amount of time until the table's cached data is automatically refreshed. From the list, choose whether the value is in seconds, minutes, hours, or days. The default value is zero, which indicates a manual refresh.

Note: Automatic refreshing is disabled if the table has changes that have not been saved to the server.

Note: With manual refreshes, you refresh table data by right-clicking the table in the Library browser and clicking **Refresh**. Otherwise, table data that is being queried by client applications is refreshed only when the application is restarted. For example, when PI System Explorer is opened or whenever the Microsoft Internet

Information Services (IIS) application pool recycles the client (the default is every 29 hours).

6. Check in your work.

Note: The **Connection** and **Query** fields are read-only. PI AF populates these fields when you link to or import an external table.

Define and populate the table in one of three ways:

- Manually define and populate the table in PI System Explorer. First, create column definitions on the **Define Table** tab, as described in [Create table column definitions](#). Next, enter data on the **Table** tab, as described in [Populate tables manually](#).
- Import a table from outside the PI AF server. See [Access to Microsoft Access](#).
- Link to a table outside the PI AF server. See [Access to Microsoft Access](#).

Conversion settings for time zones

The precise time conversion calculation depends on:

- The value that you select in the **Time Zone** list. Times are prefixed with either Universal Coordinated Time (UTC), Greenwich Mean Time (GMT), or Time Zone (TZ). The list also includes the None option.
- Whether you selected or cleared the **Convert to Local** check box.
- Whether this is an internal (either imported or defined in PI AF) or external (linked) table.

The following table explains how displayed times are determined for each possible combination. The exact options in the Time Zone list are dependent on your operating system.

Time zone	Convert to local	Internal/external	Behavior
None	✓	Internal	Fields that contain DateTime data type are automatically adjusted for time zone differences and return local times on the client.
		External	Fields that contain DateTime data type are assumed to be in the time zone of the PI AF server and are adjusted to the client's local time.
None	✗	Internal	Fields that contain DateTime data type are not translated. Useful for storing date fields where translation is not desired, such as birth date.

Time zone	Convert to local	Internal/external	Behavior
		External	Fields that contain DateTime data type are not translated. Useful for storing date fields where translation is not desired, such as birth date.
<i>UTC or GMT</i>	✓	Internal	Fields that contain DateTime data type are adjusted to local times on the client.
		External	Fields that contain DateTime data type are externally stored as UTC, but adjusted to local time on the client, represented as UTC.
<i>UTC or GMT</i>	✗	Internal	Fields that contain DateTime data type are always represented as UTC.
		External	Fields that contain DateTime data type are externally stored as UTC, and left as UTC on the client.
<i>TZ</i>	✓	Internal	Fields that contain DateTime data type are adjusted for time zone differences and are local time on the client. This combination is not normally needed except when external data is being imported into PI System Explorer.
		External	Fields that contain DateTime data type are adjusted for time zone differences, and are adjusted to local time on the client, represented as UTC.

Time zone	Convert to local	Internal/external	Behavior
TZ	X	Internal	Fields that contain DateTime data type are left in the time zone specified. A table lookup data reference adjusts as appropriate; however, other applications may not.
		External	Fields that contain DateTime data type are left in the original time zone specified, represented as UTC. A table lookup data reference adjusts as appropriate; however, other applications may not.

Create table column definitions

To create a table manually, begin by defining the columns in the table.

- Once you have completed the overall table settings on the **General** tab, click the **Define Table** tab.
- Determine the number of columns in the table and click  once for each column to be defined.
- Click the **Name** cell and replace the default label with the required column name.
- Click the adjacent **Value Type** cell and select a data type from a list of **Basic Types** or **Array Types**. For a description of data types, see [PI AF data types](#).

Tip: If any value type is set to DateTime or String, leave the column time zone value set to **None** and select a time zone value for the table overall in the **Time Zone** field on the **General** tab. That value supersedes time zones set on specific table columns.

- Optional. Click the **Unit of Measure** cell and choose one of the following actions:
 - Start typing and select a unit of measure from the list of matching UOMs.
 - Click  and select from the full list of UOMs.

Tip: We recommend you set a unit of measure for a table column so you do not need to specify one each time you select the column in a table lookup data reference.

- Optional. For any column you assign a Byte Array value type, you can set **Use Image** to True. PI System Explorer attempts to display the array as an image.
- Repeat steps 3 to 6 for each column in the table.
- To modify the table column definition, right-click a row in the grid and select an option. Alternatively, use the following icons.

To ...	Do this ...
Insert a new column	Click  .
Move a column up a row	Select a row below the top row and click  .
Move a column down a row	Select a row above the bottom row and click  .
Remove a column	Select a column and click  .

When you have completed defining table columns, click the **Table** tab so you can enter row data for each column manually.

Populate tables manually

Once you have completed table column definitions, enter row data for each column.

1. Click the **Table** tab. Based on the table columns that you created in the **Define Table** tab, enter the appropriate information in rows for each column.
2. Choose from the following actions:

To ...	Do this ...
Enter a new row	Right-click in the table grid and click Insert or New .
Copy and paste rows from an Excel spreadsheet	<ol style="list-style-type: none"> a. In the spreadsheet, copy the rows you want. b. In the table grid, right-click a new row or a range of rows and click Paste.
Replace data for specific cells	<ol style="list-style-type: none"> a. Use standard Windows selection keystrokes (such as SHIFT+<click> and CTRL+<click>) to select contiguous and non-contiguous cells in the table, as described in Select multiple objects in the viewer. b. Right-click and click Clear Cell(s). c. Enter new data in the cleared cells.
Remove a row	Right-click the row you want to remove and click Delete .

3. To save your work, press CTRL+S or click **Check In**.

Data references from outside the PI System

You can also use PI AF tables to access data that is external to the PI System. Such data might be contained in Microsoft Excel, Access, or SQL Server, or other OLE DB/ODBC data sources. You can either import the table or link to it after you have defined the table structure, as described in [Create PI AF tables](#) and [Create table column](#)

definitions.

Imported tables

PI AF tables with imported data are called imported tables. Imported tables are read/write tables. They are limited in size but are more secure than linked tables. Imported tables are sometimes called internal tables because, unlike linked tables, the table data is managed in PI AF. After the initial import, there is no further relationship between the foreign table and the PI AF table. You can edit the data directly in PI AF.

It is a good practice to limit your imported tables to 10,000 rows of data or less. Imported tables are not designed for storing very large databases. If you need to access a lot of data in PI AF tables, link to external tables instead, which do not present such storage limits. Alternatively, break the table into separate tables when importing.

Linked tables

Linked tables are sometimes called external tables, because the source data is not stored in the PI AF database. You cannot edit an external table from PI AF. Linked tables require additional security configuration because you need to configure how PI AF connects to the external data source. You should set up a reusable table connection, where you configure the type of authentication to access the external table.

Videos

For information on how to import data from external tables, watch this video:

For information on how to link to data in external tables, as well as SQL security, watch this video:

Authentication for linked tables

When a client application requests external data, the PI AF server queries the external data source and returns the data to the client as a read-only PI AF table.

For externally linked tables, the OLE DB provider and the PI AF server should share the same bitness (32-bit or 64-bit). To configure an external table connection in PI System Explorer, for example, you would use a PI AF server of the same bitness (typically, 64-bit).

When you configure the linked table, you must specify the credentials that the PI AF server uses to connect to the database. The authentication options are:

- **Impersonate Client**

If the source database supports Windows authentication, use the Windows identity of the client that is requesting the data. This is an impersonated connection. This is the most secure method of authentication and should be used wherever possible.

- **Supply Password**

If the source database does not support Windows authentication, or if the database and PI AF server are on different, non-trusted domains, specify a user name and password with the necessary access on the source database. PI AF uses this hard-coded account to read the data in the external data source. For example, MySQL database does not support Windows authentication, so you would use the user name and password of an account on the MySQL database.

Note: You can enter a user ID and password as part of the connection string and save it with a PI AF table connection, regardless of whether support for external PI AF tables for non-impersonated users has been previously enabled (with the *afdiag /DTImp* command).

- **No additional security context**

This option usually applies when you use Excel or other file-based data sources; otherwise every user needs to be granted read access to the file on the server. With this option, the external table will be accessed using the PI AF server's identity. In this case, you do not need to specify a username or password when configuring the linked table, nor is Kerberos configuration required.

Caution: Take care to configure SQL security in such a way that the PI AF server's identity does not have more privilege than necessary to retrieve the data. Only PI AF administrators are allowed to configure external tables for security reasons. For that reason, ensure that the PI AF Administrators identity and the **Admin** access right are assigned to only a limited set of users when this connection mode is enabled.

Restrictions on non-impersonated connections

Because there are security risks for linked tables that use non-impersonated connections, some PI AF server system administrators restrict or prevent their use. Your system administrator might:

- Require administrative privileges on the PI AF server and write privileges on the PI AF table.
- Prevent creation of linked PI AF tables with non-impersonated connection.
- Prevent creation of any linked tables.

If you have problems with linked tables, consult your system administrator about the PI AF server external table settings.

Risk of using non-impersonated connections

Depending on the configuration of the SQL Server, a user with PI AF administrator privileges could create attacks on the SQL Server and take full control of the system if these following conditions exist:

- A PI AF table is configured to use the PI AF server identity for linking to an external database.
- Non-impersonated linked (external) tables are enabled on the PI AF server.

By default, non-impersonated linked tables are disabled on the PI AF server. In order for a user to execute an attack, that user would need to enable non-impersonated external tables.

- The PI AF server account has administrative rights on a SQL Server.

By default, the PI AF server runs under a virtual account, NT SERVICE\AFService, and does not have administrative rights to the locally-configured SQL Server or access to remote computer databases. Without administrator rights to the remote database, the possibility for elevation of privilege attacks is limited.

Caution: For security reasons, do not grant the PI AF server administrative privileges on the computer or SQL Server when running with non-impersonated queries.

Data access recommendations for linked tables

Observe the following guidelines for linked tables:

- If access to linked tables is not needed, disable it altogether.
- Do not grant the PI AF Application Service account administrative privileges on the PI AF server or SQL Server when running with non-impersonated queries.
- You must have administrative privileges on the PI AF server to configure an external table that runs non-impersonated queries.

Security settings for linked tables

You use the PI AF Diagnostics utility (**afdiag** located in the **%PIHOME64%\AF** folder) to enable or disable support for external PI AF tables. Since the utility makes a direct connection with the associated SQL Server database, the SQL Server sysadmin or db_AFadmin role is required.

Use the PI AF Diagnostics utility to adjust security settings for external tables.

Task	Command	Default Setting
Enable support for external PI AF tables	afdiag /DT	enabled
Disable support for external PI AF tables	afdiag /DT-	
Enable support for external PI AF tables for non-impersonated users	afdiag /DTImp	disabled
Disable support for external PI AF tables for non-impersonated users	afdiag /DTImp-	
Change security settings for a specific PI AF table	In the Library browser, right-click on the table and click Security .	By default, table configuration requires administrative privileges on the PI AF server.
Change security settings for all tables	In the Library browser, right-click on Tables and click Security .	By default, table configuration requires administrative privileges on the PI AF server.

Note: You do not have to enable support for external PI AF tables for non-impersonated users. You can include a user ID and password as part of the connection string in a PI AF table connection and check it in, regardless of whether support for external PI AF tables for non-impersonated users is enabled. The defined PI AF table connection can be used within a PI AF table definition. This means that if a SQL Server Login has permission to access the data referenced in the connection string, a PI AF table linked to that PI AF table connection can retrieve the external data.

Create reusable table connections

Use the 64-bit PI System Explorer to configure connections to linked tables. It includes 64-bit OLE DB drivers, which are required for the 64-bit PI AF Server.

Create an OLE DB connection and reuse it to configure linked tables from the same data source.

1. In the navigator, click **Library**.
2. Choose from the following actions:
 - Select **Table Connections** and click **New Table Connection** on the toolbar.
 - From the browser, right-click **Table Connections** and click **New Table Connection**.

Table connection properties are displayed in the viewer with a default name in the **Name** field.

3. Optional. Edit the default name and add a description for the table connection in the **Description** field.

4. In the **Connection** field, you can either enter a connection string directly, or click **Build** to configure the connection in the Data Link Properties window.
5. In the **Provider** tab of Data Link Properties, choose an OLE DB provider and follow onscreen instructions to configure the connection.
6. Depending on the provider selected, you may need to specify the data source and location, server name, user name, password, and/or database.
7. Click **OK**.

The connection string for the reusable table connection is displayed in the **Connection** field.

8. If prompted, enter a password and click **OK**.

9. In the viewer, select a **Security** option.

Some options may not be available.

- **Impersonate Client** (recommended)
- **Supply Password**

Note: You can use the **Change Password** button to change the SQL Server password required for the table connection.

- **No additional security context**

See [Authentication for linked tables](#) for information on these options.

10. On the toolbar, click **Check In** to check in and save the table connection.

Access to Microsoft Access

To access data from a Microsoft Access database, you can link or import the data. The data in a linked table is refreshed when the table is accessed and whenever the time since the last refresh exceeds the table's **Cache Interval** setting.

Imported data is loaded into the PI AF table once. If you ever need to refresh the imported data in a table, you can right-click the table in the Library browser and click **Re-Import Table**.

You can link to or import data from a Microsoft Access table after you perform the following steps:

- Specify the source database.
- Create a query that returns the desired data.
- Enter any login credentials required to access the database.

The exact instructions depend on your hardware configuration and what you are trying to do:

32-bit PI AF server	Follow the instructions in Link or import data .
64-bit PI AF server	<ul style="list-style-type: none">• To import, follow the instructions in Link or import data.• To link, follow the instructions in Link to data on a 64-bit PI AF server.

Link or import data

These instructions describe how to import data on a 32-bit or 64-bit PI AF server and how to link to data from a

32-bit PI AF server only. To link to data from a 64-bit server, see [Link to data on a 64-bit PI AF server](#).

Important: We do not recommend using Excel files for linked tables. See the KB article: [Do not link AF tables to Excel files](#).

1. In PI System Explorer, navigate to the PI AF table or create one as described in [Create PI AF tables](#).
2. In the **Library** pane, expand the **Tables** node, and click the desired PI AF table.
The table details display in the right pane.
3. Click **Link or Import**.
The corresponding window opens.
4. Link only: If you are linking the table, enable the **Impersonate Client** option (not displayed for Import).
5. Click **Build**.
The Data Link Properties window opens.
6. On the **Provider** tab, select the provider according to the version of Microsoft Office that you are using and click **Next**.
 - Office 97-2003: select **Microsoft Jet 4.0 OLE DB Provider**.
 - Office 2007 and higher: select **Microsoft Office 12.0 Access Database Engine OLE DB Provider**.
7. On the **Connection** tab, specify the following and click **OK**.
 - **Data Source**
The location and file name of the database (such as **C:\AFTTestData.accdb**). If you are linking, the path to the file must be relative to the PI AF server.
 - **User Name**
Login credentials of a user that has been granted read access to the database.

Note: To store the password with the connection information, select the **Allow Saving Password** check box. The password is stored as plain text (not encrypted).
8. On the **Advanced** tab, in the **Access permissions** list, select **Share Deny None**.
9. To verify that the spreadsheet is accessible, return to the **Connection** tab and click **Test Connection**.
If the settings are valid, a Test connection succeeded message displays.
10. To dismiss the window and return to PI System Explorer, click **OK**.
11. To define the data to be returned from the spreadsheet, enter an SQL query in the **Query** field. To dismiss the window, click **OK**.
 - Microsoft Access example: *SELECT * FROM Table1*
12. To review the resulting data, examine the **Table** tab. If the query is specified correctly, the tab contains a table displaying the results.
13. To save your changes, right-click the table node and choose **Check In**.

[Link to data on a 64-bit PI AF server](#)

To link to data in an Access database on a 64-bit PI AF server, you must use the 64-bit Access Database Engine (ACE) data provider; there is no 64-bit Jet data provider.

Important: We do not recommend using Excel files for linked tables. See the KB article: [Do not link AF tables to Excel files](#).

1. In PI System Explorer, navigate to the PI AF table or create one as described in [Create PI AF tables](#).
2. In the **Library** pane, expand the **Tables** node, and click the desired PI AF table.
The table details display in the right pane.
3. Click **Link**.
The corresponding window opens.
4. Enable the **Impersonate Client** option.
5. In the **Connection** field, enter a valid connection string for the Access database, using the Microsoft Office 12.0 Access Database Engine OLE DB Provider (must be installed on the PI AF server), as in the following example:
 - Microsoft Access example:

```
Provider=Microsoft.ACE.OLEDB.12.0;Data Source=c:\example.accdb;Persist Security Info=False;
```
6. To define the data to be returned from the spreadsheet, enter an SQL query in the **Query** field. To dismiss the window, click **OK**.
 - Microsoft Access example: *SELECT * FROM Table1*
7. To review the resulting data, examine the **Table** tab. If the query is specified correctly, the tab contains a table displaying the results.
8. To save your changes, right-click the table node and choose **Check In**.

Access to SQL Server data

When you import data from or link to data in a Microsoft SQL Server table, you must define valid connection information. The steps for linking or importing depend on the connection method that you choose, as described in [Authentication for linked tables](#).

Use Windows impersonated security connection

Link to or import data from a SQL Server table with the **Impersonate Client** option. See [Data access recommendations for linked tables](#).

Note: If linking to a SQL Server that is not on the same computer as the PI AF server, it may be necessary to configure Kerberos to allow the client's identity to be forwarded from the PI AF server to the SQL Server.

1. [Create a local user group for impersonated clients](#).
2. [Configure security on the target table's database](#).
3. [Import or link SQL server tables](#).

Create a local user group for impersonated clients

If the table to which you want to connect resides in a SQL Server instance other than the one where the PI AF SQL database (PIFD) resides, ensure that the table is accessible via Windows authentication.

1. On the computer where the SQL Server instance resides, click **Start > Administrative Tools > Computer Management**.

- The Computer Management application starts.
2. Expand **Local Users and Groups**.
 3. Right-click **Groups** and choose **New Group**.
 4. In the New Group window, create a local user group for the users that require access to the database table.
 5. Add to this group the accounts of all users that might be impersonated.
 6. Click **OK** to add the selected users, and then click **Close** to dismiss the New Group window.
 7. Close the Computer Management application.

Use Windows non-impersonated security

Link to or import from a SQL Server table with the no additional security context option.

1. Create a local user group for PI AF application service account
2. Configure security on the target table's database
3. Import or link SQL server tables

Create a local user group for PI AF application service account

If the table to which you want to connect resides in a SQL Server instance other than the one where the PI AF database (PIFD) resides, ensure that the table is accessible to the PI AF application service account.

1. On the computer where the SQL Server Instance resides, click **Start > Administrative Tools > Computer Management**.
The Computer Management application starts.
2. Expand **Local Users and Groups**.
3. Right-click **Groups** and choose **New Group**.
4. In the New Group window, create a local user group to hold the identity of the PI AF Server Application Service.
5. Add the account of the user associated with the PI AF Server Application Service to the new group. If the PI AF Server Application Service is running under the NT AUTHORITY\NetworkService account, then add the PI AF server's computer account to this group.

Note: If the PI AF Server Application Service is running as the Local System or Local Service account, you most likely need to use SQL Server authentication (SQL Server and Windows authentication mode) instead of Integrated security. In order to avoid malicious attacks on the SQL Server, do not use Local System. Instead use the Network Service or Local Service account or a specifically created account with limited privileges.

6. Click **OK** to add the selected user.
7. Close the Computer Management application.

Use SQL Server security

If you are connecting to a remote SQL Server instance, ensure SQL Server is configured to accept Remote Connections.

If you are using a SQL Server account, ensure the SQL Server instance is configured to allow mixed mode authentication.

Link or import data from a SQL Server table using SQL Server authentication.

1. [Create a SQL Server user.](#)
2. [Configure security on the target table's database.](#)
3. [Import or link SQL server tables.](#)

Create a SQL Server user

If the target table (the table to which you want to connect) resides in a SQL Server instance other than the one in which the PI AF database (PIFD) resides, create a user and enable database access for the user as described in this topic.

1. Open Microsoft SQL Server Management Studio and connect to the SQL Server Instance that contains the target table.
2. Under the SQL Server Instance, expand the Security folder and then expand the Logins folder.
3. Create a new Login and enter a name in the **Login Name** field.
4. Select the **SQL Server Authentication** option.
5. Enter the password in the **Password** and **Confirm Password** fields.
6. From the **Default Database** list, select the database that contains the target table.
7. Select the **User Mapping** page.
8. Select the row for the Database that contains the target table.
9. Select the **Map** check box for the selected database.
10. Click **OK** to close the Login – New window and save the new Login.
11. Expand the **Databases** folder, then the folder for the target database, and grant the necessary permission to execute the query that will be used to the Login just created.
For example, if the query that will be used is a SELECT statement that specifies a single table, expand the **Tables** folder for the target database, expand the **Tables** folder, then right-click the table to which the query refers and choose **Properties**.
12. In the Table Properties window, select the **Permissions** page, then the Login, then **Grant the Login the Select Permission**. Click **OK** to close the Table Properties window.
13. Close Microsoft SQL Server Management Studio.

Configure security on the target table's database

Any account under which the specified query might be executed needs to be granted permission to execute that query.

1. Open Microsoft SQL Server Management Studio and connect to the SQL Server Instance that contains the target table.
2. Under the SQL Server Instance, expand the **Security** folder, and then expand the **Logins** folder.
3. Right-click the **Logins** folder and choose **New Login**.
4. Use the **Search** button to find the group created in the previous section and choose that group for the Login name.
5. Select the **Windows authentication** option, and select the database that contains the target table as the *Default database*.
6. Select the User Mapping page.
7. Select the row for the Database that contains the target table.
8. Select the **Map** check box for the selected database.
9. Expand the **Databases** folder, then the folder for the target database, and grant the necessary permission to execute the query that will be used to the Login just created.
For example, if the query that will be used is a *SELECT* statement that specifies a single table, expand the **Tables** folder for the target database, expand the **Tables** folder, then right-click the table to which the query refers and choose **Properties**.
10. In the Table Properties window, select the **Permissions** page, search for and select **Login**, then **Grant the Login the Select Permission** and click **OK** to close the Table Properties window.
11. Close Microsoft SQL Server Management Studio.

Import or link SQL server tables

Whether you are importing from or linking to Microsoft SQL Server tables, the process is essentially the same. The following instructions describe how to link to an existing PI AF table using the PI System Explorer.

1. To browse to the target PI AF table, display the **Library** pane, expand the **Tables** node, and click the desired table.
Table properties display in the right pane.
2. Click **Link**.
The Table Link window opens.
3. Click the **Connection** down arrow, then click **Build**.
The Data Link Properties window opens.
4. On the **Provider** tab, select **SQL Server Native Client 11.0**.
5. On the **Connection** tab, configure the SQL Server instance that contains the database to which you want to connect.
6. Configure authentication:
 - For Integrated security, select the Use Windows NT Integrated Security option. See [Authentication for linked tables](#) for more information.
 - For SQL Server security, select the Use a Specific user name and password option. Then, enter the SQL Server Login name in the **User Name** field. Click to unselect the **Blank password** checkbox and specify that a password be required. Enter a password in the **Password** field.

Note: Ensure that support for external PI AF tables for non-impersonated users has been enabled with the **afdiag /DTImp** command.

7. Click the Select the database down arrow and choose the database that contains the table to which you want to connect.
8. To verify that connection settings work, click **Test Connection**. If the settings are correct, PI System Explorer displays a success message.

Note: Test Connection verifies that the account with which the PI System Explorer is running has access to the specified database. However, if you choose Windows NT Integrated Security in the Table definition and choose the No additional security context option for table connection security, the account associated with the PI AF Server Application Service is used to connect when a user displays the data by viewing the **Table** tab.

9. Click **OK**.
10. If prompted, enter a password and click **OK**.
You are returned to the Table Link window.
11. In the **Query** field, specify the SQL query that returns the desired data and click **OK**.
If the connection string requires a user ID and password, select the Supply password option. To change the password used to connect to the SQL table, click the **Change Password** button and enter the new SQL login password. This replaces the value previously entered in the **Password** field.
12. To display the data retrieved by the query, view the **Table** tab.
13. On the toolbar, click **Check In** to check in and save the table connection.

Remove control characters from imported AF tables

After importing or linking data from an external data source, you should inspect AF tables for control characters, such as carriage returns and line feeds prior to executing a query. The presence of control characters can cause an AF table lookup query to fail. Remove control characters from these tables to avoid issues with retrieving query results. See [WHERE clause syntax](#) for information on using the WHERE clause to obtain values from a table column in a table lookup data reference.

In AF tables, cells highlighted in yellow indicate the presence of control characters. If the table contains imported data, you can view and remove control characters using the Text Visualizer text box.

Note: Cells that contain control characters in linked tables are also highlighted. You can use the Text Visualizer to view these control characters, but you cannot edit or remove them.

1. In the Library browser, navigate to the imported or linked table.
2. Click the **Table** tab.
3. On the **Table** tab, locate cells highlighted in yellow.
4. Place your mouse pointer over the highlighted cell and then click the cell.
A tool tip displays the cell contents and the <*Contains Control Characters*> text.
5. Right-click the highlighted cell, then click **Show Selected Cell's Content**.
The Text Visualizer text box opens.
6. Click the **Show Control Characters** check box to display all control characters in the cell.

Note: The Text Visualizer text box is read-only when control characters are displayed. You cannot edit cell contents or delete control characters in an imported table when the **Show Control Characters** option is selected. You must deselect the **Show Control Characters** option before you can edit cell contents in an imported table.

7. Click the **Show Control Characters** check box to deselect the option and hide all control characters.
8. Optional: If you have imported data into an AF table, you can remove all control characters, such as carriage returns (<CR>), spaces (·), and line feeds (<LF>), to ensure only essential characters remain.
9. When all control characters have been deleted, click **OK**.
The cell is no longer highlighted in yellow after control characters have been removed.
10. Repeat steps 3-9 to continue viewing and removing control characters in an imported table.
11. To save your work, right-click the table in the Library browser and select **Check In**.

Configure table lookup data references

Create a table lookup data reference when you want an attribute to obtain its value from a table column.

1. In the Elements or Library browser, select the desired element or element template.
2. In the viewer, select the attribute or attribute template for which you want a table lookup value.
3. In the **Data Reference** field in the palette, choose **Table Lookup** from the list.
4. Click **Settings**.
5. In the Table Lookup Data Reference window, select a previously defined table from the **Table** drop-down list.
You can also choose from the following options:
 - Click  (Manage Tables) to open a list of tables you can search or filter. To select a table, highlight it in the list and click **OK**.
 - Click  (Table Properties) to view or edit properties for the selected table.
 - Click  (Create New Table) to define a new table.
6. From the **Result column** list, select the column in the table from which you want to read the value.

Note: Select the **Stepped** check box for the value to be stepped when plotted in a trend. With this setting, there is no interpolation between the table values.

7. From the **Unit of Measure** list, select the appropriate unit of measure in which the data in the result column is stored.

Note: It is preferable to set the UOM directly in the table definition so that you do not need to specify it with each table lookup.

8. In **Time Zone**, you can define a setting if it has not previously been set in the table or column definition.
9. From the **Rule** list, choose an option:
 - Select first row matching criteria
Use the **Order by** list to specify the sorting order. This order is used to select a row when more than one row matches the criteria. For more information, see [Select first row matching criteria](#).
 - Summarize all rows matching criteria
Select a summary operation from the **Summary** list to perform the selected operation on the selected column over the range of rows that match the criteria. For more information, see [Summarize all rows matching criteria](#).
 - Table provided time series data
Choose this option if the table has values with associated time stamps and you wish to treat these values as time series data. From the **Time Column** list, select the table column that contains the time stamps

you want to use. Only columns with a value type of DateTime are listed. The WHERE clause is not required when you choose this option. For more information, see [Table provided time series data](#).

