International DATALYZER Partners in Continuous Improvement OEE COACH

Integrating SPC, OEE and TPM

By: Arno Koch and Marc Schaeffers

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1 Introduction

What is the essence of SPC, TPM and OEE and how do they relate?

Let's first briefly look at the individual tools and then see what the beauty of an integration is.

The focus of TPM

An important continuous improvement strategy for manufacturing organizations is Total Productive Maintenance (TPM). TPM is normally not immediately perceived to have the same goals as SPC. It is often wrongly seen as a maintenance strategy due to a wrong translation/interpretation.

The original goal of Total Productive Management: "*Continuously improve all operational conditions, within a production system; by stimulating the daily awareness of all employees" (by Seiichi Nakajima, Japan, JIPM).* A better translation would be: 'Maintaining the Total Productivity'. It is also often referred to as 'Total Productive Manufacturing'.

An accurate and practical implementation of TPM will increase productivity within the total organization, where:

(1) a clear business culture is designed to continuously improve the productivity of the total production system
(2) a standardized and systematic approach is used, where all losses are visualized, eliminated and prevented
(3) all departments, influencing productivity, will be involved to move from a reactive- to a predictive mindset
(4) a transparent multidisciplinary organization is reaching zero losses
(5) steps are taken as a journey, not as a quick menu.

The Deming-method to Plan, Do, Check, Act and the underlying idea of people empowerment at the shop floor is an important essential within TPM. In fact, this is the first pillar of TPM.

TPM has a strong focus on the equipment, being the main instrument to perform the actual conversion for raw materials into a product. Therefore, TPM puts a lot of emphasis on kaizen-activities like quick change over (Single Minute Exchange of Dies (SMED)), autonomous and preventive maintenance, SHE. But TPM has also pillars for Quality Management and Early Equipment Management and even Administrative processes.

The focus of SPC

Whatever process you run, there will always be common cause variation, like driving your car; it will certainly move between the white lines: It will not follow a straight line without any variation. SPC monitors this behavior and allows us to see when the process drifts away from its normal behavior. Now we can use statistics and mathematical tools to make a distinction between common cause variation (that should not lead to corrective interventions) and special cause variation (that requires an intervention)

SPC in its core, does not imply a full-flash improvement strategy for a complete company. In fact, we could see 'Six Sigma' and the later 'Lean Six Sigma' as efforts to create such structures around SPC as the core tool.

In practice, the organizational structure to improve shows great similarities between TPM and SPC.

SPC's main emphasis is on detecting and monitoring critical quality characteristics as requested by customers.

Basically, this fits perfectly in the Quality Management pillar of TPM.

A second big difference seems to be the way data is gathered and reported. In a classical TPM implementation, OEE data is reported as the main KPI. In SPC, control charts and capability reports are made. However, by definition of TPM, SPC data should also be gathered in TPM's QM pillar.

So, when following the guidelines for a perfect TPM implementation, OEE as well as SPC should be integrated within TPM. Doing so will be very rewarding for companies and opens the route to a zero defect and zero loss production.

