

PI World 2019 Lab

The PI System in the Manufacturing Line –
Calculating OEE Across Your Factory



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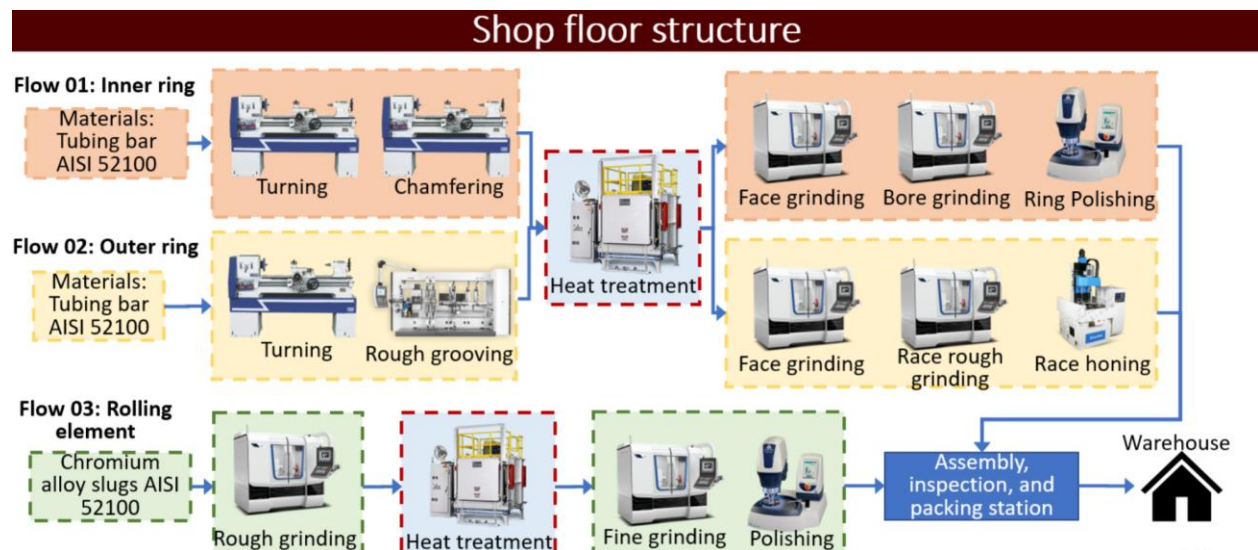
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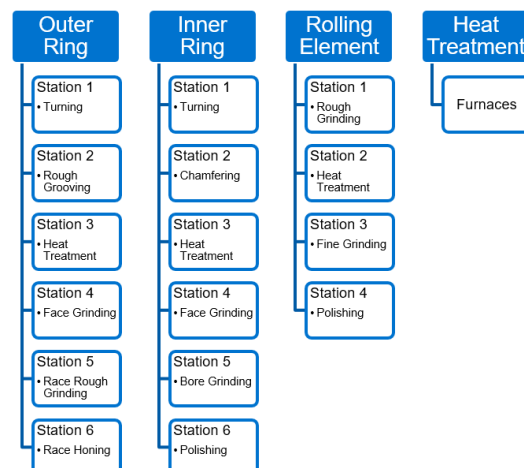
1. Introduction

1.1 Star Bearing Company

The Star Bearing Company (SBC) is a leading bearings manufacturer that has multiple plants across the world. Their manufacturing process can be split up in three lines, which represents the different components in their bearings: the inner ring, the outer ring and the rolling elements. Each of the product lines have different stations such as turning, chamfering, face grinding, bore grinding and ring polishing. They also have more than one machine in most of the stations:



SBC decided to build a hybrid AF model that is process oriented and that is composed of equipment-based elements:



They have chosen this structure because the stations might change depending on the product they are manufacturing. SBC is quite happy with their AF Structure, but they would now like to create meaningful KPI's

1.2 Lab objectives

In this lab, you will start with an existing AF Structure that models the Star Bearing1 Company assets. You will create OEE metrics using the Analysis Service and learn a few tricks along the way. With this OEE calculation setup, the SBC will be able to see almost in real-time what's the OEE instead of looking at the KPIs for the last hour.

Once you complete the AF structure, you will add the missing OEE metrics in an existing PI Vision display.



In addition, the SBC asked for a weekly report on their OEE metrics. You will use the PI Integrator for Business Analytics along with Microsoft Power BI Desktop to create the report and use it to find out which machines are problematic.

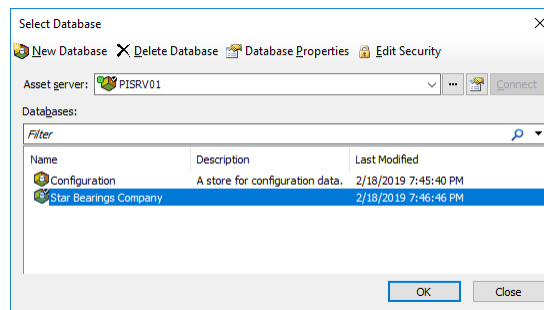
2. Directed Activity Exploring the AF Structure

2.1 Context

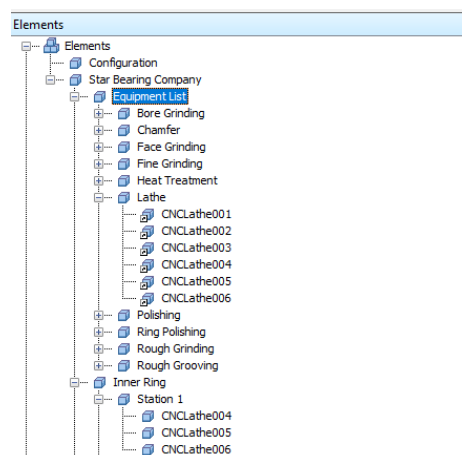
In this section, you will build and complete the Star Bearing Company AF structure, add the OEE metrics and backfill the results to get the OEE history of all their assets.

2.2 Step by step tasks

- Open PI System Explorer  from the Start Menu bar.
- Make sure you are connected to the *Star Bearings Company* AF database by clicking on the database  button:
- Select *Star Bearings Company* then click on *OK*:



- The AF Structure of SBC has two hierarchies: the one described previously in 1.1 and a second organized by equipment for their maintenance team. The elements in the Equipment List are referenced elements:



- Select *Elements – Star Bearing Company – Inner Ring – Station 1* CNCLathe004 and click on attributes, examine the attributes of that particular lathe:

The screenshot shows the PI System Explorer interface. On the left, the 'Elements' tree is expanded to 'Star Bearing Company' > 'Inner Ring' > 'Station 1', where 'CNCLathe004' is selected. The main pane displays the 'Attributes' tab for 'CNCLathe004'. The attributes are organized into categories: 'None', 'Asset Management', and 'Maintenance'.

Category	Name	Value
Category: <None>	Bad Part Count	2
	CycleTime	540 s
	Machine State	Running
	Part Count	29
	Product	6921
Category: Asset Management	RunningTime	3600
	Machine Type	Lathe
	MachineName	CNCLathe004
	No	004
	ProcessLine	Inner Ring
Category: Maintenance	Station	Station 1
	Installation Date	5/30/2016 5:00:00 AM
	Last Maintenance Date	12/14/2018 6:00:00 AM
	Manufacturer	TAKISAWA
	Model	M18

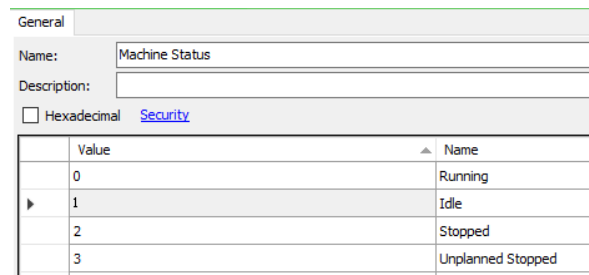
Each equipment has already some PI Point and static reference attributes configured. The Part Count and Bad Part Count are calculated at the end of each hour. The *RunningTime* is also calculated hourly and represents the amount of time the machine has been in a Running state. Explore the structure and compare it to the shop floor diagram in 1.1. Once you are familiar with it, navigate to the Library then Select *Element Templates*:

The screenshot shows the 'Library' pane in the PI System Explorer. The tree structure is as follows:

- Star Bearings empty 1
 - Templates
 - Element Templates
 - Equipment
 - CNC Lathe Template
 - Rough Grinder Template (highlighted)
 - EquipmentGroup Template
 - Global Configuration
 - Line Template
 - Station Template

The Templates are already ordered by template inheritance. That means that the *CNC Lathe Template* and *Rough Grinder Template* share the same attributes listed in the *Equipment Template*. Take note there is also a template for the stations and production lines.

There are also some Enumeration sets that were already built by the SBC. The Machine State attribute values type is the Machine Status Enumeration Set:



The screenshot shows a configuration window for an enumeration set. At the top, there is a 'General' tab. Below it, the 'Name' field is set to 'Machine Status' and the 'Description' field is empty. There is a checkbox for 'Hexadecimal' which is unchecked, and a link labeled 'Security'. Below these fields is a table with two columns: 'Value' and 'Name'.

Value	Name
0	Running
1	Idle
2	Stopped
3	Unplanned Stopped

In this lab, the machines can be Running, Idle, Stopped or in an Unplanned Stopped but you could always define additional states in your own AF Structure.

With this basic AF Structure, you are going to add some relevant KPI's related to the OEE and once built, you are going to create visual dashboards in PI Vision and also leverage Microsoft Power BI to drill down the data. Once you are comfortable with the AF structure, move on to the second chapter to start building the OEE metrics.

3. Directed Activity – Adding the OEE Metrics

3.1 Context

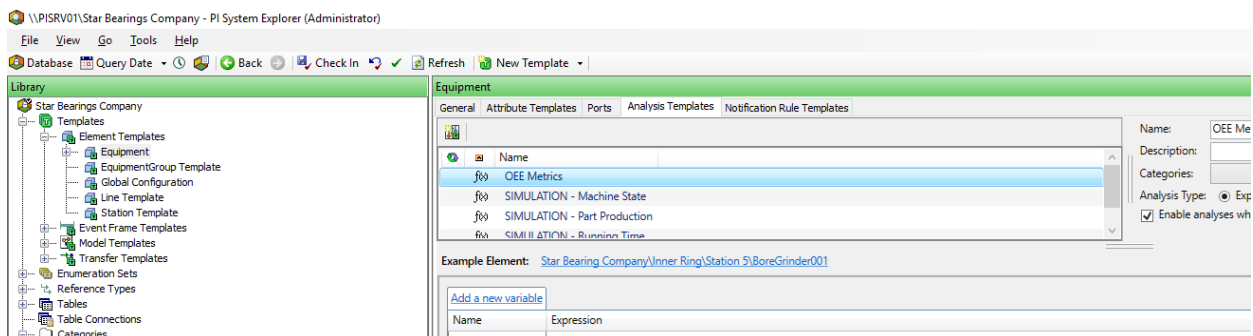
SBC would like to add the OEE Metrics for all their equipment, stations and production lines. In short, OEE, developed in the mid 1990's, enables the monitoring of plant floor productivity and improvement of the efficiency of a manufacturing process. OEE is composed of three different metrics: Availability, Performance and Quality. There are many ways of calculating the OEE, here is how Star Bearings Company decided to define these metrics:

Metric	Description	Formula
<i>Availability</i>	Percentage of time that an equipment is up and running (hourly)	Operating Time / Planned Production Time
<i>Performance</i>	Actual yield to the target yield	Part Count / (3600/Cycle Time)
<i>Quality</i>	Percentage of good units that are produced	Good Part Count / Part Count
<i>OEE</i>	<i>Availability*Performance*Quality</i>	

3.2 Step by step tasks

3.2.1 Create the OEE metrics for the machines

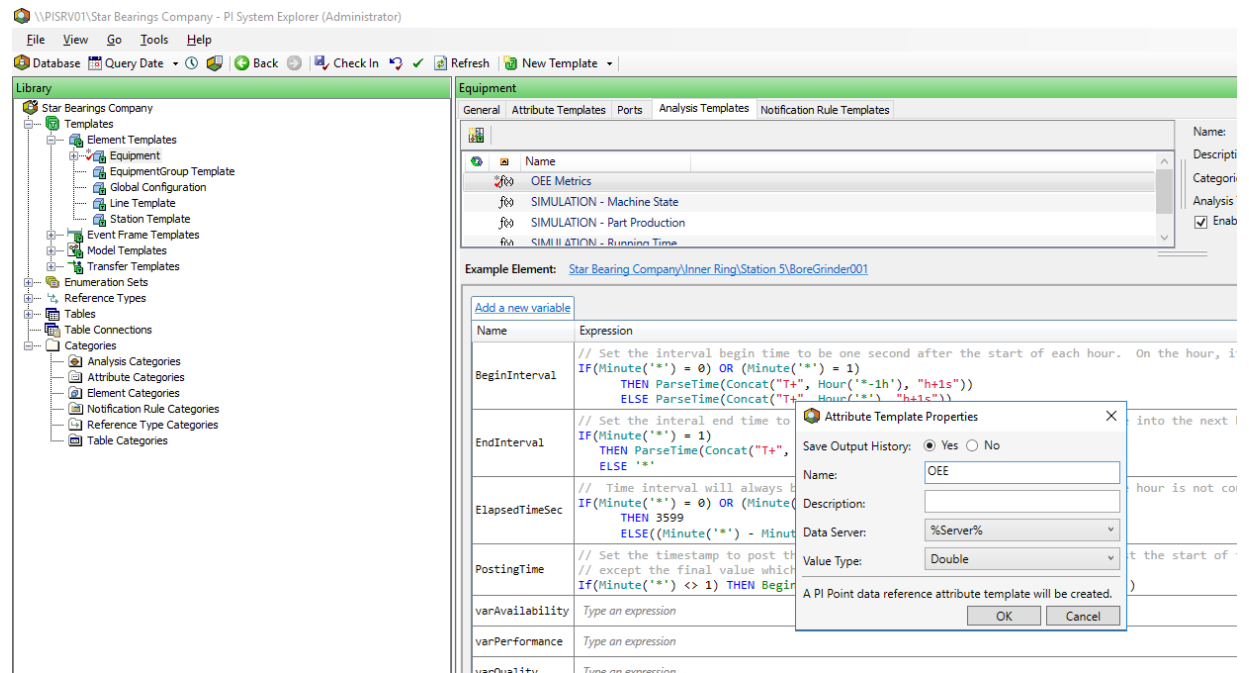
- Navigate to the Library and select the *Equipment* Template. Because the OEE needs to be calculated for all the machines, we will place the Analysis at the base template level. Select the OEE Metrics Analysis:



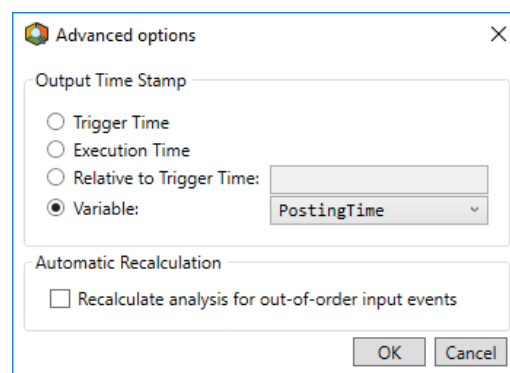
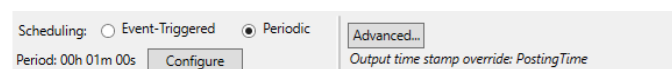
Tip

There OEE Metrics analysis were already setup with some calculations in order to avoid typing them later on. We will provide a full explanation on what they do shortly.

You can create upfront the *varAvailability*, *varQuality*, *varPerformance* and *varOEE* variables and choose to map them as new attributes (*Availability*, *Quality*, *Performance*, *OEE*) with their output history saved:

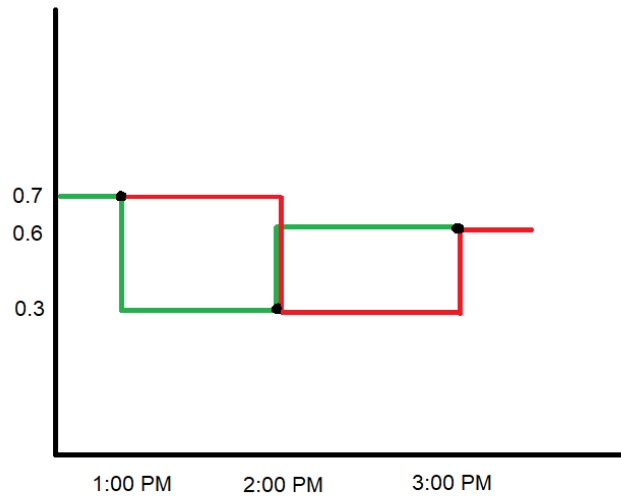


- Try to fill in the availability, performance and quality equations according to the table above. If you are all set, compare your equations with the solution on the last page of this document. Once you have validated your results, make sure that the calculation Scheduling is set to periodic (1 minute) and that the Output Time Stamp is set to variable: PostingTime:



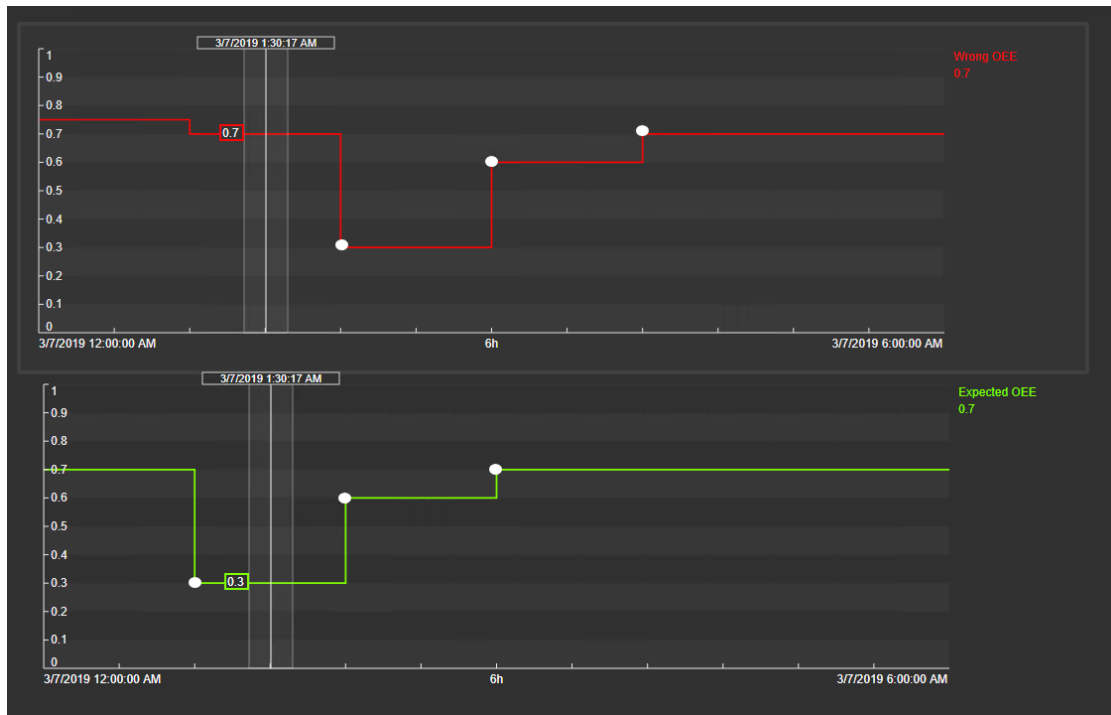
3.2.2 OEE Calculation scheduling explain

Let's take a look at the OEE data on the below trend, the black dots represent 3 availability values that have been recorded (0.7 @ 1:00 PM, 0.3 @ 2:00 PM and 0.6 @ 3:00 PM). The normal behavior of any of our visualization tools such as PI Vision is to draw the line in red. Do you think this is correct for our OEE calculation?



The trace in red is not correct because each of the values represent the calculated metric for the past hour. The OEE was at 0.3 for the 1:00 PM – 2:00 PM interval and not 0.7.

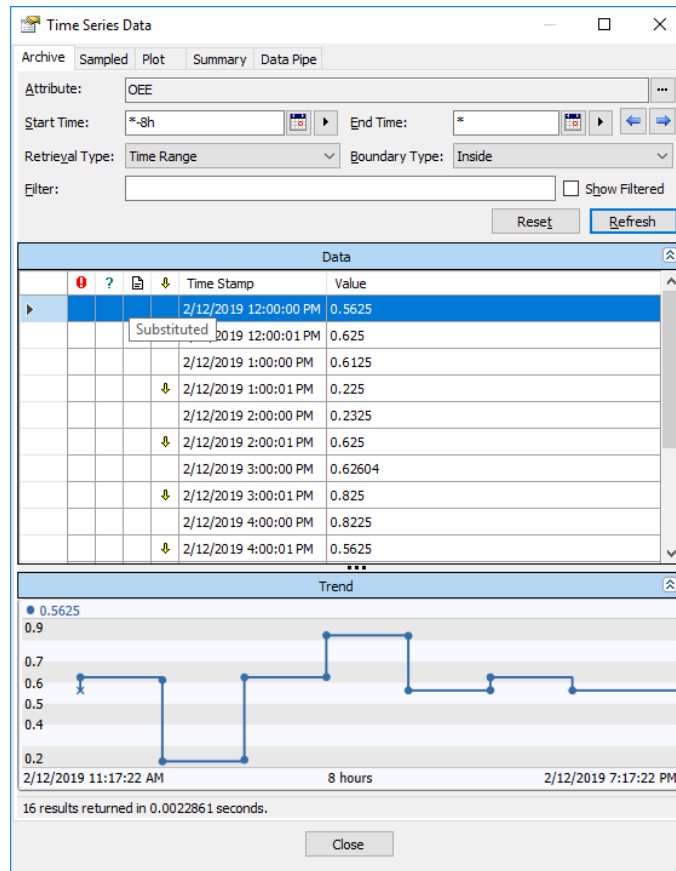
Therefore, the correct trace is the green one. If you query the system within each interval you will retrieve the correct value in the green trace. But, if you query the value at the start of the interval you will receive the value of the previous one, which is incorrect. For example, if you query the value between 1:00 PM and 2:00 PM the value is 0.3 but at exactly 1:00 PM the result will be 0.7 and not 0.3 for the green trace.



To remediate to this issue we have provided a small algorithm that acts like a totalizer. It recalculates the OEE every minute and changes the output timestamp depending on the minute it's executing the calculation. The second benefit to that methodology is that you are getting almost real-time OEE metrics besides having to wait for the result of the past hour.

Add a new variable	
Name	Expression
BeginInterval	// Set the interval begin time to be one second after the start of each hour. On the hour, it is one second after the IF(Minute('*') = 0) OR (Minute('*') = 1) THEN ParseTime(Concat("T+", Hour('*-1h'), "h+1s")) ELSE ParseTime(Concat("T+", Hour('*'), "h+1s"))
EndInterval	// Set the interval end time to be the current time, except at the first minute into the next hour. We will set this t IF(Minute('*') = 1) THEN ParseTime(Concat("T+", Hour('*'), "h")) ELSE '*'
ElapsedTimeSec	// Time interval will always be one second less since the first second of the hour is not counted. IF(Minute('*') = 0) OR (Minute('*') = 1) THEN 3599 ELSE ((Minute('*') - Minute(BeginInterval))*60)-1
PostingTime	// Set the timestamp to post the results. All values posted at one second past the start of the hour, // except the final value which is poste at the start of the next hour. If(Minute('*') > 1) THEN BeginInterval ELSE ParseTime(Concat("T+", Hour('*')))

If the current minute of the hour is different from one, the OEE value will be written with a timestamp of *the current hour + 1 second* until the minute is equal to 1, where the value at the *last hour + 1 second* will be re-written. In other words, the calculation is continuously re-writing the OEE value at every minute and the final results are written when the minute is 0 and 1. This technique is mimicking a totalizer tag, it writes "intermediate" values until the final value is saved:



The values with a ↓ means that they have been substituted. In the list of archived values above you might find odd that, the values at t+1s be a little off or seem rounded. This is due to the timing and frequency of the input values (ex: part count). Returning the exact value is possible but would require a little bit more tuning of the OEE equations and any of its calculated inputs. Real-life scenarios sometimes involve complex calculations like the one described above.

- Before doing any “check-in” of the modifications, make sure you edit the attributes of each of the OEE metrics. Add these to the OEE Category. Also, make sure you change step to 1 and that compression is set to 0:

Tag Creation Settings

Point Class: base Import...

Point Type: Float64

Point Attribute	Value
engunits	
excdev	0.1
excdevpercent	0.1
excmay	600
excmay	0
exdesc	
future	0
pointsource	Lab
ptsecurity	piadmin: A(r,w) piadmins: A(r,w) PIWo...
scan	1
shutdown	1
sourcetay	
span	100
step	1
typicalvalue	50
zero	0

OK Cancel

- Also, change the Point Name to Discrete.%Element%.%Attribute% if not already set. Add the attribute to the OEE category and define the Unit of Measure (UOM) to percent. This step is important to be able to complete the next exercises:

PI Point Data Reference

Data server: %Server%

Tag name: Discrete.%Element%.%Attribute%

☒ Tag Creation
pointtype=Float64;step=1

Attribute:

Unit of Measure
Source Units: <None>

Value retrieval methods
By Time: Automatic
Relative time:
By Time Range: End Time
Calculation basis: Time Weighted
Min percent good: 80

Preview
Example instance: [Select example instance](#)
Configuration:
Value:

☒ Read only

OK Cancel

Group by: ☒ Category ☐ Template

Name: OEE

Description:

Properties: <None>

Categories: OEE

Default UOM: percent

Value Type: Double

Default Value: 0 %

Data Reference: PI Point

Display Digits: -5

Settings...

\\%Server%\Discrete.%Element%.%Attribute
%;pointtype=Float64;compressing=0;step=1

The configuration of the other attributes can be quickly changed using a copy/paste of the configuration string:



Tip

Name	Description	Default Value
Bad Part Count		0
CycleTime		940 s
Machine State	Operating, Id...	Running
Part Count		0
Product		6921
RunningTime	Running Time L...	0

Now that you have created the calculations and edited the attributes, make sure to check-in your modifications and have a look at any of OEE attributes. You might see some “Pt Created” values, this is expected as the OEE calculations are only triggered when an input change. The values will be backfilled later on in the exercise.

