

PI DataLink: Basics

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Table of Contents

Contents

Table of Contents	3
1. Introduction	5
1.1 Learning Objectives	5
1.2 Prerequisites	5
1.3 Useful Resources	6
2. PI System Basics	7
2.1 Map of the PI System	7
2.2 What are PI Assets, Attributes and Tags?	8
2.2.1 What is a PI Point?	8
2.2.2 Assets and Attributes	9
2.3 Time in the PI System	10
2.3.1 PI Time Expressions	10
2.3.2 Fixed Time Syntax	10
2.3.3 Referenced Time Syntax	11
2.3.4 Time offset	12
2.3.5 Time offset syntax	13
2.3.6 Some rules to remember	13
2.3.7 Future Data	14
2.3.8 How does PI Adjust for Time Zones and DST?	14
2.4 Connect to the PI System	15
3. PI DataLink Basics	17
3.1 Introduction	17
3.2 Mind map of PI DataLink	18
3.3 Search for PI Tags and PI AF attributes	18
3.4 Get instantaneous PI data with PI Current Value Function	20
3.5 Get historical PI Data with PI Archive Value Function	21
3.6 Use Root Path References	21
3.7 Build KPI Reports	22
4. Compressed, Sampled and Calculated Data	24
4.1 Get Raw PI data with PI Compressed Data Function	24

- 4.2 Get Custom Interval PI data with PI Sampled Data Function 26
- 4.3 Functions returning Data 27
 - 4.3.1 Directed Activities – Single value queries 27
 - 4.3.2 Directed Activities - Multiple Value Queries..... 32
- 4.4 Interpolation and Retrieval Modes in PI DataLink 34
 - 4.4.1 Interpolated Values..... 34
 - 4.4.2 Retrieval Modes 35
- 4.5 Get Time-Summary Calculations with PI Calculated Data Function 36
- 4.6 PI Calculated Data Function – hourly range of values 38
- 5. Using Time Filtered Data in a Preventative Maintenance Example..... 41
 - 5.1 Time Filtered Data..... 41
- 6. Filtered Data Using Custom Expressions..... 46
 - 6.1 Excel Conditional Formatting 47

1. Introduction

In this course, you will learn how to use this tool to access your process data, create meaningful reports, and use them to make key decisions about your plant performance. PI DataLink is our add-in that allows users to access and deliver data to and from Microsoft Excel and create easy-to-read reports.

This course is for beginning users of PI System data and is open to anyone who wishes to learn more about PI DataLink. If you're a process engineer or a plant operator and are interested in learning about the key features of PI DataLink, how to process data, and create meaningful reports that your end users could use - then this course will be useful for you.

This course was previously titled: Creating Basic Reports with PI DataLink

1.1 Learning Objectives

By the end of this course, you will be able to:

- Understand the PI System Basics
- 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

1.2 Prerequisites

Familiarity with MS Excel is helpful. No specific knowledge of the PI System software is required.

Learners are encouraged to use their own software and data structures whenever possible. This allows each learner to immediately leave the course with something valuable to their enterprise. To complete the exercises and the final project, you need to have the following software installed:

PI DataLink 2013 or later (connected to PI Data Archive and Asset Framework)

If you do not have access to a PI System you can use the included Training Cloud Environment. Go to the Training Cloud Environment section at the end of the course to learn more about it and deploy your cloud environments.

1.3 Useful Resources

- PI DataLink User Guide, available:
 - via the F1 key or question mark on a PI DataLink task pane
 - on [LiveLibrary](#)
 - as a PDF download from the [OSIsoft Customer Portal](#)
- [PI DataLink Playbook](#), which contains:
 - Version history
 - Common data gather steps for troubleshooting issues
 - Architecture and data flow overview
 - Links to articles addressing common issues, sorted by issue type (installation, runtime, admin tasks, etc.)

2. PI System Basics

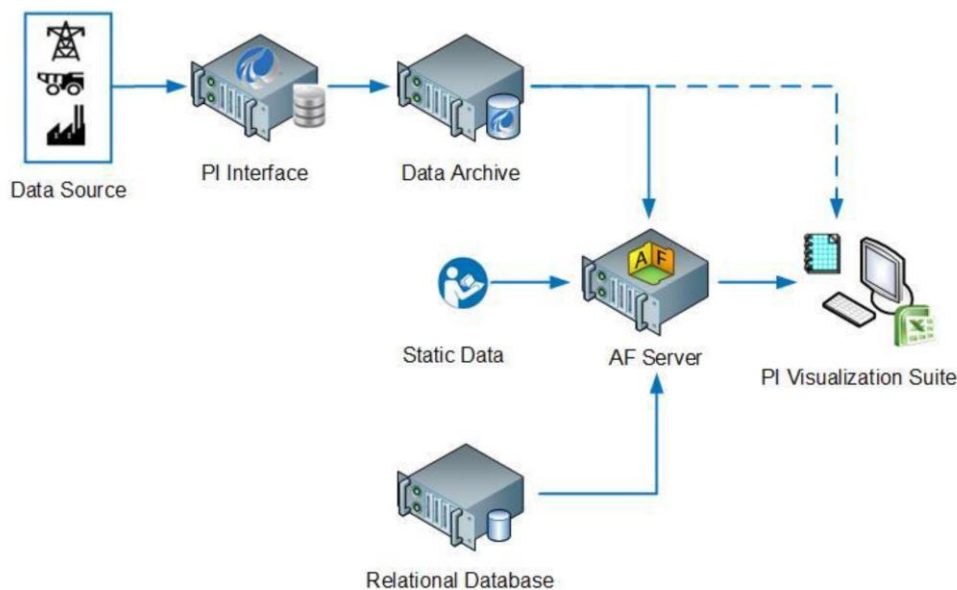
Objectives:

- Define the components of a PI System.
- Draw a diagram of the architecture of a PI System.

2.1 Map of the PI System

The PI System collects, stores, and manages data from your plant or process. You connect your data sources to one or more PI Interface nodes. The interface nodes get the data from your data sources and send it to the Data Archive. Data is stored in the Data Archive and is accessible in the assets defined in Asset Framework (AF). Data can be accessed either directly from the Data Archive or from the AF Server using tools in the PI Visualization Suite (PVS) such as PI ProcessBook. Because of the usability advantages of AF, users are encouraged to consume data by accessing the AF Server rather than directly accessing the Data Archive.