Note: To ensure that columns with DateTime value types are displayed, only specify time zone settings on the **General** tab of the overall table definition. Do not specify time zones on the column definition (on the **Define Table** tab).

10. In the **Where** pane, use the menus and buttons to build the table query.

Note: You can manually type the entire clause into the **Complete WHERE Clause** text field. See [WHERE clause syntax](#) for more information.

- From the **Column** list, select the column of the table to use in the query.
- From the **Operator** list, select the relational operator to use in the query.
- From the **Attribute or Value** list, select an attribute or a literal value to use in the query.
- Click **Add And** or **Add Or** to write the WHERE clause into the **Complete WHERE Clause** field with an AND or an OR operator.
- Edit the clause in the **Complete WHERE Clause** field as needed.

Note: The **Add And** or **Add Or** buttons automatically generate the necessary syntax, UOM, and time zone conversions when possible.

11. Optional. Edit values for table parameters.

Table parameters apply only to linked tables. For more information, see [Parameters for linked table queries](#).

12. Optional. For **Replacement Values**, choose attributes or literal values to return when the table query cannot find a matching row or encounters a null result.

Select first row matching criteria

The Select first row matching criteria rule enables you to specify the first row that matches the value returned from the WHERE clause.

Syntax

```
SELECT column FROM table WHERE where clause ORDER BY column ASC|DESC; options and  
parameters
```

Arguments

- **SELECT column**

If a column name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **FROM table**

If a table name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **WHERE clause**

In addition to =, <>, >, >=, <, <=, LIKE, and IN relational operators, you can specify INTERPOLATE to interpolate a value for the result column based on an interpolation of the specified input columns.

Beginning with PI AF 2018, you can perform two kinds of interpolation:

- Linear interpolation, in which interpolation is for 2 columns of data. To specify linear interpolation, use

INTERPOLATE(*column*, *value*) syntax.

- Standard bilinear interpolation, in which interpolation is for 3 columns of data. To specify bilinear interpolation, use INTERPOLATE(*column_X,value_X*) AND INTERPOLATE(*column_Y,value_Y*) syntax. Irregular bilinear interpolation and bilinear extrapolation are not currently supported.

Note: The default behavior of the INTERPOLATE operator is to extrapolate if the input value is outside the observed table range. Note also that extrapolation behavior changes when the **Stepped** check box is selected.

For more information on WHERE clause syntax, see [WHERE clause syntax](#). For examples of INTERPOLATE operator usage, see [Examples of linear and bilinear interpolation in table lookup data references](#).

- **ORDER BY column**

Optional. Specifies the sorting order so that the correct row is used when more than one row matches the WHERE clause. Ascending (*ASC*) order is the default unless descending (*DESC*) is specified.

- **Options**

You can enter the following options in a list separated by semicolons.

Stepped	When set to True, the returned value plots as stepped in applications.
TZ= <i>time zone</i>	Specifies the time zone of the source table. Note: Set the time zone in the general description of the table, so that you do not need to specify it with each table lookup.
UOM= <i>uom</i>	Specifies the unit of measure for the value returned by the result column. Note: You can also set the unit of measure in the table column definition, so that you do not need to specify it with each table lookup.
RWM= <i>value</i>	Specifies the value to return when there is no column match. If the value is No Data, the digital state of <i>No Data</i> is returned.
RWN= <i>value</i>	Specifies the value to return when the result column is null. If the value is No Data, the digital state of <i>No Data</i> is returned.

- **Parameters**

You can enter parameters in a list separated by semicolons. Begin each parameter name with the @ character in @*parameter*=*value* format (*value* is described in "Attribute or Value" in [WHERE clause syntax](#)). For additional information on using parameters, see [Parameters for linked table queries](#).

Example

```
SELECT [Installation Date] FROM [Equipment Specifications] WHERE [Asset ID] = '%Element%'
```

Examples of linear and bilinear interpolation in table lookup data references

Linear interpolation example

In a tank strapping table that contains a *Level* column and a *Volume* column, the following configuration string interpolates the volume based on the level reading:

```
SELECT Volume FROM MyTable WHERE INTERPOLATE(Level, @MyLevelReading)
```

Assume the sample table has the following rows:

Level	Volume
1	0.0
2	20.0
3	30.0
4	40.0
5	60.0
6	70.0

- A *Level* reading of 2.2 results in a returned *Volume* of 22.0.
- A *Level* reading of 2.7 results in a returned *Volume* of 20.0 when **Stepped** is selected (true).
- Extrapolation: A *Level* reading of 6.5 results in a returned *Volume* of 75.0 when **Stepped** is cleared (false).
- Extrapolation: A *Level* reading of 6.5 results in a returned *Volume* or 70.0 when **Stepped** is selected (true).

Bilinear interpolation example

In an air velocity table that contains an *X Horizontal Position* column, a *Y Vertical Position* column, and a *Velocity* column, the following configuration string interpolates the velocity based on the X horizontal and Y vertical positions.

```
SELECT Velocity FROM Table1 WHERE INTERPOLATE([X Horizontal Position], @X) AND  
INTERPOLATE([Y Vertical Position], @Y)
```

Assume the sample table has the following rows:

X Horizontal Position	Y Vertical Position	Velocity
180	140	4.6
220	140	4.1
260	140	2.7
180	180	4.8
220	180	4.4

260	180	2.5
180	220	4.5
220	220	4.4
260	220	2.5

An X *Horizontal Position* of 245 and a Y *Vertical Position* of 165 results in a returned *Velocity* of 3.2171875.

Summarize all rows matching criteria

The Summarize all rows matching criteria rule enables you to perform a summary operation on the rows in a table column that match your selection criteria.

Syntax

```
SELECT summary(column) FROM table WHERE where clause; options and parameters
```

Arguments

- **SELECT summary(column)**

If a column name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

You can select one of the following summary operations.

Operation	Description
Sum	The total of all row values.
Avg	The average of all row values.
Min	The minimum value of all rows.
Max	The maximum value of all rows.
Count	The number of rows.
StDev	The extent of deviation for all row values.
Var	The average measure of how far all row values differ from the mean.
None	When no operation is specified: <ul style="list-style-type: none"> • If the result attribute is not an array, the value of the selected column in the first row that matches the WHERE clause is returned. • If the result attribute is an array, an array with one value from each column of all rows that

Operation	Description
	match the WHERE clause is returned.

- **FROM table**

If a table name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **WHERE clause**

For more information on WHERE clause syntax, see [WHERE clause syntax](#).

- **Options**

You can enter the following options in a list separated by semicolons.

Stepped	When set to True, the returned value plots as stepped in applications.
TZ= <i>time zone</i>	Specifies the time zone of the source table. Note: Set the time zone in the general description of the table, so that you do not need to specify it with each table lookup.
UOM= <i>uom</i>	Specifies the unit of measure for the value returned by the result column. Note: You can also set the unit of measure in the table column definition, so that you do not need to specify it with each table lookup.
RWM= <i>value</i>	Specifies the value to return when there is no column match. If the value is No Data, the digital state of No Data is returned.
RWN= <i>value</i>	Specifies the value to return when the result column is null. If the value is No Data, the digital state of No Data is returned.

- **Parameters**

You can enter parameters in a list separated by semicolons. Begin each parameter name with the @ character in *@parameter=value* format (*value* is described in "Attribute or Value" in [WHERE clause syntax](#)). For additional information on using parameters, see [Parameters for linked table queries](#).

Table provided time series data

The Table provided time series data rule enables you to select a table containing values with a DateTime data type, and specify the column that contains time series data.

Syntax

```
SELECT column FROM table WHERE where clause; TC=column; options and parameters
```

Arguments

- **SELECT column**

If a column name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **FROM table**

If a table name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **WHERE clause**

Optional. For more information on WHERE clause syntax, see [WHERE clause syntax](#).

- **TC column**

Specifies the column that contains timestamp values. If a column name contains non-alphanumeric characters, including spaces, it must be enclosed in [] brackets.

- **Options**

You can enter the following options in a list separated by semicolons.

Stepped	When set to True, the returned value plots as stepped in applications.
TZ= <i>time zone</i>	Not supported at the column level. You need to specify the time zone in the Time Zone field on the General tab for the overall table.
UOM= <i>uom</i>	Specifies the unit of measure for the value returned by the result column. Note: You can also set the unit of measure in the table column definition, so that you do not need to specify it with each table lookup.
RWM= <i>value</i>	Specifies the value to return when there is no column match. If the value is No Data, the digital state of No Data is returned.
RWN= <i>value</i>	Specifies the value to return when the result column is null. If the value is No Data, the digital state of No Data is returned.

- **Parameters**

You can enter parameters in a list separated by semicolons. Begin each parameter name with the @ character in *@parameter=value* format (*value* is described in "Attribute or Value" in [WHERE clause syntax](#)). For additional information on using parameters, see [Parameters for linked table queries](#).

Example

In the following example,

```
SELECT [Installation Date] FROM location; WHERE RowID =@id; TZ=China Standard Time;  
TC=Installation Date
```

WHERE clause syntax

The WHERE clause uses SQL syntax and conforms in general to the syntax described on the MSDN [DataColumn.Expression Property](#) page. You can type the clause directly into the **Complete WHERE Clause** field in the Table Lookup Data Reference window, or allow PSE to provide the correct syntax by using the **Column**, **Operator**, and **Attribute or Value** lists in the **Where** section. The WHERE clause is optional for the Table provided time series data rule.

The WHERE clause syntax follows these guidelines.

Column	Column names that contain non-alphanumeric symbols must be surrounded by brackets: <i>[Asset ID] = '%Element%'</i>
Operator	<ul style="list-style-type: none">The INTERPOLATE operator is available with the Select first row matching criteria rule.The comparison operators =, <>, >, >=, <, <=, IN, and LIKE are supported for all lookup rules. <p>You can use the * and % characters interchangeably for wildcard characters in a LIKE comparison. A wildcard is allowed at the start and end of a pattern, or at the end of a pattern, or at the start of a pattern, but not in the middle of a string. If the string in a LIKE clause contains a * or %, those characters should be enclosed in [] brackets.</p>
Attribute or Value	<p><i>@attribute</i></p> <p>Returns the value of the PI AF attribute. The attribute must be enclosed in [] brackets if it contains any non-alphanumeric character, including spaces, or includes a UOM or Time Zone specification. For example:</p> <p><i>[height] >= @[Level Gauge;UOM=m]</i></p> <p><i>literal</i></p> <ul style="list-style-type: none">Strings should be enclosed in single quotes.Numeric values are not quoted and should be in invariant format (where the decimal character is '.').Timestamps are best specified in yyyy.mm.dd hh.mm.ss format (0-23 for hh), and enclosed in the # character. For example:#2015.01.30 14:00:00# <p><i>substitution</i></p>

Select or enter a substitution parameter in '%substitution parameter%' format. For more information on substitution parameters, see [List of PI AF substitution parameters](#).

The Like and IN operators

The LIKE and IN operators enable you to specify a non-exact match for query results in a WHERE clause. Use the % character to specify zero, one or multiple characters at the beginning or end of a string.

Note: You can use the LIKE and IN operators as an alternative to the = operator when query results cannot be retrieved from a table due to the presence of control characters. See [Remove control characters from imported AF tables](#) for more information on removing control characters from an imported AF table.

Failed query example

In the following example, no data is returned by the query because the search value (ValueA) is located in a cell that contains control characters and the = operator specifies an exact match on a value in the same cell. The presence of control characters prevents the SELECT statement from returning an exact match.

```
SELECT ColumnB FROM Table1 WHERE ColumnA = 'ValueA'
```

Successful query examples

You can use the LIKE or IN operators to specify a non-exact match from a column that contains control characters. Consider the following examples that execute a successful search for data in MyTable. Both ColumnA and ColumnB contain control characters.

```
SELECT ColumnA FROM MyTable WHERE ColumnB LIKE '%ValueA%'
```

Another alternative is to use the IN operator to specify multiple values in a WHERE clause.

```
SELECT ColumnA FROM MyTable WHERE ColumnB IN ('ValueA', 'ValueB', 'ValueC')
```

Parameters for linked table queries

The query for a linked table determines which data from an external source to include in the table. You can include parameters in the query, and, as you configure a table lookup data reference that uses the linked table, you can specify parameter values. This enables you to use a single linked table to obtain different results in every table lookup data reference that uses it.

Using parameters in a linked table query is useful, for example, to limit the number of rows returned from a very large external table. You can add conditions and parameters to return more targeted results, such as all rows that include a device or manufacturer ID number, specific for each table lookup data reference.

As you configure a linked table in the Table Link window, you can add table parameters to its query and set default values for them. Then, in the Table Lookup Data Reference window, as you define a data reference using the linked table, you can enter table parameter values specific for that data reference. You can also supply parameter values programmatically using AF SDK. Parameter values can be specific values or come from other attribute values or from pre-defined substitution variables, such as %Element%.

Add table parameters to a linked table query

As you define a linked table in the Table Link window, you can add parameters to the table query and set default values for them.

1. Edit the text in the **Query** box to include the new parameter(s).
Parameter names must begin with the @ character.
2. Click inside the **Parameters** table to display the new parameters from the query.
3. Enter default values for each parameter to determine the default results from the query and click **OK**.
After you have added parameters to the query, you can specify values for them as you configure a table lookup data reference that uses the linked table.

Example

Consider the following query for a linked table named MyTable. The WHERE clause limits the selection from an external table (BigTable) to those rows with a particular RowID:

```
SELECT * FROM BigTable WHERE RowID = 101
```

Replace the fixed value 101 with a table query parameter @id (note that query parameter names must begin with the @ character):

```
SELECT * FROM BigTable WHERE RowID = @id
```

Now, for every table lookup data reference that uses MyTable, you can supply different table parameter values for @id to get different results from the query.

For example, in the Table Lookup Data Reference window, as you configure a data reference, enter @AssetID for the value of @id in the **Table Parameters** list. This sets @id to the current value of the attribute AssetID. The corresponding query for this would be:

```
SELECT Result FROM MyTable; @id=@AssetId
```

This query returns rows whose RowID matches the current value of AssetID.

URI Builder data references

In previous versions of PI Notifications, you could define a web link or a link to a client application such as PI WebParts or AVEVA PI Vision as content within a notification. However, because the links were disconnected from the elements and attributes in PI System Explorer, only users with PI Notifications installed were able to go find objects referenced in the email notification itself. Also, you could only include dynamic content as a value of a parameter.

With URI Builder in PI AF 2016, you can configure data references that create dynamic links on event frames, transfers, elements or models, and include the same [Attribute references in String Builder](#) and [List of PI AF substitution parameters](#) as other data references such as String Builder or Formula. URI Builder conforms to standard syntax rules (described in the Requests for Comments document [RFC 3986 URI Generic Syntax](#)) and automatically handles the escaping of characters which are complex and cumbersome to enter manually. It supports generic web links (that use http and https schemes), as well as AVEVA PI Vision links.

You can also use PI Notifications 2016 to send the link to other users via electronic mail, an instant messaging client, or a client application such as AVEVA PI Vision.

Create URI Builder data references

When a URI Builder data reference is used in a template, value substitution takes place at run time.

Copy an existing web link or AVEVA PI Vision link and make it dynamic in a URI Builder data reference in which you substitute part of the URI with a value derived from an attribute, an attribute reference or a substitution parameter. You assign the dynamic web link value or AVEVA PI Vision link value to an attribute template or attribute.

1. Open a web browser and locate the web link or the AVEVA PI Vision link you use as a starting point in creating a link value on an attribute template or attribute.
2. Select the entire URI and copy it.
3. In the navigator pane of PI System Explorer, choose from the following actions.

To create a URI data reference on ...	Do this ...
A template	<ol style="list-style-type: none">a. Click Library.b. Expand Templates in the browser tree.c. Choose a template type and select an existing template, or click New Template.
An element	<ol style="list-style-type: none">a. Click Elements.b. Select an existing element in the browser tree, or click New Element.
A model	<ol style="list-style-type: none">a. Click Elements.b. Select an existing model in the browser tree, or right-click and click New Model.
An event frame	<ol style="list-style-type: none">a. Click Event Frames.b. Expand a search collection for event frames in the browser tree.c. Select an existing event frame, or click New Event Frame.
A transfer	<ol style="list-style-type: none">a. Click Event Frames.b. Expand a search collection for transfers in the browser tree.c. Select an existing transfer or click New Transfer.

4. Choose from the following actions.
 - In the **Attribute Templates** tab, select an existing attribute template, or click **New Attribute Template** to create a new attribute template.
 - In the **Attributes** tab, select an existing attribute, or click **New Attribute** to create a new attribute.
5. In the attribute configuration panel, configure the attribute template or attribute as needed, and choose **URI Builder** from the **Data Reference** drop-down list.
6. Click **Settings**.

7. In the URI Builder Data Reference window, click in the **Paste a URI from a web browser to use as a template for configuration** field and paste the URI you copied in step 2.
8. Click **Continue**.

The pasted URI is displayed in the URI Builder Data Reference window, broken down into its **Scheme**, **Address or Host**, **Port**, and **Path** field components. If the URI contains queries and fragments, those are also displayed in the **Query** and **Fragment** fields.

9. In the URI Builder Data Reference window, choose one of the following actions.

To configure ...	Do this ...
A dynamic web link	<p>Modify the components of the pasted URI as needed.</p> <ul style="list-style-type: none">• You can choose between Scheme values of http and https.• You can change the Port value to any number between 1 and 65535. The default values for http and https schemes are 80 and 443 respectively.• To make portions of the Path field dynamic, select a segment. Then click  and select from the following options:<ul style="list-style-type: none">• A list of other attributes for the selected object. Note that attributes must appear in single quotes.• A list of attribute references. You can also select Search to enter search criteria in the Attribute Search window.• A list of commonly used substitution parameters. For more information, see List of PI AF substitution parameters.• In the Query table, you can modify Key and Value settings as needed.<ul style="list-style-type: none">• To add a key, click . In the Key and Value fields, type a value or click  and select from the same options as above.• To delete a parameter, select a key or value and click .
A AVEVA PI Vision link	<ol style="list-style-type: none">a. Click the PI Vision option.b. In the Display field, modify the value as needed. You can also click  and select from the following options:<ol style="list-style-type: none">a. A list of other attributes for the selected object. Note that attributes must appear in

To configure ...	Do this ...
	<p>single quotes.</p> <ul style="list-style-type: none"> b. A list of attribute references. You can also select Search to enter search criteria in the Attribute Search window. c. A list of commonly used substitution parameters. For more information, see List of PI AF substitution parameters. c. In the Parameters table, modify Key and Value settings as needed. <ul style="list-style-type: none"> a. To add a key, click . In the Key field, click , select a parameter and assign a value. In addition to typing a value you can select from the same options as in step b above. b. To delete a parameter, select a key or value and click . <p>When linking to a display on an event frame, URI Builder automatically adds Asset, Start Time and End Time parameters. For more information on other parameters, see the AVEVA PI Vision topic URL parameters reference.</p>

10. Click **OK**.

Units of measure in PI AF

PI AF ships preloaded with numerous standard unit-of-measure classes and conversion factors. You can extend these classes by adding new units of measure, as well as new measurement classes. The implementation of the units of measure (UOM) feature in PI AF is based on the International System of Units (SI).

UOM database

All PI AF databases use the same set of UOMs, which are defined in the UOM database. All UOMs have the Read permission set, but other permissions can be set for the UOM database as a whole, as described in [Configure security for the UOM database](#).

Beginning with PI AF 2017 R2, users with administration privileges can review audit trail data on the UOM database by selecting **File > Audit Trail Events** after they have clicked **Unit of Measure** in the navigator. For more information, see [Track PI AF changes with Audit Trail](#).

UOM classes and canonical units

In PI AF, each unit of measure is based on a UOM *class*. Classes represent measurable properties, such as temperature, length, time, and mass. Each class has a *canonical unit*. This is the base unit from which PI AF converts values to other units when required. For example, the canonical unit for the Length class is meter, and

the abbreviation is m.

UOM conversions in client applications

The UOM feature enables automatic unit conversions in client applications. For example, suppose a PI AF attribute has a UOM of meter. A PI ProcessBook user who is viewing that attribute value can choose to view the value in a different unit, such as foot. PI AF automatically converts the data from meters to feet.

UOM abbreviations

By default, UOM abbreviations within PI AF are case insensitive. Beginning in PI AF 2015 R2 (v2.7.5), you can configure the PI System to support case-sensitive UOM abbreviations, which enables you to define abbreviations that differ only by case, such as MV (megavolt) and mV (millivolt), or s (second) and S (Siemens).

Note: All PI AF clients must be upgraded to PI AF 2015 R2 or later before they can access a PI AF server on which case-sensitive UOMs are enabled.

Time integral UOMs

Beginning with PI AF 2017, you can view the UOMs associated with a time-weighted total (**Automatic** and **Per-Day**) of rate UOMs. Rate UOMs are from classes that contain time in the denominator of their **Base Units of Measure** (for example, Mass Flow Rate contains *Time-1*, Pressure contains *Time-2*). Each time-weighted total property displays the name of the UOM that will result from a summary Total (**Per-Day**) or TotalWithUOM (**Automatic**) data call.

UOM groups

Beginning with PI AF 2017 R2, UOM groups such as **Metric**, and **US Customary** are available so that you can map UOMs in a UOM class to the setting that is most appropriate for your location. By selecting the **Display UOM Group** option in **Tools > Options**, you can then see attribute values displayed in the preferred unit of measure instead of the value selected in an attribute template's **Default UOM** field. For more information on the US Customary UOM group, see the Wikipedia article [United States customary units](#).

UOM origin

Beginning with PI AF 2017 R2, you can check the origin of a UOM definition in the UOM database. Possible values shown in the **Origin** column are:

Origin	Description
Unknown	The origin of how the UOM was defined is unknown.
System Defined	The UOM is system-defined and has not been modified.
System Modified	The UOM was system-defined but the Name and/or Description fields have been modified.

Origin	Description
System Replaced	The UOM retains its original system-defined abbreviation and canonical UOM values but other fields besides Name and Description have been modified.
User Defined	The UOM was created by the user.

Video

For information on how to edit units of measure, watch this video:

Case sensitivity of UOM abbreviations

A PI AF Client that is older than PI AF 2015 R2 (v2.7.5) cannot connect to a PI System that has been enabled to use case-sensitive UOM abbreviations. This is due to the possibility of UOM abbreviations being misinterpreted: they are often stored in data references, analysis rules, and client application files, such as spreadsheets and PI ProcessBook displays.

Note: You must upgrade a PI AF Client to PI AF 2015 R2 or later before it can use case-sensitive UOMs.

References to UOM abbreviations

When UOM case-sensitivity is enabled in PI AF 2015 R2 or later, any stored reference to a UOM abbreviation requires that the correct case for the abbreviation be used. For example:

- Data references that are configured with UOMs (such as Formula data references) must use the correct abbreviation, or else the UOM lookup fails.

- Analysis rules, such as the Convert function, fail if configured with incorrect casing: Convert('x', 'Kg') instead of Convert('x', 'kg').
- Applications or data references that programmatically access the UOM database must use the correct casing.

Note: You cannot use the case-sensitivity option in the PI System to alert you to any configured uses that contain incorrect casing.

UOM names

Unlike abbreviations, UOM names remain case-insensitive in PI AF 2015 R2 or later when UOM case-sensitivity is enabled. However, when you create a UOM abbreviation, it cannot match the name of a different UOM, even if it differs in casing.

For example, the following is valid:

Name	Abbreviation
UOM1_name	UOM1
UOM2	uom1
UOM3	Uom1

The following is invalid and generates the error message: '*uom1* already exists in Unit of Measure 'UOM1' in Unit-of-Measure Database.

Name	Abbreviation
UOM1	uom
UOM2	uom1

Configuration of case-sensitive UOM abbreviations

Although case-sensitive UOM abbreviations are enabled by default in new PI AF 2017 R2 installations, for older PI AF server versions you can change the setting for case-sensitive UOMs from the disabled state with the PI AF Diagnostics command-line utility (*afdiag*).

For more information on the *afdiag* utility, see [PI AF Diagnostics utility](#).

Enable case-sensitive UOM abbreviations

To enable case-sensitive UOM abbreviations, you enter *afdiag /ucs* on the command line.

A new UOM, millivolt with a UOM abbreviation of mV, is added to the UOM database provided that there is no conflict with existing units of measure.

Disable case-sensitive UOM abbreviations

You can reset the PI AF server to case-insensitive UOM abbreviations with the same *afdiag* utility.

To disable case-sensitive UOM abbreviations, you enter *afdiag /ucs-* on the command line.

If any existing UOM abbreviations differ only by case, the utility does not allow the feature to be disabled and displays a list of the conflicting abbreviations. At a minimum, you need to remove the millivolt unit of measure that was created when you enabled case-sensitive UOM abbreviations, because millivolt (mV) conflicts with megavolt (MV).

Base classes and derived classes

PI AF has predefined a small set of *base classes*, and a larger set of classes that are derived from the base classes, called derived classes. Derived classes are simply classes that can be expressed in terms of the UOM base classes. For example, both the Area class and the Volume class are derived from the Length class. You can define virtually all units of measure in terms of a small group of UOM base classes.

PI AF uses the canonical unit for the base class to determine the canonical units for all classes derived from that base class. You cannot change the canonical unit for a base class or a derived class. For example, since the Area class is based on the Length class, the canonical unit for Area is the square meter (m^2).

PI AF includes numerous standard UOMs, UOM classes, and conversion factors, but you can always add new ones. It is not typically necessary to create a new base class, although you might occasionally want to add one for non-physical measurements.

UOM base classes

The following predefined UOM base classes are available in PI AF.

Class	Canonical unit
Electric Current	ampere (A)
Length	meter (m)
Mass	kilogram (kg)
Moles (amount of substance)	mole (mol)
Plane Angle	radian (rad)
Quantity	count
Ratio	percent (%)
Temperature	kelvin (K)
Time	second (s)

Common UOM derived classes

The following predefined UOM derived classes are available in PI AF.

Class	Based on ...	Canonical unit
Angular Velocity	Plane Angle * Time ⁻¹	radian per second (rad/s)
Area	Length ²	square meter (m ²)
Density	Mass*Length ⁻³	kilogram per cubic meter (kg/m ³)
Electric Charge	Electric Current * Time	coulomb (C)
Electric Potential	Electric Current ⁻¹ * Length ² * Mass * Time ⁻³	volt (V)
Energy	Length ² * Mass * Time ⁻²	joule (J)
Force	Mass * Length * Time ⁻²	newton (N)
Frequency	Time ⁻¹	hertz (Hz)
Mass Flow Rate	Mass * Time ⁻¹	kilogram per second (kg/s)
Power	Mass * Length ² * Time ⁻³	watt (W)
Pressure	Mass * Length ⁻¹ * Time ⁻²	pascal (Pa)
Specific Energy, Specific Enthalpy	Length ² * Time ⁻²	joule per kilogram (J/kg)
Speed	Length * Time ⁻¹	meter per second (m/s)
Volume	Length ³	cubic meter (m ³)
Volume Flow Rate	Length ³ * Time ⁻¹	cubic meter per second (m ³ /s)

Create UOM classes

Create UOM classes when you need additions to the predefined classes in the UOM database.

1. In the navigator, click **Unit of Measure**.
2. Choose from the following actions.
 - On the toolbar, click the **New Class** icon.
 - Right-click in the Unit of Measure browser and select **New Unit-of-Measure Class**.
3. In the Unit-of-Measure Class Properties window, fill out the properties on the **General** tab.
 - a. In the **Name** field, enter a name for the class. See [Valid characters in PI AF object names](#), if necessary.
 - b. Optional. In the **Description** field, provide a description of the UOM class.
 - c. In the **Canonical UOM** field, type the name of the canonical UOM for this class. If the UOM does not

exist, PI AF creates it when it creates the new class.

- d. In the **Canonical UOM Abbreviation** field, enter a unique abbreviation.
- e. In the **Base Units of Measure** field, enter a calculation for the unit of measure. Choose from the following actions.

