AVEVA

PI DataLink: Basics

aveva.com

Table of contents

1 Introduction

Before reading this section, please refer to the following course YouTube video:
Course Introduction

This course will teach you how to use PI DataLink to access your process data, create meaningful reports, and use them to make key decisions about your plant performance. By the end of the course, you will be able to:

- Search for PI Tags and AF Attributes in PI DataLink
- Identify which PI DataLink function to use for your report
- Get current and historical PI data in PI DataLink
- Build reports with key KPIs
- Interpolate data with custom intervals
- Use calculated data
- Build reusable daily report

Throughout this class we will assume you have a basic knowledge of the PI System. If you are new to the PI System, we encourage you to complete the *PI System Basics* class that is available for free on our Learning Page.

The course consists of text-based lessons, and video lectures. You are encouraged to follow along with all video lectures using your Training Cloud Environment. Text-based lessons contain background theory, exercises, documentation, and other useful information.

Lessons are categorized using the following key words:

1. **Hands-On**: These lessons contain hands-on exercises with video step-by-step walkthroughs. While we are demonstrating how to use different functions of PI DataLink, you are encouraged to do the same on your virtual environment. If you have access to your own data, feel free to use it instead. It will give you an amazing opportunity to leave this course with some great ready-to-use reports for your organization.
2. **Knowledge check**: Exercises with step-by-step solutions to complete on your own using your virtual environment, or quizzes to keep your skills sharp.
3. **Background**: Readings or videos containing useful background information to assist your understanding. These lessons are optional but encouraged as they will give you a more well-rounded understanding of the features of PI DataLink. Throughout these sections we will link out to reference documentation. You may be examined on the content inside these references, but as the exam is open book, you're welcome to visit these references during the exam.

In the next lesson we'll cover the Learning Cloud Environment used in this class.

1.1 Background: PI System Software Used in this Class

SOFTWARE	VERSION
PI Data Archive 2018 SP3	3.4.430.460
PI AF Server 2018 SP3	2.10.6.195
PI DataLink 2019 SP1 Patch 1	5.5.2.0

2 PI DataLink Basics

2.1 What is PI DataLink?

Before reading this section, please refer to the following course YouTube video:
OSIsoft Learning: What is PI DataLink?

PI DataLink is an OSIsoft add-in for Microsoft Excel. It lets you retrieve information from your PI System directly onto a worksheet. Combined with the computational, graphic, and formatting capabilities of Microsoft Excel, PI DataLink is a powerful tool for gathering, monitoring, analysing, and reporting PI System data.

With PI DataLink, you can:

- Retrieve PI point values from a PI Data Archive server

- Retrieve attribute values from a PI Asset Framework (PI AF) server

- Retrieve system metadata to create a structured view of PI System data:

    o   PI point names and attributes

    o   PI AF attributes and elements

- Reference these items using PI DataLink functions to calculate and filter data

- Update retrieved values when the worksheet recalculates

It is important to understand the following nomenclature when working with PI DataLink and its data retrieval functions.

Term	Meaning
Data item	A PI Point name or AF attribute name, for which the PI DataLink function returns property values.
Root path	The common path to specified data items within PI System. It is optional for PI DataLink functions. Valid entries include: Data Archive name if the data item is a PI Point. AF server and database if the data item is an AF attribute. For a data item of AF Attribute, root path can also include the name of parent elements. Blank if the data item is on the default Data Archive or the default AF Server and default database.
Output cell	The worksheet cell where the function writes the result. If you select a cell before you open the function task pane, PI DataLink inserts the selected cell into the output cell field.

References:

- For more information see "Introduction" in *PI DataLink User Guide*

2.2 Background: PI DataLink functions

With PI DataLink functions, you can query any Data Archive or AF server, apply calculations to retrieved results and return values to worksheet cells. These functions return results in function arrays, which you can recalculate to update values as needed. The below table summarizes the functions available in PI DataLink.

Query Category	Function Name	What It Returns
Single value	Current Value	The current or most recent value of a Data Item
	Archive Value	Value of a Data Item at a specified time stamp
		Computed value of a performance equation at a specified time stamp
Multiple value	Compressed Data	All the values of a Data Item for a specified time period
		A specific number of Data Item values beginning at a certain time
	Sampled Data	Evenly spaced, interpolated values for a Data Item over a regular interval

		Evenly spaced, interpolated values of a performance equation over a regular interval.
	Timed Data	Actual or interpolated sample values for a Data Item at specified time stamps
		Values of a performance equation computed at specified time stamps
Calculation	Calculated Data	One or more evenly spaced, calculated values based on a Data Item's values and specified calculation preferences
		One or more evenly spaced, calculated values based on an evaluated performance equation and specified calculation preferences
	Time Filtered	The amount of time that a performance equation evaluates to true during a specified time period

References:

- Documentation for the PI DataLink functions can be found *here*.

2.3 Background: Search for PI Tags and PI AF Attributes in PI DataLink

Before reading this section, please refer to the following course YouTube video:
Search for PI Tags and PI AF Attributes in PI DataLink

In this lesson you will learn how to:

- Search for PI Points in PI DataLink
- Find element and element attributes within the PI Asset Framework (AF) hierarchy in PI DataLink

PI DataLink offers two ways to search for data items:

- Search tool

- Asset Filter Search function (this will be covered in a later section)

On first use, the tool starts at the Home node, which shows all the Data Archives and AF servers listed in Connection Manager. You must limit the search to a single Data Archive or single AF server and can limit the search further to a single database on an AF server, and then to specific elements and parent attributes.
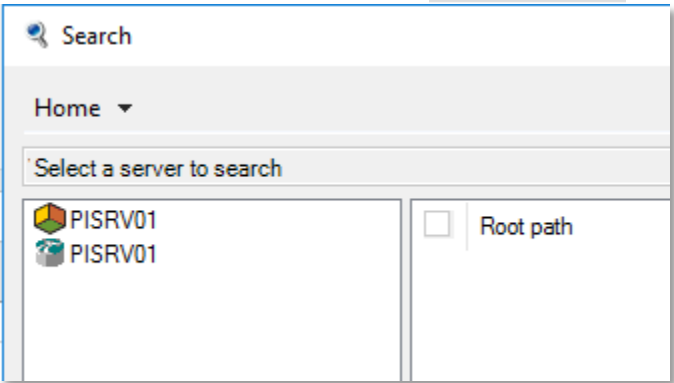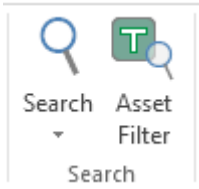
When your search scope is a Data Archive, the top search field is applied to the PI Point Name, only. Set the fields under Filters to specify any additional criteria the retrieved PI Points must match.
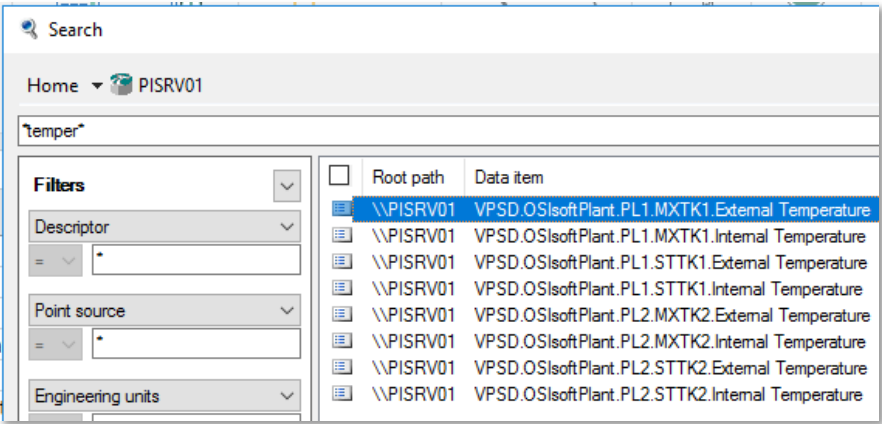
When your scope is an AF Server or Database, the top search field is applied to AF Attribute name as well as the name, description, and categories of the *parent element*.
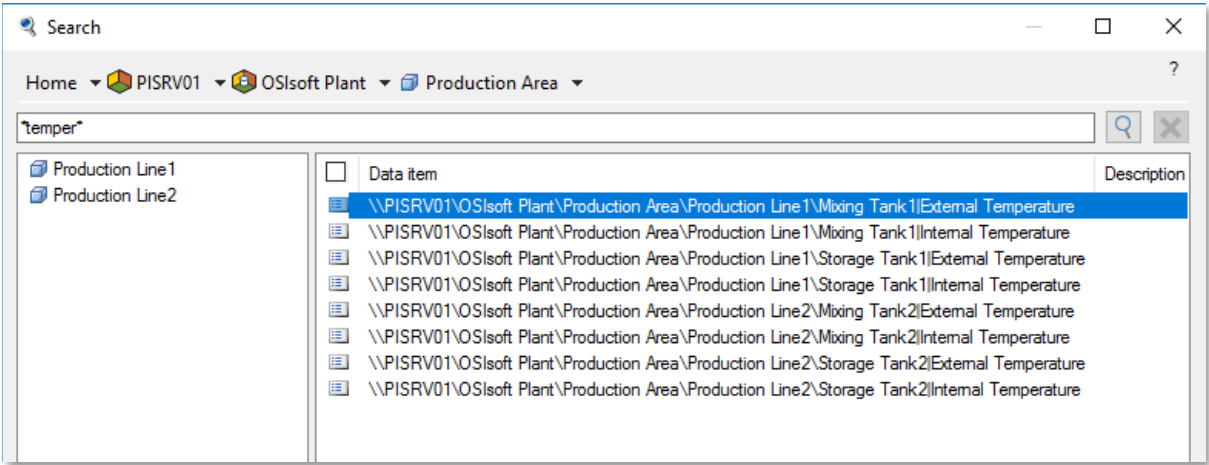
You can change columns displayed in the results pane by right clicking a column name in the results pane and selecting which column you would like to be displayed.
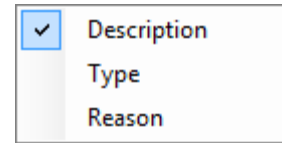
You can use wildcard characters to augment your search, for example:
Use * to replace any number of characters:
Flow* = Flow_meter1, flow_meter2, flow_meter3, flowrate_pump1, flowrate_pump2
Use ? to replace one character:
Flow_meter? + flow_meter1, flow_meter2, low_meter3

References:

- Documentation for the PI DataLink search can be found *here*.