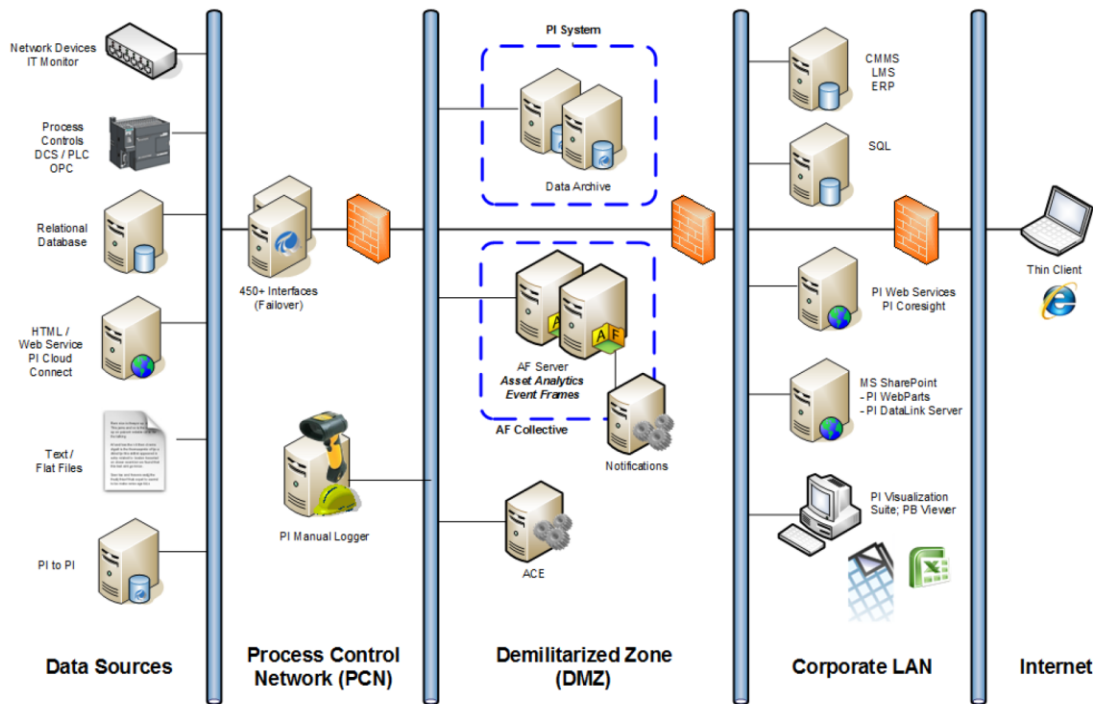
The following is a diagram of the components of a typical PI System:



Sometimes the architecture can be very simple. Some customers have as few as one or two interfaces feeding data to a Data Archive, from which the data can be read through various applications. The following is an example of a fully developed PI System which includes most of the widely used OSIsoft products.

PI Server = Data Archive + PI Asset Framework (AF)

In some companies, there are many Data Archives used for aggregating data.



Note: In computer security, a demilitarized zone, named after the military usage of the term and normally abbreviated to DMZ; also known as a Data Management Zone or Demarcation Zone or Perimeter Network, is a physical or logical subnetwork that contains and exposes an organization's external services to a larger, untrusted network, usually the Internet. The purpose of a DMZ is to add an additional layer of security to an organization's Local Area Network (LAN); an external attacker only has access to equipment in the DMZ, rather than the whole of the network. [Reference: <http://en.wikipedia.org>]

2.2 What are PI Assets, Attributes and Tags?

Objectives

- Define the terms of PI Asset Framework (AF) Asset and its components: elements and attributes.
- Define AF attribute types: static (none), PI Point, point array, formula, string builder, table lookup and Analysis.

2.2.1 What is a PI Point?

PI Point (or PI Tag) is a unique storage point for data in the Data Archive. It is simply a single point of measurement. It has been the traditional storage unit in the PI Server.

Data Archive points have a set of properties called point attributes that define the PI points. Some of these properties are commonly used in client tools for display or informational purposes and are briefly described in the following.

Point name

Unique name is required to create points for storage in the Data Archive. It is a common practice to name the PI Points based on the Control Systems point names. Since the point is the name that identifies the point to users, consistent point-naming convention should be used that is meaningful to people in your organization. Knowing the naming convention can be helpful in searching for points. For example, try to determine what the following point may refer to:

Point name: M03_E1P1_MOTDRV1202_RUNSTAT

It refers to: Machine3 Enclosure 1 Panel 1 Motor Drive 1202 Run Status which is not intuitive.

Some of the other common point attributes that are often used in client tools are listed in the following table.

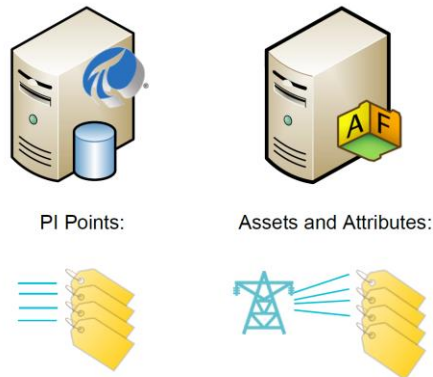
Attributes	Description
Descriptor	This is the human-friendly description of the Data Archive Point. The descriptor is often a search criterion since the point name is not always intuitive. Often the point name is some sort of abbreviated convention, and the descriptor captures the “full name.”
EngUnits	Engineering units (units of measure)
Zero and Span	These define the minimum and maximum values and are used in a number of places. Most obvious are the upper and lower boundaries of object like the trend, bar graph, or multistate symbol.
Point source	Allows grouping of PI points by their interfaces that collect data and is occasionally used in point searching. It requires the knowledge of data source, which is instruments that generate the data of interest (e.g. DCS, PLC, or other sources).

2.2.2 Assets and Attributes

In AF, each piece of equipment or process or company locations and sites is represented by an Element (Asset). It organizes all equipment into a structure that makes it easy to find information. AF can be helpful to users of the Data Archive who know the assets and processes but are not familiar with attribute nomenclature. With assets, data can be located without understanding the technical details of each piece of equipment as the assets are organized hierarchically and logically.

Attributes represent a unique property associated with an asset. Attributes can hold simple values, representing fixed information, such as the diameter of a tank. An attribute can reference a PI point, a formula, a value from a relational database, and more. All relevant data about an asset is tied to the element representing that asset.

AF can automatically generate points as assets are created.



2.3 Time in the PI System

You can use a special syntax, called PI time, to specify inputs for timestamps and time intervals in PI client applications, for example PI Vision. PI time uses specific abbreviations and rules in building valid time expressions.

2.3.1 PI Time Expressions

There are two categories of time specification within the PI system:

- **Fixed Time:** An expression that signifies a specific date and time, which will never change.
 - When to use it: 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 analyzes an equipment failure event which occurred on the 5th of January.
- **Reference Time:** An expression that signifies a date and time relative to the current date and time.
 - When to use it: 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 is creating a report that summarizes the weekly production totals. By using relative time expressions, the user will be able to re-use this report every week.

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

2.3.2 Fixed Time Syntax

A fixed time expression is an expression which includes a date, and optionally a time. If the time is omitted, midnight is assumed.

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

The PI System can interpret 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. For example:

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

2.3.3 Referenced Time Syntax

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

Abbreviation	Full	Reference time
*		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-DD	april-DD	00:00:00 (midnight) on the DDth day of April in the current year

YYYY		00:00:00 (midnight) on the current day and month in year YYYY
M-D or M/D		00:00:00 (midnight) on the Dth day of month M in the current year
DD		00:00:00 (midnight) on the DDth 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
2015	00:00:00 (midnight) current day and month in 2015

2.3.4 Time offset

When specifying PI time, you can use specific abbreviations, listed below, that represent time units. These would be used in constructing *Time Offsets*.

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

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

2.3.5 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	8:00 a.m. today
y-8h	4:00 p.m. the day before yesterday
mon+14.5h	2:30 p.m. last Monday
sat-1m	11:59 p.m. last Friday
1-jan-15-1d	Midnight 31 December 2014

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

2.3.6 Some 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 not valid:
 - * + 1d +4h
 - t – 1d + 12h
- **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 Time is not specified, then the default value would be Midnight.
 - If Day is not specified, then the default value would be Current Day.
 - If Month is not specified, then the default value would be Current Month.
 - If Year is not specified, then the default value would be Current Year.