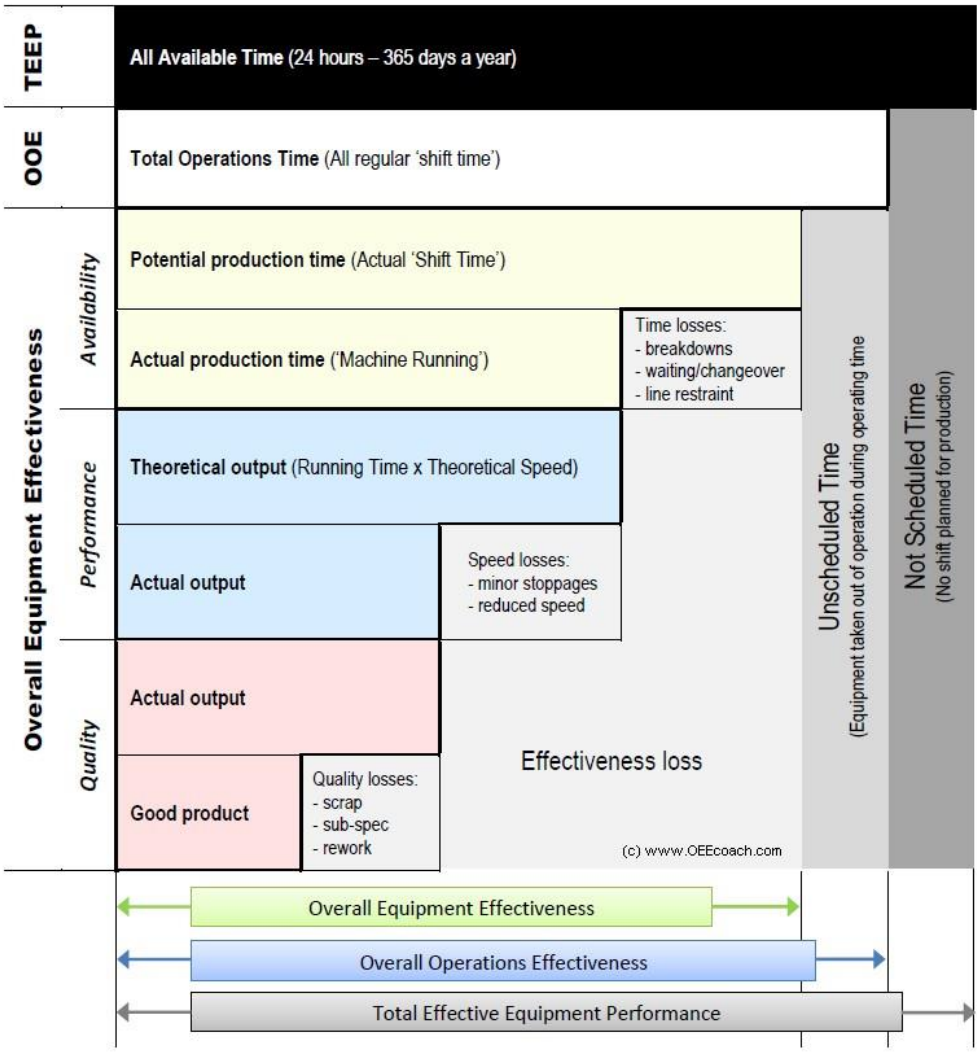
In this document, we will show how SPC methods will help to improve OEE analysis and how OEE analysis and reports are integrated in DataLyzer.

2 OEE ratios

The only generic standard on how to define OEE is described at www.oeefoundation.org. It gives guidelines about how to visualize ALL losses on value adding equipment, but per situation these guidelines need to be customized. DataLyzer's OEE Coach software can handle any type of equipment and is extremely flexible so that you can use your own categories and definitions.

How is OEE being calculated?

OEE is part of a wider loss cascade that starts with the total available time. This is 24 hours x 7 days a week.



Not Scheduled time

From this **total time**, the time where no production is scheduled needs to be subtracted. This gives us the total **operations time**. Examples of NOT SCHEDULED time are for example, no production during the weekend, Christmas holidays etc.

Total operations time	Not scheduled time

What now remains is basically our **normal shift-time**.

Unscheduled time

Even from this time, we may decide not to use parts. We now UNSCHEDULE the initially scheduled time. This is normally a decision of the operations management.