2.4 Knowledge check: Searching in PI DataLink

In this exercise, you will practice searching for PI Points and AF Attributes in PI DataLink.

Perform the following steps:

1. Open Microsoft Excel.

2. On the **PI DataLink** ribbon, select *Search***.**

3. Select a Data Archive

   a. Search for ***temper***

   b. Select an item and then **OK.**

4. Select the AF Server > OSISoft Plant

5. Search for **flow*.**

6. Choose all items in the list.

7. Select OK

2.5 Background: PI Time

Before reading this section, please refer to the following course YouTube video:
OSIsoft Learning: PI Time

In PI there are two ways to specify time:

1. **Fixed Time**: An expression that signifies a specific date and time. Used when you want to save a view of your PI System data for a specific time in history.

   Example: A user is creating a report that analyses an equipment failure event which occurred on the 25th of July 2013 at 11 am, so 25-Jul-2013 11:00:00 AM

2. **Reference Time**: An expression that signifies a date and time relative to the current date and time. Used when you want to create a dynamic view of your data, which can be used to view data in real-time, or re-used on a periodic basis to create periodic reports.

   Example: A user creates a report that summarizes weekly production totals. By using relative time expressions, the user will be able to re-use this report every week, so define a start date of "Monday" meaning start the report from last Monday.

Both Fixed Time and Reference Time can be used with Time Offsets; Time Offsets can be used alone.

2.5.1 Fixed Time Syntax

A fixed time expression is an expression which includes a date, and optionally a time.

When the time component is omitted, **Midnight** is assumed. And midnight occurs at the beginning of the day, not the end.

Expression	Meaning
5-jan-92 12:34	12:34 p.m. on January 5, 1992
25-sep-12	00:00:00 (midnight) on September 25, 2012

The PI System interprets many different formats for fixed time. In the event of an ambiguous input, the Windows Region and Language settings of the computer where the PI Visualization Tool is installed take precedence.

Note the following:

Expression	Region and Language Format	Meaning
1/5/2015	English (United States)	00:00:00 (midnight) on January 5th 2015
1/5/2015	Rest of the world	00:00:00 (midnight) on May 1st 2015

2.5.2 Reference Time Syntax

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

Abbreviation	Meaning	Reference time
*	Now	Current time
t	today	00:00:00 (midnight) of the current day
y	yesterday	00:00:00 (midnight) of the previous day
fri	friday	00:00:00 (midnight) on the most recent Friday
may	may	00:00:00 (midnight) on the current day in May of the current year
apr-15	april-15	00:00:00 (midnight) on the 15th day of April in the current year
YYYY	Year	00:00:00 (midnight) on the current day and month in year *YYYY*
M-D or *M/D* Or *D-M, D/M*	USA The world	00:00:00 (midnight) on the *D*th day of month *M* in the current year
15		00:00:00 (midnight) on the *15*th day of the **current** month

Use the first three letters as an abbreviation for any day of the week and any month of the year. For example:

Expression	Meaning
thu	00:00:00 (midnight) on the most recent Thursday
MAR	00:00:00 (midnight) on the current day in March of the current year

2.5.3 Time Offset

When specifying PI time use specific abbreviations that represent time units. These are used in constructing *Time Offsets* as in the table.

Abbreviation	Time Unit
s	second
m	minute
h	hour
d	day
mo	month
y	year
w	week

Specify the abbreviation, the full time unit or the plural version of the time unit, such as *s*, *second*, or *seconds*. Time offset is any of the time units with a valid value and a + or – sign included, e.g. +8h.

Time offsets can be used alone in a time field or come with a fixed time or reference-time abbreviation.

2.5.4 Time Offset Syntax

Reference Time or Fixed Time and Offset Expression

When included with a reference-time abbreviation or with a fixed time, a time offset adds or subtracts from the specified time (indicated by either + or -) and a time unit with a value

Expression	Meaning
*-1h	One hour ago
t+8h	08:00:00 (8:00 a.m.) today
y-8h	16:00:00 (4:00 p.m.) the day before yesterday
mon+14.5h	14:30:00 (2:30 p.m.) last Monday
sat-1m	23:59:00 (11:59 p.m.) last Friday
1-jan-20 – 1d	Midnight 31 December 2019

Time Offsets Used Alone

Entered alone in a time field, time offsets specify a time relative to an implied reference time. The implied reference time depends on the field where you enter the expression:

- For a start time, the reference time is the current clock time.
- For an end time, the reference time is the start time.

- For a single time stamp, the reference time is the current clock time.

Time field	Expression	Meaning
Start time	-1d	One day before the current clock time (24 hours before the current clock time)
End time	+6h	Six hours after the start time
End time	-30m	30 minutes before the start time
Time stamp	-15s	15 seconds before the current clock time

2.5.5 Rules to Remember

Rule 1: You can only include a single time offset in an expression. Including multiple offsets can lead to unpredictable results. For example, the following time expressions are <u>not valid</u>:

<div align="center">

*+1d+4h

t-1d+12h

</div>

Rule 2: To define a time offset you must include a valid value with any time unit. Only for *seconds*, *minutes*, or *hours*, you can specify a fractional value. You cannot specify fractional values for other time units.

Rule 3: A fixed timestamp consists of the fields of Year, Month, Day and Time (hours, minutes and seconds). If any of these fields are not specified in the PI time expression, the following values will be assumed by default:
- If <u>Time</u> is not specified, then the default value would be <u>Midnight</u>.
- If <u>Day</u> is not specified, then the default value would be <u>Current Day</u>.
- If <u>Month</u> is not specified, then the default value would be <u>Current Month</u>.
- If <u>Year</u> is not specified, then the default value would be <u>Current Year</u>.

2.6 Knowledge check: Practice PI Time

The quiz in this course is taken online. Please check the course listing online for more details.

3 Single value queries

3.1 Background: Get PI data with current and archive value functions

Most of the functions in PI DataLink can be done using these simple steps

> - *Select the Target cell*
>   *Data/Information will be inserted below and to the right of the target cell*
>
> - *Choose the Function*
>   *Search/Snapshot Value or any other function*
>
> - *Fill out the required parameters, or use cell references to make later editing easier*

3.1.1 Obtain a Current Value

For the **Current Value** function no timestamp is required, as it is always assumed to be **NOW** (***** in PI time or **=NOW()** in Excel time).
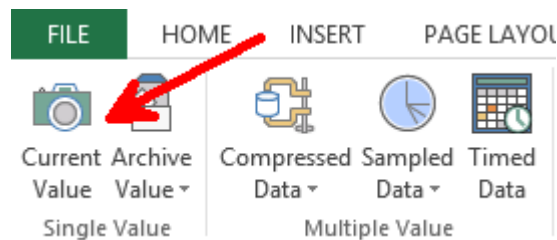
You can retrieve PI data from any PI System currently connected to your client machine. You must specify:

1. **Data item(s)**
   o Can specify 1 or more, explicitly or via a cell reference

2. **Output cell**
   o Any data currently in this cell will be replaced.

The result of this query will be the most current value and timestamp of the data item specified.

	A	B
1	06-Jan-20 05:18:51	45.92473

Note: Current Value is a **volatile function**: the function *recalculates and updates values* whenever Excel calculates or recalculates any cell in the worksheet. To force an immediate recalculation, press F9.

3.1.2 Obtain an Archive Value

The other PI DataLink function that returns a single value is the **Archive Value**. This function retrieves an archived value at a specific timestamp.

You specify:

1. **Data item(s)**
   - o   1 or more

2. **Time stamp**
   - o   Excel Time Format or
   - o   PI Time Format

Archive Value   ▾ ✕

?

◉ Data item
○ Expression

Root path (optional)
\\PISRV01\OSIsoft Plant\Productic

Data item(s)
Flow Rate   🔍

Time stamp
*-1h

Retrieval mode
auto   ⌄ 🖳

Output cell
'Sheet1'!A1

○ No time stamp
◉ Time at left
○ Time on top

OK   Apply

The result being:

	A	B
1	06-Jan-20 04:22:38	195.9313

3.2 Hands-On: Single value query

During this section, please refer to the following course YouTube video:
Single value query

Activity description

You would like to prepare a report that shows the current value of External Temperature, Pressure and Flow Rate of Mixing Tank2. You are also interested in knowing the value of these measurements at 7 am yesterday.

Approach

Part I – Get Current Values

1. Open Excel and in cell A1 type Current Values as a heading.

2. Click on cell A2. Select **Current Value** function.

3. Click on the magnifying glass next to **Data Item(s)** box.

4. Search for the External Temperature of Mixing Tank2.

5. Select *Time at Left* and click *OK*.

6. Repeat these steps for Pressure and Flow Rate in cells A3 and A4, respectively.

Part II – Add Archive Values

1. In cell C1 type Archive Values as a heading.

2. Click on cell C2. Select *Archive Value* function.

3. Click on the magnifying glass next to **Data Item(s)** box.

4. Search for the External Temperature of Mixing Tank2.

5. Type Y+7h in the **Time stamp** box. What time stamp will be retrieved? _____

6. Select *Time at Left* and click *OK*.

7. Repeat these steps for Pressure and Flow Rate in cells C3 and C4, respectively.

Part 3 – Do you think this is an efficient way to search for the data item every time a value is retrieved? Check out the next lesson if you are unsure of the answer!