2.3.7 Future Data

Future data is data associated with a future time stamp. Data Archive 2015 allows storage and retrieval of data with time stamps beyond current time, allowing you to store data within a time range of January 1970 through January 2038. With Data Archive 2015 you can capture and analyze data with future time stamps and use PI visualization tools to graphically create possible forecasts or predictions for your business.

Just as with historical data, to specify inputs for timestamps, you can enter time expressions previous discussed fixed time, reference times, and reference-time abbreviations or fixed times with a time offset. The difference being the timestamp will be in the future. Some example expressions are:

Input	Meaning
* + 1h	An hour from now
t + 3d	Three days from today at midnight
Y + 1y	A year from yesterday

2.3.8 How does PI Adjust for Time Zones and DST?

The short answer is it doesn't!

When Data Archive collects data, it converts the time to UTC (Universal Coordinated Time), or what used to be called Greenwich Mean Time (GMT). This means that each day has exactly 24 hours. The local machine clock of the user looking at the data makes any adjustments for time, such as time zone or Daylight-Saving Time (DST).

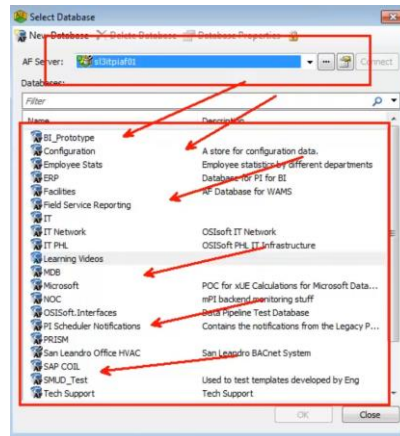
So once a year the day will look like it has 23 hours and another 25, but the Data Archive never knows anything other than 24-hour days.

Also, because the clients and Data Archive know what time zone they are in, the data can be viewed in either Server Time or Client Time. This is determined by a setting in the client tool.

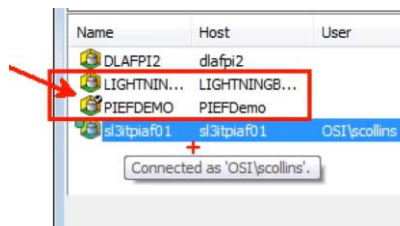
2.4 Connect to the PI System

PI System Explorer is a way we work with a PI AF server. And it's a way we explore what's on our PI System. Once we open it, there is a database button. And once we open the databases, we can see what PI Systems we can connect to. So, when you hit the drop down, these are the PI Systems that are available. Let's say I'm interested in SL3PIAF01. So, I'm going to click on that. And then below, I have a list of all the different databases that are available. Each one of these PI Systems is like a realm of data, it's where we stored a lot of data.

Now what if your PI System that you are interested in isn't on this list?



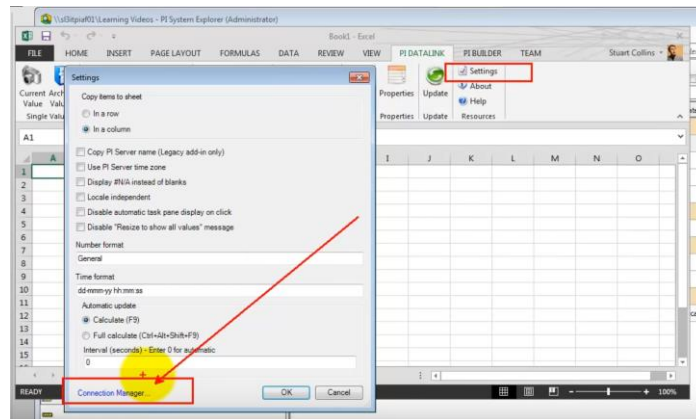
What you can do is you can add the PI System, so you can connect to a system that you aren't connected to yet. And you do that by pressing the Browse "three dots" icon. Once you are in here, you'll see a list of all the PI servers that you can connect to. So right now, I'm already connected to SL3ITPIAF01. If I wanted to add it, all I need to do is right click, add an AF server or you can just click add AF server. And then you are brought to a window which asks what PI System do you want to connect to? So, you just put in the name here, or copy and paste it. And then you press test the connection, connect to the AF server. And if things were successful, you'll see all these fields will get filled out. And you can say OK. And then it is there in your list of systems.



The checkmark means this is the default server. So, when I connect, this is the system that I want to go look at first. Well, let's say this is not the one I want to use. I want to use the one I just added. So, I'm going to right click on it, and I can set it as the default AF server. If you have multiple servers out there, you probably want to set one as the default, which ever one you use, set as default. Say OK.

So, with PI DataLink, PI DataLink is the plug-in to Excel. So, it's just another tab on top here. And the way I would connect to different servers is I'll go to settings. And then connection manager. And I can right click and add an AF server. But I also have

the option of adding one of the classic connections, a PI data archive server. I can do that as well. So, this list includes both of those -- PI Systems and PI servers.



And then in ProcessBook, file, and there are connections and PI Systems. If I select PI Systems, I get the same dialogue box. Select the database, it's the same one that I saw in PI System Explorer.

3. PI DataLink Basics

3.1 Introduction

PI DataLink from OSIsoft allows you to bring PI System data into Microsoft Excel and since Excel is the world's tool of choice for numbers PI DataLink is a very common tool for OSIsoft users. PI DataLink is an Excel add in. It has a separate install file that's downloadable from OSIsoft.com and installed on top of Excel. Once installed PI DataLink appears on the Microsoft Excel ribbon bar. The handful or so of DataLink functions are available by clicking the ribbon buttons and are configured with easy-to-use sidebar wizards. Many people use PI DataLink for either building reports or analyzing their process.

Reporting: before they first use PI DataLink, we often find people copying or pasting or importing raw data from text files and with PI DataLink that's completely unneeded. Your sheets update with live data, and you can ask for more data anytime. At the end of every day, you can open a reports spreadsheet and PI DataLink replaces yesterday's data with today's data and can then email it off. You can have a single spreadsheet template for all your heat exchanger assets and all you need to do is select the heat exchanger from this drop-down list and the spreadsheet calls the data for that heat exchanger. It's all from a single spreadsheet and you save the time you would otherwise spend collecting and formatting data from all over the plant.

Analysis: so, there are many native Microsoft Excel functions that are very powerful for analyzing data, but they just aren't designed with time series data in mind and that's the type of data that the PI system collects for me to process. So, for instance say you have these sensor readings from the past twenty-four hours, if you want to see the maximum sensor reading every hour and what time that reading happened PI DataLink has a function for that and can quickly tell me. To do the same thing with the native Microsoft Excel function you would need to divide the raw data by hour, run a different maximum calculation for each hour and then cross reference with the raw data to find the time that that maximum happened and well that's a lot of steps that PI DataLink can do in one step. And what's more, if all you want to see are the maximum hourly sensor readings, you don't even need all the raw sensor data on the sheet at all; you can clear it away and now the spreadsheet files are much smaller and calculate much faster without all that raw data

The bottom line is PI DataLink puts PI System data in Excel. As a bonus spreadsheets run faster with smaller file sizes, and you have special functions for working with all the time series process data.