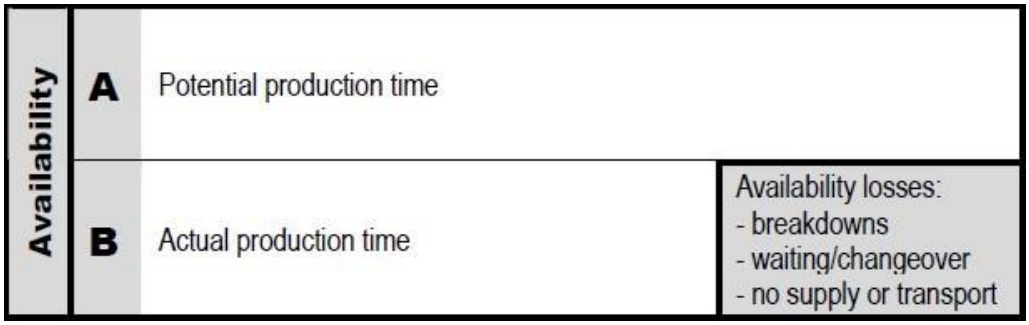
Planned (or 'potential') production time

The now remaining **potential production time** is the starting point for the OEE calculations.

The OEE is the multiplication of 3 ratios. The availability, the performance and the quality. So OEE = availability x performance x quality.

Availability

The **availability** is the ratio between **actual production time** and the **potential production time**.



The 3 big losses in availability loss are:

- Setup's, change-overs and other waiting time (**organizational issues**)
- Breakdowns of the machine (machine related **technical issues**)
- Line-restraints (flow and **supply chain issues**)

Example:

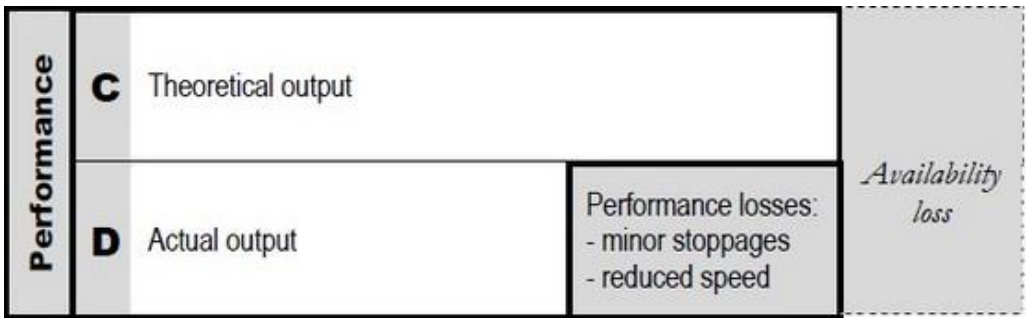
If the machine delivers 360 minutes of output (regardless of speed and quality) during an 8-hour shift (=480 minutes), then the availability rate is:

360 / 480 = 75%

In other words, 25% of the available time is 'lost'

Performance

The **performance** ratio is the **actual output / theoretical output**.



The 2 big losses in speed loss are:

- **Minor stops** (usually smaller than 1 to 5 minutes, including speed fluctuations)
- **Reduced speed** (deliberately running at a lower speed)

The difference between minor stops and a breakdown is in the duration of the 'stop'. With a small minor stop, the machine sometimes doesn't even really stop. There is a loss in speed. Examples are a blocked cavity or a jam in packaging so one or 2 places stay empty. With minor stops the production can be started almost instantly again.

Example:

The machine operates 360 minutes

Production speed is 10 pieces/minute

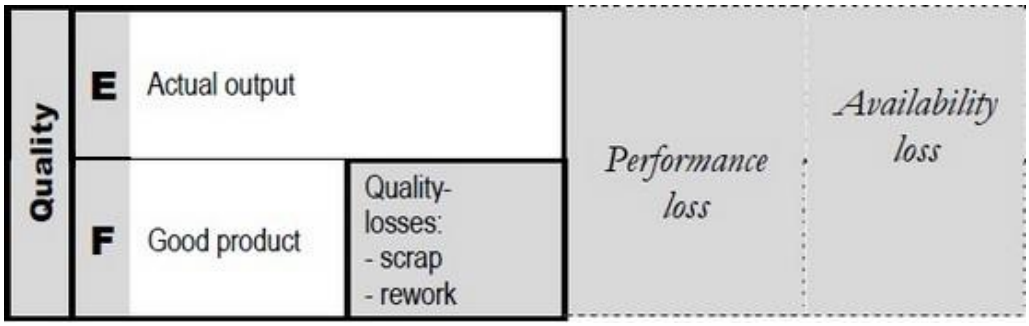
Theoretical output is 360 x 10 = 3600 pieces

