Is Overall Equipment Effectiveness (OEE) an Effective Metric?

If you search Google for the definition of Overall Equipment Effectiveness (OEE), you will get some of the following statements:

- "OEE (Overall Equipment Effectiveness) is the gold standard for measuring manufacturing productivity. Simply put – it identifies the percentage of manufacturing time that is truly productive."
- "Overall equipment effectiveness (OEE) is a measure of how well a manufacturing operation is utilized (facilities, time and material) compared to its full potential, during the periods when it is scheduled to run."
- "OEE (Overall Equipment Effectiveness) is a "best practices" metric that identifies the percentage of planned production time that is truly productive."

Sounds like the perfect metric to use on a scorecard or to track performance, doesn't it? But you also see comments like this:

- "Yes, OEE is absolutely a flawed manufacturing metric, and there is one big reason for that. OEE multiplies three different percentages together which basically gives you an arbitrary number. If OEE is low, it will tell you things aren't going well or performing how they should, but there is no detail."

A different view of the benefit of OEE. So, is OEE a great metric or is it flawed? Well, it depends on how you are using it. You get the most benefit out of it by examining the three individual components that make up the OEE metric. While the value of OEE itself does not give you any real insights into the process, the components that make up OEE do.

This publication examines the OEE metric. In this publication:

OEE Calculations

The goal behind OEE is noble. OEE attempts to combine the effects of availability, rate of quality product, and performance efficiency into a metric that lets you know how production is performing. OEE is a score that represents the combination of these three things. It is calculated using the following equation:

*OEE = Availability * Rate of Quality Products * Performance Efficiency*

Larger values of OEE are desired. OEE is often applied to a single piece of equipment, but can be a line, department or even a plant. You can monitor OEE over various time periods - daily, weekly, monthly, etc. The various components of this equation are explained below.

Components of OEE

The first component of OEE is availability. The availability of a machine is defined as the following:

Availability = Uptime/Scheduled Time

Scheduled time is the total hours available minus any "not scheduled time". Suppose we are looking at tracking a machine daily. The total time available is 24 hours for round-the-clock operation. You would subtract any not scheduled time from that to obtain the scheduled time. Suppose there is a two-hour safety meeting. This represents not scheduled time, so the scheduled time would be 24 – 2 = 22 hours for the day.

Uptime is the time that the machine is up and running during the scheduled time. Suppose the machine runs for 16 hours out of the 22 hours of scheduled time. There was 6 hours of downtime due to a mechanical failure. You can then calculate the % availability using the following:

- Total available time: 24
- Not scheduled time: 2
- Scheduled time = 24 – 2 = 22
- Uptime: 16
- Downtime: 6

Availability = Uptime/Scheduled Time = 16/22 = 0.727 = 72.7%

Note that uptime is the time the machine is up and running – doesn't matter how fast it is running – just that it is running. "How fast" is discussed below.

What statistical tools could accompany the % availability over time? There are two that come to mind quickly: an individuals control chart (X-mR) to monitor the daily % availability over time and a Pareto diagram to monitor downtime reasons. For more information on this, please see our SPC Knowledge Base article SPC, Downtime, and Overall Equipment Effectiveness.

The second component of OEE is the rate of quality product. It is simply the ratio of the amount of good product to the total product run. The time frame for each of these components is the same, so this would be the daily rate of quality product. Assuming you have just two possibilities for "bad" product – scrap and rework – the rate of quality product is given by:

Rate of Quality Product = (Run Weight - Scrap Weight - Rerun Weight)/Run Weight = Good Weight/Run Weight

Run weight is the total product weight run – good or bad. You can also use other metrics in place of weight, such as pieces. Suppose in the 16 hours of uptime above, 14,500 pounds of product were run with 225 pounds of scrap and 100 pounds of rework. The rate of quality product is then:

Rate of Quality Product =(14,500 - 225 - 100)/14,500 = 14,175/14,500 = 0.978 = 97.8%

Again, what statistical tools can you use with the rate of quality product? The individuals control chart can be used to monitor the daily rate of quality product. And, of course, Pareto diagrams can be used to monitor the reasons for scrap and rework.

