



Calculations and Asset Analytics

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Lesson 1 – Welcome to the course!

Sample AF Databases

Welcome to the Asset Analytics: Basics Online Course!

To complete this course, you will progress through a series of short videos and exercises to learn and practice how to apply asset analytics to your PI systems. If you are using the course Cloud Environment, you will notice that you already have all of the AF databases mentioned in the course videos and exercises. Additionally to the two databases used for exercises introduced below, the videos are also using two databases which are part of the [Asset Based PI example kits](#).

If you are not using the course Cloud Environment to complete the course, you can find the necessary databases for exercises attached to the course page. The PI Big Tires Company and Wind Farm databases (attached here), which are used for several exercises and examples, require a few tags to be created. For PI Big Tires Company, there is an attached tag list as well for you to be able to view this data. The Wind Farm database creates the required tags through analyses.

Though detailed knowledge about the background of these databases is not necessary to follow the course, we will still introduce the databases briefly.

PI Big Tires Co.

As a consultant for a tire manufacturing company, PI Big Tires Co., you help create a smarter AF structure; your client wants to have more insight on his operations by taking advantage of the calculation and analytics features provided by the PI System. The tire curing presses are an essential part of the production process and currently there is a lack of key performance metrics; your client wants you to start working on this section of the factory.

Here is how a Tire Curing Press works: raw tires are loaded individually into a Tire Curing Press. Once the tire is loaded, the press closes up and temperature and pressure is applied to cook and mold the tire. After the cooking time has elapsed, the press opens up and the tire is unloaded into a cooling unit where fans blow air until the tire reaches a specific temperature.

There is a solution database available on the Cloud Environment and attached for download here. To implement this database, create a new database and right-click on the database in the Select Database window or open the database, select Import from File... and select the file C:\OS\soft\PI Big Tires Co\Solution\PI Big Tires Co 2018 (Solution).xml. Enable the analyses in the Management tab. If there are errors you might need to Create or Update Data Reference which can be done for the entire hierarchy through right-click on Elements.

Wind Farm

Calculation of and immediate feedback on wind turbine performance is an important part of maximizing revenue from wind generation assets. Waiting for a daily or monthly rundown of performance of a wind farm can cost thousands of dollars of lost production each day. Common causes of deviations from the expected power can be due to equipment issues such as the pitch or yaw system, a curtailment, or an outage. Being able to determine the generation shortfalls from the expected power in near or real time allows the site to take prompt corrective action with the intent to either resolve the performance issue quickly or schedule maintenance to inspect or repair the turbine. Monthly reporting is also helpful in understanding performance issues but if the issues can be resolved sooner, the lost generation can be minimized because the cause may be able to be promptly resolved. Monthly reporting can then be utilized to track top outage causes and plan long term maintenance to correct issues and schedule tower inspections.

Goals

Now it's time to think about your personal objectives of this course. What sort of calculations does your company need? What kind of data do you need to further analyze? The course will present general examples, and it would be good practice for you to think of the ways you will apply these concepts to your personal industries and processes.

Keep in mind that while Asset Analytics within Asset Framework is the typical tool of choice for most calculations, it is not always the right choice. For example, simple operator calculations can be done within a Formula Data Reference, and a Totalizer may be a better choice if a summary calculation with snapshot data is required and recalculation is unimportant. By the end of this course, you should have an idea of the wide scope of possibilities available with Asset Analytics, as well as an understanding of when to use another calculation tool.

For more details on the right PI methods for calculations, take a look at the following [KB - Analytics: Which tool is best for the job](#)

Lesson 2: Calculation Options in AF

Overview of Calculation Options

Asset Framework (AF) provides several options to enhance the data with calculations that are carried out on top of the values in the Data Archive. What is the overall efficiency of a process? Which facility had the highest average production last week? And what about last month?

Users often run calculations on raw data to make key decisions such as which assets require maintenance, or to determine the profitability of a production site. However, these calculations often reside in spreadsheets, with data ranges, methods, or errors as numerous as the individuals who maintain them. Asking one question can therefore lead to a range of different, and potentially contradictory, answers.

AF offers a range of options to perform calculations on the raw data of the Data Archive and other sources in a central place for users to consume with the various client tools of the PI System. These calculations transform raw process data into decision making information that is provided by the PI System.

In this section we will give a brief overview of these options. In the following lessons we will go through them in more detail.

AF Calculation Option	Examples
Value Retrieval Methods (defined in PI Point Data Reference)	Get interpolated value for a PI Point from a particular point in time (e.g. from 2 hours ago), get aggregated data for a PI point for a defined time period (e.g. maximum from the last 24 hours)
Formula Data Reference	Ad-hoc calculation (e.g. add volumes from two tanks)
Asset Analytics (Expression, Rollup, Event Frame Generation, SQC)	<u>Expression</u> : perform all kind of simple and complex calculations such as summaries, consumptions, metric data, KPIs etc. <u>Rollup</u> : aggregate/summarize data over several levels in the asset hierarchy (e.g. maximum temperature for all reactors, overall production in all production lines) <u>EF Generation</u> : monitor process for special conditions and capture in Event Frames (e.g. downtimes, process excursions) <u>SQC</u> : online statistical calculations

How to find the right tool for a task

For a decision on what calculation options to use, consider the following aspects:

- What load will the calculation place on the PI System?
- Do I need to keep the history for the calculation?
- Will the calculation be applied to multiple assets?
- How complex is the calculation?

To help you with the selection for the best calculation option, use the following table. For more information on how to find the right calculation tool see also [How to choose the right AF calculation tool?](#), [Client data Flow for Asset Analytics](#) and [PI System Analytics: Which tool is best for the job?](#).

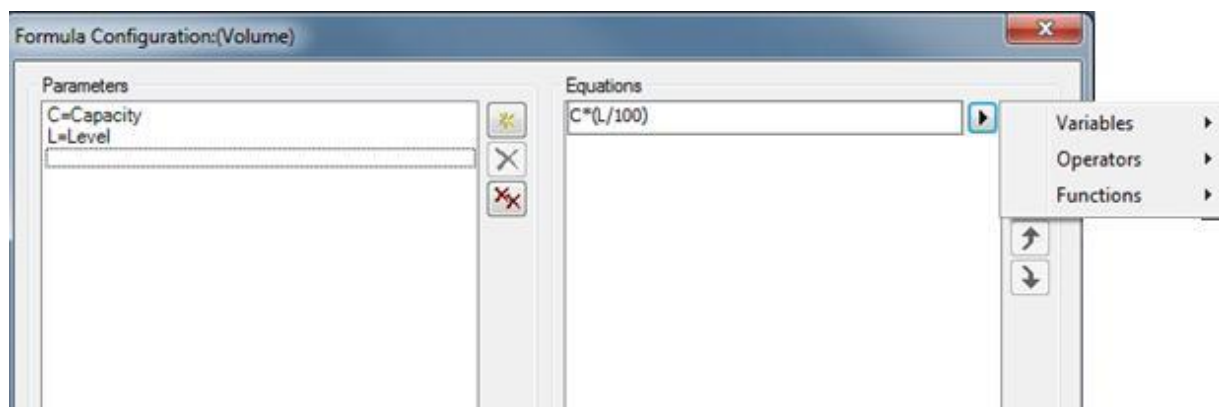
	Value Retrieval Methods	Formula Data Reference	Expression Analysis (Output to non PI Point Attribute)	Expression Analysis (Output to PI Point Attribute)
Creation Method	Configuration	Expression	Expression	Expression
Functions	No	Limited	PE	PE
Historization	No	No	No	Yes
Recalculation/ Backfilling	No	No	No	Yes
Calculation Load	Server	Client	Client	Server
Time Awareness	Relative	No	Yes	Yes

When you are looking for a tool for more complex calculations you will probably want to use Asset Analytics which offers the best performance, flexibility and allows to store the history in PI Points. In the next section we will introduce Asset Analytics in more detail before we go through the different calculation tools.

Formula Data Reference and Value Retrieval Modes

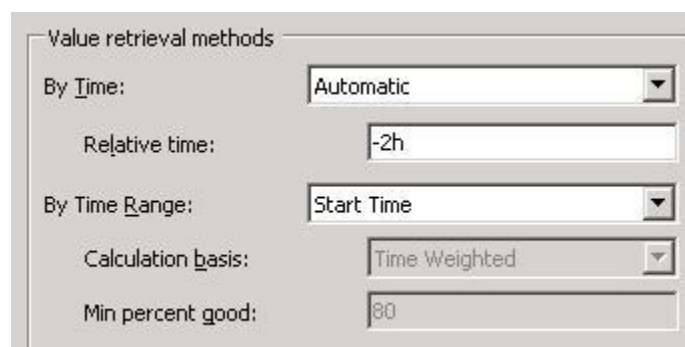
Formula Data Reference

- Ad-hoc calculation, no history saved
- Calculation is defined in one or multiple equations
- Equation syntax based on variables, operators (+, *, ...) and functions (sin, cos, abs, sqrt,...)
- Examples: volume based on capacity and level, value of your stock based on amount of goods and current prize



Value Retrieval Modes

- Configurable option within the PI Point Data Reference
- By default the current value of a tag is displayed
- By Time: get data from another point in time (e.g. value from 2 hours ago)
- By Time Range: get aggregated data (e.g. maximum value from last 15 minutes, total amount of material based on the inflow)



Introduction to Asset Analytics and the Analysis Service

Assets Analytics has become the calculation engine of choice for the PI System thanks to its ease of use and vast capabilities. With Assets Analytics, you can take advantage of your AF hierarchy and perform calculations on all your assets.

With Asset Analytics, you can easily configure server-side calculations with pre-built functions and *Intellisense* that will auto-populate suggestions as you type. Asset Analytics also provides a simple configuration option to write calculation results back to PI Points on either a timed (periodic) or events-driven schedule. All of this is possible with a no-coding-required user interface and enables large-scale deployment of calculations that are more manageable and powerful than could be handled within a typical spreadsheet.

For those using Performance Equations on the Data Archive, the same functionalities (and more!) are available in Asset Analytics where analyses can be easily deployed, backfilled, and managed at scale from a single user interface. OSIsoft strongly recommends to make use of the calculation features of PI Asset Framework rather than using tag-based analytics in Data Archive.

Analysis Types and Capabilities of Asset Analytics

An analysis is a scheduled calculation that gets input values from attributes in any level of your AF hierarchy and outputs its results to other AF attributes.

Asset analytics features four types of analysis:

- Expressions: Wide range of functions to create powerful analyses. Expressions use the Performance Equation syntax.
- Rollup: Aggregation calculations for a group of selected attributes.
- Event Frame Generation: Specify conditions to trigger the start and the end of an event.
- SQC: Uses Statistical Quality Control (SQC) methods to monitor that attribute values lie within pre-determined boundaries.

In this course we will work with Expression and Rollup analyses. If you want to learn more about Event Frame Generation you can take the course *Event Frames and Notifications*. SQC analyses will be presented in a future course offering.

Asset analytics provides the following capabilities:

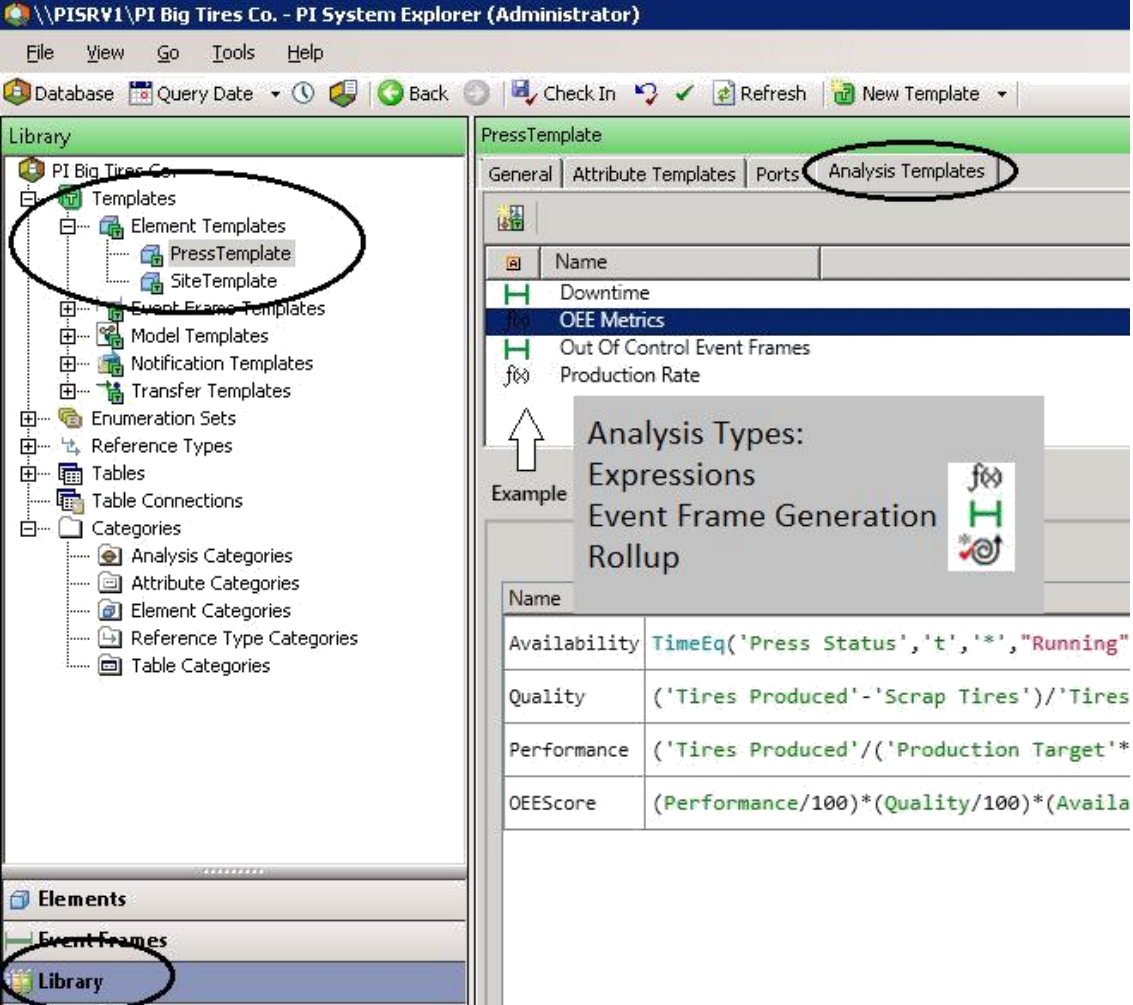
- Historization: When the output attribute is mapped to a PI Point, the calculation results are archived in the Data Archive.
- Backfilling/Recalculation:
Backfilling: Run the analysis over an earlier time period to backfill data

for the PI Points mapped to its outputs. Example: a new analysis to calculate daily overall consumptions is created on April 1st. With Backfilling the overall consumptions are calculated for a past period such as e.g. January - March and stored in the archive of the output tag. Recalculation: In case the values for the inputs of a calculation have changed the recalculation feature allows to update the calculation results accordingly.

- Security: It is possible to configure and manage permissions to limit access to analyses and analysis templates.
- Preview and Test: Calculation results can be previewed before putting the analyses into production.
- Calculation Dependencies: The result of a calculation can be used as an input to another calculation.
- Scheduling options: Calculations can be configured to be executed according to a schedule or they can be event based.

Working with Analyses

Every analysis is associated with an element and can be created directly on that element by selecting the **Analyses** tab; however, it is recommended that analyses be associated with an element template. To do this, select the corresponding Element Template and then use the **Analysis Templates** tab (see figure below).



PI System Explorer (Administrator)

File View Go Tools Help

Database Query Date Back Check In Refresh New Template

Library

- PI Big Tires Co.
 - Templates
 - Element Templates
 - PressTemplate
 - SiteTemplate
 - Event Frame Templates
 - Model Templates
 - Notification Templates
 - Transfer Templates
 - Enumeration Sets
 - Reference Types
 - Tables
 - Table Connections
 - Categories
 - Analysis Categories
 - Attribute Categories
 - Element Categories
 - Reference Type Categories
 - Table Categories

Elements

- Event Frames
- Library

PressTemplate

General Attribute Templates Ports Analysis Templates

Name

Downtime

OEE Metrics

Out Of Control Event Frames

Production Rate

Analysis Types:

- Expressions
- Event Frame Generation
- Rollup

Example

Name	Expression
Availability	<code>TimeEq('Press Status','t','*', "Running")</code>
Quality	<code>('Tires Produced'-'Scrap Tires')/'Tires</code>
Performance	<code>('Tires Produced'/'Production Target'*</code>
OEE Score	<code>(Performance/100)*(Quality/100)*(Availa</code>

Analyses can be managed (e.g. start, stop, backfill) directly at the element level under the *Analyses* tab, or by using the *Management* plug-in from the navigator panel. See below a screenshot presenting a short description of the different components of the Management plug-in.

Management of your Analyses or your Notification Rules

List of the Analyses along with their status

Enable/Disable analyses and manage backfilling, automatic and manual recalculation for one or multiple analyses

Filter analyses using personalized Searches

Click here to select all your analyses

Right-click in this pane to

Shortcut to Element

Status in AF and Analysis Service

Status	Symbol	AF Status	Service Status
New		Enabled	-
Starting/Stopping		Enabled/Disabled	Starting/Stopping
Running		Enabled	Running
Disabled		Disabled	-
Error		Error	Error
Warning		Warning	Warning
Suspended (2038)		Enabled	?
Unknown		Enabled	Suspended

The Analysis Service

The Analysis Service runs all analyses of a AF Server. In later lessons we will look into Best Practices to avoid overloading this service through badly configured analyses and provide information how to approach troubleshooting.

The configuration of the service can be viewed and changed by right-clicking in the Operations panel of the Management plug-in (shown in the screenshot above) and selecting **Edit Analysis Service Configuration**. Here it can be set if the service should automatically recalculate analyses with late-arriving inputs (Auto Recalculation) or the maximum downtime of the service to automatically backfill once the service is running again (Auto Backfilling) as well as a couple of other setting influencing the operations of the service. For a full list of configuration options see [Analysis service configuration](#).

Reachable via the same right-click menu are the Analysis Service Statistics by clicking **View Analysis Service Statistics**. These statistics are particularly important in diagnosing and identifying a solution for performance issues.

See also [Analysis Service management](#) for additional information.

Lesson 3: Creating Calculations with Formula Data References

Creating Formula Data References

[OSIsoft: On Demand Calculations using Formula Data References \[v2.9.5.8368\]](#)

Formula Data References allows the creation of simple custom calculations. Calculations can be in the form of a single formula or a sequence of calculations. The calculations are executed on demand, and the results are not archived anywhere. The functions available are limited and they are not time-weighted.

Note: If calculation results should be stored in a PI Point or if calculations are getting more complex it is recommended to create an Analysis instead. We will discuss Asset Analytics later in the course.



For full information regarding the available operators and functions refer to "[Formula data reference operators](#)" and "[Formula data reference functions](#)" in the OSIsoft Live Library

Units of Measures in Formulas

You can perform unit conversions by setting the units of measure (UOM). Units of measure can be explicitly set for the parameters as well as for the result. Do this from the parameters configuration section by choosing the appropriate UOM from the *Unit of Measure* drop down. Do this also in the *Result* section at the bottom left.

Note: It is recommended that you **always** assign the units explicitly! If you leave units selector at "<default>" then no unit conversion takes place. If the default UOM of an attribute is changed later on, then no corresponding conversion will happen, and results will not be correct!

Knowledge Check: Create a simple calculation using a Formula Data Reference


You can complete this exercise by using the "**PI Big Tires Company**" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can create a similar calculation on your own processes.

Objective: Currently we only have attributes displaying the total number of tires produced (Tires Produced) and how many of those are unusable (Scrap Tires). Now the number of good tires should get shown on a Vision display. For this purpose we want to calculate the value in an attribute for which we do not need to archive the results and only need to display the current value.

Hint: Create a new attribute template Good Tires for PressTemplate and use the formula data reference to calculate the number of good tires.

Solution: Create a simple calculation using Formula Data Reference

Create a new attribute template for PressTemplate with the following configuration:

Name:	Good Tires
Description:	
Properties:	<None> ▼
Categories:	Production 
Default UOM:	Tires ▼
Value Type:	Double ▼
Default Value:	0 Tires
Display Digits:	-5
Data Reference:	Formula ▼
Settings...	

Click on Settings... to complete the configuration. Click on  in the Parameters area to enter the two parameters needed via the Parameter Configuration window.

Parameter Configuration

Variable	Attribute	Unit of Measure
S	Scrap Tires	Tires

Absolute:

Server relative:

Database relative:

Child Element:

Parent Element:

Sibling Element:

OK Cancel

Configure a parameter for each of the two attributes *Scrap Tires* and *Tires Produced*. See the complete Formula Configuration below for reference.