3.3 Hands-on: Single value queries using cell reference

> During this section, please refer to the following course YouTube video:
> *Single value queries using cell reference*

Activity description

You would like to include the <u>current value</u> of External Temperature of Mixing Tank1 in our daily report. You are also interested in the value of this tank's Internal Temperature at 7 am today.

Approach

<u>Part I – Build a Template</u>

1. Open Excel and click on cell A2. Click on **Search**.

2. Select the AF Database of <u>OSIsoft Plant</u>. Type **Ext*Temp*** in the search box and click 'Enter'. The External Temperature of all four tanks should show up on the search results list.

3. Select the external temperature of Mixing Tank1 and click **OK**.

4. In cell B1 type <u>Current Value</u>. In cell D1 type <u>Archive Value</u> as headings.

5. In cell A4 type <u>Timestamp</u>, in B4 type <u>t+7h</u>. What time do you expect to see?_____

Your report template will look similar to this:

	A	B	C	D	E
1		Current Value		Archive Value	
2	\\PISRV1\OSISoft Plant\Production Area\Production Line1\Mixing Tank1|External Temperature				
3					
4	Timestamp	t+7h			

<u>Part II – Query PI Data</u>

1. Select cell B2 (this will be your Output cell). Click on **Current Value** function.

2. Refer to cell A2 in the **Data Item** field and select **Time at left**. Click **OK**.

3. Select cell D2 (this will be your Output cell). Click on **Archive Value** function.

Refer to cell A2 in the **Data Item** field. In the **Time stamp** field refer to cell B4. Do not change any of the other options. Select **Time at left** and click **OK**.

3.4 Knowledge check: Temperature at a glance

Activity description

You would like to include the current value of the External Temperature of all Tanks in your daily report. You are also interested in knowing the value of the tanks' Internal Temperature at midnight.

Approach

1. Open the file *PI_DataLink_Exercises.xlsx*.

2. Save it as *<your initials>_ PI_DataLink_Exercises.xlsx* then work on sheet *Temperature at a Glance* and fill in data into all of the fields.

3. Use the **Current Value and Archive Value** queries to fill in the template. We should base our PI DataLink queries on cell references whenever possible.

3.5 Background: Retrieval mode

When bringing the archive value to our report, we saw that a timestamp needs to be specified and the archived value will be retrieved for that timestamp. There may or may not be a value archived at the specified timestamp; how does PI DataLink decide just what data is retrieved?

You can decide the data retrieval behaviour by selecting different options from the **Retrieval Mode** drop down list. The default option is **Auto**. Different modes will retrieve the value differently, as listed in the following table:

Retrieval Mode	Data retrieval behaviour
Auto	(**Default**) Interpolates at the exact timestamp provided, unless the data item is a step point, which would retrieve the previous value.
Interpolated	Always interpolates at the exact timestamp provided.
Previous, Next	Retrieves the previous or next compressed event from the timestamp specified. If a compressed event does exist at the exact timestamp, it is retrieved.
Previous Only, Next Only	Same as Previous, Next, except it will ignore any event at the exact timestamp specified.
Exact Time	Retrieves the value if and only if an archived value exists at that exact timestamp (down to the second).

The graph and table below exemplify the different retrieval modes.
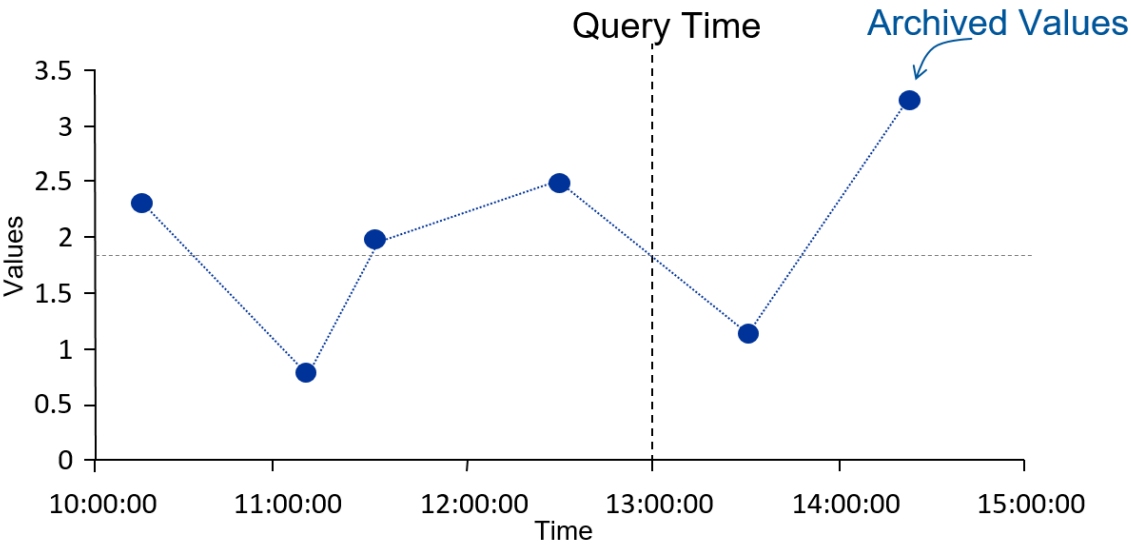
Retrieval Mode	Timestamp	Value
Interpolated	13:00:00	1.8
Previous	12:30:00	2.5
Next	13:30:00	1
Exact	No events found.	No events found.

The next graph shows the difference between Auto and Interpolated for a step point and an analogue point.
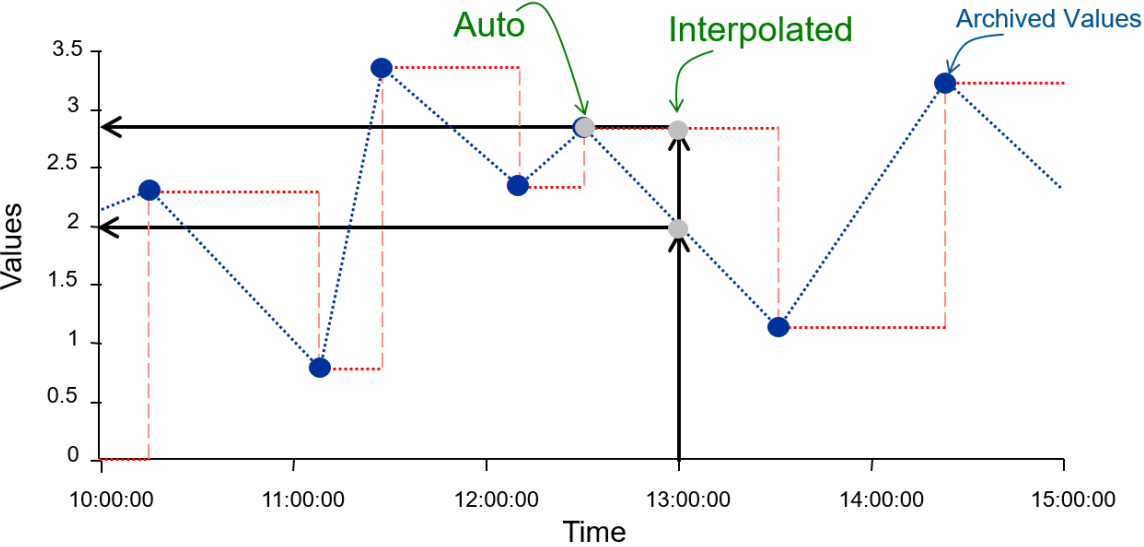
	Auto	Interpolated
Step OFF (Rate point)	13:00:00 - 2	13:00:00 - 2
Step ON	**12:30:00 – 2.8**	13:00:00 – 2.8

3.6 Hands-on: Activity report

During this section, please refer to the following course YouTube video:
Activity report

Activity Description

Your manager needs a report they can open each afternoon to see the current values of KPI's for Mixing Tank2, which are:

- External Temperature
- Internal Temperature
- Level
- Flow Rate

Your manager needs to see the KPIs values at midnight today. Not trusting this new "PI Thing" your manager wants to see archive values around midnight as well as be able to type in a timestamp and see if there is an archive value at an exact time.

Approach

- Open *<your initials>_PI_DataLink-Exercises.xlsx* then work on sheet *Activity Report* and fill in the data in all fields.

- Use the **Current Value and Archive Value** queries to fill in a template.

4 Multiple value queries

4.1 Background: Get PI data with compressed, sampled, and timed data functions

There are three types of queries that return multiple values.

Compressed Data	Actual archived data and is more properly termed Archived data, as not all data may be compressed.
Sampled Data	Evenly spaced interpolated data
Timed Data	Interpolates events to match existing timestamps

Below is a graph of Compressed Data compared to Sampled Data. The Compressed Data function returns all the data that had been archived for the data item of interest. Time intervals between the compressed data values are uneven and depend on when the data was received and archived by the PI System.

You may need to know the value of a data item at specific timestamps, for example at the beginning of every shift. Or you may need to compare the values of two different data items and having unevenly spaced time intervals would not be that helpful. In these cases, using the Sampled Data function is helpful in creating a PI DataLink report.
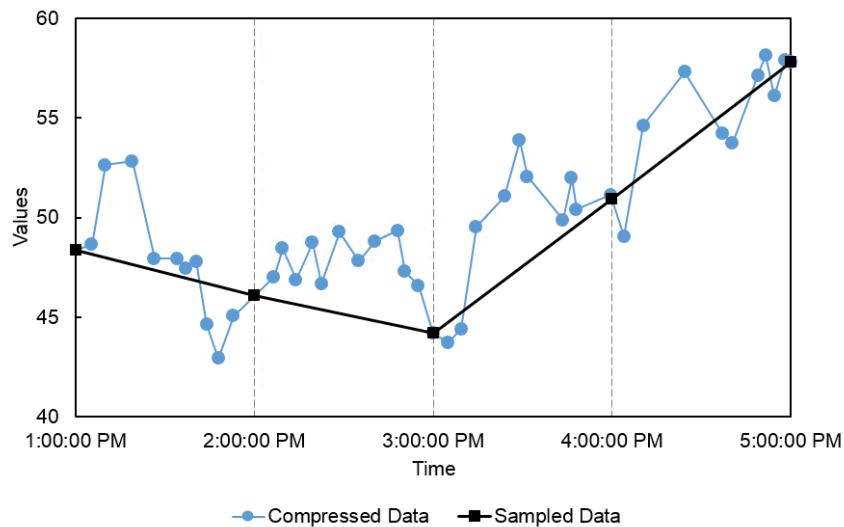
4.1.1 Retrieving Compressed Data

The Compressed Data function retrieves the actual archived data from the Data Archive.