The third component of OEE is the performance efficiency. The performance efficiency is the ratio of the product that was run during the day to the "best run rate." The best run rate can be defined several ways. It may be the capacity of the machine. It may be the best of the runs with this product over time. The performance efficiency is given by:

Performance Efficiency = (Run Weight/Uptime)/Best Run Rate

From above, the run weight is 14,500. The uptime is 16 hours. Assume that the machine capacity is 1200 pounds per hour. The performance efficiency is then given by:

% Performance Efficiency = (14,500/16)/(1200) =0.755 = 75.5%

Once again, what statistical tools can be used with performance efficiency? The individuals control chart can be used to monitor the % performance efficiency over time.

Now, the OEE can be calculated from the three components. It is given by:

OEE = Availability * Rate of Quality Products * Performance Efficiency = 0.727*0.978*0.755 = 0.537 = 53.7%

To determine the value of OEE, we multiplied the three components together. Let's look what the equation represents.

OEE = Availability * Rate of Quality Products * Performance Efficiency

OEE = Uptime/Scheduled Time*Good Weight/Run Weight*(Run Weight/Uptime)/Best Run Rate

OEE = Good Weight/(Scheduled Time * Best Run Rate)

This is a simple equation for OEE. In this example:

OEE = Good Weight/(Scheduled Time * Best Run Rate) = 14175/(22*1200) = 0.537 = 53.7%

This is the same result we obtained from multiplying the three components together.

The OEE is 53.7%. What does that mean?

Interpretation of OEE

What does the value of OEE stand for? What can you tell about your process from the value of OEE? The statements given at the start of this publication included "it identifies the percentage of manufacturing time that is truly productive."

53.7% of the manufacturing time is truly productive? If you use the simple equation above, it essentially means that the equipment ran at 53.7% of its best run rate during the scheduled time. That doesn't sound very good. But then you ask why? What is it that is causing this low OEE?

You don't really get any information from the OEE number by itself - whether it is calculated using the simple equation above or by multiplying the three components together. You get a value that you may think is high and good, like 90%, or one that is low and not good, like our 53.7%.

The reality is that there is not very much you can tell about the process by the value itself. Yes, you know that you are not at 100% - but you probably knew that anyway – and you don't know what is causing the result by the value itself. In fact, you can have many combinations of the three components that will give the same OEE result.

To effectively interpret an OEE value, you must look at the three components: availability, rate of quality product, and performance efficiency. This is what gives you insights to what is going on. And there is no better way to gain these insights than by using a control chart.

Control Charts and OEE

One option is to use control charts to plot the values of OEE and the three components over time. The data for 25 days are shown in Table 1.

