



OEE Reference Guide

OEE stands for Overall Equipment Effectiveness and it is a powerful method of reducing complex manufacturing systems into single metrics. These metrics simplify measurement and improvement tracking by distilling productivity loss into key performance indicators (KPIs).

The OEE calculation is based on three key aspects of the manufacturing process: availability, performance, and quality. Once calculated, OEE is expressed as a percentage. This percentage can be calculated on the scale of a cell, a single machine, or a whole production line.

OEE is expressed as the following formula:

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}$$

Like any KPI (key performance indicator), OEE helps decision makers draw a clearer line between production and fiscal reporting. It serves as a benchmarking tool and an indicator of growth and improvement.

ANALYZING OVERALL EQUIPMENT EFFECTIVENESS

OEE analysis and calculation starts with identifying the factors that an OEE calculation will utilize. The goal of this exercise is to explore production losses and how their elimination or reduction maximizes the **fully productive time** of operations.

Plant Operating Time

Before determining the fully productive time of a process, first we need to start with the total time, then deduct losses.

Plant operating time is the total amount of time that your facility is open—your hours of operation. This is a gross amount of time from which we will subtract known nonproduction time, otherwise known as **planned shutdown time**.

Planned shutdown time includes breaks, scheduled maintenance, changeovers, tool replacement—any time that is designated to be nonproductive.

After planned shutdown time is subtracted from gross plant operating time, the result is the net amount of time that will be used for production. This is referred to as **planned production time**.

$$\text{Planned Production Time} = \text{Plant Operating Time} - \text{Planned Shutdown Time}$$

An overall equipment effectiveness evaluation seeks to uncover and measure loss events that occur within the window of planned production time. These loss events are divided into three categories: **downtime loss**, **speed loss**, and **quality loss**.

Availability

Availability encompasses the loss category of downtime loss. Downtime loss is defined as any event that halts planned production for a significant amount of time. The duration that is considered significant varies, but a good rule of thumb is that if it's long enough to be logged, it counts as a loss.

There are a wide variety of causes of downtime loss. Line changeovers, tool swapping, materials delays or shortages, equipment malfunction or failure, and human error are all examples of potential causes of downtime loss.

It is important to remember that an OEE calculation uncovers and reports on the state of operations. Invisible issues will never be resolved, and visibility leads to action. An OEE calculation does not provide solutions to these issues, but it does uncover them so that the appropriate actions can be taken to remedy common sources of downtime loss.

From our net **planned production time**, time losses due to downtime loss events are subtracted to produce **operating time**.

$$\text{Operating Time} = \text{Planned Production Time} - \text{Total Downtime Loss}$$

Performance

Performance addresses the loss category concerned with speed. **Speed losses** are events that cause a process, machine, or workstation to run at less than optimal speed. Speed can deteriorate as a result of a number of factors, but some common examples include poorly maintained equipment, operator inexperience or error, loading or feeding errors, and overall process construction.

Speed losses are distinct from downtime losses because during the former, production is still happening, albeit at less than optimal speeds. During downtime losses, production is completely halted.

The total speed losses are subtracted from **operating time** to produce **net operating time**.

$$\text{Net Operating Time} = \text{Operating Time} - \text{Total Speed Loss}$$

Quality

The quality factor of an OEE calculation addresses **quality loss** events, or loss due to production that fails to meet quality standards. Quality loss usually occurs through the time required for rework, or the time required to transport pieces to scrap.

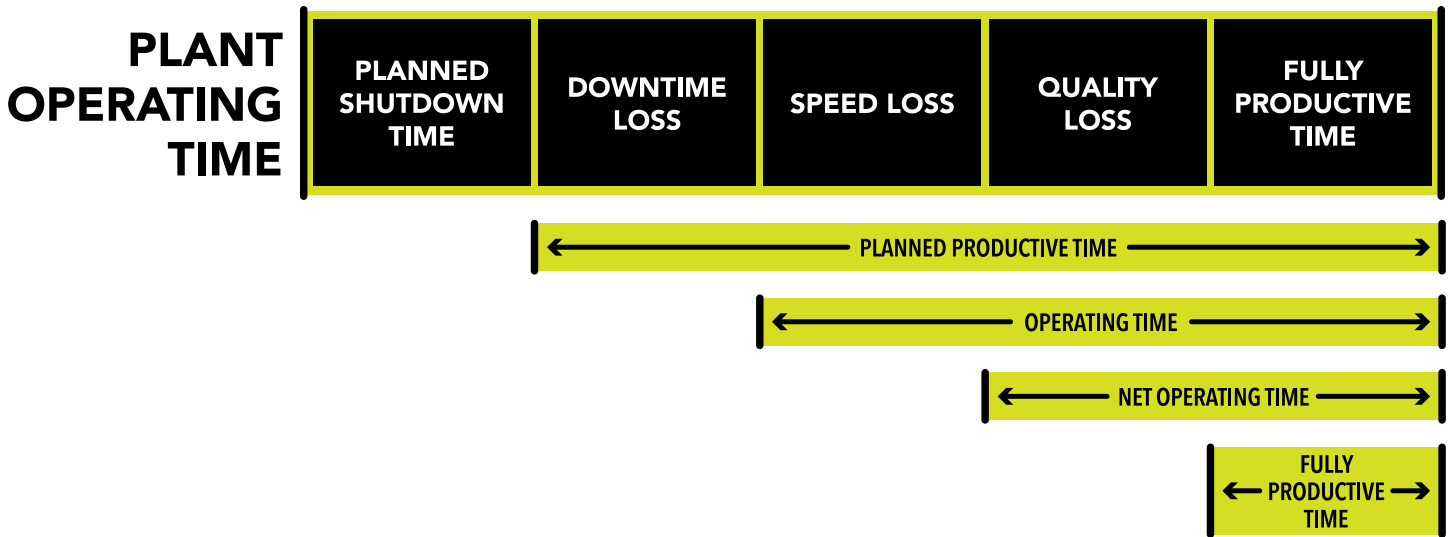
After quality losses have been deducted from net operating time, we have reached our goal of determining **fully productive time**.

$$\text{Fully Productive Time} = \text{Net Operating Time} - \text{Total Quality Loss}$$

Fully Productive Time

Fully productive time is the time that is spent producing at the highest possible capacity. It should be the goal of every manufacturing professional or decision maker to maximize fully productive time within operations or within a process.