You must specify:

- **Data item(s)**
  - Can specify 1 or more
- **Output cell**
  - Any data currently in this cell will be replaced
- **Start Time** and **End Time**.

Note: If you switch the timestamps for **Start** and **End Times**, the data will be returned in reverse order

There are several optional checkboxes that will affect what is displayed, none of which are selected by default:

- **Hide count**: When this box is unchecked, the top line of your results will return the number of events found within that time range. When this box is checked, this count is not displayed and only the results are shown.

- **Show time stamps:** This checkbox determines if only the point values are returned, or if the corresponding timestamp is also retrieved.

- **Show Value Attributes** and **Show Annotations:** will return additional fields if there are any annotations or quality bits associated with the compressed events within the time range specified.

- **Column** and **Row**: This pair of radio buttons determine if the results are returned in columns or rows.

- The **Number of Values** option for this query behaves similarly, but rather than a specific time range, you will specify a **Start Time** and the **Number of Values** that you would like to retrieve. You can also check the box to have this go backwards, rather than forwards in time.

4.1.2 Obtaining Sampled Data

Sampled Data retrieves evenly spaced interpolated values from the archive. You specify:
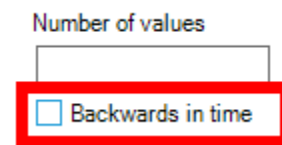
- **Data item(s)**
  - o Can specify 1 or more
- **Output cell**
  - o Any data currently in this cell will be replaced
- **Start Time** and **End Time**.
- **Time Interval**
  - o **Used to divide the time range into discreet intervals.**

4.1.3 Timed Data

The Timed Data function retrieves interpolated events to match existing timestamps. These time stamps are already in your spreadsheet and may be as a result of a related data item query.

The **Data item**, **Retrieval mode**, and **Output cell** need to be specified. In this case, the times used to retrieve events will be a range of cells containing timestamps. This is typically done by querying one point for events, and then using those timestamps to find the values for other, related points. The graph below shows an example of the External Temperature for Mixing Tank1 queried for Compressed data, then going to Mixing Tank2 and getting the Compressed Data then the Timed Data matched to Mixing Tank1 External temperature timestamps.

Compressed and Timed Data

In this hands-on you would like to analyse the archived values of the External Temperature of Mixing Tank1 in your daily report for the first two hours of every day. You would also like to see this temperature value every 10 minutes during these two hours.

You are also interested in doing a comparison between Mixing Tank1 and Mixing Tank2 at the timestamps where there is a value archived for external temperature of Mixing Tank1.

4.2 Hands-on: Archived, sampled, and timed data functions

During this section, please refer to the following course YouTube video:
Archived, sampled, and timed data functions

Approach

Part 1 – Build a Template

1. In Excel, create a Template for your report by typing Data Item, Start Time, End Time and Time Interval in cells A1, A3, A4 and B5, respectively.

2. Using Search, find the attribute External Temperature for Mixing Tank1 and Mixing Tank2 and place them in cells B1 and B2, respectively.

3. Type the Start Time of **T** (in cell B3), End Time of **T+2h** (in cell B4) and time interval of **10m** (in cell B5).

		Mixing Tank1		Mixing Tank2	
	\\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1\External Temperature				
Data Item	\\PISRV01\OSIsoft Plant\Production Area\Production Line2\Mixing Tank2\External Temperature	Compressed	Sampled	Compressed	Sampled
Start Time	T				
End Time	T+2h				
Time Interval	10m				

<u>Part 2 – Query PI Data</u>

1. Obtain the compressed data for Mixing Tank1 External Temperature and list it in cell C3.

2. Do the same for Mixing Tank2 in cell G3.

3. Obtain the sampled data for Mixing Tank1 External Temperature in cell E3.

4. Comparing the timestamps of the compressed data for the two mixing tanks you notice they are not the same so the comparison can't be accurately done. To have a better comparison, use **Timed Data** function and get the External Temperature of Mixing Tank2 at the timestamps in Column C.

4.3 Knowledge check: Tank analysis report

In this knowledge check you will practice extracting values and attributes from the PI System using the compressed and sampled data functions.

Activity Description

Your task is to show the archived values of the **Pressure** of the two **Mixing Tanks** listed in your daily report for the **past 24 hours**. When retrieving the raw archived data for this process variable, you prefer to see **one value each hour for the past 24 hrs**. You will use this report to do some analysis on this critical process variable of the mixing tanks.

Approach

1. Spend a few minutes and fill out the following table:

Data Item	
Start Time	
End Time	
Time Interval	

2. Open *<your initials>_PI_DataLink-Exercises.xlsx* then work on sheet *Tank Analysis Report* and fill in data for all of the fields.

3. Use the **Compressed Data** and **Sampled Data** queries to fill in a template.

Bonus 1

Using Excel functions, modify your report such that you get one value at the top of each hour for the past 24 hours.

Bonus 2

The Excel Insert tab in the **Sparklines** section has several options to show lines and columns as well as additional options to format the axes and colors.

To use this functionality, first select the cell where you want to place the Sparkline. Then choose the Sparkline type. For Data Range, select the cells with the data (just select the values, not the timestamps). Verify your output cell and choose OK. The result is a small trend of your data, with an assumption of evenly spaced values over time.
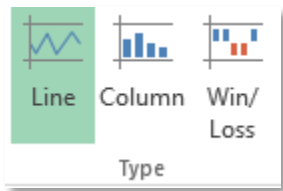
4.4 Background: Element relative PI DataLink reports

PI DataLink promotes the reusability of PI DataLink reports and the creation of Element Relative PI DataLink Reports.

This functionality is provided via Search.

You will need to:

- Set the Root path length to the mark *before* **Name Only**

- Insert root paths in: **Drop-down list**
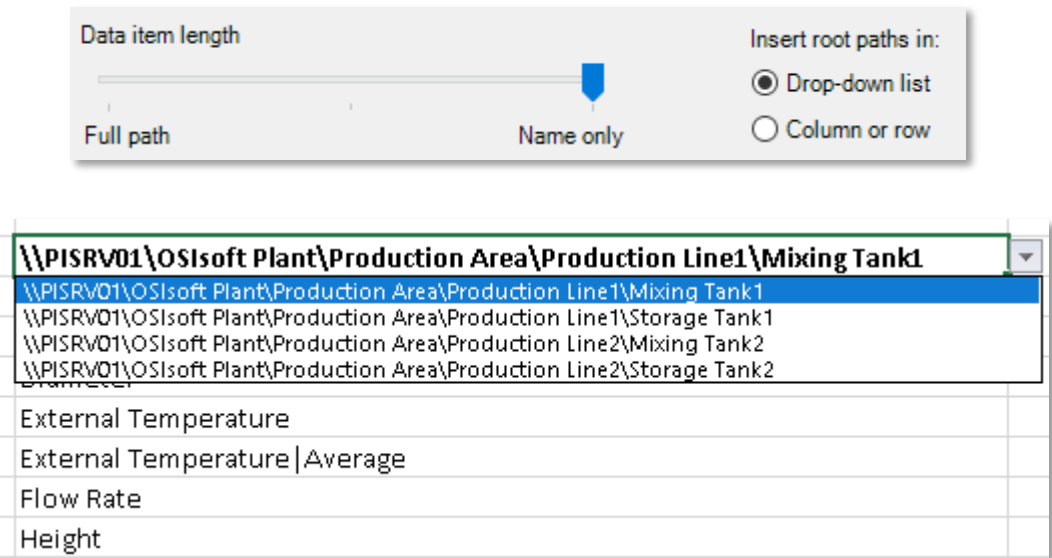
resulting in:

Search for Assets by Filtering

The Element Relative search functionality is provided in PI DataLink through the Asset Filter search option. The Asset Filter is helpful for searching the AF database for elements and filtering the returned elements by the attribute values. Note that you must select an element template to filter elements if using attribute values.

The Asset Filter Search function returns assets that meet specified filter criteria. The returned assets can be used in the worksheet as a function array which can update automatically, or as static values.

The filter criteria include:

- Element name
- Element template
- Element category
- Element description
- Value of attributes

Using the Asset Filter, you will have the option of returning the search results in a Drop-down list which would be used in building reusable reports.

Insert elements in:
◉ Drop-down list
○ Column

Note: The Asset Filter option provides more options in filtering different assets and attributes when creating an Element Relative Report. However, it requires a template for filtering the related assets.

4.5 Hands-on: Element relative PI DataLink reports

During this section, please refer to the following course YouTube video:
Element relative PI DataLink reports

Activity Description

You want to create a report to review the internal and external temperatures for all of the tanks.

Approach

We will follow two approaches in creating this report. The first approach is to use the Search functionality while the second approach is to use the Asset Filter functionality.

Method 1: Using Search

1. Choose cell A1 in Excel

2. Select the AF Server 🗄 > OSIsoft Plant > Production Area in Search.

3. Search for *TEMP*
   You will notice that the results include all the attributes because their parent elements are based on the template named "Generic Tank Template".