To ...	Do this ...
Add a base class calculation	<ol style="list-style-type: none"> i. Click . ii. In the Add Base UOM Class window, select a base class from the Base UOM Classes list. iii. In the Base Power field, type the exponent value or click one of the arrow keys until the exponent you want is displayed. iv. Click OK. v. Repeat these steps as needed, to create a multiplication (positive base power) or division (negative base power) calculation.
Remove a base class calculation	<ol style="list-style-type: none"> i. Select a base class calculation entry. ii. Click . iii. In the Delete confirmation window, click Yes.

Note: If you are defining a base class, leave the **Base Units of Measure** field blank.

4. Optional. You can add new units of measure to the class you are defining.
 - a. Click the **Units of Measure** tab.
 - b. Right-click in the list and select **New Unit of Measure**.
 - c. In the Unit of Measure Properties window, define the new unit of measure. For more information, see [Create units of measure](#).
5. Click **OK**.

Create units of measure

You create units of measure for a UOM class in the UOM database.

1. In the navigator, click **Unit of Measure**.
 2. In the Unit of Measure browser, select the class to which you want to add a new unit of measure.
 3. Choose from the following actions.
 - On the toolbar, click **New UOM**.
 - Right-click the class in the browser and select **New Unit of Measure**.
 - Right-click in the UOM viewer and select **New Unit of Measure**.
 4. In the Unit of Measure Properties window, enter a unique name for the unit of measure in the **Name** field.
- Note:** The name cannot be the same as a previously defined UOM abbreviation or UOM name.
5. In the **Abbreviation** field, enter a unique abbreviation for the unit of measure.

If UOM case-sensitivity has been enabled, you can use the same abbreviation as a previously defined UOM abbreviation, so long as the case is different. For example, you can use FR, fr, Fr, and fR for four different UOM abbreviations.

Note: The abbreviation cannot be the same as a previously defined UOM name, regardless of case.

6. Optional. In the **Description** field, enter a description for the unit of measure.
7. In the **Reference UOM** field, select the unit of reference class from which the new unit can be converted. The default value is the same as the read-only **Canonical UOM** value.
8. Choose one of the following conversion methods.

Caution: Conversions that are based on **Formula** have some limitations as well as impact on performance. You should only select **Formula** when **Simple** conversions are inadequate.

Option	Description
Simple	<p>Converts a UOM based on scaling factor and base offset values that you enter in the following fields.</p> <ul style="list-style-type: none">• In the Factor field, enter the conversion factor from the reference UOM to the new UOM. For example, °C has a factor of 1 relative to kelvin.• In the Offset field, enter a conversion offset from the reference UOM value. For example, °C has an offset of 273.15 from kelvin. <p>Note: Although PI AF supports time-weighted totalizations that can automatically assign the appropriate units of measure, it is essential that the conversion factor of the UOM be defined to as precise a level as possible for this feature to activate. For example, if you were to define a flow rate UOM such as US gallons per day with a conversion factor of 4.38126E-08, automatic conversions for this UOM would be disabled, whereas if the conversion factor were 4.381263638889E-08, automatic conversions would be active.</p>
Formula	Converts a UOM based on a complex conversion calculation. For more information, see UOM conversion calculation with a formula .

9. Optional. To establish an alternative UOM name so that users can see attribute values returned in their preferred UOM, in the **Mappings** list, select a UOM name from the **Mapping** list for each UOM group.

Note: Although default mappings are provided for **Metric** and **US Customary**, you can modify them as needed. To modify multiple UOM mappings in UOM groups, use PI Builder.

10. Click **OK** to save the new UOM.

UOM conversion calculation with a formula

In general, you should specify UOM conversion calculations with a scaling factor and base offset from the Reference UOM value.

Caution: Conversions that are based on **Formula** have some limitations as well as impact on performance. You should only select **Formula** when **Simple** conversions are inadequate.

Conversion calculation limitations

The following constraints exist with UOM conversion calculations.

Conversion type	Limitations
Factor	None.
Factor with offset	For delta conversion calculations, you need to define a separate UOM. See the Temperature (Delta) UOM class for examples.
Formula	<ul style="list-style-type: none">Delta calculations are not assigned UOMs.Summary calculations over a range of data are not assigned UOMs. This affects analysis expression functions, such as Maximum, Minimum, Popular Standard Deviation, Range, Standard Deviation, and Total. It also affects programmatic Summary data calls against PI point data references with a UOM assigned.Searches for attribute values exclude attributes whose value is measured in formula UOMs.

UOM formula evaluation

PI AF uses C# for UOM formula evaluation. Follow these guidelines:

- Write all Units of Measure in terms of the UOM abbreviation. If an abbreviation is not a valid C# variable name, enclose it in brackets.
- Adhere to C# evaluation rules.
- You can optionally invoke standard .NET static methods, such as *Math.Log10()*, to perform the computation. You are limited to what is available in the System Assembly ([.NET Framework Math Class](#)).

Formula conversion method example

As an example, watts (W) is the canonical UOM in the Power class. To create a UOM of Decibel-milliwatts (dBm) in the Power class, you could enter the following formula:

```
W = Math.Pow(10, (dBm - 30)/10)
```

```
dBm = 10 * Math.Log10( W ) + 30
```

Calculate conversion values for a UOM

Use the Unit of Measure Conversion Calculator to convert a given UOM quantity into an equivalent value for other members in its class.

1. In the navigator, click **Unit of Measure**.
2. In the Unit of Measure browser, select a UOM class.
3. In the **Quantity** field of the **Conversion Calculator** pane, enter the quantity you want to convert.
4. Optional. In the **UOM** field, change the UOM from the default value to another UOM in the class.
Converted values for each UOM in the class are displayed.

UOM groups

Beginning with PI AF 2017 R2, units of measure that are included as part of PI AF are mapped to UOM groups, such as **Metric** and **US Customary**. Once you have selected which UOM group you prefer to use at your location, you can display all attribute values with units of measure mapped to that UOM group rather than the default UOMs that are defined in attribute templates.

You select which UOM group you prefer in **Tools > Options**. When no preferred UOM group is selected, all attribute values are displayed with the default UOM defined in attribute templates, unless **Use Source Unit-of-Measure for attribute display** is also selected. For more information, see [PI System Explorer customization options](#).

Sample mappings for a UOM class

As an example, the table below illustrates mappings for the Length UOM class.

UOM	Metric UOM group	US Customary UOM group
centimeter		inch
foot	meter	
inch	centimeter	
international nautical mile		
kilometer		mile
meter		yard
millimeter		sixteenth of an inch
sixteenth of an inch	millimeter	
yard	meter	

If a mapping is not defined, such as international nautical mile, a UOM is not mapped and uses the original UOM setting.

UOM database

UOM groups are available to all users and are stored on the PI AF server as part of the UOM database. Each user's UOM group selection in **Tools > Options** is also stored in the UOM database.

Users with permission to modify the UOM database can modify the UOM groups and mappings, including those shipped by default. For more information, see [Configure security for the UOM database](#).

UOM database import/export

You can import and export UOM groups, as well as their mappings, with **File > Export to File** and **File > Import from File**. When you export, ensure that **Include All Referenced Objects** option is selected.

Manage UOM groups

To create, modify, and delete UOM groups, you must have Write permission for the UOM database.

In addition to the **Metric** and **US Customary** UOM groups that are installed with PI System Explorer, you can create additional UOM groups to which you can map units of measure. You can also modify and delete group names and descriptions.

1. To manage UOM groups, click **Unit of Measure** in the navigator.
2. Choose from the following actions.
 - On the toolbar, click the **UOM Groups** icon.
 - Click **File > UOM Groups**.
3. Choose from the following actions.

To...	Do this...
Create a new group	<ol style="list-style-type: none">a. Click New UOM Group.b. In the Unit-of-Measure Properties window, enter a unique name for the UOM group in the Name field.c. Optional. In the Description field, enter a description for the UOM group.d. Click OK. The new group is added to the list in the UOM Groups window.
Modify a group	<ol style="list-style-type: none">a. Select the group you want to modify and click Properties.b. In the Unit-of-Measure Properties window, make changes as needed to the name and/or description.c. Click OK.

To...	Do this...
Delete a group	<p>a. Select the group you want to delete and click Delete.</p> <p>b. In the Delete confirmation window, click Yes.</p> <p>Note: If the deleted UOM group was previously selected in Tools > Options on the General tab, the Display UOM Group value is reset to <None>. Attributes are reset to the default UOM defined in the associated element template.</p>

- Check in your changes to the UOM database.

Origin of UOMs

Beginning with PI AF 2017 R2, you can check the origin of a UOM definition in the UOM database. The **Origin** field is included in the Unit of Measure Properties window, as well as the UOM viewer. It is also supported in PI Builder.

Possible values shown in the **Origin** column are:

Origin	Description
<i>Unknown</i>	The origin of how the UOM was defined is unknown.
<i>System Defined</i>	The UOM is system-defined and has not been modified. Note: If only a UOM mapping is changed, Origin remains set to <i>System Defined</i> .
<i>System Modified</i>	The UOM was system-defined but the Name and/or Description fields have been modified.
<i>System Replaced</i>	The UOM retains its original system-defined abbreviation and canonical UOM values but other fields besides Name and Description have been modified.
<i>User Defined</i>	The UOM was created by the user.

If a UOM is modified that results in **Origin** being set to either *System Modified* or *System Replaced*, but is later reset to the original definition, **Origin** also reverts to *System Defined*.

Security configuration in PI AF

PI AF supports both claims-based authentication via OpenID Connect (OIDC) and integrated Windows security for authentication. PI AF also provides its own authorization to PI AF objects through PI AF identities and mappings.

You can map roles to PI AF identities on claims-aware PI AF servers. See [Map a role to a PI AF identity](#) for more

information.

Note: The security configuration information described in this section presumes a PI AF 2015 server and a PI AF 2015 client.

The PI AF security model enables administrators to configure access for PI AF identities at each level of the PI AF hierarchy. PI AF uses Windows integrated security to grant or deny connection to the PI AF server, view or edit databases, and change collections.

For detailed information on how security is implemented on Data Archive, see Data Archive security.

Video

For information on how to create, map, and grant permissions to PI AF identities on a PI AF server that uses Windows authentication, watch this video:

PI AF identities and mappings

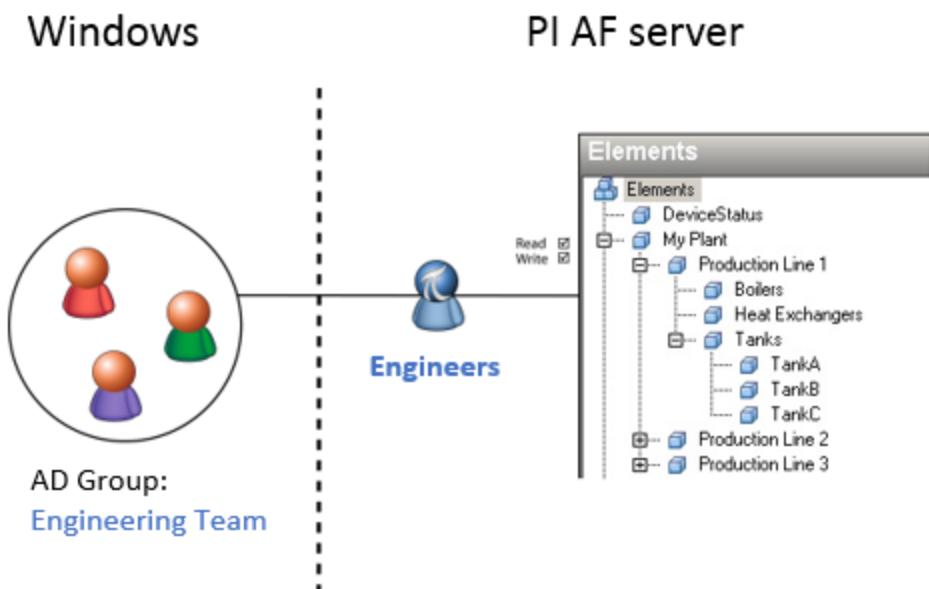
A PI AF identity represents a set of access permissions on the PI AF server. Each PI AF mapping points from a Windows user or group or an Identity provider (IdP) role to a PI AF identity.

A role represents a group of users with similar job functions and access permissions. Roles are stored and managed by the IdP service. The AVEVA Identity Manager is the provided identity service for PI Server 2023. A role that is mapped to a PI AF identity inherits the access permissions for that identity.

Beginning with PI AF Server 2015 (v2.7), you cannot directly grant a Windows user or group access to a PI AF server resource (such as an element collection or objects). Instead, you create a PI AF identity that has that access and then you create a PI AF mapping between the Windows user or group and that PI AF identity.

Members of the Windows groups that are mapped to a PI AF identity are also automatically granted the access permissions for that PI AF identity. For example, in the following illustration, the PI AF identity called Engineers has read/write access to the Elements collection. Because the Active Directory (AD) group Engineering Team is mapped to Engineers, all the members in that AD group get read/write permission for the Elements collection.

AD group mapping to a PI AF identity

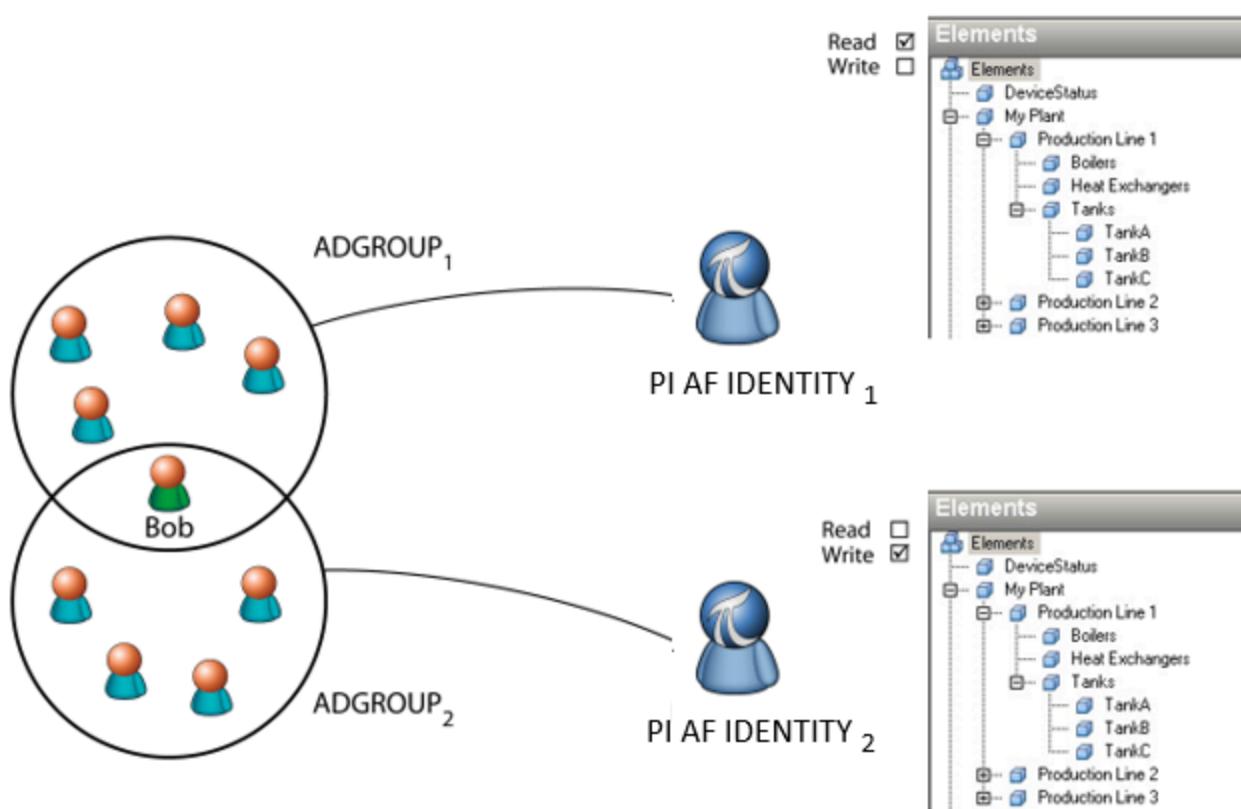


All members of AD Group [Engineering Team](#) are mapped to [Engineers](#) identity and can read/write to the Elements collection

Multiple identities

A single Windows user can be mapped to multiple PI AF identities, typically via mappings of the various Windows group memberships to which he or she belongs. A user is granted permissions based on *all* the PI AF identities to which he or she is mapped. Effective permissions are determined by taking the union of all identities' allowed permissions and removing the union of all denied permissions. For example, in the following illustration, the Windows user Bob belongs to both AD groups. Bob therefore gets the permissions that are configured for PI AF IDENTITY₁ and PI AF IDENTITY₂.

Windows user with cumulative access permissions



Bob can read and write to the **Elements** collection

Additionally, a user must have read permission on a PI AF database to be able to read any object within it. Likewise, a user must have write permission on a PI AF database to write to any object within it.

For more information on working with identities and mappings, see [Manage identities in PI AF](#) and [Manage mappings in PI AF](#).

Built-in PI AF identities

The following table includes a list and descriptions of all the built-in PI AF identities.

PI AF identity	Description
Administrators	<p>By default, this identity has all access permissions to every collection and object on the PI AF server, including all databases. It cannot be modified or deleted. Mappings, however, can be added and removed, and this identity can be denied access permissions to objects if the need arises.</p> <p>Access to this identity should be restricted to only a few users.</p>
Asset Analytics	(Part of PI Analysis Service installation.) This identity has the necessary access permission to work with

PI AF identity	Description
	analyses. By default, the account used to run PI Analysis Service is mapped to this identity during installation. Mappings to this account can be added or removed.
Asset Analytics Recalculation	(Part of PI Analysis Service installation.) This identity has Execute permission, allowing users mapped to it to backfill and recalculate analyses. ¹
Engineers	<p>This identity has the same privileges as Administrators, with the exception of the Admin (a) permission. This identity is also not allowed to delete PI AF databases.</p> <p>This identity should be restricted only to users who are defining the asset database. Additional identities should be created to narrow the scope of access within PI AF.</p>
Notifications	(Part of PI Notifications Service installation.) This identity has the necessary access permission to work with notification rules. By default, the account used to run PI Notifications Service is mapped to this identity during installation. Mappings to this account can be added or removed.
Owner	<p>This read-only identity can be explicitly added to the security configuration of specific PI AF objects to enable administrator users to configure privileges for the owner of an object. The following restrictions apply:</p> <ul style="list-style-type: none"> • You cannot add mappings to this identity. • You cannot modify, disable, or delete this identity. • Beginning with PI AF 2018 SP2, this identity no longer automatically has Read and ReadData permission. Read and ReadData permission must be set in another of the user's mapped identities.
World	<p>This identity has read access permissions to every collection and object on the PI AF server. It cannot be modified or deleted. Mappings, however, can be added and removed.</p> <p>By default, this identity is mapped to the Windows Everyone users group.</p>

¹If you have installed 2017 (version 2.9) or later versions for the first time, users need to be added to the Asset Analytics Recalculation identity in order to backfill or recalculate. If you are upgrading from versions prior to 2017 (version 2.9), all users will automatically be mapped to Asset Analytics Recalculation identity. It is recommended that upon upgrading, such automatic mapping for all users is removed and users that require backfilling or recalculation permissions are explicitly mapped.

Note: In a typical installation, for security reasons, we recommend providing users with identities that grant them the minimum viable permissions to perform the tasks for their business needs.

Security hierarchy

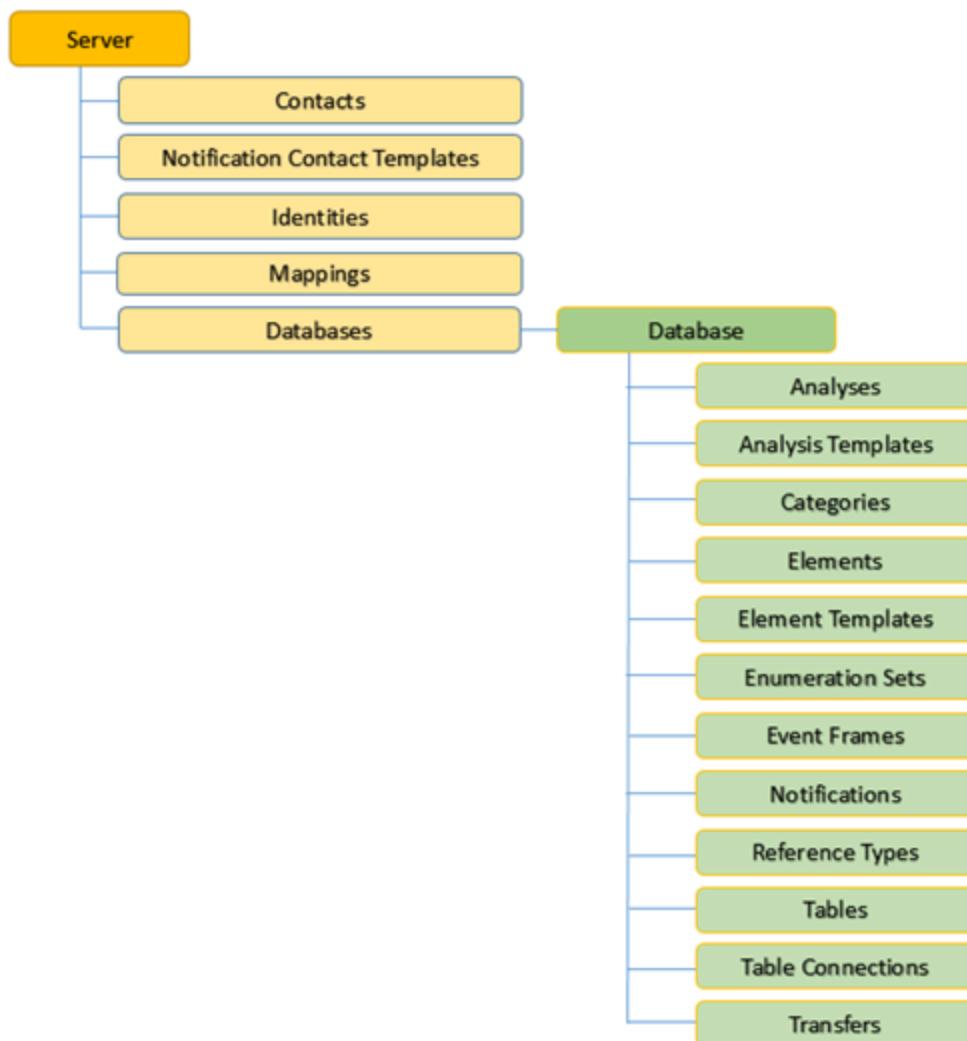
PI AF supports both OpenID Connect (OIDC), used for implementing claims-based authentication, and Windows integrated security to authenticate users and establish their PI AF identities through mappings.

If you use OIDC for authentication, you can map Identity provider roles to PI AF identities to assign a group of users to one or more PI AF identities.

PI AF uses the PI AF identities to control read, write, delete, and various other permissions on PI AF components shown in the following illustration. Each securable PI AF object (element, event frame, and notification, and so on) throughout the hierarchy has an associated security descriptor that contains the access permissions information for that object.

All PI AF objects of the same type belong to a collection. For example, every PI AF element in a database belongs to the Elements collection for that database. Each collection also has an associated security descriptor that contains access permission information. Security descriptors for some collections are configured for an entire PI AF server (such as Identities and Mappings), whereas others (such as Analyses, Elements, and Event Frames) can be configured for a specific database.

PI AF hierarchy of securable collections



For more information on collection security, see [PI AF collection security](#).

Security inheritance of PI AF objects

The following table provides details on the security that is required to create specific objects.

Object	Security inheritance
Element	A child element inherits the security of its parent element if it is added as a Parent-Child (strong) or Composition reference. For more information, see Permission inheritance of element objects . The security rights of an element created at the database level are derived from the Element collection associated with a PI AF database. For more information, see PI AF collection security .
Event frame	A child event frame inherits the security of its parent

Object	Security inheritance
	<p>event frame if it is added as a Parent-Child (strong) reference. If an event frame does not have a Parent-Child reference, security rights are derived from the event frame template if it was created from a template. If it was not created from a template, security rights are derived from the Event Frame collection associated with a PI AF database.</p> <p>Note: To allow users to make changes to event frames that are based on a template, but prevent them from modifying the source template, you configure security rights on the event frame template by setting the following access permissions for the associated PI AF identities:</p> <ul style="list-style-type: none"> • To prevent users from accessing or modifying an event frame template, clear the Allow check box on the Write permission in the Security Configuration window. See Configure security for objects to learn how to set access permissions for PI AF identities. • Select the Write Data permission to enable users to make changes to event frames that are based on the template. • Select the Read Data permission to give users the ability to view and read the event frame object. Granting the Read Data permission on an object also grants the Read permission. <p>See PI AF access rights for more information on access permissions.</p>
Transfer	If a transfer is created from a template, security rights are derived from the template. If it was not created from a template, security rights are derived from the Transfer collection associated with a PI AF database.
Case	Security rights are derived from the analysis that owns the case.

For all other types of objects, initial security access rights are calculated from the corresponding collection associated with a PI AF database. For example, security access rights for a notification are initially derived from a PI AF database's Notification Rule collection.

Note: When an analysis or analysis template is associated with a legacy notification or notification template, (Notifications 2012 or earlier), security access rights for the two objects are synchronized.

Permission inheritance of element objects

When you change access permissions for an element, the access permissions for any parent or child elements might also change. The behavior depends on the reference type.

Parent-child reference type

When an object or collection is created, a default set of access permissions is assigned, based on the access permissions that are set on the parent. When access permissions are set on a parent, the following **Child Permission** settings on the **Permissions** page of the Security Configuration window are evaluated:

Option	Description
Do not modify child permissions	Prevents access permissions that have been set for the current object or collection from being replicated to child collections and objects in the PI AF hierarchy. This option is the default when the connected PI AF server is running 2.5 and earlier versions.
Update child permissions for modified identities	For each selected item on the Items to Configure list in the Security Configuration window, replicates the access permissions for all child collections and objects for each identity on the Identities list whose access permissions have been modified. This option is the default when the connected PI AF server is running 2.6 and later versions. This option is not available when the connected PI AF server is running 2.5 and earlier versions.
Replace child permissions for all identities	For each selected item on the Items to Configure list in the Security Configuration window, replaces all child permissions for every identity on the Identities list with the parent access permissions. Note: Before you apply this option, be sure to review access permission settings for all items on the Items to Configure list to avoid unintentionally overwriting custom permissions that may have been applied elsewhere in the collection hierarchy. Review the following example for clarification.

Examples

The following hierarchy has three elements, each with a different access permissions setting.

Sample element hierarchy

The screenshot shows a 'Elements' view with a search bar at the top. Below it is a table with columns 'Name' and 'Description'. The hierarchy is as follows:

- EasternUS
- SavannahSite
 - ProductionLine1

- The Administrators and World identities have access permissions to all three elements: EasternUS, SavannahSite, and ProductionLine1.
- The Savannah_IT identity has access to the SavannahSite element.
- The SavnEngineers identity has access to the ProductionLine1 element.