Formula Configuration

Parameters

S=Scrap Tires;UOM=Tires
T=Tires Produced;UOM=Tires

☐ Default Values Allowed

Equations

T-S

Result

UOM: Minimum: Maximum: ☐ Stepped

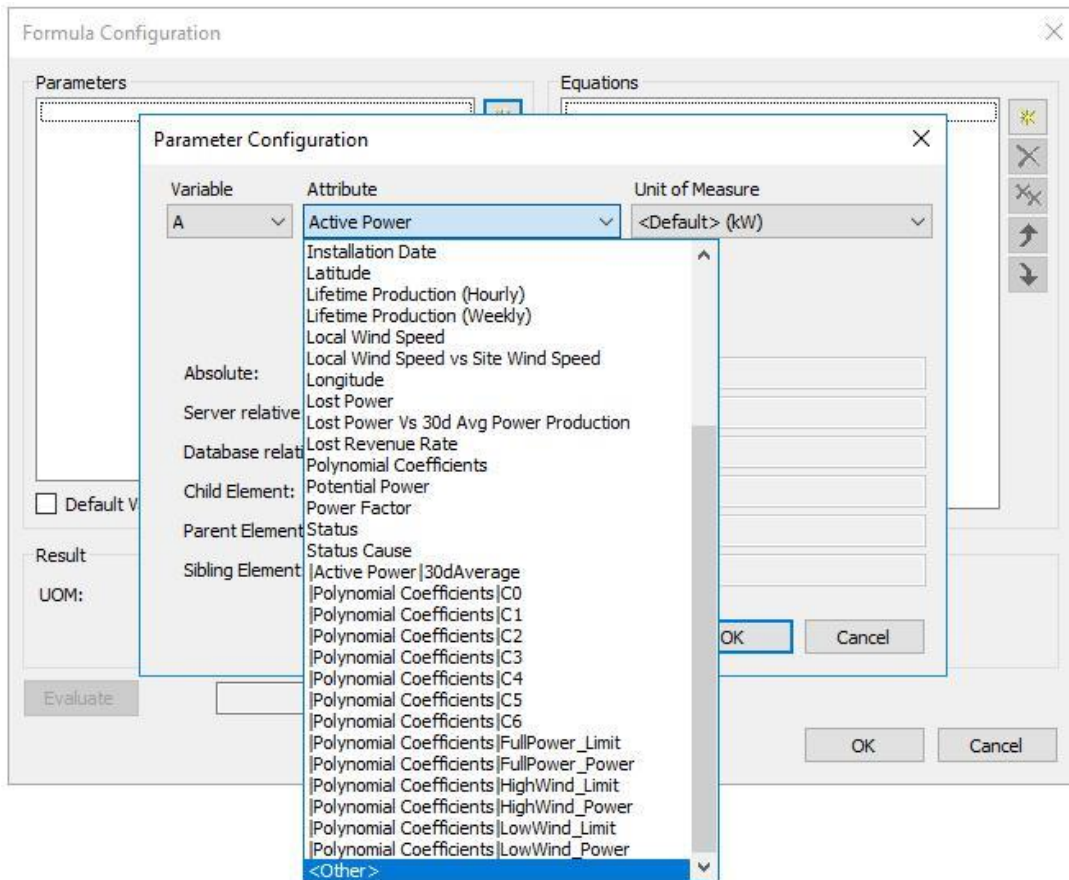
Evaluate

OK Cancel

Referencing Attributes from other Levels of the Hierarchy

With Formula Data References other attributes of the same element or from other elements can be used for calculation.

When we define a new parameter for the formula, we can choose an attribute from the same element from a drop-down list. To select an attribute from another element we can choose <Other>.



We can then type the attribute path in manually in the Attribute field (some syntax examples are listed in the bottom half of the window for reference) or click on the ellipsis (...) to search for an attribute.

Parameter Configuration

Variable	Attribute	Unit of Measure
A	<Other>	<None>

Attribute: ...

Examples:

Absolute:	\\System\\Database\\Element\\Attribute
Server relative:	\\Database\\Element\\Attribute
Database relative:	Element\\Attribute
Child Element:	..\\SubElement\\Attribute
Parent Element:	..\\Attribute
Sibling Element:	..\\SiblingElement\\Attribute

OK Cancel

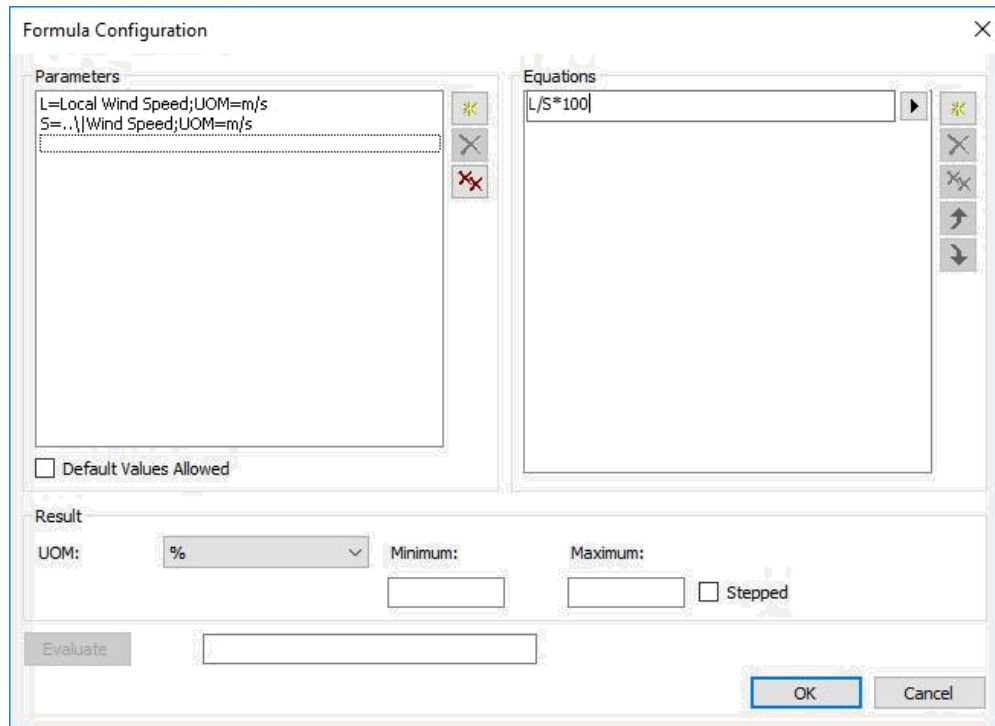
Especially for the configuration of attribute templates we need to consider where to use relative or absolute references. When do we need which kind of reference?

- Relative references are used when we are looking for something *relative* to the current element. Example: We need an attribute from the respective parent element of each element.
- Absolute references are used when the attribute should be coming from the same element for each element from a template. Example: We need an attribute from an element from another branch of the hierarchy. All elements from the template require the attribute from that same element.

With the Attribute Search we create absolute references, but those can also be changed manually to relative references if needed. For creating relative references it is in general easier to type the reference directly.

As an example, we take a look at the configuration of an attribute *Local Wind Speed vs Site Wind Speed (Formula)* in the Turbine template of the Wind Farm database which calculates the percentage of Local Wind Speed to the Wind Speed at the site (in this case the parent element). Note: In the Wind Farm database the same calculation is also done via an expression analysis.

The Formula Configuration window shows that there are two parameters used for the calculation: L which is the Local Wind Speed attribute from the element and S which is the Wind Speed attribute of the parent element.



The **Formula Configuration** dialog box is shown. It has two main sections: **Parameters** and **Equations**.

Parameters: A list box contains two entries: "L=Local Wind Speed;UOM=m/s" and "S=..\\Wind Speed;UOM=m/s". To the right of the list box are three icons: a yellow star, a cross, and a red X.

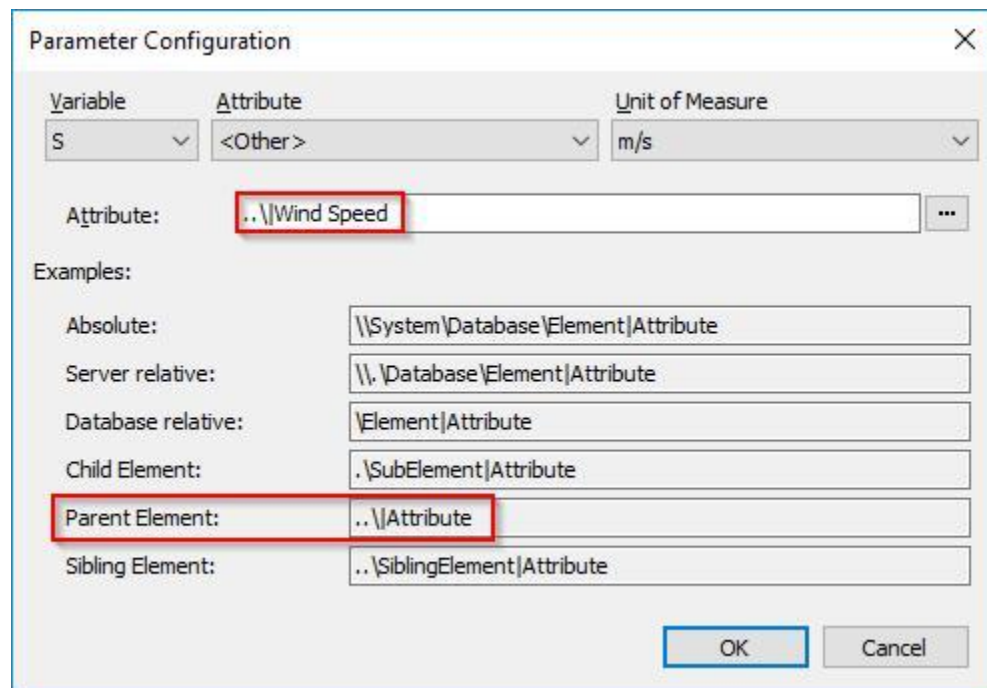
Equations: A text box contains the formula "L/S*100". To the right of the text box are four icons: a yellow star, a cross, a red X, and a double arrow.

Result: A section with a **UOM:** dropdown menu set to "%", **Minimum:** and **Maximum:** text boxes, and a **Stepped** checkbox.

Evaluate: A text box for the result value.

Buttons: **OK** and **Cancel** buttons at the bottom right.

We take a look at the Parameter Configuration of the parameter S to see how it was configured (double-click the parameter). The Attribute drop-down list was set to <Other>. Since an attribute of the respective parent element is needed the configuration follows the syntax example given for parent element.



The **Parameter Configuration** dialog box is shown. It has a table with three columns: **Variable**, **Attribute**, and **Unit of Measure**.

Variable	Attribute	Unit of Measure
S	<Other>	m/s

Attribute: A text box contains the value "S..\\Wind Speed".

Examples: A list of examples with corresponding text boxes:

- Absolute:** \\System\\Database\\Element\\Attribute
- Server relative:** \\, \\Database\\Element\\Attribute
- Database relative:** \\Element\\Attribute
- Child Element:** .\\SubElement\\Attribute
- Parent Element:** ..\\|Attribute (highlighted with a red box)
- Sibling Element:** ..\\SiblingElement\\Attribute

Buttons: **OK** and **Cancel** buttons at the bottom right.

Splitting Calculations in Multiple Lines

Calculations can be split into multiple lines to increase readability and make them easier to maintain.

In the example below the volume of a cylindrical tank is calculated in a variable V which is then used to calculate the mass contained in the tank.

Formula Configuration:(Mass)

Parameters

D=Density;UOM=kg/m3
 L=Level;UOM=m
 R=Radius;UOM=m

Equations

V=pi()*R^2*L
 V*D

☐ Default Values Allowed

Result

UOM: kg Minimum: Maximum: ☐ Stepped

Evaluate OK Cancel

Dealing with Missing Inputs and Results out of Range

The settings discussed below determine how to handle missing inputs and results which are out of range.

Minimum/Maximum

The range of returned values can get limited through the definition of minimum and maximum values. If a minimum is specified and the calculated value is less than the defined minimum, the data reference returns this minimum value instead of the calculated value. Likewise, if a maximum is specified and the calculated value is greater than the maximum, the maximum is returned.

Leave the Minimum and Maximum boxes blank if the value range should not be limited.

Default Values Allowed

It is possible to use the default values of the input attributes in the case that there is no data.

If the Default Values Allowed check box is disabled, the calculations fails when there is no data for any of the input attributes.

Lesson 4: Working with Value Retrieval Modes

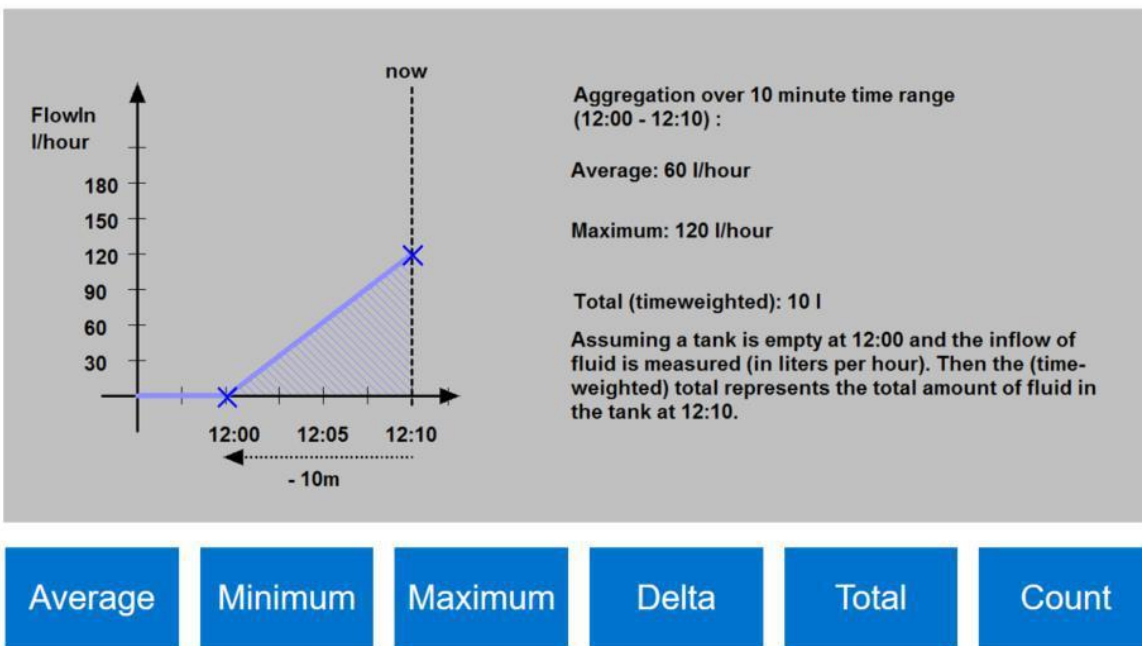
[OSIsoft: On Demand PI tag Summary Calcs using Value Retrieval Methods \[v2.9.5.8368\]](#)

Introduction into Value Retrieval Modes

By default, the PI Point Data Reference retrieves the current value of a particular point. The value retrieval methods of the PI Point Data Reference can be configured so that the value will be either

- the result of a calculation on the point's value over a time range, e.g. an average (**By Time Range** retrieval mode)
- the value of a point at a specific time (**By Time** retrieval mode).

By Time Range – Retrieving the result of an aggregation.



By Time Range options are:

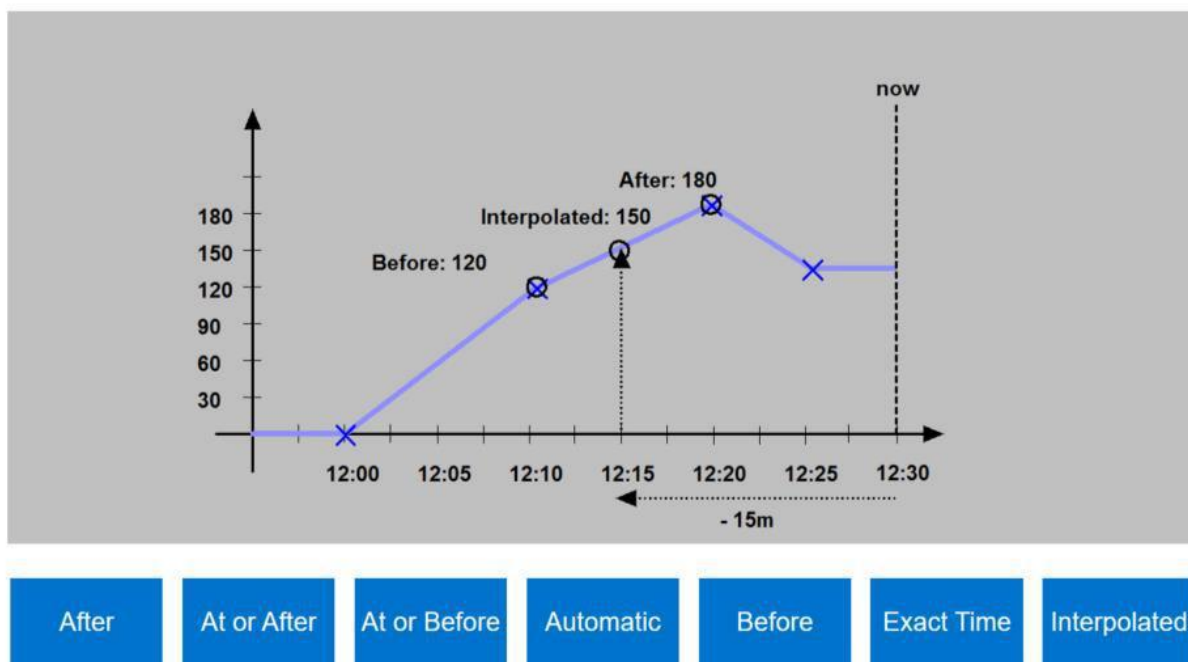
Average (time-weighted), Count, Delta, Maximum, Minimum, Population Standard Deviation, Standard Deviation, Start Time, End Time, Total.

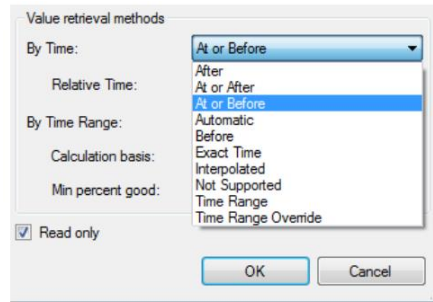
In case of Total, an extra drop-down appears to specify the time units of the rate point or attribute over which the calculation is performed. That is required since the Data Archive always assumes a rate point to be in units/day. Selecting the right time units is thus essential to retrieve a correct result.

The options in the **By Time** field for a **By Time Range** retrieval are **Not Supported**, **Time Range** and **Time Range Override**. Depending on what time context the client application is providing the behavior is in the following table.

By Time Setting	Meaning
Not Supported	If client application sends a time range, it is considered for the calculation
Time Range	If client application sends a time range, it is considered for the calculation. If client application sends point in time (and not a time range), the time range specified under Relative Time is used.
Time Range Override	The time range specified under Relative Time is used in any case.

By Time - Retrieving a value other than the current one.





By Time mode options are **After**, **At or Before**, **At or After**, **Automatic**, **Before**, **Exact Time** and **Interpolated**. To get a value other than the current value these options are used in context with the **Relative Time** field. Relative time expressions have to be in the PI System Time format (see examples below).

By Time	Relative Time	Meaning
At or After	-15m	Returns the recorded value from 15 minutes before the current time. If no value exists at that time, the next recorded value is returned.
After	-2h	Returns the first recorded value after the point in time that is two hours ago. If a value exists exactly at that time, it is not returned.
Exact	-2h	Returns the recorded value from two hours before the current time. If no value exists at that time, "No Data"-error is returned.
Interpolated	T+6h	Returns an interpolated time for 6:00:00 of the current day.

Note: Do not choose the Not Supported, Time Range, and Time Range Override options for **By Time**. These options are for attribute values based on time range calculations (see above).

Knowledge Check: Creating Attributes using Value Retrieval Modes

You can complete this exercise by using the "PI Big Tires Company" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can create a similar calculation on your own processes.

The maintenance coordinator would like a new attribute to display the total steam consumed during the last 24 hours. He does not need to archive the result of that calculation in the Data Archive.

Hint: When selecting the By Time setting remember that the attribute should show the total steam consumed during the last 24 hours independent of the time range provided by a client.

Solution: Creating Attributes using Value Retrieval Modes

Create a new attribute on the *PressTemplate* and use the value retrieval methods to calculate the total.

The image shows two overlapping windows from the PI System software. The background window is the 'Attribute Configuration' form, and the foreground window is the 'PI Point Data Reference' dialog box.

Attribute Configuration Form (Background):

- Group by: ☒ Category ☐ Template
- Name: Total Steam 24 hrs
- Description: 24h - Rolling Total Steam consumed
- Properties: <None>
- Categories: (empty)
- Default UOM: kilogram
- Value Type: Double
- Default Value: 0 kg
- Data Reference: PI Point
- Settings... button
- Footer text: |Steam Inlet;TimeMethod=TimeRangeOverride;RelativeTime=-24h;TimeRangeMethod=Total;UOM=kg;RateConversion=hour

PI Point Data Reference Dialog Box (Foreground):

- Data server: %Server%
- ☐ Tag name: (empty)
- ☐ Tag Creation
- ☒ Attribute: Steam Inlet
- Unit of Measure: Source Units: kg / hour
- Value retrieval methods:
 - By Time: Time Range Override
 - Relative time: -24h
 - By Time Range: Total
 - Calculation basis: Time Weighted
 - Min percent good: 80
- ☒ Read only
- OK and Cancel buttons

Lesson 5: Expression Syntax

[Video: Explore Analysis Syntax and Create an Expression Analysis](#)

The *expression analysis* allows you to create and schedule calculations using the Performance Equation (PE) syntax and a broad gallery of functions. Before discussing expression analysis in detail, it is essential to review the syntax for expression analysis, also referred as Performance Equation (PE) syntax.

Syntax for Expression Analysis (PE Syntax)

The syntax for expression analysis is an algebraic syntax used to perform calculations and filter data in multiple client and server products from the PI System suite. Besides Analysis Service, the following products use this syntax:

- Data Archive through Performance Equation points.
- PI ProcessBook through a PI Calculation dataset.
- PI Datalink through use of Filter Expressions or PI Expressions.
- Notifications through use of a PI PE Trigger Condition.
- PI Vision Calculations

This syntax has three (3) rules when it comes to writing expressions:

1. AF Attributes or Data Archive tag names and time stamps are written enclosed in single quotes (''):

For example: 'Pressure', 'CDT158', '*-1h', '03-Feb-2013 13:38'
2. Text (strings) or digital states are written enclosed in double quotes (""):

For example: "This is a comment.", "OFF", "Active", etc.
3. Mathematical operators and PE functions are written as is.

For example: +, -, *, ^, TagTot(), FindGT(), etc.

The expression functions reference guide is available under the PSE help menu.