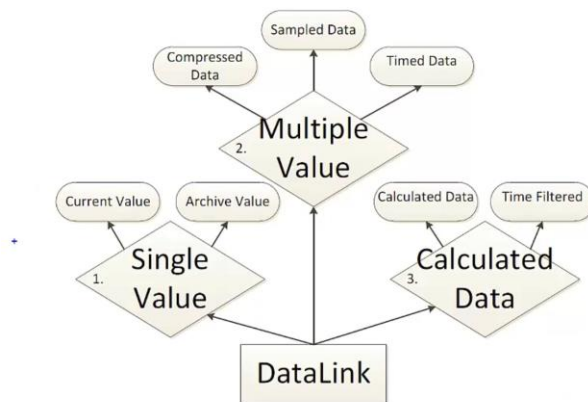
If you are using PI DataLink 2013, the add-in should be activated automatically when you run the install kit. If not, open Microsoft Excel. Then browse to the file section. Then select options. Then select add-ins. Then at the bottom of the window, you can then select the com section and press on go. In this section, you should find the PI DataLink add-in.

If it's not there, you will normally find the file under the program file 32-bit folder. Then PIPC and then Excel. We can now take a look at the connections of PI DataLink. In this version, the connection manager will be found under the settings menu at the bottom of the window. In it, you will be able to see which PI server, the blue one. And

which PI AF server, the orange one, you will have access to. If your server is not there, to add it, simply right click in a blank section of the window and select add another server, either PI AF server or PI server. All you would need to enter after that is simply the name or the IP address of the machine hosting your server.

3.2 Mind map of PI DataLink

The functions found in PI DataLink are setup in three different sections. The single value section, the multiple value, and the calculated value section.



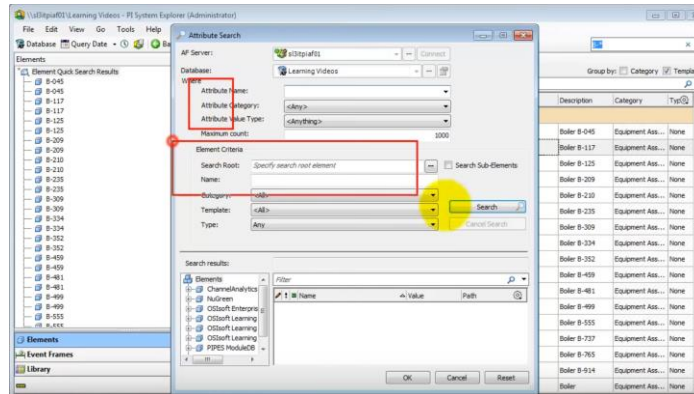
In the single value, you will find the current value function and the archived value function. The current value returns the latest value available that we also call snapshot value for a specific data item of your system. As for the archive value function, you will obtain a value of a tag or attribute for a specific moment in time

The multiple value section is composed of the compressed data function, the sample data function, and the time data function. The compressed data will return all the archived value of your PI system for a data item. The sample data works a little bit the same way as the compressed data function. But this time, instead of getting all the archive value, you will get the value that would follow a specific time interval.

Finally, the last function of this section is the time data function. This function will return the value for a specified timestamp. The calculated data section is composed of two different functions which would be the calculated data and the time filter function. The first one will return a calculation such as the average, the minimum, the maximum or the total over a specific period of time for a data item. The time filter function will return the time spent respecting specific criteria for a data item.

3.3 Search for PI Tags and PI AF attributes

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



Procedure

1. In the navigator pane, click Elements.
2. Choose from the following actions
 - a. From the PI System Explorer menu, select Search > Attribute Search.
 - b. In the browser, right-click the Element Searches collection and select New Attribute Search.
3. Set the Attribute Search window to find the desired attributes in the PI AF database:
 - a. Under Where, set the fields to restrict attributes retrieved:
 - i. **Attribute name** - Enter the name of the attribute to retrieve. You can enter special characters to match part of a name.
 - ii. **Attribute description** - Enter a string (of up to 440 characters) that retrieved attributes must match.
 - iii. **Attribute category** - Select the category that retrieved attributes must match.
 - iv. **Attribute value type**- Select the type of value that the retrieved attributes must store.
 - v. **Maximum results** - Enter the maximum number of matching attributes to retrieve.
 - b. In the Element Criteria area, set the fields to restrict the elements searched for matching attributes:
 - i. **Search Root** - Enter the element that you want to use as the root or base level for the attribute search. Type the exact name or click Browse (...) to open the Element Browser window, where you can view the element hierarchy and select an element. You cannot include wildcard characters in the entered name. If you do not specify an element, you set the main level of the element hierarchy as the root. Depending on your PI AF hierarchy, specifying an element in the Search Root field can improve search performance. Select the **Search Sub-Elements** check box to search the entered root and any sub-elements. Clear this check box to search only the entered root.
 - ii. **Name** - Enter the name of the elements in which you want to search for attributes. You can enter special characters to match part of a name.
 - iii. **Description** - Enter a string (of up to 440 characters) to retrieve only those elements that match.
 - iv. **Category** - Select the category of the elements in which you want to search for attributes.

- v. **Template** - Select the template of the elements in which you want to search for attributes.
- vi. **Type** - Select the type of the elements in which you want to search for attributes.

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

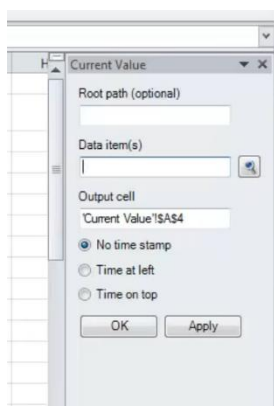
4. Click **Search** to retrieve the matching attributes into the **Search results** table.
Alternatively, use the element tree under **Search results** to browse for attributes under particular elements, and then select the attributes to add them to the **Search results** table.
Remember that the attributes available by searching and the attributes available by browsing the element hierarchy depend on the configuration properties of the attributes.
5. Select items in the search results list and click **OK**.
The results are displayed in the viewer and in the browser tree.

3.4 Get instantaneous PI data with PI Current Value Function

The Current Value function returns the most recent value of a historical PI point or PI AF attribute. For a future PI point, the value returned depends on the time stamps of recorded values relative to the current time:

- If all recorded values have time stamps before the current time, the function returns the last recorded value.
- If recorded values have time stamps that straddle the current time, the function returns an interpolated value.
- If all recorded values have time stamps after the current time, the function returns no data.

What do we need to call for the current value of something in our PI System?



Root path – the common path to specified data items

Data item – one or more PI point names or PI AF attribute names, for which the function returns values.

Output cell - where on the sheet we will put the actual output

No time stamp - return only values

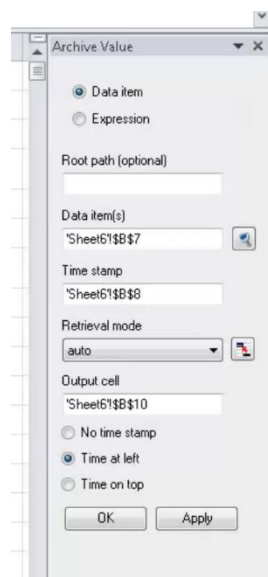
Time at left - the time stamp in the left column and the value in the right column.

Time on top - return two rows: the time stamp in the top row and the value in the bottom row.

3.5 Get historical PI Data with PI Archive Value Function

If you select the Data item option, the Archive Value function returns the value of a PI point or a PI AF attribute at a specified time stamp. This function supports bulk calls.

If you select the Expression option, the Archive Value function returns the computed value of a performance equation at a specified time stamp.



Root path – the common path to specified data items

Data item – one or more PI point names or PI AF attribute names, for which the function returns values.

Expression - One or more performance equations that the function computes a value for.

Time stamp – the time stamp for which the function returns values. Specify either a fixed time or a time expression relative to the current time.