Access permissions for sample hierarchy

Item	Security String
EasternUS	Administrators:A(r,w,rd,wd,d,x,a,s,so) World:A(r,rd)
SavannahSite	Administrators:A(r,w,rd,wd,d,x,a,s,so) World:A(r,rd) Savannah_IT:A(r,w,rd,wd,d,x,a,s,so)
ProductionLine1	Administrators:A(r,w,rd,wd,d,x,a,s,so) SavrEngineers:A(r,w,rd,wd,d,x,s,so) World:A(r,rd)

Suppose you want to add a CorporateEngineering identity to each element in the hierarchy. You would add the identity to the parent element EasternUS:

Add identity to parent element

Items to Configure:

Item	Security String
<input checked="" type="checkbox"/> EasternUS	Administrators:A(r,w,rd,wd,d,x,a,s,so) World:A(r,rd)

Identities: [Add...](#) [Remove](#)

Name
Administrators
World
CorporateEngineering

Permissions for CorporateEngineering:

Permission	Allow	Deny
All	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read/Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read/Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Delete	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Admin	<input checked="" type="checkbox"/>	<input type="checkbox"/>

To replicate the parent permissions without affecting identities already assigned access permissions, you would set the **Child Permissions** option to **Update child permissions for modified entries**. The security string for all three elements shows that the CorporateEngineering identity has been added, but the other identities remain unchanged:

Replicate identity and modify existing access permissions

Items to Configure:

Item	Security String
<input checked="" type="checkbox"/> EasternUS	Administrators:A(r,w,rd,wd,d,x,a,s,so) World:A(r,rd) CorporateEngineering:A(r,w,rd,wd,d,x,a,s,so)
<input checked="" type="checkbox"/> SavannahSite	Administrators:A(r,w,rd,wd,d,x,a,s,so) World:A(r,rd) Savannah_IT:A(r,w,rd,wd,d,x,a,s,so) CorporateEngineering:A(r,w,rd,wd,d,x,a,s,so)
<input checked="" type="checkbox"/> ProductionLine1	Administrators:A(r,w,rd,wd,d,x,a,s,so) Engineers:A(r,w,rd,wd,d,x,s,so) World:A(r,rd) CorporateEngineering:A(r,w,rd,wd,d,x,a,s,so)

Identities: [Add...](#) [Remove](#)

Name
Administrators
World
CorporateEngineering
Savannah_IT
Engineers

Permissions for Administrators:

Permission	Allow	Deny
All	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read/Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Read/Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Delete	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Admin	<input checked="" type="checkbox"/>	<input type="checkbox"/>

To replicate the parent permissions for all identities down the hierarchy, you would set the **Child Permissions** option to **Replace child permissions for all identities**. The security string for all three elements shows that the CorporateEngineering identity has been added, but has replaced the access permissions with those assigned to the EasternUS element:

Replicate identity and replace existing access permissions

The screenshot shows the security configuration for the 'EasternUS' item. In the 'Item' column, 'EasternUS' has a security string of 'Administrators:A(r,w,rd,wd,d,x,a,s,so)|World:A(r,rd)|CorporateEngineering:A(r,w,rd,wd,d,x,a,s,so)'. Below it, 'SavannahSite' and 'ProductionLine1' also inherit this security string. The 'Identities' section lists 'Administrators', 'World', and 'CorporateEngineering' with 'Add...' and 'Remove' buttons. The 'Permissions for Administrators' table shows various permissions like All, Read, Write, etc., with checkboxes for Allow and Deny.

Name	Permission	Allow	Deny
All	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Read	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Read/Write	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Read Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Read/Write Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Delete	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Admin	<input checked="" type="checkbox"/>	<input type="checkbox"/>	

Notice that the Savannah_IT and SavnEngineers identities no longer appear in the security string for the SavannahSite and ProductionLine1 elements because they were not included in the **Identities** list of the parent EasternUS element.

Composition reference type

Access permissions for child and parent are always the same.

If you change the access permissions for the child, the parent access permissions are automatically changed to match the child permissions. Similarly, if you change the access permissions for the parent, the child access permissions are automatically changed to match the parent permissions. These changes cascade down (and up) through the hierarchy.

Weak reference type

Access permissions are never inherited.

PI AF access rights

The following table describes the access permissions you can assign to PI AF identities for all objects in the hierarchy.

Access right	Security string abbreviation	Definition
Read	r	Enables a user to view the object. Read security rights are required to view the object in client applications. The Read permission also enables a user to view configuration values from

Access right	Security string abbreviation	Definition
		<p>attributes of elements.</p> <p>The following objects always have Read permission regardless of their security settings, so long as the logged-in user has Read access to the PI System and the PI AF database. The one exception is the notification contact template, where the logged-in user only requires Read access to the PI System:</p> <ul style="list-style-type: none"> • Analysis template • Categories • Element template • Enumeration set • Event frame template • Model template • Notification contact template • Notification template • Reference type • Transfer template • UOM database
Write	w	<p>Enables a user to create and modify an object. The exception is that event frames and transfers also require Write Data permission on the element template from which they are created, and cases require Write Data permission on the analysis in which they are contained.</p>
Read/Write	Not applicable	<p>Enables a user to read and write to the associated object. When selected, automatically selects the Read and Write permissions.</p>
Read Data	rd	<p>Enables a user to read non-configuration values from attributes of elements (the Configuration Item property for an</p>

Access right	Security string abbreviation	Definition
		<p>attribute is cleared). Additionally, this permission controls whether a user can see transfers created from a specific transfer element template. Similarly, it controls whether a user can see cases created in a specific analysis.</p> <p>If the following objects have Read Data permission, they are also granted Read permission:</p> <ul style="list-style-type: none"> • Case • Element • Event frame • Model • Notification • Transfer
Write Data	wd	<p>Enables a user to write non-configuration values to attributes of elements (the Configuration Item property for an attribute is cleared). Additionally, this permission controls whether a user can create or modify event frames or transfers created from a specific transfer element template.</p> <p>Similarly, it controls whether a user can create or modify cases in a specific analysis.</p>
Read/Write Data	Not applicable	<p>Enables a user to read data and write data to the associated object. When selected, automatically selects the Read and Write Data permissions.</p>
Delete	d	<p>Enables a user to delete an object. Delete security rights are required to delete an object, either directly or indirectly by removing it from other objects.</p> <p>Note: All users have Delete permission on the PI System</p>

Access right	Security string abbreviation	Definition
		regardless of other security settings as long as the logged-in user has Read access to the PI System. This permission enables the user to remove an AF Server from a list of registered servers on the local machine only.
Execute	x	Enables a user to queue backfilling or recalculation of analyses in the analysis service. It also enables a user to perform most actions on an analysis case.
Admin	a	<p>Enables a user to modify the security settings, or owner, of an object. Administration security rights are required to force an Undo Check Out on an object that is checked out to another user, as well as to lock and unlock an event frame.</p> <p>Note: Users with the administration permission on the PI AF server object are granted all rights not only to the system, but to all objects within the system, including databases.</p>
Subscribe	s	Enables a user to subscribe and unsubscribe to a notification.
Subscribe Others	so	Enables a user to subscribe and unsubscribe other users to a notification.
Annotate	an	<p>Enables a user to annotate and acknowledge event frames.</p> <p>Note: This access right was added in PI AF 2016. After an upgrade from earlier server versions, objects with the Write Data (wd) access right are granted the Annotate access right automatically. Both client and server upgrades must use this new permission.</p>

PI Data Archive permissions

In order to connect to a Data Archive server, PI AF requires that Read permission be configured on that server. Note that because determining the permissions on a Data Archive server requires an actual connection to be made, the full list of Data Archive servers configured on a client machine is always available. Data Archive also always has Delete permission.

Deny permission option

You select the **Deny** option for these cases:

- To exclude a subset of an identity mapping that has allowed permissions.
- To exclude one special permission when you have already granted full control to an identity.

Note: PI Module Database does not support the Deny option. If you are using both PI MDB and PI AF, avoid the Deny option to prevent synchronization problems. In addition, if a user is mapped to an identity that has the Admin permission assigned at the server level, any Deny option will be overridden.

Security Configuration window

You can view and configure access permissions for identities, and also look up a user's permissions and restrictions by assigned identities in the Security Configuration window. Access permissions are shown for both Windows domain users and users who have signed on using claims-based authentication.

You can open the Security Configuration window in PI System Explorer anywhere a **Security** link appears in a window or **Security** is displayed on a context menu.

Permissions tab

You can view and configure access permissions for individual or multiple items by a PI AF identity on the **Permissions** tab of the Security Configuration window.

Security Configuration

Permissions Effective Access

Items to Configure:

<input checked="" type="checkbox"/> Item	Security String
<input checked="" type="checkbox"/> Kaboom	World:A(r,rd) Administrators
<input checked="" type="checkbox"/> Kaboom - Contacts	Administrators:A(r,w,rd,w)

Identities: Add... Remove

Permissions for World:

Name	Permission	Allow	Deny
All	<input type="checkbox"/>	<input type="checkbox"/>	
Read	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Write	<input type="checkbox"/>	<input type="checkbox"/>	
Read/Write	<input type="checkbox"/>	<input type="checkbox"/>	
Read Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Write Data	<input type="checkbox"/>	<input type="checkbox"/>	
Read/Writ...	<input type="checkbox"/>	<input type="checkbox"/>	
Subscribe	<input type="checkbox"/>	<input type="checkbox"/>	

Child Permissions

Do not modify child permissions

Update child permissions for modified identities

Replace child permissions for all identities

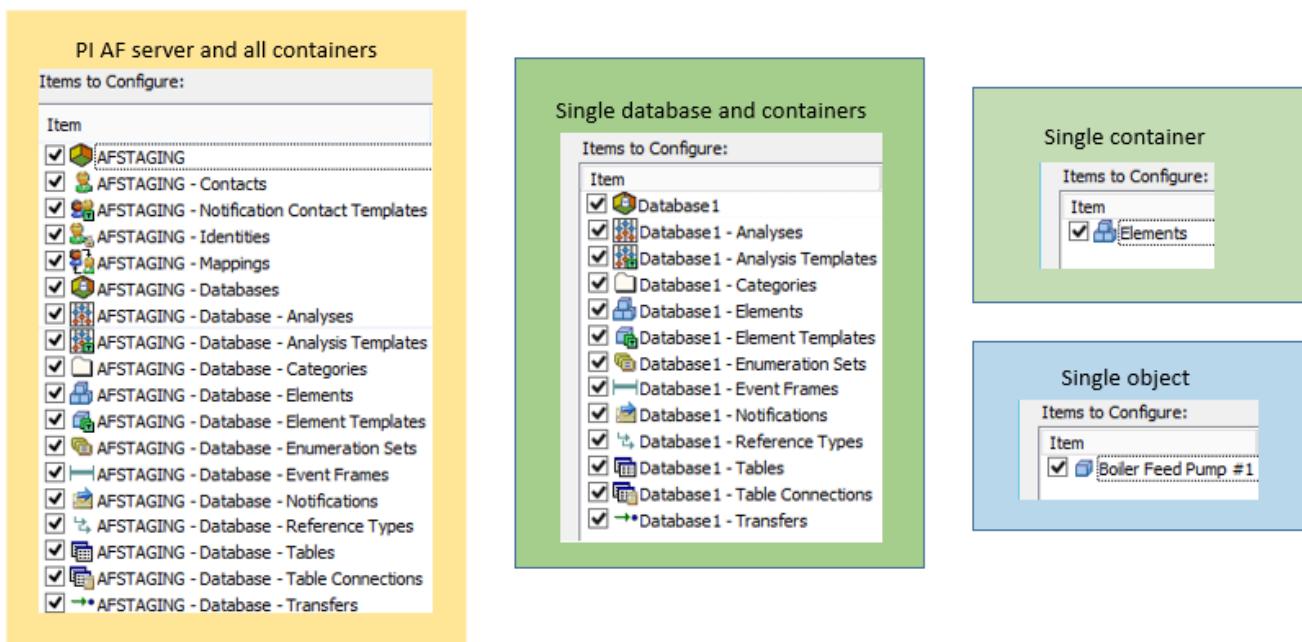
OK Cancel Apply

Note: If you signed on using OpenID Connect (OIDC), the **Effective Access** tab displays the current user's permissions on PI AF objects.

Items to Configure list

The content of the **Items to Configure** list is determined by the hierarchy context and indicates whether you can configure access permissions for the entire PI AF hierarchy, a single database and containers, or a single

container and single object.



To configure access permissions for only some of the items, you can clear those you do not want to configure.

Identities list

The **Identities** list contains a list of identities that have permissions for *all* checked items in the **Items to configure** list. You use the **Add** and **Remove** functions to manage which identities appear on the list.

If the currently connected PI AF server does not support identities (PI AF 2014 or earlier), the Security Configuration window displays access permissions for Groups or Users and you can add and remove Windows accounts using standard Active Directory windows.

Permissions list

As each identity is selected in the **Identities** list, the permissions associated with that identity for the checked entries in the **Items to Configure** list are shown in the **Permissions** list. You can allow or deny permissions as desired for each identity without losing the changes. The access permissions you set for each identity are retained until you click the **OK**, **Cancel**, or **Apply** button.

Note: If more than one **Items to Configure** entry is selected and the currently selected identity has one of the permissions in one or more, but not *all* entries selected in the **Items** list, the checkbox for that permission displays a dot () to indicate some entries in the **Items** list have the permission set whereas some do not.

Effective access tab

Effective access allows you to see a user's overall access permissions on PI AF objects, such as databases and collections. Access permissions are based on the user's current PI AF identity mappings. Each identity has its own set of access permissions on the PI AF server. Access permission settings allow or deny a user the ability to read, write, delete, and take additional actions on objects. A user's access rights are determined by "merging" or

taking the union of all identities' allowed permissions and removing the union of all denied permissions. A user is then granted effective access to items based on the "merged" permissions of his or her mapped identities.

For example, the Windows user Maria is a member of the PI AF Engineers, Administrators, and Plant Operators identities. Both the Engineers and Administrators identities can read analyses, but the Plant Operators identity is denied access to reading analyses. As a result, Maria's effective access in PI AF is the ability to read analyses. To learn more about identities and mapping, see [PI AF identities and mappings](#).

Effective Access tab

The screenshot shows the 'Security Configuration' dialog box with the 'Effective Access' tab selected. The 'Account' section displays the domain user 'xyz_user' and their User SID. The 'Identities' section lists the mapped identities: Administrators, Engineers, PI System Directory Users, and World. The 'Items to View Access:' section lists various database objects under the 'AFSTAGING' database, including Analyses, Analysis Templates, Categories, Elements, Element Templates, Enumeration Sets, Event Frames, Notification Rules, Reference Types, Tables, Table Connections, and Transfers. The 'Permissions:' section on the right lists the available permissions: Read, Write, Delete, and Admin. At the bottom, there are 'OK', 'Cancel', and 'Apply' buttons.

Security Configuration

Permissions Effective Access

Account

Domain User: xyz_user

User SID: S-1-5-21-2084324470-1890137325-1469997231-134222

Identities:

- Administrators
- Engineers
- PI System Directory Users
- World

Items to View Access:

- AFSTAGING
- AFSTAGING - Contacts
- AFSTAGING - Notification Contact Templates
- AFSTAGING - Security Identities
- AFSTAGING - Security Mappings
- AFSTAGING - Databases
- AFSTAGING - Database - Analyses
- AFSTAGING - Database - Analysis Templates
- AFSTAGING - Database - Categories
- AFSTAGING - Database - Elements
- AFSTAGING - Database - Element Templates
- AFSTAGING - Database - Enumeration Sets
- AFSTAGING - Database - Event Frames
- AFSTAGING - Database - Notification Rule
- AFSTAGING - Database - Notification Rule T...
- AFSTAGING - Database - Reference Types
- AFSTAGING - Database - Tables
- AFSTAGING - Database - Table Connections
- AFSTAGING - Database - Transfers

Permissions:

- Read
- Write
- Delete
- Admin

OK Cancel Apply

Account section

The **Account** section is where you enter a Windows domain user name, for example rsmith, to begin viewing his or her permissions on items. The user's security identifier and identity mappings are also displayed in this section.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

Items to View Access list

The **Items to View Access** list is based on the items selected for security configuration on the **Permissions** tab. To view a user's permissions on an item, select the item in the **Items to View Access** list.

Permissions list

You can view a user's specific access permissions on a selected item in the **Permissions** list. For more information about assigned permissions, see [PI AF access rights](#).

View effective access by user

Use the **Effective Access** page of the Security Configuration window to view details about a user's access permissions on PI AF objects.

To display a user's access permissions, you need the user's Windows domain name.

1. Choose one of the following methods to open the Security Configuration window:

To open from ...	Do this ...
PI AF Server Properties window	<ol style="list-style-type: none">a. On the toolbar, click .b. In the PI AF Server Properties window, click the Security link.
Select Database window	<ol style="list-style-type: none">a. On the toolbar, click the Database button.b. In the Select Database window, click the Edit Security button.
PI System Explorer browser	<ol style="list-style-type: none">a. Right -click an object or collection and click Security.b. In the PI AF Server Properties window, click the Security link.

2. In the Security Configuration window, click the **Effective Access** tab.
3. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
4. Press Tab or Enter to validate your entry.

Note: You can click  next to the **Domain User** or **OIDC User** field to search for a user's Windows domain

name.

The fields and lists on the **Effective Access** page are populated with the following information:

- **User SID** field: Displays the user's security identifier
- **Identities** list: Lists all the PI AF identities that are mapped to the Windows domain user account entered in step 3
- **Items to View Access** list: Displays the item(s) selected for security configuration. This list is reflective of the item(s) shown in the **Items to Configure** list on the **Permissions** card.
- **Permissions** list: Displays the access permissions for the currently selected item in the **Items to Configure** list.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

5. Click-and-drag the horizontal splitter bar up or down to adjust the amount of information shown in the list boxes.
6. Select a different item in the **Items to View Access** list.
The user's access permissions for the selected item are displayed in the **Permissions** list. To learn more about access rights, see [PI AF access rights](#).
7. Repeat step 6 as needed to view access permissions for other items.
8. Click **OK** to exit the Security Configuration window.

PI AF server security

When PI AF Server is first installed, admin access (all permissions) is given to the built-in Administrators identity, and read access to all objects and collections is given to the World identity. For all other identities that are mapped to Windows users and groups, an administrator needs to configure appropriate access to the PI AF server, databases, collections and objects.

Configure security for a PI AF server

To connect to a PI AF server, an identity must have read permissions to the PI AF server object.

Configure access permissions for a connected PI AF server so that a PI AF identity can access databases, collections and objects.

1. Choose one of the following methods to open the **Permissions** tab on the Security Configuration window for a PI AF server:

To open from ...	Do this ...
Servers window	<ol style="list-style-type: none">Select File > Connections.In the Servers window, right-click the default connected () PI AF server and click Security.
PI AF Server Properties window	<ol style="list-style-type: none">On the toolbar, click .In the PI AF Server Properties window, click the

To open from ...	Do this ...
	Security link.
Select Database window	<p>a. On the toolbar, click the Database button.</p> <p>b. In the Select Database window, click the Edit Security button.</p>

In the Items to Configure list of the Security Configuration window, the server and every collection is selected.

2. Clear those collections that you do not want to be assigned the same permission settings as the server. For example, you might want to assign access rights for server-wide collections such as Mappings and Identities, but use a different set of access permissions for databases and their collections.
3. In the **Identities** list, review existing identities and validate their permissions. You can also add and remove identities, as needed.

To ...	Do this ...
Add or modify permissions of existing identities	<p>a. Select an identity in the Identities list.</p> <p>b. In the Permissions for Identity list, select or clear the Allow or Deny check boxes beside the permissions you wish to set.</p>
Add another identity to the Identities list	<p>a. Click Add.</p> <p>b. In the Select Identity window, select the identity you wish to add.</p> <p>c. Click OK. The identity is added to the list.</p> <p>d. In the Permissions for Identity list, set the access permissions as needed (the default setting is all are selected).</p> <p>Tip: If you need to create a new identity and mapping, click New Identity. For more information, see Manage identities in PI AF.</p>
Remove an identity from the Identities list	<p>a. Select an identity in the Identities list.</p> <p>b. Click Remove.</p>

4. Select one of the **Child Permissions** options. For more information, see [Permission inheritance of element objects](#).
5. Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
6. Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
7. Optional. Press Tab or Enter to validate your entry.
8. Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the

Effective Access tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

PI AF database security

To view a PI AF database, an identity must have at least read permissions to the database object. You configure permissions individually for each database, or for the entire databases collection.

Beginning with PI AF 2017 R2, it is no longer necessary for users to have write permission on a PI AF database in order to have write permission on other objects in the database. Users need only be assigned an identity with write access to objects such as elements to be able to edit them. To prevent users from having write access to specific objects, assign them to an identity with read-only access to those objects.

Configure security for new PI AF databases

Configure default [PI AF access rights](#) for all identities that need access to databases on a PI AF server.

1. On the toolbar, click the **Database** button.
2. In the Select Database window, click the **Edit Security** button.

In the **Items to Configure** list of the Security Configuration window, the server and every collection is selected.

3. In the **Items to Configure** list, clear the server and the following collections: **Contacts**, **Notification Contact Templates**, **Identities**, and **Mappings**. **Databases** and all **Database - Collections** should be selected.
4. In the **Identities** list, review existing identities and validate their permissions. You can also add and remove identities, as needed.

To ...	Do this ...
Add or modify permissions of existing identities	<ol style="list-style-type: none">a. Select an identity in the Identities list.b. In the Permissions for Identity list, select or clear the Allow or Deny check box beside each permission you wish to set.c. Repeat for each identity.
Add another identity to the Identities list	<ol style="list-style-type: none">a. Click Add.b. In the Select Identity window, select the identity you wish to add.c. Click OK. The identity is added to the list.d. In the Permissions for Identity list, set the access permissions as needed (the default setting is all are checked). <p>Tip: If you need to create a new identity and mapping, click New Identity. For more information, see Manage identities in PI AF.</p>
Remove an identity from the Identities list	<ol style="list-style-type: none">a. Select an identity in the Identities list.

To ...	Do this ...
	b. Click Remove .

5. In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
6. Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
7. Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
8. Optional. Press Tab or Enter to validate your entry.
9. Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

Configure security for a single PI AF database

For a single database, configure [PI AF access rights](#) for identities that need access to its collections and objects.

1. On the toolbar, click the **Database** button.
2. In the Select Database window, right-click a database in the **Databases** list and click **Security**.
In the **Items to Configure** list of the Security Configuration window, the database and every collection in the database is selected.
3. Optional. Clear any collection that you do not wish to modify from their default settings and assigned identities.
4. In the **Identities** list, review existing identities and validate their permissions. You can also add and remove identities, as needed.

To ...	Do this ...
Add or modify permissions of existing identities	<ol style="list-style-type: none"> a. Select an identity in the Identities list. b. In the Permissions for Identity list, select or clear the Allow or Deny check boxes beside the permissions you wish to set. c. Repeat for each identity.
Add another identity to the Identities list	<ol style="list-style-type: none"> a. Click Add. b. In the Select Identity window, select the identity you wish to add. c. Click OK. The identity is added to the list. d. In the Permissions for Identity list, set the access permissions as needed (the default setting is all are checked).
Tip: If you need to create a new identity and	

To ...	Do this ...
	mapping, click New Identity . For more information, see PI AF identities and mappings .
Remove an identity from the Identities list	<ol style="list-style-type: none"> Select an identity in the Identities list. Click Remove.

- In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
- Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
- Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
- Optional. Press Tab or Enter to validate your entry.
- Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

PI AF collection security

The security descriptor for a PI AF collection determines access permissions to that collection, as well as default access permissions for new objects in the collection. For example, the Elements collection permissions determine which identities can create and delete elements. The Elements collection permissions are replicated as the security descriptor for any newly-created Element objects.

You can configure access permissions to collections at several points in the PI AF hierarchy. You can set them at the server level so that permissions assigned to identities on the server are also assigned to the same identities for every collection in every database (see [Configure security for a PI AF server](#)). You can set them at the database level so that permissions assigned to identities in a database are also assigned to the same identities for every collection in that database (see [Configure security for a single PI AF database](#)).

Note: Library objects (Templates, Enumeration Sets, Reference Types, and Categories) always have Read (r) permission regardless of their security settings.

Configure security for collections

Assign access permissions for a specific collection in a PI AF database.

- Choose one of the following methods to open the Security Configuration window for a database collection:

To open ...	Do this ...
Elements collection	In the Elements browser, right-click the Elements collection () and click Security .
Event Frame collection	In the Event Frames browser, right-click an event

To open ...	Do this ...
	frame search () and click Security .
Transfer collection	In the Event Frames browser, right-click a transfer search () and click Security .
Element Templates collection	In the Library browser, right-click Element Templates and click Security . Note: Access permissions for the Element Templates collection also set access permissions for Event Frame Templates, Model Templates, and Transfer Templates.
Enumeration Sets collection	In the Library browser, right-click Enumeration Sets and click Security .
Reference Types collection	In the Library browser, right-click Reference Types and click Security .
Tables collection	In the Library browser, right-click Tables and click Security .
Table Connections collection	In the Library browser, right-click Table Connections and click Security .
Categories collection	In the Library browser, right-click Categories and click Security .

In the **Items to Configure** list of the Security Configuration window, the collection is selected.

2. In the **Identities** list, review existing identities and validate their permissions. You can also add and remove identities, as needed.

To ...	Do this ...
Add or modify permissions of existing identities	<ol style="list-style-type: none"> Select an identity in the Identities list. In the Permissions for Identity list, select or clear the Allow or Deny check box beside each permission you wish to set. Repeat for each identity.
Add another identity to the Identities list	<ol style="list-style-type: none"> Click Add. In the Select Identity window, select the identity you wish to add. Click OK. The identity is added to the list. In the Permissions for Identity list, set the access permissions as needed (the default setting is all are selected).

To ...	Do this ...
	Tip: If you need to create a new identity and mapping, click New Identity . For more information, see Manage identities in PI AF .
Remove an identity from the Identities list	<ol style="list-style-type: none"> Select an identity in the Identities list. Click Remove.

- In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
- Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
- Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
- Optional. Press Tab or Enter to validate your entry.
- Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

PI AF object security

You can set specific access permissions for an identity that differ from the default settings inherited from elsewhere in the PI AF hierarchy on any object (or object group) and collection in a database.

Configure security for objects

Set access permissions for identities to objects in the browser or the viewer in situations where access needs to be different from inherited permissions. You can also set custom permissions for identities to a specific collection in the Library.

Note: You must have administrative privileges and belong to the PI AF Administrators identity to configure security settings.

- Choose from the following actions:

To set access permissions for ...	Do this ...
A browser object	Right-click the object and click Security .
Multiple objects	<ol style="list-style-type: none"> With multiple objects listed in the viewer (after a search, for example), use standard Windows keystrokes to highlight contiguous (SHIFT+<click>) or non-contiguous (CTRL+<click>) objects. Right-click and click Security.

2. In the **Identities** list, review the identities and validate their permissions. You can also add to and remove an identity from the list.

To ...	Do this ...
Add or modify permissions of existing identities	<ul style="list-style-type: none"> a. Select an identity in the Identities list. b. In the Permissions for Identity list, select or clear the Allow or Deny check boxes beside the permissions you wish to set. c. Repeat for each identity.
Add another identity to the Identities list	<ul style="list-style-type: none"> a. Click Add. b. In the Select Identity window, select the identity you wish to add. c. Click OK. The identity is added to the list. d. In the Permissions for Identity list, set the access permissions as needed (the default setting is all are selected). <p>Tip: If you need to create a new identity and mapping, click New Identity. For more information, see Manage identities in PI AF.</p>
Remove an identity from the Identities list	<ul style="list-style-type: none"> a. Select an identity in the Identities list. b. Click Remove.

3. In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
4. Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
5. Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
6. Optional. Press Tab or Enter to validate your entry.
7. Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

Configure security for analyses and analysis templates

Use the Security Configuration window to manage access permissions for PI AF identities that can work with analyses or analysis templates.

For information on specific permissions that are needed to work with analyses, see [PI AF access rights](#).

1. Choose from the following actions:

To ...	Do this ...
Configure access permissions for an analysis	<ul style="list-style-type: none"> a. In the Elements browser, select the element that contains the analysis. b. Click the Analyses tab. c. Right-click the analysis name and click Security.
Configure access permissions for an analysis template	<ul style="list-style-type: none"> a. In the Library browser, select the element template that contains the analysis template. b. Click the Analysis Templates tab. c. Right-click the analysis name and click Security.
Configure access permissions for all analyses in a PI AF database	<ul style="list-style-type: none"> a. On the toolbar, click Database. b. In the Select Database window, right-click the database name and click Security. c. In the Security Configuration window, clear the Item check box above the Items to Configure list. d. Select the database - Analyses item.
Configure access permissions for all analysis templates in a PI AF database	<ul style="list-style-type: none"> a. On the toolbar, click Database. b. In the Select Database window, right-click the database name and click Security. c. In the Security Configuration window, clear the Item check box above the Items to Configure list. d. Select the database - Analysis Templates item.