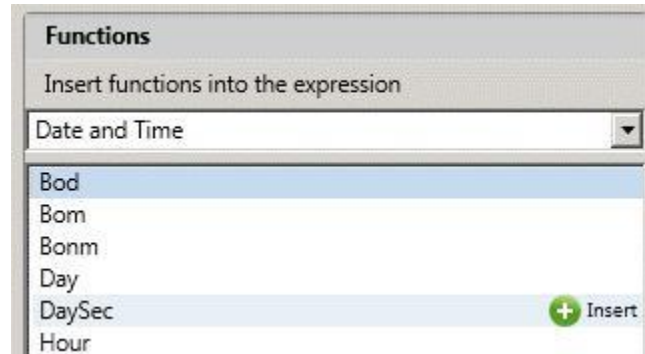
Tips for Working with Expressions

Here are some tips concerning entry of expressions:

- **Tip1:** Auto completion (aka. IntelliSense) is available to assist you with the syntax.
- **Tip2:** If you enter something that is syntactically incorrect, a curly underline will occur:

```
TimeEq('Press Status','t','*', "Running")/DaySec('*')100
```

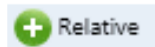
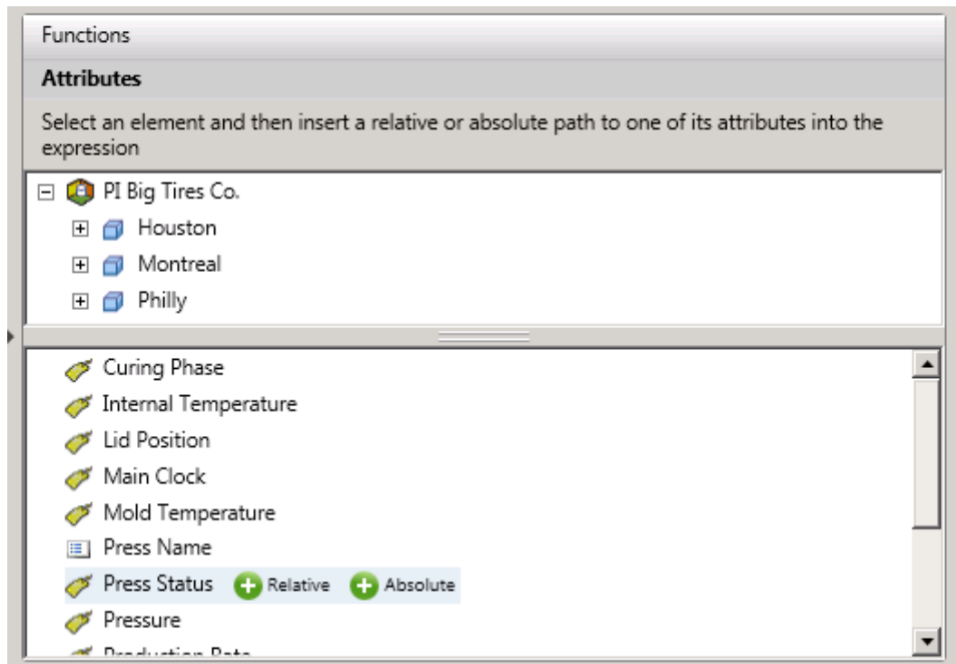
- **Tip3:** If you click on *Functions* in the right hand side, the pane will list all available functions. The drop-down on the top allow to filter function groups (e.g. *Date and Time*). Select a function and click on the green plus icon to add it into the expression (you don't have to type it).



- **Tip4:** You can add comments to explain what you are doing. Comments start with two forward slashes (//). To start a new line use Shift-Enter.

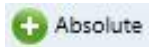
Name	Expression
Availability	<pre>// Is the ratio between the time the press is running // and the full time it is supposed to operate. // The press is supposed to run all time Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")</pre>

- **Tip5:** If you click on *Attributes* in the right hand side, the pane will list all available attributes. The upper part allows to navigate in the asset tree. Select an attribute and click on either one of the green Plus icons to add it into the expression (you don't have to type it)



Insert Relative:

The attribute is inserted without the path in the element tree. This refers to the attribute in its actual element context.



Insert Absolute:

The attribute is inserted along with the absolute element path. This refers to the attribute in the specified element path.

You can pick attributes from other elements by navigating in the asset tree shown above. An example for use of an absolute path is when the attribute has a general meaning, e.g. the outside air temperature at a location:

'\Houston|OutsideAirTemperature'

Knowledge Check: Expression Analyses Syntax

Each of the following expressions has a mistake in the syntax. Identify the mistake and write out the correct analysis syntax. (Hint: test it in PI System Explorer):

Question #1

Goal: If Attribute1 value multiplied by 50 is greater than a threshold of 200 then output 1. If it is less or equal 200 then output 0.

Expression: "If" 'Attribute1'*50 > 200 "THEN" 1 "Else" 0

Question#2

Goal: Output the addition of 2 attribute values

Expression: Attribute1 + Attribute2

Question #3

Goal: Provide a rolling sum of an attribute's values that have come in over the last 10 minutes

Expression: TagTot('Attribute1',*-10m,*)

Question #4

Goal: Output the number 4 if Attribute1 shows a value of ON, otherwise output 0

Expression: If 'Attribute1' = ON then 4 else 0

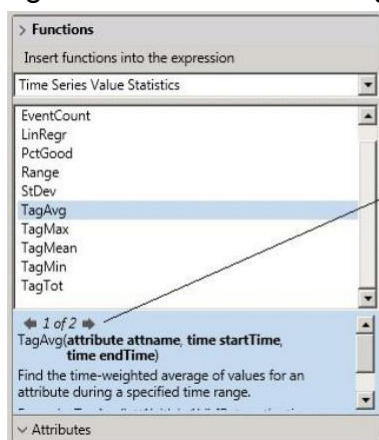
Solution: Expression Analyses Syntax

- 1) Corrected: `If 'Attribute1' * 50 > 200 Then 1 Else 0`
Reason: No double quotes around if, then, else
- 2) Corrected: `'Attribute1' + 'Attribute2'`
Reason: Attributes require single quotes
- 3) Corrected: `TagTot('Attribute1', '*-10m', '*')`
Reason: Time inputs require single quotes
- 4) Corrected: `If 'Attribute1' = "ON" then 4 else 0`
Reason: Strings require double quotes

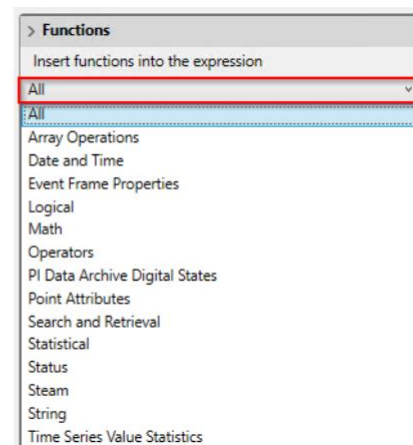
Video: [Use Different Functions for Analyses](#)

Expression analyses offer a library of functions which can be used to allow access to certain information (e.g. from the Data Archive) and complex calculations. Information about analysis expression functions can be found at:

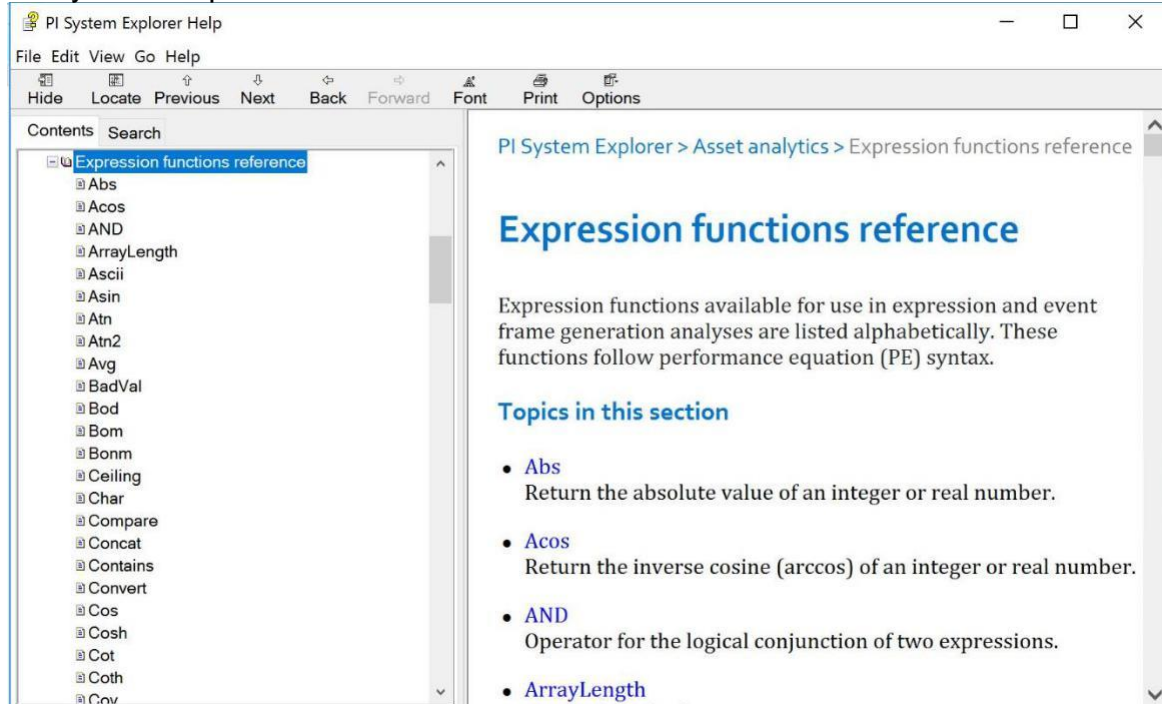
1. **Analyses tab (Elements and Element Templates):** Select the Analyses tab and create a new analysis if there are not any created yet. Expression Functions are listed alphabetically at the right-hand side. Use the drop-down for segregation according to functionality. This is helpful when the name of a function is unknown or to familiarize with the options within one category. See the screenshot on the right for the available categories.



For some functions, click on right/left arrow to display alternative parameter lists.



2. **PI System Explorer Help:** Help > Help Topics > (Verify tab is Contents) Asset Analytics > Expression Functions Reference



3. OSIsoft Documentation: PI Server > Asset Analytics and Notifications > Asset Analytics > [Expression Functions Reference](#)
4. [myOSIsoft portal](#) > PI System Explorer User Guide > Asset Analytics > [Expression Functions Reference](#)

Knowledge Check: Exploring Expression Analysis Functions

Question#1:

Go to the Expressions Functions Reference Guide in PI System Explorer (PSE Help> Help Topics> Asset Analytics> Expressions Functions Reference). Research a few functions that you have not used or heard of before, and see if you can find the relevant functions for the following situations. Spend a view minutes coming up with potential expressions.

- 1) This function will make my calculation NOT write a result.
- 2) This function will return the timestamp for the start of the month from a given time expression.
- 3) This function will return the maximum value of an attribute or tag over a specified time range.

Solution: Exploring Expression Analysis Functions

- 1) This function will make my calculation NOT write a result.

NoOutput()

- 2) This function will return the timestamp for the start of the month from a given time expression.

BOM

- 3) This function will return the maximum value of an attribute or tag over a specified time range.

TagMax

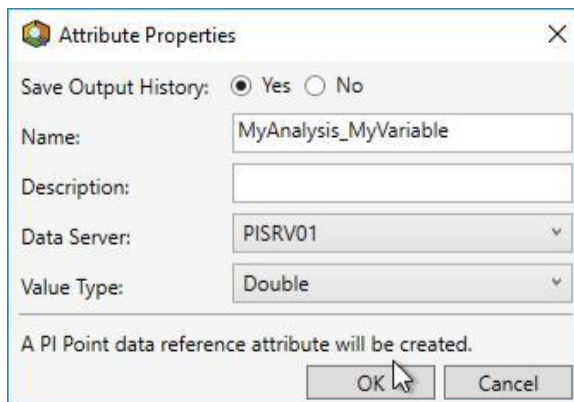
Lesson 6: Creating Expression Analyses

Video: [Map Outputs of Analyses to Attributes](#)

Two options for outputting results to attributes

The output of an expression can be mapped to either an existing or a new attribute. To map it to an existing attribute click *Map* and select the corresponding attribute. If the output should be mapped to a new attribute, a decision must be made if the output history should be saved or not. Depending on the selection for "*Save output history*" the system will create the corresponding type of attribute:

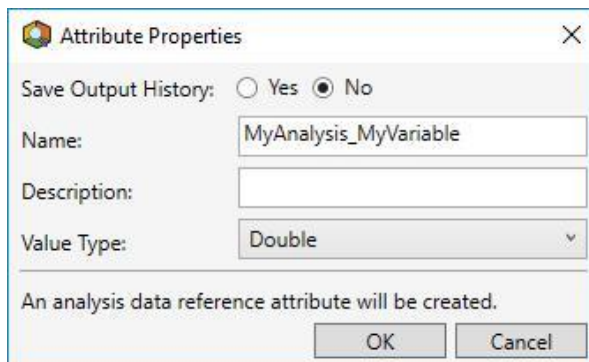
- **Yes:** An attribute with a PI point data reference and the corresponding PI point on the Data Archive are created.



The dialog box titled "Attribute Properties" has a close button (X) in the top right corner. It contains the following fields and controls:

- Save Output History:** Radio buttons for "Yes" (selected) and "No".
- Name:** Text box containing "MyAnalysis_MyVariable".
- Description:** Empty text box.
- Data Server:** Dropdown menu showing "PISRV01".
- Value Type:** Dropdown menu showing "Double".
- Status:** A message at the bottom states "A PI Point data reference attribute will be created."
- Buttons:** "OK" and "Cancel" buttons at the bottom right.

- **No:** An attribute with an Analysis data reference is created. Note that the Analysis data reference type is set automatically by the system and cannot be set manually. Analyses configured in this way are only calculated when the data for the attribute is requested by a client.



The dialog box titled "Attribute Properties" has a close button (X) in the top right corner. It contains the following fields and controls:

- Save Output History:** Radio buttons for "Yes" and "No" (selected).
- Name:** Text box containing "MyAnalysis_MyVariable".
- Description:** Empty text box.
- Value Type:** Dropdown menu showing "Double".
- Status:** A message at the bottom states "An analysis data reference attribute will be created."
- Buttons:** "OK" and "Cancel" buttons at the bottom right.

The default name for the attribute is assembled by the name of the analysis and the variable name and can be changed in the dialog box manually.

Analysis Data Reference

For a detailed discussion of the Analysis Data Reference see [KB - The Analysis Data Reference: Use Case, Configuration and Caveats](#). In particular take note of the following points:

- Avoid outputting to attributes with a Data Reference set to *None*. AF 2015 and newer automatically assigns an Analysis Data Reference when the output attribute is created from the Analyses configuration tab as shown in the video and described in the article. Using *None* Data Reference attributes can compromise the performance of the backend SQL Server since this setting causes changes in value to be written to an SQL table.
- Not all functions are supported for outputting to Analysis Data References. See the article for a list of functions with this limitation. Those functions can only be used with a PI Point as output.
- Some older client applications do not support Analysis Data References.
- The entire analysis must be evaluated *by the client* when a value of an attribute with an Analysis Data Reference is requested.

PI Point Data Reference

When output history is saved, a PI point is created using the default naming pattern *%Element%.%Attribute%.%ID%*. The PI point gets created automatically when the analysis is started (usually when the changes are checked in, unless the analysis is disabled). If the name of the PI point should be changed from the default, this can be done in the PI Point Data Reference settings of the attribute before starting up the analysis.

PI Point Data Reference

Data server: PISRV01

☒ Tag name: %Element%. %Attribute%. %ID%

☐ Attribute:

Unit of Measure

Source Units: <None>

Value retrieval methods

By Time: Automatic

Relative time:

By Time Range: End Time

Calculation basis: Time Weighted

Min percent good: 80

☒ Read only

OK Cancel

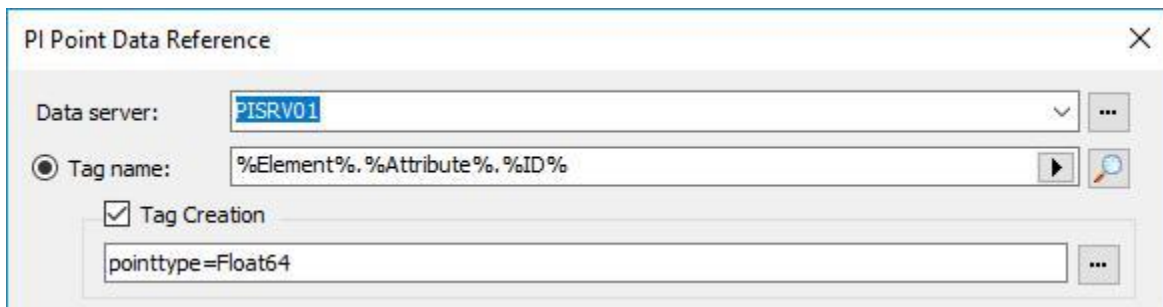
Special considerations when working with Templates

While a new analysis can be created for an individual template-based element, restrictions apply when mapping the output. This means that a new attribute for mapping the output can only be created for an individual element if extensions are allowed for the template.

This being said, instead of allowing extensions the preferred method would be to convert the analysis to template and create output attributes on the template level. If the analysis should not be applied to all elements of a template consider splitting those which have the analysis into a derived template.

General remarks on creating PI Points out of AF

When working with templates, the PI Point Data Reference can be set to automatically create tags on the Data Archive. This is set automatically when an attribute (for which output history should be saved) is created through the Analyses tab. For attributes which are created through different means this can be set manually.



PI Point Data Reference

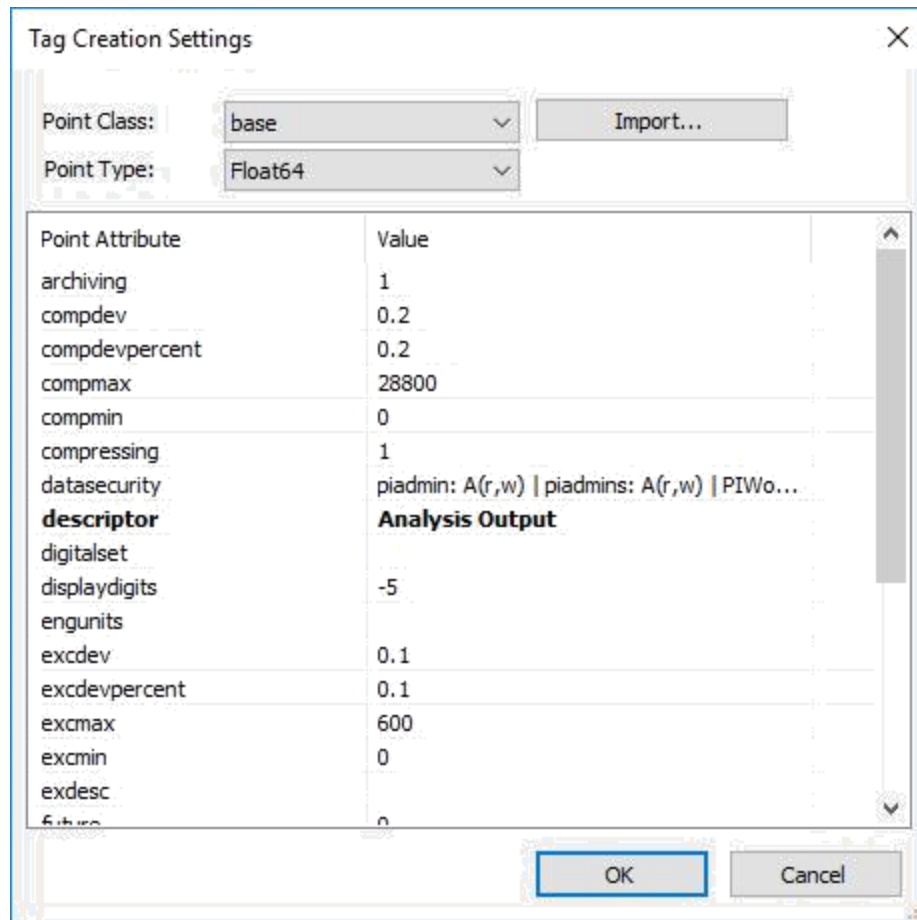
Data server: PISRV01

Tag name: %Element%.%Attribute%.%ID%

☒ Tag Creation

pointtype=Float64

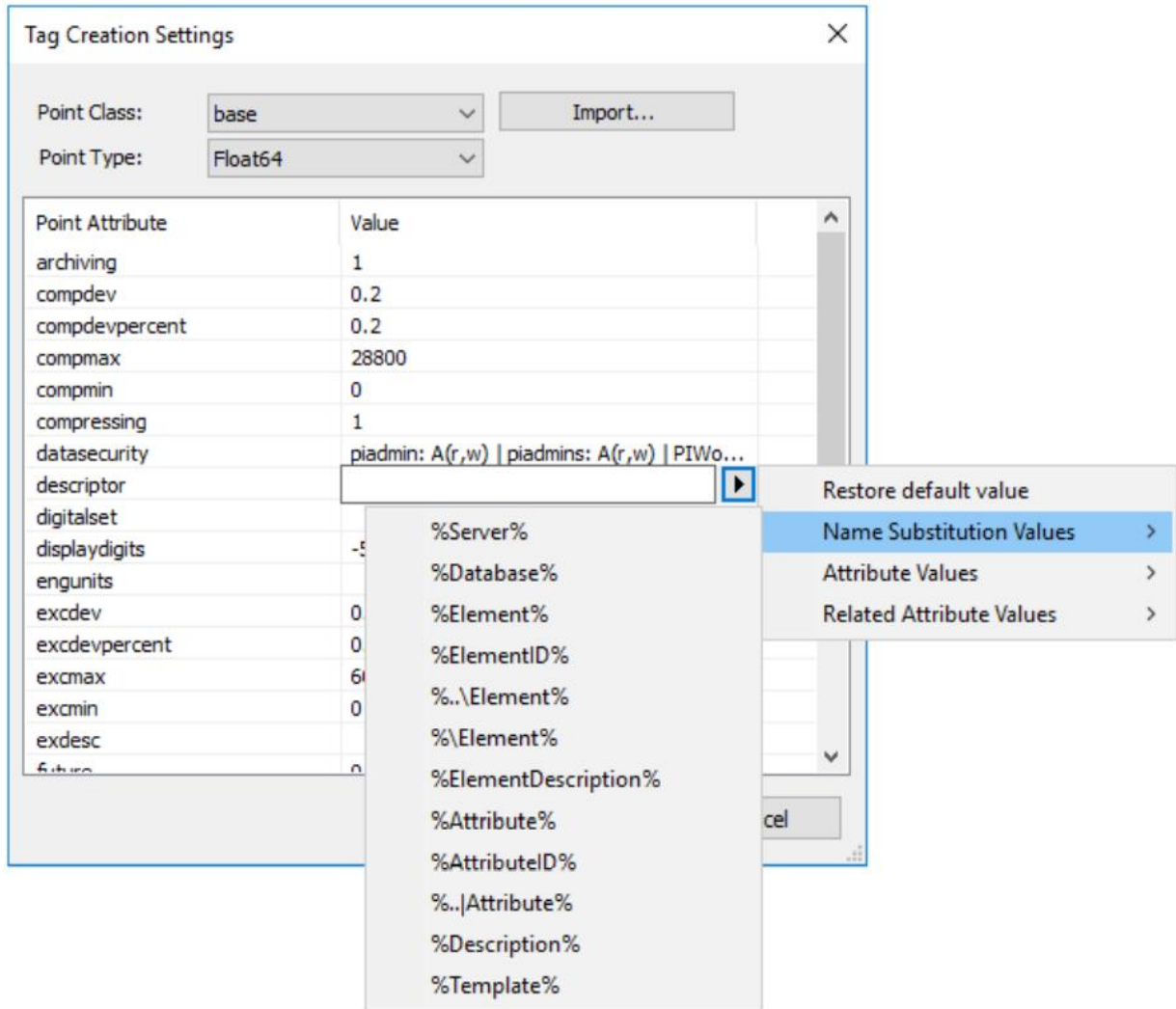
When automatic tag creation is enabled, you can use substitution parameters to name the points. **%Element%.%Attribute%.%ID%** is the default for asset analytics output points (we will show in a later lesson how the default setting can be changed). With the ellipsis button the settings for other PI point properties can be accessed and changed. Changes to the default values are highlighted in bold.