Retrieval mode – Available if you select the Data item option. The method the function uses to determine returned values: previous (returns the value that exactly matches or precedes the specified time stamp), previous only (returns the value that precedes the specified time stamp), interpolated (returns the interpolated value at the specified time), auto (returns the interpolated value at the specified time, or follows the previous method, uses the previous method for data items

with step attributes), next (returns the value that exactly matches or follows the specified time stamp), next only (returns the value that follows the specified time stamp), exact time (returns only a value that exactly matches the time stamp, or returns No events found if no value exists at that time stamp).

Output cell - where on the sheet we will put the actual output

No time stamp - return only values

Time at left - the time stamp in the left column and the value in the right column.

Time on top - return two rows: the time stamp in the top row and the value in the bottom row.

3.6 Use Root Path References

The root path is the common path to specified data items. Valid entries include:

- PI Data Archive server name if the data item is a PI point.
- PI AF server and database if the data item is a PI AF attribute.
- Blank if the data item is a PI point on the default PI Data Archive server.

When you define a function, you specify the paths to data items with the Data item, Expression, and Filter expression fields along with the optional Root path field. You can specify:

- Fully qualified paths in the Data item, Expression, or Filter expression fields. A fully qualified path begins with two backslashes (\\) and evaluates to either a PI point or a PI AF attribute.
- Partial paths in the Data item, Expression, or Filter expression fields and the common base path in the Root path field. PI point names or PI AF attribute names are examples of partial paths. PI DataLink combines the common base path with the partial path to set the full path that evaluates to either a PI point or PI AF attribute.

PI DataLink requires a full path to find the data item. To find a PI point, PI DataLink must know the PI Data Archive server to search and the point name. To find a PI AF attribute, PI DataLink must know the PI AF server, the database, the element, and any sub-elements or parent attributes. Use a pipe (|) to separate attributes from elements or parent attributes.

You can leave the Root path field blank if the Data item, Expression, and Filter expression fields contain a fully qualified path or a PI point on the default PI Data Archive server.

If specified, the Root path field indicates the common path to the specified data items.

Type of data item	Content of root-path field
PI point	<p>PI Data Archive server that stores the point or a blank to indicate the default PI Data Archive server. Valid entries include:</p> <ul style="list-style-type: none"> • MyPIDataArchiveServer • \\MyPIDataArchiveServer
PI AF attribute	<p>PI AF server and database along with any elements, sub-elements, and parent attributes not specified in Data item. Valid entries include:</p> <ul style="list-style-type: none"> • \\MyPIAFServer\\MyDatabase • \\MyPIAFServer\\MyDatabase\\MyElement • \\MyPIAFServer\\MyDatabase\\MyElement\\MySubElement • \\MyPIAFServer\\MyDatabase\\MyElement\\MyParentAttribute • \\MyPIAFServer\\MyDatabase\\MyElement\\MyParentAttribute1 MyParentAttribute2

Note: The PI AF server and database must be in the same field. You cannot specify the PI AF server in the Root path field and the database in the Data item field.

3.7 Build KPI Reports

So, let's start with a blank spreadsheet. The first thing you will need to do is to define the different data that you will want to obtain the KPIs. The easiest way to obtain such information within PI DataLink is to use the search functionality that you find just right there. If you click on the icon, you will have two different options, the first one will be search through the PI Server, for the PI Points you're interested, but the other problem with that kind of search is that you need to know every single name of those points. The second option, which is easier, is to browse through the error key of the PI AF

Database, in order to find elements that you are looking for. In that case, if you browse into the wind field PI database, and select the wind field generation fleet and Black Mesa Windfarm you will be able to search for a common KPI. Let's say, in the case the monthly energy actual. This will be the first KPI we are interested in.

Monthly KPIs for Black Mesa Wind Farm

	Monthly Energy Actual KPIs	Monthly Energy Last Month KPIs	Monthly Energy Expected KPIs
4. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE1	40002.50	376429.69	424467.47
5. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE2	40002.50	42700.00	400029.97
6. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE3	40002.50	36400.00	400029.97
7. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE4	40002.50	36700.00	400029.97
8. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE5	40002.50	37000.00	400029.97
9. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE6	40002.50	37300.00	400029.97
10. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE7	40002.50	37600.00	400029.97
11. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE8	40002.50	37900.00	400029.97
12. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE9	40002.50	38200.00	400029.97
13. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE10	40002.50	38500.00	400029.97

Daily KPIs for Black Mesa Wind Farm

	Daily Energy Actual KPIs	Daily Energy Expected KPIs	Operating Efficiency KPIs
1. \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE1	40002.50	376429.69	75.40

Search Panel:

Root path (optional): \\\PIA4\Wind\api\Wind Power Generation Fleet\Black Mesa Wind Farm\UE1

Data item (optional): Monthly Energy Actual

Property: Monthly Energy Actual

Output cell: 1

Buttons: OK, Cancel

What you will be able to do after that is to separate the root path from the data item to present the KPIs in the form of a table. In this case the root path selection represents different windmills found in the farm, and the data item is the actual KPI value. Once this is selected, you can either import it in column or row or in a drop-down list. For this one let's just select a column or row options, and import. All you have to do is click on OK. Once this is done, we can select the other KPIs we are interested in. So, you can either search for them with the search functionality or if you know their name, simply write it down like this into the Excel spreadsheet. Once this is done, you can do the same thing but this time for daily KPIs. So, if you open the search panel, you will be able to select the root path, but this time for the daily KPI. And this time you will select the drop-down list. After that, all we need to do is add the different KPIs to the table, and we're set as for the data icon.

Now that this is done, let's get the first value of the first KPI, in this case it will be the monthly energy actual. In order to obtain the last value for this data item, we will be using the current value function, the function that returns the latest value from a specific data item of your PI Service. If we click on this function, a panel will open on the right side of the screen. We can see that there are only three sections. The first section, the root path is the value we obtained from the search function. In this case, this value also represents the wind mill we are interested in. The second one, the data item, is the actual KPI. And finally, the last one, is the output cell, is where you want the value to be shown. We could simply directly enter the values in the corresponding fields of the function, but it's a lot more practical to use the cell references. Cell reference will give you the opportunity to change any parameters of the function directly from your spreadsheet, making your reports a lot more dynamic.

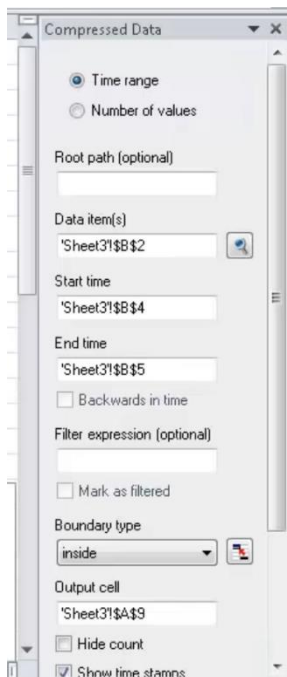
4. Compressed, Sampled and Calculated Data

4.1 Get Raw PI data with PI Compressed Data Function

If you select the Time range option, the Compressed Data function returns all the values of a PI point or PI AF attribute along with a count of values that occur during a specified time period.

If you select the Number of values option, the Compressed Data function returns a specific number of point values or attribute values beginning at a certain time.

Note: Values stored in the archive of PI Data Archive undergo a compression algorithm that removes all values that represent the same slope. Values stored in the PI Data Archive snapshot have not undergone this compression algorithm. If you specify the current time in the time period of the Compressed Data function, the function retrieves a snapshot value for that time. That snapshot value might not be subsequently stored in the archive due to compression.