4. Repeat the search for *TEMPER*

5. Select all eight (8) results using the <Shift> Click (or individually with Ctrl Click).

6. Use the **Root path length** slider set to the mark before **Name Only.**

7. Set 'Insert root paths in:' to Drop-**down list**.

8. Choose cell B2 and select the **Current Value** function.

9. Select the cells for **Data item(s)** and **Root Path**.

10. Now the Tank path can be modified with the drop-down list.
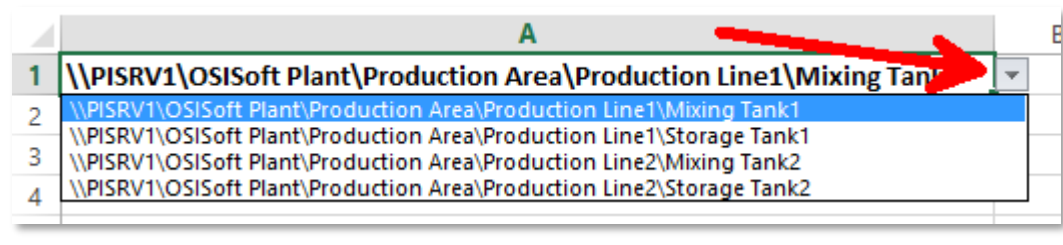
Method 2: Using Asset Filter

1. Add a new sheet.

    a. Choose cell A2.

> ! When working with Asset Filter and selecting the Drop-down list, the drop-down list will appear in the cell **above** your Output cell. The selected Output cell is where the selected attributes will start being listed.

2. Click on **Asset Filter** from the Search section.

3. Under the **Root path** specify the path to the Production Area Element in the form of \\PISRV01\OSIsoft Plant.

4. Under the **Element template,** select "Generic Tank Template".

5. Under the **Attributes to display,** select External Temperature and Internal Temperature.

6. Select **Drop-down list.**

7. Click **Apply.**

4.6 Knowlegde check: Operational start up

Activity Description

You want to determine if there is any deviation between start-up of operations for today compared to yesterday, during the same period of time. Four tanks exist on your plant, and you want to be able to build and reuse a single report for both tanks.

- Your daily shift starts at 6:30 am and the critical start up time is the first 2 hours after the start up.

- Gather the values for the external temperature for this period of time for today and yesterday

- Compare the two by calculating the ratio of the two days' values (ideally, the ratio should stay as close as possible to 1).

Approach

1. Spend a few minutes to fill out the following table:

Root Path			
Data Item			
Yesterday's Start Time		Yesterday's End Time	
Today's Start Time		Today's End Time	
Time Interval	4 Minutes		
Excel function for Comparison (ratio)			

2. You will use the template provided in sheet *Operational Start Up* of the file *<your initials>_PI_DataLink-Exercises.xlsx*.

3. Use both PI DataLink functions of Compressed and Sampled data in retrieving the values and doing the comparison.

4. Which PI DataLink function, do you think, would be more suitable for the purpose of comparison of yesterdays and today's values?
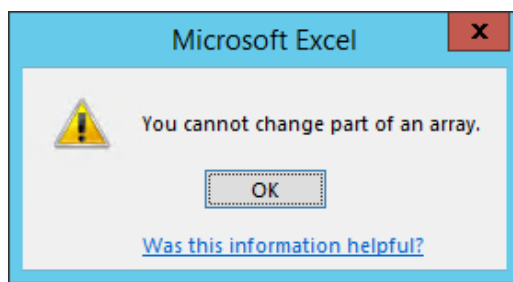
4.7 Background: Excel arrays in PI DataLink

During this section, please refer to the following course YouTube video:
https://www.youtube.com/watch?v=EabeWgcjjfQ&t=1s&ab_channel=OSIsoftLearning

4.7.1 Workflow prior to Dynamic Arrays – PI DataLink version 2019 and earlier

When using the PI DataLink product, end users may see this message below:

The **Multiple Value** functions just discussed actually return an array of values and timestamps. This array cannot be modified cell by cell, but the entire array can be modified. These values can change in size based on the point used, the time range specified, and exception and compression settings. Therefore, it can be necessary to resize the array.

If too many values are returned, you will receive the message "**Resize to show all values**" at the bottom of the array.

To resize an array is to right click anywhere in the array, and choose **Recalculate (Resize) Function**
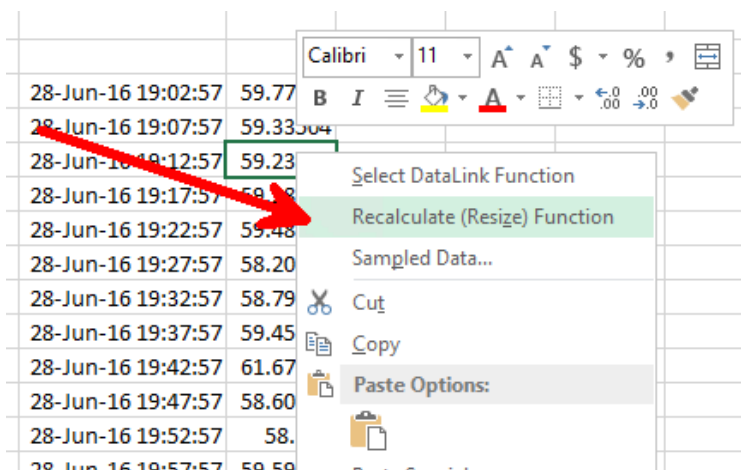
4.7.2 Workflow with Dynamic Arrays – PI DataLink version 2022

Starting with Office 2021 and Office 365 (January 2020 build or later), Microsoft introduced support for *dynamic arrays*. Dynamic arrays can resize themselves if the data they contain updates. For instance, if a compressed data array shows the events which occurred over the last day, and that number of events increases the next time, the spreadsheet opens, and the dynamic array will resize itself without user interaction.

By default, DataLink continues to write legacy function arrays. However, where dynamic arrays are supported, the user has the option to right-click on a legacy function array and convert to a dynamic array. After this conversion, any subsequent modifications to the function through the task pane will write to the sheet as a dynamic array.
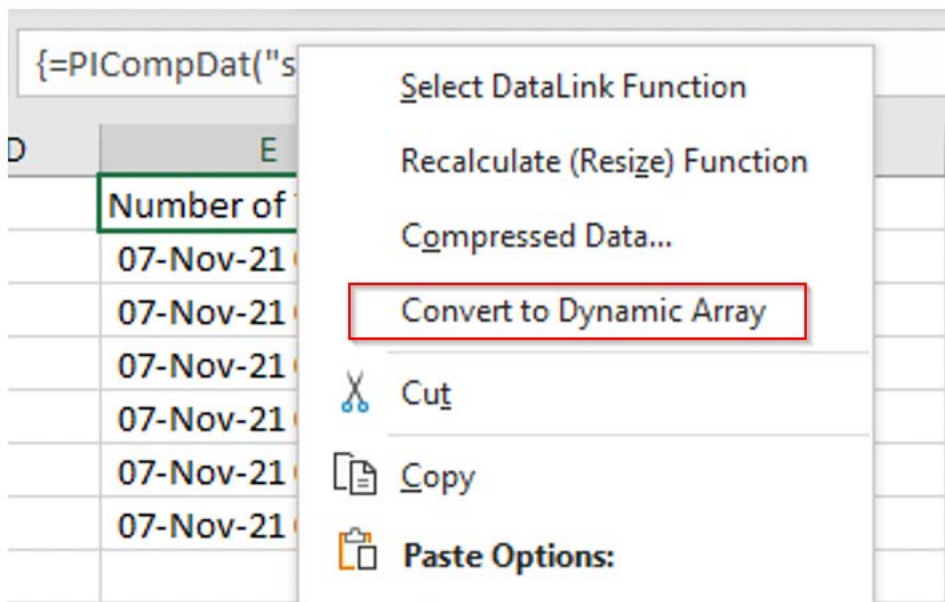
References:

- For more information see "Function arrays" in *PI DataLink User Guide*

4.8 Background: Units of measure and descriptions as context in reports

It is possible to add Units of Measure (UOM) and Descriptions to reports. Doing so will add more context to consumers. It is possible to retrieve these attributes, and any other attributes, for a data item using the **Properties** function.
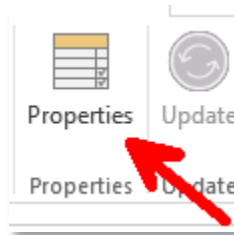
Different Properties will be shown depending on the Data Item listed. For both PI Points and AF Attributes, the Units of Measure are shown as UOM in PI DataLink Properties list.

Data Archive   *AF Server*

5 More PI DataLink functions

5.1 Background: More PI DataLink functions

In the previous lessons, we used different PI DataLink functions to access the raw data stored in PI Server. However, you may not be interested in bringing all the raw data but instead apply calculations on these raw values as they are retrieved from PI Server.

PI DataLink offers two ways to bring in calculated values:

1. Use different predefined calculation modes in PI DataLink as part of the Calculated Data function.

2. Use custom expressions in defining your desired calculation. The syntax used in these calculations is the same as Performance Equations syntax which is explained later.

5.1.1 Calculated Data

The Calculated Data function returns a single calculated value or evenly spaced calculated values for a PI Point or an AF Attribute. Calculation modes are:

- *Total*
- *Minimum*
- *Maximum*
- *Standard deviation*
- *Range*
- *Average*
- *Count*
- *Mean*

These **summary** calculations provide statistical information for data over a specified time period.

Selecting the Data Item radio button of the Calculated Data Function, you will see most of the fields are similar to the other PI DataLink functions you have already worked with.

Some of the fields specific to this function are:

- **Time interval**: An optional field. If used, it allows the behaviour to be similar to the <u>Sampled Data</u> function and the calculations will be done for the evenly spaced time intervals.

- **Calculation mode**: The available modes are the ones listed above.

- **Show percent good:** Checking this option displays the percentage of good data for the calculation time range. You can use this to determine if you want use data that may not be 100% 'good'.

> **Note:** A Bad value for PI System is defined as any of the digital states from the System Digital State Set in the Data Archive. Examples are I/O Timeout, No Data, Shutdown, No Sample, Intf Shut and Arc Offline. It makes no inferences about the Quality of the data in the plant.