Actual output (good and rejected) = 2880 pieces

➔ Performance is: 2880 / 3600 = 80%

Quality

The **quality** ratio is **[good output] / [total output]**



The 3 big losses in quality are:

- Production rejects, that need to be '**scrapped**'
- Production rejects, that can be 'saved' by **rework**ing them.
- Sub Spec: the product does not meet the specifications (and thus is a reject) but can be sold e.g. as a **'B'class** product.

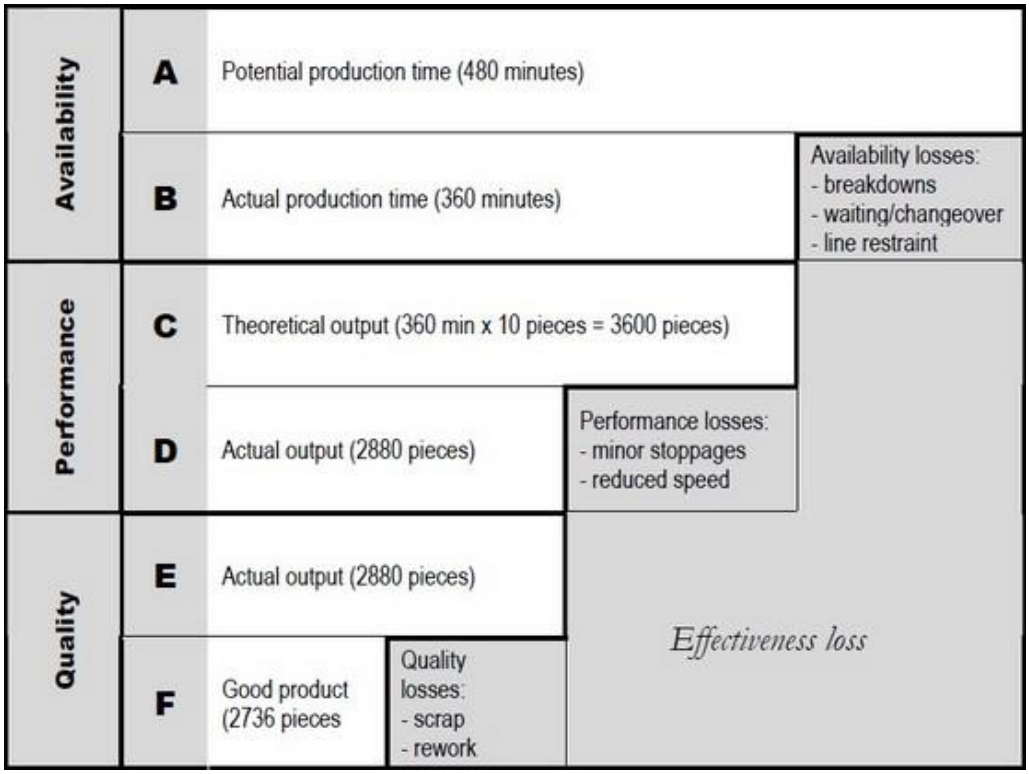
Example

Produced:	**2880 pieces**
Rejected:	**144 pieces**
Good product:	**2880 – 144 = 2736 pieces**