The image shows a 'Tag Creation Settings' dialog box. At the top, there are two dropdown menus: 'Point Class' set to 'base' and 'Point Type' set to 'Float64'. To the right of these is an 'Import...' button. Below these is a table with two columns: 'Point Attribute' and 'Value'. The table contains several rows of attributes and their corresponding values. One row, 'descriptor', has a value that is a substitution parameter: 'piadmin: A(r,w) | piadmins: A(r,w) | PIWo...'. Below this row, the text 'Analysis Output' is visible. At the bottom of the dialog are 'OK' and 'Cancel' buttons.

Point Attribute	Value
archiving	1
compdev	0.2
compdevpercent	0.2
compmax	28800
compmin	0
compressing	1
datasecurity	piadmin: A(r,w) piadmins: A(r,w) PIWo...
descriptor	Analysis Output
digitalset	
displaydigits	-5
engunits	
excdev	0.1
excdevpercent	0.1
excmax	600
excmin	0
exdesc	
future	0

Substitution parameters can be used to dynamically use the element context etc. for the point attribute.



Knowledge Check: Create Analyses to Calculate OEE Metrics

Now it's your turn to configure a few expression-type analyses for your process. You can complete this exercise by using the "**PI Big Tires Company**" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can create an OEE calculation on your own processes.

Problem Description:

As a consultant for a tire manufacturing company, PI Big Tires Co., you help create a smarter AF structure; your client wants to have more insight on his operations by taking advantage of the calculation and analytics features provided by the PI System. The tire curing presses are an essential part of the production process and currently, there is a lack of key performance metrics; your client wants you to start working on this section of the factory.

The goal is to find your daily Overall Equipment Effectiveness (OEE) metric for the presses at the company. The time frame for these calculations should be from today at midnight ('T' in PI time) until now ('*' in PI Time). Here is the definition for each part of the OEE metrics:

Metric	Description	Formula
<i>Availability</i>	Percentage of time that an equipment is up and running	Operating Time / Planned Production Time
<i>Performance</i>	Actual yield to the target yield	Total pieces / Target
<i>Quality</i>	Percentage of good units that are produced	Good pieces / Total Pieces
<i>OEE</i>	<i>Availability*Performance*Quality</i>	

On the **HOU.Press.01** (under the Houston element) configure an analysis called OEE that uses 4 variables (Availability, Performance, Quality, OEE) to calculate your daily OEE metric.

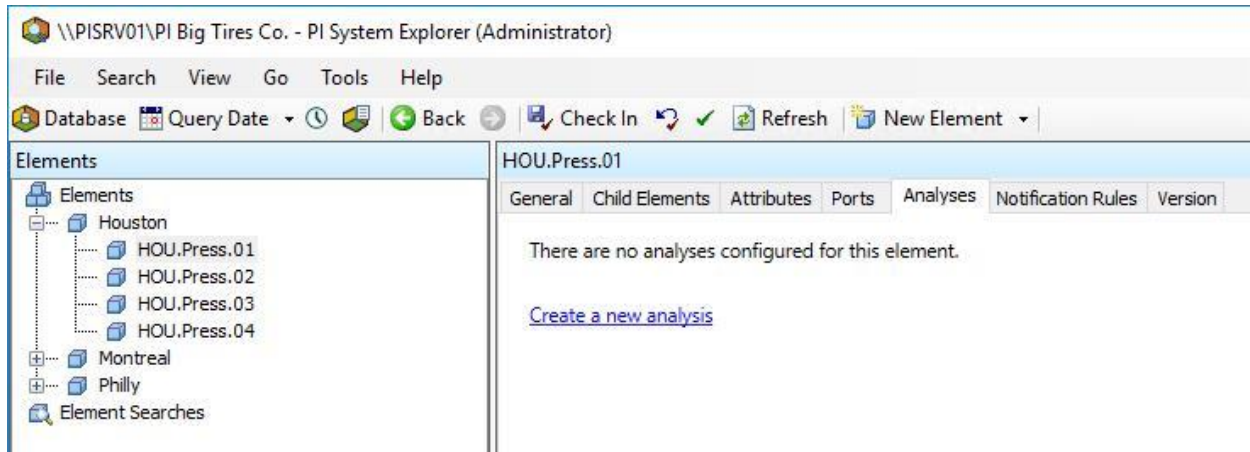
- Hint for Availability: The press is considered to be operating when the **Press Status** attribute has the value of "**Running**", and the planned production time is all day, every day.
- Hint for Performance: Total pieces are only the Good tires produced and the **Production Target** attribute designates the target value.

Note: Since the HOU.Press.01 is based on a template which does not allow extensions we won't be able to create new attributes on the element level to map the output. We will turn the analysis into a template and map the output once we learned about templated analyses in one of the next sections. In general, it is recommended to configure the analyses directly at the template level.

Solution: Create Analyses to Calculate OEE Metrics

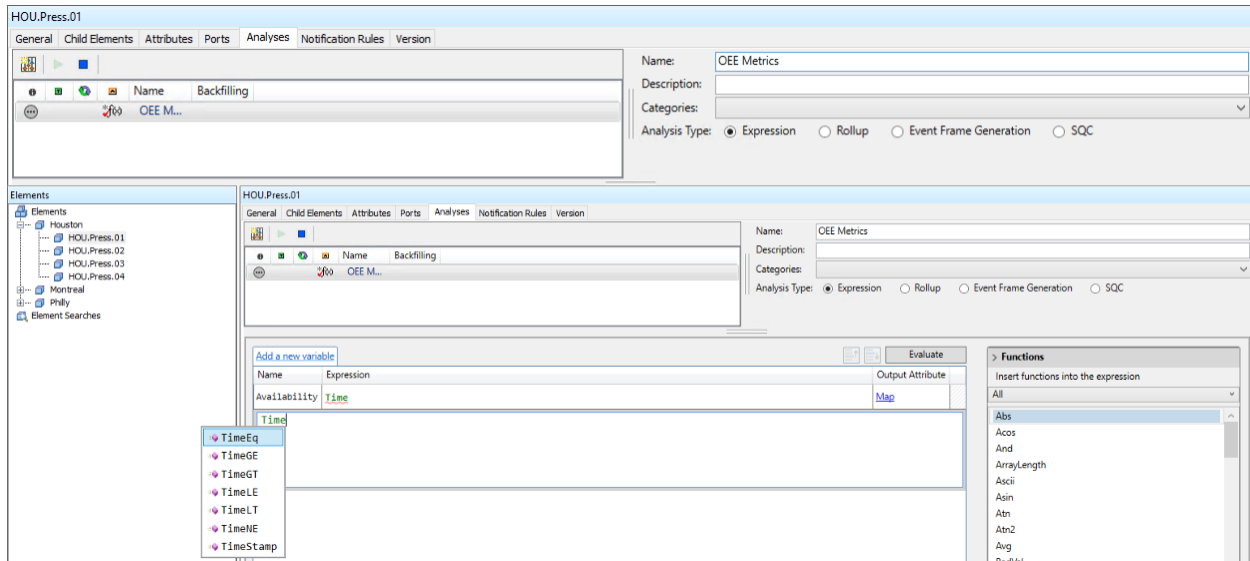
In this solution we will go through the required steps and give some tips on how to enter the expressions. If you are already experienced with expression analyses and are looking to compare the complete configuration directly, please scroll to the bottom of the page.

Navigate to the element HOU.Press.01 and open the Analyses tab. Click on *Create a new analysis*.

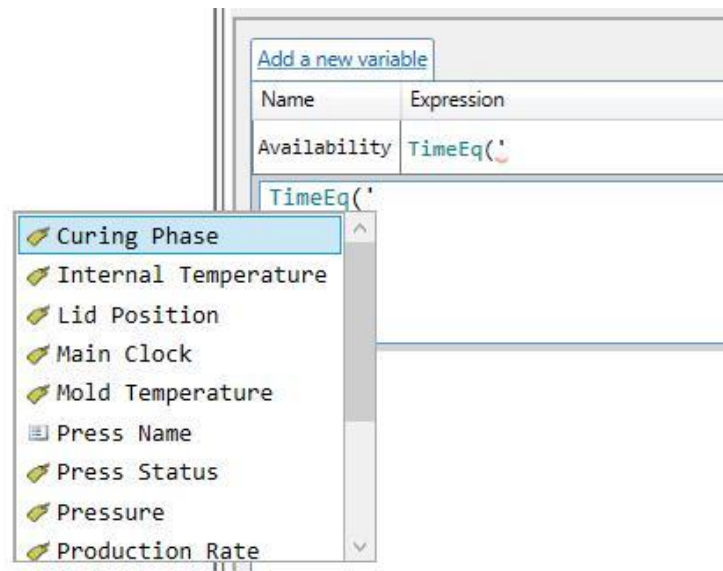


As a name for the analysis enter *OEE Metrics*. Change the name for the first variable to Availability and click in the expression field to type in the calculation for the press availability.

Since we are looking for Operating Time / Planned Production Time, we need to calculate the amount of time during each day the press was in the running state. We can use the TimeEq function for this: `TimeEq('Press Status','t','*', "Running")`. Notice when you start typing that all available options which are matching the first characters which have been entered are presented. You can select TimeEq from the list and press the tab key or type in the complete name manually. Note that another option is to select the function from the Functions menu on the right.



Tips: When you continue to enter the expression there will be more help provided by Intellisense. When entering a single quote after TimeEq(you will get a menu with all the element's attributes.



You will also notice the yellow info boxes giving hints regarding the syntax required for the specific function.

Add a new variable

Name	Expression
Availability	TimeEq('Press Status'

TimeEq('Press Status'

TimeEq(attribute attname, time startTime, time endTime, value x)
attname: attribute name enclosed in single quotes

To calculate the Planned Production Time which should be the whole day, we can use the function DaySec which gives the amount of seconds from midnight until given time. In our case we use the current time (*). The complete expression to calculate the availability is then TimeEq('Press Status','t','*', "Running")/DaySec('*'). You can test if the expression gives a sensible result by clicking the Evaluate button.

Add a new variable

Name	Expression	Value at Evaluation	Value at Last Trigg	Output Attribute
Availability	TimeEq('Press Status','t','*', "Running")/DaySec('*')	0.10218	0.10227	Map

Evaluate

It is good practice to assign units explicitly. We do this using the Convert function.

Add a new variable

Name	Expression	Value at Evaluation	Value at Last Trigg	Output Attribute
Availability	Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")	0.10203 ratio	0.10227 ratio	Map

Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")

Evaluate

We continue in the same way with the other calculations by clicking *Add a new variable* for each calculation.

HOU.Press.01

General Child Elements Attributes Ports Analyses Notification Rules Version

Name: OEE Metrics

Description:

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

Name	Expression	Value at Evaluation	Value at Last Trigger	Output Attribute
Availability	Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")	0.10499 ratio	0.10465 ratio	Map ⊗
Quality	Convert(('Tires Produced'-'Scrap Tires')/'Tires Produced', "ratio")	0.80952 ratio	0.80952 ratio	Map ⊗
Performance	Convert(('Tires Produced'/'(Production Target'*Hour('*')+Production Target'*Minute('*')/60)), "ratio")	0.64533 ratio	0.64533 ratio	Map ⊗
OEE Score	Convert(Availability*Quality*Performance, "ratio")	0.05485 ratio	0.054668 ratio	Map ⊗

Add a new variable

Evaluate

Note: A unit of measure called "ratio" was created in the database for this exercise. You may have an equivalent and correct answer without the conversion to the created units.

Best Practice: There are some options to make the calculations more robust and improve readability. The following screenshot provides an example how to avoid divisions by zero and how to distribute the calculation into more steps to achieve that.

Name	Expression
OperatingTime	// number of seconds since midnight when press was running <code>TimeEq('Press Status','t','*', "Running")</code>
PlannedProductionTime	// press should run all time, so get the seconds since midnight <code>DaySec('*')</code>
Availability	//calculate the ratio, avoid division by zero <code>If PlannedProductionTime=0 then 0 else Convert(OperatingTime/PlannedProductionTime,"ratio")</code>
GoodPieces	// subtract scrap from total number of produced tires <code>'Tires Produced'-'Scrap Tires'</code>
TotalPieces	// total number of tires <code>'Tires Produced'</code>
Quality	// calculate the ratio, avoid division by zero <code>IF TotalPieces=0 THEN 0 else Convert(GoodPieces/TotalPieces,"ratio")</code>
Target	// how many tires should have been produced since minutes? <code>'Production Target'*Hour('*')+ 'Production Target'*Minute('*')/60</code>
Performance	// calculate the ratio, avoid division by zero <code>if Target=0 then 0 else Convert(TotalPieces/Target,"ratio")</code>
Score	<code>Convert(Availability*Quality*Performance,"ratio")</code>

Video: Review Analysis Statuses, Scheduling, and Future Outputs

Scheduling

Two scheduling options are available: periodic and event-triggered.

- Event-triggered scheduling is event driven: the calculation is executed whenever one or multiple input attributes receive a new value. You get to choose which input attributes trigger the calculation.
- Periodic scheduling is clock-based and in the configuration window, you can specify a period and an offset from Midnight. When no offset is specified the evaluation is starting each day at Midnight. If the period is not divisible by 24 hours (for example 9 hours) the evaluation times are reset every day to the beginning of the day, so that the schedule would be 00:00, 09:00, 18:00 every day (see also [Analysis Scheduling](#)). Example evaluation times are listed in the window for guidance how the settings will take effect.

Testing an expression

Once the expression and the scheduling are defined, it is time to test it. The *Evaluate* button executes the expressions against values at evaluation (i.e. now) and against values at Last Trigger (in our case when the current minute has started). This will help you determine whether the results makes sense. When working from a template, you will have to click on *Example Element* before you can test the expression.

Example Element: [Houston\HOU.Press.01](#)

Name	Expression	Value at Evaluati	Value at Last Tri	Output Attribute	
Availability	<code>Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")</code>	0.40477 ratio	0.40434 ratio	OEE Availability	⊗

Another great way to validate your expression is to run it against archived values; we call this feature “preview results”. Right click the analysis name and select *Preview Results* (see screenshot below).

Tip: You can export the results table to a spreadsheet or you can copy selected rows from the results table into other applications.

The screenshot shows the PressTemplate application interface. On the left, the 'Analysis Templates' tab is active, displaying a list of templates. A right-click context menu is open over the 'OEE Metrics' template, with 'Preview Results' highlighted. The 'Preview results for OEE Metrics' dialog box is open on the right, showing a table of results.

Preview results for OEE Metrics

Start Time: *-15m Generate Results

End Time: * Export Results

Trigger Time	Availability	Press Status
1/6/2017 11:19:00 AM	0.47865	Press set-up
1/6/2017 11:20:00 AM	0.47794	Press set-up
1/6/2017 11:21:00 AM	0.47724	Press set-up
1/6/2017 11:22:00 AM	0.47654	Press set-up
1/6/2017 11:23:00 AM	0.47584	Press set-up
1/6/2017 11:24:00 AM	0.47515	No Operator
1/6/2017 11:25:00 AM	0.47445	No Operator
1/6/2017 11:26:00 AM	0.47376	No Operator
1/6/2017 11:27:00 AM	0.47307	No Operator
1/6/2017 11:28:00 AM	0.47238	No Operator
1/6/2017 11:29:00 AM	0.4717	No Operator
1/6/2017 11:30:00 AM	0.47101	No Operator
1/6/2017 11:31:00 AM	0.47033	No Operator
1/6/2017 11:32:00 AM	0.46965	No Operator
1/6/2017 11:33:00 AM	0.46898	No Operator

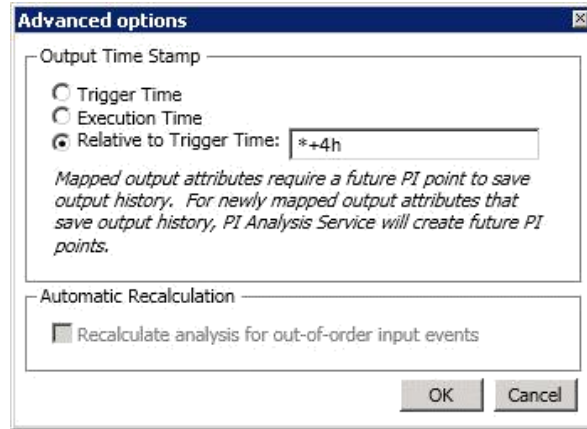
Please note that for both the Evaluate button and Preview Results the calculations are performed by PI System Explorer using the user account running this application and are using compressed archive data as inputs. Once the analysis is started the calculations are performed by the Analysis Service (with the permissions of the service account) using snapshot data. Due to these differences the results of the Evaluate and Preview options might differ from the real-time output of the analysis. More information can be found in [KB](#)

- [Asset Analytics "Evaluate" and "Preview Results" buttons show different results from real-time output.](#)

Advanced Scheduling Options

For any scheduled analysis, the default timestamp for output values is the trigger time. For periodic scheduling, the trigger time is the scheduled evaluation time, and for event-triggered scheduling, the trigger time is the time that a specified attribute changes values.

Using Advanced Options (available for Analysis Service 2015 and newer), you can specify the timestamp of analysis output values.



This can be used to write results with a timestamp in the future. The timestamp has to be defined relative to the trigger time. For more details on using this feature see [How do I create a Future/Forecast analysis in PI Asset Framework \(AF\)?](#) and for general information on future data in the PI System see [OSIsoft: How is Future Data Stored in PI System?](#).

Option	Behavior
Trigger Time	Default value. The clock time that a schedule specifies or that an input value changes.
Execution Time	The clock time at which the analysis calculates the value.
Relative to Trigger Time:	A time specified by a PI time expression. Enter a valid time expression, such as a time relative to the trigger time or a fixed time. A relative time in the future will create events with timestamp in the future. For mapped output points this requires a future PI point (available for Data Archive 2015).
Automatic Recalculation	In case you expect that data from your inputs will be late-arriving or be out-of-order, you can request automatic recalculation for an analysis. The Management list allows to set this option for multiple analyses within one command.

When can the *Relative to Trigger Time* option be useful?

You need a daily summary for the raw material consumption in the plant for 24 hour periods (yesterday midnight – midnight today). Asset Analytics is used to calculate the sum. However, due to the operation in the plant it is not possible to have all the required input data ready with a delay of 10 - 15 minutes. With a scheduled daily execution at 12:15AM for the analysis the *Relative to Trigger*

Time option is set T (today midnight) so the output result gets stamped at midnight (even though the summary is done 15 minutes later).

Automatic Recalculation

Analysis Service 2017 R2 (2.9.5) introduces a new feature called automatic recalculation, which allows the analysis service to automatically recalculate analyses for data that is out-of-order or late-arriving. When enabled, automatic recalculation improves the data fidelity of the analysis calculations by re-evaluating calculations that may have been made with an incomplete dataset due to unreliable data stream. To learn more about how this works in detail see [Automatic Recalculation with the Analysis Service: Technical Details](#).

Impact of analysis scheduling on performance

When we set the scheduling on an analysis we should always also have performance in mind and consider how frequently we really need the result. It might be tempting to just evaluate as often as new input data is coming in (and that might be necessary in some cases where frequent updates are needed), but for many calculations a periodic schedule which evaluates less frequently will be sufficient.

Consider the following example:

The chief maintenance engineer wants to keep track of the **Availability Monthly Average** for the purpose of identifying which units have undergone the longest monthly downtime. He needs the results of this calculation twice a week for his meetings with the maintenance team. This analysis uses the function **TagAvg()** and spans over the last month of data. The analysis is set to trigger on a periodic basis with a **1-minute frequency!**

Why should we trigger the analysis every minute if the results are needed only twice a week? These 1-minute evaluations pose an unnecessary workload on the Analysis Service. The impact becomes even more significant when backfilling or recalculating the analysis over a long period of time, as the Analysis Service will have to perform many evaluations “in bulk”. For example, given a 1-minute frequency, backfilling over the last 6 months would yield 259 200 evaluations. If we set it to daily frequency, we go down to 180 evaluations for the same time span (less than 0.07% of the initial number of evaluations).

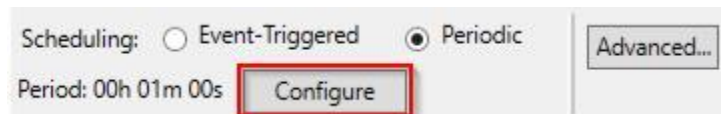
Knowledge Check: Configure OEE Calculation Schedule

Problem Description: Your coworkers want to see the results of your OEE analysis created in the last exercise, starting at midnight (12:00:00) each morning and updated every 5 minutes. Adjust your analysis to comply with your coworkers' requests.