2. In the **Identities** list, review the identities and validate their permissions. You can also add to and remove an identity from the list, as described in [Configure security for objects](#).
3. In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
4. Optional. To view all of a user's access permissions on items in PI AF based on his or her current PI AF identity mappings, click the **Effective Access** tab.
5. Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
6. Optional. Press Tab or Enter to validate your entry.
7. Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

Configure security for the UOM database

Units of measurement (UOM) always have Read permission set regardless of other security settings.

You cannot set permissions for individual UOMs or UOM classes. However, you can set permissions for the entire UOM database.

1. In the navigator, select **Unit of Measure**.
2. On the toolbar, click **UOM Security**.

In the **Items to Configure** list of the Security Configuration window, the **Unit-of-Measure Database** item is selected.

3. In the **Identities** list, review existing identities and validate their permissions. You can also add and remove identities, as described in [Configure security for objects](#).
4. In the **Child Permissions** section, choose one of the permission inheritance options. For more information, see [Permission inheritance of element objects](#).
5. Optional. To view a user's access permissions on PI AF objects based on his or her current PI AF identity mappings, click the **Effective Access** tab.
6. Optional. In the **Domain User** field, enter a user's Windows domain name whose permissions you want to view. If you are using OIDC, enter the user's name in the **OIDC User** field.
7. Optional. Press Tab or Enter to validate your entry.
8. Click **OK**.

Note: If you are using OpenID Connect (OIDC) for claims-based authentication and role mapping, the **Effective Access** tab shows the OIDC user's permissions on PI AF objects. The **User SID** field is not shown.

Differences from Data Archive security model

Although the security model is similar to that which Data Archive uses, there are a number of differences:

- The Deny privilege is supported. See [Deny permission option](#).
- A more expansive set of access permissions is available. See [PI AF access rights](#).
- The equivalent of PI user and PI group identities are not supported.
- PI trusts and PI explicit logins are not supported.
- The concept of an undeletable flag on an identity or mapping is not supported.
- Mappings cannot be disabled. Only PI AF identities can be disabled.
- A single Windows user identity can be mapped to more than one PI AF identity.
- An Identity provider role can be mapped to multiple PI AF identities.
- A different built-in set of identities is installed: Administrators, Engineers, and World.

Event frames in PI AF

Capturing important events in your process and collecting relevant data around those events can help analyze why they occurred. For example, you can closely monitor events such as asset downtime, process excursions, equipment startup or shutdown, and environmental excursions to identify possible causes or potential points of failure.

Collecting data around repeatable time periods such as product tracking batches, product runs, or operator shifts can help make those processes more efficient. The capture of comprehensive data associated with such an event

helps track, compare, or analyse the process or event.

Just as elements allow you to collect and store data about assets, event frames allow you to collect and store data about events. It is recommended you use asset analytics to track your events using event frames. PI Datalink, AVEVA PI Vision, and PI WebParts are the client tools that support event frame visualization.

Sample event data

An event frame encapsulates the time period of the event with relevant, comprehensive asset data:

Event Information							Related Data				
Name	Start Time	End Time	Primary Element	Operator	Phase	Reason Code	Level Start	Temp. Max	Temp. Start		
Template: Downtime											
DT20120805 22:56	8/5/2012 10:56:00 PM	8/5/2012 11:00:00 PM	RE200	Vivian White	Material Add 1	DRIVE FAILURE	0 L	12.935262298...	0.41429677605629 deg C		
DT20120805 23:00	8/5/2012 11:00:00 PM	8/6/2012 12:00:00 AM	RE400	Don Wallace	XFER_OUT	No Oil	69.978393554...	110.66223907...	40.0944023132324 deg C		
DT20120805 23:26	8/5/2012 11:26:00 PM	8/5/2012 11:29:00 PM	RE100	Bobby Johnson	Material Add 1	No Oil	4.6750192642...	5.4764796495...	3.44453287124634 deg C		
DT20120805 23:56	8/5/2012 11:56:00 PM	8/6/2012 12:00:00 AM	RE200	Vivian White	Inactive	DRIVE FAILURE	3.5982928276...	8.9376313209...	8.93763160705566 deg C		
DT20120806 0:14	8/6/2012 12:14:00 AM	8/6/2012 12:18:00 AM	RE400	Don Wallace	XFER_OUT	ESTOP	74.283164978...	56.506531524...	56.5065307617188 deg C		
DT20120806 0:26	8/6/2012 12:26:00 AM	8/6/2012 12:29:00 AM	RE100	Bobby Johnson	Dwell	UNKNOWN	62.131874084...	101.77695465...	98.174674987793 deg C		
DT20120806 0:56	8/6/2012 12:56:00 AM	8/6/2012 1:00:00 AM	RE200	Vivian White	Agitate	ESTOP	46.672977447...	62.632131067...	62.6321296691895 deg C		
DT20120806 1:14	8/6/2012 1:14:00 AM	8/6/2012 1:18:00 AM	RE400	Don Wallace	Heat	DRIVE FAILURE	68.781196594...	96.730087280...	72.2844924926758 deg C		

Videos

For information on event frames, watch this video:

Alternatively, you can view all the videos on the event frames playlist:

Structure of event frames

Each event frame has a name, start time, end time, one or more attributes, and one or more referenced PI AF elements. As with elements, you should create event frame templates to standardize and manage the attributes for different types of events.

With event frames you can easily search the PI System for the events themselves, rather than search for events by time. You can configure event frames to return all related event data automatically in real-time so that you do not need to query multiple systems for event and process data, and then merge them together manually. You can also set up event frames to retrieve historical data.

When to use event frames

There are two categories of trackable events that would fit an event frame profile:

- "Good" events: Events that you want to track as a normal part of business, such as product tracking, shifts, and so on.
- "Bad" events: Events that are unexpected and need to be analyzed and perhaps fixed quickly if they ever occur, such as expected shutdowns or excursions. These are events that you want to track and report in aggregate, over a period of time.

Asking questions such as these can help identify events or conditions that must be tracked:

- What are all the times that event X occurred on this type of asset?
- Can I associate data from different tags for a time-range, or for a single point in time?
- What is the associated data for a particular time period when a problem occurred or may occur in the future?
- What are the critical process events that someone needs to be notified on?

- Are there digital states for PI tags that are significant when they change, and must they trigger other actions?

Advantages of event frames

Event frames provide these advantages:

- **Flexibility**

Event frames:

- Reference multiple elements within the same event.
- Support multiple overlapping events on a PI AF element.
- Capture any event; a "batch" is just one type of capturable event.

- **Easy search options**

Searches can be specified on a number of configurable event frame attributes: it is optional to specify a time range. For example, you can search just by entering the name of the event frame. The most commonly searched event frame attributes can be configured as indexed attributes through event frame templates, which speeds up end-user searches.

- **Scalability**

Event frames are extremely scalable whereas search performance degrades with a large number (tens of thousands) of batches.

Examples of event frames

Example of event frames in a wind power generation company

Take the example of a wind power generation company that has different types of windmills across different locations and uses PI AF to organize their data. Their asset framework structure is based off a base element template of type "windmill", and has various child templates based off OEM, model, and megawatt ratings. The wind operator may want to win favorable warranty contracts by showing that the blades are operating safely. Or, the operator may need to monitor parameters such as oil bearing pressure, maximum voltage, power-factor, or performance of electronic and mechanical brakes in the minutes before process trips occur. In all these cases, you can associate event frames with the specific event frame attributes.

The sample windmill element may include these asset attributes and associated event frame attributes:

Asset attribute	Event frame attribute
RPM	Instantaneous and maximum speeds
Voltage	Maximum voltage
Power	Power at current time
Yaw	Yaw at current time
Pitch	Pitch at current time

Asset attribute	Event frame attribute
Oil bearing pressure	Maximum oil bearing pressure

Since all types of turbines share many identical attributes, you can create just one event frame template and use it to monitor similar events across the different assets. For example, you may be interested in the RPM attribute to capture a speed-based event. Using the special notation .\Elements[.]|RPM in the template enables you to use the template on any windmill, and access the attribute of the particular referenced element.

Example of event frames using Asset Analytics

For an example of creating event frames using asset analytics, see [Create event frames automatically to track inefficiency](#).

Event frames or batch?

Batch provides you with a means to generate batch event data based on PI tags. Event frames provide you with a way to track and analyze process and business data related to events that are defined on PI AF attributes.

Different companies and users come from different levels of PI System implementation and use of PI System features; hence, the recommendation of whether to choose batch or event frames is highly subjective. However, as a general recommendation, all customers should migrate to event frames in the near future. Here are a few examples of scenarios that customers may find themselves in:

- You are a batch user and use RtReports.
- Since RtReports 4.1 now supports AF and event frames, you should run the 'Batch To Event Frames' migration, and then migrate your RtReport templates to utilize AF contexts.
- You do not currently use Batch but have batch use-cases or must use RtReports.
- Event frames are recommended. Event frames will support all your needs!
- You do not use Batch and do not have batch use-cases.
- You must use event frames. Typical event frame use-cases include downtime or outages in power industries, excursions in water utility industries, and so on.

Note: Do not run dual or parallel instances of Batch and event frame interfaces in production as it adds to your migration complexity.

Ways to create event frames

Although you can create event frames with several different of our products, we strongly recommend asset analytics.

Asset analytics

Data Archive supports creation of single-layer events and can trigger expressions that open or close event frames. See [Event frame generation analyses](#).

PI Event Frame Generator (PI EFGen)

PI EFGen uses both PI SDK and AF SDK to create a hierarchy of events or to convert a PI BaGen structure to an event frame generator structure. Use PI System Explorer or PI Builder to create the event frame templates, associated attributes and PI point references.

For instructions on how to create event frames with PI EFGen, watch this video:

PI interfaces for batch and manufacturing execution systems

PI Batch Framework 3.x and later versions can create event frames within a PI AF database or PI Batch objects within a PI Batch database. For more information on creating event frames and using PI interfaces to populate the PI AF database with events-based data, see:

- [PI Event Frames Interface Manager](#)

Programmable interfaces

You can create your own custom program using AF SDK to create and monitor events.

Manual creation of event frames

The manual creation and management of event frames is strongly discouraged. Instead, use Data Archive with asset analytics support or PI Batch, depending on your process needs. See [Event frames or batch?](#)

Visualization of event frames

You can use PI Datalink, AVEVA PI Vision, and PI WebParts client tools to visualize event frames. You can also use PI OLEDB Enterprise, PI JDBC Driver, or PI Web Services to integrate event frame data into other third-party

reporting tools.

Note: PI ProcessBook, PI BatchView, and PI Manual Logger do not currently support event frame visualization.

- **PI Datalink**

PI Datalink support for event frames includes exploring and comparing hierarchical events. For more information, see [Events in worksheets](#).

- **AVEVA PI Vision**

AVEVA PI Vision enables you to view and analyze your PI System data during the time range of a particular event. For example, you may want to examine the performance of an asset during an operator shift or compare the data for several assets during a downtime period.

AVEVA PI Vision supports event frames through the "Related Events" viewer. For more information, see [Analyzing and comparing events](#).

- **PI WebParts**

PI WebParts does not include specific features related to event frame visualization. However, you can create a data set based on a relational data source that retrieves event frame data via PI OLEDB Enterprise. This event frame data can then be displayed in a PI Table web part, for example, and used to provide context, such as start and end times, to other web parts on the page.

Event frame templates

Using event frame templates, you can define and standardize the related data (event frame attributes) associated with different types of events. For consistency, it is recommended to create event frame objects from templates. To learn more, see [Base and derived templates](#). You can use event frame attributes to provide additional context around the event that are useful for searches and reports. For example, downtime events often have a reason code that users want to search for or filter on during analysis of their downtime events.

Note: Event frames cannot be created directly from templates marked **Base Template Only** (BTO). You create a derived template from the BTO template and then create event frames from the derived template. When you create an event frame based on a derived template, it inherits all the attributes of the derived template and the BTO template.

You can also configure event frame attributes to reference process data in the context of the event. For example, a temperature excursion event is likely to have an attribute for the maximum temperature. You can configure event frames to record those values for you. Additionally, for each event type, you can configure an index for the most frequently searched attributes. This approach enables faster and easier searches on the PI AF server when you track several event types or millions of events.

Data references in event frame templates

When you create event frames dynamically with event frame templates, you typically need to reference elements, attributes, templates or other related objects based on those event frame templates. Because each individual event frame occurs in a slightly different context, you can use substitution parameters to reference other PI AF objects dynamically, rather than static, absolute references. For example, you can use a downtime event frame template for any number of assets, such as a pump, motor, boiler, compressor, and so on.

In PI point data references, substitution parameters are useful for:

- Building tag name references based on hierarchy or other attribute values.

- Referencing other PI point attributes, such as from an event frame to the primary referenced element.

The main limitation of PI point data references is that the element attribute must also be a PI point data reference.

In String Builder data references, substitution parameters are useful for:

- Obtaining numeric values or string values when referenced element attributes do not have a PI point data reference.
- Creating a string by concatenating multiple values from referenced element attributes and other text.
- Passing a time context, including the end time of the event frame.
- Obtaining the name of referenced elements or their parents.

The limitation of String Builder data references is that they do not perform unit of measure conversions or perform aggregations or calculations.

A specific syntax is required to reference attributes from event frame templates, as described in [Data references to attributes in the primary referenced element](#) and [Data references to attributes in other elements](#).

Video

For information on how to set up event frame templates, watch this video:

Primary referenced element

Each event frame references one or more elements. The event frame's **Referenced Elements** tab lists all elements that the event frame refers to. The main element referenced by the event frame is called the primary referenced element, and is indicated by a checkmark on the element icon: 

By default, the first referenced element added is set as the primary referenced element, but you can change it by right-clicking on another element and selecting **Set as Primary Element Reference**.

Note: If you delete the reference to the primary element, PI System Explorer does not automatically set a new primary referenced element. You must select a new primary referenced element manually.

Data references to attributes in the primary referenced element

In data references from an event frame template, you can refer to an attribute in an event frame's primary referenced element with the syntax:

```
.\Elements [.]|AttributeName
```

.	Indicates the current object, which is the event frame.
\Elements	Specifies the elements collection of the current object.
[.]	Indicates the default object of the current object. In this case, it is the event frame's primary referenced element.
/AttributeName	Specifies the name of the attribute.

For example, `.\Elements [.]|Flowrate` obtains the value of the *Flowrate* attribute from the primary referenced element.

Note: This syntax is primarily used to reference PI point data references. For more information on assigning a static value to an attribute, see [Configuration Item attribute property](#), [Define constant values for attribute templates](#), and [Create attributes on event frames](#).

Data references to attributes in other elements

In data references from an event frame template, you can reference other elements and attributes with collection filters and relative paths.

Examples that use collection filters

You can reference other elements and attributes with the collection filters shown in the following table.

Collection filter	Example	Explanation
@Category	<code>.\Elements[@Category=MyCategory]</code>	Obtains the value of the first referenced element that is assigned to the <i>MyCategory</i> category.
@Description	<code>.\Elements[@Description=MyDescription]</code>	Obtains the value of the first referenced element that has the <i>My Description</i> description.
@Index	<code>.\Elements[@Index=3]</code>	Obtains the value of the third referenced element.
	<code>.\Elements[@Index=2] FlowRate</code>	Obtains the value of the <i>FlowRate</i> attribute from the second referenced element.

Collection filter	Example	Explanation
@Name Note: You can use wild cards with @Name.	.\Elements[@Name=Tank1]	Obtains the value of the element named <i>Tank1</i> .
	.\Elements[@Name=*2]/FlowRate	Obtains the value of the <i>FlowRate</i> attribute from the first referenced element whose name ends in 2.
@ReferenceType	.\Elements[@ReferenceType=Area]	Obtains the value of the first referenced element that uses the <i>Area</i> reference type.
@Template	.\Elements[@Template=MyTemplate]	Obtains the value of the first referenced element that uses the <i>MyTemplate</i> template.
	.\Elements[@Template=PumpTemplate]/%attribute%	Obtains the value of the attribute that has the same name as this event frame attribute from the first referenced element that uses the <i>Pump Template</i> .
@Trait	.\Elements[@Name=Tank*]/Attributes[@Trait=LoLo]	Obtains the value of the attribute with a <i>LoLo</i> trait in the first referenced element whose name begins with <i>Tank</i> .
@Type	.\Elements[@Name=Tank*]/Attributes[@Type=System.Int32]	Obtains the value of the first attribute that has an <i>Int32</i> value type in the first referenced element whose name begins with <i>Tank</i> .
@UOM	.\Elements[@Name=Tank*]/[@UOM=meter]	Obtains the value of the first attribute that uses the <i>meter</i> unit of measure in the first referenced element whose name begins with <i>Tank</i> .

Examples that combine collection filters

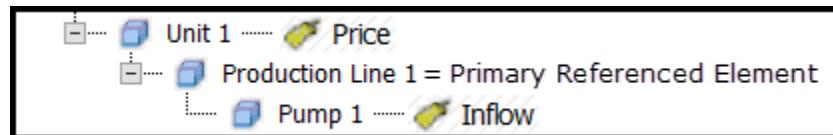
You can also combine collection filter criteria, as shown in the following examples:

Example	Explanation
\Elements[@Name=*2][@Category=Pump]/FlowRate	Obtains the value of the <i>FlowRate</i> attribute from the first referenced element whose name ends in 2 and whose element category is <i>Pump</i> .
\Elements[@Name=Pump*][@Template=Pump Template]/FlowRate	Obtains the value of the <i>FlowRate</i> attribute from the first referenced element whose name starts with <i>Pump</i> and whose element template is <i>Pump Template</i> .
\EventFrames[@Template=Machine Template]/Pressure	Obtains the value of the <i>Pressure</i> attribute from the first child event frame whose template is <i>Machine Template</i> .
.\EventFrames[@Template=Machine Template][@Index=-1]/Pressure or .\EventFrames[@Template=Machine Template][-1]/Pressure	Obtains the value of the <i>Pressure</i> attribute from the most recent child event frame whose template is <i>Machine Template</i> . Note: Beginning with PI AF 2017, you can use a negative number for an index from the end of a collection (for example -1 indicates the last item, -2 indicates the penultimate item). The <i>@Index</i> filter is optional if another filter is specified before the index filter.

Examples that use relative paths

You can use relative path syntax to navigate the **Elements** hierarchy from an event frame and obtain other attribute values. For example, suppose you have the following element hierarchy:

In an event frame that has Production Line 1 as the primary referenced element, you can obtain the value of the Price attribute that is assigned to the Unit 1 parent element with the following syntax:



.\Elements[.]\..\|Price

If the Price attribute were two levels up the hierarchy, you would use:

.\Elements[.]\..\..\|Price

You can obtain the value of the Inflow PI point attribute that is assigned to the Pump 1 child element with the following syntax:

.\Elements[.]\Pump 1\Inflow

If the Pump 1 child element were based on the Pump element template, you would use:

.\Elements[.]\[@Template=Pump]\Flow

Create event frame templates

Create and configure event frame templates to ensure consistent definitions for event frames in your asset structure.

1. In the navigator, click **Library**.
2. In the Library browser, click **Event Frame Templates**.
3. To create a new event frame template, choose one of the following actions:
 - On the toolbar, click **New Template**.
 - Right-click **Event Frame Templates** and click **New Template**.
 - Right-click in the **Event Frame Templates** pane and click **New Template**.
4. In the **General** tab of the Event Frame Template Properties window, enter a unique name and a description for the event frame template in the **Name** and **Description** fields.
5. Adjust settings on tabs to configure the event frame template. PI System Explorer provides defaults for all required settings, but you can configure settings yourself. The settings include:

Option	Description
Base Template	You can base the template on an existing event frame template, which you select from the drop-down list. For more information on base templates, see Base and derived templates .
Severity	Select a severity setting for event frames based on the template. You can choose None (default), Information , Warning , Minor , Major , and Critical . Note: Event frames that have already been created with a specific severity setting are not updated automatically if the Severity setting in an event frame template is later changed.
Categories	Optional. Organize event frame templates by grouping them into element categories. To browse available categories or to create a new category, click  .
Default Attribute	Optional. After you have created attributes for the template, you can select a default attribute from the drop-down list. For more information, see Default attribute .
Naming Pattern	Optional. You can enter a text string, or click  to choose from the following substitution parameters to define a naming pattern. <ul style="list-style-type: none">• %STARTTIME:yyyy-MM-dd HH:mm:ss.fff% The current local start time of the object using

Option	Description
	<p>the specified formatting. If no formatting is specified, the default formatting is used. The formatting uses standard format strings supported by the <code>DateTime.ToString</code> method, as described in Format strings for time substitution parameters.</p> <ul style="list-style-type: none">• %UTCSTARTTIME:yyyy-MM-dd HH:mm:ss.fff% The current Coordinated Universal Time (UTC) start time of the object using the specified formatting. If no formatting is specified, the default formatting is used.• %TEMPLATE% The name of the object's template.• %@Attribute% The value of the object's attribute template, represented by the path.• %ELEMENT% The name of the primary referenced element of the object's event frame.• %ELEMENTDESCRIPTION% The description of the primary referenced element of the object's event frame. You can also use other naming pattern substitution parameters. For example, if you want an event frame generation analysis name included in the naming pattern, enter <code>%ANALYSIS%</code> as a substitution parameter. For a complete list of naming pattern substitution parameters, see Naming patterns. Each element derived from the template will have a unique, identifiable name. To ensure that new elements created from the template have an incremental number, enter * at the end of any pattern you enter here. Naming patterns are re-evaluated on an event frame when the Start time, End time, or primary referenced element is modified after it has been created. It will not be re-evaluated when loaded from another application. To force an element or event frame to re-evaluate its naming pattern, right-click the object and click Reevaluate Naming Pattern. Some substitution parameters may not be

Option	Description
	<p>applied when a derived event frame is created. To ensure a derived event frame's name fully reflects the naming pattern, right-click the event frame and click Reevaluate Naming Pattern.</p> <p>Note: The name generated by the naming pattern must be less than the maximum name length of 260 characters.</p> <p>If left blank, PI System Explorer uses the following rules:</p> <ul style="list-style-type: none"> Event frames that are generated by event frame generation analyses use a default naming pattern of: %ANALYSIS% %STARTTIME:yyyy-MM-dd HH:mm:ss.fff% Event frames that are created by other methods use the name of the event frame template and the current date: %TEMPLATE%yyyyMMdd
Allow Extensions	<p>Select this check box to enable additional attributes to be defined for an event frame, beyond those defined in its template. For more information, see Extensions.</p> <p>Note: Categories, analyses and notifications are not affected by whether the Allow Extensions check box is enabled.</p>
Can Be Acknowledged	<p>Select this check box to enable users to acknowledge an event frame. For more information, see Acknowledgment of event frames.</p> <p>Note: This setting only affects event frames that are created after a template is created or modified.</p>
Base Template Only	<p>Select this checkbox to assign the Base Template Only (BTO) property to an event frame template. An event frame cannot be created directly from a BTO template. For more information, see Base and derived templates.</p>
Extended Properties	<p>This link is an advanced feature. For more information, see Storage of application-specific information.</p>
Location	<p>Click this link if you wish to specify location attribute traits for the event frame template. For more information, see Set location attribute traits.</p>
Reason	<p>Click this link if you wish to set up reason attribute</p>

Option	Description
	traits for the event frame template so that users can select reason codes for downtime, excursions, and other events. For more information, see Set reason attribute traits .
Security	Click this link if you wish to set up custom access permissions to the event frame template beyond those already established at the server and database level. For more information, see Configure security for objects .

6. Use the **Attribute Templates** tab to create an attribute template for each property or data item for the template. See [Create attribute templates](#).

Change event frame templates

Exercise caution when you change an event frame template, since there can be unintended consequences. For example, attributes could be deleted if they were defined by the old template and are not present in the new template. Be sure that attributes with the same name in both the old and new template have the same data type.

You can change the template on which an existing event frame is based, or add a template to an event frame that is not currently based on a template.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, right-click the **Event Frame Searches** collection and click **New Search**.
3. In the Event Frame Search window, enter criteria to locate the event frame that you want to change.
4. Right-click the appropriate event frame in the browser and click **Convert > Change Template**.
5. In the Choose Event Frame Template window, select the desired template from the **Event Frame Template** list.
 - Optional. To display only templates in a specific category, select a category from the **Templates of category** list.
6. Click **OK**.

Create event frames

Although you typically use event-frame-generation analyses or PI Event Frames Generator (PI EFGen) to create event frames, you can create an event frame manually. It is simply not recommended.

1. In the navigator, select **Event Frames**.
2. To create a new event frame, choose one of the following actions:
 - On the toolbar, click **New Event Frame**.
 - In the Event Frames browser, right-click the **Event Frame Searches** collection and click **New Event Frame**.
 - In the viewer, right-click and click **New > New Event Frame**.

3. In the **Event Frame Template** section of the Choose Event Frame Template window, select an event frame template and click **OK**.

The new event frame is displayed in the viewer with four tabs for configuring the event frame.

4. In the **General** tab, enter a unique name and a description for the event frame in the **Name** and **Description** fields.
5. Adjust settings on tabs to configure the event frame. PI System Explorer provides defaults for all required settings, but you can configure settings yourself. The settings include:

Option	Description
Template	Displays the template that you selected when you created the event frame. To review the template properties, click  .
Severity	Select a severity setting for the event frame. You can choose None (default), Information , Warning , Minor , Major , and Critical .
Start time	Defaults to current date and time. Press F2 or click  to open the Date and Time Picker window where you can select a different start time.
End time	Defaults to no date or time. Press F2 or click  to open the Date and Time Picker window where you can select a different end time.
Categories	Optional. You can organize event frames by grouping them into element categories. To browse available categories, click  .
Default Attribute	Optional. This field is read-only if the event frame is based on a template. After you have created attributes for the event frame in the Attributes tab, you can select a default attribute from the drop-down list. For more information, see Default attribute .
Extended Properties	This link is an advanced feature. For more information, see Storage of application-specific information .
Annotations	Click this link if you wish to enter a comment and/or add a file attachment specific to the event frame. For more information, see Add annotations to event frames .
Location	Click this link if you wish to specify location attribute traits for the event frame. For more information, see Set location attribute traits .

Option	Description
Reason	Click this link if you wish to set up a reason attribute trait for the event frame. For more information, see Set reason attribute traits .
Security	Click this link if you wish to set up custom access permissions to the event frame beyond those already established at the server and database level. For more information, see Configure security for objects .

6. Optional. You can choose from the following actions, as needed.

Option	Description
Capture values	To improve performance, you can save event-frame attribute values in PI AF rather than have data references calculated and executed. For more information, see Value capture for event frames and transfers .
Lock	<p>After the underlying action for an event frame has completed, such as batch completion, you can click this link to prevent further changes to it. For more information, see Lock event frames or transfers.</p> <p>Note: Only Administrator users can unlock an event frame.</p>
Acknowledge	If the event frame is based on a template where both the Can Be Acknowledged setting and the annotation access right are enabled, click this link to indicate that you have acknowledged the event frame. For more information, see Acknowledgment of event frames .

7. Edit the remaining tabs as needed.

- To add attributes, see [Create attributes on event frames](#).
- To set a primary referenced element, see [Primary referenced element](#).

Create attributes on event frames

Create attributes on event frames in the same way as on elements.

1. In the Event Frames browser, find and select the parent event frame.
2. In the viewer, select the **Attributes** tab.
3. If no attributes exist, click the **New Attribute** link. Alternatively, click **New Attribute** on the toolbar.