➔ Quality rate: 2736 / 2880 = 95 %

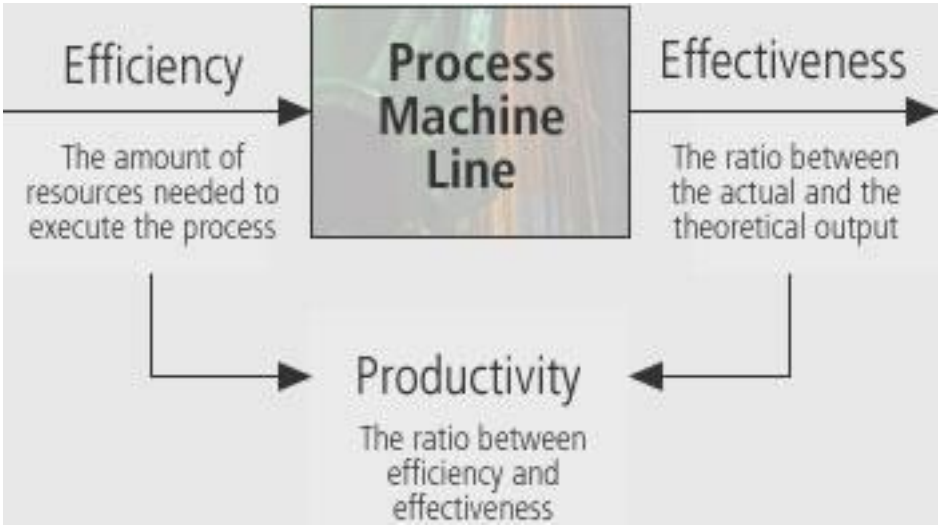
OEE

OEE = Availability * Performance * Quality
As you can see, OEE is a cascade, starting from what is potentially possible to what is actually realized. But more important, it gives a glimpse into why that did **NOT happen**!



(Diagrams from the book 'OEE for the production team' by Arno Koch)

To improve the net productive time, the OEE ratios need to be improved without lowering the efficiency by adding more people, square meters, raw material or complexity etc. Remember: OEE measures the EFFECTIVENESS of the equipment, not its efficiency!



3 The ‘OEE Questionnaire’

So, when applying OEE basically your questions are:

1. **Is the machine running or not?**
   When not: what was the reason?
   - ➔ Was there a machine related technical problem (a **FAILURE**)
   - ➔ Or was there an organizational problem (The machine itself was ok, but there was something missing: it was **WAITING**)
   - ➔ And when the machine was technically ok, and all organizational conditions were met, did it have input from previous steps or could it put through to the next step? (Was there a **LINE RESTRAINT**)

2. **When the machine was actually running**,
   was it running at its theoretical maximum speed?
   - ➔ Or was it deliberately reduced to a lower ‘set speed’ (e.g. to prevent quality problems?) (**REDUCED SPEED**)
   - ➔ And when running at this Set Speed, did it actually bring the expected output at this speed? Or were there minor stops that almost invisibly reduced the expected output at the Set Speed? (**MINOR STOPS**)

3. And finally: when product came out of the equipment:
   - ➔ did it meet the required specifications? (**GOOD PRODUCT**)
   - ➔ or should we throw it away? (**SCRAP**)
   - ➔ Or do we have to rework it? (**REWORK**)
   - ➔ Or sell it as B-quality? (**SUB-SPEC**)

4 OEE Coach

The definition of the OEE ratios is clear, however measuring the different ratios in a running operation is not always so easy. Measuring the total speed loss is possible but it is not always easy to determine which part of the speed loss is caused by small stops and which part is caused by running with reduced speed.

It is commonly believed that all information is available in the PLC of the machine and the information can be extracted easily and the different ratios can be calculated in detail. This can be quite disappointing for several reasons.

Keep it simple

OEE Coach's primary (and pragmatic) approach is to keep things simple: It may sound illogical but even if we don't have a PLC connection, we still should - and can- get a very good impression of the OEE factors and get the right information to drive the improvement process.

Precise vs. Correct

OEE Coach makes a distinct difference between **PRECISE** and **CORRECT** data. OEE does not need to be highly precise; no need for a registration on the millisecond level. Rounded minutes mostly are more than good enough. But then it must be correct: If we think a failure occurred for 20 minutes, it should indeed have been a failure and not something else! Or when we enter parts produced or read it from a sensor, it can never be more than the theoretical speed of the equipment. Here is the problem we see in many databases: massive amounts of data in high precision, but absolutely not correct.