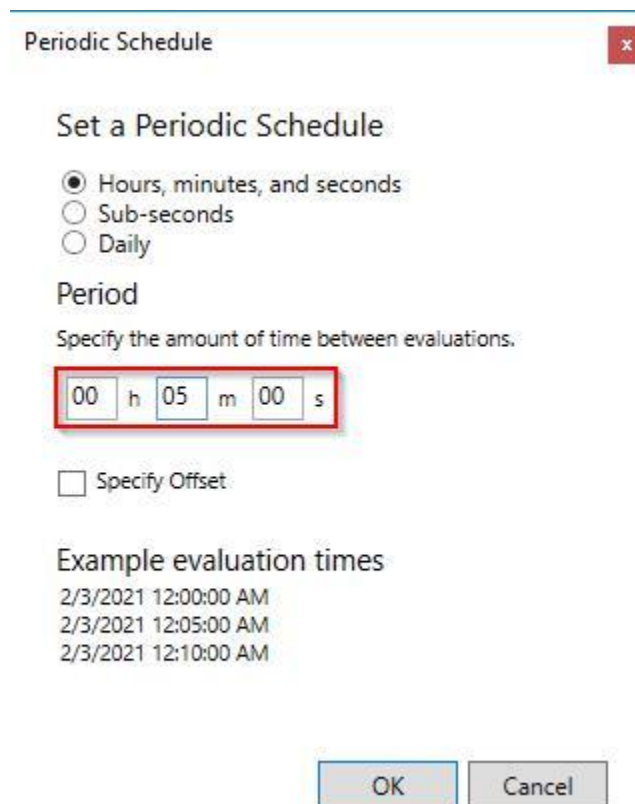
Note: You can complete this exercise by using the "PI Big Tires Company" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can model the exercise on your own processes.

Solution: Configure OEE Calculation Schedule

The objective of this exercise is to change the scheduling from **Event Triggered** to **Periodic**.



Then configure the period as shown below with a 5-minute frequency (no offset is required to make it start at midnight correctly).



Video: [Templatize Analytics](#)

When creating analyses for template-based elements, it is recommended to configure the analyses directly at the template level.

Note: To test an analysis template, an example element needs to be chosen to borrow attribute values for the evaluation.

In the next exercise we will convert the OEE Metrics analysis we created earlier for one press to a template, here we will discuss the steps for configuring the analysis directly at the template level.

As a walk-through example, be sure you are in the **PI Big Tires Co.** database, navigate to Library → Templates → Element Templates → open the Press Template and click on the *Analysis Templates* tab. In this window (see figure below) you will be able to set up analyses that will be automatically created when a new instance of the corresponding element is added to the AF structure.

First, click on 'Create a new analysis template', then enter a name and a meaningful description for the analysis (e.g OEE Metrics), and then select the expression analysis type using the radio buttons.

PressTemplate			
General Attribute Templates Ports Analysis Templates Notification Rule Templates			
<table border="1"> <thead> <tr> <th>Name</th> </tr> </thead> <tbody> <tr> <td>fco OEE Metrics</td> </tr> </tbody> </table>	Name	fco OEE Metrics	Name: OEE Metrics Description: OEE Metrics for Curing Press Categories: Analysis Type: <input checked="" type="radio"/> Expression <input type="radio"/> Rollup <input type="radio"/> Event Frame Generation <input type="radio"/> SQC <input checked="" type="checkbox"/> Enable analyses when created from template
Name			
fco OEE Metrics			

Note: We have selected to enable the analysis right-away when it is created from the template. Uncheck the option if you are not confident that your analysis does the right calculation. The analyses can be started at a later time for the related elements

Knowledge Check: Apply the OEE Calculation to Multiple Assets

Problem Description:

Now that your coworkers have seen the analysis you started to set up on the HOU.Press.01, you are getting requests to roll it out for every press. Go ahead and add the OEE Metrics analysis to all of your other presses.

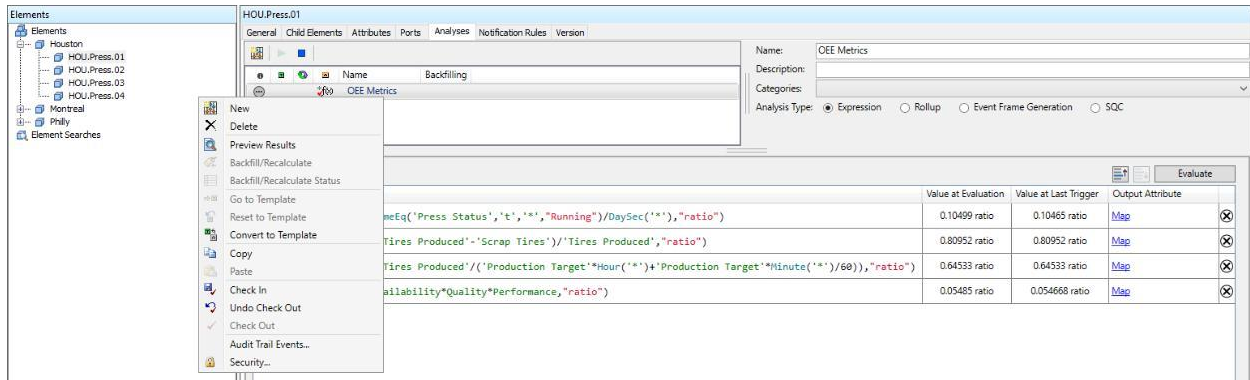
Approach:

Convert the analysis you have set up for HOU.Press.01 to a template and map the output of all variables to attributes with PI Point DR.

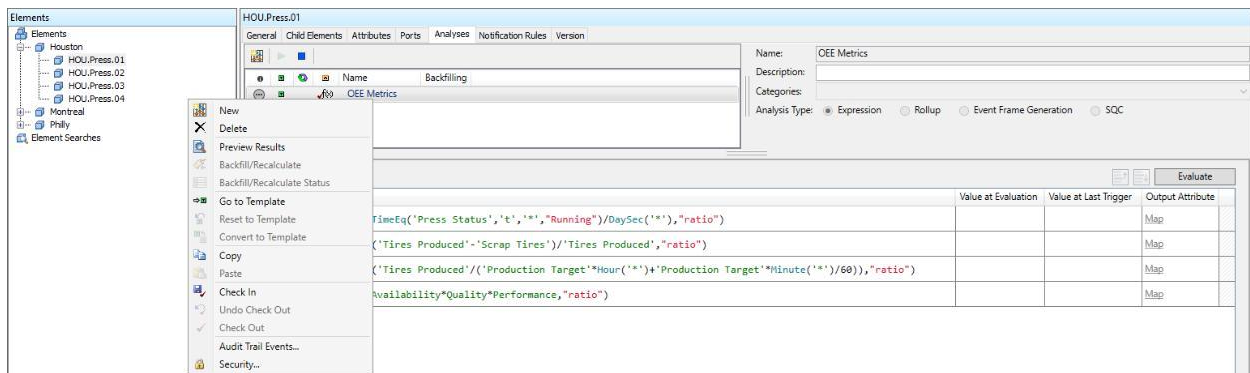
Note: You can complete this exercise by using the "**PI Big Tires Company**" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can model the exercise on your own processes.

Solution: Apply the OEE Calculation to Multiple Assets

Right click on your OEE Metrics analysis and select “Convert to Template”.



Since we still need to map the output to attributes, we need to go to the template to continue the configuration. The quick way to navigate there is to use the right-click menu again and select “Go to Template”.



For the template we can click *Map* in the Output Attribute column for each of the variables and click *New Attribute Template* to create a new attribute template for each.

PressTemplate

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: OEE Metrics

Description:

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

☒ Enable analyses when created from template

Example Element: [Houston\HOU.Press.02](#)

Add a new variable

Name	Expression	Output Attribute
Availability	<code>Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")</code>	Map
Quality	<code>Convert(('Tires Produced'-'Scrap Tires')/'Tires Produced', "ratio")</code>	New Attribute Template
Performance	<code>Convert(('Tires Produced'/'Production Target'*Hour('*')+'Production Target'*Minute('*')/60), "ratio")</code>	Curing Phase
OEE Score	<code>Convert(Availability*Quality*Performance, "ratio")</code>	Internal Temperature

Map

New Attribute Template

- Curing Phase
- Internal Temperature
- Lid Position
- Main Clock
- Mold Temperature
- Press Name
- Press Status
- Pressure
- Production Rate
- Production Target
- Reference Type
- Scrap Tires
- Steam Inlet
- Tires Produced

For the variable Availability we name the attribute OEE Availability and leave the other settings as default since we want to save the output history and use a value type of double for the PI Point.

Attribute Template Properties

Save Output History: ☒ Yes ☐ No

Name:

Description:

Data Server:

Value Type:

A PI Point data reference attribute template will be created.

OK Cancel

Analogously, we map the output for all four variables.

PressTemplate

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: OEE Metrics

Description:

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

☒ Enable analyses when created from template

Example Element: [Houston\HOU.Press.02](#)

Add a new variable

Name	Expression	Output Attribute	
Availability	Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")	OEE Availability	⊗
Quality	Convert(('Tires Produced'-'Scrap Tires')/'Tires Produced', "ratio")	OEE Quality	⊗
Performance	Convert(('Tires Produced'/'Production Target'*Hour('*')+Production Target*Minute('*')/60), "ratio")	OEE Performance	⊗
OEE Score	Convert(Availability*Quality*Performance, "ratio")	OEE Score	⊗

Evaluate

Check-in the change and verify the other presses picked up the analysis and the output attributes were created and are getting values.

Optional: Using Expression Functions for Advanced Applications

Analyze Asset Performance using a Correlation of Parameters

In many applications it is not sufficient to view parameters individually to evaluate if a piece of equipment is performing well. Instead, the correlation of two (or more) parameters has to be monitored and compared to a function of these parameters which describes optimal behavior.

As an example, we will be looking into the expected power produced by a wind turbine in dependence of the wind speed. Within AF we can think of different methods for reflecting this expected power curve:

- A AF Table look-up – allows the input of the power curve wind speed and corresponding active power to be input into a table which can be manually entered, copied from Excel and pasted into AF, or accessed via a link. Values in between the listed points are derived through linear interpolation.
- The CURVE function – allows the use of multiple (x,y) points to accurately define the power curve. This is essentially the analytics equivalent of using an AF table as it is also using linear interpolation between the listed values.
- The power curve analytic equation – The power curve can be represented by a polynomial equation with the wind speed. This equation takes a few minutes of effort up from to be developed if it is not known but combining it with some simple IF/Then logic to confine the power curve calculation to the points when the turbine should be online or at full power capacity, can result in the power curve evaluations being done very quickly.

Here we focus specifically on Wind Assets as the example. Below are a few other examples of variables involved in calculating efficiency in other assets. Many manufacturers provide metrics for expected efficiency of their assets. These metrics typically define how the relationship between different variables should correlate (on an XY-plot).

- Centrifugal Pump: Head and Flow
 - Centrifugal Pressure: Differential Pressure or Brake Power and Flow
 - Cake Filtration: Flow Rate and Pressure Drop
 - Transformer Tap Changer: Tap Position and Voltage Ratio
 - PV Solar Output: Incident Luminance and Power
 - Separation Columns (Distillation/Absorption/Stripping): Column Pressure Drop and Liquid/Vapor Flow
 - Gas Turbine: Thermal Efficiency and Turbine Inlet Temperature
 - Any Asset: Energy Loss
-

In the following we briefly show implementation examples. These can be found in the **“Wind Farm”** AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1.

Use a Table Lookup Data Reference to Model the Power Curve

A Table Lookup Data Reference can also be used when there is no direct match with the values in the table. Instead a linear interpolation between the values can be used. In our example database the correlation between Wind Speed and Potential Power is provided through the table PowerCurve (see below) which can be found in the Tables section of the Library.

PowerCurve		
General Table Define Table Version		
PowerCurve		
Filter		
	Wind Speed	Potential Power
▶	0	0
	4	78
	5	193
	6	358
	7	589
	8	898
	9	1289
	10	1732
	11	2172
	12	2573
	13	2856
	14	2971
	15	2996
	16	3000
	17	3000
	18	3000
	19	3000
	25	3000
	26	0
	100	0
*		

The elements built from the Turbine template are using the attribute Expected Power (Tabular) to interpolate between the table values to find the Expected Power corresponding to the attribute Adjusted Wind Speed. The configuration can be seen below:

Table Lookup Data Reference

Table: PowerCurve

Result column: Potential Power

Unit of Measure: kW

Behavior

Rule: Select first row matching criteria

Order by: <None> ASC

Where

Column: Wind Speed Operator: INTERPOLATE Attribute or Value: Adjusted Wind Speed

Add And

Add Or

Complete WHERE Clause:

INTERPOLATE([Wind Speed], @[Adjusted Wind Speed;UOM=m/s])

Table Parameters

Parameter	Value
-----------	-------

Replacement Values

Value to return when no matching row found: No Data

Value to return when NULL result found: DBNull

OK Cancel

Use the Curve Function to Model the Power Curve

Alternatively, we can use an analysis to perform this interpolation. In our example database this is realized in the analysis *Expected Power (Curve Function)*:

Variable	Expression
----------	------------

ExpectedPower	<pre>// Using data points of wind speed vs power, use curve function to return an Expected Power for a given Wind Speed. Convert function explicitly assigns UOM to calculation results. // Convert(Curve('Adjusted Wind Speed', (0,0) (3.99,0) (4,78) (5,193) (6,358) (7,589) (8,898) (9,1289) (10,1732) (11,2172) (13,2573) (14,2971) (15,2996) (16,3000) (25,3000) (25.01,0) (100,0)), "kW")</pre>
---------------	--

The **Curve** function is useful when one has a set of data points describing a curve or line.



Tip

The Curve function calculates a best fit curve for a given set of data points (x,y pairs) provided. An x value is passed along with the data pairs and a corresponding y value is returned based on the curve fit. The syntax is as follows:

Curve(x, (x1,y1) (x2,y2) ... (xn,yn))

Use a Polynomial Fit to Model the Power Curve

A more accurate representation of the Power Curve can be achieved through a (high order) polynomial function. In this example we fit our curve to a 6th order polynomial, so our expression will use the following equation:

$$y = C_0 + C_1x + C_2x^2 + C_3x^3 + C_4x^4 + C_5x^5 + C_6x^6$$

where y is the Expected Power and x is the Adjusted Wind Speed.

In the Wind Farm database the analysis *Expected Power (Polynomial)* looks like this:

Variable	Expression
AdjustedWindSpeedVar	<code>TagVal('Adjusted Wind Speed')</code>
Polynomial	<pre>// Calculate Expected Power based on polynomial model of Power vs Wind Speed // 'Polynomial Coefficients C0'*AdjustedWindSpeedVar^0 + 'Polynomial Coefficients C1'*AdjustedWindSpeedVar^1 + 'Polynomial Coefficients C2'*AdjustedWindSpeedVar^2 + 'Polynomial Coefficients C3'*AdjustedWindSpeedVar^3 + 'Polynomial Coefficients C4'*AdjustedWindSpeedVar^4 + 'Polynomial Coefficients C5'*AdjustedWindSpeedVar^5 + 'Polynomial Coefficients C6'*AdjustedWindSpeedVar^6</pre>
Output	<pre>//The calculated Expected Power is only valid in a range. At low end and high end of range, fixed (low & high) values apply //</pre>

```

Convert( If AdjustedWindSpeedVar< 'Polynomial Coefficients|LowWind_Limit'
      then 'Polynomial Coefficients|LowWind_Power'
    else if AdjustedWindSpeedVar>= 'Polynomial Coefficients|LowWind_Limit'
    and AdjustedWindSpeedVar< 'Polynomial Coefficients|FullPower_Limit'
      then Polynomial
    else if AdjustedWindSpeedVar>= 'Polynomial Coefficients|FullPower_Limit'
    and AdjustedWindSpeedVar< 'Polynomial Coefficients|HighWind_Limit'
      then 'Polynomial Coefficients|FullPower_Power'
    else if AdjustedWindSpeedVar>= 'Polynomial Coefficients|HighWind_Limit'
      then 'Polynomial Coefficients|HighWind_Power'
    else 'Polynomial Coefficients|HighWind_Power' , "kW")

```

Another way to achieve the same is to use the Poly function instead of writing out the polynomial. In contrast to the previous version, the coefficients need to be entered as numbers in the Poly function and cannot be attributes. See below how the variable Polynomial looks like in the analysis Expected Power (Poly Function). The other variables are same as in the previous example.

Variable	Expression
Polynomial	<pre>// Calculate Expected Power based on polynomial model of Power vs Wind Speed // Poly(AdjustedWindSpeedVar, 2212.93122, -2039.7283, 742.05611, - 136.46349, 13.84902, -0.69895, 0.01358)</pre>



Best Practice

Adding **Var** (or similar) to the end of variables helps add clarity when referencing those variables.

When an attribute shares the name of the variable, it can be confusing to determine which the item in the expression is when the only difference is the quotes surrounding it.

Implementing Condition Based Maintenance

In the effort to shift maintenance cycles from a fixed schedule to a scheduling which takes the condition of the equipment into account, expression analyses can help in calculation the metrics to determine the right time for a maintenance

– to avoid unnecessary downtime either by scheduling the maintenance too early when it was not yet needed or having an equipment failure when the maintenance was not performed in time.

The approach usually takes into account the run time of the equipment since the last maintenance. In expression analyses this can be tracked using the **TimeEq** function if the running state is identified by a status. If there is no status attribute available, the activity might be identified by other measures like revolutions per minute in which case the **TimeGE** or **TimeGT** functions might

be of use. These functions can be also used to track extreme conditions which cause extra wear of the equipment.

Another metric can be the number of startups of the equipment as well as switch or valve actuations. These events can be counted through the **NumOfChanges** functions if there is an attribute for which a change of value/state directly indicates a switch to be tracked (like ON and OFF or equivalent). If a startup procedure goes through different stages there might be additional calculations needed.

Dynamically Reference Attributes through Analyses

Below, we present an example how to dynamically change input attributes within an expression. As suggested in the example, this might be useful to switch between different product types on a production line. This example is taken from [AF Analytics: How to construct an attribute reference and use its value in an equation.](#)

You can use an expression to dynamically reference other attributes.

	Name	Value	Time Stamp
	ProductType	Type2	12/15/2016 12:28:01.744 PM
	TargetTime	20	12/15/2016 12:28:06.46 PM
	Type1	10	1/1/1970 12:00:00 AM
	Type2	20	1/1/1970 12:00:00 AM
	Type3	30	1/1/1970 12:00:00 AM

For example, you can have the value of `TargetTime` be that of `Type1`, `Type2`, or `Type3`, depending on the value of `ProductType`.

Name	Expression	Value at Evaluation	Value at Last Trigg	Output Attribute
Type	<code>Concat("TargetTime ", 'ProductType')</code>	TargetTime Type2	TargetTime Type2	Map
OutputValue	<code>TagVal(TagNum(Type))</code>	20	20	TargetTime

Type: `Concat("TargetTime|", 'ProductType')`

OutputValue: `TagVal(TagNum(Type))`

The variable `Type` returns the name of the attribute, `TargetTime|Type2`, as a string. [TagNum\(\)](#) accepts the string and returns the PI Point ID of the PI Point that the attribute references. [TagVal\(\)](#) accepts the PI Point ID and a timestamp and returns the value of the PI Point at that timestamp.

Lesson 7: Configure Rollup Analyses

Video: [Create Rollup Analyses on Templates](#)

The rollup analysis allows you to perform aggregations or summary calculations based on attributes associated with an element. The power of rollup analyses lies in their ability to perform aggregations on an element's children.

As an example, you might need to calculate the total energy consumption for a group of motors in a paper mill. To do this, you create a rollup analysis on the parent element (the paper mill) that sums the energy consumption attributes from its child elements the motors.

When designing and building an AF hierarchy, the use of categories is going to pay off when you start using the rollup analysis type. This is because when configuring a rollup analysis, the attributes to be included in the calculation are selected by name or category.

Creating a roll-up analysis

When selecting the Rollup analysis type for a new analysis a list of all available attributes is displayed on the right pane. It is now necessary to select from that list the ones that will participate in the rollup calculation. You can narrow down your search by filtering by element category or template. You can then type-in the attribute name or category. The matching results will show a checkmark.



Best Practice

You can add or delete elements or attributes in your hierarchy without the need to update Rollup analyses. Because a Rollup identifies input attributes each time it is executed, it automatically includes any new attributes that meet its selection criteria.

Selecting the roll up function

After selecting the attributes for the rollup, it is time to specify the function or type of summary calculation the rollup analysis will run. There are six available summary functions:

- Sum
 - Average
 - Minimum
 - Maximum
 - Count
 - Median
-

Tip: You can select multiple functions in a rollup calculation, each one mapped to a specific output attribute.

Mapping the output to an attribute

Once the function is selected, you can map the output to an attribute. In case the output attribute does not exist yet, you will be prompted to create a new one.

Note that for Rollups you can only create attributes with PI Point DR (save output history = yes). Rollup outputs might cause performance issues if they were mapped to an Analysis DR attribute since the calculation would then need to be evaluated on the client side which can be problematic for calculations which require a lot of input data and are requested by many users as it is likely the case for many Rollups.

Scheduling the roll-up calculation

The same two scheduling options presented for the expression analysis type are available for rollups: event-triggered and periodic.

Tip: Before starting the analysis, it is a good idea to click on the evaluate button to preview the result. Furthermore, you can right-click on the analysis name and select *Preview Results*; this will show you a trend with the result of the calculation had it run for a previous period of time. These two actions will help you validate your rollup calculation.

Note: If the PI point of the output attribute is not created use *Create or Update PI Point* function from the attributes right-mouse button context menu.

Check the status of the calculation for any errors and validate that the output attribute is updating.

The video is using the following databases:

- Asset Based PI Example Kit for Power Generation Load Forecasting
- Asset Based PI Example Kit for Oil & Gas Well Downtime Tracking

See all of the available [Asset Based PI Example Kits](#).