Root path - The common path to specified data items, including those in expressions.

Data item(s) - One or more PI point names or PI AF attribute names, for which the function returns values.

Start time - The start of the time period for which the function returns values.

End time - The end of the time period for which the function returns values.

Number of values - The number of values that the function returns, beginning at Start time.

Backwards in time - Select this check box to return values recorded at Start time and earlier. Available if you select the Number of values option and enter a value in the Number of values field. If you enter a cell reference in the Number of values field, this check box is disabled.

Filter expression - A Boolean performance equation that the function uses to filter values. When the expression evaluates to false, the function excludes corresponding values.

Mark as filtered - Select this check box to insert the label “Filtered” in place of a value or block of values that the function filtered from the output based on Filter expression.

Boundary type – The method that the function uses to determine which values to return near the start time or end time:

- inside (default) - Returns values at start and end times, if they exist, or the nearest values that occur within the range.
- Outside - Returns the nearest values that occur immediately outside the range.

- **Interpolated** - Returns interpolated values at the start and end times.
- **Auto** - Returns interpolated values, but uses the inside method for data items with step attributes.

Output cell - The worksheet cell where the function writes the resulting function array.

Hide count - Select this check box to hide the count of returned values and show only returned values. Available if you select the Time range option.

Show time stamps - Select this check box to show the time stamp that corresponds to each returned value. PI DataLink shows time stamps to the left of values displayed in a column or above values displayed in a row.

Show value attributes - Select this check box to show the extended status bits associated with returned values. PI DataLink shows value attributes in a column to the right of the values. Possible status bits include:

- **A** - Annotated. Indicates the value has a comment.
- **S** - Substituted. Indicates the value has changed from its originally recorded value.
- **Q** - Questionable. Indicates that there is some reason to doubt the accuracy of the value.

Show annotations – Select this check box to show annotations associated with returned values. Annotations contain notes or comments that describe a data value. PI DataLink shows annotations in a column to the right of the value.

Column – Click this option to return values in a column.

Row - Click this option to return values in a row.

Note: If you specify a range of items in Data item(s) or a range of expressions in Expression(s), PI DataLink automatically selects Column or Row to match the orientation of the specified range.

4.2 Get Custom Interval PI data with PI Sampled Data Function

If you select the Data item option, the Sampled Data function returns evenly spaced, interpolated values for a PI point or PI AF attribute over a regular interval.

If you select the Expression option, the Sampled Data function returns evenly spaced, interpolated values of a performance equation over a regular interval.

Root path - The common path to specified data items, including those in expressions.

Data item(s) - One or more PI point names or PI AF attribute names, for which the function returns values.

Expression - One or more performance equations that the function computes a value for.

Start time – The start of the time period for which the function returns values.

End time – The end of the time period for which the function returns values.

Time interval - The frequency that the function returns calculated values during the time period. Enter a value and time unit. For example, enter 15m (15 minutes) to return a value for every 15-minute interval in the time period.

Filter expression - A Boolean performance equation that the function uses to filter values. When the expression evaluates to false, the function excludes corresponding values.

Mark as filtered - Select this check box to insert the label Filtered in place of a value or block of values that the function filtered from the output based on Filter expression.

Output cell - The worksheet cell where the function writes the resulting function array. If you select a cell before you open the function task pane, PI DataLink inserts the selected cell into the Output cell field.

Show time stamps – Select this check box to show the time stamp that corresponds to each returned value. PI DataLink shows time stamps to the left of values displayed in a column or above values displayed in a row.

Column – Click this option to return values in a column.

Row - Click this option to return values in a row.

Note: If you specify a range of items in Data item(s) or a range of expressions in Expression(s), PI DataLink automatically selects Column or Row to match the orientation of the specified range.

4.3 Functions returning Data

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.

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

4.3.1 Directed Activities – Single value queries

Learning Outcomes

- Retrieve a current value for a data item
- Retrieve an archived value for a data item

- Describe the different retrieval modes
- Retrieve data item attributes

Directed Activity – Single Value Query



You are invited to perform the same steps at the same time to explore the different concepts presented in this chapter or section. *Use your own data if you have access to such data.*

Objectives

- Perform Single Value Queries in PI DataLink

Activity Description

We 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 1 – Get Current Values

- Step 1 :** Open Excel and in cell A1 type Current Values as a heading.
- Step 2 :** Click on cell A2. Select **Current Value** function.
- Step 3 :** Click on the magnifying glass next to **Data Item(s)** box.
- Step 4 :** Search for the External Temperature of Mixing Tank2.
- Step 5 :** Select **Time at Left** and click **OK**.
- Step 6 :** Repeat these steps for Pressure and Flow Rate in cells A3 and A4, respectively.

Part 2 – Add Archive Values

- Step 1 :** In cell C1 type Archive Values as a heading.
- Step 2 :** Click on cell C2. Select **Archive Value** function.
- Step 3 :** Click on the magnifying glass next to **Data Item(s)** box.
- Step 4 :** Search for the External Temperature of Mixing Tank2.
- Step 5 :** Type Y+7h in the **Time stamp** box. What time stamp will be retrieved? _____
- Step 6 :** Select **Time at Left** and click **OK**.
- Step 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?

Directed Activity – Single Value Query Using Cell Reference



You are invited to perform the same steps at the same time to explore the different concepts presented in this chapter or section. *Use your own data if you have access to such data.*

Objectives

- Perform Single Value Queries in PI DataLink

Activity Description

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

Approach

Part 1 – Build a Template

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

Step 2 : Select the AF Database of OSIsoft Plant. 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.

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

Step 4 : In cell B1 type Current Value. In cell D1 type Archive Value as headings.

Step 5 : In cell A4 type Timestamp, in B4 type t+4.5h. What time do you expect to see?

Step 6 : 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			

Part 2 – Query PI Data

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

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

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

Step 4 : 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**.

Exercise –Temperature at a Glance



This solo or group activity is designed to maximize learning in a specific topic area. You can access the PI Square space of this course if you need assistance during the activity. *Use your own data if you have access to suitable data.*

Objectives

- Extract values and attributes from the PI System using the following functions:
 - Current value
 - Archive value

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 7 am today.

Approach

Step 1 : Open the file *PI_DataLink-Exercises.xlsx*.

Step 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.

Step 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.

Exercise – Activity Report



This solo or group activity is designed to maximize learning in a specific topic area. Access the PI Square space of this course if you need assistance during the activity. *Use your own data if you have access to such data.*

Objective

- Extract values and attributes from the PI System using the following functions:
 - Current value
 - Archive value

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 9 AM this morning. Not trusting this new “PI Thing” your manager wants to see archive values around 9 AM as well as be able to type in a timestamp and see if there is an archive value at an exact time.

Approach

Step 1 : Open *<your initials>_PI_DataLink-Exercises.xlsx* then work on sheet *Activity Report* and fill in data into all of the fields.

Step 2 : Use the **Current Value** and **Archive Value** queries to fill in a template.

✓ Quick Check

Can you:

- retrieve a current value?
- retrieve an archived value?
- describe the different retrieval modes?
- retrieve data item attributes?

If you answered NO to any of these questions, join the community on PI Square for assistance.

4.3.2 Directed Activities - Multiple Value Queries

Directed Activity – Archived, Sampled and Timed Data Functions



You are invited to perform the same steps at the same time to explore the different concepts presented in this chapter or section.

