PI World 2019 Lab

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



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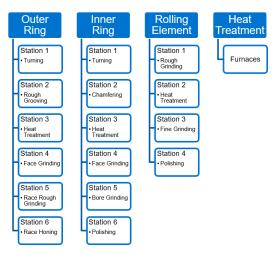
1. Introduction

1.1Star 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

1.2Lab 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

2.1Context

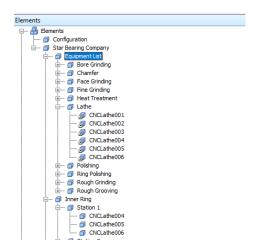
In this section, you will build and complete the Star Bearing Company AF structure, add the OEE metrics and backfill the results to get the OEE history of all their assets.

2.2Step by step tasks

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

Select Database	te Database 😁 Database <u>P</u> roperties	s 🔒 <u>E</u> dit Security
Asset server: 🤓 PISRV0	1	✓
Databases:		
Filter		• م
Name	Description	Last Modified
Configuration	A store for configuration data.	2/18/2019 7:45:40 PM
🗳 Star Bearings Compan	У	2/18/2019 7:46:46 PM
		OK Close

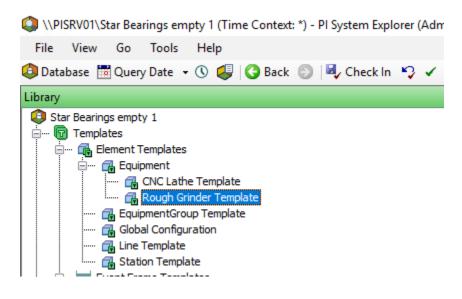
• The AF Structure of SBC has two hierarchies: the one described previously in 1.1 and a second organized by equipment for their maintenance team. The elements in the Equipment List are referenced elements:



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

ments	CNCLathe004
Elements	General Child Elements Attributes Ports Analyses Notification Rules Versio
	Filter
	Value
	Category: <none></none>
CNCLathe005 CNCLathe006	Ø
🗄 ···· 🗇 Station 2	CycleTime 540 s
i ☐ Station 3	⊘ ■ ♦ 🛷 Machine State Running
termini Station 5 termini Station 6	♂ ■ 🔶 🍼 Part Count 29
🖅 🗇 Outer Ring	Product 6921
i∃ 🗇 Rolling Element	
Element Attribute Search Results 1	Category: Asset Management
	Addine Type Lathe
	MachineName CNCLathe004
	■ (III) No 004
	ProcessLine Inner Ring
	Station Station
	Category: Maintenance
	Installation Date 5/30/2016 5:00:00 AM
	Last Maintenance Date 12/14/2018 6:00:00 AM
	Manufacturer TAKISAWA
	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 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:

Gener	al									
Name	Machine Status									
Description:										
Пн	exadecima	l <u>Security</u>								
	Value	*	Name							
	0		Running							
•	1		Idle							
	2		Stopped							
	3		Unplanned Stopped							
			1							

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

3.1Context

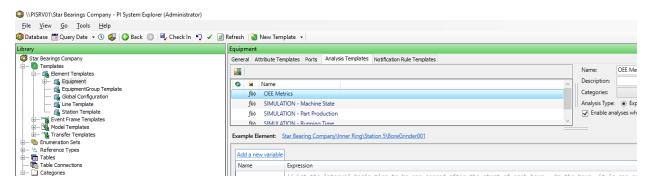
SBC would like to add the OEE Metrics for all their equipment, stations and production lines. In short, OEE, developed in the mid 1990's, enables the monitoring of plant floor productivity and improvement of the efficiency of a manufacturing process. OEE is composed of three different metrics: Availability, 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		
Availability	Percentage of time that an equipment is up and	Operating Time / Planned		
	running (hourly)	Production Time		
Performance	Actual yield to the target yield	Part Count / (3600/Cycle Time)		
Quality	Percentage of good units that are produced	Good Part Count / Part Count		
OEE	Availability*Performance*Quality			

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:





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:

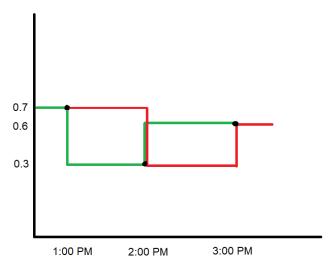
🔕 Database 🛅 Query Date 👻 🕔 🥥 🚱 Back 🏐 🗟 Check In 🗳		nplate 👻								
Library	Equipment									
Star Bearings Company	General Attribute Te	General Attribute Templates Ports Analysis Templates Notification Rule Templates								
🚊 🦏 Element Templates										
🗄 🖓 🖓 Equipment	🚯 🔳 Name					Descripti				
EquipmentGroup Template	Sfite OEE Me	etnics				Categori				
Global Configuration		ATION - Machine State				Analysis				
Station Template	V	ATION - Part Production				valajois ✓ Enab				
Event Frame Templates	,,,,	ATION - Running Time				~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~				
Hodel Templates										
	Example Element:	Star Bearing Company\Inner Ring\Station 5\8	BoreGrinder001							
B		7								
1 Tables	Add a new variable									
🛅 Table Connections	Name	Expression								
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Htribute Categories Generation Categories	BeginInterval	<pre>IF(Minute('*') = 0) OR (Minute) THEN ParseTime(Concat("T- ELSE ParseTime(Concat("T-</pre>	('*') = 1) +", Hour('*-1h'),	"h+1s"))	of each hour.	On the hour, i				
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- 🝺 Element Categories - 📺 Notification Rule Categories	EndInterval	<pre>IF(Minute('*') = 0) OR (Minute THEN ParseTime(Concat("T- ELSE ParseTime(Concat("T- // Set the interal end time to IF(Minute('*') = 1)</pre>	('*') = 1) +", Hour('*-1h'), +" Hour('*') "h- Attribute Templa	"h+1s")) +1s")) te Properties		1				
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Delement Categories Diffication Rule Categories Diffication Categories Diffication Categories	EndInterval	<pre>IF(Minute('*') = 0) OR (Minute THEM ParseTime(Concat('T ELSE ParseTime(Concat('T [K]St the interal end time to IF(Minute('*') = 1) ELSE '*' // Time interval will always IF(Minute('*') = 0) OR (Minute THEM 3599 ELSE((Minute('*') - Minute) THEM 359</pre>	('*') = 1) +", Hour('*-1h'), f Hour('*-1h'), "ha autribute Templa Save Output History: Name: (Description: t Data Server: Value Type:	"h+1s")) te Properties • Yes O No OEE %Server% Double	×	into the next i				
Delement Categories Diffication Rule Categories Diffication Categories Diffication Categories	EndInterval ElapsedTimeSec	<pre>IF(Minute('*') = 0) OR (Minute THEN ParseTime(Concat('T- ELSE ParseTime(Concat('T- ELSE ParseTime(Concat('T- F(Minute('*') = 1) IF(Minute('*') = 1) IF(Minute('*') = 0) OR (Minute THEN 3599 ELSE((Minute('*') - Minut // Set the timestamp to post th // except the final Value whick If(Minute('*') <> 1) THEN Begin</pre>	('*') = 1) +", Hour('*-1h'), f Hour('*-1h'), "ha autribute Templa Save Output History: Name: (Description: t Data Server: Value Type:	"h+1s")) te Properties • Yes O No OEE %Server%	×	into the next i				
Delement Categories Diffication Rule Categories Diffication Categories Diffication Categories	EndInterval ElapsedTimeSec PostingTime	<pre>IF(Minute('*') = 0) OR (Minute THE ParseTime(Concat('T- ELSE ParseTime(Concat('T- ELSE ParseTime(Concat('T- F(Minute('*') = 1) F(Minute('*') = 1) // Time interval will always IF(Minute('*') = 0) OR (Minute THEN 3599 ELSE((Minute('*') - Minur // Set the timestamp to post th // except the final Value whick If(Minute('*') <> 1) THEN Begin (Minute('*') <> 1) THEN</pre>	('*') = 1) +", Hour('*-1h'), f Hour('*-1h'), "ha autribute Templa Save Output History: Name: (Description: t Data Server: Value Type:	"h+1s")) te Properties • Yes O No OEE %Server% Double mnce attribute template	×	: into the n				