Note: If the event frame is based on a template, you cannot add an attribute unless the template allows

extensions.

4. In the **Name** field, enter a unique name for the attribute.
5. In the **Description** field, enter a description for the attribute.
6. In the **Properties** field, select attribute properties as needed. For more information, see [Attribute properties](#).
7. Optional. In the **Categories** field, assign the attribute to a category. To browse available categories, click .
8. In the **Default UOM** field, select the unit of measure for the attribute.
9. In the **Value Type** field, select the data type of the attribute.
10. To assign a value to the attribute, choose from the following actions.

To ...	Do this ...
Enter a static value	Type a value in the Value field.
Derive or calculate a value from a data reference	<ol style="list-style-type: none">a. Select a data reference type from the Data Reference list.b. Click Settings to configure the data reference. For details about configuring a data reference, see Configuration of data references.

11. Optional. When the **Use DisplayDigits for Attribute and Attribute Template values** system option is selected, you can override the default DisplayDigits property value of -5 and specify the number of digits to display in the **Display Digits** field. Only numeric values in the **Value** field are affected. For attributes that are not based on a template, the precision of PI point data references is obtained from the PI point itself.
 - Enter a negative number up to -20 to indicate the total number of digits to display.
 - Enter a positive number up to 10 to indicate the number of digits after the decimal point to display, including trailing zeros.For more information, see [Control the display of attribute and attribute template values](#) and [PI System Explorer customization options](#).
12. To save your work, press CTRL-S or click **Check In**.

Value capture for event frames and transfers

To display values for an event frame or transfer, PI AF executes data references to retrieve associated attribute values for the time period. You can, however, use **Capture Values** to save those values in a PI AF database table (**AFEventFrameAttributeValue**). Doing this can improve performance, since it is faster to display the saved values than to retrieve them.

You can also use **Capture Values** to ensure attribute values displayed for event frames are the same at any future point as when they were captured. Additionally, **Capture Values** provides a way to preserve values that might not be available later, such as streaming data that is not persisted long-term.

Value recapture

Automatic recapture occurs whenever the start time and end time of a captured event frame or transfer is modified.

Whenever you add new attributes to an event frame or transfer, you must recapture values to ensure that values

are also captured for the new attributes.

Note that when you recapture values, data loss can occur if a data reference has changed since the initial value capture: For example, if values in a table accessed by a table lookup data reference have been modified.

Capture values

You capture values to save event frame or transfer attribute values to a table in the PI AF database. This can improve performance since PI AF does not execute any data references.

Note: If you add new attributes to event frames or transfers with captured values, you should recapture those values to ensure that values are also captured for the new attributes.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, choose from the following actions.

To capture values for ...	Do this ...
All transfers or parent event frames in a collection	<ol style="list-style-type: none">a. Right-click a search or recent collection.b. Click Capture or Recapture Values. Alternatively, follow these steps.c. Click a search or recent collection.d. In the viewer, right-click below the list of event frames or transfers.e. Click Capture or Recapture Values.
Child event frames in a collection	<ol style="list-style-type: none">a. Click a search or recent collection.b. In the viewer, click <input checked="" type="checkbox"/> beside each event frame for which you want to capture values. The child event frames are displayed.c. In the viewer, use Windows selection keystrokes to select event frames and child event frames:<ol style="list-style-type: none">a. To select contiguous objects, press SHIFT+<click>.b. To select non-contiguous objects, press CTRL+<click>.c. To select all displayed objects, press CTRL+A.d. Right-click a selected event frame.e. Click Capture or Recapture Values.
A single event frame	<ol style="list-style-type: none">a. Expand a search or a recent event frame collection.b. Select the event frame.c. Choose from the following actions.

To capture values for ...	Do this ...
	<p>a. In the General tab, click the Capture Values link.</p> <p>b. Right-click and click Capture or Recapture Values.</p> <p>Note: For subsequent value captures, the link changes to Recapture Values.</p>
A single transfer	<p>a. Expand a search or a recent transfer collection.</p> <p>b. Select the transfer.</p> <p>c. Right-click and click Capture or Recapture Values.</p>

3. In the Capture or Recapture Values window, check the status and click **Close**.

A Has Captured Values icon () is displayed in the viewer beside each event frame or transfer that has a captured value.

Lock event frames or transfers

After the underlying action for an event frame or transfer has completed (for example, after a batch has finished), the event frame or transfer is still open and can continue to receive data. You can lock an event frame or transfer, preventing further changes to it.

Unlocking an event frame or transfer requires Administrator permission. Only users with Administrator permissions on an object have the ability to unlock it.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, open the **Event Frame Searches** (or **Transfer Searches**) collection that contains the object you want to lock.
3. Right-click the object and click **Lock**.
4. To verify that the object is locked, select the event frame or transfer search collection that contains the object.

The object is displayed in the viewer with next to it in the Lock column.

Acknowledgment of event frames

In PI AF 2016 and later, you can require that an event frame be acknowledged. The acknowledgment feature is used by notifications and PI AF client applications, such as AVEVA PI Vision. The event-frame acknowledgment feature replaces the acknowledge notification functionality in the legacy version of Notifications.

- For more information on setting up event-frame acknowledgment in notifications, see Configuration of notification rules for analyses or event frames.
- For more information on viewing and acknowledging event frames using AVEVA PI Vision, see the AVEVA PI Vision user guide.

Security for event-frame acknowledgment

A user needs to have a PI AF identity for which the Annotate permission (an) is enabled. For more information on access rights, see [PI AF access rights](#).

Setup of event-frame acknowledgment

You set up an acknowledgment by selecting the **Can Be Acknowledged** check box as you configure an event frame template. Any event frame that is based on that template displays an **Acknowledge** link on the **General** tab. In event frames based on event frame templates where the **Can Be Acknowledged** check box is not selected, the **Acknowledge** link is inactive. You also cannot acknowledge event frames that are not based on an event frame template.

Note: The **Can Be Acknowledged** setting only affects event frames that are created after a template is created or modified.

Search for event-frame acknowledgments

You can search for event frames that can be acknowledged, as well as those that have been acknowledged. You review acknowledgment status in the Viewer for the Event Frame Searches collection, where an Acknowledged column is displayed (⚠). Possible values are:

⚠	Is not acknowledged
OK	Is acknowledged
blank	Not acknowledgeable

To group event frames by their acknowledged status, click the ⚠ column icon.

Acknowledge event frames

You acknowledge event frames in the Event Frames browser or in the **General** tab of a selected event frame in the Event Frames viewer.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, click an Event Frame Search collection.
The contents of the collection are displayed in the viewer.
3. Optional. To group event frames by their acknowledged status, click the ⚠ column icon.
4. Choose from the following actions.

To ...	Do this ...
Acknowledge an event frame	<ol style="list-style-type: none">a. Choose one of the following actions:<ol style="list-style-type: none">a. Right-click an event frame in the viewer and click Acknowledge on the context menu.b. Double-click an event frame in the viewer

To ...	Do this ...
	<p>and, on the General tab, click the Acknowledge link.</p> <p>b. Click Yes in response to the Are you sure you want to acknowledge Event_Frame_Name? prompt.</p> <p>c. The following changes occur:</p> <ul style="list-style-type: none"> a. In the Event Frame Search collection that is displayed in the viewer, the Acknowledged (⚠) column changes to OK status. b. On the General tab, the Acknowledged field is displayed with a time and date stamp. The user ID of the user who made the acknowledgment is displayed in the By field.
Review an acknowledgment	<p>a. In the Event Frame Search collection that is displayed in the viewer, double-click an event frame that has a status of OK (ⓘ).</p> <p>b. On the General tab, review the time and date stamp in the Acknowledged field, as well as the user ID of the user who made the acknowledgment.</p>

Transfers

Transfers are a type of event frame. They mark movement of material in discrete quantities. They have a start time and an end time. Transfers are unique in a model because they are temporal and appear in a model only when a transfer of material has taken place. For example, use transfers to track material movements in and out of the facility, track raw materials used in the process and finished product being stored, and track tank-to-tank material transfers.

Create transfer templates

Create and configure transfer templates to ensure consistent definitions for transfers in your asset structure.

1. In the navigator, click **Library**.
2. In the Library browser, click **Transfer Templates**.
3. To create a new transfer template, choose one of the following actions:
 - On the toolbar, click **New Template**.
 - In the **Transfer Templates** pane, click **New Template**.
 - Right-click **Transfer Templates** and click **New Template**.
4. In the **General** tab of the Transfer Template Properties window, enter a unique name and a description for the transfer template in the **Name** and **Description** fields.

5. Adjust settings on tabs to configure the transfer template. PI System Explorer provides defaults for all required settings, but you can configure settings yourself. The settings include:

Option	Description
Base Template	You can base the template on an existing transfer template, which you select from the list. For more information on base templates, see Base and derived templates .
Categories	Optional. Organize transfer templates by grouping them into element categories. To browse available categories or to create a new category, click  .
Default Attribute	Optional. After you have created attributes for the template, you can select a default attribute from the list. For more information, see Default attribute .
Naming Pattern	<p>Optional. You can enter a text string, or click  to choose from the following substitution parameters to define a naming pattern.</p> <ul style="list-style-type: none"> • %TIME:yyyy-MM-dd HH:mm:ss.fff% The current local time of the object using the specified formatting. If no formatting is specified, the default formatting is used. The formatting uses standard format strings supported by the <code>DateTime.ToString</code> method, as described in Format strings for time substitution parameters. • %UTCTIME:yyyy-MM-dd HH:mm:ss.fff% The current Coordinated Universal Time (UTC) time of the object using the specified formatting. If no formatting is specified, the default formatting is used. • %STARTTIME:yyyy-MM-dd HH:mm:ss.fff% The current local start time of the object using the specified formatting. If no formatting is specified, the default formatting is used. • %UTCSTARTTIME:yyyy-MM-dd HH:mm:ss.fff% The current Coordinated Universal Time (UTC) start time of the object using the specified formatting. If no formatting is specified, the default formatting is used. • %TEMPLATE% The name of the object's template. • %@Attribute%

Option	Description
	<p>The value of the object's attribute template, represented by the path.</p> <ul style="list-style-type: none"> • %SOURCE% Name of the source element for the transfer. • %DESTINATION% Name of the destination element for the transfer. <p>You can also use other naming pattern substitution parameters. For a complete list of naming pattern substitution parameters, see Naming patterns.</p> <p>Each transfer derived from the template will have a unique, identifiable name. To ensure that new transfers created from the template have an incremental number, enter * at the end of any pattern you enter here.</p> <p>Naming patterns are re-evaluated on a transfer when the Start time is modified after it has been created. It will not be re-evaluated when loaded from another application. To force a transfer to re-evaluate its naming pattern, right-click the object and click Reevaluate Naming Pattern.</p> <p>Some substitution parameters may not be applied when a derived transfer is created. To ensure a derived transfer's name fully reflects the naming pattern, right-click the transfer and click Reevaluate Naming Pattern.</p> <p>Note: The name generated by the naming pattern must be less than the maximum name length of 260 characters.</p> <p>If left blank, PI System Explorer uses the name of the transfer template and the current date: <code>%TEMPLATE%yyyyMMdd</code></p>
Allow Extensions	<p>Select this check box to enable additional attributes to be defined for a transfer, beyond those defined in its template. For more information, see Extensions.</p> <p>Note: Categories are not affected by whether the Allow Extensions check box is enabled.</p>
Base Template Only	<p>Select this checkbox to assign the Base Template Only (BTO) property to a transfer template. BTO templates can only be used to create derived</p>

Option	Description
	templates. Transfers cannot be created directly from BTO templates. For more information, see Base and derived templates .
Extended Properties	This link is an advanced feature. For more information, see Storage of application-specific information .
Reason	Click this link if you wish to set up a reason attribute trait for the transfer template. For more information, see Set reason attribute traits .
Security	Click this link if you wish to set up custom access permissions to the transfer template beyond those already established at the server and database level. For more information, see Configure security for objects .

6. Use the **Attribute Templates** tab to create an attribute template for each property or data item for the template. See [Create attribute templates](#).
7. Optional. Use the **Ports** tab to define additional ports that define end-points for connections between transfer elements, or to modify the default **In** and **Out** ports. See [Create transfer ports](#).

Create transfers

Default **In** and **Out** transfer ports with Boundary and Node connection types are automatically created for every transfer.

You create a transfer in the Event Frames browser.

1. In the navigator, click **Event Frames**.
 2. In the Event Frames browser, click the **Transfer Searches** (or **Recent Transfers**) collection.
 3. To create a new transfer, choose one of the following actions:
 - On the toolbar, click the **New Transfer** button.
 - In the **Event Frames** browser, right-click the **Transfer Searches** collection and click **New Transfer**.
 - In the viewer, right-click and click **New Transfer**.
 4. In the Choose Transfer Template window, choose an existing template for the transfer. Although not recommended, you can also choose **<None>**.
 - Optional. To assign the transfer to a category, select one from the **Templates of category** list.
 5. Click **OK**.
- The new transfer is displayed in the viewer with three tabs for configuring the transfer. In the **General** tab, a default name for the new transfer is displayed based on the naming pattern, as well as a default start time.
6. Optional. Replace the default name with a unique name and enter a description for the transfer in the **Name** and **Description** fields.

7. Optional. You can organize objects by grouping them into categories. To browse the available categories, click . See [Categorization of objects](#) for more information.
8. In the **Start time** and **End time** fields, enter the start and end times for when the transfer takes place. To browse for a date, click .
9. In the **Source** and **Port** fields, select the element and port providing the material of the transfer.
10. In the **Destination** and **Port** fields, select the element and port receiving the transfer.
11. If the transfer is based on a template, a read-only value is displayed in the **Default Attribute** field. However, if you are creating a transfer manually, you can select a default attribute after you have added attributes in the **Attributes** tab.
12. Optional. To add an annotation to the transfer, click **Annotations**. For more information, see [Add annotations to transfers](#).

If the **Allow Extensions** check box is selected in the transfer template or you are creating a transfer manually, follow these additional steps.

- Use the **Attributes** tab to define an attribute for each property or data item. See [Create attribute templates](#).
- Use the **Ports** tab to define additional ports that define end-points for connections between transfer elements, or to modify the default **In** and **Out** ports. For more information, see [Create transfer ports](#).

Create transfer ports

You can only modify or add ports for a transfer derived from a template if **Allow Extensions** is enabled on the transfer template.

Use the **Ports** tab to review settings for default **In** and **Out** transfer ports.

1. To create a new transfer port or review existing ports, choose one of the following actions:
 - In the Event Frames browser, expand a **Transfer Searches** collection. Select a transfer, or right-click a transfer and click **Properties**.
 - In the Library browser, expand **Transfer Templates**. Select a transfer template, or right-click a transfer template and click **Properties**.
2. Click the **Ports** tab.
3. Choose from the following actions.

To ...	Do this ...
Create a new port	<ol style="list-style-type: none">a. Choose one of the following actions.<ol style="list-style-type: none">a. On the toolbar, click New Port.b. Right-click in the viewer and click New Port.b. Choose one of the following actions. Refer to Transfer Ports tab properties for descriptions of required values.<ol style="list-style-type: none">a. Edit the values in the Ports columns directly.b. Right-click the port and click Properties. Enter values and click OK to save your

To ...	Do this ...
	changes.
Modify an existing port	<p>Choose one of the following actions. Refer to Transfer Ports tab properties for descriptions of required values.</p> <ul style="list-style-type: none"> • Edit the values in the Ports columns directly. • Right-click the port and click Properties. Edit values and click OK to save your changes.
Specify a default port	<ol style="list-style-type: none"> a. Right-click a port that displays the  icon. b. Select Set as Default Port.
Modify a default port	<ol style="list-style-type: none"> a. Right-click a port that displays the  icon. b. Select Properties. c. In the Port Properties window, clear the Default Port check box. d. Click OK.

4. Check in your changes.

Transfer Ports tab properties

The **Ports** tab for a transfer contains the following columns.

Field	Description
Name	The name of the port.
Description	Optional. The description of the port.
Port Type	Indicates the type of port: Input , Output , or Undirected (for meters, for example).
Allowed Categories	The categories to which the port belongs. To assign categories, click  and select categories in the Categorize window.
Maximum Connections	The maximum number of connections that can be made to the port. The default number of connections for a transfer is 1. A value of zero indicates an unlimited number of connections.
Connection Type	The type of connections to which the port can connect. The default connection types for a transfer are Boundary and Node . For more information on

Field	Description
	connection type values, see Element types in models .
Allowed Template	Defaults to all element templates, but you can select a specific template from the list.

Annotations in PI AF

Beginning with PI AF 2016, the annotation feature is used by client applications such as AVEVA PI Vision, but can easily be used by administrators to make notes on the following objects:

- Case
- Element
- Event frame
- Model
- Transfer

File attachments

Users can attach a single file to an annotation. By default, the following file types are allowed:

File type	Allowed extension
MS Office	csv, docx, pdf, xlsx
Text	rtf, txt
Image	gif, jpeg, jpg, png, svg, tiff

The maximum file size defaults to 10MB.

Administrators can use the [PI AF Diagnostics utility](#) (`afdiag` located in the `\PIPC\AF` folder) to specify the file types that can be attached to annotations (with the `FileExtensions` parameter), as well as the maximum file size (with the `FileMaxLength` parameter).

Security for annotations

A user needs to have a PI AF identity for which the Annotate permission (`an`) is enabled. For more information on access rights, see [PI AF access rights](#).

Element annotations

Users can annotate an element, as well as upload a file to link to an annotation.

Setup of element annotations

You set up an annotation by opening an Annotations window for a specific element that you have selected in the Elements browser or viewer. In the Annotations window, you can add, edit, and delete annotations, as well as upload, change, and delete an attachment for an annotation.

Review of element annotations

You review annotation status for an element in the Elements viewer, where an Is Annotated column is displayed ().

To view the content of an annotation, move the mouse pointer over the  icon beside an element to see the annotation text. If a file is attached, the name of the file is also displayed.

Add annotations to elements

You can add one or more annotations to an element.

1. In the navigator, click **Elements**.
2. In the Elements browser, choose one of the following actions.
 - Click the **Elements** collection.
 - Navigate to the specific element you want to annotate.
3. To add a new annotation, choose one of the following actions.
 - In the Elements browser, right-click an element and click **Annotate**.
 - If an element is selected in the Elements browser, click the **Annotations** link on the **General** tab in the viewer.
 - If the **Elements** collection is selected in the browser, right-click an element in the viewer and click **Annotate**.

Note: To add another annotation to a previously annotated element in the viewer, double-click  beside the element.

4. In the Annotations window, click **New Annotation**.
5. Enter an annotation in the **Comment** field.

Note: If you require more space as you type, press F2 and enter an annotation in the Text Visualizer window. Click **OK** to close the window.

6. To attach a file to the annotation, click **Add Attachment**.
 - a. In the Open window, navigate to the directory where the file you wish to upload is located.
 - b. Select the file and click **Open**.The filename is displayed in the **Attachment** field.
7. Click **Close**.

When elements are listed in the Elements viewer, an Is Annotated column is displayed beside the element. Move the mouse pointer over the icon to see the annotation text. If a file is attached, the name of the file is also displayed.

Event frame annotations

Users can annotate an event frame, as well as upload a file to link to an annotation.

Setup of event frame annotations

You set up an annotation by opening an Annotations window for a specific event frame that you have selected in the Event Frames browser or viewer. In the Annotations window, you can add, edit, and delete annotations, as well as upload, change, and delete an attachment for an annotation.

Search for event frame annotations

You can search for event frames that have been annotated. You review annotation status in the viewer for an Event Frame Searches collection, where an Is Annotated column is displayed (■).

To group event frames by their annotation status, you click the ■ column icon.

Add annotations to event frames

To annotate a locked event frame, a user with Administrator permission must first unlock it.

You can add one or more annotations to an event frame.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, click an **Event Frame Searches** collection.
The contents of the collection are displayed in the viewer. Event frames with existing annotations display an Is Annotated icon (■) beside them.
3. To add a new annotation, choose one of the following actions.
 - In the viewer, right-click an event frame and click **Annotate**.
 - In the viewer, double-click an event frame and click the **Annotations** link on the **General** tab.
 - In the Event Frames browser, right-click an event frame in an event frame search collection and click **Annotate**.
 - To add another annotation to a previously annotated event frame, double-click ■ beside the event frame.
4. In the Annotations window, click **New Annotation**.
5. Enter an annotation in the **Comment** field.
Note: If you require more space as you type, press F2 and enter an annotation in the Text Visualizer window. Click **OK** to close the window.
6. To attach a file to the annotation, click **Add Attachment**.
 - a. In the Open window, navigate to the directory where the file you wish to upload is located.
 - b. Select the file and click **Open**.The filename is displayed in the **Attachment** field.
7. Click **Close**.

In the Is Annotated column,  is displayed beside the event frame. Move the mouse pointer over the icon to see the annotation text. If a file is attached, the name of the file is also displayed.

Transfer annotations

Users can annotate a transfer, as well as upload a file to link to an annotation.

Setup of transfer annotations

You set up an annotation by opening an Annotations window for a specific transfer that you have selected in the Event Frames browser or viewer. In the Annotations window, you can add, edit, and delete annotations, as well as upload, change, and delete an attachment for an annotation.

Review transfer annotations

You can review annotation status in the viewer for a Transfer Searches collection, where an Is Annotated column is displayed ().

To group transfers by their annotation status, you click the  column icon.

Add annotations to transfers

You can add one or more annotations to a transfer.

1. In the navigator, click **Event Frames**.
2. In the Event Frames browser, click a **Transfer Searches** collection.
The contents of the collection are displayed in the viewer. Transfers with existing annotations display an Is Annotated icon () beside them.
3. To add a new annotation, choose one of the following actions.
 - In the viewer, right-click a transfer in the search result list and click **Annotate**.
 - In the viewer, double-click a transfer and click the **Annotations** link on the **General** tab.
 - In the Event Frames browser, right-click a transfer in a **Transfer Searches** collection and click **Annotate**.
 - To add another annotation to a previously annotated transfer, double-click  beside the transfer.
4. In the Annotations window, click **New Annotation**.
5. Enter an annotation in the **Comment** field.

Note: If you require more space as you type, press F2 and enter an annotation in the Text Visualizer window. Click **OK** to close the window.

6. To attach a file to the annotation, click **Add Attachment**.
 - a. In the Open window, navigate to the directory where the file you wish to upload is located.
 - b. Select the file and click **Open**.The filename is displayed in the **Attachment** field.
7. Click **Close**.

In the Is Annotated column,  is displayed beside the transfer. Move the mouse pointer over the icon to see the annotation text. If a file is attached, the name of the file is also displayed.

Process models in PI AF

A PI AF model consists of connected elements that represent a logical model of your process. A model is itself an element, but with two additional element properties: layers and connections. Elements in the model can represent physical entities in your process, such as tanks, pipes, and process units, or logical entities, such as recipes and summary data. The model is composed of connected elements.

PI AF models can be simple, containing only a handful of elements, or they can be very complex, containing thousands of elements and measurements. The size of the model is only limited by the data available to fulfill the information requirements of an analysis on the model.

The scope of a PI AF model

While the number or variety of elements that a model encompasses does not change how a model is stored, it does help in planning both the initial model design and the information needed to complete a model analysis and get meaningful results. When considering the scope of a model, remember that it needs to be small enough for the relationships between properties to be well defined, but large enough to include some redundant data. Redundant data can be calculated from other data in the model.

At different levels of scale, or modeling scope, the consumers of the resulting information will change. For example, an engineer looking at equipment performance of a section of the facility may need more detailed information than a resource planning individual who tracks materials throughout a facility. The planner needs measurements in the model that are different from the measurement needs of the engineer. Elements that are common to both models use the same source elements; this aids in the construction of a variety of models using the same element library.

Three modeling levels, in order of increasing scope, are the following:

- Unit Model
 - This level of modeling typically includes the smallest details of information within a processing unit or area. This scope is useful for monitoring equipment performance and is used primarily by the engineers on that equipment. Auxiliary loops and heating systems that occur at this modeling level might not have influence outside of this area, and therefore would not be included at the next scale.
 - To perform a meaningful analysis on a unit level model, detailed data must be available on the materials and quantities within the unit. If there is only information available on the parameter of the unit (the inputs and the outputs), this is an indication that the data model is at its smallest granularity.
- Multi-Unit Model
 - When considering unit-to-unit type models, detail within the unit is typically summarized by the connections to and from that unit. Material added and sent to storage areas (tanks, stockpiles, etc.) would also be included.
 - At the multi-unit modeling level, measurements within the unit that do not affect the main inputs and output quantities are not included in the model.
- Boundary Model (Facility and Business Unit)
 - It is useful to create an analysis for the materials entering and leaving the "fence line" of the facility,

further summarizing the unit-to-unit information to only the transactions to and from the process from material transfer points (shipping docks, weigh scales, tank feeds, pipelines). This level is also useful to analyze transactions between business units within a facility.

Guidelines for PI AF models

Consider the following rules as you set up a model for analysis:

- Use a systematic approach to identify the location and calibration setup for each instrument in the model.
- Associate every instrument with the correct flow, and make sure that temperature and specific gravity corrections are applied to flow measurements if needed. Check whether this function of correction is performed by your control system or historian.
- Validate tank/inventory properties by building a tank-only model, including shipments and receipts. Enter the materials list with its properties at the same time.
- Determine the calibration tolerance of each instrument (you can use ISO 5167 for orifice meters), or refer to meter data sheets and manufacturers.
- Build and examine individual unit models before attempting to connect them and run a multi-unit analysis.
- After you achieve full unit connectivity, examine the entire drawing, and then run a balance analysis to identify flows and connections that cannot be solved.

Submodels

A model is also an element, which means that a model can be composed of other models - referred to as submodels. This allows for either top-down or bottom-up development of a plant model. The boundary elements of a model normally define the elements with ports that can be used for connections outside the model.

Element types in models

Six core element types are used to enforce connectivity rules between elements of a model.

- Use a **Node** to represent a physical entity in your model, such as a tank, valve, or process unit.
- Use **Measurement** to indicate that the element is used for ascertaining dimensions, quantities, capacities, etc., such as, meters or scales.
- Use **Flow** to indicate that the element carries material from one element to another.
- Use **Transfer** as a temporal flow. The existence of a transfer in a model is only available in the context of time, for example, in a case. Transfers can also be accessed by performing time-based searches of the database.
- Use **Boundary** to define the input and output ports for the model.
- Use **Other** to represent a logical collection of attributes, such as a recipe.

In addition to the core element types, two other types are supported: **Any** and **None**. Use the **Any** and **None** element types when you define the connectivity rules for a port.

Create PI AF models

You create a PI AF model in the **Elements** browser.

1. In the navigator, click **Elements**.
2. Right-click the collection of elements and click **New Model**.
3. In the Choose Model Template window, select a template on which to base the model or select **None**.
4. Click **OK**.
The model configuration tabs appear in the viewer.
5. In the **Name** field of the **General** tab, enter a name for the model.
6. Optional. In the **Description** field, enter a description for the model.
7. The read-only **Template** and **Type** fields list the template and element type chosen when the model was created. To view the template properties, click Element types are described in [Element types in models](#).
8. Optional. You can organize objects by grouping them into categories. To browse the available categories, click .
9. To assign a default attribute, select the attribute from the **Default Attribute** drop-down list. Note that you must add attributes in the **Attributes** tab first before they appear in the list. This field is read only if the model is based on a template; the box displays the attribute specified in the template.
10. Optional. To specify location attribute traits for the model, click the **Location** link. For more information, see [Set location attribute traits](#).
11. Optional. To specify asset health attribute traits for the model, click the **Health** link. For more information, see [Set health attribute traits](#).
12. Optional. To configure access permissions for the new model that are different from those inherited from the Elements collection, click the **Security** link. For more information, see [Configure security for objects](#).
13. Click **OK** and check in your work.

Edit PI AF models

You view or edit PI AF models in the <Model Name> Connections window.