Objectives

- Retrieve archive data with the different multiple value functions

Activity Description

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.

Approach

Part 1 – Build a Template

Step 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.

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

Step 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).

	A	B	C	D	E	F	G	H	I	J
1	Data Item	\\PISRV01\OS\soft Plant\Production Area\Production Line1\Mixing Tank1\External Temperature	Mixing Tank 1		Mixing Tank 2					
2		\\PISRV01\OS\soft Plant\Production Area\Production Line2\Mixing Tank2\Internal Temperature	Compressed		Sampled		Compressed		Sampled	
3	Start Time	T								
4	End Time	T+2h								
5	Tim Interval	10m								
6										

Part 2 – Query PI Data

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

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

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

Step 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.

Exercise – Tank Analysis Report



This solo or group activity is designed to maximize learning in a specific topic area. Ask the PI Square community if you need assistance during the activity. *Use your own data if you have access to suitable data.*

Objective

- Extract values and attributes from the PI System using the following functions: Compressed Data, Sampled Data.

Activity Description

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

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

Data Item	
Start Time	
End Time	
Time Interval	

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

Step 3 : We will use the **Compressed Data** and **Sampled Data** queries to fill in a template.

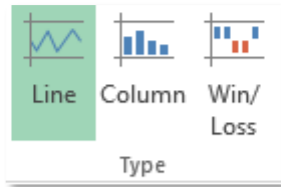
Bonus 1

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.



✓ Quick Check

Can you:

- Retrieve compressed data for a point?
- Retrieve sampled data for a point?
- Retrieve timed data for a point?

If you answer NO to any question, ask the PI Square community for assistance.

4.4 Interpolation and Retrieval Modes in PI DataLink

4.4.1 Interpolated Values

Many PI DataLink functions can return interpolated values, useful for PI points associated with time stamps. For example, you might request that the Archive Value function return an interpolated value at a particular time stamp rather than the last recorded value that precedes the time stamp. The interpolated value depends on the time stamps of the recorded values and possibly on the type of PI point:

- For time stamps before the first recorded value, the function returns either Pt Created or No Data.
- For time stamps between two recorded values, the function determines the value at the time stamp using linear interpolation between the recorded values. For points that store discrete values, such as digital state points or step points, the function returns the last recorded value that precedes the time stamp.
- For time stamps after the last recorded value, the returned value depends on the point type:
 - For historical PI points, the function returns the most recent value.
 - For future PI points, the function returns No Data.

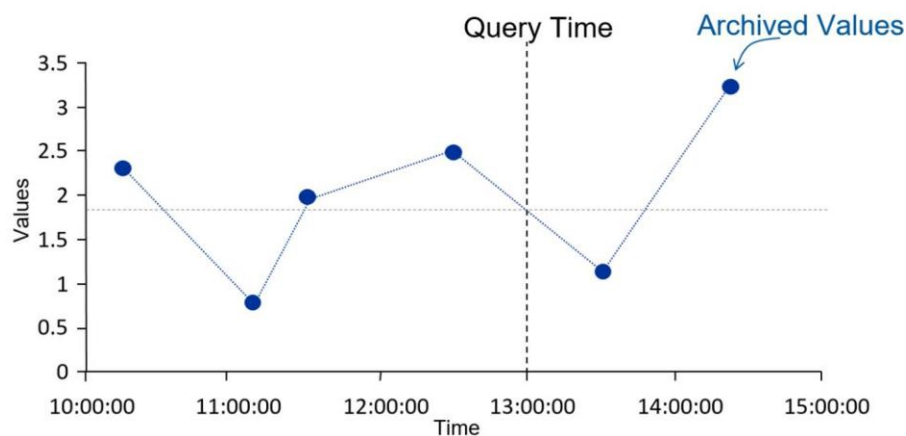
4.4.2 Retrieval Modes

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 behavior 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:

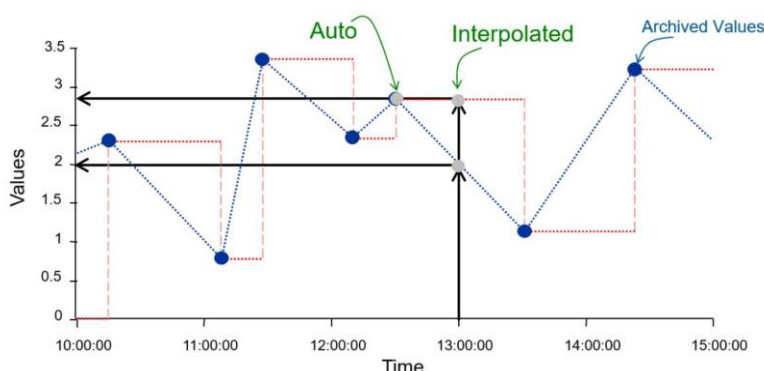
Retrieval Mode	Data retrieval behavior
Auto	(Default) Interpolates at the exact timestamp provided, unless the data item is a step point, which would retrieve the previous value.
Interpolated	Always interpolates at the exact timestamp provided.
Previous, Next	Retrieves the previous or next compressed 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	12:30:00 – 2.8

4.5 Get Time-Summary Calculations with PI Calculated Data Function

If you select the Data item option, the Calculated Data function returns one or more evenly spaced, calculated values based on PI point or PI AF attribute values and specified calculation preferences. If you specify no filter expression and no time interval, the function supports bulk calls.

If you select the Expression option, the Calculated Data function returns one or more evenly spaced, calculated values based on an evaluated performance equation and specified calculation preferences.

Root path - The common path to specified data items, including those in expressions.

Data Item(s) - One or more PI point names or PI AF attribute names, for which the function returns values.

Expression(s) - One or more performance equations that the function computes a value for.

Start time – The start of the time period for which the function returns values.

End time – The end of the time period for which the function returns values.

Time interval - The frequency that the function returns calculated values during the time period.

Filter expression - A Boolean performance equation that the function uses to filter values. When the expression evaluates to false, the function excludes corresponding values.

Conversion factor - A factor that the function applies to returned values. Enter 1 if a conversion factor is not needed. For time-weighted total calculations, specify a factor that converts recorded rate values to the server default time unit (units per day).

For example, common conversion factors include:

- for values that store units/day
- 24 for values that store units/hour
- 1440 for values that store units/minute
- 86400 for values that store units/second

Calculation mode - The type of calculation that the function performs:

- **total** - Sums values during the interval.
- **minimum** - Finds the minimum value during the interval.
- **maximum** - Finds the maximum value during the interval.
- **standard deviation** - Computes the standard deviation of values during the interval.
- **range** - Computes the maximum value minus the minimum value during the interval.
- **count** - Counts the number of seconds in the interval if the Calculation basis field is set to time weighted. Counts the number of values stored during the interval if the Calculation basis field is set to event weighted.
- **average (time-weighted)** - Computes the time-weighted average of the recorded values during the interval.
- **average (event-weighted)** - Computes the event-weighted average of the recorded values during the interval.

Calculation basis - The calculation method:

- **time-weighted** - Default for all calculation modes except for event-weighted average. The function weights each recorded value by the length of time that the value applies. The function interpolates values at the interval boundaries.
- **event-weighted** - The function weights each recorded value equally. Select this option for batch values. This method requires at least one recorded value in a time period (two recorded values for standard deviation calculations).

If you enter an expression in the Expression(s) field and set the Expression sampling field to interpolated, then the function interpolates values at the time interval boundaries when there are no recorded values.