Knowledge Check: Identify the Total Production Rate for Each Site

Problem Description:

The director of the production for the PI Big Tires Company has requested a total of all the **GOOD** tires produced at each site in the “PI Big Tires Company” database. To do so, you may first need to make a calculation to find the good tires produced from each press. Schedule your calculation to update every time a press at the site produces a new tire.

Hint: Making a template for your site may be the best way to go.

Note: You can complete this exercise by using the "**PI Big Tires Company**" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can model the exercise on your own processes.

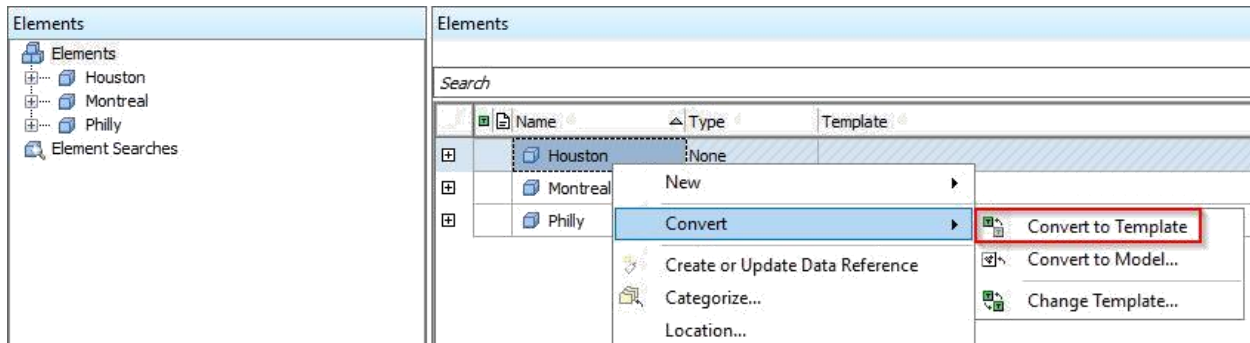
Solution: Identify the Total Production Rate for Each Site

We can complete the following steps in the **Library Pane** on the template level to ensure all of our presses receive the Good Tires attribute, and that each site receives the rollup analysis. To make this calculation with only **GOOD** tires, we should first configure an expression analysis or a Formula Data reference to subtract the **Scrap Tires** from the **Tires Produced** value for PressTemplate. We went through the configuration of the Good Tires attribute already in an earlier exercise. Below is the configuration again in case you skipped that exercise.

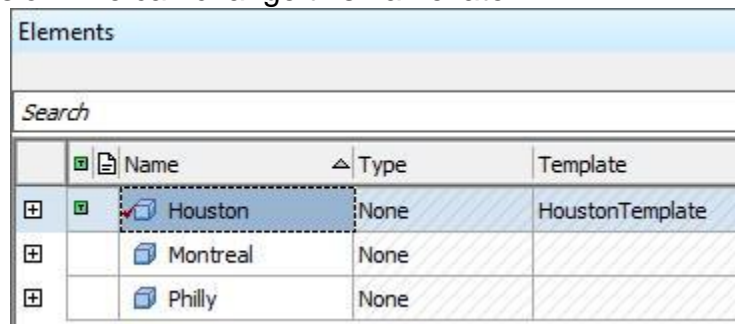
The screenshot shows the 'Formula Configuration:(Good Tires)' dialog box. It has two main sections: 'Parameters' and 'Equations'. The 'Parameters' section contains two entries: 'S=Scrap Tires;UOM=Tires' and 'T=Tires Produced;UOM=Tires'. The 'Equations' section contains one entry: 'T-S'. Below these sections is a 'Result' section with 'UOM:' set to 'Tires', and empty fields for 'Minimum:' and 'Maximum:'. There is a 'Stepped' checkbox and an 'Evaluate' button. At the bottom are 'OK' and 'Cancel' buttons.

Then we can set up a **Rollup Analysis** to do a **sum** of the **Good Tires** attribute that we created above. The easiest way to achieve this for all sites is to create a SiteTemplate first and configure the Rollup on the template level.

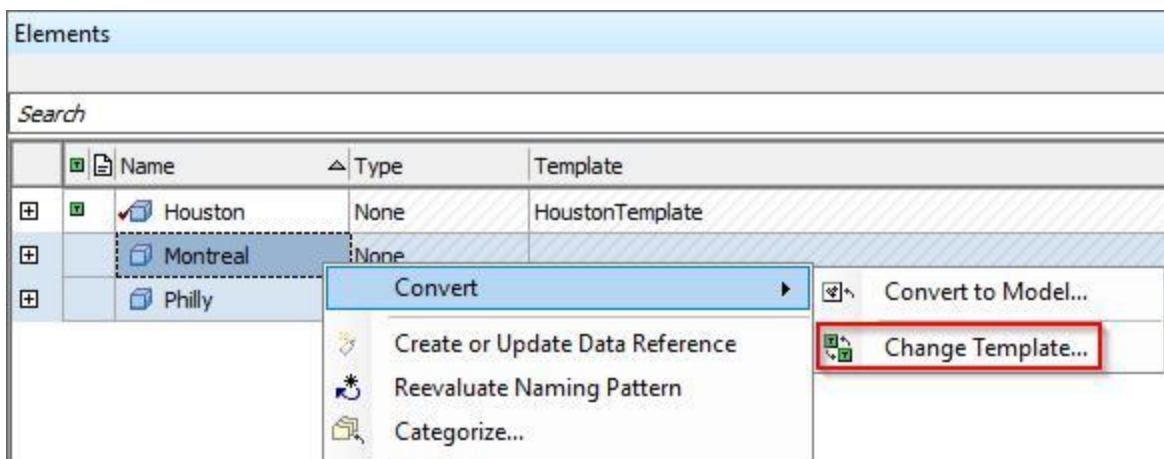
1. Click on Elements in the Browser on the left and right-click on any one of the sites (Houston, Montreal or Philly). Select Convert > Convert to Template.



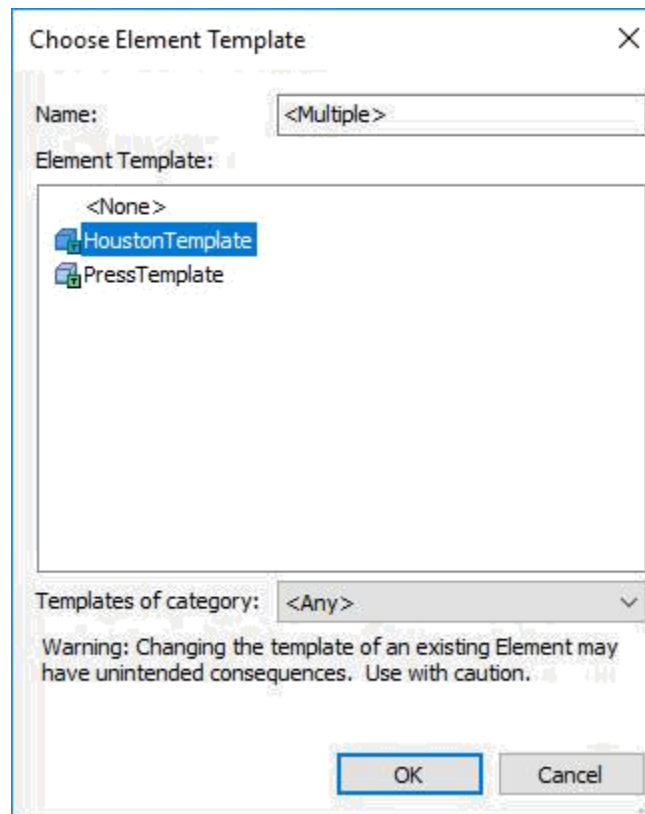
- The newly created template will be named after the element that was used for the conversion. We can change this name later.



- Select the two sites which have no template assigned yet, right-click and select Convert > Change Template.



- Select the new template (here HoustonTemplate) and click OK.



5. Navigate to the template in the Library. On the General tab we can change the name to SiteTemplate.
6. Then navigate to the Analysis Template tab to create the Rollup analysis. Click on *Create a new analysis template*. Give the analysis a meaningful name, e.g. Total Good Tires produced and choose Rollup as the Analysis Type. *Select an example element* to see the available attributes. As an attribute selection criterion we are typing the Attribute Name *Good Tires*. A green tick mark should appear next to the name in the attribute list. Tick Sum in the list of functions and click Map in the Output(s) column to create an output attribute. Name it Total Good Production and select an integer value type (Int32). Check in the changes to start the analyses for all sites and create the PI Points for the output attributes.

SiteTemplate

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: Total Good Tires Produced

Description: current day's good tires produced

Categories:

Analysis Type: ☐ Expression ☒ Rollup ☐ Event Fram

☒ Enable analyses when created from template

Example Element: Houston

Rollup attributes from
☒ Child elements of Houston ☐ This element - Houston

To select attributes set criteria below

Attribute Name: Good Tires

Attribute Level: Root Level

Attribute Category:

Element Category:

Element Template:

Select the function(s) to write to an attribute

Function Output(s) Value At Evaluation Value At Last Trigger

☒ Sum Total Good Production

☐ Average

☐ Minimum

☐ Maximum

☐ Count

☐ Median

☐ Population standard deviation

☐ Sample standard deviation

Sample Child Element: HOU.Press.01 Group By: None

Name	Parent Element
✓ Good Tires	HOU.Press.01
Curing Phase	HOU.Press.01
Internal Temperature	HOU.Press.01
Lid Position	HOU.Press.01
Main Clock	HOU.Press.01
Mold Temperature	HOU.Press.01
OEE Availability	HOU.Press.01
OEE Performance	HOU.Press.01
OEE Quality	HOU.Press.01
OEE Score	HOU.Press.01
Press Name	HOU.Press.01
Press Status	HOU.Press.01
Pressure	HOU.Press.01
Production Rate	HOU.Press.01
Production Target	HOU.Press.01
Reference Type	HOU.Press.01
Scrap Tires	HOU.Press.01
Steam Inlet	HOU.Press.01
Tires Produced	HOU.Press.01

Hint: If you create the Rollup analysis on the element level and convert to template later you need to enable the "Include Tag Creation" checkbox in the "Convert Attribute to Template" dialogue box. This is needed because no tags have yet been created to store the results of the Analysis.

Explore Selection Options with Rollup Analyses

Rollup analyses allow calculation of statistical values of attributes both from the element itself and from its child elements. Since input attributes are identified before every execution, the rollup dynamically includes any newly added attributes which match the selection criteria. This saves maintenance work, for example when new child elements are added since the rollup will include those automatically. On the other hand, the selection criteria have to be set with care to avoid unwanted effects like unintended inclusion of (newly added) attributes which happen to match the selection criteria, but where not thought of when those were designed. In the following we discuss the various options for setting the selection criteria.

Rollup attributes from
☒ Child elements of Santaella ☐ This element - Santaella

To select attributes set criteria below

Attribute Name:

Attribute Level: Root Level

Attribute Category:

Element Category:

Element Template:

The screenshots are showing examples from the Farm template of the Wind Farm database.

Selection using Attribute Name

The complete name of an attribute or parts of a name combined with wildcard characters can be used for the selection. For example, if we have multiple attributes for temperature measurements and we want to calculate the average, we can search for a common string (e.g. *temp*). We need to be aware that newly added attributes which match this search string will be included automatically.

Selection using Attribute Category

Using the attribute category for the selection, we can include all attributes of a category or make further selection within this group through other filter criteria.

For example, we might have various input flows which should be summed. The attributes cannot be queried by a common part of their name, but they are grouped together in a category.

Rollup attributes from
☒ Child elements of Santaella ☐ This element - Santaella

To select attributes set criteria below

Attribute Name:

Attribute Level:

Attribute Category:

Element Category:

Element Template:

Sample Child Element: Group By:

Name	Parent Element	Categories
✓ Expected Power (Curve)	GE001	Calculated Data
✓ Expected Power (Poly Function)	GE001	Calculated Data
✓ Expected Power (Polynomial)	GE001	Calculated Data
✓ Expected Power (Tabular)	GE001	Calculated Data
Active Power	GE001	Production
Adjusted Wind Speed	GE001	Potential Production
Apparent Power	GE001	Production

Selection using Element Category or Element Template

If the child elements of the element belong to different categories and/or templates, it can make sense to filter for element category or element template.

Note: The attribute table shows the attributes of the Sample Child Element. Selected attributes are not necessarily shown in the table, if this element belongs to a different category/element template then specified in the selection criteria.

Selection on Root Level/Child Level

Within one rollup analysis only child attributes or attributes at the top-level can be chosen. This is set by the Attribute Level selection criterion.

In the example below we see that by choosing the Root Level we can only see the attributes at the root level of the parent element.

Rollup attributes from
☒ Child elements of Santaella ☐ This element - Santaella

To select attributes set criteria below

Attribute Name:

Attribute Level: **Root Level**

Attribute Category:

Element Category:

Element Template:

Select the function(s) to write to an attribute Evaluate

Function	Output(s)	Value At Eval	Value At Last
<input type="checkbox"/> Sum			
<input type="checkbox"/> Average			
<input type="checkbox"/> Minimum			
<input type="checkbox"/> Maximum			
<input type="checkbox"/> Count			
<input type="checkbox"/> Median			
<input type="checkbox"/> Population standard deviation			
<input type="checkbox"/> Sample standard deviation			

Sample Child Element: **GE001** Group By: **None**

Name	Parent Element
Active Power	GE001
Adjusted Wind Speed	GE001
Apparent Power	GE001
Curtailment Cause	GE001
CutOut	GE001
Elevation	GE001
Expected Power (Curve)	GE001
Expected Power (Poly Function)	GE001
Expected Power (Polynomial)	GE001
Expected Power (Tabular)	GE001
High Wind Speed Calculations_EquipmentDamagePossible	GE001
High Wind Speed Calculations_HighWindPercentage	GE001
Installation Date	GE001
Latitude	GE001
Lifetime Production (Hourly)	GE001
Lifetime Production (Weekly)	GE001
Local Wind Speed	GE001
Local Wind Speed vs Site Wind Speed	GE001
Local Wind Speed vs Site Wind Speed (Formula)	GE001
Longitude	GE001
Lost Power	GE001
Lost Power Vs 30d Avg Power Production	GE001
Lost Revenue Rate	GE001
Manufacturer	GE001
Model	GE001
Polynomial Coefficients	GE001
Potential Power	GE001
Power Factor	GE001
Site	GE001
Status	GE001
Status Cause	GE001

When Child Level is selected, we only see child attributes (in the screenshot those are child attributes of Active Power and Polynomial Coefficients).

Rollup attributes from
☒ Child elements of Santaella ☐ This element - Santaella

To select attributes set criteria below

Attribute Name:

Attribute Level: **Child Level**

Attribute Category:

Element Category:

Element Template:

Select the function(s) to write to an attribute Evaluate

Function	Output(s)	Value At Eval	Value At Last
<input type="checkbox"/> Sum			
<input type="checkbox"/> Average			
<input type="checkbox"/> Minimum			
<input type="checkbox"/> Maximum			

Sample Child Element: **GE001** Group By: **None**

Name	Parent Element
Active Power 30dAverage	GE001
Polynomial Coefficients C0	GE001
Polynomial Coefficients C1	GE001
Polynomial Coefficients C2	GE001
Polynomial Coefficients C3	GE001
Polynomial Coefficients C4	GE001
Polynomial Coefficients C5	GE001
Polynomial Coefficients C6	GE001
Polynomial Coefficients FullPower_Limit	GE001
Polynomial Coefficients FullPower_Power	GE001
Polynomial Coefficients HighWind_Limit	GE001
Polynomial Coefficients HighWind_Power	GE001
Polynomial Coefficients LowWind_Limit	GE001
Polynomial Coefficients LowWind_Power	GE001



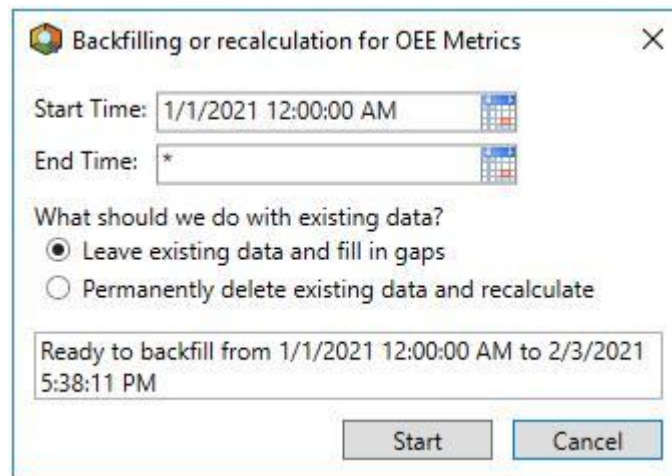
For full information refer to "[Rollup analyses](#)" in the OSIsoft online documentation.

Lesson 8: Analysis Management

Video: [Manage Analyses in Bulk, and Backfill or Recalculate your Data](#)

An analysis writes new data to its output attributes starting from the moment it is created. It is however also possible to calculate the data for past periods of time. There are two related options for that, which control how existing data should be handled.

Example: you create a new analysis on February 3rd, 2021 to calculate the heat energy consumption, which is added from various sources. The designated output attribute with the total consumption will have values for the time from that date onwards. To get values from January 1st, 2021 as well you can use the backfill feature.



The two options are:

1. *Leave existing data and fill gaps*: existing data is retained and only missing data is back filled.
2. *Permanently delete existing data and recalculate*: existing data will be deleted before the new data are backfilled.

Notes:

- The option for existing data handling is new with AF 2016 R2. In previous AF versions data were never deleted. This had to be carried out manually before the backfill.
- Backfilling/recalculation requires that the output attributes have been mapped to PI Points.
- Backfilled data is added into the archive files. With Data Archive versions before 2012 an upfront intervention could be required to make backfilling to work properly (e.g. PI archives reprocessing)

- For an Event-Frame-generation analysis, data is automatically deleted and recalculated (which is the only mode allowed). Be aware that annotations on those Event Frames will be lost.

Analyses can be managed (e.g. start, stop, backfill) directly at the element level under the *Analyses* tab, or by using the *Management* plug-in from the navigator panel. See below a screenshot presenting a short description of the different components of the Management plug-in.

The screenshot shows the Management plug-in interface with several annotations:

- Management of your Analyses or your Notification Rules:** Points to the left sidebar containing 'Management', 'Analyses', and 'Notification Rules'.
- Filter analyses using personalized Searches:** Points to the 'Search Name' and 'Add Criteria' section in the left sidebar.
- List of the Analyses along with their status:** Points to the main table listing analyses with columns for Status, Element, Name, Template, and Backfilling.
- Click here to select all your analyses:** Points to the 'Select All' checkbox in the table header.
- Enable/Disable analyses and manage backfilling, automatic and manual recalculation for one or multiple analyses:** Points to the 'Operations' pane on the right, which includes buttons for 'Enable', 'Disable', 'Start', 'Stop', 'Backfill', and 'Recalculate'.
- Right-click in this pane to:** Points to the right-click context menu options: 'View Analysis Service Statistics', 'Edit Analysis Service Configuration', and 'Open Recalculation Log Folder'.
- Status in AF and Analysis Service:** Points to a table showing the status of analyses in the Analysis Frame (AF) and the Analysis Service.
- Shortcut to Element:** Points to the 'Analysis Details' pane at the bottom, which provides more information about the selected analysis.

Status	Symbol	AF Status	Service Status
New		Enabled	-
Starting/Stopping		Enabled/Disabled	Starting/Stopping
Running		Enabled	Running
Disabled		Disabled	-
Error		Error	Error
Warning		Enabled	Warning
Suspended (2018)		Enabled	?
Unknown		Enabled	Suspended

When the Analysis Service is down for any reason the gaps can be filled automatically through **automatic backfilling**. This is enabled by default. To change the settings, right click in the blank space in the Management tab and open the Analysis Service Configuration. For more information, see parameters `AutoBackfillingEnabled` and `MaximumAllowedAutoBackfillingSpanInHours` in [Analysis service configuration](#). Also in the Analysis Service Configuration the global settings for **automatic recalculation** can be changed (`AutoRecalculationEnabled`). By default it is enabled for the service, but needs to be enabled on the individual analysis. This can be done in the Analysis tab of an the element or through the operations pane in the Management tab.

For additional information see:

- [OSIsoft Documentation: Backfilling and recalculation of analyses](#)
- [KB - Backfilling and Recalculating Analyses with Asset Analytics](#)
- [Management of analyses](#)

Note on video: In the video Event Frame analyses are used as a example of backfilling. The described procedure is the same for other analyses types. Event Frames are discussed in course *Event Frames and Notifications*.

Knowledge Check: Backfilling OEE Metrics

Activity Objectives

- Learn how to backfill a calculation.
- Get familiar with the *Management* plug-in and perform some administration tasks.

Problem Description

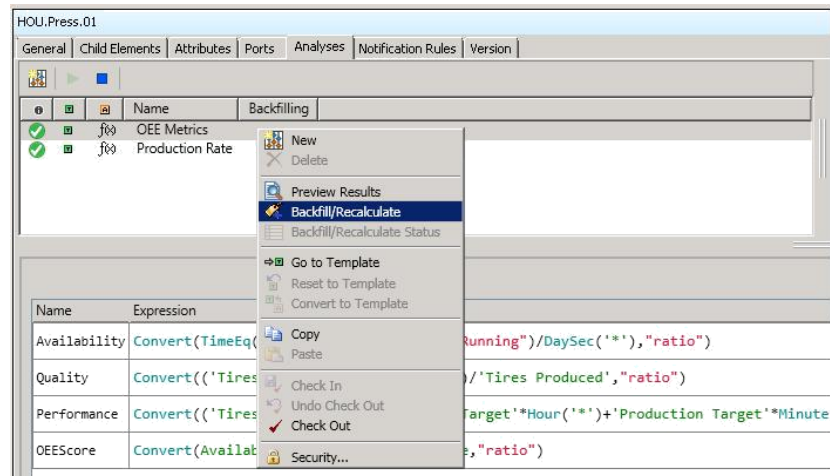
Management is very happy seeing real-time updates for the OEE score so they want more details. They have asked you to trend the OEE score for the last week for all presses belonging to the Houston site where they recently acquired innovative technology.

Approach

First, make sure that the OEE Metrics analyses are running and showing no errors. In order to do this, you can take advantage of the *Management* plugin under the *Navigator* pane.