1. Right-click on a model in the **Elements** browser and click **Model Connections**.
The <Model Name> Connections window shows a visual representation of the elements in the model and how they are connected.
2. To edit the model:
 - Right-click an element in the **Connections** pane to create a new connection or to view or edit the properties of the element.
 - Click an element to center it in the **Connections** pane and show any other connected elements. You can move along the flow of the model this way, element by element.
 - Click a connection to view or edit the connection or to add another source or destination.
 - Right-click a connection to make another connection, view the properties of the selected connection, or to copy and paste the properties of the connection.

Ports and connections

Elements in a model are connected through any number of ports, which are defined by the element template. A port can be defined as an input port, an output port, or as an undirected port. The port defines how many connections can be made and the types of elements that can be connected.

In analyses, directed ports (input and output ports) represent positive material flow and are used by connections. Undirected ports are used by attachments of meters and analyzers. The most common type of attachment in a model is a measurement or meter attached to a flow element.

A connection represents the link between the ports of two elements. The ports, which are defined by the element template, can be defined as input ports, output ports, or undirected ports.

Create ports

To specify a port as the default port, you must open the Properties window.

1. In the Elements browser, select an element and then click the **Ports** tab in the viewer.

Note: If the element is based on a template, you cannot add a port unless the template allows extensions.

2. Click **New Port**, and create a port for the element. Right-click an existing port to view or edit its properties.
3. Configure the port.

- **Port Type:** Select the port type: **Input**, **Output**, or **Undirected** (for meters, for example).
- **Allowed Categories:** Select the categories of which the port is allowed to be a member.
- **Maximum Connections:** Specify the maximum number of connections that can be made to the port. Enter zero for an unlimited number of connections.
- **Connection Type:** Select the type of element to which the port can connect, for example, Node, Boundary, Measurement, and so on.
- **Allowed Templates:** Select elements allowed to connect to the port. Select only elements created from the selected template.

Create connections

Use the **Connections** tab to display the connections in a model.

1. To create a new model in the Elements browser, right-click the collection of elements as described in [Create PI AF models](#), and click **New Model**.
2. Follow these steps to fill in the **Connections** tab.
 - a. Right-click in the field and select **New Connection**.
 - b. In the Make Connection window, right-click an existing connection to view or edit its properties.
 - c. In the **Source** field, select the source for the connection. Select the appropriate port of the source in the corresponding **Port** field.
 - d. In the **Destination** field, select the destination for the connection. Select the appropriate port of the destination in the corresponding **Port** field.

To include child elements, select the **Include Child Elements** check box.

Layers

You can organize the elements of a model into layers. Layers provide a mechanism for including or excluding portions of the model as needed for analysis. An element of a model can belong to more than one layer. You can also use the Layers feature with a graphic modeling tool, such as PI ProcessBook, to provide a visual overlay functionality.

Create layers

Create a Layer to enable you to include or exclude portions of a model.

1. In the Elements browser, select the model to which you want to add a layer.
2. Click the **Layers** tab in the viewer.
3. Right-click and click **New Layer**.
4. In the **Name** field of the Layer Properties window, enter a unique name for the layer.
5. Optional. In the **Description** field, describe the purpose of the layer.
6. In the element list, select one or more elements that comprise the layer.
7. Click **OK**.

PI AF utilities and plug-ins

After you install PI AF, several utilities are available to assist you in your administration of PI AF and management of plug-ins.

Launch PSE with command line options

The PI System Explorer (PSE) can be invoked with command line options that control its initial selection. The PI System Explorer application is named **AFExplorer.exe** and is located in the **\PIPC\AF** folder.

1. Open a Windows command window and change to the **\PIPC\AF** folder.
2. Type:

```
afexplorer parameter=paramValue
```

where *parameter* is one of the following three parameters:

- */system*
- */database*
- */navigator*

To display a list of available parameters, type:

```
afexplorer /?
```

AFExplorer parameters

The following table lists the available parameters for the AFExplorer utility.

Parameter	Description	Example
<code>/system</code>	Sets the system parameter to the hostname of the PI AF server to which PSE should connect by default.	<code>afexplorer /system=MyAFServer</code>
<code>/database</code>	Sets the database parameter to the name of the PI AF database that PSE should open initially.	<code>afexplorer /database=MyAFDatabase</code>
<code>/navigator</code>	Sets the navigator parameter to the browser plug-in that should be selected initially in PSE.	<code>afexplorer /navigator=Elements</code>

Navigator parameter values

The following table lists the available values for the navigator parameter.

Parameter value	Example
Elements	<code>afexplorer /Navigator=Elements</code>
EventFrames	<code>afexplorer /Navigator=EventFrames</code>
Library	<code>afexplorer /Navigator=Library</code>
UnitOfMeasure	<code>afexplorer /Navigator=UnitOfMeasure</code>
Analyses	<code>afexplorer /Navigator=Analyses</code>
MyPI	<code>afexplorer /Navigator=MyPI</code>
	Note: Use only if legacy notifications are present on a PI AF client computer.
Notifications	<code>afexplorer /Navigator=Notifications</code>
	Note: Use only if legacy notifications are present on a PI AF client computer.
AFContactNavigator	<code>afexplorer /Navigator=AFContactNavigator</code>
Management	<code>afexplorer /Navigator=Management</code>

PI AF Diagnostics utility

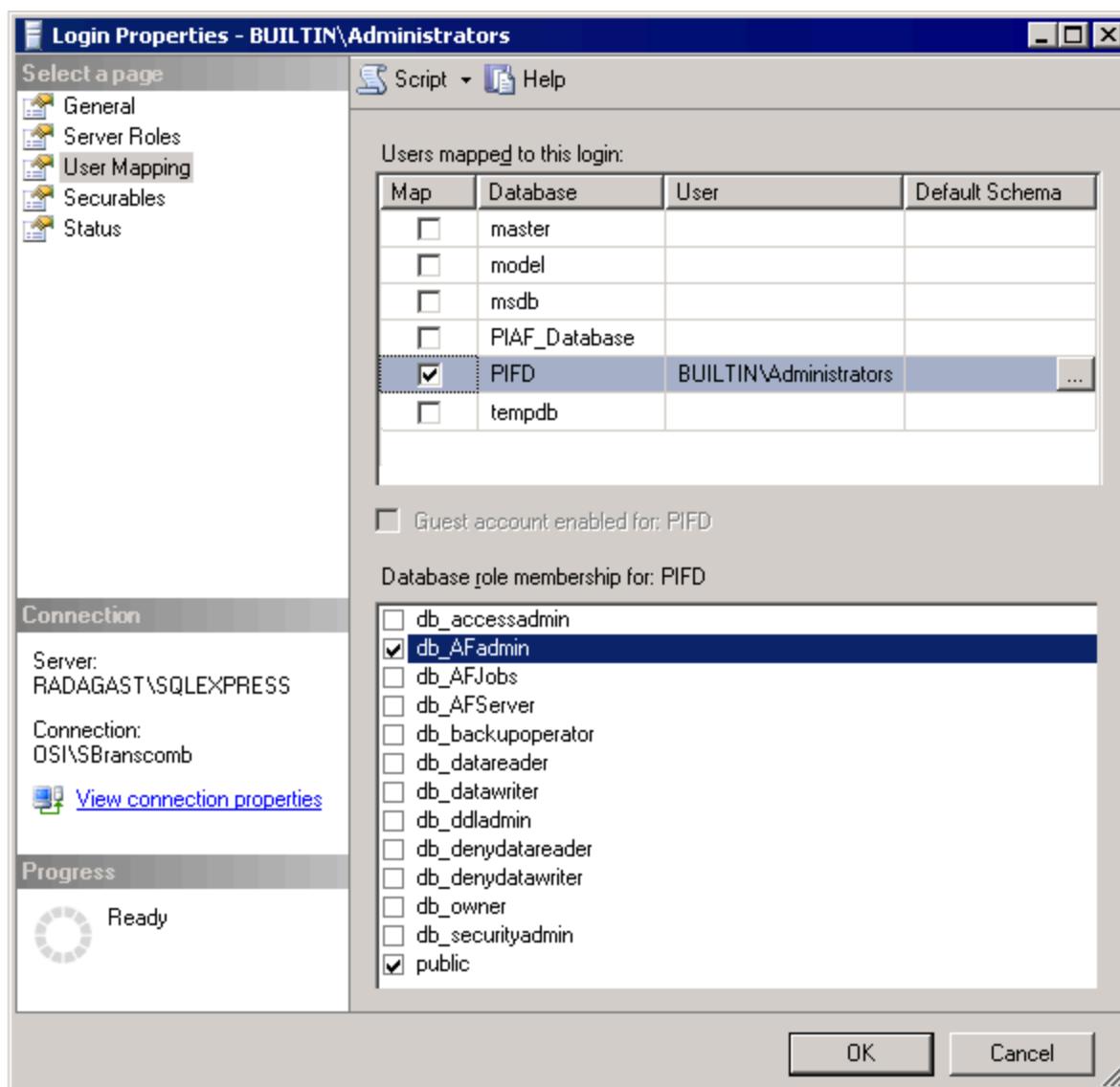
The PI AF Diagnostics (AFDiag) utility is a command-line utility that you can use to enable or disable PI AF server features and perform other administrative functions. The utility makes a direct connection with the associated SQL Server database and requires the SQL Server *sysadmin* or *db_AFadmin* role.

AFDiag is located in the **\PIPC\AF** folder.

Grant permissions for PI AF Diagnostics utility

To use the PI AF Diagnostics utility, you need to grant the *db_AFadmin* database role to the SQL Server Login.

1. In the Microsoft SQL Server Management Studio, connect to the SQL Server instance in which the PIFD database resides.
2. Under the SQL Server instance, expand the **Security** folder; then expand the **Logins** folder.
3. Right-click the login that corresponds to the appropriate Windows user and select **Properties**.
4. Select the **User Mapping** page.
5. Select the row for the PIFD database.
6. Select the **Map** check box for the PIFD database.
7. With the database still selected, select the **db_AFadmin** database role check box, as shown in the following figure.



- Click **OK** to save your changes and close the Microsoft SQL Server Management Studio.

Run the AFDiag utility

You run the **AFDiag** utility in an elevated Windows command prompt window.

- As an administrator, open a Windows command prompt and change directory to **\PIPC\AF**.
- Choose one of the following actions.

To ...	Do this ...
Display current configuration settings	Type afdiag with no parameter specified. A list of current settings is displayed for the PI AF server, database, Active Directory, and other configuration items such as audit trail, file extensions, and maximum size for files attached to

To ...	Do this ...
	PI AF objects.
Display a list of available parameters	Type <code>afdiag /?</code>
Execute a specific configuration task	Type <code>afdiag parameter</code> where <i>parameter</i> is one of the parameters listed in AFDiag utility parameters .

AFDiag utility parameters

Parameters for the **AFDiag** utility are listed in alphabetical order below.

- **/ActiveDirectory:string or /AD:string**

Tests access to Active Directory using the currently configured settings in the PI AF server. An optional user account can be specified to test another account. If an account is specified or set in the PI AF server settings, you also need to specify the *Password* parameter.

- **/AddIdentity:string or /AI:string**

Adds a security identity with the specified permissions to all security strings in the system. For example, to allow read and write access for *IdentityName* to all security strings, enter:

```
/AI:"IdentityName:A(r,w)"
```

If the specified security identity does not exist, it is created. Use PI System Explorer to create and/or configure mappings to the new identity.

- **/AuditTrailCleanupAdd:string or /ATCA:string**

Adds the specified user to the audit trail cleanup list. The audit cleanup job deletes audit records associated with this user from the PI AF SQL Server database. This parameter may be specified more than once.

- **/AuditTrailCleanupRemove:string or /ATCR:string**

Removes the specified user from the audit trail cleanup list. The audit cleanup job no longer deletes audit records associated with this user from the PI AF SQL Server database. This parameter may be specified more than once.

- **/CertificateAdd or /CA**

Adds the specified client certificate to the PI AF SQL Server database. Use the *Password* parameter to specify a password for the certificate, if required.

- **/CertificateList or /CL**

Lists the client certificates stored in the PI AF SQL Server database.

- **/CertificateRemove or /CR**

Removes a client certificate from the PI AF SQL Server database by specifying the name of the certificate.

- **/CertificateSet:string or /CS:string**

Sets the server certificate in the PI AF server configuration file to the specified file. Use the *Password* parameter to specify a password for the certificate, if required.

- **/CertificateThumbprint or /CT**

Updates the PI AF server's certificate thumbprint used for TLS encryption by specifying the thumbprint

string.

Example: /ct:1217545db7fd6981dd749d5c07a063e5118786ag

- **/CertificateValidationMode or /CVM**

Updates the PI AF server's certificate validation mode for TLS connections. Certificate validation mode will also be used by AF Client applications on the same machine as the server. The following validation modes are supported:

- *None*: No validation of the certificate is performed.
- *AllowExpiredOrRevoked*: This mode allows the system to accept certificates that have expired or been revoked.
- *SystemDefault*: The system's default certificate validation mode is used, which means that the standard system security policies and practices for certificate validation are used.

Example: /cvm:AllowExpiredOrRevoked

- **/ChangeID:string or /CID:string**

Changes the ID for the PI AF server to the specified GUID.

- A return value of 1 means that the configuration change will be delayed.
- A return value of 2 means that you must restart the PI AF server.
- A negative return value indicates an error has occurred.

- **/ClearChangeTables or /CCT**

Clears the **findChanges** and **aftdiag** tables, which record information on changes to the system.

- **/DeleteAuditTrail or /ATD**

Disables audit trail feature and deletes audit trail records in the PI AF SQL Server database. This operation permanently deletes the audit trail records, and requires sysadmin privileges. The audit trail records cannot be recovered if a delete is performed.

- **/DeleteCases:string or /DelC:string**

Deletes cases from the PI AF SQL Server database with a start time between the dates specified in local time format, using standard date notation or PI time syntax (described in PI time). If only one time is provided, it is treated as the end time.

- To specify a time, include a time string in *hh:mm:ss* format.
- To specify a database, include a database string in */Database:"DBname"* or */DB:"DBname"* format.
- To specify a template in a database, include a template string in */Template:"Template Name"* or */Temp:"Template Name"* format, in addition to the database string.

For example, to delete cases that start between 11 P.M. on January 31st, 2017 and 4 P.M. on June 21st, 2017, enter */DelC:"2017-01-31 23:00:00"; "2017-06-21 16:00:00"*.

- **/DeleteDuplicates or /DD**

When used in conjunction with */FindDuplicates*, deletes the duplicates that were found in SQL object tables. It is recommended that you make a backup of the PI AF SQL Server database (PIFD) before you use this parameter to delete the duplicate entries.

- **/DeleteEventFrames:string or /DelEF:string**

Deletes event frames from the PI AF SQL Server database with an end time between the dates specified in local time format, using standard date notation or PI time syntax (described in PI time). If only one time is provided, it is treated as the end time.

- To specify a time, include a time string in *hh:mm:ss* format.

- To specify a database, include a database string in */Database:"DBname"* or */DB:"DBname"* format.
- To specify a template in a database, include a template string in */Template:"Template Name"* or */Temp:"Template Name"* format, in addition to the database string.

For example, to delete event frames that end between 11 P.M. on January 31st, 2017 and 4 P.M. on June 21st, 2017, enter */DelEF:"2017-01-31 23:00:00";"2017-06-21 16:00:00"*.

Note: Child event frames are also deleted, even if they do not match the criteria.

- **/DeleteTransfers:string or /DelTR:string**

Deletes transfers from the PI AF SQL Server database with an end time between the dates specified in local time format, using standard date notation or PI time syntax (described in PI time). If only one time is provided, it is treated as the end time.

- To specify a time, include a time string in *hh:mm:ss* format.
- To specify a database, include a database string in */Database:"DBname"* or */DB:"DBname"* format.
- To specify a template in a database, include a template string in */Template:"Template Name"* or */Temp:"Template Name"* format, in addition to the database string.

For example, to delete transfers that end between 11 P.M. on January 31st, 2017 and 4 P.M. on June 21st, 2017, enter */DelTR:"2017-01-31 23:00:00";"2017-06-21 16:00:00"*.

- **/EnableAuditTrail or /AT**

Enables audit trail feature for the PI AF SQL Server database.

- **/EnableAuditTrailCleanup[-] or /ATC[-]**

Enables audit trail cleanup feature for the PI AF SQL Server database. Requires sysadmin privileges.

- **/EnableExternalDataTables[-] or /DT[-]**

Enables or disables support for external PI AF tables.

- **/EnablePropagationOfTargetDeletion[-] or /PTD[-]**

Enables support for propagating the deletion of targets (elements) to the referencing analyses and notifications.

- **/ExeFile:string or /F:string**

The path to the PI AF server executable file. Default value is **AFService.exe**.

- **/ExternalDataTablesAllowNonImpersonatedUsers[-] or /DTImp[-]**

Enables support for external PI AF tables for non-impersonated users.

- **@file**

Reads response file for more options. The response file must contain one parameter per line. Comment lines start with the '#' character.

- **/FileExtensions:string or /FE:string**

Defines the types of file objects that can be attached to a PI AF file object, such as an annotation. The following file types are supported:

- MS Office: csv, docx, pdf, xlsx
- Text: rtf, txt
- Image: gif, jpeg, jpg, png, svg, tiff

Enter the extensions as a colon-separated list, for example:

/FE:docx:xlsx:csv:pdfd;jpg:png

- **/FileExtensionsAdd:string or /FEA:string**

Adds an additional file extension to the list of allowed PI AF file object types. See the list of supported file types above.

You can specify this parameter more than once.

- **/FileExtensionsRemove:string or /FER:string**

Removes a file extension from the list of allowed PI AF file object types. See the list of supported file types above.

You can specify this parameter more than once.

- **/FileMaxLength:integer or /FML:integer**

Defines the maximum size in megabytes of a PI AF file object, such as an annotation. A value of zero disables support for all files. The default maximum allowed file size is 10MB.

- **/FindDuplicates or /FD**

Searches for duplicate entries in all object tables and returns a list of tables. It identifies how many duplicates were found in each object table and logs them in an XML file. Be sure to make a backup of the PI AF SQL Server database (PIFD) before you use this parameter in conjunction with the */DeleteDuplicates* parameter to delete the duplicate entries.

Note: Since duplicate rows are unexpected under normal circumstances, contact Technical Support to help diagnose how the duplicate rows may have been created.

- **/MaintenanceJob or /MJ**

Manually runs the AF Maintenance job, which performs the following housekeeping tasks to improve PI AF Server's responsiveness: Cleans up orphaned and deleted database elements, updates the path cache, rebuilds the index, and updates statistics. This parameter can be used to perform Azure SQL maintenance tasks.

Note: While running the AF Maintenance job helps to improve SQL Server performance, you may experience slower system response times during run-time. You should schedule the AF Maintenance job during off-peak hours, such as at night or during a scheduled maintenance window to avoid system disruptions.

- **/NewID or /NID**

Generates a new ID for the PI AF server.

- A return value of 1 means that the configuration change will be delayed.
- A return value of 2 means that you must restart the PI AF server.
- A negative return value indicates an error has occurred.

- **/Password or /PWD**

Specifies a certificate password for the *ActiveDirectory*, *CertificateAdd*, *CertificateSet*, or *PasswordEncryptionCertificate* options.

- **/PasswordEncryptionCertificate:string or /PEC:string**

Replaces the default password encryption for external database passwords with a custom certificate file. Use the *Password* option to specify a password for the certificate, if required.

- **/PlugInVerifyLevel:level or /VL:level**

Configures the level of verification required for plug-ins to run. Valid levels are:

- *RequireSigned*

Runs only plug-ins with valid signatures.

- *RequireSignedTrustedProvider*

Runs only plug-ins with a valid signature from a trusted provider.

Note: The *None* and *AllowUnsigned* levels are only supported in PI AF Client 2018 SP3 Patch 1 and earlier versions. (*None*: Disables validation; runs all plug-ins. *AllowUnsigned*: Runs unsigned plug-ins and plug-ins with valid signatures.)

- **/Port:integer or /P:integer**

Tests the specified port to the PI AF server. This is used to perform a basic port test to see if specified port on the computer used by the PI AF server can be opened and something is listening for a connection on the port. The standard ports used by the PI AF server are 5457 and 5459. This is similar to attempting to test a port using Telnet. It tests all IP addresses for the computer (both IPv4 and IPv6 addresses). Typically, you would test both ports 5457 and 5459.

- **/RebuildPathCache or /RPC**

Rebuilds the path cache to each element in the PI AF SQL Server database. The path cache can become outdated after significant data insertions, edits, and/or deletions. Rebuilding the path cache can improve the PI AF server's performance.

Note: The stored procedure used to rebuild the path cache is not supported on a secondary PI AF server (a subscriber) in a PI AF collective.

- **/Reindex or /RI**

Completely rebuilds every index in the PI AF SQL Server database. This substantially improves the PI AF server's performance after a massive data insertion.

- **/ResetAdministrator:string or /SRA:string**

Resets the permissions on the Administrators identity to allow full privileges on the local PI System. This parameter requires sysadmin or db_owner privileges.

The default /sra enables privileges for the BUILTIN\Administrators account.

/sra:domainName\username enables privileges for a particular user account.

- **/ResetIdentityColumnSeeds**

Resets and synchronizes the element count in the SQL object tables. This parameter should be run after a successful PI AF database migration to Azure SQL.

- **/Silent[-] or /S[-]**

Runs silent mode and prevents message display.

- **/TrustedProviderAdd:providername or /PA:providername**

Adds the specified provider to the list of trusted plug-in providers. To add providers, you must have SQL Server sysadmin server role or db_AFadmin database role.

- **/TrustedProviderList or /PL**

Displays a list of trusted plug-in providers. To list providers, you must have SQL Server sysadmin server role or db_AFadmin database role.

- **/TrustedProviderRemove:providername or /PR:providername**

Removes the specified provider from the list of trusted plug-in providers. To delete providers, you must have SQL Server sysadmin server role or db_AFadmin database role.

- **/UomCaseSensitive[-] or /UCS[-]**

Changes configuration of UOM abbreviations from case insensitive to case sensitive in the PI AF SQL Server database. When enabled, only a 2015 R2 (v2.7.5) or later PI AF Client can connect.

For more information, see [Configuration of case-sensitive UOM abbreviations](#).

- **/UpgradeAuditTrail or /ATU**

Upgrades audit trail records in the PI AF SQL Server database. Supports upgrades from PI AF 2.6 or later.

- **/Version or /V**

Displays version information.

Audit Trail implementation

You can use the audit trail feature to examine audit trail records in the PI AF SQL database. Once enabled, audit trail records are created using SQL Server Agent jobs. You can view the audit trail with PI System Explorer.

Requirements

The audit trail feature uses SQL Server Change Data Capture (CDC) to generate an audit trail. CDC is supported in the following versions of SQL Server:

Version	Standard	Enterprise	Developer ¹	Evaluation ¹
SQL Server 2008	✗	✓	✓	✓
SQL Server 2008 R2	✗	✓	✓	✓
SQL Server 2012	✗	✓	✓	✓
SQL Server 2014	✗	✓	✓	✓
SQL Server 2016 ²	✗	✓	✓	✓
SQL Server 2016 SP1 and later ²	✓	✓	✓	✓

¹ Development system only.

² Only supported in 2016 and later. For more details on CDC support, see the knowledge base article: PI AF error: Could not find stored procedure sys.sp_cdc_parse_captured_column_list.

The audit trail feature has the following additional requirements:

- The SQL Server Agent must be running before you enable the audit trail feature.
- You must be a member of the sysadmin role on the SQL Server that contains the PI AF SQL database.

Enable audit trail

To enable the audit trail feature, you use the **AFDiag** utility and the *EnableAuditTrail (/AT)* parameter. For example:

```
afdiag /AT
```

Disable audit trail

To disable the audit trail feature and delete all audit trail records permanently, you must have sysadmin privileges on the SQL Server. To disable the audit trail feature, you use the **AFDiag** utility and the *DeleteAuditTrail (/ATD)* parameter. For example:

```
afdiag /ATD
```

Once you use this parameter, the audit trail is not recoverable.

Previous versions

The audit trail feature that was released in PI AF 2014 or later is supported by this installation and is upgraded when the PI AF SQL scripts are executed. At that time, the audit trail records are upgraded to the current format. If for some reason a failure occurs during the upgrade, you can use the **AFDiag UpgradeAuditTrail (/ATU)** parameter to fix the audit trail tables and records.

Versions of the audit trail feature prior to PI AF 2014 have a different format and are no longer updated with new change records after an upgrade of the PI AF SQL database. Existing tables and data remain intact, but new records cannot be added.

Audit trail support in SQL Server availability groups

The audit trail feature is supported in SQL Server availability groups. For instructions on how to enable audit trail on secondary machines in a SQL Server high availability environment, please see the installation topic [Use PI AF Audit Trail in a SQL Server availability group](#).

Audit trail support in PI AF collectives

The audit trail feature is not supported on secondary members of PI AF collectives. If the audit trail feature is currently enabled on a server that you wish to add as a secondary server to a PI AF collective, you must run the **AFDiag** utility and disable the feature. Audit trail data is only stored on the primary member of a PI AF collective and is not replicated to any secondary member of a PI AF collective.

Note: When you are designing SQL Server backup procedures for your PI AF data, please be aware that if the primary member of a PI AF collective becomes unavailable, the audit trail data will also be unavailable. If the primary member of a PI AF collective cannot be recovered from a backup, the audit trail data cannot be recovered either.

Re-enabling audit trail

If you add an existing PI AF server with audit trail enabled to a collective as a secondary member, but later remove that server from the collective, you need to re-enable the audit trail feature on that particular server. Otherwise, auditing remains disabled.

AF Update Plug-in Configurations utility

The **AFUpdatePluginConfigurations** utility provides a *Repair*, a *CreateConfig*, and a *ReplacePIServer* feature that enable you to perform bulk updates of attribute configuration strings with a single command. After you run the

utility, click  Refresh in PI System Explorer to see the changes.

The following table lists the available parameters for the AFUpdatePluginConfigurations utility. Only one feature can be specified at a time in combination with the /Root, /List, and /EventFrames parameters.

Parameter	Description
<i>/Root:string</i>	Use in conjunction with <i>/Repair</i> , <i>/CreateConfig</i> , and <i>/Replace</i> parameters. Specifies the PI AF server or database on which to operate. Enclose the entire parameter string in quotation marks ("").
<i>/Repair[-]</i>	<p>Default parameter if no parameter is specified. For attributes on the PI AF server or database specified in the <i>/Root</i> parameter, corrects PI Point data reference attributes for which the stored configuration string has become out of synchronization with the Data Archive. This can occur for the following reasons:</p> <ul style="list-style-type: none"> Deleted PI points: When PI points are deleted and then recreated with the same name, the ID of the new point does not match the ID in the stored configuration string. Renamed PI points: When PI points are renamed, the stored configuration string still uses the old PI point name. Unresolved attributes: If the PI point to which a data reference points is not yet created, the stored configuration string does not contain the point ID.
<i>/CreateConfig [-]</i>	<p>For attributes on the PI AF server or database specified in the <i>/Root</i> parameter, creates the PI point if it does not already exist, or updates it with any changes.</p> <p>This is the same operation as when you right-click an element or attribute in PI System Explorer and choose Create or Update PI Point.</p>
<i>/ReplacePIServer: string</i>	<p>For PI Point data reference attributes on the PI AF server or database specified in the <i>/Root</i> parameter, redirects attributes to a different Data Archive.</p> <p>Use a colon (:) to precede the existing Data Archive name. Separate the existing Data Archive name from the new Data Archive name with a semi colon (;).</p> <p>Short form: <i>/Replace</i></p>
<i>/List [-]</i>	Use in conjunction with <i>/Repair</i> , <i>/CreateConfig</i> , and <i>/Replace</i> parameters. For the PI AF server or database

Parameter	Description
	specified in the <i>/Root</i> parameter, lists all attributes to be operated on.
<i>/EventFrames:string</i>	Use in conjunction with <i>/Repair</i> , <i>/CreateConfig</i> , and <i>/Replace</i> parameters. Performs specified operation on each attribute of all event frame templates and event frames that occurred between the start and end time specified, format, using standard international date notation YYYY-MMDD. Use a semi colon to separate the start and end time. Short form: <i>/EF</i>
<i>/? or /help</i>	Displays list of parameters
<i>@file</i>	Uses the specified file to provide additional input arguments. The file should contain one argument per line. Comment lines start with the '#' character.