• 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:

Scheduling: Period: 00h 0		Advanced Output time stamp override: PostingTime
	Q Advanced options	×
	Output Time Stamp Trigger Time Execution Time Relative to Trigger Time: Variable:	PostingTime ~
	Automatic Recalculation	out-of-order input events

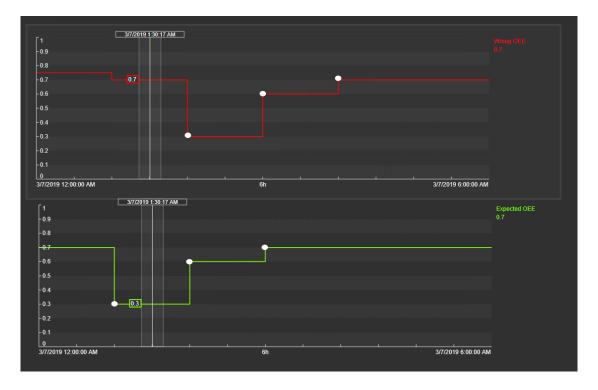
3.2.2 OEE Calculation scheduling explain

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	<pre>// 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"))</pre>
EndInterval	<pre>// Set the interal 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 '*'</pre>
ElapsedTimeSec	<pre>// 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</pre>
PostingTime	<pre>// 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('*')))</pre>

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:

🚰 Tim	e Se	ries [Data								_			×
Archive	San	npled	P	lot	Summary	Data Pipe								
<u>A</u> ttribut	e:	[OEE				_							
Start Time: *-8h							F	End Time:	*		1	•	4	•
Retrieval Type: Time Range					~	Boundary Type:	Inside					\sim		
Filter:] =, .,,				Show	Filtor	d		
Citter.									-		_			
										Res	e <u>t</u>	R	efres	_
								ta						8
	0	?	₿	Ŷ	Time Stamp		_	/alue						1
▶					2/12/2019 1			.5625						
			Su	bsti	tuted 2019 1	2:00:01 PM	1 0	.625						
					2/12/2019 1	:00:00 PM	0	.6125						
				Ŷ	2/12/2019 1	:00:01 PM	0	.225						
					2/12/2019 2	:00:00 PM	0	.2325						
				Ŷ	2/12/2019 2	:00:01 PM	0	.625						
					2/12/2019 3	:00:00 PM	0	.62604						
				Ŷ	2/12/2019 3	:00:01 PM	0	.825						
					2/12/2019 4	:00:00 PM	0	.8225						
				Ŷ	2/12/2019 4	:00:01 PM	0	.5625						
	- '	- '	_	_			_							(
• 0.562	5						Tre	nd						ļ
0.9	5													
0.7							Τ	I						
0.6	1				+		4		1					
0.5	^							-	_	·				
0.4														
0.2				-										
2/12/20	19 11	1:17:	22 A	М			8	hours			2/12	/2019 7:	:17:22	2 P
16 result	s ret	urne	d in I	0.00	22861 second	ls.								
								llose						
								1030						

The values with a \downarrow 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:

Point Class:	base	 ✓ Import 	
Point Type:	Float64	~	
Point Attribute engunits		Value	
excdev		0.1	
excdevpercent		0.1	
excmax		600	
excmin		0	
exdesc			
future		0	
pointsource		Lab	
ptsecurity		piadmin: A(r,w) piadmins: A(r,w) PIWo	
scan		1	
shutdown		1	
sourcetag			
span		100	
step		1	
typicalvalue		50	
zero		0	-

• 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	×]	
Tag Creation pointtype=Float64;step Attributg: Unit of Measure	Element%.%Attribute%		
Source Units: <none></none>	> ~		Group by: 🗹 Category 🔲 Template
Value retrieval methods		Name:	OEE
By <u>T</u> ime: At	utomatic ~	Description:	
Relative time:		Properties:	<none> ~</none>
By Time <u>R</u> ange: Er	nd Time 🗸 🗸	Categories:	OEE
Calculation <u>b</u> asis:	Time Weighted $\qquad \qquad \lor$	Default UOM:	percent ~
Min percent good:	80	Value Type:	Double ~
Preview		Default Value:	0 %
	example instance	Data Reference:	PI Point ~
Configuration:		Display Digits:	-5
Value:			Settings
Read only	OK Cancel		ete.%Element%.%Attribute t64;compressing=0;step=1

The configuration of the other attributes can be quickly changed using a copy/paste of the configuration string: Attribute Templates Ports Analysis Templates Notification Rule Te Group by: 🗹 Category 🗌 Ter Descriptio ✓ i ♦ R Name A Description Default Value xv: <None> 🔹 🍕 Bad Part Count Categories 6 Default UOM <None CycleTime 540 s Тір Value Type: Int32 🔶 🍊 Machine State Operating, Id... Running Default Value 🔶 🍕 Part Count Data Reference: PI Point Reduct 6921 -5 Display Digits: ♦ A RunningTime Running Time I... 0 ory: Asset Manaj Machine Type 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:

IVPISRV01\Star Bearings Company - PI S	ystem Explorer (Adminis	trator)						-
File View Go Tools Help								
🔕 Database 🛗 Query Date 🔹 🕔 🥥	Back 💿 🗟 Check	In 🍤 🖌 🛃 Refresh 🔡 New Templat	e 🕶					Search Element Te
Library	Station Template							
Star Bearings Company	General Attribute Tem	plates Ports Analysis Templates Notifica	tion Rule Templates					
Element Templates					Name:	Station OEE Perfor	mance	
Equipment	🚯 🗖 Name				Description:			
🚮 CNCLatheTemplate	****	EE Performance			Categories:			
🔂 Rough Grinder Templat	•••			_	-			
🔂 EquipmentGroup Template	🏀 🖓 Station O	EE Availability				 Expression 	· ·	Event Frame Generation
🔂 Global Configuration	Station B	ad Part Count			 Enable an 	alyses when created	l from templat	e
🖓 Line Template	At Station P.	art Count		\sim				
Station Template	Example Element: St	tar Bearing Company\Outer Ring\Station 1						
🗈 🗠 😭 Model Templates								
	Rollup attributes from	m		Sample	Child Element:	CNCLathe001	 Group 	By: None v
🗄 🗝 🖓 Enumeration Sets	 Child elements of 	of Station 1 🕜 This element - Station 1		<u>`</u>				· · · · · ·
Machine Status	To select attributes s	et criteria below			Name	Pare	ent Element	Categories
Machine Unplanned Downtime Re		Performance		√ Perfor	mance	CNCLathe0	01	
OEE Metrics	Autoore Humes			Availa	bility	CNCLathe0	01	OEE
Operators	Attribute Level:	Root Level	¥	Bad Pa	art Count	CNCLathe	01	OEE
📵 Part Creation Flag	Attribute Category:		~	CycleT	ïme	CNCLathe	01	
🕲 Part Quality	Element Category:			Install	ation Date	CNCLathe	01	Maintenance
····· 🕲 Products				Last M	laintenance Da	te CNCLathe0	01	Maintenance
📵 Shift Information	Element Template:		¥		ne State	CNCLathe		
🛄 Station status	Select the function(s) to write to an attribute	Evaluate		ne Type	CNCLathe		Asset Management
Reference Types					ne type neName	CNCLatheo		
🔅 🛅 Tables 🛅 Table Connections	Function	Output(s) Value At Eval Value At Last			nervame facturer	CNCLatheo		Asset Management Maintenance
Categories	Sum							
Analysis Categories	Average Pe	rformance		Mode		CNCLathe		Maintenance
Attribute Categories				No		CNCLathe		Asset Management
	Minimum			OFF.		CNCI ather	01	OFF