- **Conversion Factor**: If the calculation mode is set to **Total,** the conversion factor may need to be changed to a number other than 1.

  For time-weighted total calculations, use the Conversion Factor calculator. From the dropdown make a selection based on the units of measure of the process variable. The required conversion factor number will then be calculated and placed in the Conversion factor field.

  When you click on the calculator icon next to the Conversion factor entry field you will get a popup that lets you select the appropriate conversion factor:
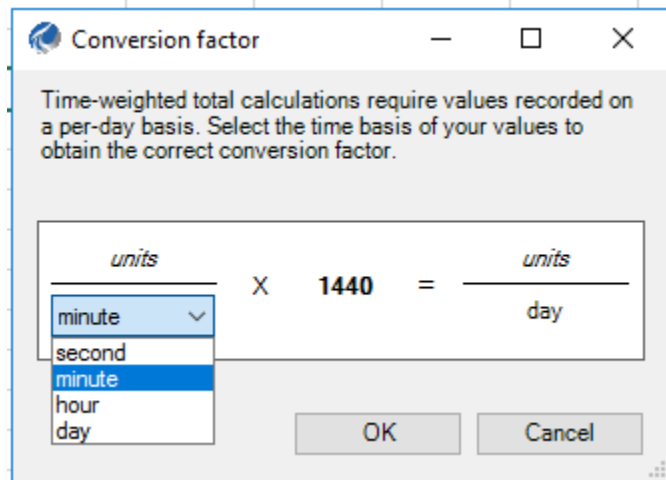
5.2 Hands-on: Calculated data

During this section, please refer to the following course YouTube video:
Calculated data

Activity Description

We want to practice how to use Calculated Data and obtain the Average, Maximum and Minimum of Flow Rate for Mixing Tank1 for the period of past two hours and for the past one day.

Approach

1. In Excel create a template with

   a. **Root Path**: \\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1

   b. **Data Item**: Flow Rate

   c. **Start Time**: *

    d.   **End Time**: *-2h

2.   Obtain the <u>Average,</u> <u>Maximum</u> and <u>Minimum</u> of <u>Flow Rate</u> for this tank and for the past one day.

3.   Change the End Time to *-1d to see the PI Server recalculate these values.

	A	B	C	D	E
1			Average	Maximum	Minimum
2	Root Path	\\PISRV1\OSISoft Plant\Production Area\Production Line1\Mixing Tank1			
3	Data Item	Flow Rate			
4	Start Time	*			
5	End Time	*-2h			

5.3 Background: Calculating total and conversion factor

The conversion factor is a multiplier used to change a number from one unit of measure to another.

Ex: 1000 g per kg, 2.54 cm per inch, 24 hours per day, 1440 minutes per day

Since the Data Archive is not aware of engineering units, it assumes that rate points are in terms of units per day. Typically, this assumption is inaccurate as many points are measured in terms of units per second, units per minute, or units per hour. When using the **Total** function in **Calculated Data**, a conversion factor must be used to correct PI's assumption that the data is in units per day. The conversion factor is equal to 1.0 when the source data are in units per day.

Actual Engineering Unit of the Rate Point	Engineering Unit Assumed by Data Archive	Conversion Factor
units / day	units / day	1
units / hour	units / day	24
units / minute	units / day	1440
units / second	units / day	86400

Example: Flow rate is measure in litres per minute (l/m) and stored in the Data Archive. We are interested in calculating **total** litres for an 8-hour period. Shown in the following illustration, flow rate is:

- 3 l/m for 3 minutes
- 5 l/m for 2 minutes
- 1 l/m for 3 minutes
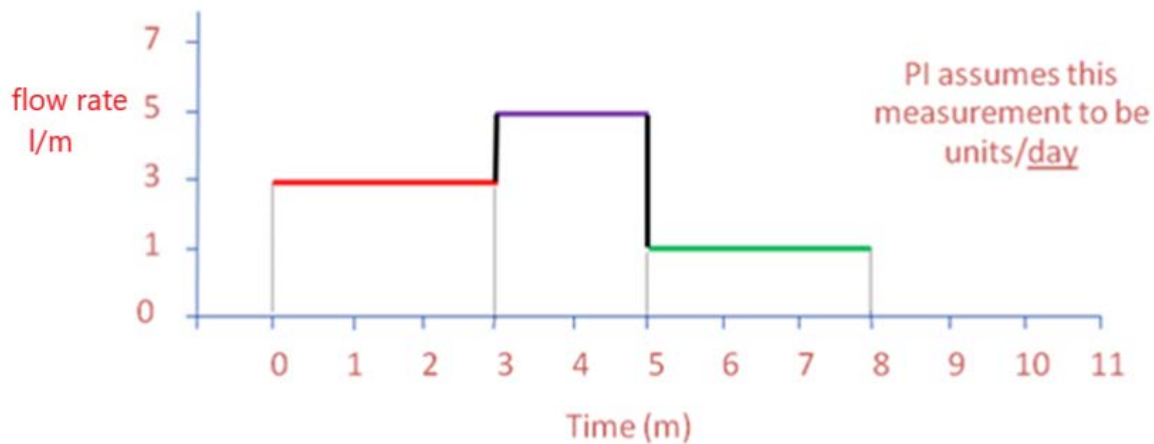
The expected total flow would, therefore, be:

(3 l/m x 3 min) + (5 l/m x 2 min) + (1 l/m x 3 min) = 22 litres

Data Archive, however, assumes the unit of measure of the flow rate is gallons per day. Without applying the conversion factor, the total flow calculated by Data Archive is returned as:

(3 litres per **day** x 3 min x 1 day/1440 min) + (5 litres per **day** x 2 min x 1 day/1440 min) + (1 litre per **day** x 3 min x 1 day/1440 min) = 0.01528 litres

The total computed by the Data Archive must be multiplied by the conversion factor of 1440 to get 22 litres:

0.01528 litres x 1440 = 22 litres

When the calculation mode is **Total** and part of the archived data within the range is bad, the reported value is equal to the calculated total value divided by the fraction of the time period with good archived data. This data normalization is equivalent to the assumption that for the bad data time range, the point value takes on the average value of the entire range. However, this assumption may not be valid when a large fraction of the time range contains bad data. Therefore, we recommend that you always look at the **percent good** value before using the calculation result.

References:

- For more information see "Calculated Data" in *PI DataLink User Guide*

5.4 Hands-on: Calculating the total

During this section, please refer to the following course YouTube video:
Calculating the total

Activity Description

We want to calculate the total Flow and the Average Flow Rate of Mixing Tank1 for yesterday. To know what conversion factor to use, we need to bring the UOM of Flow Rate for Mixing Tank1.

Approach

1. In Excel create a template with

   a. **Root Path**: \\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1

   b. **Data Item**: Flow Rate

   c. **Start Time**: Y

   d. **End Time**: T

2. Add a cell to your report template titled UOM and get this value for Flow Rate using **Properties**.

3. Add a cell to your report template titled Conversion Factor and write the appropriate value there.

4. Calculate the Average

5. Calculate the Total of Flow for the time range (don't forget the Conversion Factor!)

6. Add the percent good.

Root path	\\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1	average	total	% good
Data item	Flow Rate			
Start time	Y			
End time	T			
UOM				
TOTAL conversion factor				

5.5 Knowledge check: Production summaries

Activity Description

As the production manager, you want to create a report showing last week's production statistics. You want to display the following for the production from each day of the past week:

- Total
- Average

- Maximum

You also want to do the same calculations for the <u>entire week</u>.

Approach

1. On the PI Server, the production is the sum of the productions from the two production lines and is stored as an attribute named **Production** under the element of **Production Area**. It is defined as the sum of the flows of the two Mixing Tanks in litres per minute.

2. Spend a few minutes and fill out the following table:

Root Path	
Data item	
Start time:	
End time:	
Time interval:	
UOM	

3. You will use the template provided in sheet *Production Summaries* of the file *<your initials>_PI_DataLink-Exercises.xlsx*. Use the values of your table in the provided template.

> **Note:** When working with the weekly total, do not use the time interval. Only use it for the daily total.
>
> Be sure to show the Start Time for the daily Calculations.
>
> The percent good field is located to the right of an aggregate calculation, so use ☑ Show percent good with the Maximum**.**

5.6 Background: Using time filtered data in a preventative maintenance example

You have a Pump and would like to implement a Preventative Maintenance program. Firstly, you need to determine the period that the pump was running. These total hours can then be checked against the replacement period as indicated in the pump manufacturer's datasheet; every 10,000 hours, for example.

If you have a PI Point recording the status of the pump (when it is ON or OFF) you can report your Preventative Maintenance program by using the **Time Filtered** function. This function returns the amount of time that a performance equation evaluates to true during a specified time period.

You need to specify the following fields for this function:

- **Expression(s)**

  o Can specify 1 or more and it would follow the Performance Equation format. Data items permitted in expressions are:

    PI points

    AF attributes that store data references to PI points

    AF attributes that store constant values

- **Start Time** and **End Time**.

- **Time Unit**

  o i.e., The pump was running for 5 seconds/minutes/hours/days

5.7 Hands-on: Controller state

During this section, please refer to the following course YouTube video:
Controller state

We want to determine the amount of time a controller has been in the **CASCADE** state. The controller is a digital point, named **CDM158**, and has five (5) discrete states. We are only concerned with the CASCADE state at this time.

Approach

1. In Excel create a label for the output cell **Time in Cascade mode (hours).**

2. Choose an empty output cell.

a. Select the Time Filtered function.

3. Use the following values for different fields:

   a. **Expression(s):** 'CDM158' = "CASCADE"

   b. **Start Time:** T-3d

   c. **End Time:** T

   d. **Time Units:** Hours

	A
1	**Time in Cascade mode (hours)**
2	36.267
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

Time Filtered

Root path (optional)

Expression(s)

'CDM158' = "CASCADE"

Start time

T-3d

End time

T

Time interval (optional)

5.8 Knowledge check: Mixing tank level control

Activity Description

Mixing tank1 level going above 7 is an indication of malfunctioning of the pump. In our analysis report, we want to find out for how many hours the pump was malfunctioning during yesterday.