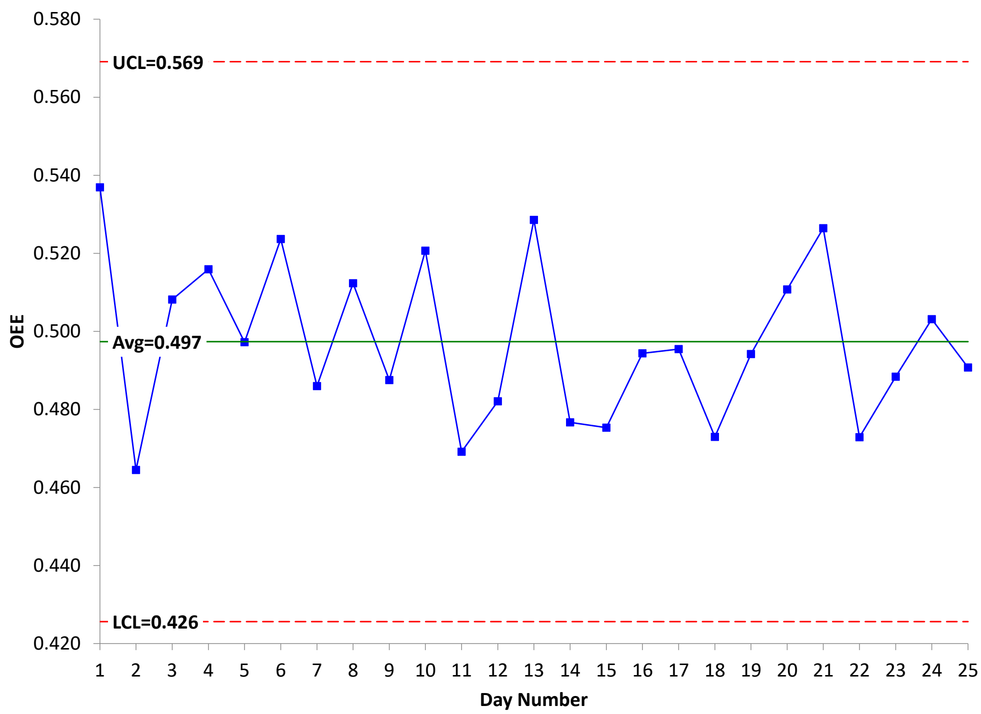
Table 1: OEE Data

Day	OEE	Availability	Rate of Quality Product	Performance Efficiency
1	0.537	0.727	0.978	0.755
2	0.465	0.917	0.955	0.530
3	0.508	0.938	0.951	0.570
4	0.516	0.875	0.964	0.612
5	0.497	0.896	0.951	0.584
6	0.524	0.833	0.978	0.642
7	0.486	0.871	0.948	0.588
8	0.512	0.917	0.975	0.573
9	0.488	0.792	0.940	0.655
10	0.521	0.746	0.969	0.720
11	0.469	0.875	0.941	0.570
12	0.482	0.688	0.948	0.739
13	0.529	0.667	0.982	0.807
14	0.477	0.875	0.971	0.561
15	0.475	0.917	0.970	0.535
16	0.494	0.708	0.959	0.728
17	0.495	0.604	0.964	0.851
18	0.473	0.583	0.940	0.862
19	0.494	0.667	0.946	0.784

20	0.511	0.858	0.984	0.604
21	0.526	0.542	0.980	0.992
22	0.473	0.646	0.941	0.778
23	0.488	0.542	0.969	0.930
24	0.503	0.583	0.946	0.912
25	0.491	0.625	0.973	0.807

The control chart for OEE is shown in Figure 1. This is the individuals (X-mR) control chart, but we will show only the X chart here.

Figure 1: X Chart for OEE



What does Figure 1 tell you about the OEE process? It is in statistical control. It is consistent and predictable. There are no out of control points. Here is the irony of this: you have an in control process for a metric that really doesn't tell you too much. The control chart really doesn't tell you too much either, does it?

If the OEE metric is in statistical control, does that mean that the three variables that make it up are in statistical control? No, it does not.

When you begin to rollup variables, you run the risk of masking signals. It is always best to chart the individual variables (e.g., availability, quality, and efficiency) instead of or in addition to the rolled up variable (OEE). These control charts are shown in Figures 2 to 4. What do these charts tell you?