конир attributes from) This element - Statio	on 1		Sample Child Element	: CNCLathe
To select attributes se	et criteria belov	, M			Name	
Attribute Name:	Performance	•			✓ Performance	CN
					Availability	CN
Attribute Level:	Root Level			~	Bad Part Count	CN
Attribute Category:				~	CycleTime	CN
Element Category:				¥	Installation Date	CN
Element Template:			🔕 Attribute Templat	e Prope	rties	
Select the function(s) to write to an	attribute	Save Output History:	Yes	No No	CN
Functio	on	Output(s)	Name:	Perfor	mance	CN
Sum Sum			B 1.0			
Average		Map	Description:			
Minimum			Data Server:	%Ser	ver%	
Maximum			Value Type:	Doub	le	Y CN
Count			A PI Point data referer	nce attri	bute template will be c	reated. CN
🗌 Median					OK Ca	ancel CN
Population stan	dard deviation				RunningTime	CN

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

					ρ -	Name:	Performance	2	Group by
i e f	Name	△ Description De	fault Value		©	Description:			
Cate	gory: <none></none>				-04	Properties:	<none></none>		
Cutto		PI Point Data Ref	ference		×	Categories:	OEE		
	🗄 Element Name								
٠	🔄 Station Status	Data server:	%Server%		~	Default UOM:	percent		
Cate	gory: OEE	Tag name:	Discrete. %Elen	nent%.%Attribute%	•	Value Type:	Double		
•			K			Default Value:	0 %		
×	Kailability	✓ Tag C				Data Reference:	PI Point		
٠	KAR OEE	pointtype	=Float64						
٠	Karley Performance	Attribute:	Tag Creation Sett	ings				×	
•	Kan a state of the second s	Ũ	-	-					
×	Quality	Unit of Measu	Point Class:	base		~	Import		pointtype=
Cate	gory: Production	Source Units:							,, ,
٠	Kad Part Count		Point Type:	Float64		\sim			
٠	Kart Count	Value retrieva	Point Attribute	Valu	•				
×	Van Count	By Time:	archiving	1	-				
			compdev	0.2					
		Relative ti	compdevpercent	0.2					1
		By Time Range	computervpercent	2880	10				
		by time Kange	compmin	0	0				
		Calculation	compressing	ol					
			datasecurity		min: A(r. w)	piadmins: A(r,w)			
		Min percer	descriptor	pida	1000 A(1707	[piddmins: A(r,w) [10000		
			digitalset						
		Preview	displaydigits	-5					
		Example insta	engunits	-5					
			excdev	0.1					
		Configuration	excdevpercent	0.1					
		Value:	excmax	600					
		(adder	excmin	0					
			exdesc						
		Read only	future	0					
			pointsource	Lab					
			ptsecurity		min: A(r.w)	piadmins: A(r,w)	PTWo		
			scan	1		10.000000000000000000000000000000000000			
			shutdown	1					
			sourcetag	-					
			span	100					
			step	100					
			typicalvalue	50					
			zero	0					

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

File View Go Tools Help Database 🛅 Query Date 🔹 🔇 🥥 Back 💿 🔍 Check In	🍤 🖌 👩 Refresh 🛛 谢 New Ten	mplate 🔹 😪 New Attribute Template 🛛	🖻 Cate	gory: OEE			
Terrer Tester Coord Coord Part Coor	Station Template General Attribute To Piter Category: Category: Safe Safe Safe Safe Safe Safe Safe Safe	emplates Parts Analysis Templates Notification Rule Templates eDescription Defluit Value citizene> Element Name 0	\$	Performant	New Att Locatior Health c Categor	Visibility All All	

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

New	mance			Name	ilability		
elete	l Part Count	New New			ormance		
-	t Count	X Delete		h B	ad Part Coun	t	
view Results	tus Calc	Review Re	sults	h P	art Count		
ackfill/Recalculate	r Bearing Con	Backfill/Rec	alculate		tar Bearing C	omnanu/Roll	ling F
ackfill/Recalculate Status		Backfill/Rec	alculate Status		tar bearing c	ompany (non	ing t
to Template		⇔ Go to Temp	olate	iro	m		
set to Template	Station 2 🤇	🖹 Reset to Te	mplate	:5 (of Station 2	 This eler 	ment
onvert to Template	criteria belo	Convert to	Template	s s	set criteria be	low	
	Performance	🖹 Сору			Availability		
рру	Root Level	🖺 Paste			Root Level		
aste		🖳 Check In		y:			
heck In		😏 Undo Chec	k Out	<i>r</i> :			
ndo Check Out		🖌 Check Out		2:			
eck Out		Audit Trail	Events	n(s) to write to	an attribute	
udit Trail Events	to write to ar	B Security		cti	on	Out	put(s
Security			Sur	n			

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

Image: A star Bearings Company - PI star Bear	ystem Explorer (Administrator)			
File View Go Tools Help				
🔕 Database 🛗 Query Date 🔹 🕔 🥥	3 Back 🏐 💐 Check In 🍤 🖌 👩 Refresh 🛛 🔞 New Template 🔹			
Library	Station Template			
🗳 Star Bearings Company	General Attribute Templates Ports Analysis Templates Notification Rule Templates			
🖮 🐨 Templates		Name:	Station OEE Availability	
Equipment	I Name	Description:		
🚮 CNCLatheTemplate	Not Station OFF Profession	Categories:		
🔤 🖓 Rough Grinder Templa	•••	-	: O Expression Rollup	Event Fran
🔂 EquipmentGroup Template	Station OEE Availability			Event Fran
🔐 Global Connigul autori	Station Bad Part Count	✓ Enable an	alyses when created from template	
Station Template	Image: Station Part Count			
Event Frame Templates	f(x) Station Status Calc			
🗄 🗝 Model Templates	Image: Station Status Sum			
⊞…	30 Station OEE			
Bad Part Reason				
Machine Status				
📵 Machine Unplanned Downtime R				
📵 OEE Metrics				
Operators Part Creation Flag				
Part Creation Flag Part Quality				
Products				
📵 Shift Information				
🛄 Station status				
im the second se				
Table Connections				
Categories	Example Element: <u>Star Bearing Company\Outer Ring\Station 1</u>			
💽 Analysis Categories	Rollup attributes from	Council a Child Flore and	Children I. Come Bu	
Attribute Categories	Child elements of Station 1 This element - Station 1	Sample Child Element:	CNCLathe001 v Group By:	None
@ Element Categories @ Notification Rule Categories	To select attributes set criteria below	Name	Parent Element)
Reference Type Categories		✓ Availability	CNCLathe001	OEE
Table Categories	Attribute Name: Availability	Bad Part Count	CNCLathe001	OEE
	Attribute Level: Root Level v	CycleTime	CNCLathe001	
	Attribute Category: v	Installation Date	CNCLathe001	Maintena
1				A 4 5 4

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:

🔕 \\PISRV01\Star Bearings Company - PI Sy	/stem Explorer (Administrator)		- 0 ×
File View Go Tools Help			
🕲 Database 🛗 Query Date 👻 🔇) Back 💿 💐 Check In 🦻 🖌 👔 Refresh 📲 New Template 👻		Search Element Templates 🔎
Library	Station Template		
Star Bearings Company	General Attribute Templates Ports Analysis Templates Notification Rule Templates		
🗑 Templates			
🖶 🛶 Element Templates		Name: Station OEE	
🚊 🗝 🚰 Equipment	🕼 🖻 Name	Description:	
🔚 CNCLatheTemplate	*0x 0x 0 0FF	Categories:	
🔚 🖓 🖓 🖓 🖓 🖓 🖓			
🔂 EquipmentGroup Template	Contraction OEE Performance	Analysis Type: Expression Rollup Expression Rollup Expression Comparison Compariso	ent Frame Generation 🛛 🔿 SQC
····· 🕋 Global Configuration	Contraction OEE Availability	 Enable analyses when created from template 	
····· 🔂 Line Template	Station Bad Part Count		
Station Template			
Event Frame Templates			
🗄 📽 Model Templates	f(a) Station Status Calc		
i⊞— "∰ Transfer Templates	⊘f Station Status Sum		
🔞 Enumeration Sets			
- G Machine Status			
Machine Status Machine Unplanned Downtime Re			
GeE Metrics			
Operators	Example Element: Star Bearing Company\Outer Ring\Station 1		
Part Creation Flag	Compressioner Star ocompany (Otter King (Station 1		
- @ Part Quality			
Products	Add a new variable		1 Evaluate
Shift Information	Name Expression	Value at Evaluatio V	/alue at Last Trigc Output Attribute
G Station status			
🗈 🗠 🗟 Reference Types	varQuality Convert(('Part Count'-'Bad Part Count')/'Part Cou	unt',"ratio")	Quality
🐵 🔚 Tables			
🛅 Table Connections	varOEE 'Availability' * 'Performance' * varQuality		<u>OEE</u> 🛞
🗄 🦲 Categories		· · · ·	

• 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:

File View Go Tools Help							
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lanagement	Ana	lyses					
Choose a type	12 t	otal analyse	s selec	ted (12 on this page)		1 - 12 of 12 < >	Operations
Analyses		Status 🔇		Element	Name	Template	Enable Disable selected analyses
O Notification Rules	v	9	Ø	Star Bearing Company\Rolling Element	Line Bad Parts Produced	Line Bad Parts Pr	Enable Disable automatic recalculation for selected analys
Analysis Searches	-	Ø	ø	Star Bearing Company\Outer Ring	Line Bad Parts Produced	Line Bad Parts Pr	
+×	-	9	Ø	Star Bearing Company\Inner Ring	Line Bad Parts Produced	Line Bad Parts Pr	Backfill/Recalculate selected analyses
All	• 🗸	9	f(s)	Star Bearing Company\Rolling Element	Line OEE	Line OEE	Start *-30d
Enabled	•	9	fø	Star Bearing Company\Inner Ring	Line OEE	Line OEE	End *
	- V	9	Ø	Star Bearing Company\Rolling Element	Line OEE Availability	Line OEE Availab	End
Disabled	•	Ø	Ø	Star Bearing Company\Inner Ring	Line OEE Availability	Line OEE Availab	What should we do with existing data?
OEE Metrics	1	9	Ø	Star Bearing Company\Rolling Element	Line OEE Performance	Line OEE Perforn	 Leave existing data and fill in gaps
EquipmentGroup OEE	▶ 🗸	Ø	đ	Star Bearing Company\Inner Ring	Line OEE Performance	Line OEE Perforn	 Permanently delete existing data and recalculate
Station OEE		9	Ø	Star Bearing Company\Rolling Element	Line Parts Produced	Line Parts Produ	Recalculate dependent analyses
	/	9	Ø	Star Bearing Company\Outer Ring	Line Parts Produced	Line Parts Produe	Oueue
Line OEE	1	9	Ø	Star Bearing Company\Inner Ring	Line Parts Produced	Line Parts Produc	
							Recalculation will permanently delete all the data within the time range. For event frames this will result in loss of annotations

• Create a filter for the *Equipment, EquipmentGroup, Line* and *Station* templates using the ticon. 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*".

Q \\PISRV01\Star Bearings Company - PI S	ys
File View Go Tools Help	
🔕 Database 🛗 Query Date 👻 🔇 🥥	
Management	1
Choose a type Analyses Notification Rules	1
Analysis Courses	
Search Name: Line OEE	
Name: Line *	
Add Criteria 🕶	
* Analyses that match all of these criteria will be displayed.	

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

Start	*-30d
End	*
	hould we do with existing data? eave existing data and fill in gaps
	ermanently delete existing data and recalculate P Recalculate dependent analyses
п	Pecalculation time range for dependent analyses nay get expanded depending on analysis onfiguration.
0	Queue
data fran	alculation will permanently delete all the a within the time range. For event nes this will result in loss of annotations 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:

🔲 🥑 🞯 Star Bearing Company\Equipment List\Bore Grinding	Equipm
✓ Ø ft Configuration\3.2.2 Example	Lathe00
Image: Configuration (3.2.2 Example Image: Configuration (3.2.2 Example) Image: Configuration (3.2.2	Lathe0

4. Directed Activity – Creating a PI Vision Dashboard

4.1Context

PI Vision is already installed an 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:

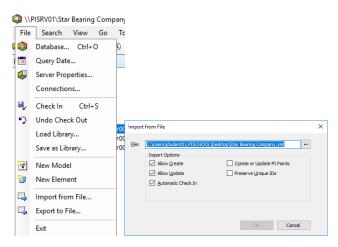
discrite manufacturing. CER Exerce Colume Exerce HOME BY EQUIPMENT TYPE Breachdrag Chartle Free Grinding Free Grinding Free Grinding Free Grinding Rough Genoting Rough Genoting Rough Genoting	SHOP FLOOR	40 50 60 70 77.546 % AVAILABILITY e - Outer Ring	ODUCTION uter Ring Proce 90 20 90 10 100 0	70,417 % VAILABILITY	80 20 99 10 100 0 k on equipment	93.75 %	70 50 100	QUALITY AN	NALYTICS	CEE EQUIPMENT OEE EQUIPMENT OEE KPIS of the Latest Hour	t Effectiven and Equipment	OEE Details	[₿ [:) \BOUT
HOME BY EQUIPMENT TYPE Bore Gridding Chamter Face Gridding Heat Treatment Latte Databing Ring Politabing Rough Grouving	SHOP FLOOR	77.546 % AVAILABILITY e - Outer Ring Station	uter Ring Proce	70,417 % VAILABILITY	of the Latest Ho 80 20 99 10 100 0 k on equipment	93.75 %	70 50 100	QUALITY AP	NALYTICS	COEE CUIPMENT COEE EQUIPMENT COEE KPIs of the Latest Hour COEE KPIs of the Latest Hour	OEE ANALY	OEE Details	
BY EQUIPMENT TYPE Bore Grinding Chamfer Face Grinding Heat Treatment Lathe Polishing Rough Growing Rough Growing	Process Lin Asset CNCLame001 CNCLame02 CNCLame02	77.546 % AVAILABILITY e - Outer Ring Station	uter Ring Proce	70,417 % VAILABILITY	of the Latest Ho 80 20 99 10 100 0 k on equipment	93.75 %	70 50 100	QUALITY AN	BoreGrinder006	EQUIPMENT OEE KPIs of the Latest Hour 30 40 50 30 20	DETAILS		1BOUT
Bers Schinding Chamfer Face Grinding Fine Grinding Heat Treatment Latthe Polialing Ring Policiting Rough Grouving Rough Grouving	Process Lin Asset CNCLathe001 CNCLathe003	77.546 % AVAILABILITY e - Outer Ring Station A Station 1	ProcessLine	70.417 % AVAILABILITY List (Double-clic) Machine Type	80 20 99 10 100 0 k on equipment	40 50 60 93.75 % AVAILABILITY			30 40 50 60 7	OEE KPIs of the Latest Hour		30 40 50 60	70
Chamfer Face Gohding Fine Grinding Heat Treatment Lathe Polision Rong Policiting Rough Grouving Rough Grouving	Asset CNCLathe001 CNCLathe002 CNCLathe003	e - Outer Ring Station A Station 1	ProcessLine	70,417 % AVAILABILITY List (Double-clic) Machine Type		93.75 % AVAILABILITY			30 40 50 60 7	OEE KPIs of the Latest Hour		30 40 50 60	70
Face Ganding Fine Grinding Heat Treatment Lathe Boliaking Rong Pakahang Rough Grouving Rough Grouving	Asset CNCLathe001 CNCLathe002 CNCLathe003	e - Outer Ring Station A Station 1	ProcessLine	AVAILABILITY List (Double-clic) Machine Type		AVAILABILITY			30 40 50 60 7	80 20 40 50	60 70 80 21 90 10	40 50 60 30	70
Fine Grinding Heat Treatment Lathe Pailshing Ring Polishing Roush Grinding Raugh Growing	Asset CNCLathe001 CNCLathe002 CNCLathe003	e - Outer Ring Station A Station 1	ProcessLine	AVAILABILITY List (Double-clic) Machine Type		AVAILABILITY			20,	80 20 -90 10	80 21 90 10		80
Heat Treatment Lathe Polishing Rough Grinding Rough Growing	Asset CNCLathe001 CNCLathe002 CNCLathe003	Station A Station 1	ProcessLine	Machine Type						-90 10	90 10		.90
Lathe Polishing Ring Polishing Rough Grinding Rough Growing	Asset CNCLathe001 CNCLathe002 CNCLathe003	Station A Station 1	ProcessLine	Machine Type					10	100 0	- 100 0-		- 100
Polishing Ring Polishing <u>Rough Grinding</u> Rough Grooving	CNCLathe002 CNCLathe003		Outer Ring			Availa Per	formance Qua	ity	83.333 %	75 %		100 %	
Ring Polishing Rough Grinnling Rough Growing	CNCLathe003	Station 1		Lathe	Idle	100	90	100	AVAILABILITY	PERFORM	IANCE	QUALITY	_
Rough Grinding Rough Grooving		Station 1	Outer Ring Outer Ring	Lathe	Running	83.333 58.333	75	100	Equipment Name:	BoreGrinder006			
Rough Grinding Rough Grooving	RoughGroover00	Station 2	Outer Ring	Rough Grooving	Running	75	75	100	Equipment No:	006	Part Count:		
Rough Grooving	RoughGroover00		Outer Ring	Rough Grooving	Running	58 333	60	100	Manufacturer:	Mazak	Product:	6921	
	Troognoroonoroo		Outer Ring	Rough Grooving	Running	83.333	75	100	Model:	M11	Cycle Time:	540 s	
BY PROCESS LINE		Station 3	Inner Ring	Heat Treatment	Running	66.667	60	100	Installation Date:	3/24/2016 5:00:00 AM			
BY PROCESS LINE	Furnace002	Station 3	Inner Ring	Heat Treatment	Running	75	75	100	Last Maintenance Date	1/24/2019 6:00:00 AM	Machine State	e: Running	
	FaceGrinder004	Station 4	Outer Ring	Face Grinding	Unplanned Stopped	66.667	60	100					
Inner Bing	FaceGrinder005	Station 4	Outer Ring	Face Grinding	Running	75	75	100					
Inner Bing	FaceGrinder006	Station 4	Outer Ring	Face Grinding	Stopped	83.333	75	100					
Outer Ring	BoreGrinder004	Station 5	Outer Ring	Bore Grinder	Running	83.333	75	100	Part Count	III ALL IN ALL IN	11.1		
Rolling Element	BoreGrinder005	Station 5	Outer Ring	Bore Grinder	Running	100	105	100					-
Kompy Clement	BoreGrinder006	Station 5	Outer Ring	Bore Grinder	Running	83.333	75	100	Bad Part Count				
EQUIPMENT ALARM	RingPolisher001	Station 6	Inner Ring	Ring Polishing	Running	83.333	75	100	-0.2				
	RingPolisher002	Station 6	Inner Ring	Ring Polishing	Running	83.333	75	100	2/11/	019 9.45.10 PM	7d	2/18/2019 9	45.10 PM
		Station 6	Inner Ring	Ring Polishing	Running	68.667	60	100					
	RingPolisher003	o fluence											

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

📙 🛃 📕 🖛 Exe	rcise file	25			
File Home	Share	View			
\leftrightarrow \rightarrow \checkmark \uparrow	C:\Use	rs\student01.PISCHOOL\Desktop\Exercise	files		
		Name	Date modified	Туре	Size
🖈 Quick access		-	2/20/2010 7-40 DM	Microsoft Power B	40 KB
Desktop	*	HierarchySlicer.pbiviz	2/20/2019 7:48 PM	Microsoft Power B	49 KB
		PIVision.bak	2/22/2019 7:57 PM	BAK File	47,279 KB
🕂 Downloads	*	PowerBl Solution.pbix	2/21/2019 9:32 PM	Microsoft Power B	632 KB
Documents	*	🖹 Star Bearings Company Blank.xml	2/19/2019 3:18 PM	XML Document	1,158 KB
Pictures	*	🔮 Star Bearings Company Solution.xml	2/22/2019 7:58 PM	XML Document	1,450 KB
Exercise files					

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



4.2Directed Activity – Adding symbols to PI Vision

- Use the PI Vision shortcut and 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:

Advanced Edition × 💿 PI Vision	× +		- o ×
← → C 🔒 https://pisrv01.pischool.int/PIVisi	on/#/		☆ ⊖ :
O PI Vision			🕈 New Display 🔢 PISCHOOL\student01 🕐
Show private displays	Favorites (1)		
Search Favorites			
Filter by Keywords	Game of a 122 with a		
All Displays	- The Addition of the Addition		
☆ Favorites			
My Displays	r		
() Recent			
I 2 ○ ≅	discrete manufacturing_Home PISCHOOL\student01		
☆ Home	± 0 🗙		
- Tiscrete Manufacturing			

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:
 HOME SHOP FLOOR PRODUCTION LINE LINE PERFORMANCE INLINE QUALITY ANALYTICS

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



Tip

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.

	ng OEE Equ	<u></u>	Asset: B	oreGrinde	r002+ V	0		3		Verall Equipmer		ess (OE	
HOME	SHOP FLOOR	1	PRODUCTIC	IN LINE	LINE P	ERFORMAN	CE II		TY ANALYTICS	OEE	OEE ANALYT	TICS	ABOUT
BY EQUIPMENT TYPE Bore Grinding Chamfer Face Grinding Fine Grinding Heat Treatment	Borr 30 10 0		BORE GRIN prment OEE KPI 70 80 90 11 100 0	s of the Latest F	Hour 60 70 80 90 - 10	20 10	⁵⁰ ⁶⁰ ⁷⁰ 100 %	ю ∠90 100	Bore-Grinder00. 30 20 19- 75 %	COEE KPIs of the Latest Hour		³⁰ 100 %	0 70 60 90 -100
Lathe Polishing Ring Polishing	Bore Grine	availability		PERFORM	MANCE		IUALITY		Equipment Name: Equipment No:		Part Count:	QUALITY 5	
	Asset	Station	ProcessLine	Machine T	Machine S	Availability	Performance	Quality A	Manufacturer	OKUMA	Product:	6921	
Rough Grinding	BoreGrinder001	Station 5	Inner Ring	Bore Grinder	Running	63.333	75	100	Model:	M15	Cycle Time:	540 s	
Rough Grooving	BoreGrinder002	Station 6	Inner Ring	Bore Grinder	Running	75	75	100	Installation Date:	5/8/2016 5:00:00 AM	Machine State		
	BoreGrinder003	Station 5	Inner Ring	Bore Grinder	Unplanned Stopped	75	75	100	Last Maintenance	Date: 2/2/2019 6:00:00 AM	Machine State		
BY PROCESS LINE	BoreGrinder004	Station 5	Outer Ring	Bore Grinder	Running	66.667	60	100					
Inner Ring	BoreGrinder005	Station 5	Outer Ring	Bore Grinder	Running	75	75	100		Parts Count and Bad Parts C	ount Irend		
Outer Ring	BoreGrinder006	Station 5	Outer Ring	Bore Grinder	Running	83.333	75	100	Part Count	0.8			
Rolling Element									5 Bad Part Count 0 %	0.6 0.5 0.4 0.3 0.2			
										3/11/2019 11:17:53 AM	êh	3/11/2019	7:17:53 PM

• 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 ^{III} 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 <u>equipment group</u>, which is the Lathes for this particular page:

LATHE EQUI	IPMENT SUMMARY		
Lathe Equipment OEE KPIs of the La	atest Hour		
40 50 60 70			
20 80			
10.090			
0-100			
86.111 AVAILABILITY	PERFORMANCE	QUALITY	
Lathe Equipment List			
(Double-click on equipment in list to view more	e detaile >>)		

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:

D	PI Vision							
0	Assets	descrete manufacturing_OEE_Equip_ * Asset Lathe V						
병								
UØ\	Search in Equipment List							
	Company	HOME SHOP FLOOR PRODUCTION LINE LINE PERFORMANCE INLINE QUAL						
	< Star Bearing Company							
	Equipment List	LATHE EQUIPMENT SUMMARY						
	🕀 Bore Grinding >	Rec.Scholog Lathe Equipment OCE XP1s of the Latest Hour Chamler 40_55 N						
	Face Grinding							
	Fine Grinding	Hust Tradment 86,111						
	Heat Treatment							
	🕅 Lathe 💙	Policing Latho Equipment List						
	Polishing	Nrg Palahing (Coulde-click on equipment in lief to view more details >>)						
	Ring Polishing	Ricgh Grindry						
		Rough Growing						
	Attributes	BY PROCESS LINE						
	Lathe	how fire						
	Availability	Quine: Bira						
	Bad Part Count	Rolina Electroni						
	Em Current Shift	EQUIPMENT ALARM						

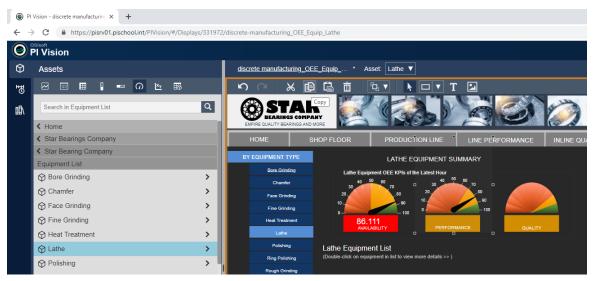
• Right click on the gauge and select Format Gauge...



• 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*:



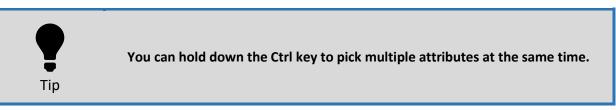
• Click on paste and move the gauge on top of Quality. The newly created gauge still shows the data for the performance. To fix it, select the quality attribute and drag it on the gauge:

© PI	Vision - discrete manufacturing × +	
\leftarrow	C https://pisrv01.pischool.int/PIVision/#/Displays/331972	/discrete-manufacturing_OEE_Equip_Lathe
0	PSiseft PI Vision	
Θ	Assets	<u>discrete manufacturing_OEE_Equip</u> * Asset: Lathe ▼
퍵		
۵Ð	Search in Equipment List	
	< Home	EMPIRE QUALITY BEARINGS AND MORE
	< Star Bearings Company	HOME SHOP FLOOR PRODUCTION LINE LINE PERFORMANCE INLINE QUALIT
	< Star Bearing Company	BY EQUIPMENT TYPE LATHE EQUIPMENT SUMMARY
	Equipment List	
	🕅 Bore Grinding	Chamfer 40 50 60 50 60 50 60 50 50 60 50 50 50 50 50 50 50 50 50 50 50 50 50
	🕥 Chamfer >	Classifier 30 70 30 70 30 70 20 70
	G Face Grinding	
	☆ Fine Grinding	
	•	Heat Treatment 86.111 AVAILABILITY PERFORMANCE QUALITY
	Heat Treatment	Lathe

• 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:



Pl Vision - discrete manufacturin × + → C https://pisrv01.pischool.int/PlVision/#/Displays/33	1972/discrete-manufacturing OFF Fou	in Lathe			- 0 아☆ €
OSISOR	risiti asecte manadetarnig_otte_equ	p_same		O NO	w Display
Assets	discrete manufacturing_OEE	E Equip Asset: CNCLathe003+ V			Ad Hoc Display
	S S S				
Search in Lathe	BEARINGS COMPAN		000	Overall Equip	ment Effectiveness (OEE) Summary and Equipment OEE Details
< Home	+ EMPIRE QUALITY BEARINGS AND M				
 Star Bearing Company 	HOME SH	HOP FLOOR PRODUCTION LINE	LINE PERFORMANCE INLI	INE QUALITY ANALYTICS OEE	OEE ANALYTICS ABOUT
Equipment List Lathe	BY EQUIPMENT TYPE	LATHE EQUIPMENT S	UMMARY	EQUI	PMENT DETAILS
CNCLathe001	Bore Grinding	Lathe Equipment OEE KPIs of the Latest Hour	-	No Data OEE KPIs of the Lat	est Hour
CNCLathe002	Charrier		¹ ² ² ² 2 ² 2 ² 2 ² 2 ² 2 ² 2	30 50 00 70	
CNCLathe003	Face Orinding	10 20 20 10 20	10 10 II	10,000,000	
CNCLathe004	Fine Grinding Heat Treatment	0	-100 0 -1	91,667 %	
CNCLathe005	Lathe	86.111 ANNLABILITY PERFOR	RMANCE QUALITY	AVAILABILITY	PERFORMANCE QUALITY
CNCLathe006	Polishing	Lathe Equipment List		Equipment Name: No Data	
() enclaneous	Ring Polishing	(Double-click on equipment in list to view more details >>)		Equipment No:	Part Count: No Data
	Rough Grinding			Manufacturer: Model:	Product: Cycle Time:
	Rough Grooving			Installation Date: Last Maintenance Date:	Machine State:
Attributes	BY PROCESS LINE				
OEE	imer Rhg		HZ.	Parts Count and Bad	
Availability	Outer Ring		ЩΨ	Part Count 0.5 No Data 0.7	
I OEE	Rolling.Element			Part Count 0.8 No Data 0.7 Biad Part Count 0.9 No Data 0.2 -0.2	
Performance	EQUIPMENT ALARM			-02 0 2/12/2019 7:54 03 PM	7d 2/19/2019 7:54 03 Pb
Cuality Quality				212/2010 7:54/03 PM	21122019/7.54 03 PM
<none></none>					
III Bad Part Count					
CycleTime					
Machine State					
Part Count					
Product					
III RunningTime	2/12/2019 7:54:03 PM		🚽 7d		Now 2/19/2019 7:54:0

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



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

J								
Asset	Machine T	Machine	N	ProcessLine	Station	Ava	ilability	Performance
CNCLathe001	Lathe	CNCLath	he001	Outer Ring	Station 1		75	7
CNCLathe002	Lathe	CNCLat	Cor	nfigure Table			83.333	75
CNCLathe003	Lathe	CNCLat		J			91.667	90
CNCLathe004	Lathe	CNCLat	Add	Multi-State.			91.667	9
CNCLathe005	Lathe	CNCLat	Add	Navigation	Link		91.667	90
CNCLathe006	Lathe	CNCLat					83.333	75
			Add	Dynamic Se	earch Criteri	a		

• 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...*

3						
Asset	Station	ProcessLine	Machine S	Availability	Performance	Quality
CNCLathe001	Station 1	Outer Ring	Running	75	75	100
CNCLathe002	Station 1	Outer Ring	Configure	Table	5	100
CNCLathe003	Station 1	Outer Ring	Configure	and the second second	o	100
CNCLathe004	Station 1	Inner Ring	Add Multi	-State	0	100
CNCLathe005	Station 1	Inner Ring	Add Navi	gation Link	D	100
CNCLathe008	Station 1	Inner Ring			5	100
			Add Dyna	amic Search	Criteria	
CNCLathe006	Station 1	Inner Ring	Add Dyna	amic Search	Criteria	

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

 Colun 	nns				
Current	Colu	mns:			
Asset Station Proces Machir Availat Perforn Quality	sLine ne Sta pility mance	ate			
🖌 Ena	ble N	1ulti-S	State		
	Ba	ad da	ata		
				Ad	d
	≤			100	×
	≤			90	×
	≤			70	×
	2			0	

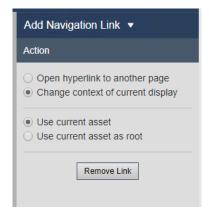
• Repeat the same configuration for Performance and Quality. If time permits, add multi-state to the rectangles underneath each gauge:



• 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...