3.2.3 Create the OEE metrics for the lines, stations and equipment groups

The OEE metrics have been created for the equipment but not for the stations, lines and equipment groups. Navigate to the library – Station Template – Analysis Template and create a new rollup calculation and name it *Station OEE Performance*. Select average, map the output to a new attribute and call it Performance:

Star Bearings Company - PI System Explorer (Administrator)

File View Go Tools Help

Database Query Date Back Check In Refresh New Template Search Element Te

Library

- Star Bearings Company
 - Templates
 - Element Templates
 - Equipment
 - CNCLatheTemplate
 - Rough Grinder Template
 - EquipmentGroup Template
 - Global Configuration
 - Line Template
 - Station Template
 - Event Frame Templates
 - Model Templates
 - Transfer Templates
 - Enumeration Sets
 - Bad Part Reason
 - Machine Status
 - Machine Unplanned Downtime Reason
 - OEE Metrics
 - Operators
 - Part Creation Flag
 - Part Quality
 - Products
 - Shift Information
 - Station status
 - Reference Types
 - Tables
 - Table Connections
 - Categories
 - Analysis Categories
 - Attribute Categories

Station Template

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: Station OEE Performance

Description:

Categories:

Analysis Type: ☐ Expression ☒ Rollup ☐ Event Frame Generation

☒ Enable analyses when created from template

Example Element: Star Bearing Company\Outer Ring\Station 1

Rollup attributes from

☒ Child elements of Station 1 ☐ This element - Station 1

To select attributes set criteria below

Attribute Name: Performance

Attribute Level: Root Level

Attribute Category:

Element Category:

Element Template:

Select the function(s) to write to an attribute

Function Output(s) Value At Eval: Value At Last

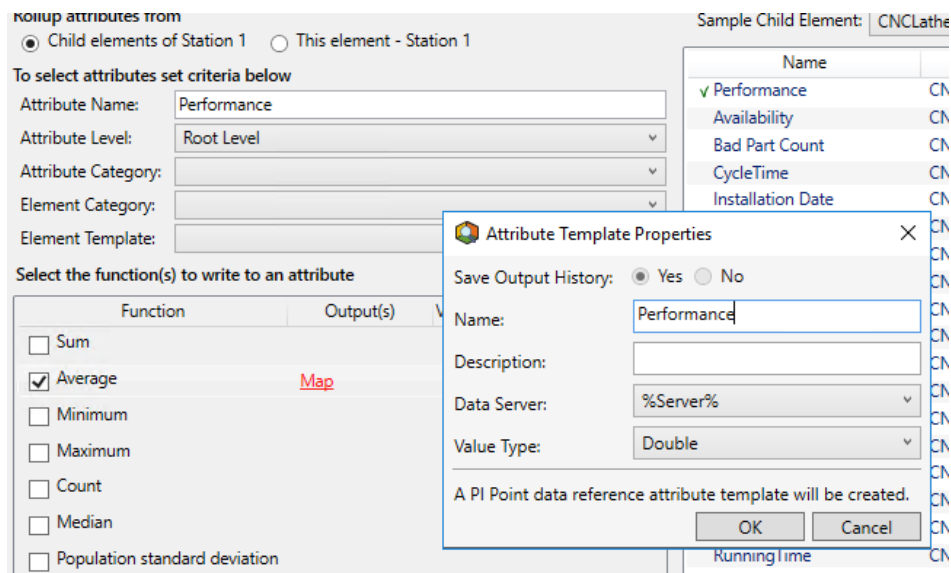
☐ Sum

☒ Average Performance

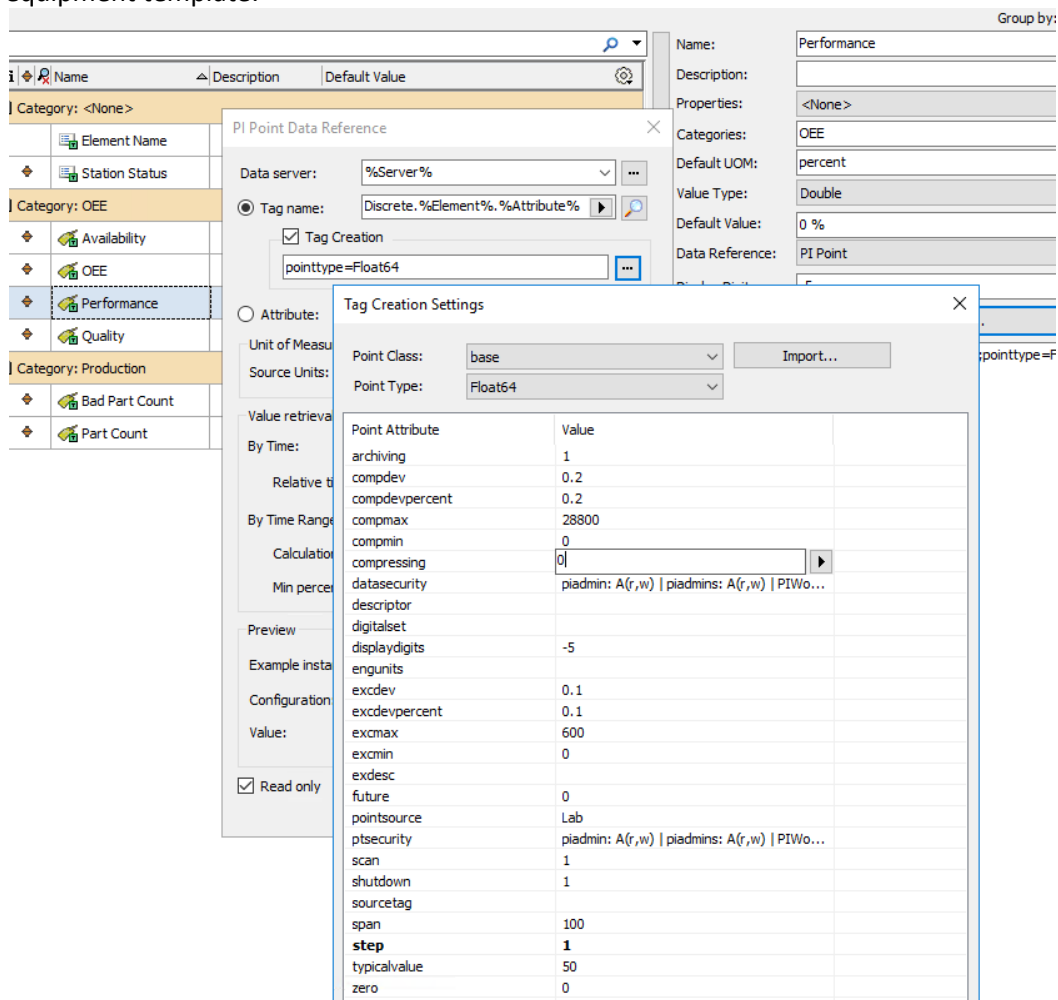
☐ Minimum

Sample Child Element: CNCLathe001 Group By: None

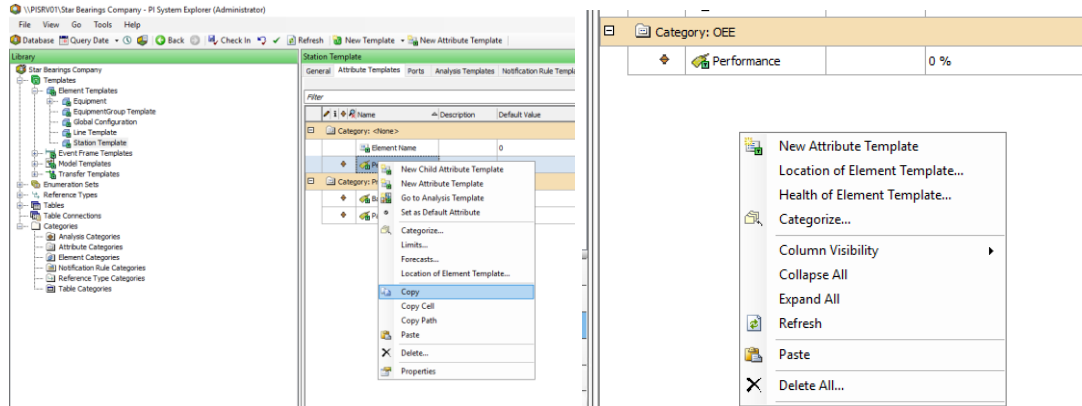
Name	Parent Element	Categories
Performance	CNCLathe001	
Availability	CNCLathe001	OEE
Bad Part Count	CNCLathe001	OEE
CycleTime	CNCLathe001	
Installation Date	CNCLathe001	Maintenance
Last Maintenance Date	CNCLathe001	Maintenance
Machine State	CNCLathe001	
Machine Type	CNCLathe001	Asset Management
MachineName	CNCLathe001	Asset Management
Manufacturer	CNCLathe001	Maintenance
Model	CNCLathe001	Maintenance
No	CNCLathe001	Asset Management
OEE	CNCLathe001	OEE



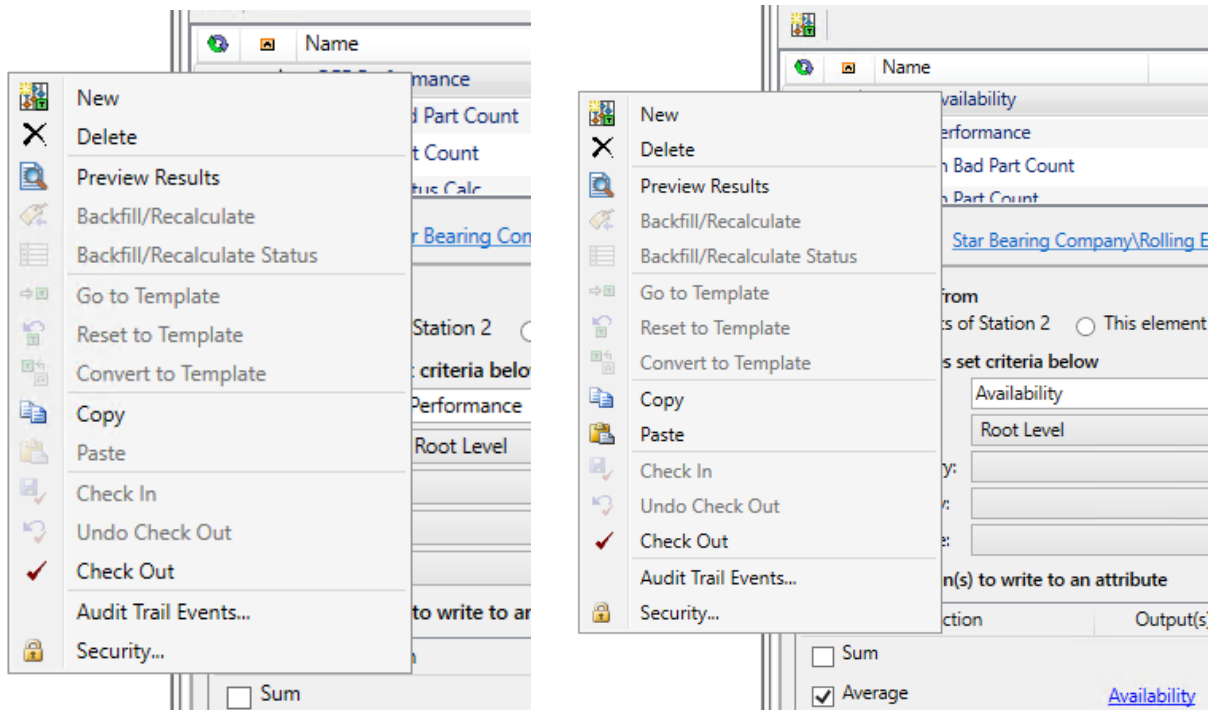
- Don't forget to change the step and compression settings, add the category and UOM like in the equipment template:



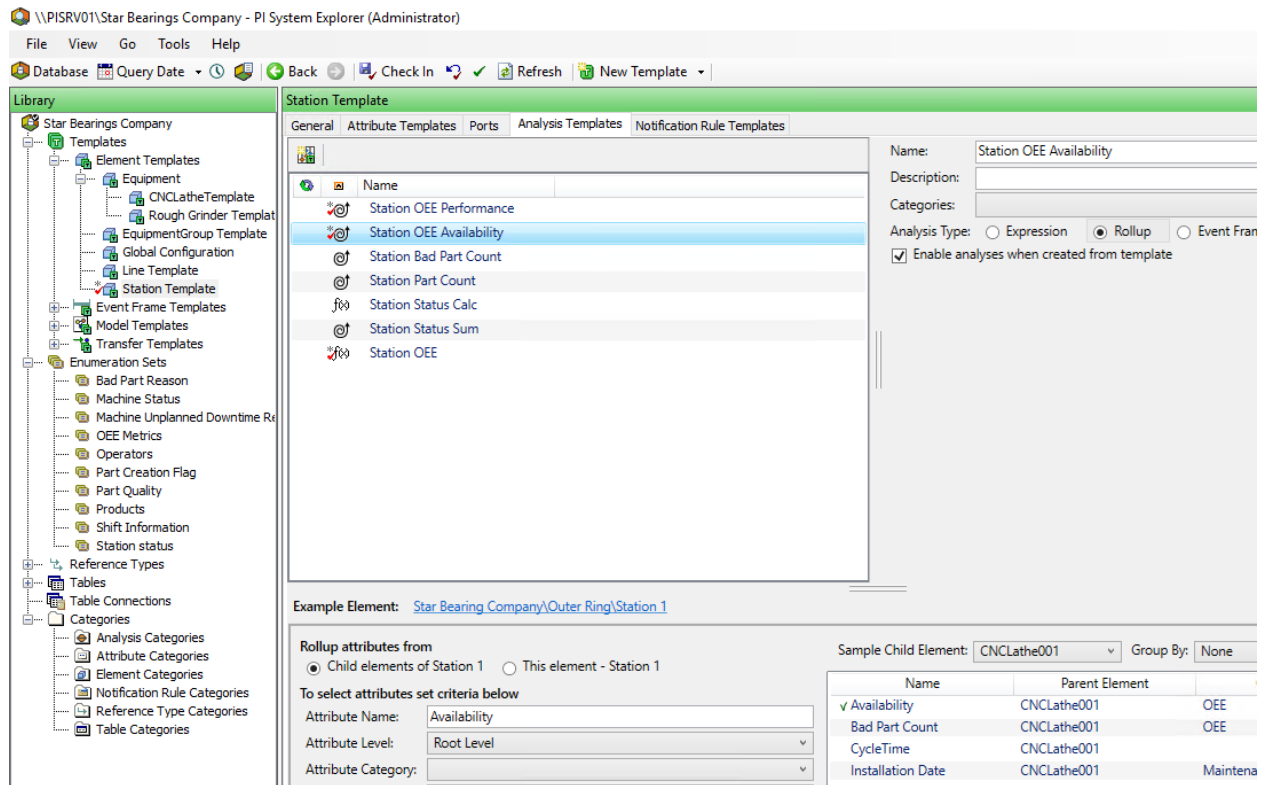
- Copy the *Performance* attribute, paste it and rename it to *Availability*:



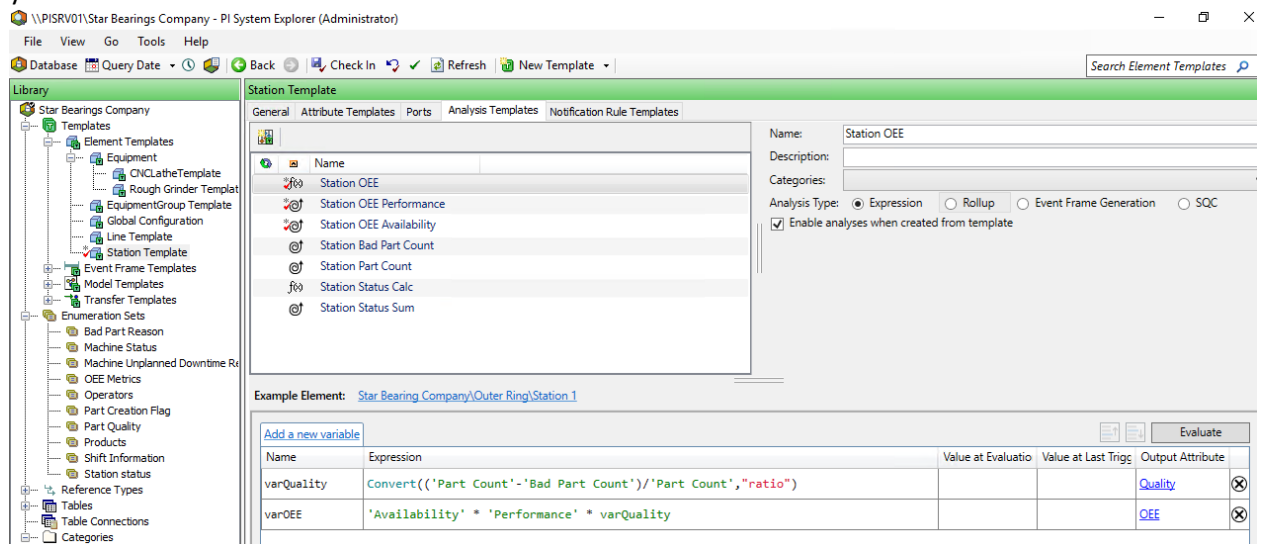
- Go to the Analysis Template, copy the *Station OEE Performance* analysis and paste it:



- Rename the Analysis to *Station OEE Availability* and make sure the output is mapped to the *Availability* attribute:



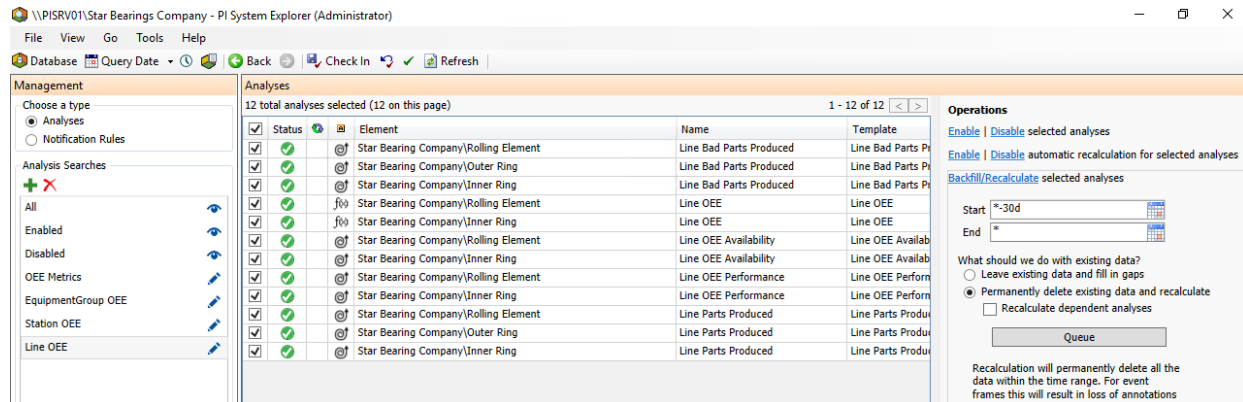
Since the Bad Part Count and Part Count exist in the line, station and equipment groups, you will need to create an Expression analysis to calculate the Quality. You also have all three OEE metrics; therefore, you can calculate the OEE:




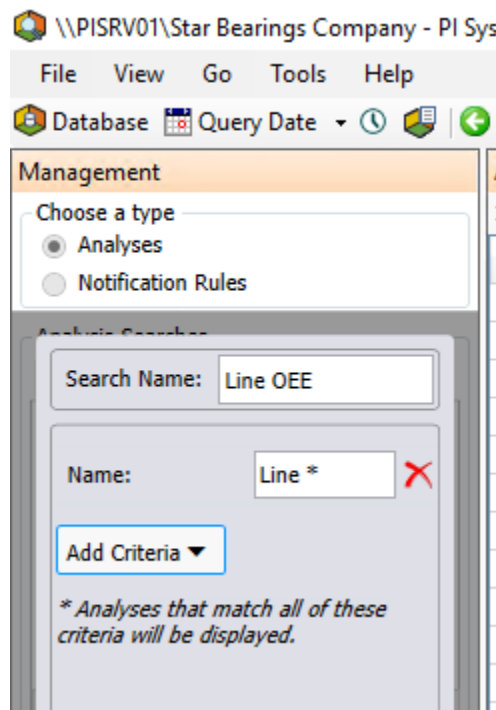
- You will need to replicate the same process of creating the *Performance*, *Availability* and *Quality* analysis for the *Line Template* and *EquipmentGroup Template*.

3.2.4 Backfilling the OEE results

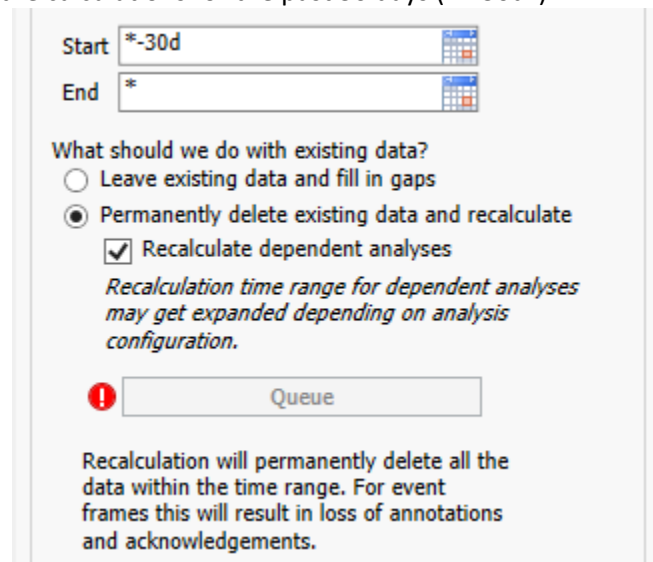
The Management menu in PI System Explorer lets you manage your calculations in bulk. Filters can be created to select only a subset of calculations:



- Create a filter for the *Equipment*, *EquipmentGroup*, *Line* and *Station* templates using the  icon. Use the name field to filter out the only the calculations relevant to each element template. For example the Line calculations all start with “Line” so the filter can be “Line*”.



- Backfill each of the calculations for the past 30 days ("*-30d"):



Start

End


What should we do with existing data?

☐ Leave existing data and fill in gaps

☒ Permanently delete existing data and recalculate




☒ Recalculate dependent analyses

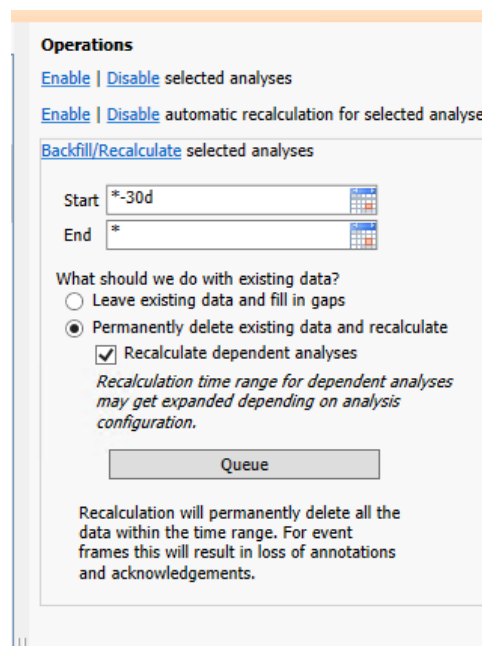
Recalculation time range for dependent analyses may get expanded depending on analysis configuration.



Recalculation will permanently delete all the data within the time range. For event frames this will result in loss of annotations and acknowledgements.

- Find the Configuration\3.2.2 Example Analysis. Enable it and backfill it for 30 days. It must be the last analysis that you choose to backfill. This analysis will “tamper” with the data a little bit for the last section of the lab:

- | | | | | |
|-------------------------------------|-------------------------------------|---|---|----------|
| <input type="checkbox"/> | <input checked="" type="checkbox"/> |  | Star Bearing Company\Equipment List\Bore Grinding | Equipme |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |  | Configuration\3.2.2 Example | Lathe00 |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> |  | Star Bearing Company\Rolling Element | Line Bar |



Operations

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

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

[Backfill/Recalculate](#) selected analyses

Start

End

What should we do with existing data?

☐ Leave existing data and fill in gaps

☒ Permanently delete existing data and recalculate

☒ Recalculate dependent analyses

Recalculation time range for dependent analyses may get expanded depending on analysis configuration.

Recalculation will permanently delete all the data within the time range. For event frames this will result in loss of annotations and acknowledgements.

4. Directed Activity – Creating a PI Vision Dashboard

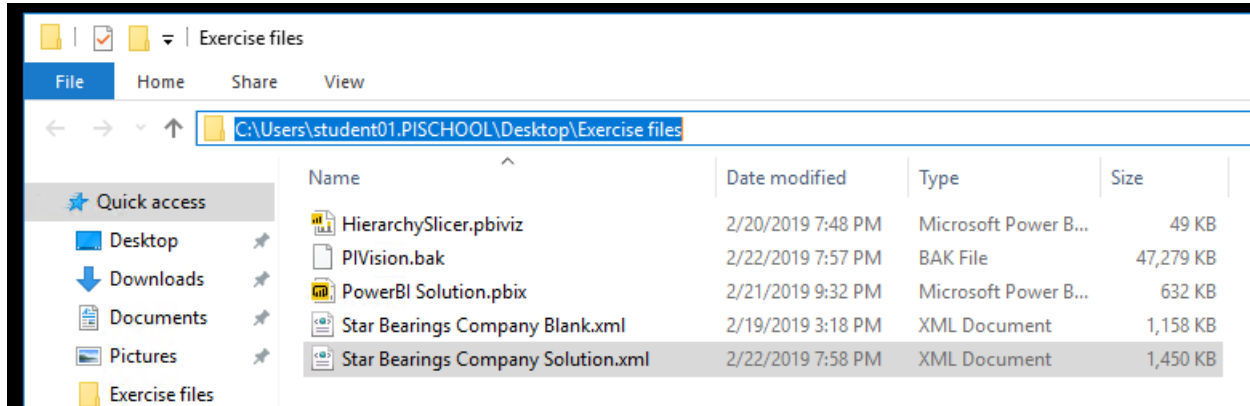
4.1 Context

PI Vision is already installed and up and running and they have made some progress displaying their newly created OEE metrics in PI Vision but there is still some work to do. Here is what the final result should look like:

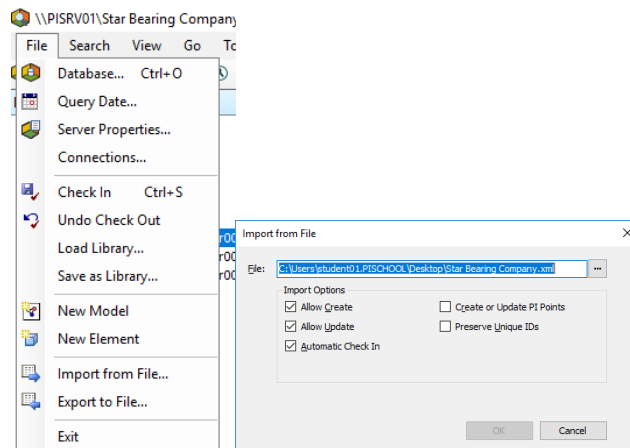


In this exercise, you will start with an existing page and add the missing symbols to properly show the OEE metrics page.