/Repair syntax example

To repair stored configuration strings in the specified PI AF database so that they correctly map to the PI points on the Data Archive, use the following syntax:

```
afupdatepluginconfigurations "/Root:\\MyAFServer\\MyAFDatabase" /Repair
```

/CreateConfig syntax example

To perform the CreateConfig operation in bulk on all attributes in a PI AF database, use the following syntax:

```
afupdatepluginconfigurations "/Root:\\MyAFServer\\MyAFDatabase" /CreateConfig
```

To perform the CreateConfig operation on all attributes on a specific PI AF server, use the following syntax:

```
afupdatepluginconfigurations "/Root:\\MyAFServer" /CreateConfig
```

/ReplacePIServer syntax example

To redirect all PI point data reference attributes in a specified PI AF database to a new Data Archive, use the following syntax:

```
afupdatepluginconfigurations "/Root:\\MyAFServer\\MyAFDatabase"  
/ReplacePIServer:OldPIDataArchive;NewPIDataArchive
```

/EventFrames syntax example

To perform the CreateConfig operation in bulk on all event frame attributes in a PI AF database over a specific time range, use the following syntax:

```
afupdatepluginconfigurations "/Root:\\MyAFServer\\MyAFDatabase" /EF:"2017-01-31  
23:00:00";"2017-06-21 16:00:00" /CreateConfig
```

Set PI AF server utility

The SetPISystem utility (**setpisystem**) enables you to configure known PI AF servers. **setpisystem** is located in the **PIPC\AF** directory.

SetPISystem utility parameters

The following table lists the available parameters for the SetPISystem utility.

Parameter	Short form	Description
<i>/Name:string</i>	<i>/N</i>	Specifies the name of the PI AF server to modify or create. If not specified, the default PI AF server is used.
<i>/Host:string</i>	<i>/H</i>	Specifies the hostname for the PI AF server.
<i>/Protocol:Tcp NamedPipe</i>	<i>/C</i>	Specifies the protocol for the PI AF server.
<i>/Port:integer</i>	<i>/P</i>	Specifies the port for the PI AF server.
<i>/Timeout:integer</i>	<i>/T</i>	Specifies the timeout for the PI AF server in seconds.
<i>/AccountName:string</i>	<i>/A</i>	Specifies the account name for the PI AF server.
<i>/DefaultPISystem</i>	<i>/D</i>	Sets the specified PI AF server as the default PI AF server.
<i>/Remove</i>	<i>/R</i>	Removes the specified PI AF server from the list of known PI AF servers.
<i>/Silent[-]</i>	<i>/S</i>	Establishes silent mode, which prevents message display.
<i>/List</i>	<i>/L</i>	Lists the current known PI AF servers.
<i>/AddAlias:string</i>	<i>/AA</i>	Adds the specified alias to the PI AF server.
<i>/RemoveAlias:string</i>	<i>/RA</i>	Removes the specified alias from the PI AF server.

Capture AF SDK event trace output

You use the **AFGetTrace** utility (**aftgettrace.exe**) to capture event trace output from the AF SDK. Event tracing can help you debug an application and perform capacity and performance analysis.

Note: Starting with PI AF 2018, the AFGetTrace utility includes a graphical user interface (GUI) that allows you to configure and view event trace sessions. By default, the **AFGetTrace** utility runs in GUI mode. To run **AFGetTrace** in the old console mode, use the **/NoGUI (/NG)** switch.

1. Open a command window and change directory to **PIPC\AF**.
2. Choose from the following actions:

To ...	Do this ...
Display syntax and parameters	At the command prompt, type: aftgettrace /?
Run AFGetTrace with default settings	At the command prompt, type: aftgettrace Default output goes to standard output.
Run AFGetTrace with specific parameters	At the command prompt, type: aftgettrace /parameter Refer to AFGetTrace utility parameters for details on the parameters you can use.
Terminate event tracing	In the command window, type: X Note: If you close the command window without terminating aftgettrace , trace events continue to be generated, which can slow down your AF SDK applications.

AFGetTrace utility parameters

The following table lists the available parameters for the AFGetTrace utility.

Parameter	Short form	Description
/Provider:string	/P	Specifies the name of the event tracing session. You only need to specify to use an existing event trace provider. The default value is AFGetTrace .
/Level:{Critical Error Warning Info rmation Verbose Detail}	/L	Specifies the level of detail to be included in the events written by

Parameter	Short form	Description
		<p>the AF SDK. Detail at or above severity of the level chosen is generated. The default value is Verbose.</p> <p>You can specify that only a particular level is written to the log file:</p> <ul style="list-style-type: none"> • Critical: Only Critical events are generated. • Error: Error and Critical events are generated. • Warning: Warning events plus Error and Critical are generated. • Information: Information events plus Warning, Error, and Critical events are generated. • Verbose: Verbose AF SDK events and Information PI Data Archive events plus Information, Warning, Error, and Critical are generated. • Detail: Detail AF SDK events and Verbose PI Data Archive events plus Information, Warning, Error, and Critical are generated.
<i>/Keywords:{None Server Connection Cache Events Trace Data All}</i>	<i>/K</i>	<p>Specifies the keywords used to determine the category of events that you want the AF SDK to write. The default value is All. The AF SDK writes the event if any of the event's keywords match the keywords specified in this setting.</p> <p>You can specify to have one or more keywords written to the log file:</p> <ul style="list-style-type: none"> • None: No events associated with keywords will be generated. Only Warning, Error,

Parameter	Short form	Description
		<p>and Critical level events will be generated.</p> <ul style="list-style-type: none"> • Server: Events are logged when calling a remote method to the PI AF Server or PI Data Archive. • Connection: Events are logged for PI AF Server or PI Data Archive connection information. • Cache: Events are logged for object caching information. • Data: Events are logged when making data access calls. • Events: Events are logged when raising client events. • Trace: Events are logged for AFTrace messages. • All: Events for all keywords will be generated.
/EnableAF[-]	/AF	Enables messages from the AF SDK message provider. The default value is True.
/EnablePI[-]	/PI	Enables messages relating to communication with the Data Archive from the MDA message provider. The default value is True.
/LogFile:string	/Log	Specifies the name of the log file for trace output messages. Messages are still displayed on standard output unless you specify the <i>Silent</i> parameter.
/LogFileMaxSize:double	/FileMax	Specifies the maximum size of the log file in megabytes. The trace ends once the size is reached. Enter 0 for no limit. The default value is 0.
/Timeout:integer	/TO	Specifies the number of minutes before the trace ends. Enter 0 for no timeout. The default value is 0.

Parameter	Short form	Description
/Mask:string	/M	Prevents any message containing the specified mask from being displayed. Enclose the mask in quotes if it contains spaces. This parameter can be specified more than once, but values must be unique.
/MaskPID:UInt32	/MPID	Prevents any message associated with the specified Process ID from being displayed. This parameter can be specified more than once. Note: This parameter is ignored if the <i>ProcessID</i> parameter is specified.
/MaskTID:UInt32	/MTID	Prevents any message associated with the specified Thread ID from being displayed. This parameter can be specified more than once. Note: This parameter is ignored if the <i>ThreadID</i> parameter is specified.
/NoGui	/NG	Specifies that the AFGetTrace utility be launched in console mode.
/NoHeader[-]	/NH	Disables header information on each message. Header information includes the time stamp, process identifier, and thread identifier.
/ProcessID:UInt32	/PID	Displays any message associated with the specified process ID. This parameter can be specified more than once.
/ThreadID:UInt32	/TID	Displays any message associated with the specified thread ID. This parameter can be specified more than once.
/WordWrap	/W	Word wraps output messages to the width of the console.
/Silent[-]	/S	Establishes silent mode, which

Parameter	Short form	Description
		prevents message display.

Track PI AF changes with Audit Trail

If Audit Trail is enabled for your system, users with administration privileges can use the utility to view changes to PI AF objects from all PI AF databases, or to a single object.

Beginning with PI AF 2017 R2, users with administration privileges can right-click an object in the browser or an object on a list in the viewer and click **Audit Trail Events** to review audit data specific to that object only.

See [Audit Trail implementation](#) for details about enabling the Audit Trail feature.

Each row in the table of the AF Audit Trail window contains data that identifies a specific change to a PI AF object. You can double-click a row to view details about that change in the AF Audit Trail Details window.

You can press CTRL+C and CTRL+V to copy and paste rows from either window into another document, such as a spreadsheet.

Overview of Audit Trail

The Audit Trail feature allows you to review changes to PI AF objects, as well as certain system and security settings. You must have administrative privileges to turn on or off Audit Trail and view audit information. See [Audit Trail implementation](#) for instructions on how to enable Audit Trail.

Note: Audit Trail requires the use of SQL Server Change Data Capture (CDC), which is a feature of Microsoft SQL Server. Audit Trail does not capture changes related to enabling or disabling the CDC table.

What is audited?

The following PI AF objects are tracked when Audit Trail is enabled:

- Element objects:
 - Databases
 - Elements
 - Static attribute values that are not data references
 - Analyses
 - Notifications
 - Models
- Event frame objects:
 - Event frames
 - Transfers
 - Cases
- Library objects:
 - Templates

- Enumeration sets
- Reference types
- Tables and table connections
- Categories

What user actions are audited?

The following user actions are recorded when Audit Trail is enabled:

- When an AF object is added, modified, or deleted. For example, when an object is renamed or when its description is changed.
- Changes to the security rights for a system collection, a database collection or an individual object.
- Changes to the UOM database. For example, adding a UOM.
- Changes to the AF Server. For example, turning on the Audit Trail feature or removing a plug-in.
- When the Audit Trail feature is turned on
- Changes to an AF security certificate (when a certificate is added, modified or deleted)
- When an AF plug-in is added or deleted
- When a trusted AF plug-in provider is added or deleted
- When an AF database is deleted
- When analyses, legacy notifications or notification rules are enabled or disabled

When Audit Trail is enabled, you can view changes that are tracked and also export or copy and paste audit records to a file. See [Review changes with the Audit Trail utility](#) for how to view and export audit trail information using PI System Explorer.

Review changes with the Audit Trail utility

Only users given administrator privileges to the AF Server can use the Audit Trail utility.

Use the Audit Trail utility to track changes to one or more PI AF objects.

1. Choose from the following actions:

To ...	Do this ...
Review changes to PI AF objects in all databases	Click Tools > Audit Trail .
Review changes to a single PI AF object	<ol style="list-style-type: none">a. Open the database that contains the object you want to audit.b. In the navigator, click the object type you want to audit. For example, to audit a table, click Library.c. In the browser, expand the tree until the object you want to audit is displayed in either the browser tree or listed in the viewer.

To ...	Do this ...
	d. Right-click the object and click Audit Trail Events .
Review changes to the UOM database	a. In the navigator, click Units of Measure . b. Click File > Audit Trail Events .

2. In the table displayed in the AF Audit Trail window, review changes made to PI AF data. The following columns are displayed:

Column	Description
Date	The date and time of the change.
Action	The type of change (Insert, Update, or Delete).
Type	The type of object that changed.
Database	The PI AF database containing the changed object.
Path	The hierarchical path to the changed object (when the object is a child of a parent object, the path shows the parent object).
Name	The name of the changed object.
User	The user who made the change, in the form of <i>domain\user</i> .

You can filter the results shown in the **AF Audit Trail** window by changing the start and end times:

To ...	Do this ...
Adjust the time period	<p>a. Change Start Time and End Time to adjust the time period. You can choose from the following actions:</p> <ul style="list-style-type: none"> a. Click  to choose or enter a new date and/or time. b. Click  to construct a relative time expression. b. Click  (or press Enter) to display the updated table.
View changes for a subsequent time period	Click  .
View changes for a previous time period	Click  .
Adjust the number of change rows for current time period	a. In the Maximum field, enter the number of records you want returned in the results list.

To ...	Do this ...
	<p>b. Click  (or press Enter) to refresh the results in the list.</p> <p>c. If there are additional records that are not displayed in the results list, the Next button appears active. Click Next to display the next page of records in the query results.</p> <p>Note: You can also display additional records by increasing the value in the Maximum field and then pressing Enter.</p>
Filter the returned results	<p>a. Click  to select a filter type.</p> <p>b. Enter text in the Filter field.</p> <p>c. If necessary, click .</p> <p>The table displays only those rows that contain your filter criteria.</p>

3. Optional. To view details for a specific row, double-click it.

- a. In the AF Audit Trail Details window, review the details of the row you selected. In addition to **Path**, **Name**, **Identity** and **Date**, the following information is displayed:

Column	Description
Action	Type of change (Insert, Update, or Delete) and the PI AF object sub-object (such as an attribute or attribute value).
Name	The PI AF sub-object; can be blank.
Id	The identity of the object referenced in the detail record. The value is either a GUID or an integer. The identity can be useful in situations where an object is renamed, since the underlying identity does not change.
Property Name	The column name from the SQL table in PI AF SQL Database (PIFD) for the changed sub-object. This name provides a specific reference to the data within the record that has been changed.
Old Value	The value before the change.
New Value	The value after the change.

- b. Click **Close** to return to the AF Audit Trail window.

4. Optional. You can export selected data grid rows or all the rows from the time range (if no rows are selected) in CSV format:

- a. In the **Export to File** field, enter a name for the export file.
- b. Click  to open the Save As window and navigate to a specific directory.
- c. If you want to export the data from Audit Trail Details window for each selected row, select the **Detailed** check box.
- d. Click **Export All** or **Export Selected**, depending on whether you selected specific rows. (A tooltip indicates the number of rows selected.)

The status bar initially indicates the total number of rows and then appends the time when the export completed. Note that while the export is executing, you can cancel it by clicking **Cancel Export**. The status bar indicates the time when the export was canceled.

5. To exit the Audit Trail utility, click **Close**.

View installed plug-ins

You check on installed plug-ins in the PI AF Server Properties window.

1. Select **File > Server Properties**.
2. In the PI AF Server Properties window, click the **Plug-Ins** tab.
 - Move the pointer over a plug-in to see whether it is loaded and the version loaded.
 - Right-click a plug-in and select **Properties** to view details, such as the assembly, version, loaded version, support assemblies, and so on.

Note: The loaded plug-in version usually matches the version on the PI AF server. However, if the version on the server changes, you must restart PI System Explorer to load the new plug-in version on the server.

Command-line plug-in registration

You can register different Plug-In implementations and support assemblies on the command line, using the **RegPlugIn** and **RegPlugIn64** utilities. For a list of parameters, see [RegPlugIn parameters](#).

Note: The AF SDK .NET 3.5 is no longer shipped beginning with the release of PI AF 2018 SP3 Patch 2. Customers should migrate to the AF SDK .NET 4 and update their plugins accordingly.

The Plug-In registration utilities are located in the **\PIPC\AF** folders for their corresponding **Program Files** directories:

```
\Program Files\PIPC\AF\RegPlugIn64.exe  
\Program Files (x86)\PIPC\AF\RegPlugIn.exe
```

Examples

In the following examples, *MyPISystem* is the PI AF server where the Plug-In is to be registered, *MyPlugIn.dll* is the name of the Plug-In assembly, and *Support.dll* is the name of a support assembly for the Plug-In.

- .NET 3.5 Only Plug-In Targeting Any CPU

The simplest to register, this implementation works on any operating system architecture and both versions of the .NET Framework. It cannot use new features that are specific to the .NET 4 version of AF SDK.

```
RegPlugIn /PISystem:MyPISystem PlugIns\MyPlugIn.dll
```

- .NET 4 Only Plug-In Targeting Any CPU

This implementation works on any operating system architecture and the .NET 4 Framework. It does not work with the .NET 3.5 version of the AF SDK.

```
RegPlugIn /PISystem:MyPISystem PlugIns\4.0\MyPlugIn.dll
```

- .NET 3.5 and .NET 4 Plug-In Targeting Any CPU

This Plug-In has two implementations. One targets the .NET 3.5 Framework and works with the .NET 3.5 version of AF SDK, and the other targets the .NET 4 Framework and works with the .NET 4 version of AF SDK. Both implementations are registered with the following command:

```
RegPlugIn /PISystem:MyPISystem PlugIns\MyPlugIn.dll PlugIns\4.0\MyPlugIn.dll
```

- .NET 3.5 Only Plug-In Targeting 32- and 64-Bit Platforms

This Plug-In has two implementations for the .NET 3.5 Framework. One implementation targets 32-bit operating systems and the other one targets 64-bit operating systems. With both implementations registered, the Plug-In works on any operating system architecture and both versions of the .NET Framework, but cannot use the new features that are specific to the .NET 4 version of AF SDK.

```
RegPlugIn /PISystem:MyPISystem PlugIns\x86\MyPlugIn.dll
```

```
RegPlugIn64 /PISystem:MyPISystem PlugIns\x64\MyPlugIn.dll
```

- .NET 3.5 and .NET 4 Plug-In Targeting 32- and 64-Bit Platforms

This Plug-In has four implementations. Two implementations are for the .NET 3.5 Framework, one for 32- and one for 64-bit platforms. The other two implementations are for the .NET 4, one for 32- and one for 64-bit platforms. With all implementations registered, it works on any operating system architecture and both versions of the .NET Framework.

```
RegPlugIn /PISystem:MyPISystem PlugIns\x86\MyPlugIn.dll PlugIns\4.0\x86\MyPlugIn.dll
```

```
RegPlugIn64 /PISystem:MyPISystem PlugIns\x64\MyPlugIn.dll PlugIns\4.0\x64\
```

```
MyPlugIn.dll
```

- .NET 3.5 Only Plug-In and Support Assembly Targeting Any CPU

This implementation, with its support assembly, works on any operating system architecture and both versions of the .NET Framework. It cannot use the new features that are specific to the .NET 4 version of AF SDK.

```
RegPlugIn /PISystem:MyPISystem PlugIns\MyPlugIn.dll PlugIns\Support.dll
```

- .NET 3.5 and .NET 4 Plug-In and Support Assembly Targeting Any CPU

This Plug-In has two implementations with two implementations of its support assembly. One targets the .NET 3.5 Framework and works with the .NET 3.5 version of AF SDK. The other targets the .NET 4 Framework and works with the .NET 4 version of AF SDK. Both implementations along with their support assemblies are registered with the following command.

```
RegPlugIn /PISystem:MyPISystem PlugIns\MyPlugIn.dll PlugIns\Support.dll PlugIns\4.0\
```

```
MyPlugIn.dll PlugIns\4.0\Support.dll
```

RegPlugIn parameters

The following table lists available parameters for the RegPlugin utility.

Parameter	Short form	Description
/PISystem:string	/P	Specifies the PI AF server to process. If not specified, the default

Parameter	Short form	Description
		PI AF server is used.
<i>/OutputFile:string</i>	<i>/O</i>	Specifies an output file. If specified, a SQL script is generated to create Plug-Ins. Use the <i>AppendFile</i> parameter to append to an existing file.
<i>/AppendFile[-]</i>	<i>/A</i>	Used in conjunction with the <i>OutputFile</i> parameter, specifies whether to append to an existing output file.
<i>/List</i>	<i>/L</i>	Lists registered assemblies in the specified PI AF server.
<i>/Recursive[-]</i>	<i>/R</i>	Automatically processes support assemblies in subdirectories based upon assembly and directory names. Use the <i>RootDirectory</i> parameter to specify a root directory that is different than the current working directory.
<i>/Force[-]</i>	<i>/F</i>	Forces registration of assemblies that are older than currently registered assemblies or forces the deregistration of assemblies that do not appear to be registered.
<i>/Silent[-]</i>	<i>/S</i>	Silent mode. Prevents messages from being displayed.
<i>/Unregister</i>	<i>/U</i>	Removes assembly and plug-ins from the specified PI AF server.
<i>/RegFile:string</i>	<i>/RF</i>	Creates a registration XML file for the specified assembly that can be used to register a plug-in assembly and all its related support assemblies. Any additional files specified are treated as support assemblies.
<i>/Version</i>	<i>/V</i>	Displays version information. All other parameters are ignored.
<i>/User:string</i>	<i>/user</i>	Specifies a different Windows user

Parameter	Short form	Description
		account to connect to the PI AF server.
<i>/Password:string</i>	<i>/PW</i>	Used in conjunction with the <i>User</i> parameter, specifies the password of a different Windows user account to connect to the PI AF server.
<i>/Owner:string</i>	<i>/Own</i>	Provides the owner file name of all specified support assemblies. Normally used with the <i>Directory</i> parameter when registering support assemblies. By default, the directory name will be determined relative to the <i>RootDirectory</i> parameter or current working directory if the root directory is not specified.
<i>/Directory:string</i>	<i>/Dir</i>	Provides the directory name for all specified support assemblies. Normally used with the <i>Owner</i> parameter when registering support assemblies. By default, the directory name is determined relative to the <i>RootDirectory</i> parameter or current working directory if the root directory is not specified.
<i>/RootDirectory:string</i>	<i>/RootDir</i>	Registers all assemblies relative to the specified root directory name. Normally used with the <i>Recursive</i> parameter when registering assemblies instead of using the <i>Directory</i> parameter. By default this parameter is set to the current working directory.
<i>/Exclude:string</i>	<i>/E</i>	Specifies input files or directories to exclude when searching a directory for files. You can specify this parameter more than once, but values must be unique.
<i>files</i>		Specifies the input assembly files, registration files, or directories to

Parameter	Short form	Description
		<p>process. You can use the following wildcard specifiers to filter files processed in directories:</p> <ul style="list-style-type: none"> • '*' matches zero or more characters • '?' matches exactly one character <p>You can also use the <i>Exclude</i> parameter to filter the processed files.</p>
@file		Provides additional input parameters to the specified file. The file should contain one parameter per line. Comment lines start with the '#' character.
/?, /help		Displays these option descriptions.

Create an XML registration file

Note: The AF SDK .NET 3.5 is no longer shipped beginning with the release of PI AF 2018 SP3 Patch 2. We recommend all customers migrate to the AF SDK .NET 4 and update their plugins accordingly. There are no plans for additional development work on the .NET 3.5 version of the AF SDK.

For complex or frequently-executed registrations, you can create an XML file that contains the required settings.

To create the XML file, invoke *RegPlugin*, specifying both the required settings and the XML file name using the */RegFile: (RF:)* parameter.

Example

To create an XML file that registers a .NET 3.5 and .NET 4.0 version of **MyPlugIn.dll**, issue the following command:

```
RegPlugIn /RF: PlugIns\MyPlugIn.dll PlugIns\4.0\MyPlugIn.dll
```

The resulting registration file can be edited to supply any additional information required for the registration of the plug-in (not normally necessary). For 64-bit plug-ins, the registration file must be edited to set *LoadProperties* to *x64* and ensure that *Directory* is set to *x64*:

```
<SupportAssembly>
<FilePath>x64\AFDRTest32Bit64Bit.dll</FilePath>
<ID>1e00000c-3228-366a-3809-737433324269</ID>
<Name>AFDRTest32Bit64Bit</Name>
<Description>AFDRTest32Bit64Bit.dll Support Assembly</Description>
<Directory>x64</Directory>
<LoadProperties>x64</LoadProperties>
```

```
</SupportAssembly>
```

To register both implementations using the registration file, issue the following command:

```
RegPlugIn /PISystem:MyPISystem MyPlugIn.xml
```

Create an SQL registration script

To create an SQL registration script, invoke the **RegPlugIn** utility, specifying the required details and the **/OutputFile** or **/AppendFile** parameter. The resulting script can be loaded into the SQL database using SQL Server Management Studio or executed from a command line using the **sqlcmd** utility, enabling you to install plug-ins on machines where the PI AF SDK is not installed.

Note: For plug-in developers: The SQL script needs to be generated every time you compile a new version of the plug-in.

The AF SDK .NET 3.5 is no longer shipped beginning with the release of PI AF 2018 SP3 Patch 2. It is recommended that customers migrate to the AF SDK .NET 4 and update their plugins accordingly.

Example

For example, to create a script that registers a .NET 3.5-only Plug-In targeting any CPU, issue the following command:

```
RegPlugIn /O:MyPlugIn.sql PlugIns\MyPlugIn.dll
```

To generate an SQL registration script named **MyPlugIn.sql** that registers two implementations of MyPlugIn, a .NET 3.5-only Plug-In targeting x86 and x64, issue the following commands:

```
RegPlugIn /O:MyPlugIn.sql PlugIns\x86\MyPlugIn.dll  
RegPlugIn64 /A:MyPlugIn.sql PlugIns\x64\MyPlugIn.dll
```

To generate an SQL registration script from a previously-created XML registration file, specify the XML file name on the command line. For example:

```
RegPlugIn /O:MyPlugIn.sql MyPlugIn.xml
```

Register plug-ins with generated SQL scripts

You register a plug-in from Microsoft SQL Server Management Studio or from the command line.

1. Launch Microsoft SQL Server Management Studio.
2. Choose **File > Open > File**
3. Browse to the script and load it.
4. Execute the script.
5. To run the script from the command line, invoke the **sqlcmd** utility, specifying the **-i inputfile** option with the path and name of the SQL script as *inputfile* and the connection settings required to connect to the database server.

Plug-in provider management

By default, you can run PI AF plug-ins from any provider. For increased security, you can configure PI AF so that

only plug-ins from trusted providers are allowed to be loaded and executed in the client application (PI AF server 2.5 and higher). Plug-in providers are encouraged to code-sign their plug-ins using Authenticode technology. You control how plug-in security is enforced by setting the verify level.

Verification level

You can display the verification level used when plug-ins are loaded by issuing the **afdiag** command with no parameters. The verification level is listed in the Configuration Settings section of the resulting output as *PluginVerifyLevel*.

/PlugInVerifyLevel parameter

You set the verify level with the **afdiag** command, and specify the */PlugInVerifyLevel* parameter. Valid levels are:

- None: Disable validation; run all plug-ins. This level is only supported in the PI AF Client 2018 SP3 Patch 1 and earlier versions.
- AllowUnsigned: Run unsigned plug-ins and plug-ins with valid signatures. This level is supported only in the PI AF Client 2018 SP3 Patch 1 and earlier versions.
- RequireSigned: Run only plug-ins with valid signatures.
- RequireSignedTrustedProvider: Run only plug-ins with a valid signature from a trusted provider.

Other AFDIAG parameters for managing plug-in providers

The following **afdiag** parameters are available to manage plug-in providers:

- Display a list of trusted providers: */TrustedProviderList*
- Add a trusted provider: */TrustedProviderAdd:providername*
- Remove a trusted provider: */TrustedProviderRemove:providername*

For more information on these parameters, see [AFDIAG utility parameters](#). You can locate the provider name by viewing the digital signature for the plug-in DLL, as described in [Locate the names of trusted providers](#).

Locate the names of trusted providers

Determine the name of a trusted provider of a plug-in DLL by viewing the details of its digital signature. The string for the trusted provider name must be contained in the certificate's subject.

1. Right-click the plug-in DLL and click **Properties**.
2. In the Properties window, click the **Digital Signatures** tab. (If the plug-in is unsigned, this tab is absent.)
3. Select a **Name of signer** in the **Signature list** and click **Details**.
4. In the Digital Signature Details window, click **View Certificate**.
5. In the Certificate window, click the **Details** tab and scroll to the **Subject** field.

The value displayed for this field is the name of the trusted provider. You can use any subset or the whole name of any of the names that are part of the subject as the *<providername>* variable for the */TrustedProviderAdd* and */TrustedProviderRemove* parameters.



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