Therefore, OEE Coach has intelligent algorithms built in, that continually monitor the incoming data: *"It this plausible to be correct?"*

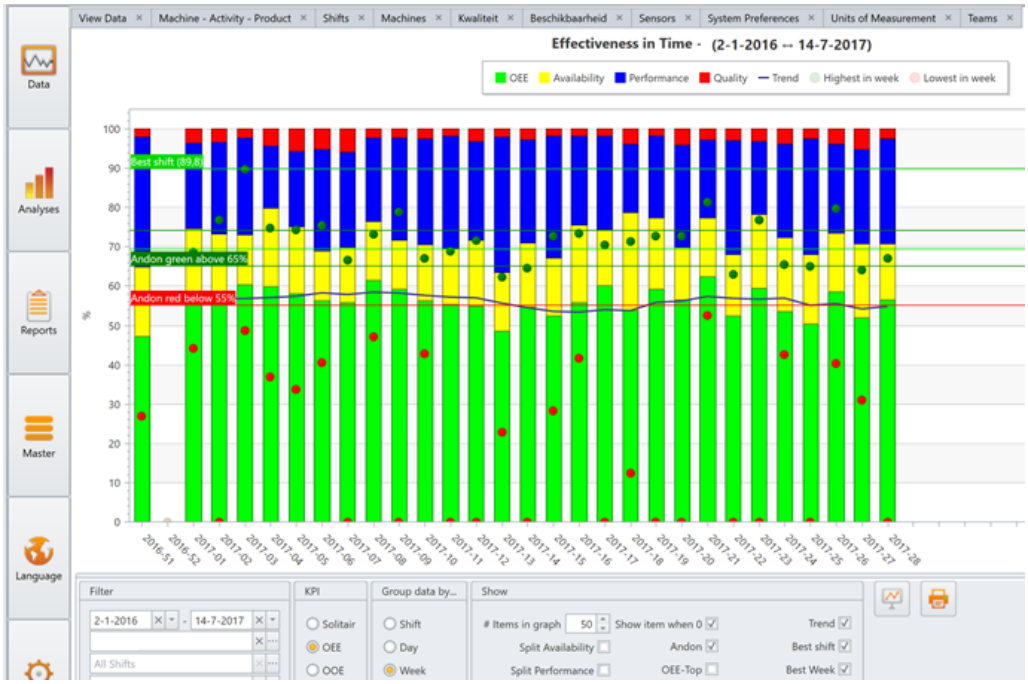
Configurable: Achieve a common language

In OEE Coach, the OEE registration can be setup easily by using among others machines, products and activities. The system takes into consideration all kind of special situations; we dare to claim that we can visualize ANY effectiveness loss on ANY equipment. For us, it is of high importance that shop floor personnel AND management follow the same logic and both clearly understand how things are being measured and why. This should make sense to everyone.

Only in that way a **common language** can be created, which is the first secret key to continuous improvement.

For real-time OEE, DataLyzer offers OEE Coach.

The OEE Coach software is a flexible real-time module that can accommodate loss visualizations within TEEP, OEE, OEE and other related effectiveness indicators, allowing manual downtime registration to full data collection from machines through sensors, serial hardware connection devices, ethernet software and hardware tools and OPC to obtain production information from your equipment. Data from heterogeneous machines can be integrated providing a machine, line, department, plant and companywide single interface, dashboard and reporting system for OEE and SPC. OEE Coach software seamlessly integrates with the DataLyzer SPC system helping it to reap the enormous benefits of both TPM and SPC as continuous improvement techniques offering one user interface for the operator.