Expression sampling - The method that the function uses to determine when to evaluate an expression:

- **Compressed** - The function evaluates the expression during the time period at time stamps where PI points or PI AF attributes in the expression have stored values. If there are no stored values, the function returns either no value or an interpolated value. For best results, select interpolated rather than compressed during time periods with few stored values.

- **Interpolated** - The function evaluates the expression at evenly spaced sampling intervals, determined by Expression sampling frequency.

Expression sampling frequency - The frequency that the function evaluates an expression. Required if you set Expression sampling to interpolated.

Minimum percent good - The minimum percentage of good data required in each time interval to calculate and return a value for that interval. The function returns the label “Insufficient good data” for an interval that does not meet this percentage.

Output cell - The worksheet cell where the function writes the resulting function array.

Show start time – Select this check box to show the start time of the time interval used to calculate the returned value.

Show end time – Select this check box to show the end time of the time interval used to calculate the returned value.

Show min/max time – Select this check box to show the time stamp that corresponds to the minimum or maximum value during the interval used to calculate the value.

Show percent good - Select this check box to show the percentage of time that good values were returned during the array time period. Good values are recorded values that PI Data Archive determined were valid, and not in an error state.

Column - Click this option to return values in a column.

Row - Click this option to return values in a row.

With calculated data you can very easily do all these calculations on the PI Server, so you don't need to have your spreadsheet filled with lots of raw values that then you're doing calculations with Excel calculations on. It can all be done on the PI Server, which is faster, you'll have a lighter weight spreadsheet. You can do all sorts of powerful time range calculations; things that aren't available to you in the standard Excel functions.

4.6 PI Calculated Data Function – hourly range of values

To see the hourly range of values from midnight today until the present time for the PI point sinusoid, set the following inputs for the Calculated Data function:

Input	Value
Data item(s)	sinusoid
Start time	T
End time	*
Time interval	1h
Calculation mode	range
Calculation basis	time-weighted
Show start time	selected
Show end time	selected
Column	selected

In this example, the function calculates the range for each one-hour interval. You can specify any available calculation over any interval. The function returns the following array:

27-Aug-12 00:00:00	27-Aug-12 01:00:00	24.07529
27-Aug-12 01:00:00	27-Aug-12 02:00:00	18.15997
27-Aug-12 02:00:00	27-Aug-12 03:00:00	7.87962
27-Aug-12 03:00:00	27-Aug-12 04:00:00	6.306436
27-Aug-12 04:00:00	27-Aug-12 05:00:00	17.04949
27-Aug-12 05:00:00	27-Aug-12 06:00:00	24.06163
27-Aug-12 06:00:00	27-Aug-12 07:00:00	24.06163
27-Aug-12 07:00:00	27-Aug-12 08:00:00	18.65239
27-Aug-12 08:00:00	27-Aug-12 09:00:00	6.653669
27-Aug-12 09:00:00	27-Aug-12 10:00:00	6.846051

Exercise – Production Summaries



This solo or group activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Objective

- Extract calculated values using the **Calculated Data** function.

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 entire week.

Approach

Step 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.

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

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

Step 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 (hint).

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.

✓ Quick Check

Can you:

- Obtain calculated values?
- Obtain filtered values?
- Understand Conversion factors?

If you answered NO to any of these questions, ask your instructor for assistance.

5. Using Time Filtered Data in a Preventative Maintenance Example

Learning Outcomes

- Using the Time Filtered Function

5.1 Time Filtered Data

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)**
 - 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**
 - i.e. The pump was running for 5 seconds/minutes/hours/days

Directed Activity – Controller state



You are invited to watch what the instructor is doing or perform the same steps at the same time to explore the different concepts presented in this chapter or section.

Objectives

- Extract Time Filtered data in PI DataLink

Activity Description

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

Step 4 : In Excel create a label for the output cell **Time in Cascade mode (hours)**.

Step 5 : Choose an empty output cell.

- Select the Time Filtered function.

Step 6 : Use the following values for different fields:

- Expression(s):** 'CDM158' = "CASCADE"
- Start Time:** T-3d
- End Time:** T
- 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)

Start time

End time

Time interval (optional)

Directed Activity – Mixing Tank Level Control



You are invited to watch what the instructor is doing or perform the same steps at the same time to explore the different concepts presented in this chapter or section.

Objectives

- Use an expression in the **Time Filtered** function

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

- Step 1 : In Excel create a report template similar to the screenshot at the end of the activity.
- Step 2 : Select cell B1 and search for the Mixing Tank1 Level attribute.
- Step 3 : Modify the expression and apply the PE syntax rules to 'level'>7

Important 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.

Step 4 : Complete the report template with these values:

- a. Start Time: T
- b. End Time: Y
- c. Time Units: Hours

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

<div><div>▼</div><div>⋮</div><div><div>✕</div><div>✓</div><div><i>f_x</i></div><div>"Level ' > 7"</div></div></div>	
A	B
Root Path	\\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1
Expression	'Level ' > 7
Start Time	T
End Time	Y

Exercise – Condition based Inspection



This solo or group activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Objective

- Calculate the operating time with the **Time Filtered** function.

Activity Description

The pumps on our mixing and storage tanks need to be visually inspected every 4 months only if they have been running for over 2,000 hours. 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 the pump only runs when the tank **Level** is greater than 1.2. 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.

Step 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.

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

	A	B	C
1	Condition Based Inspection		
2			
3	Start time		
4	End time		
5	Expression	'Level'>1.2	
6			
7			
8	Asset (Root Path)	Operating Time (hours)	
9			
10			
11			
12			

✓ Quick Check

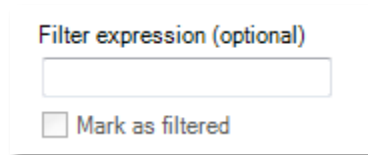
- Can you use the Time Filtered function?
- If NO, then ask your instructor for assistance.

6. Filtered Data Using Custom Expressions

Learning Outcomes

- Using Filtered expressions

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



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.



For more information see the “Expressions” section in the *PI DataLink User Guide*.

6.1 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

Directed Activity – Filtered Data Value Queries



You are invited to watch what the instructor is doing or perform the same steps at the same time to explore the different concepts presented in this chapter or section.

Objectives

- Apply a filter expression to the values retrieved using **Compressed Data** function

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

Step 3 : In Excel create a sheet with

- **Data Item:** CDT158
- **Start Time:** T
- **End Time:** T-1d
- **Filter Expression:** “CDT158’ > 150

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

Step 4 : Retrieve the Compressed Data and verify there are no values less than 150.

Step 5 : Values below 150 are unnecessary and we would not need to include them on our report.

Part 2

Step 6 : On a new sheet, create a sheet with

- **Tank:** \\PISRV01\OSIsoft Plant\Production Area\Production Line1\Mixing Tank1
- **Process Variable:** External Temperature
- **Start Time:** T
- **End Time:** T-1d
- **Filter Expression:** “External Temperature’ > 200

	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

Step 7 : Retrieve the Compressed Data and verify there are no values less than 200; the filter expression removed them.

Exercise – Production Level Report



This solo or group activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Objectives

- Use the **Filter Expression** option of the **Sampled Data** function to constrain the values that are extracted.

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

Step 8 : 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	

Step 9 : 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?

✓ **Quick Check**

Having completed this topic:

- Do you understand the use of Filtered Expressions?

If you answered NO, ask your instructor for assistance.