Asset	Station	ProcessLine	Machine S	Availability	Performance	Quality
CNCLathe001	Station 1	Outer Ring	Running	Availability 75	Performance 75	100
CNCLathe002	Station 1	Outer Ring	Running	83.333	75	100
CNCLathe002	Station 1	Outer Ring	Running		75	100
CNCLathe003	Station 1	Inner Ring	Configure '		75	100
CNCLathe005	Station 1	Inner Ring	Configure	75	100	
CNCLathe006	Station 1	Inner Ring	Configure I	Multi-State	90	100
GNGLathe000	Station 1	inner King	Add Navig	90		
			Add Navig	ation Ellik		
			Add Dynar	nic Search C	riteria	
			Outitab Out	abelte		
			Switch Syn	ndoi to	•	

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



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:

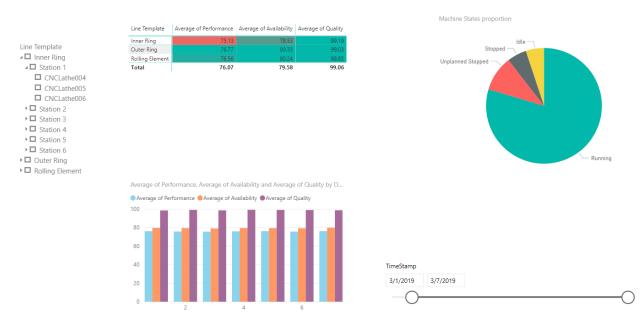
HOME	SHOP FLOOR		PRODUCTIO	ON LINE	LINE P	ERFORMAN			UALITY	ANALYTICS	OEE	OEE ANALYT	ICS ABOUT
BY EQUIPMENT TYPE Bore Grinding Chamfer Face Grinding Fine Grinding Heat Treatment Lathe	Bor 30 10 0	e Grinding Equi	- 100 0		Hour 60 70 80 90 10	20 10 0 0		30 90 100		BoreGrinder002	EQUIPMENT OEE KPIs of the Latest Hou 70 80 20 40 50 100 0 775 % PERFOR	60 70 80 20 90 10 100 0	30 40 50 00 70 80 80 100 % QUALITY
Polishing	Bore Grin	ding Equip	ment List							Equipment Name:	BoreGrinder002		
Ring Polishing	(Double-click	on equipment in	list to view mor	e details >>)						Equipment No:	002	Part Count:	5
Rough Grinding	Asset	Station	ProcessLine	Machine T	Machine S	Availability	Performance	Quality	A	Manufacturer:	OKUMA	Product:	6921
Rough Grooving	BoreGrinder001 BoreGrinder002 BoreGrinder003	Station 5 Station 5 Station 5	Inner Ring Inner Ring Inner Ring	Bore Grinder Bore Grinder Bore Grinder	Running Running Running	66.667 83.333 75			100 100 100	Model: Installation Date: Last Maintenance Date	M15 5/8/2016 5:00:00 AM 2/2/2019 6:00:00 AM	Cycle Time: Machine State:	540 s Running
BY PROCESS LINE	BoreGrinder004	Station 5	Outer Ring	Bore Grinder	Running	91.667	90		100				
Inner Ring	BoreGrinder005 BoreGrinder008	Station 5 Station 5	Outer Ring Outer Ring	Bore Grinder Bore Grinder	Running Running	83.333 83.333			100 100		rts Count and Bad Parts C	Count Trend	
Outer Ring										Part Count -0.8	terres da la constante de la		

5. Directed Activity – Analyzing the data in Power BI

5.1Context

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

5.21Directed 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:

Sign in	01.pischool.int:1313	
nups//pisiv	o npisenoorane ro ro	
Username	pischool\student01	
Password		

• Click on Create Asset View, name the view OEE Metrics

Advanced Edition × +					-	o ×
← → C https://pisrv01.pischool.int:1313					†	Θ:
Ξ		My Views			L PISCHOOL\s	tudent01 🗢
Create Asset View Build a data view starting with your asset hierarchy Event Streaming View Build a data view starting with your event fisme hierarchy		ver Selected view				
Name Run Status	Туре	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	
OEE Metrics	
Cancel Create V	iew

• Click on Create a New Shape

import a shape from an existing view or create a new one
Create a New Shape
Import a Shape from Another View

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

Advanced Edition	× PI Vision - discrete manufacturing ×	-	× +		_	vledns10086.westus.clo
← → C 🔒 http	os://pisrv01.pischool.int:1313/Designer					
Ξ			٥	DEE Metrics Solution		
Select Data > Mo	dify View > Publish					
Source Assets		~	🕅 Search Shape			✓ Matches
Server	PISRV01	×	🖥 Asset Shape			Found 42 Matches
Database	[🔺 🕥 Line Template		ø×	🕨 🕞 Inner Ring
	Star Bearings Company	0 ,	 Station Template 		ø×	🕨 🕜 Inner Ring
			 Equipment 		<i>∦</i> ×	🕨 🕜 Inner Ring
 Configuration 			I Availability		€×	🕨 🕜 Inner Ring
🔺 💮 Star Bearing Compa	ny		🗬 Bad Part Count		<i>∦</i> ×	🕨 🕜 Inner Ring
🔺 💮 Equipment List			CycleTime		<i>∦</i> ×	Inner Ring
 Bore Grinding 			Installation Date		# ×	🕨 🕜 Inner Ring
 Chamfer 			📰 Last Maintenance Date		# ×	🕨 🕜 Inner Ring
 Face Grinding 			🔗 Machine State		# ×	🕨 🕞 Inner Ring
 Fine Grinding 			I Machine Type		# X	Inner Ring
 Heat Treatment 	t		I MachineName		# X	🕨 😚 Inner Ring
🔺 💮 Lathe			III Manufacturer		# X	🕨 😚 Inner Ring
CNCLathe0	01		III Model		# X	🕨 🕜 Inner Ring
CNCLathe0	02		III No		# X	🕨 🕜 Inner Ring
CNCLathe0	03				# X	🕨 💮 Inner Ring
	***	_ = =	Part Count		# X	🕨 💮 Inner Ring
Attributes Filter		×	Performance		# X	🕨 💮 Inner Ring
		. 15	III ProcessLine		ø×	 Outer Ring
C Deselect All			Product		ø ×	 Outer Ring
Availability		0	P Quality		# ×	 Outer Ring
🗬 Bad Part Count		θ	RunningTime		ø ×	Outer Ring
🔳 CycleTime		θ	IIII Station		ø ×	Outer Ring
🔳 Installation Date		θ				Outer Ring
🔳 Last Maintenance Da	te	θ				Outer Ring
🕨 🛷 Machine State		θ				 Outer Ring
🔳 Machine Type		θ				Outer Ring
🔳 MachineName		0				Outer Ring
🔳 Manufacturer		0				 Outer Ring

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

Edit Filters	×
Asset Name	
Inner Ring	
Asset Template Search Derived Templates	
Line Template	•
Asset Category	
	*
Cancel Sav	/e

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

Edit Filters		
Asset Name		
Station 1		
✓ Asset Template		
Station Template		
Asset Category		
Add Filter		
	Cancel	Sav