If you had difficulties with the previous chapter, you can use the AF database solution located on `C:\Users\student01.PISCHOOL\Desktop\Exercise files`

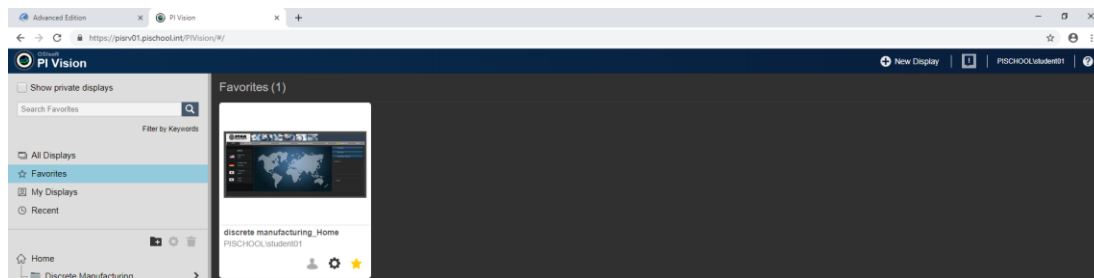


To import it select *File – Import from File...* and pick *Star Bearings Company Solution.xml*

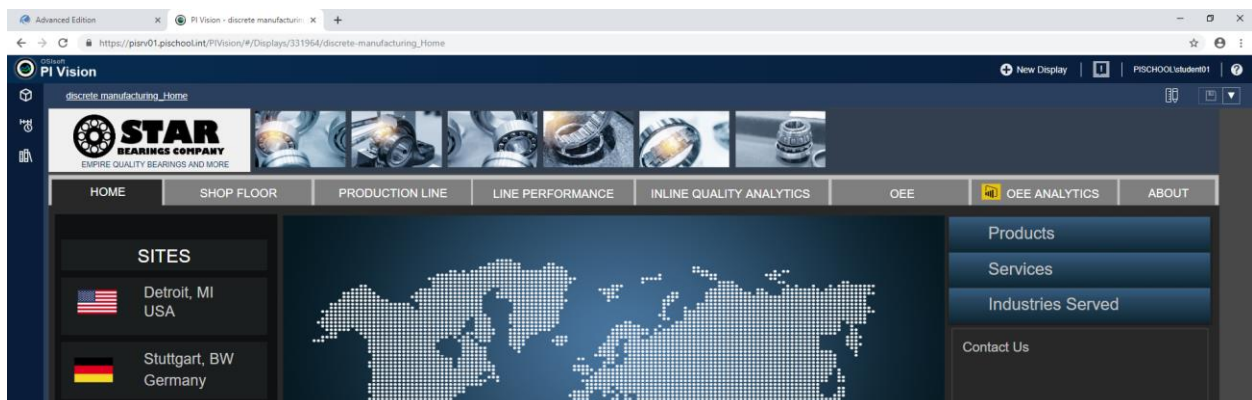


4.2 Directed Activity – Adding symbols to PI Vision

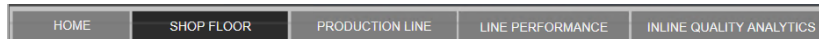
- Use the PI Vision shortcut  on the Desktop to navigate to SBC's PI Vision page.
- Click on *Favorites*, you can use that tool to mark some of your favorite displays. In this case we have included the discrete manufacturing home display. Click on it:



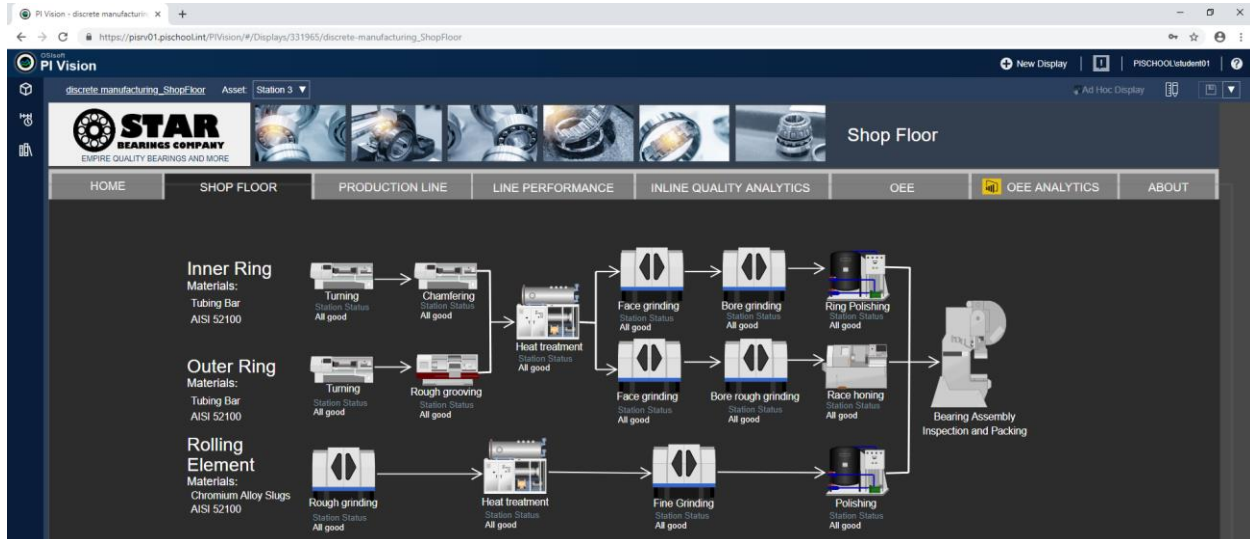
This page acts as the homepage. Links that look like a toolbar (in gray) have been added to navigate between pages. Take note that some of the linked pages are still in construction and will not work for this lab.



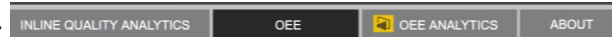
- Click on *SHOP FLOOR*:



This page provides an overview of each of the stations. The arrangement also represents SBC's process:



- Next, click on the *OEE* tab:

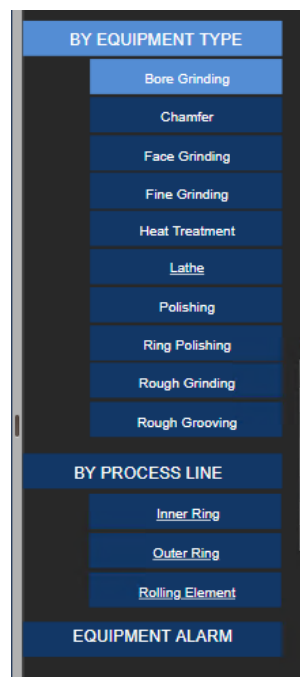



The navigation bar is actually made out of text and rectangle objects that have been configured to look like a navigation links. Each “tab” of the bar is a different PI Vision page and since the links are consistent between pages the users will think of this as a navigation bar.


This display shows the OEE metrics of all of the Bore Grinders in the middle. If you click on any of the Bore Grinders in the table, the specific OEE metrics and additional information will be displayed on right side of the display. Depending on the OEE value, the color of the values will change from green to orange to red.



- Take a look at the links on the left and click on *Lathe*. The users can browse the same page by equipment type and by process line. Only the Bore Grinding and Lathe pages and the ones for the process line have been built so far:

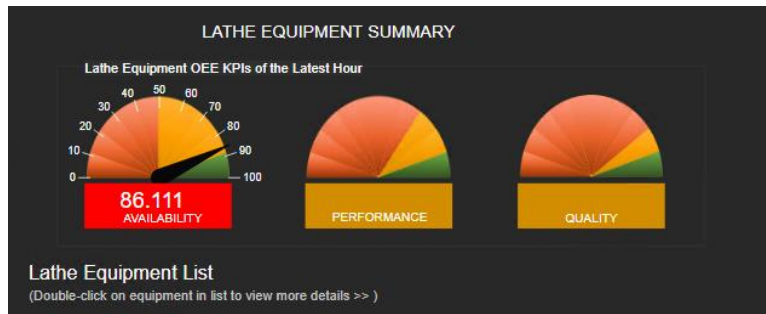


You might find errors  in this page, this is intentional. The page needs some work.


- Start by enabling the build mode  by clicking on the icon.
- Then, move the rectangle over the lathe in the left menu. As you can see, the "Menu" is just a rectangle!

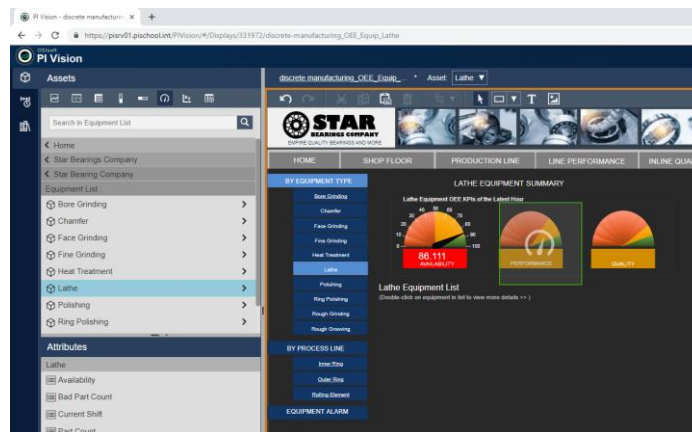


The middle of the page is dedicated to OEE metrics for the equipment group, which is the Lathes for this particular page:

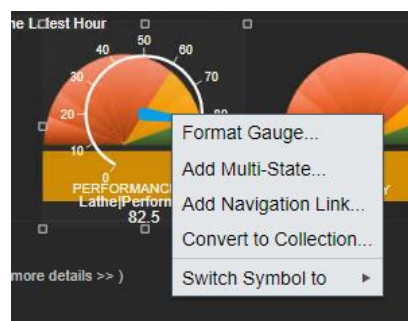


The Availability is already done, you have the choice to either copy and paste the objects or build it from scratch for the performance and quality.

- To add the gauge, drill down to the *Star Bearing Company\Equipment List\Lathe* level and select the Gauge symbol  and then drag the performance attribute in the middle:



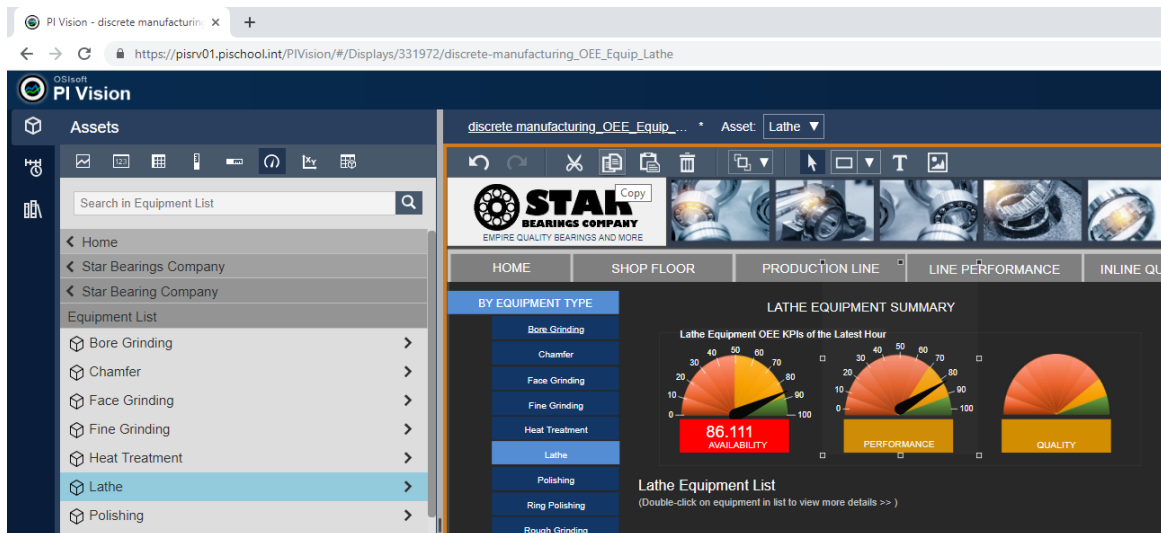
- Right click on the gauge and select *Format Gauge...*




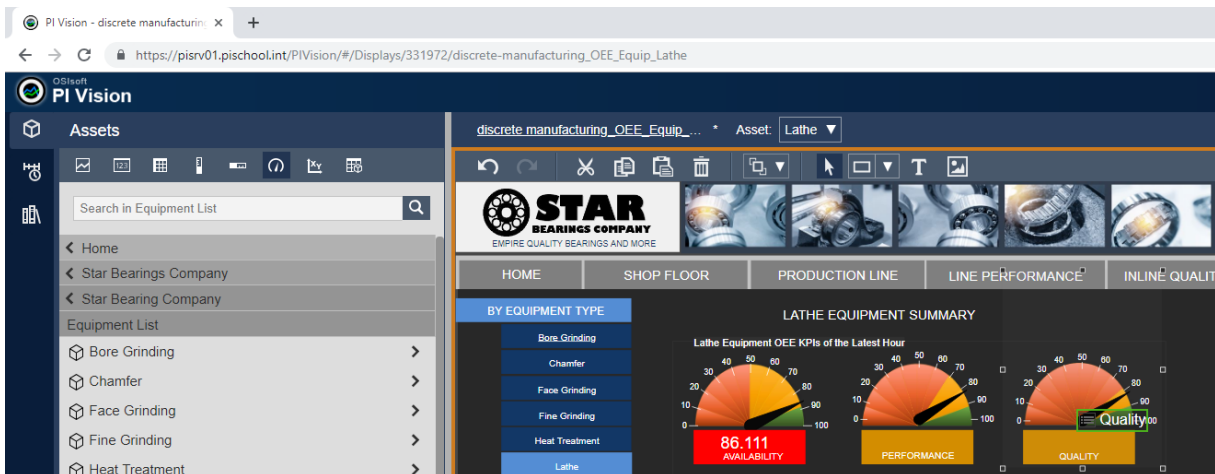
- Try to change the settings to obtain a gauge that is similar to the one for the availability:



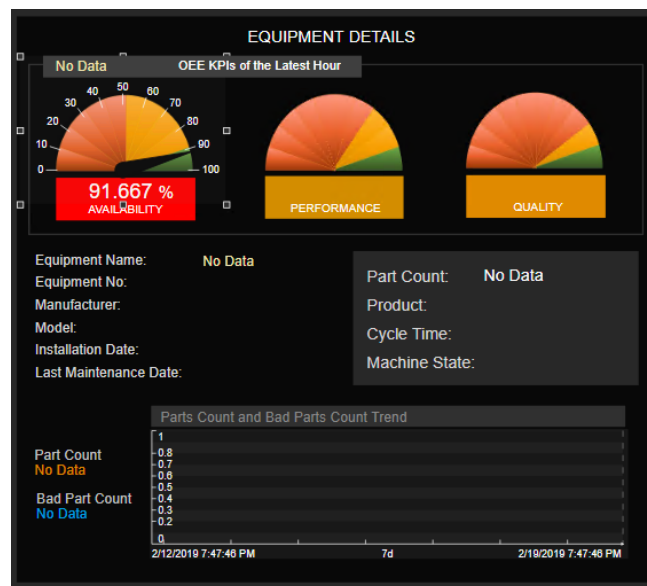
- To do the Quality gauge, use the copy/paste feature of PI Vision. Select the gauge you have created and either use the copy button or hit **Ctrl + c**:




- Click on paste  and move the gauge on top of Quality. The newly created gauge still shows the data for the performance. To fix it, select the quality attribute and drag it on the gauge:



- Use the same methodology to fill out the values underneath each gages. If time permits, also fill in the information on the right part of the display for the Star Bearing Company\Equipment List\Lathe\CNCLathe003

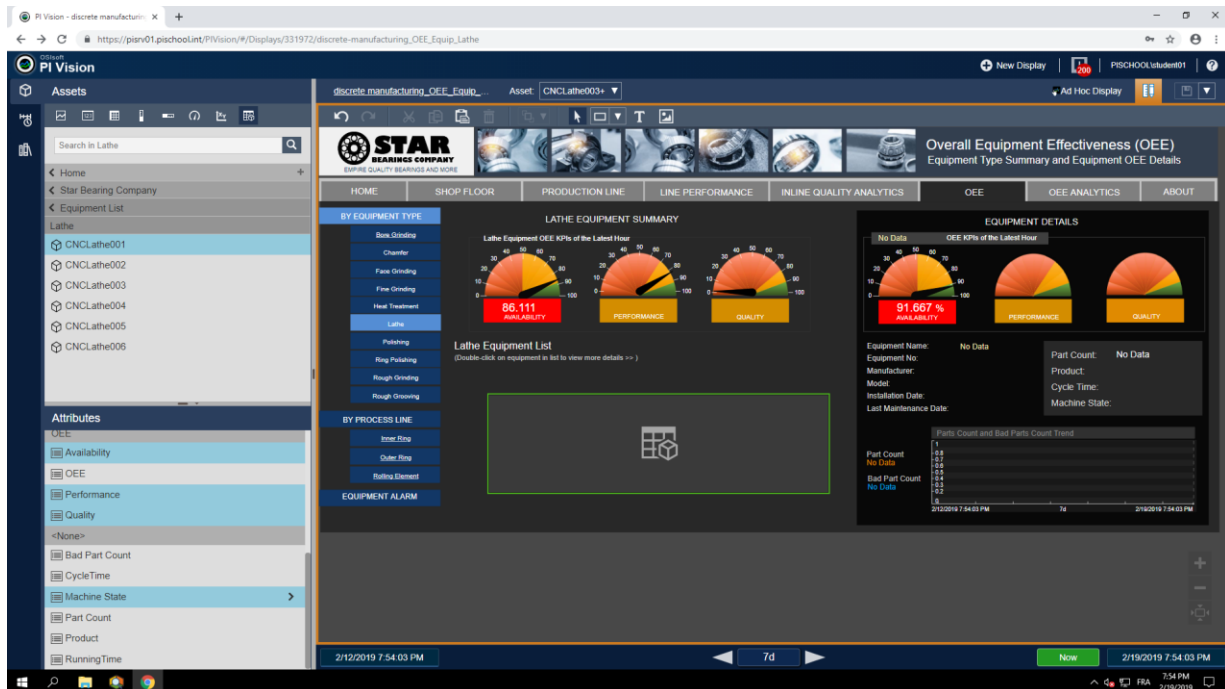


- Select the Asset Comparison symbol  and navigate to *Star Bearing Company\Equipment List\Lathe\CNCLathe001* and select *Asset, Station, ProcessLine, Machine Type, Machine Status, Availability, Performance and Quality*:

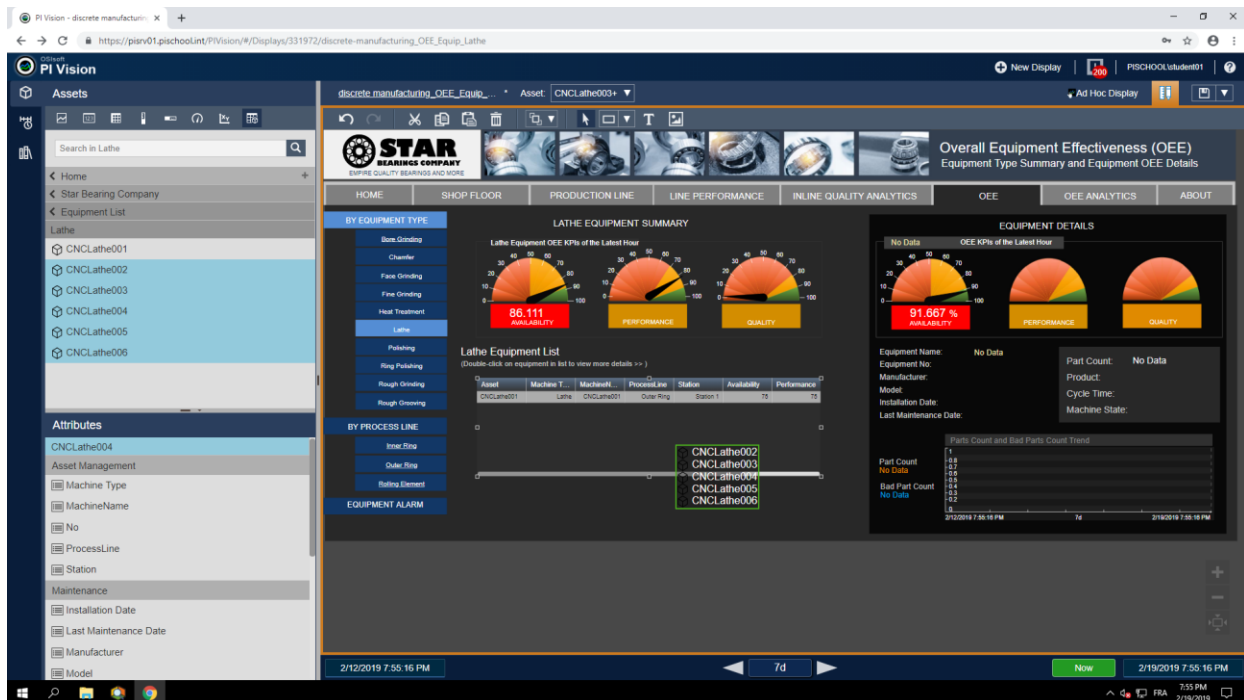


Tip

You can hold down the Ctrl key to pick multiple attributes at the same time.



- Select CNCLathe002 to CNCLathe006 and drag them to the Asset Comparison table:



- Right-click on it and select *Configure Table...*

Lathe Equipment List
(Double-click on equipment in list to view more details >>)

Asset	Machine T...	MachineN...	ProcessLine	Station	Availability	Performance
CNCLathe001	Lathe	CNCLathe001	Outer Ring	Station 1	75	75
CNCLathe002	Lathe	CNCLathe002	Outer Ring	Station 1	83.333	75
CNCLathe003	Lathe	CNCLathe003	Outer Ring	Station 1	91.667	90
CNCLathe004	Lathe	CNCLathe004	Inner Ring	Station 1	91.667	90
CNCLathe005	Lathe	CNCLathe005	Inner Ring	Station 1	91.667	90
CNCLathe006	Lathe	CNCLathe006	Inner Ring	Station 1	83.333	75

Context menu options:
 Configure Table...
 Add Multi-State...
 Add Navigation Link...
 Add Dynamic Search Criteria...
 Switch Symbol to

- Try to re-order the columns to obtain the following result:



- The last step is to configure the multi-states to make the color change depending on each OEE metric value. Start with the table, right-click on it and choose *Add Multi-State...*

Lathe Equipment List
(Double-click on equipment in list to view more details >>)

Asset	Station	ProcessLine	Machine S...	Availability	Performance	Quality
CNCLathe001	Station 1	Outer Ring	Running	75	75	100
CNCLathe002	Station 1	Outer Ring	Running	83.333	75	100
CNCLathe003	Station 1	Outer Ring	Running	91.667	90	100
CNCLathe004	Station 1	Inner Ring	Idle	91.667	90	100
CNCLathe005	Station 1	Inner Ring	Running	91.667	90	100
CNCLathe006	Station 1	Inner Ring	Idle	83.333	75	100

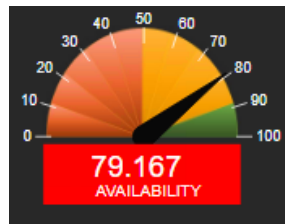
Context menu options:
 Configure Table...
 Add Multi-State...
 Add Navigation Link...
 Add Dynamic Search Criteria...
 Switch Symbol to

- Select Availability and click on *Enable Multi-State* then configure it as follow:

The 'Columns' configuration panel shows the following settings:

- Current Columns:** Asset, Station, ProcessLine, Machine State, **Availability** (highlighted), Performance, Quality.
- ☒ **Enable Multi-State**
- Bad data:** Represented by a red square.
- Value ranges:**
 - Green: ≤ 100
 - Yellow: ≤ 90
 - Red: ≤ 70
 - White: ≥ 0

- Repeat the same configuration for Performance and Quality. If time permits, add multi-state to the rectangles underneath each gauge:



- The last step is to add a navigation link in the Asset Comparison Table. That will act as a way to choose which lathe will be displayed on right side. To add the navigation link right-click on the table and select *Add Navigation Link...*

Lathe Equipment List
(Double-click on equipment in list to view more details >>)

Asset	Station	ProcessLine	Machine S...	Availability	Performance	Quality
CNCLathe001	Station 1	Outer Ring	Running	75	75	100
CNCLathe002	Station 1	Outer Ring	Running	83.333	75	100
CNCLathe003	Station 1	Outer Ring	Running	75	75	100
CNCLathe004	Station 1	Inner Ring			75	100
CNCLathe005	Station 1	Inner Ring			75	100
CNCLathe006	Station 1	Inner Ring			90	100

Right-click context menu options:

- Configure Table...
- Configure Multi-State...
- Add Navigation Link...**
- Add Dynamic Search Criteria...
- Switch Symbol to ▶

- Select *Change context of current display* in the options:

Add Navigation Link ▾

Action

☐ Open hyperlink to another page
☒ Change context of current display

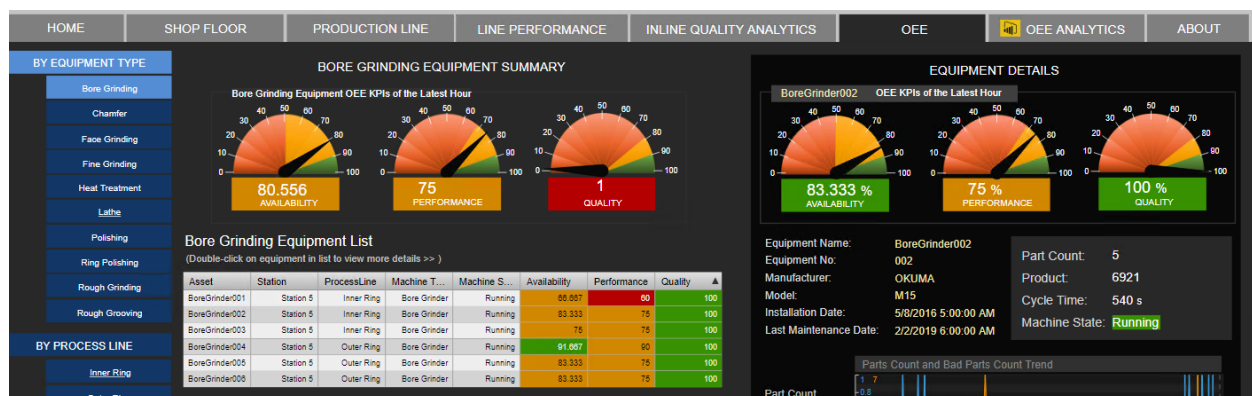
☒ Use current asset
☐ Use current asset as root

Remove Link

If you had time to fill in the gauges for the equipment and other missing information you will see that clicking on any of the assets in the Asset Comparison Table will change the asset on the right side of the display. If you didn't had time to complete this part, save your display then click on the *Bore Grinding* operation and try to click in the Asset Comparison Table:



The Bore Grinding page can be used as an example:



5. Directed Activity – Analyzing the data in Power BI

5.1 Context

In addition to their PI Vision dashboard, the Star Bearing Company would like to have a report where they can drill down the OEE data. They already have Microsoft Power BI and the PI Integrator for Business Analytics installed and running for another project so they are going to use these tools for this report.