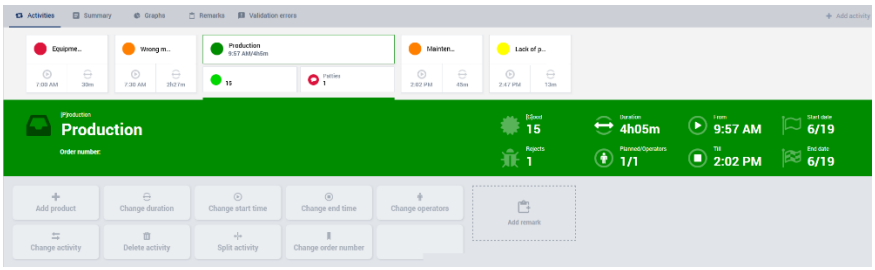


OEE Coach software

5 The fundamentally different perspective between OEE and SPC

‘Above the surface’

As you can see, OEE collects data about the ‘losses’. Some of these losses are planned - and are even required. For example, preventive maintenance or changeovers are required downtimes. OEE concentrates on ALL - undesired - losses like failures, organizational downtimes due to bad planning etc. This means that it looks at the phenomena of these undesired or ‘out of control’ situations at the machine level: each undesired loss will then be visualized, whether it is a technical breakdown, the missing of raw materials, fluctuations in speed, or the output of scrap; all are phenomena associated with uncontrolled processes and should be eliminated.



‘Below the surface’

SPC on the other hand, looks exactly at the other side of the situation: SPC looks mainly at the quality and process characteristics when the machine is running. The aim typically, is to optimize the quality of a product and reduce scrap.

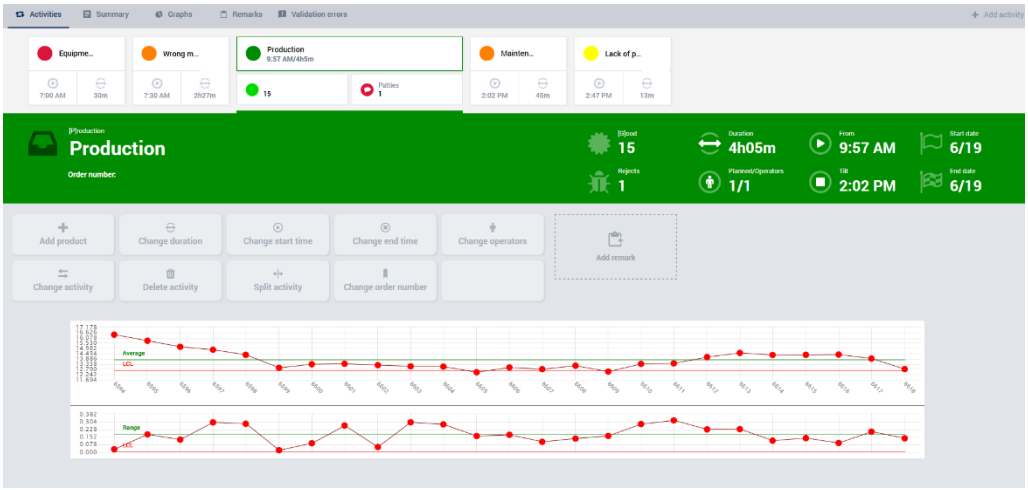
We can however also use SPC to monitor process characteristics to predict downtime of machines: in other words, SPC can be used to PREDICT (and thus PREVENT) the phenomena measured in OEE! This is especially the case for the quality loss. SPC is the perfect tool to reduce quality losses.