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

Advanced Edition	× +				– ø ×
← → C 🔒 http:	c//pisrv01.pischooLint:1313/Designer				☆ ⊖ :
≡		OEE Metrics		^م به م	PISCHOOL\student01 O
Select Data > Mod	lify View > Publish				Next
Source Assets		Search Shape		✓ Matches	
Server	PISRV01 T	₩ Asset Shape		Found 42 Matches	
Database	Star Bearings Company	A 🕥 Line Template	€×	 O Inner Ring 	
	star bearings company 0	 Station Template 	€×	 O Inner Ring 	
⊕ Assets		A ③ Equipment	∂×	 O Inner Ring 	
Configuration		Availability	€×	 O Inner Ring 	
A 💮 Star Bearing Company	y .	Pad Part Count	e ×	Inner Ring	
Equipment List		I ost Maintenance Date		Inner Rinn	

• 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:

							Back Next	
Start Time	e		End Ti	ime				
*- <u>7d</u>		[****	*			1000 	Apply	
faintenance Date	Machine State	Machine Type	OEE	Part Count	Performance	Product	RunningTime	=
6.00.00 VM	Dunning	Chamfer	62.5	5	75	6021	0 891 810	

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

Edit Value Mode		×
 ● Sampled Values ● Sample values every 10 ▼ minutes ▼ ● Interpolate ④ ○ Exact ④ 		
© Use Key Column Availability ▼	Cancel	Save Changes

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

arget Configuration	Overwrite Options	Summary
MyBIViews	 The selected target only supports overwriting old data 	Shape and Matches
		There are 42 Matching Instances
Run Mode		Timeframe and Interval
Run Once		• Your Start Time is *-7d
) Run on a Schedule		Your End Time is * Your Time Interval gets an interpolated measurement Every 10 minutes
		Publish

 Overview
 Log
 Security
 View Configuration
 Statistics

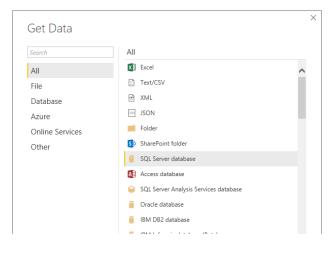
 Run Status
 Publishing 4%

 View Name
 OEE Metrics Solution

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

5.3Creating the Dashboard in Microsoft Power BI Desktop

- Open the Power BI Exercise file using the shortcut on the desktop
- PowerBi Exercise.pbix
- Click on Get Data
 Get
 and select SQL Server database



• Enter PISRV01 in the Server field

Server ()			
PISRV01			
Database (optional)			
Data Connectivity mode 🛈			
 Import 			
 DirectQuery 			
Advanced options			

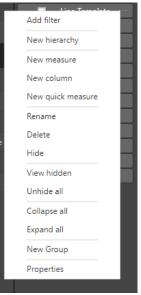
• Select Use my current credentials

	SQL Server database	\times
Windows	pisrv01	
Database	Use your Windows credentials to access this database.	
Microsoft account	Use my current credentials Use alternate credentials User name Password	
	Back Connect	Cancel

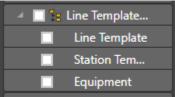
• Choose the OEE Metrics view in the MYBIViews. You should see data in the right tab. Click on load. You should now see a blank canvas.

	Q	OEE Met	rics			
Display Options 🔹	Lo	Id	Line Template	TimeStamp	Station Template	Equipme
PISRV01 [6]		1	Inner Ring	2/13/2019 6:38:35 PM	Station 1	CNCLath
MyBIViews [2]		2	Inner Ring	2/13/2019 6:39:35 PM	Station 1	CNCLath
OEE Metrics		3	Inner Ring	2/13/2019 6:40:35 PM	Station 1	CNCLath
		4	Inner Ring	2/13/2019 6:41:35 PM	Station 1	CNCLath
OEE Metrics1		5	Inner Ring	2/13/2019 6:42:35 PM	Station 1	CNCLath
D 🥛 PIFD		6	Inner Ring	2/13/2019 6:43:35 PM	Station 1	CNCLath
PlintegratorDB		7	Inner Ring	2/13/2019 6:44:35 PM	Station 1	CNCLath
PlintegratorLogs		8	Inner Ring	2/13/2019 6:45:35 PM	Station 1	CNCLath
PlintegratorStats		9	Inner Ring	2/13/2019 6:46:35 PM	Station 1	CNCLath
		10	Inner Ring	2/13/2019 6:47:35 PM	Station 1	CNCLath
PIVision		11	Inner Ring	2/13/2019 6:48:35 PM	Station 1	CNCLath
		12	Inner Ring	2/13/2019 6:49:35 PM	Station 1	CNCLath
		13	Inner Ring	2/13/2019 6:50:35 PM	Station 1	CNCLath
		14	Inner Ring	2/13/2019 6:51:35 PM	Station 1	CNCLath
		15	Inner Ring	2/13/2019 6:52:35 PM	Station 1	CNCLath
		16	Inner Ring	2/13/2019 6:53:35 PM	Station 1	CNCLath
		17	Inner Ring	2/13/2019 6:54:35 PM	Station 1	CNCLath
		18	Inner Ring	2/13/2019 6:55:35 PM	Station 1	CNCLath
		19	Inner Ring	2/13/2019 6:56:35 PM		CNCLath
		20	Inner Ring	2/13/2019 6:57:35 PM	Station 1	CNCLath
			Inner Ring	2/13/2019 6:58:35 PM	Station 1	CNCLath
			Inner Ring	2/13/2019 6:59:35 PM		CNCLath
			Inner Ring	2/13/2019 7:00:35 PM	Station 1	CNCLath
		<				>

• 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:

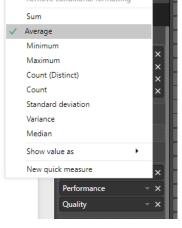


• Create a new HierarchySlider and drag the Line Template hierarchy in the Fields section:

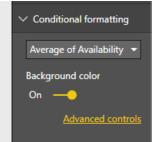
		✓ Search	
F =		 OEE Metrics ∑ Availability 	
Line Template Inner Ring	🐺 🖩 🖩 R 🎯 📰	■ ∑ Bad Part Count ■ Equipment	
 Outer Ring Rolling Element 	Fields	 ■ ∑ Id ■ Last Maintena ■ Line Template 	
	Line Template Hierarchy * × Line Template ×	✓ ✓ Line Template ✓ Line Template	
	Station Template × Equipment ×	 ✓ Station Tem ✓ Equipment Machine State 	

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 Formating 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	e of Availability	×
Format by Color scale Learn more		
Based on field	Summarization	Default formatting ①
Average of Availability	Average 🔻	As zero 🔻
Minimum		Maximum Highest value
75		(Highest value)
Diverging		

① ⊕ ⊕	=		
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

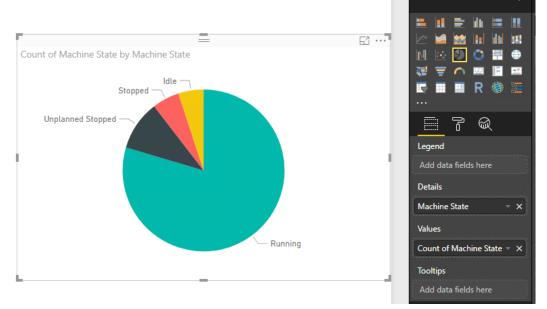
• Your table should like this (the values and colors will be different):

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

TimeStamp



• 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.

D 🕕 🖨	=		
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 solution, bit 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	<pre>IF(Minute('*') = 1) THEN ParseTime(Concat("T+", Hour('*'), "h")) ELSE '*'</pre>	Map
ElapsedTimeSec	<pre>// 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</pre>	<u>Map</u>
PostingTime	<pre>// 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('*')))</pre>	Map
varAvailability	Convert('RunningTime'/3600,"ratio")	Availability
varPerformance	Convert('Part Count' / (3600 / 'CycleTime'),"ratio")	Performance
varQuality	Convert(('Part Count'- 'Bad Part Count')/'Part Count',"ratio")	Quality
varOEE	Convert(varAvailability*varPerformance*varQuality,"ratio")	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*0.9*1=0.81 instead of 90*90*100/10000 = 81).

5.3 Power BI dashboard

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





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.

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