Approach

1. In Excel create a report template similar to the screenshot at the end of the activity.

2. Select cell B1 and search for the Mixing Tank1 Level attribute.

3. Modify the expression and apply the PE syntax rules to 'level'>7

> **Note:** The first ' in an Excel cell is used to signify that the cell content is text and that no Excel formulas should be interpreted. To include an expression in a cell, you need to put a ' at the beginning of the expression.

4. Complete the report template with these values:

   a. Start Time: T

   b. End Time: Y

   c. Time Units: Hours

5. Select the Time Filtered function and use the output cell as B6.

| | "Level'>7 |

	A	B
Root Path	\\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1
Expression	'Level'>7
Start Time	T
End Time	Y

5.9 Knowledge check: Condition based inspection

Activity Description

The pumps on our mixing and storage tanks need to be <u>visually inspected every 4 months only if they have been running for over 2,000 hours</u>. As the person in charge of the Preventative Maintenance program, you want to know the operating time for the pumps on the tanks.

A PI Point does not exist to determine if the pump is ON or OFF, but <u>the pump only runs when the tank **Level** is greater than **1.2**</u>. Find the amount of time the pumps on each of the tanks have been running for the past 4 months and find out if any of the pumps need to be inspected.
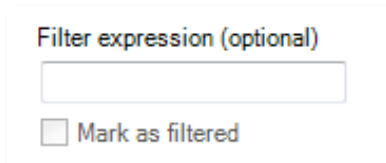
Approach

You will use the template provided in sheet *Condition Based Inspection* of the file *<your initials>_PI_DataLink-Exercises.xlsx*. Get the total Operating Time of the pumps associated with tanks.

1. Use **Asset Filter Search** to bring the list of Assets without any attribute.

    a. Specify the appropriate Root Path and Element Template in the search dialogue box and without selecting any attributes, click Ok.

2. Use **Time Filtered** function to calculate the number of hours each pump was running.

5.10 Background: Filtered data using custom expressions

When using different PI DataLink functions, we noticed an optional field of Filter Expression.

Filter expression (optional)

☐ Mark as filtered

This option is available for the functions of:

- Compressed Data

- Sampled Data

- Calculated data

PI DataLink applies the filter expression to the raw data retrieved and only the values that make the specified expression **True**, would be included. Therefore, for the two functions of Compressed Data and Sampled Data, only the values that make the specified filter expression True would be listed in the output cell. For the Calculated Data function, only the raw values that make the filter expression True, would be considered in the calculations. With the use of Filter Expression, an option of **Mark as filtered** becomes available for the Compressed and Sampled Data functions; if the **Mark as filtered** option is selected, a **Filtered** status is returned for each group of values that does not satisfy the filter expression.

The Filter Expression is a performance equation and follows the formatting rules discussed in the previous section.

> **Note:** When using a cell reference for your Filter Expression, be sure that if the Filter Expression begins with a timestamp or point name that you use two single quotes. The first single quote is used in Excel to identify a text string, rather than a value, and will not be seen by the filter expression. Another option is to enclose the entire filter expression in parenthesis, in which case the extra single quote is not needed.

References:

- For more information see "Expressions" in *PI DataLink User Guide.*

5.11 Background: Excel conditional formatting

This topic is not specific to PI DataLink, but the **Conditional Formatting** found in Microsoft Excel can give your PI DataLink reports a great perspective. It is useful for visually comparing values extracted from PI. **Conditional Formatting** is found in the **Home Ribbon** in the **Styles** section. You can use this functionality to provide highlighted maxima or minima, bar graph backgrounds, and many other visual cues about the data being displayed.

To use this functionality, first highlight the group of cells you wish to format. Then click on the **Conditional Formatting** button and choose a group and rule. For the **Highlight Cells Rules** and **Top/Bottom Rules**, you will see a preview of the formatting once you configure the appropriate limits. For **Data Bars**, **Colour Scales,** and **Icon Sets**, simply hover the mouse over each preconfigured option to preview its effect on the cells you selected. Click the desired rule to select it.

If none of the preconfigured rules suit your needs, you can configure additional rules using **Conditional Formatting > New Rule**. Multiple rules can be applied in configurable order using **Conditional Formatting > Manage Rules.**

> **Note:** The MS Excel `TODAY()` function returns the serial number of the current date. The serial number is the date-time code used by Microsoft Excel for date and time calculations. Microsoft Excel stores dates as whole number of days starting at 1900. Dates and times are values and therefore can be added, subtracted, and included in other calculations.
>
> Syntax: `=TODAY()`
>
> Example: `=TODAY()- 10 + 16/24)` is today minus 10 days at 4 PM

5.12 Knowledge check: Filtered data value queries

Activity Description

Retrieve data using the Compressed Data function and filter out all values below 150 because they are irrelevant to our report.

Approach

Part 1

1. In Excel create a sheet with

   a. **Data Item: CDT158**
   b. **Start Time: T**
   c. **End Time**: T-1d
   d. **Filter Expression**: ''CDT158' > 150

	A	B
2	Point	cdt158
3	Start Time	T
4	End Time	T-1d
5	Filter Expression	'cdt158' > 150

2. Retrieve the Compressed Data and verify there are no values less than 150.
3. Values below 150 are unnecessary and we would not need to include them on our report.

Part 2

1. On a new sheet, create a sheet with

   e. **Tank**: \\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1
   f. **Process Variable**: External Temperature
   g. **Start Time**: T
   h. **End Time**: T-1d
   i. **Filter Expression**: ''External Temperature' > 200

2. Retrieve the Compressed Data and verify there are no values less than 200; the filter expression removed them.

	A	B
1	Tank	\\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1
2	Process Variable	External Temperature
3	Start Time	T
4	End Time	T-1d
5	Filter Expression	'External Temperature' > 200

5.13 Knowledge check: Production level report

Activity Description

As a quality control manager, you want to examine the level of product in Mixing Tank1. Since this is an analogue point, it is better to perform a **Sampled Data** query rather than a **Compressed Data** query.

You want to build a report for the level **yesterday** over **10-minute intervals**. The report filters out mean tank levels, which is defined as a level **between 4 and 6**.

Approach

1. Spend a few minutes and fill out the following table:

|	
Root Path	
Data Item	
Start Time	
End Time	
Interval	
Upper Limit	
Lower Limit	
Filter Expression	

2. You will use the template provided in sheet *Production Level Report* of the file *<your initials>_PI_DataLink-Exercises.xlsx*.

> **Note:** Are you familiar with the Excel function of **CONCATENATE**?

6 Event-related features of PI DataLink

6.1 Background: Understanding the Event Explore and Compare functions

PI DataLink allows browsing and comparing PI Events within Microsoft Excel.
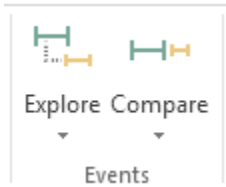
These two Events functions return events that meet specified criteria in an AF database.

- **Explore Events:** this function returns one event per row and nests child events under parent events. This function is useful to show child events under a parent event while preserving the hierarchy structure.

- **Compare Events**: this function returns one event per row but can return attributes from related events in that same row. Specifically, to facilitate event comparison, the function can return attributes from child events or parent events in the same row as the returned event. This function is useful to flatten the hierarchy to show a particular child event that is common for each parent event.

6.2 Knowledge check: Monitoring downtime events

Activity Description

Operations manager needs a report that lists the amount of time that the tanks at your site had been down due to mechanical issues (and not due to scheduled maintenance). Learn how to use event frames data in excel reports.

Approach

1. In Excel select an Output cell

2. Select Explore from the Events tab

3. Make the following selections:

    a. **Database**:
       \\PISRV01\OSIsoft Plant
    b. **Event name**: *
    c. **Search start**: *-1d
    d. **Search end**: *
    e. **Event template**: Downtime
    f. **Element name**: *

4. Expand the More search options section. On the Attribute value filters select the "Reason Code" for the Attribute:

    a. **Reason Code** = mechanical

5. From Columns to display select Event name, Start time, End time, Duration, Primary element, Maximum External Temperature, Maximum Internal Temperature, Reason Code and Temperature Difference.

6. Click Ok.
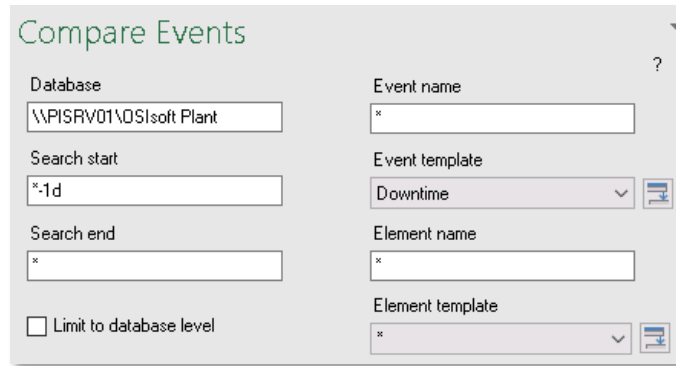
6.3 Knowledge check: Analyzing downtime events

Activity Description

The operations manager now needs a report that shows which downtime reason is most prevalent and a comparison showing which tanks are the most problematic. He also would like to see information about the total production loss from the tanks.

Approach

1. Use the template provided in sheets *Downtime Raw Data* and *Evaluating Tank Downtime* of the file *<your initials>_PI_DataLink-Exercises.xlsx*.