To backfill an analysis, one option is to browse to the corresponding element and then right click the desired analysis and select *Backfill/Recalculate*.



However, since we want to backfill an analysis belonging to multiple elements, it would take too many clicks to complete this task element by element. The *Management* plug-in offers the possibility to perform backfills in bulk.

Note: You can complete this exercise by using the "**PI Big Tires Company**" AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1. If you do not wish to use the database provided, then you can model the exercise on your own processes.

Solution: Backfilling OEE Metrics

In the Management plug-in select the analyses. This can be done manually or you can use a filter to simplify the selection. Under Analysis Searches, use the green plus symbol to add a new search. For the purpose of this exercise a filter like the one shown below would select the requested analyses.

Management

Choose a type

☒ Analyses

☐ Notification Rules

Analysis Searches

Search Name: Houston OEE

Element Name: HOU*

Name: OEE Metrics

Add Criteria ▼

* Analyses that match all of these criteria will be displayed.

OK Cancel

Click on *Queue backfilling or recalculation for selected analyses* under the *Operations* pane. Next, enter the start time and end time then hit *Queue*.

Analyses

4 total analyses selected (4 on this page)

1 - 4 of 4

✓	Status	Element	Name	Template	Backfilling
✓	✓	f09 Houston\HOU.Press.04	OEE Metrics	OEE Metrics	
✓	✓	f09 Houston\HOU.Press.03	OEE Metrics	OEE Metrics	
✓	✓	f09 Houston\HOU.Press.02	OEE Metrics	OEE Metrics	
✓	✓	f09 Houston\HOU.Press.01	OEE Metrics	OEE Metrics	✓

Operations

[Enable](#) | [Disable](#) selected analyses

[Enable](#) | [Disable](#) automatic recalculation for selected analyses

[Queue](#) | [Cancel](#) backfilling or recalculation for selected analyses

Start: *-7d

End: *

What should we do with existing data?

☒ Leave existing data and fill in gaps

☐ Permanently delete existing data and recalculate

Queue


Analysis Organization and Consolidation

Organizing analyses in a clear manner is not just about the aesthetics.

Consider the OEE calculation we have created in the previous exercises. We have created one analysis comprised of four variables. Another option would have been to split up the calculation into four distinct analyses.

You can choose between consolidating and splitting analysis expressions by considering the three criteria below:

- **Dependency.** If one analysis output depends on the results of another analysis, it often makes more sense to consolidate the analyses. This ensures that the dependent expression gets evaluated only when all the inputs have been evaluated using the most recent data.
In our example, the OEE should only be calculated when Availability, Quality and Performance have been calculated.
- **Scheduling.** If a group of related expressions should be evaluated at the same time, it is usually best to consolidate them.
However, if some of these expressions need to be evaluated at a much higher frequency, it is better to create independent analyses to avoid needless evaluations of the slow-paced expressions.
- **Manageability.** Consolidating analyses facilitates management and troubleshooting. In case the analysis is failing, using the **Evaluate** or **Preview Results** options will guide you to the faulty expression.

 Best Practice	When deciding whether to consolidate several expressions under the same analysis, take into consideration Dependency, Scheduling and Manageability.
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Lesson 9: Learn about Best Practices for using the Analysis Service

An overloaded **Analysis Service** (the Windows service running Asset Analytics) will result in lagging calculations, skipped evaluations, and slow backfilling/recalculations. This lesson provides best practices that will help you achieve optimum scalability and performance. For more information, please visit page: [Analysis Service Best Practices](#), which also provides considerations on the Analysis Service global configuration parameters and the Data Archive tuning parameters relevant to the Analysis Service.

Optimizing Input Data Retrieval

When building analyses consider the input data that needs to be retrieved to perform the calculation.

The source of the data has an influence on the performance since the data references of the inputs have to be evaluated by the client first. This makes inputs other than PI Points more expensive for the Analysis Service. Input attributes with Analysis Data Reference, Formula, Table Lookup or String Builder can be very expensive depending on the calculation or query that needs to be executed. Also dependency chains can be very resource-intensive if multiple dependent calculations must be performed to resolve the input.

Another aspect to consider regarding input data is to avoid pulling the same data multiple times. Especially when working with summary calls (like calculating the average over a long time interval) where the result is needed in more than one place within the calculation, it is better to save the result to a variable that can be used for subsequent expressions.



Best Practice

Use expression variables whenever you want to repeat a block of your analysis logic, such as a summary operation for the same tag and time span. This will improve the performance of the Analysis Service as well as simplify the analysis management.

Detailed examples can be found in [Asset Analytics Best Practices - Part 1: Use Variables](#) and [Asset Analytics Best Practices - Part 3: Input Attributes](#).

Client vs. Server Calculations

When deciding which calculation method and output type to choose you should also consider where the data retrieval and calculation load will be, on the server or on the client. Especially for calculations which are computationally intensive, require a large amount of input data or where the outputs are consumed by many users will often be better to have them calculated on the server instead of the client. Any Ad-hoc calculation types as Formula and Analysis Data References are calculated on the client while analyses with PI Point Data Reference types are calculated on the server and the client only needs to retrieve the data stored on the Data Archive. Detailed information is given in [Client data Flow For Asset Analytics](#).

Considerations when Testing Analyses

When we use the **Preview Results** tab, it gives us evaluation statistics for **client-side evaluations**. In other words, when you click on Preview Results you are **not** calling the Analysis Service itself; instead, you are using the **resources of the client machine** you are on. In our case, we are working in PI System Explorer on the PI Server machine itself, but normally you would open it from your client machine.

The evaluation statistics provided by the Preview Results window are often a bit *pessimistic*, as the machine hosting the Analysis Service is usually more performing (in terms of memory and processor speed) than the client machine you use. As a rule of thumb, we suggest making sure that the average (client-side) evaluation time is significantly below the triggering frequency.

Video: [Dependency Chain Overview](#)

Dependency Chains occur when the output of one analysis is used as the input for another.

Note when backfilling or recalculating analyses in a dependency chain:

- When backfilling or recalculating a single analysis from the analysis tab of a specific element, dependencies are ignored unless the option **Recalculate dependent analyses** is selected.
- Backfills and recalculations requested from the Management tab will take analysis dependencies into account and is thus preferred over requesting backfills and recalculations for an analysis within a specific element.

More details are given in [KB - Backfilling and Recalculating Analyses with Asset Analytics](#).

When working with expensive function, for example summary functions with large time ranges, it is better to separate those from analysis that trigger very often and instead use a period schedule and output the result to a PI Point attribute. This can be used as an input in an analysis which is trigger more frequently. See also [KB - Analysis Service Best Practices](#) for details and [Analysis Dependency Explained](#) for general information on analysis dependencies.

If you would like to learn more about the impact of data density and scheduling on the Analysis Service, please visit these PI Square posts: [Asset Analytics Best Practices - Part 2: Data Density and Data Pattern](#) and [Asset Analytics Best Practices - Part 5: Scheduling](#).

Making Analyses easier to Read and Manage

Here we want to give some tips which are more focused on style but should help you to design your analyses in a way that they are easy to understand and troubleshoot.

Comments:

You can add comments to explain what you are doing. This is important for others who want to understand the logic behind your analyses and also for yourself when you are looking at the analyses you wrote some time in the future and cannot remember the logic. Comments start with two forward slashes (/).

Name	Expression
Availability	<pre>// Is the ratio between the time the press is running // and the full time it is supposed to operate. // The press is supposed to run all time Convert(TimeEq('Press Status','t','*', "Running")/DaySec('*'), "ratio")</pre>

Line Breaks:

Line breaks can also help to make the expressions (and comments) more organized visually. To start a new line use Shift+Enter.

It is also possible to return a result in multiple lines by using Char(10). For examples see [How to insert a new line into AF Analysis expression](#).

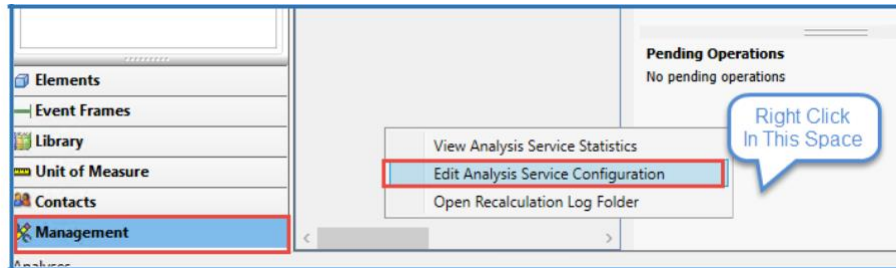
Variables:

As we discussed in *Optimizing Input Data Retrieval*, variables are a great way of reducing the load when a piece of data or calculation is needed multiple times within an analysis or in other analyses (in which case the output needs to be mapped to an attribute). Another purpose or side-effect is to make the analyses easier to read since complicated expressions can be summarized by a telling variable name.

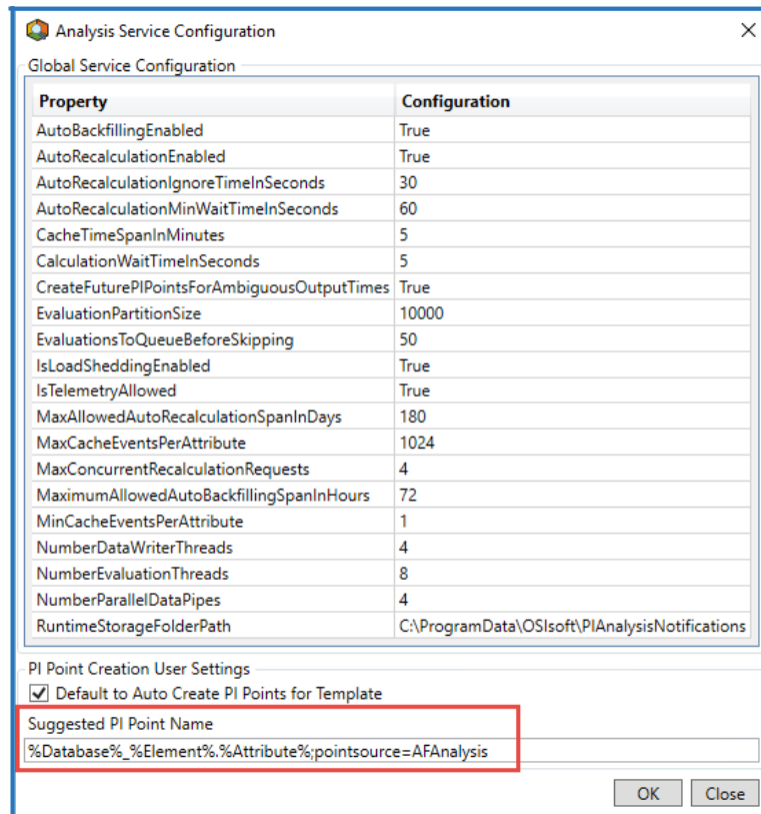
Set Suggested PI Point Name Default for Analysis Generated Attributes:

The Suggested PI Point Name default is configured on a per-user and per machine basis. For frequent analysis creators, setting the default configuration helps to save time as well as safeguard against creating tags that do not follow the convention in place.

1. In the PSE **Management** Pane, right mouse click in the white space of the **Pending Operations** space. Choose the **Edit Analysis Service Configuration** menu.



2. Set the **Suggested PI Point Name** following the desired convention (for example %Database%_%Element%.%Attribute%). In addition, a point source for analysis generated PI Tags is added using “;pointsource=AFAnalysis”. Click OK.





Best Practice

Setting the **pointsource** of analysis output tags easily allows you to segregate them from other PI tags. In addition, although not shown here, it is critical to **set appropriate point & data security on the tags**. Use a dedicated identity for the Analysis Service that is only allowed to write to analysis output tags.

Using UOMs in Equations

To ensure correctness and consistency of results we need to understand how UOMs (Units of Measure) are used in equations.

To evaluate an analysis expression that specifies an operation on input attributes, Analysis Service strips the UOM for the attributes before performing the operation. The result of the calculation takes on the UOM of the output attribute without any conversion.

To avoid unexpected results, you can use the Convert function to convert input attribute values to UOMs which lead to a result in the UOM of the output attribute. For additionally making the result independent of potential changes of the output attribute's default UOM setting, the Convert function can also be applied on the result to explicitly set it into the correct unit.

Example




As an example, we want to calculate the mass from the **Volume** and **Density** Attributes and assign it to the **Mass** Attribute. We make sure by using the Convert function that the UOM for **Volume** and **Density** are in the units that will give us the resulting mass in **lb**. By doing this the calculation would still work if the units for the input attributes are changed later on.

Name	Expression	Value at Evaluat	Value at Last Tri	Output Attribute
Dens	<code>Convert('Density','lb/ft3')</code>	6.5 lb/ft3	6.5 lb/ft3	Map
Vol	<code>Convert('Volume','ft3')</code>	561.46 ft3	561.46 ft3	Map
Mass	<code>Vol * Dens</code>	3649.5	3649.5	Mass

The output attribute of the analysis gives the correct result.

	Density	6.5 lb/ft3
	Mass	3649.47916666667 lb
	Volume	100 bbl




Sometime later, someone has changed the default unit of measure for the **Mass** Attribute from **lb** to **kg**. We now get the wrong answer.

	Density	6.5 lb/ft3
	Mass	3649.47916666667 kg
	Volume	100 bbl

If we were smarter when we first created the Analysis and used the Convert function also on the output this would not have been a problem. If we put in the following additional Variable in the expression and map that to the **Mass** Attribute, then all will be correct.

Name	Expression	Value at Evaluati	Value at Last Tri	Output Attribute
Dens	<code>Convert('Density','lb/ft3')</code>	6.5 lb/ft3	6.5 lb/ft3	Map
Vol	<code>Convert('Volume','ft3')</code>	561.46 ft3	561.46 ft3	Map
Mass	<code>Vol * Dens</code>	3649.5	3649.5	Map
MassInLb	<code>Convert(Mass,'lb')</code>	3649.5 lb	3649.5 lb	Mass

The Element now shows the correct value.

	Density	6.5 lb/ft3
	Mass	1655.37590447396 kg
	Volume	100 bbl

KB - UOM Automatic Conversions Using Analysis Service gives more details on UOM behavior in expressions.

Data Density, Data Pattern and Scheduling

Consider how much data needs to be pulled from the Data Archive (or other sources like tables) to perform a calculation. The more data needs to be retrieved the greater the load on the service. Properly configured exception and compression filtering on the input points are important to avoid an unnecessarily high amount of data since a high data density of the input points lead to slower data retrieval and (if event triggered scheduling is used) high triggering frequencies which would also affect dependent analyses.

Make sure that the calculation is **only executed as often as really needed**. Especially when working with input data which is updated very often it might not be necessary to run the calculation every time any of the inputs are updated. To avoid issues when working with dense input data consider triggering only when certain inputs are updated or using periodic scheduling.

Even when the execution time of a single analysis does not seem have a big impact it is extremely important to **think about scalability**! If an *ill-configured* analysis was based on an analysis template and there were hundreds or thousands of other analyses based on the same analysis template, the performance difference at the group level (all analyses based on the same template) would be on the order of seconds, perhaps even minutes.

Detailed examples of the issues that can be caused by misconfiguration in this area and how to go about finding the issue is given in [Asset Analytics Best Practices - Part 2: Data Density and Data Pattern](#) and [Asset Analytics Best Practices - Part 5: Scheduling](#). These articles also give some insight into the technical details of scheduling for the Analysis Service to understand how to troubleshoot skipped calculations when the service is overloaded.

Handling Issues with Bad Data

Inputs in error can affect the performance of the Analysis Service. The impact on performance depends on the data reference of the input and the error being thrown. Even if the analysis handles the error using the BadVal() function, there may be an effect on performance. If an input is in error, it should be fixed, or if it is expected to be in error, it should have the excluded property set and the analysis should be configured to handle the excluded property using the BadVal() function. This functionality is available as of 2018.

Note: If the cause of the issue cannot be resolved, for example because the input tags are not created yet or the configuration is not finalized, analyses which are in Warning or Error should be disabled. In the section *Addressing Analyses in Error* we show how to do this.

The following are suggested expressions to **identify** if an attribute called Value is Stale, Flat-Lined or Bad for the period specified. In this example the time dimension for both stale and flat-line data is defined through the attribute Data Quality Period, e.g. if the attribute has a value of 1 hour we are looking for values that have been stale or flat-lined for 1 hour.

Name	Expression	Output Attribute	
V	// Data Quality Target 'Value'	Map	⊗
P	'Data Quality Period'	Map	⊗
ET	// End Time for Analysis **'	Map	⊗
ST	// Start Time for Analysis ET - Convert(P, "s")	Map	⊗
Stale	// If the value is updating it is healthy If PrevEvent(V, ET) < ST Then "Unhealthy" Else "Healthy"	Stale.Health	⊗
Flatline	// If the value is changing it is healthy If Stale = "Unhealthy" Then // if it has not updated it must be flat "Unhealthy" Else If StDev(V, St, ET, 0) = 0 Then "Unhealthy" Else "Healthy"	FlatLine.Health	⊗
Bad	// If the value has been good during the period is is healthy If PctGood(V, ST, ET) = 0 Then "Unhealthy" Else "Healthy"	IsGood.Health	⊗

The following two exercises are around error checking in analyses and avoiding unnecessary execution.

Knowledge Check: Build Error Checking into an Analytic

Objective

One key measure admins can take on an ad-hoc basis to improve the performance of the Analysis service is to stop calculations that are generating errors. One step better than stopping calculations in error is to write calculations that do not generate errors because they incorporate robust error checking.

Error checking has additional benefits, beyond performance:

- More accurate results from the calculations
- More reliable calculation output
- Less user confusion

The Asset Analytics engine also attempts to restart calculations in an error state every fifteen minutes by default. This can cause significant performance issues if there are a large number of Analytics in an error state.

Tasks

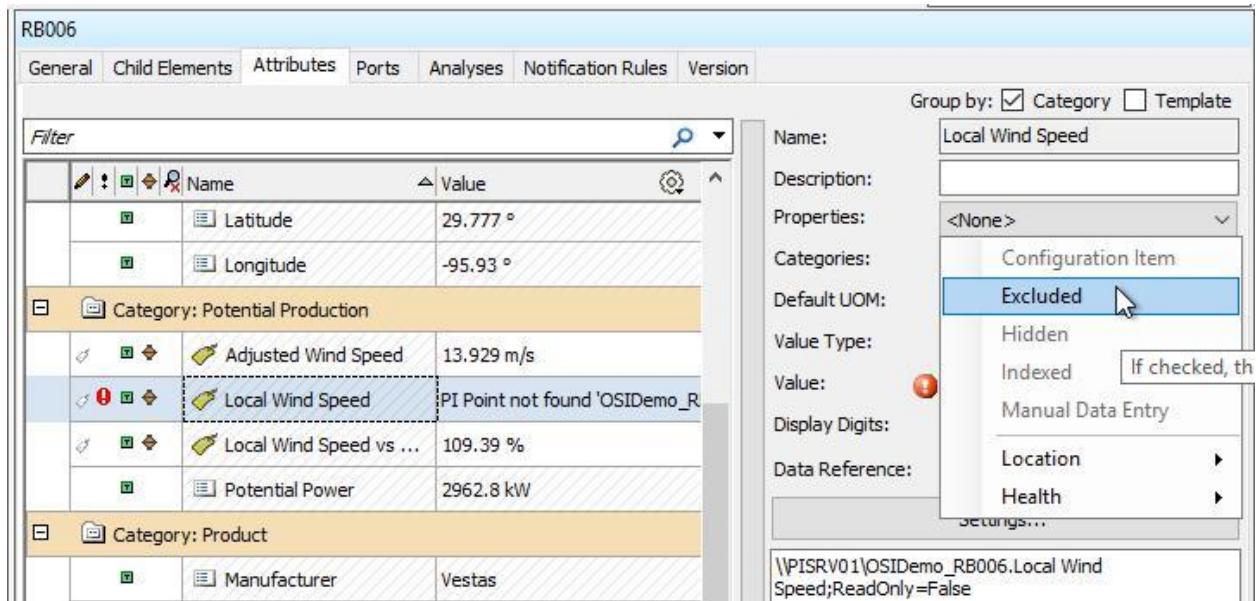
For this exercise use the “**Wind Farm**” AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1.

- Exclude the “Local Wind Speed” attribute on turbine RB006 under Scirocco\Finisterre that does not have a local wind speed sensor. Observe the effect this has on the status of the analysis.
 - Add error checking to the “Local Wind Speed vs Site Wind Speed” analytic. Check input values for “Local Wind Speed” using the BadVal() function and Exit() when the input values do not contain good data (Check out turbines GE001 and RB001 to see where problems occur).
-

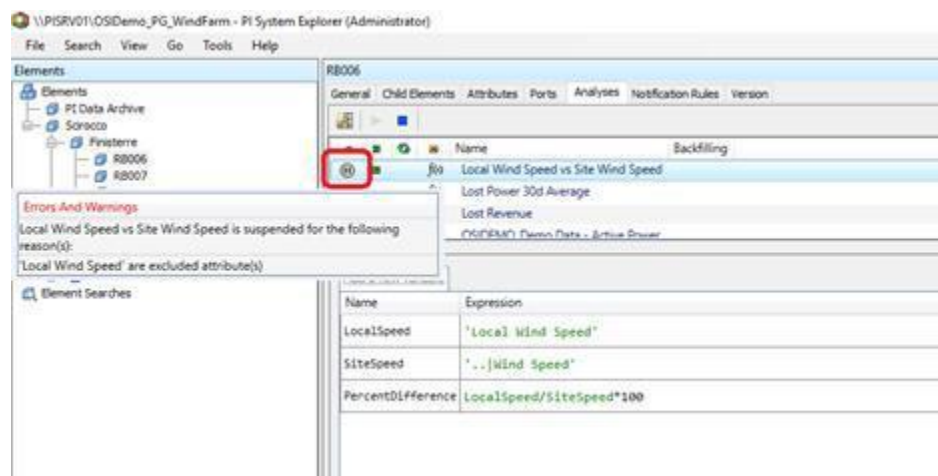
Solution: Build Error Checking into an Analytic

Exclude Attributes not available on certain assets

1. Launch PI System Explorer.
2. Navigate to the Elements view.
3. Navigate to the “RB006” element under “Scirocco\Finisterre”. Select the “Local Wind Speed” attribute and add the “Excluded” property using the attribute properties pane on the right.