Figure 2: X Chart for Availability

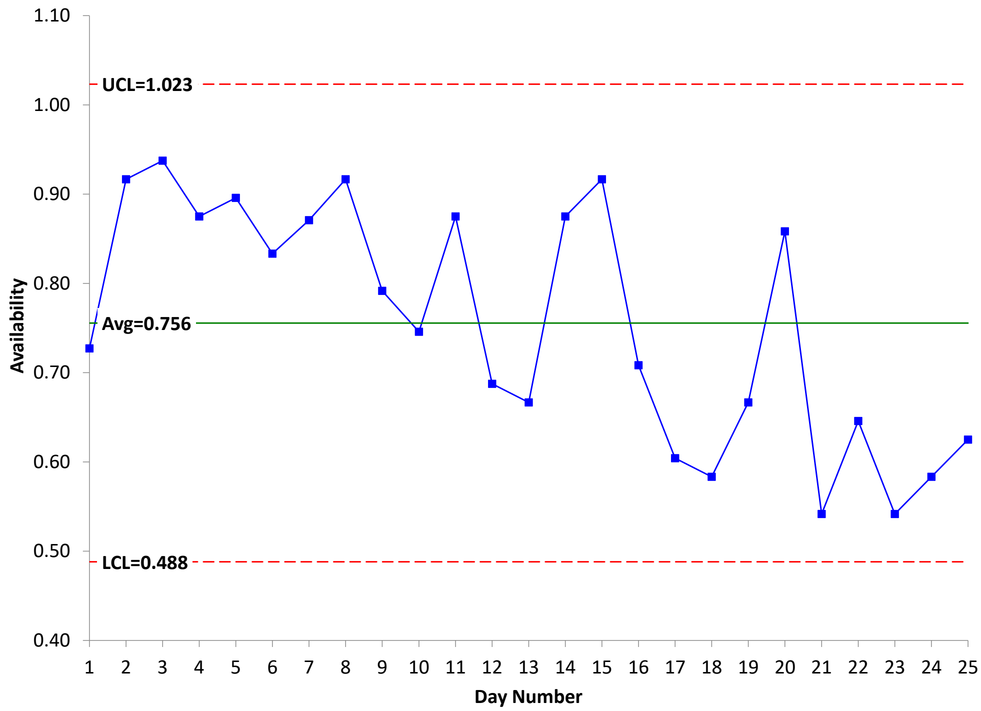


Figure 3: X Chart for Rate of Quality Product

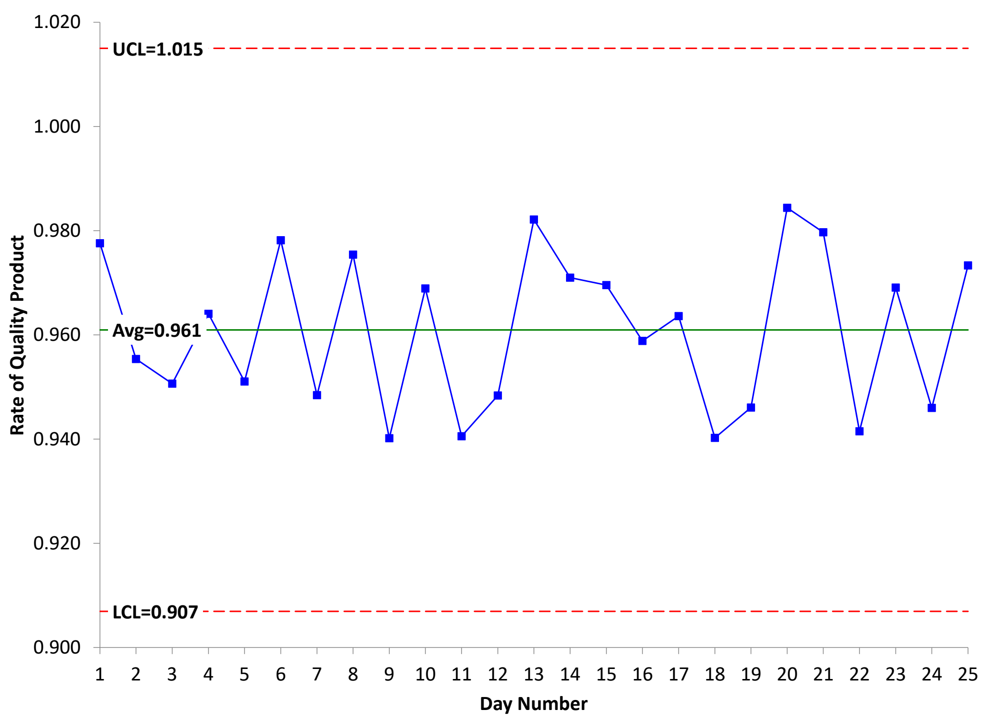


Figure 4: X Chart for Performance Efficiency

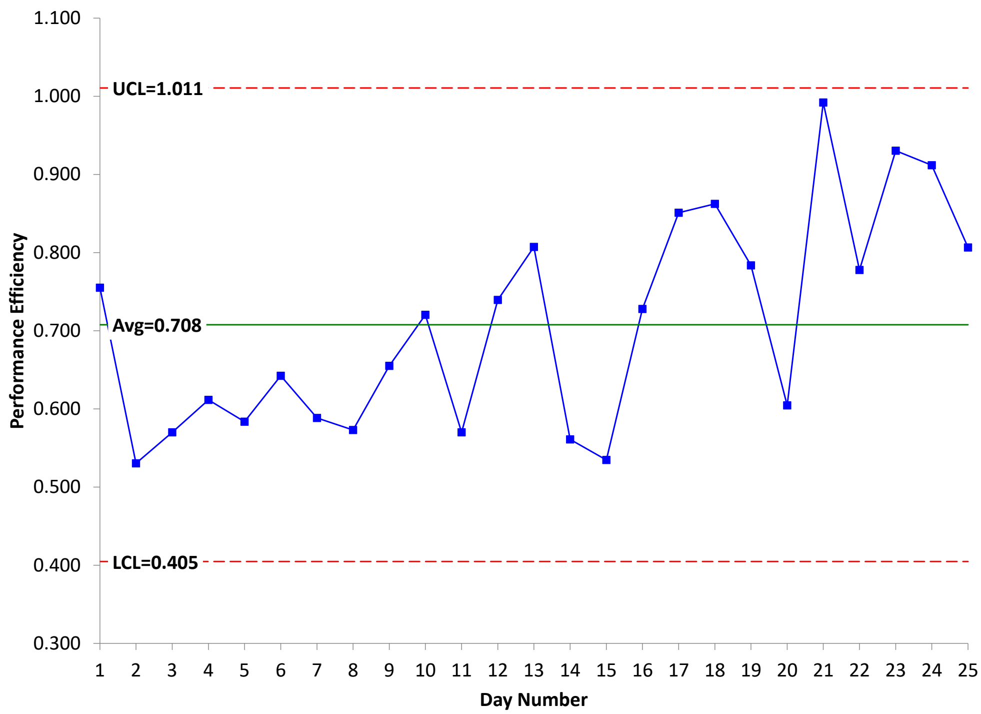


Figure 2 shows that availability has been decreasing over this time period. The downward trend is obvious even if there are no points beyond the control limits. There is a run of 8 above the average at the start of the chart. Availability is decreasing. But this did not show up in Figure 1 for OEE. This trend is masked when the variables are rolled up into OEE.

Figure 3 for the rate of quality product is in statistical control. The rate of quality product is consistent and predictable.

What about Figure 4 for performance efficiency? You can see that the performance efficiency has increased in the later portion of the chart. 9 out of the last 10 points are above the average. This increase in performance efficiency is not seen in the OEE chart in Figure 1.

For this example, we have the availability decreasing, the rate of quality product remaining the same, and the performance efficiency increasing. You don't see this if you focus just on OEE.

When dealing with OEE data, you should look at the individual components in control chart format. This is where the information is to guide you to process improvement.

Summary

This publication addressed the question of whether OEE is an effective metric. The answer is, by itself, it is not. It is determined by multiplying the availability, rate of quality product, and performance efficiency together. This rolling up of the data tends to mask the variation in the individual components. The real benefit and information do not come from the OEE metric, but from examining the individual components. And it is best to examine these using control charts.

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Thanks so much for reading our publication. We hope you find it informative and useful. Happy charting and may the data always support your position.

Sincerely,

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