2. Open the *Downtime Raw Data* Tab Select cell A7 as your Output cell

3. Select the Compare from the Events tab

4. Make the following selections:

a. **Database**: \\PISRV01\OSIsoft Plant

b. **Event name**: *

c. **Search start**: *-1d

d. **Search end**: *
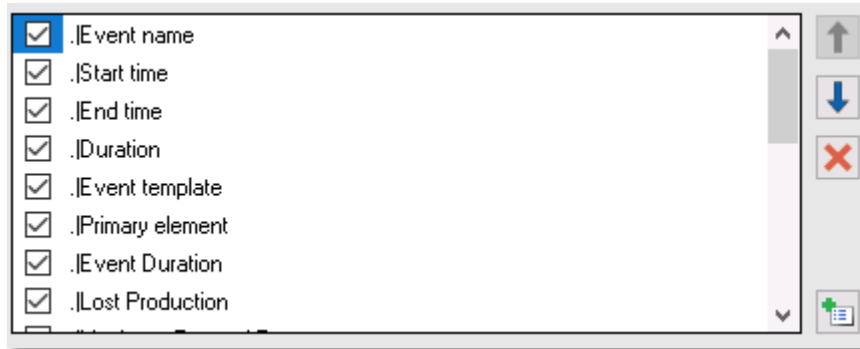
e. **Event template**: Downtime

f. **Element name**: *

5. From Columns to display select:

Event name, Start time, End time, Duration, Event Template,

Primary element, Event Duration, Maximum External Temperature,

Maximum   Internal Temperature, Reason Code, Lost Production, and Temperature Difference.

6. Open the *Evaluating Tank Downtime* sheet.

7. Select the PivotTable under *Comparing Reason Codes*, then, from the Analyse tab, select Refresh
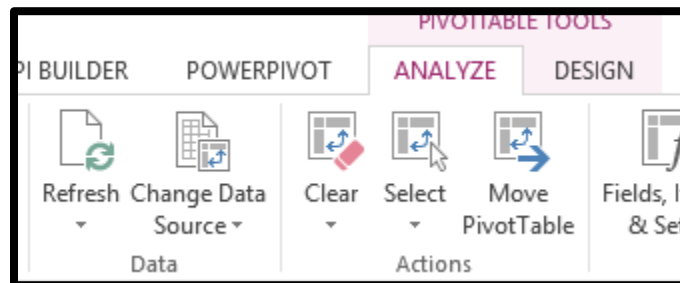
8. Select the PivotTable under *Comparing Tanks*, then, from the Analyze tab, select Refresh

9. Which Reason Code caused the most production loss overall? _____

10. Which Reason Code caused the most production loss for the Storage tanks? _____

11. Which Tank has caused the most production loss? _____

7 Functions using an expression

7.1 Background: Functions using an expression

As we saw earlier, some PI DataLink functions accept either a data item or an expression as input. These functions have **Data item** and **Expression** options at the top of the task pane. So far, we only worked with the Data Item option. In PI DataLink, expressions are performance equations that you can use to incorporate mathematical operations and calculations based on PI System data items.

PI DataLink functions that can use Expressions (as well as Data Item) include:

- **Archive Value** function

- **Sampled Data** function

- **Timed Data** function

PI Expressions behave much the same way that PI PE do. They follow the same expression syntax and can use one or many of the following **Data items:**

> **PI points**
>
> **AF attributes that store data references to PI points**
>
> **AF attributes that store constant values**

The benefit to PI Expressions is that they only calculate on demand. However, the downside is that, unlike PI PE, there is no history of these calculations stored on the PI Server, so it is more difficult to see historical trends.

7.1.1 How is calculated data function different from PI expressions?

One difference between PI Calculated Data and PI Expressions is shown in an example below. The PI Calculated Data computes the maximum of the point over each 1-day period for the last 7 days. The PI Expression shown computes the maximum of the Sampled Data of point for the most recent 8 hours of every 1-day period, for the last 7 days.

Sampled Data ▾

○ Data item
● Expression

Root path (optional)
[ ]

Expression(s)
[TagMax('Sinusoid','*-8h','*]

Start time
[*-7d]

End time
[*]

Time interval
[1d]

Filter expression (optional)
[ ]

☐ Mark as filtered

Calculated Data ▾

● Data item
○ Expression

Root path (optional)
[ ]

Data item(s)
[Sinusoid] [🔍]

Start time
[*-7d]

End time
[*]

Time interval (optional)
[1d]

Filter expression (optional)
[ ]

Conversion factor
[1]

Calculation mode
[maximum ▾] [⬇]

PI Calculated Data

[*-7d]   [*]

time ────────────────────────────►
 1day   1day   1day   1day   1day   1day   1day
 max   max   max   max   max   max   max

PI Expression

 1day   1day   1day   1day   1day   1day   1day
time ────────────────────────────►
 8h   8h   8h   8h   8h   8h   8h
 max   max   max   max   max   max   max
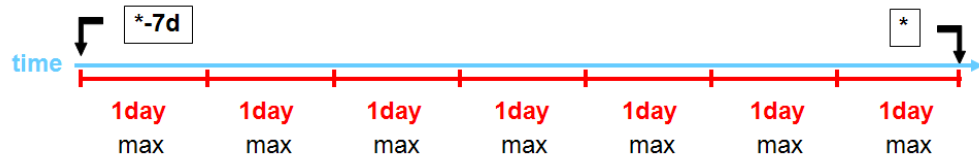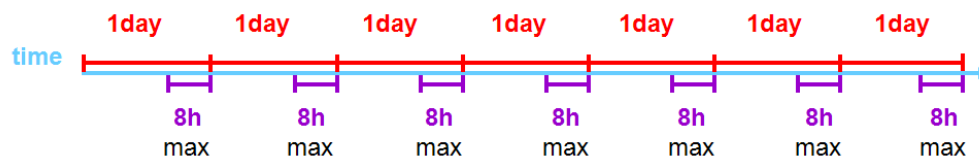
The format for the PI Expression is: TagMax('TagName','*-8h','*')

Just like the PI Calculated Data, it would be configured with a start time of ***-7d**, an end time of *, and an interval of **1 day** (1d). Keep in mind that the '*' in the expression does not always go to the current time of the machine, the '*' in this case is represented by the right side of the 8-hour bar below. If the PI expression was changed to `TagMax('tag','*-1d','*')`, the results of the PI Calculated Data and the PI Expression would be identical. However, the PI Expression will contain an extra interval at the start time of the expression when compared directly with PI Calculated Data

7.2 Knowledge check: Expression queries

Activity Description

We showed how we would be able to see the values of the Flow Rate of Mixing Tank2 for the past one day at the top of each hour, using Sampled Data function.

Here, instead of bringing the raw values of the flow rate, we are interested in getting the <u>difference between the flow rate value and its average for the past day</u>, and have it included in our Excel report.

Note: For simplicity, we will use PI Points in this example. You would be able to do this exercise using the AF Attribute and the Concatenate function in Excel for building the expression.

Approach

1. Open Microsoft Excel.

2. Create a Template with:

   a. **Start Time**: y

   b. **End Time**: t

   c. **Time Interval**: 1h

   d. **Expression**: TagVal('VPSD.OSIsoftPlant.PL2.MXTK2:Flow Rate')-TagAvg('VPSD.OSIsoftPlant.PL2.MXTK2:Flow Rate', '*-24h','*')

3. Use *Sampled Data* function and use *Expression* in retrieving the data

	A	B	C	D	E
1	Start Time	y			
2	End Time	t			
3	Time Interval	1h			
4	Expression	TagVal('VPSD.OSIsoftPlant.PL2.MXTK2:Flow Rate')-TagAvg('VPSD.OSIsoftPlant.PL2.MXTK2:Flow Rate', '*-24h','*')		Flow Rate of Mixing Tank2 Compared with the Daily	
5				30-Jun-16 00:00:00	1487.533
6				30-Jun-16 01:00:00	-863.096
7				30-Jun-16 02:00:00	1185.073

7.3 Knowledge check: Material balance report

**Activity Description**

Two products, named Product A and Product B are being mixed in a tank, as shown in the following schematic.

The flow of Product A is stored in a PI Point named
VPSD.OSIsoftPlant.PL1.MXTK1:FlowRate
and the flow of Product B is stored in a PI Point named
VPSD.OSIsoftPlant.PL2.MXTK2:FlowRate.

PRODUCT B
6.72
1/4/2015 8:17:19 PM

PRODUCT A
127.42
1/4/2015 8:16:49 PM

% of PRODUCT A

You are interested in including the Percentage of Product A in the mix, as it is a critical indicator. There is no PI Point storing this value and you need to calculate it.

You are building this report for the **past 7 days** and would like to list this percentage for the **period of every 2 hours**.
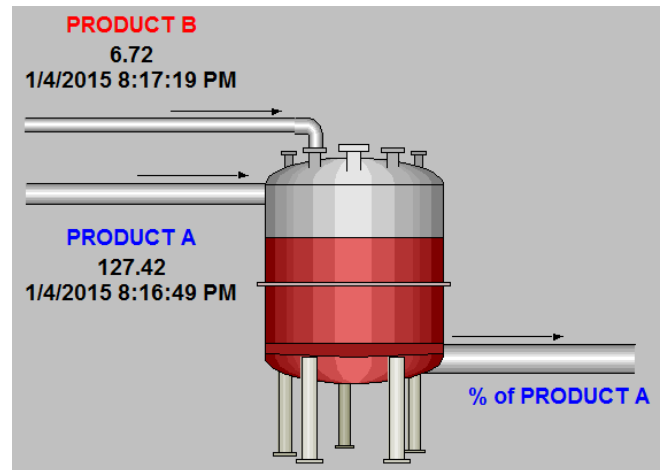
Approach

1. Develop the expression for calculating the Percentage of Product A in the resulting mix.

2. Spend a few minutes and fill out the following table:

Expression	
Start Time	
End Time	
Time Interval	

3. You will use the template provided in sheet *Material Balance Report* of the file *<your initials>_PI_DataLink-Exercises.xlsx*.

4. How would you change the expression if one of the two Products was not flowing, and the associated point was showing a bad value of "Shutdown"? (Hint: If Then Else)

8 Final Exam

The final exam in this course is taken online. Please check the course listing online for more details.