4. Check in your changes.
5. Change to the Analyses tab for the “RB006” element.
6. Observe that the “Local Wind Speed” analytic is in a paused state because an input variable is an “Excluded” attribute.



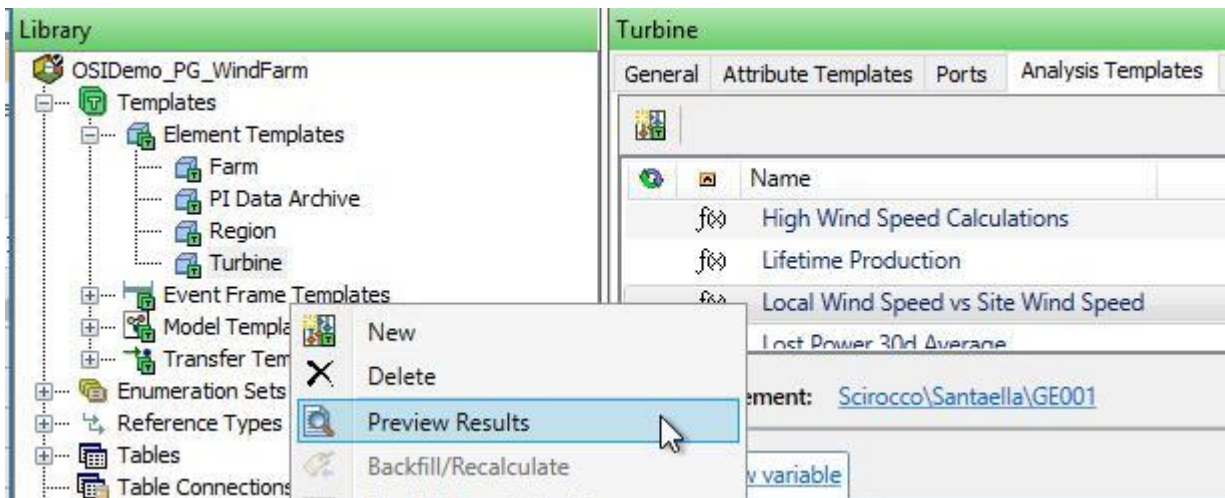


Tip

If the excluded attributes are not wrapped in “BadVal()” function checks, they will cause the analytic to pause. If there are other calculations that should take place within the Analytic unrelated to the excluded attributes, make sure to use the “BadVal()” function to test the input as in section B below.

Local Wind Speed vs Site Wind Speed - Check input values and Exit() when the input values do not contain good data.

1. In PI System Explorer, select the Library view.
2. Navigate to the “Turbine” element template.
3. On the “Analysis Templates” tab, select the “Local Wind Speed vs Site Wind Speed Analytic”.
4. With a turbine GE001 selected as the Example Element, preview the results of the analytic.



5. Note that the value of the input “Local Wind Speed” sometimes evaluates to “Comm Fail”, causing calculations to fail.

Preview results for Local Wind Speed vs Site Wind Speed

Start Time: t End Time: * Generate Results

Trigger Time	LocalSpeed	SiteSpeed	PercentDifference (%)	Local Wind Speed (m/s)	Evaluation
2/21/2020 2:37:20 AM	Comm Fail	20.612	Calc Failed	Comm Fail	100%
2/21/2020 2:37:30 AM	19.041	19.897	95.701	19.041	Progress
2/21/2020 2:37:40 AM	20.944	21.748	96.307	20.944	
2/21/2020 2:37:50 AM	20.226	19.923	101.52	20.226	
2/21/2020 2:38:00 AM	23.257	21.485	108.25	23.257	0ms
2/21/2020 2:38:10 AM	Comm Fail	21.164	Calc Failed	Comm Fail	Min
2/21/2020 2:38:20 AM	18.762	19.915	94.209	18.762	
2/21/2020 2:38:30 AM	20.024	20.114	99.553	20.024	204.5ms
2/21/2020 2:38:40 AM	21.285	21.075	101	21.285	Max

6. Add error checking and use the “Exit()” function to stop processing if there is a bad value on the local wind speed input:

```
LocalSpeed IF BadVal('Local Wind Speed') THEN Exit() ELSE 'Local Wind Speed'
```

```
IF BadVal('Local Wind Speed')
THEN Exit()
ELSE 'Local Wind Speed'
```




Tip

Use **Shift+Enter** to add line breaks within an expression in PSE.

- The “BadVal(‘Local Wind Speed’)” function will return true if there is a problem with the input, either a missing tag or a bad state in the tag value itself.
 - The “Exit()” function will stop processing of the analytic and save processing time and further errors if there is a bad value on the input.
7. Preview the analytic results for both a GE turbine and an RB turbine, and note that now there are no errors.

8. Check in your changes in PI System Explorer.

 Tip	<p>For analytics that read their own output, a “Totalizer” type functionality for example, error checking is critical! A simple error getting into the results tag could result in continuing errors.</p>
--	--

Summary

Error checking, both for data errors within the tags and for non-existing tags, can be critical to analytics performance at a large scale.

The “BadVal()” function is key to solve situations where tags are receiving bad values occasionally (for example communication failures). Attribute exclusion is a good way to solve situations where tags are not available for certain assets and make it obvious that it is a known factor that a particular asset does not have a certain tag.

Knowledge Check: Use Exit() Function to Optimize Conditional Calculations

Objective

Some Analytics are extremely expensive, but necessary under certain conditions. Originally the best way to deal with this was “IF-THEN-ELSE” logic to avoid expensive calculations and the “NoOutput()” function to avoid storing an unnecessary result. In the **2018 SP2** release of Analytics, a new function was added that takes this a step further. The “Exit()” function allows Analytics to stop processing entirely when desired, skipping all further rows (variables) without evaluating. Although this could previously be accomplished with the “IF-THEN-ELSE” logic and the “NoOutput()” function, using the “Exit()” function can be much cleaner and even saves a few processing cycles by skipping all further calculations in the analytic.

Although less necessary from a performance perspective, the “Exit()” function is also useful to build calculations that execute on a slower schedule than the “Daily” option provided by the Analytics scheduler. For example, a weekly calculation rather than daily. To accomplish this, check the date or day using the time functions of Analytics, and use the “Exit()” function if the calculation should not be executed at the current time.

Example Element: [WeeklytotalCalc1](#)

[Add a new variable](#)

Name	Expression	Value at Evaluation	Value at Last Trigger
TodayTimestamp	<code>ParseTime("")</code>	2/18/2020 3:11:17 AM	2/17/2020 6:00:00 PM
WeekdayToday	<code>Weekday(TodayTimestamp)</code>	3	2
ExecutionTime	<code>IF WeekdayToday = 3 THEN True else Exit()</code>	True	-
WeeklyTotal	<code>TagTot('SourceVariable', '-7d', '')</code>	964.16	-

Periodic Schedule

Set a Periodic Schedule

☐ Hours, minutes, and seconds
☐ Sub-seconds
☒ Daily

Every day at

06 : 00 PM

Example evaluation times

2/18/2020 6:00:00 PM
 2/19/2020 6:00:00 PM
 2/20/2020 6:00:00 PM

OK Cancel

Tasks

For this exercise use the “**Wind Farm**” AF Database supplied in the Cloud Environment as well as an XML file that can be found under Sample AF Databases in Lesson 1.

- Modify the “High Wind Speed Calculations” analytic to only execute when the wind speed is high. Modify the “WindSpeedHigh” variable to exit when the variable does not evaluate to true.
- Alter the “HighWindPercentage” line within this analytic to only execute if it has been more than a minute since the last high wind event (Hint: Use the HasChanged() function).

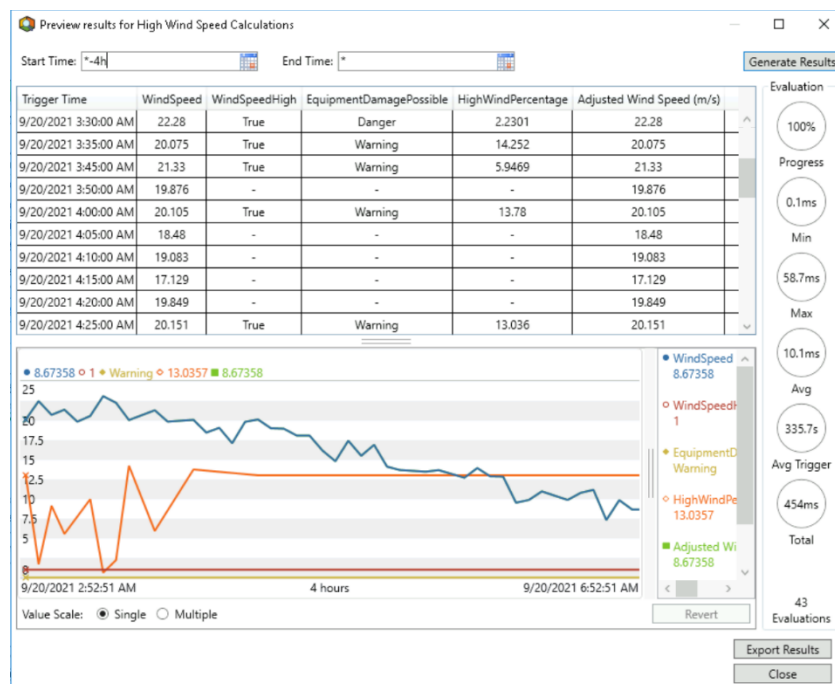
Solution: Use Exit() Function to Optimize Conditional Calculations

Add IF THEN ELSE with Exit() to the calculation

1. In PI System Explorer, navigate to the Library, select the “Turbine” element template, then the “High Wind Speed Calculations” analytic
2. Note that the Analytic executes fully even if the Wind Speed is not higher than 20.
3. Modify the “WindSpeedHigh” variable to be “true” if wind speed is greater than 20 and to “Exit()” otherwise

WindSpeedHigh	IF WindSpeed>20 THEN true ELSE Exit()
---------------	---------------------------------------

4. Preview results and note that the Analytic displays “—” for results unless the wind speed is high. This indicates that the Analytic is exiting.



Execute only if more than a minute passed since the last event

5. Alter the “HighWindPercentage” line to only execute if it has been more than a minute since the last high wind event by adding “IF HasChanged(‘High Wind Speed Calculation_HighWindPercentage’,’*-1m’) THEN Exit() ELSE “ to the variable:

HighWindPercentage	IF HasChanged('High Wind Speed Calculations_HighWindPercentage', '*-1m') THEN Exit() ELSE	High Wind Speed Calculations_HighWindPercentage
	IF HasChanged('High Wind Speed Calculations_HighWindPercentage', '*-1m') THEN Exit() ELSE Convert(TimeGT('Adjusted Wind Speed', '*-30s', '*', WindSpeed)/(30*24*60*60)*100, '%')	



Tip

The “HasChanged(<Attribute>,<Time>)” function can be useful if there is an expensive calculation that needs to take place sometimes, but does not need to be executed at more than a certain frequency.


6. Check in your changes.

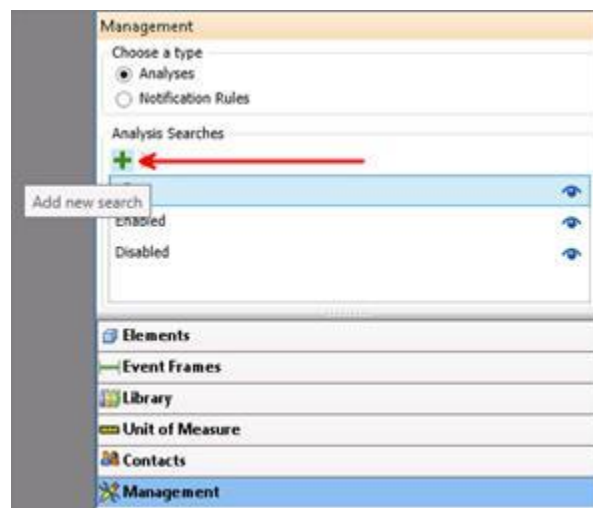
Addressing Analyses in Error

Why is this relevant for us?

If analyses are enabled before they are configured correctly, **the Analysis Service will automatically try to restart them every 15 minutes, causing unnecessary strain.**

In order to disable all the analyses in error state, proceed as follows:

1. Go to the Management tab and click on the  symbol to add a new search.



2. Name your search **Analyses in Error state**. Add the filter criterion **Service Status**.

Search Name: Analyses in Error state

Add criteria to search for specific items.

Add Criteria ▼

- Name
- Description
- Element Name
- Template
- Category
- Enabled/Disabled
- Service Status

OK Cancel

3. Select the **Error** status and then click OK.

Search Name: Analyses in Error state

Service Status: Running

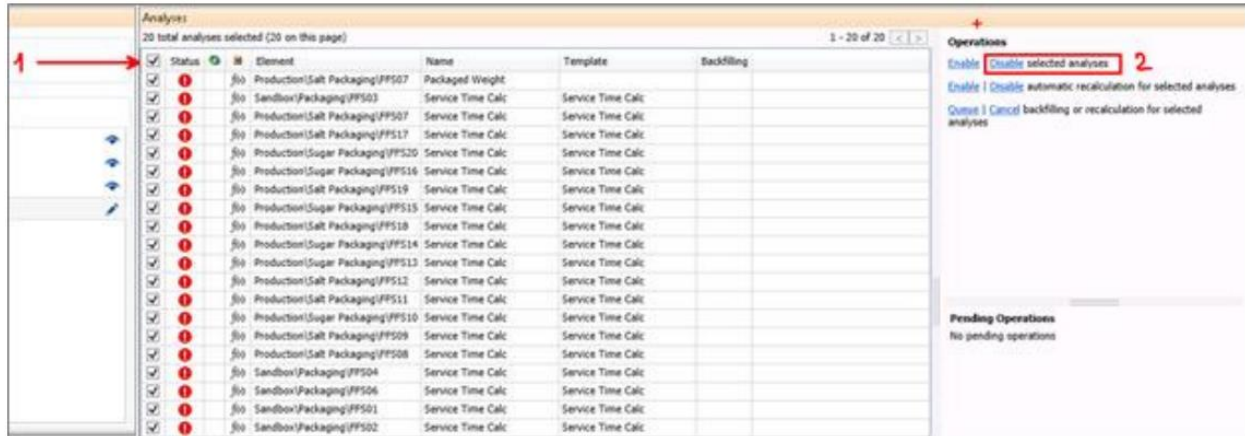
Add Criteria ▼

* Analyses that match

- Running
- Stopped
- Warning
- Error
- Suspended

OK Cancel

4. Select all the filtered analyses using the first checkbox on the top.
5. Disable the selected analyses.



Analyses

20 total analyses selected (20 on this page)

1 - 20 of 20

Status	Element	Name	Template	Backfilling
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS07	Packaged Weight		
<input checked="" type="checkbox"/>	f00 Sandbox/Packaging/FFS03	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS07	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS17	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS20	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS16	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS19	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS15	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS18	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS14	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS13	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS12	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS11	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Sugar Packaging/FFS10	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS09	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Production/Salt Packaging/FFS08	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Sandbox/Packaging/FFS04	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Sandbox/Packaging/FFS06	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Sandbox/Packaging/FFS01	Service Time Calc	Service Time Calc	
<input checked="" type="checkbox"/>	f00 Sandbox/Packaging/FFS02	Service Time Calc	Service Time Calc	

Operations


Enable **Disable selected analyses** 2

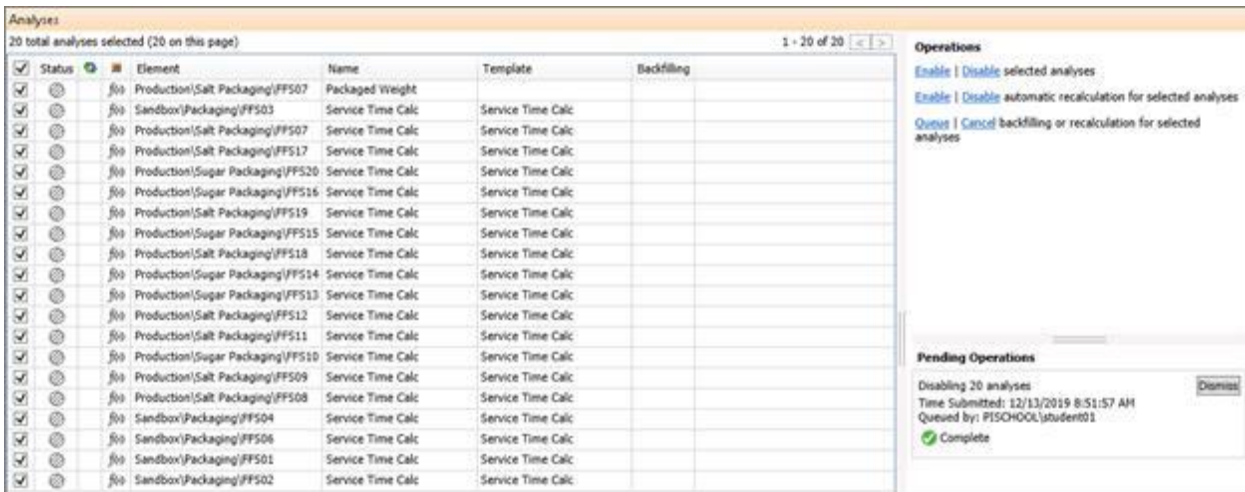
Enable | Disable automatic recalculation for selected analyses

Queue | Cancel backfilling or recalculation for selected analyses

Pending Operations

No pending operations

The analyses should now display as disabled .



Analyses

20 total analyses selected (20 on this page)

1 - 20 of 20

Status	Element	Name	Template	Backfilling
	f00 Production/Salt Packaging/FFS07	Packaged Weight		
	f00 Sandbox/Packaging/FFS03	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS07	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS17	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS20	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS16	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS19	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS15	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS18	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS14	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS13	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS12	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS11	Service Time Calc	Service Time Calc	
	f00 Production/Sugar Packaging/FFS10	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS09	Service Time Calc	Service Time Calc	
	f00 Production/Salt Packaging/FFS08	Service Time Calc	Service Time Calc	
	f00 Sandbox/Packaging/FFS04	Service Time Calc	Service Time Calc	
	f00 Sandbox/Packaging/FFS06	Service Time Calc	Service Time Calc	
	f00 Sandbox/Packaging/FFS01	Service Time Calc	Service Time Calc	
	f00 Sandbox/Packaging/FFS02	Service Time Calc	Service Time Calc	

Operations

Enable | **Disable selected analyses**

Enable | Disable automatic recalculation for selected analyses

Queue | Cancel backfilling or recalculation for selected analyses

Pending Operations

Disabling 20 analyses

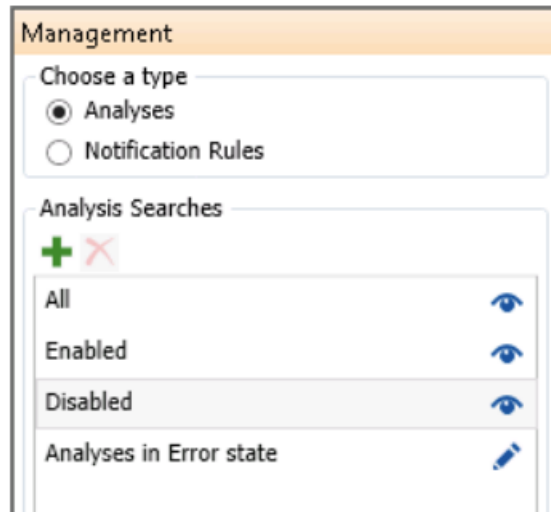
Time Submitted: 12/13/2019 8:51:57 AM

Queued by: PISCHOOO@student01

Complete

Dismiss

Should you want to view all the disabled analyses (for example when cleaning up your database from analyses that are no longer needed), you can use the default search option “Disabled”.



A detailed example of the impact of analyses in warning or error states on the Analysis Service is provided in the PI Square post [Asset Analytics Best Practices - Part 4: Analyses in Warning or Error](#).



Best Practice

Disable all analyses in Warning or Error state until their configuration is fixed.

Lesson 10: Troubleshoot Asset Analytics

Video: [Troubleshooting Analysis When Outputting Calc Failed](#)

The video presents troubleshooting steps for a common issue with analyses. Here we summarize some of the information and provide links to more detailed resources. General information about Asset Analytics and the Analysis Service including troubleshooting guidelines and links to more detailed information can be found in [Playbook - Asset Analytics / Analysis Service](#).

The troubleshooting work flow as presented in the example:

1. Check if analysis will calculate with REAL TIME data using the Evaluate button.
2. Check if analysis will calculate with HISTORICAL data using Preview Results. See if there are any Calc Failed values in the output and check for unexpected values in the input.
3. Check if we can backfill or recalculate the analysis. Note that in contrast to the previous tests this process will be performed by the Analysis Service and not by the client.
4. Increase log level using the configuration files to get more information. The previous troubleshooting steps should have helped to narrow down at which process the issue occurs. The processes used by the Analysis Service are:
 - **PIAnalysisManager**: This process spawns the PIAnalysisProcessor and PIRecalculationProcessor and is responsible for managing any client connection.
 - **PIAnalysisProcessor**: Performs real-time calculations.
 - **PIRecalculationProcessor**: Performs analysis backfilling and recalculation.
5. Since logging in the Analysis Service is version-specific, please check the article corresponding to your version for the location of the logs and the configuration steps here:
 - [How to Set the Executable Message Log Level for Analysis Service \(2.7.0-2.8.0\)](#)
 - [How to Set the Executable Message Log Level for Analysis Service \(2.8.5+\)](#)
6. Copy the full path of the analysis from PSE to filter the log for messages related to the analysis in error. The following steps depend on what is found in those messages.

For other scenarios where the output of an analysis is unexpected or issues with the Analysis Service see [Asset Analytics "Evaluate" and "Preview Results" buttons show different results from real-time output](#) and [Asset Analytics - Common Troubleshooting scenarios](#)

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