Advantages of integrating SPC and OEE

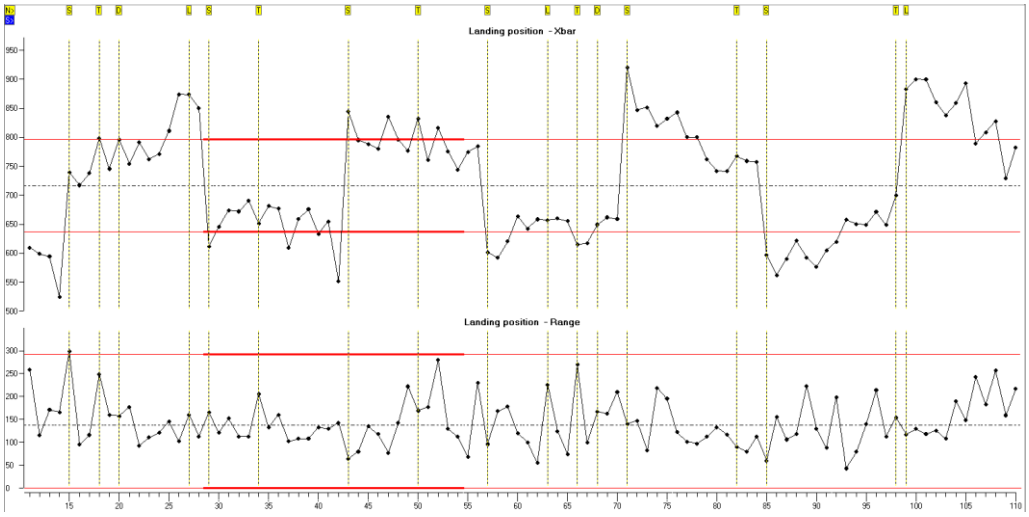
If companies are using OEE and SPC, we typically see that they use OEE primarily for registration of downtime losses and use SPC to improve product quality. But we state that out of control situations will often show in both systems simultaneously and the shop floor will benefit by integrating the 2 approaches.

When looking at OEE data, it is very useful if you can show on the same timeline the behavior of a specific quality characteristic. And vice versa, when analyzing the control chart for a specific quality characteristic, it would be very useful to see the timeline of downtimes in the same graph.

The below graph shows the quality characteristic during an activity in OEE:



This graph shows the OEE activities as note remarks in the control chart.



Some other examples where integration of SPC and OEE will assist the organization in their continuous improvement process:

Food industry:

You want to apply OEE on a production line, but you also need to measure the weight of the products every 20 minutes. This 20-minute rule is based on a continuous running machine but how do you apply the rule if there are downtimes? The advantage of an integrated approach is that the OEE system can trigger the weight measurement based on the right business rules and the correct downtime information.

Injection moulding industry:

You need to perform quality measurements on the product, preferably per cavity and the tool should be able to handle blocked cavities, but you also want to measure OEE and want to have an analysis if downtimes are influencing the product quality. For example, after a production stop, the first few shots are rejected but how many shots should that be and is that related to the duration of the downtime?

Process characteristics might offer an early warning system for downtimes. If the cycle time is going to vary, this is typically an early warning system of an upcoming downtime. *An integrated SPC and OEE solution can provide the tools to analyze correlations between process characteristics and production downtimes.*

Automotive industry:

An OEE system is essential to push for very reliable lead times at the lowest cost. At the same time, the customer needs to perform SPC measurements according to the control plan e.g., every 5th product and provide capability reports according to TS16949 requirements.

An integrated DataLyzer SPC and OEE Coach solution can easily offer this functionality.

Pharmaceutical industry:

To optimize the usage of resources, more and more pharmaceutical industries are applying OEE but at the same time they need to perform quality measurements and comply with CFR 21 Part 11 regulations.

The DataLyzer SPC and OEE Coach combination has all this knowledge and solution capability in house in their standard solutions.

In conclusion, integrating the two approaches in one improvement approach and using an integrated software solution has various advantages, including:

- Productivity and quality will be equally important, and the company will truly benefit if both are improved.
- The methodology for continuous improvement will be accepted faster when both methods are integrated and supported by one approach and an integrated software solution.
- When companies use both methods, the time required for training, system support and system maintenance is reduced.

6 Contact

For further information, please contact DataLyzer International:

Europe

DataLyzer International bv
Eindhoven
Netherlands
Tel : +31-40-2940980
Email: sales@datalyzer.com

USA

DataLyzer International Inc.
Wixom, MI 48393, USA
Tel : +1-248-960-3535
Tel : +1 800-553-4772 USA only
Email: sales@datalyzer.com

Asia

DataLyzer India
Bangalore
India
Tel: + 91 8026615292
Email: salesindia@datalyzer.com