Here's an example of the final result:

Star Bearing Company - OEE Analysis



5.21 Directed Activity – Using the PI Integrator for Business Analytics

- Open the PI Integrator for BA webpage using the desktop link
- You might get a prompt to connect to the Integrator webpage. The username is pischool\student01 and the password is the same one you used to login to the environment:



The PI System in the Manufacturing Line – Calculating OEE Across Your Factory

Sign in

https://pisrv01.pischool.int:1313

Username

Password

- Click on *Create Asset View*, name the view OEE Metrics

Advanced Edition

← → ↻

https://pisrv01.pischool.int:1313

☆ ⓘ

☰

My Views

PISCHOOL\student01

+

Create Asset View

Build a data view starting with your asset hierarchy

+

Create Event View

Build a data view starting with your event hierarchy

+

Create Streaming View

Build a streaming view with a custom output shape

✎

Modify View

Modify existing data view

✖

Remove View

Remove selected view

Name	Run Status	Type	Run Mode	Start Time	End Time	Last Run Time
OEE Metrics Solution	Published	Asset	Once	*-7d	*	Feb 21, 2019 7:37:57 PM

Create New Asset View


Asset View Name

- Click on *Create a New Shape*

import a shape from an existing view or create a new one

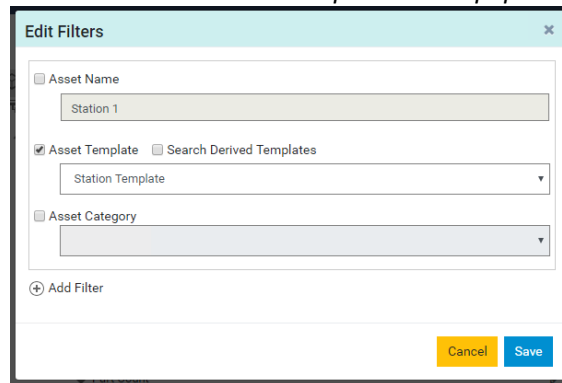
- Select all of the attributes and drag them in the middle pane.

The screenshot displays the OEE Metrics Solution web application. The 'Select Data' tab is active, showing 'Source Assets' and 'Search Shape' panes. The 'Source Assets' pane lists 'Server' (PISRV01) and 'Database' (Star Bearings Company). The 'Search Shape' pane shows a tree view of 'Asset Shape' with 'Line Template' and 'Station Template' expanded. The 'Matches' pane on the right shows 'Found 42 Matches' for 'Inner Ring' and 'Outer Ring'. A large 3D cube icon is visible in the background.

- Click on the Pen  icon next to the *Inner Ring* element and Uncheck *Asset Name* and select *Asset Template*:

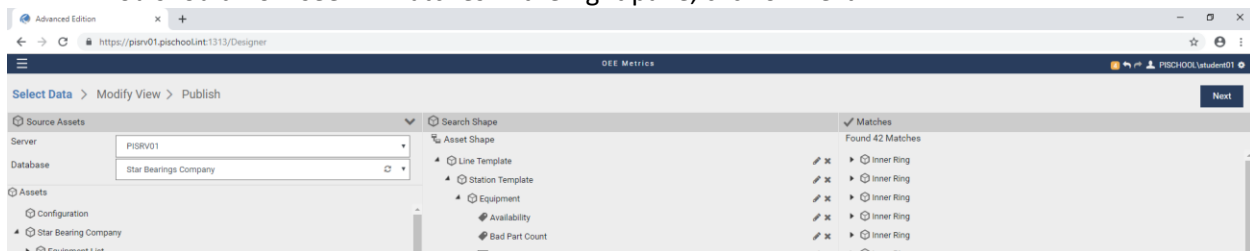
The 'Edit Filters' dialog box is shown. It contains three sections: 'Asset Name' (unchecked), 'Asset Template' (checked), and 'Asset Category' (unchecked). The 'Asset Template' section shows a dropdown menu with 'Line Template' selected. There are 'Cancel' and 'Save' buttons at the bottom right.

- Repeat the same procedure for the *Station Template* and *Equipment*:



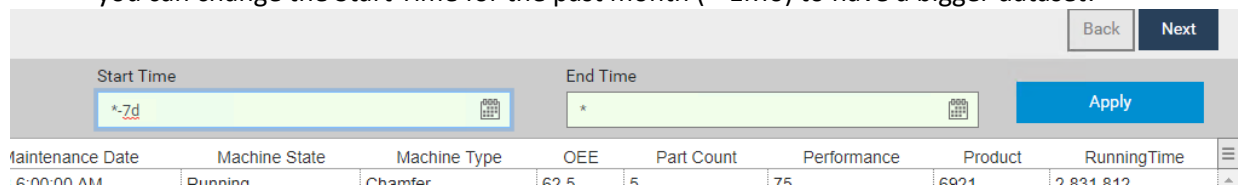
The 'Edit Filters' dialog box is shown. It has a title bar with a close button. Inside, there are three filter sections: 'Asset Name' with a text input field containing 'Station 1'; 'Asset Template' with a checked checkbox and a dropdown menu showing 'Station Template'; and 'Asset Category' with an unchecked checkbox and an empty dropdown menu. At the bottom left is an 'Add Filter' button with a plus icon. At the bottom right are 'Cancel' and 'Save' buttons.

- You should now see 42 Matches in the right pane, click on *Next*.



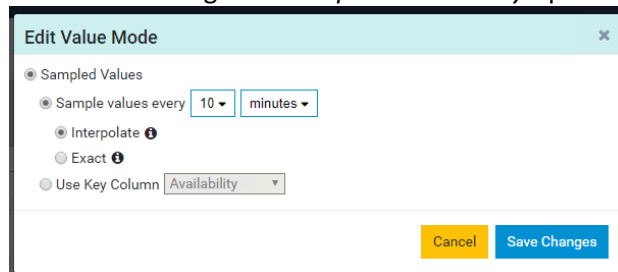
The screenshot shows the PI System Designer interface. The 'Source Assets' pane on the left shows 'Server: PISRV01' and 'Database: Star Bearings Company'. The 'Search Shape' pane in the center shows a tree view with 'Line Template', 'Station Template', 'Equipment', 'Availability', and 'Bad Part Count'. The 'Matches' pane on the right shows 'Found 42 Matches' and a list of matches including 'Inner Ring'. A 'Next' button is visible in the top right corner.

- Change the Start Time to **-7d*, the report will use 7 days of data. If you have more time to wait, you can change the Start Time for the past month (**-1Mo*) to have a bigger dataset:



The screenshot shows the time selection interface. It has a 'Start Time' field with the value '*-7d' and an 'End Time' field with the value '*'. There are 'Back' and 'Next' buttons at the top right. Below the time fields is an 'Apply' button. At the bottom, there is a table with columns: Maintenance Date, Machine State, Machine Type, OEE, Part Count, Performance, Product, and RunningTime. The first row of data shows: 6:00:00 AM, Running, Chamfer, 62.5, 5, 75, 6001, 2 831 812.

- Click on *Edit Value Mode* and change the *Sample values every* option to 10 minutes.



The 'Edit Value Mode' dialog box is shown. It has a title bar with a close button. Inside, there are three radio button options: 'Sampled Values' (selected), 'Interpolate' (with an information icon), and 'Exact' (with an information icon). Under 'Sampled Values', there is a 'Sample values every' section with a dropdown menu showing '10' and a unit dropdown showing 'minutes'. Under 'Exact', there is a 'Use Key Column' dropdown menu showing 'Availability'. At the bottom right are 'Cancel' and 'Save Changes' buttons.

- Click on *Next* and select *MYBIViews* as the Target Configuration. Click on *Publish*

Select Data > Modify View > **Publish**

Target Configuration

MyBIViews

Overwrite Options

The selected target only supports overwriting old data

Summary

Shape and Matches

- There are 42 Matching Instances

Timeframe and Interval

- Your Start Time is *-7d
- Your End Time is *
- Your Time Interval gets an interpolated measurement **Every 10 minutes**

Publish

Run Mode

☒ Run Once

☐ Run on a Schedule

It will take a 2-3 minutes to generate the data. You can see the progress in the bottom bar:

Overview **Log** Security View Configuration Statistics

Run Status

Publishing 4%

View Name OEE Metrics Solution

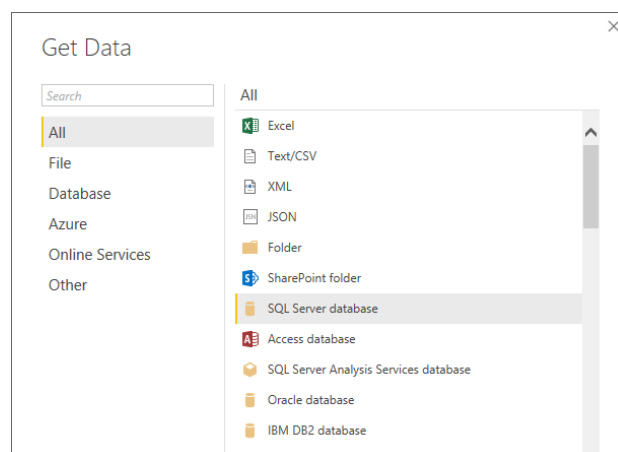
- When the view is fully published, you can close the PI Integrator webpage.

5.3 Creating the Dashboard in Microsoft Power BI Desktop

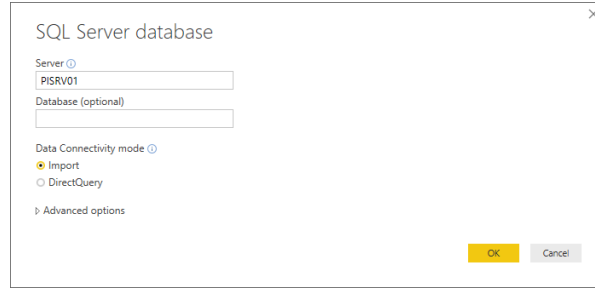
- Open the Power BI Exercise file using the shortcut on the desktop



- Click on *Get Data* and select *SQL Server database*



- Enter PISRV01 in the Server field



SQL Server database

Server

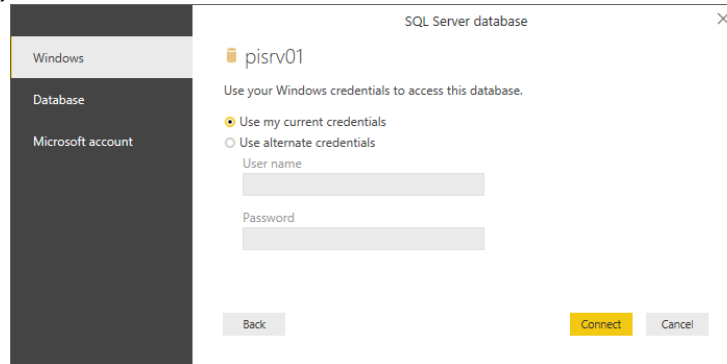
Database (optional)

Data Connectivity mode ☒ Import ☐ DirectQuery

> Advanced options

OK Cancel

- Select *Use my current credentials*



SQL Server database

pisrv01

Use your Windows credentials to access this database.

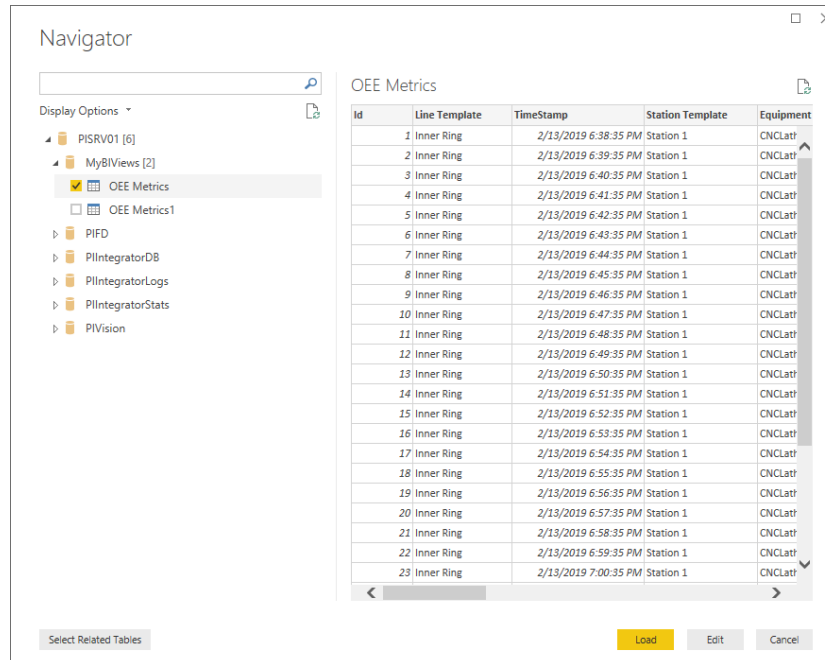
☒ Use my current credentials ☐ Use alternate credentials

User name

Password

Back Connect Cancel

- Choose the OEE Metrics view in the MYBIViews. You should see data in the right tab. Click on load. You should now see a blank canvas.