As we have seen in the step-by-step approach above, fully productive time is the production time that is left once losses have been deducted from our **plant operating time** or total time.



CALCULATING OVERALL EQUIPMENT EFFECTIVENESS

We know that OEE is the product of multiplying availability, performance, and quality. Here, we'll explore the formulas used to calculate each of the components of overall equipment effectiveness.

Availability

Availability represents the deduction of downtime loss from planned production time. It is a single-step calculation that is the quotient of operating time divided by planned production time.

$$\text{Availability} = \frac{\text{Operating Time}}{\text{Planned Production Time}}$$

Performance

Performance represents the deduction of speed loss from operating time. It is calculated by multiplying the ideal cycle time by the total piece count, then dividing that value by the total run time.

$$\text{Performance} = \frac{(\text{Ideal Cycle Time} \times \text{Total Count})}{\text{Run Time}}$$

Quality

Quality represents the deduction of quality loss from operating time. It is a single-step calculation that is the quotient of dividing the number of total pieces by the number of pieces that pass quality control measures.

$$\text{Quality} = \frac{\text{Number of Good Pieces}}{\text{Total Number of Pieces}}$$

Overall Equipment Effectiveness

Overall equipment effectiveness is the single metric that takes each of these three factors into account.

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}$$

PUTTING THE PIECES TOGETHER – WORLD CLASS OEE

A final OEE number is not the only goal of overall equipment effectiveness calculation, however. While that number is an easy way to convey changes within operations, the best way to understand overall equipment effectiveness is by looking at all three KPIs together. Laying them out in a table is an effective way to compare the values for each factor to see how they contribute to the final OEE number.

World class OEE is defined as maintaining an OEE value of 85 percent or better, with the individual factor goals shown in the chart. Because OEE is the product of each of the three factors together, hitting world class goals in the areas of availability, performance, and quality will bring the final OEE number higher as a result.

| FACTOR | VALUE (%) |
|--------------|-----------|
| Availability | 90.0 |
| Performance | 95.0 |
| Quality | 99.9 |
| OEE | 85.0 |

These are general guidelines. Some manufacturers will have higher expectations; for example, Six Sigma organizations generally shoot for higher quality scores than 99.9 percent.

SAMPLE OEE CALCULATION

| PLANT OPERATING TIME | ONE SHIFT OF 8 HOURS (480 MINUTES) |
|-----------------------|--|
| Planned Shutdown Time | Two 15 min breaks, one 30 min break, line changeovers of 29 mins (total 89 mins) |
| Downtime | 34 mins |
| Ideal Cycle Time | 60 pieces per minute |
| Total Pieces | 19,991 |
| Rejected Pieces | 204 |

PLANNED PRODUCTION TIME:

$$\text{Planned Production Time} = \text{Plant Operating Time} - \text{Planned Shutdown Time}$$

$$480 - 89 = 391 \text{ mins}$$

$$\text{Planned Production Time} = \mathbf{391 \text{ mins}}$$

OPERATING TIME:

$$\text{Operating Time} = \text{Planned Production Time} - \text{Total Downtime Loss}$$

$$391 - 34 = 357 \text{ mins}$$

$$\text{Operating Time} = \mathbf{357 \text{ mins}}$$

GOOD PIECES:

$$\text{Good Pieces} = \text{Total Pieces} - \text{Rejected Pieces}$$

$$19,991 - 204 = \mathbf{19,787 \text{ pieces}}$$

AVAILABILITY:

$$\text{Availability} = \frac{\text{Operating Time}}{\text{Planned Production Time}}$$

$$\text{Availability} = 357/391$$

$$\text{Availability} = .913$$

$$\text{Availability} = \mathbf{91.3\%}$$

PERFORMANCE:

$$\text{Performance} = \frac{(\text{Ideal Cycle Time} \times \text{Total Count})}{\text{Run Time}}$$

$$60 \text{ pieces per minute}/60 \text{ seconds} = 1.0 \text{ piece per second}$$

$$357 \text{ minutes} \times 60 \text{ seconds} = 21,420$$

$$\text{Performance} = (1 \times 19,991)/21,420$$

$$\text{Performance} = .933$$

$$\text{Performance} = \mathbf{93.3\%}$$

QUALITY:

$$\text{Quality} = \frac{\text{Number of Good Pieces}}{\text{Total Number of Pieces}}$$

$$\text{Quality} = 19,787/19,991$$

$$\text{Quality} = .989$$

$$\text{Quality} = \mathbf{98.9\%}$$

OEE:

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}$$

$$\text{OEE} = .913 \times .933 \times .989$$

$$\text{OEE} = .842$$

$$\text{OEE} = \mathbf{84.2\%}$$

| FACTOR | VALUE (%) |
|--------------|-------------|
| Availability | 91.3 |
| Performance | 93.3 |
| Quality | 98.9 |
| OEE | 84.2 |