Navigator

Display Options

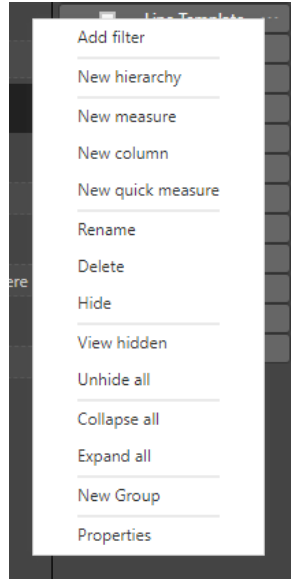
- PISRV01 [6]
 - MyBIViews [2]
 - ☒ OEE Metrics
 - OEE Metrics1
 - PIFD
 - PIIntegratorDB
 - PIIntegratorLogs
 - PIIntegratorStats
 - PIVision

OEE Metrics

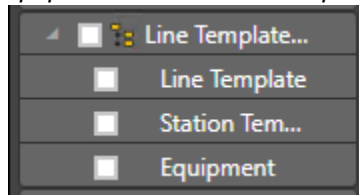
Id	Line Template	TimeStamp	Station Template	Equipment
1	Inner Ring	2/13/2019 6:38:35 PM	Station 1	CNCLatr
2	Inner Ring	2/13/2019 6:39:35 PM	Station 1	CNCLatr
3	Inner Ring	2/13/2019 6:40:35 PM	Station 1	CNCLatr
4	Inner Ring	2/13/2019 6:41:35 PM	Station 1	CNCLatr
5	Inner Ring	2/13/2019 6:42:35 PM	Station 1	CNCLatr
6	Inner Ring	2/13/2019 6:43:35 PM	Station 1	CNCLatr
7	Inner Ring	2/13/2019 6:44:35 PM	Station 1	CNCLatr
8	Inner Ring	2/13/2019 6:45:35 PM	Station 1	CNCLatr
9	Inner Ring	2/13/2019 6:46:35 PM	Station 1	CNCLatr
10	Inner Ring	2/13/2019 6:47:35 PM	Station 1	CNCLatr
11	Inner Ring	2/13/2019 6:48:35 PM	Station 1	CNCLatr
12	Inner Ring	2/13/2019 6:49:35 PM	Station 1	CNCLatr
13	Inner Ring	2/13/2019 6:50:35 PM	Station 1	CNCLatr
14	Inner Ring	2/13/2019 6:51:35 PM	Station 1	CNCLatr
15	Inner Ring	2/13/2019 6:52:35 PM	Station 1	CNCLatr
16	Inner Ring	2/13/2019 6:53:35 PM	Station 1	CNCLatr
17	Inner Ring	2/13/2019 6:54:35 PM	Station 1	CNCLatr
18	Inner Ring	2/13/2019 6:55:35 PM	Station 1	CNCLatr
19	Inner Ring	2/13/2019 6:56:35 PM	Station 1	CNCLatr
20	Inner Ring	2/13/2019 6:57:35 PM	Station 1	CNCLatr
21	Inner Ring	2/13/2019 6:58:35 PM	Station 1	CNCLatr
22	Inner Ring	2/13/2019 6:59:35 PM	Station 1	CNCLatr
23	Inner Ring	2/13/2019 7:00:35 PM	Station 1	CNCLatr


Select Related Tables Load Edit Cancel

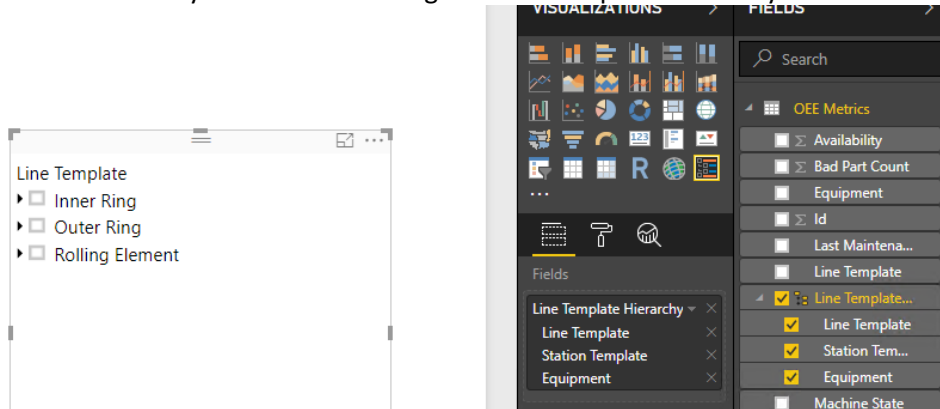
- Find the Fields section in right pane and Right click on the LineTemplate and select *New hierarchy*:




- Drag *Station Template* then *Equipment* on the *Line Template hierarchy*:



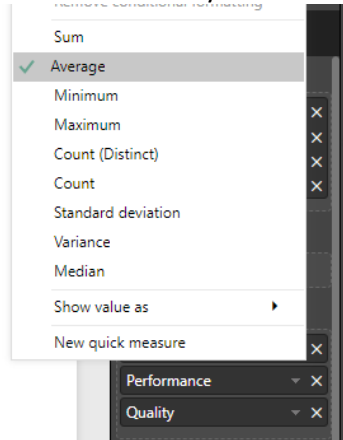
- Create a new HierarchySlider  and drag the Line Template hierarchy in the Fields section:



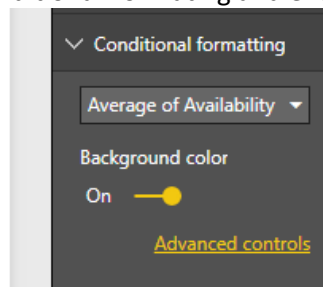
The HierarchySlider provides a hierarchy similar to the one in SBC's AF structure. You can select objects in there and the canvas will display the metrics only for your selection. The next step is to add the OEE metrics.

- You are going to use the Matrix tool . Drag the *Line TemplateHierarchy* in the Rows, the *Availability*, *Performance* and *Quality* in the Values field.

- Change the Availability, Performance and Quality fields to Average:



- Go to the format tab and select Conditional Formatting and enable Background color:



- Go to Advanced controls and change the Minimum to Number and enter 75. Repeat for the Quality and Performance.

Background color - *Average of Availability*

Format by

Color scale

[Learn more](#)

Based on field

Average of Availability

Summarization

Average

Default formatting ⓘ

As zero

Minimum

Number

75

Maximum


Highest value

(Highest value)

☐ Diverging

- Your table should like this (the values and colors will be different):


Line Template	Average of Availability	Average of Performance	Average of Quality
Inner Ring	78.49	75.07	99.17
Outer Ring	80.23	76.65	99.01
Rolling Element	80.24	76.54	98.81
Total	79.53	75.99	99.04

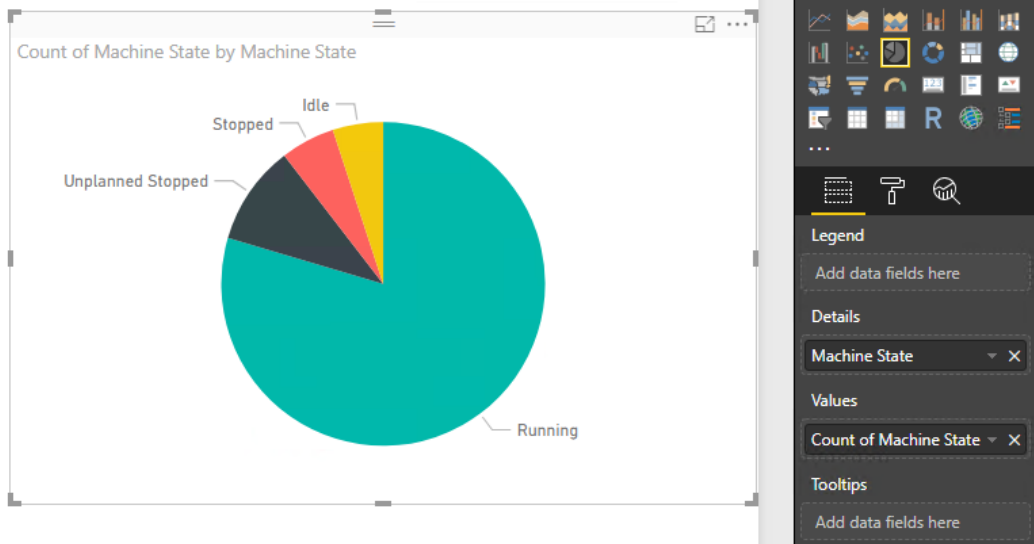
- Add a slider  and drag the TimeStamp. You can use the slider to change the timerange of the OEE display.

TimeStamp


2/28/2019 3/8/2019

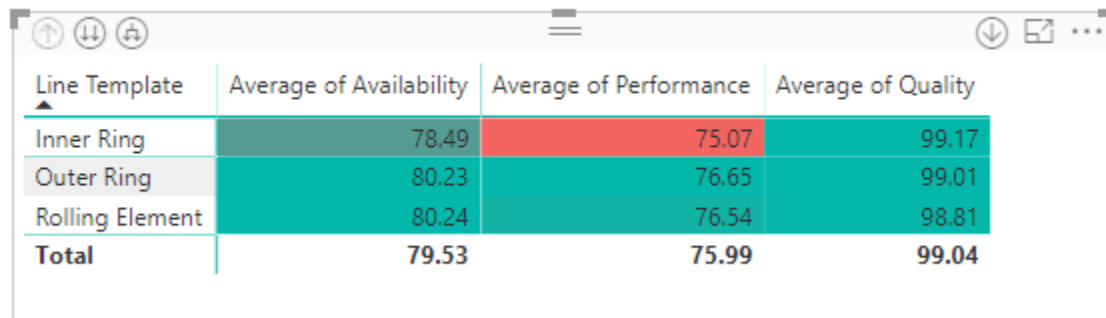


- Add a PI Chart  and drag the Machine state in both Details and Values fields:



Now that you have a basic OEE Power BI dashboard, try to find any issues with the equipment. You can

use the double arrow symbol  to drill down in the data. Is there any machine(s) that are problematic? If so, what's the issue? The solution can be found in the solution section.



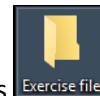
Line Template	Average of Availability	Average of Performance	Average of Quality
Inner Ring	78.49	75.07	99.17
Outer Ring	80.23	76.65	99.01
Rolling Element	80.24	76.54	98.81
Total	79.53	75.99	99.04

Try to add more visualization symbols and use the other attributes such as the Machine State or the Product to complete your dashboard.



- Take a look also at the [PowerBI Solution.pbix](#) and compare it to your own dashboard.

That's it! You have created the OEE metrics, added the KPIs in a PI Vision page and created a Power BI dashboard in a short period of time. If you want to import any of the data such as the AF Structure, PI



Vision dashboard and Power BI file, you can grab them from the Exercise files [Exercise files](#) folder on the desktop.

6. Solution

3.2.1 OEE Calculations

Name	Expression	Output Attribute
EndInterval	<code>IF(Minute('*') = 1) THEN ParseTime(Concat("T+", Hour('*'), "h")) ELSE '*'</code>	Map
ElapsedTimeSec	<code>// Time interval will always be one second less since the first second of the hour is not counted. IF(Minute('*') = 0) OR (Minute('*') = 1) THEN 3599 ELSE (Minute('*') - Minute(BeginInterval))*60-1</code>	Map
PostingTime	<code>// Set the timestamp to post the results. All values posted at one second past the start of the hour, // except the final value which is posted at the start of the next hour. IF(Minute('*') <> 1) THEN BeginInterval ELSE ParseTime(Concat("T+", Hour('*')))</code>	Map
varAvailability	<code>Convert('RunningTime'/3600,"ratio")</code>	Availability
varPerformance	<code>Convert('Part Count' / (3600 / 'CycleTime'),"ratio")</code>	Performance
varQuality	<code>Convert(('Part Count' - 'Bad Part Count')/'Part Count',"ratio")</code>	Quality
varOEE	<code>Convert(varAvailability*varPerformance*varQuality,"ratio")</code>	OEE

The Convert function is an elegant way to handle unit of measures within a calculation. In this case, the ratio UOM represents 100%. The results of any of the OEE metrics will be within 0 and 1 but the users will want to show the results in percentage (0-100%). This is done by setting up the attribute UOM to Percentage. By leveraging the Convert function we don't have to divide by 10000 (Ex: $0.9 \times 0.9 \times 1 = 0.81$ instead of $90 \times 90 \times 100 / 10000 = 81$).

5.3 Power BI dashboard

The CNCLathe004 should have a low Availability because it's in a Stopped state for a greater proportion of the time compared to the other equipment. The performance is also affected because it's not machining enough parts.



Have an idea how to
improve our products?
**OSIsoft wants to hear
from you!**

<https://feedback.osisoft.com/>





Save the Date!

OSIsoft PI World Users Conference in Gothenburg, Sweden. September 16-19, 2019.

Register your interest now to receive updates and notification early bird registration opening.

https://pages.osisoft.com/UC-EMEA-Q3-19-PIWorldGBG-RegisterYourInterest_RegisterYourInterest-LP.html?_ga=2.20661553.86037572.1539782043-591736536.1533567354

