How to Calculate OEE – The Real OEE Formula with Examples

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Image via Wikipedia

A lot of time and effort can be wasted collecting data and analyzing the results. Fortunately, Overall Equipment Effectiveness, or OEE, is one of those metrics that is easily calculated and can be applied to any process, department, or the entire organization.

We have created a number of Excel spreadsheets that are immediately available from our FREE Downloads page or from the Free Downloads widget on the side bar. These spreadsheets can be modified as required for your application.

OEE is comprised of three factors: Availability, Performance, and Quality. While calculating these factors is fairly straightforward, it is important to recognize that a standard industry definition for OEE does not exist. It is important to understand the assumptions you are making to make sure that you understand the final OEE result. This is increasingly more important when attempting to compare the results of one department or plant against the performance of another.

OEE measures how effectively TIME is used to produce a quality product. We have established the following definitions of TIME to be used to calculate OEE:

1. Scheduled Production Time or Planned Production Time
2. Planned Down Time: Scheduled down time events
3. Unplanned Down Time: Unscheduled down time events
4. NAT = Net Available Time (Scheduled Production Time – Planned Down Time)
5. NOT = Net Operating Time (Net Available Time – Unplanned Down Time)
6. IOT = Ideal Operating Time (Time to Produce All Parts at Rate)
7. LOT = Lost Operating Time Due to Production of Scrap or Non-Saleable Product.

Although we will provide examples of these calculations, the following formulas are used to calculate each of the OEE factors and overall OEE:

1. Availability % = NOT / NAT * 100
2. Performance % = IOT / NOT * 100
3. Quality = (IOT – LOT) / IOT * 100
4. OEE = Availability * Performance * Quality

You will notice that a quick way to check your OEE result is to calculate the time required to make good parts divided by the Net Available Time:

$$OEE = (IOT – LOT) / NAT$$

A word on Availability:

Availability is based on the actual "scheduled production time". Assuming a production process is scheduled to run over an 8 hour shift or 480 minutes (60 * 8), the following definitions are applied for planned and unplanned downtime.

Planned Downtime:

1. Scheduled break times.
2. Scheduled clean up at the end of the shift.
3. Scheduled Preventive Maintenance.

Unplanned (Process/Equipment) Downtime:

1. Setup / Tool Changes
2. Material Changes
3. Material Handling
4. Quality Concerns
5. Process Downtime
6. Equipment Failures
7. Personnel Relief

While it could be argued that setup or tool changes are planned events, they are considered part of the overall production process. If tool change or set up events affect equipment or capacity utilization, then an effort to reduce these times will reflected by improved availability and an increase in available capacity. It also makes capacity utilization much easier to calculate. Again, knowing what is in the definition is important. The purpose of establishing OEE is to drive improvement in your organization. For example, Quick Die Change, or SMED, programs are specifically geared to improve the change over process. If a separate program is used to manage the change over process, then you may so choose to leave this activity as a separate entity.

A word of caution! OEE is a metric, not a program. Use existing systems and processes wherever possible to manage or support your OEE activities at launch. New initiatives often fail because they are introduced in isolation and are often accompanied by "new ways" of doing business and tend to disrupt other existing work flows. A true improvement or initiative that saves the company time and money will stand on its own merits. This same initiative can be acted upon regardless of whether an "OEE Improvement Plan" exists.

I highly recommend reading **Velocity:** Combining Lean, Six Sigma and the Theory of Constraints to Achieve Breakthrough Performance – A Business Novel. This engaging story exemplifies the challenges of integrating new initiatives into a company and how to overcome them. This book ranks among the best with other books like The Goal.

Calculating OEE: A real life example

An 8 hour shift is scheduled to produce three parts as shown in the schedule below. The shift has two 10 minute breaks and a 5 minute clean up period.

Production Schedule:

- M/C: A Part #: A123, Cycle: 10 (seconds), Produced: 2240, SCRAP: 50, Unplanned Downtime: 32 minutes
- M/C: B Part #: B456, Cycle: 45 (seconds), Produced: 450, SCRAP: 25, Unplanned Downtime: 18 minutes
- M/C: C Part #: C789, Cycle: 70 (seconds), Produced: 229, SCRAP: 11, Unplanned Downtime: 22 minutes

Lets start by calculating our time factors for each machine:

Net Available Time: Since each machine is scheduled to run for the full 8 hour shift, the Net Available Time for each machine is calculated as follows:

1. Scheduled Time = 8 hours = 480 Minutes (8 * 60)
2. Planned Down Time = 2 breaks * 10 minutes + clean up 5 minutes = 25 minutes
3. Net Available Time **(NAT)** = 480 – 25 = **455** minutes

Machine A

1. Unplanned Downtime = 32 minutes
2. Net Operating Time **(NOT)** = Net Available Time – Unplanned Downtime
3. **NOT** = 455 – 32 = 423 minutes
4. Ideal Operating Time **(IOT)**: 2240 total parts * 10 seconds = 22400 / 60 = 373.33 minutes
5. Lost Operating Time **(LOT)**: 50 scrap parts * 10 seconds = 500 / 60 = 8.33 minutes

Machine A: OEE Factors are calculated as follows:

1. Availability: NOT / NAT = (423 / 455) * 100 = 92.97 %
2. Performance: IOT / NOT = (373.33 / 423) * 100 = 88.26%
3. Quality: (IOT – LOT) / IOT = (373.33 – 8.33) / 373.33 * 100 = 97.77%
4. OEE = A * P * Q = 92.97% * 88.26% * 97.77% = 80.22%

We could also have calculated OEE using the Quick Check as shown below:

Time to produce good parts ONLY: 373.33 – 8.33 = 365

$$OEE = (IOT – LOT) / NAT = (373.33 – 8.33) / 455 * 100 = 80.22\%$$

Using the same formulas as above the time factors for Machines B and C follow.

Machine B

1. Unplanned Downtime = 18 minutes
2. Net Operating Time **(NOT)** = Net Available Time – Unplanned Downtime
3. **NOT** = 455 – 18 = 437 minutes

4. Ideal Operating Time **(IOT)**: 450 total parts * 45 seconds = 20250 / 60 = 337.5 minutes
5. Lost Operating Time **(LOT)**: 25 scrap parts * 45 seconds = 1125 / 60 = 18.75 minutes

Machine B: OEE Factors are calculated as follows:

1. Availability: NOT / NAT = (437 / 455) * 100 = 96.04 %
2. Performance: IOT / NOT = (337.5 / 437) * 100 = 77.23%
3. Quality: (IOT – LOT) / IOT = (337.5 – 18.75) / 337.5 * 100 = 94.44%
4. OEE = A * P * Q = 96.04% * 77.23% * 94.44% = 70.05%

We could also have calculated OEE using the Quick Check as shown below:

Time to produce good parts ONLY: 337.5 – 18.75 = 318.75

$$OEE = (IOT – LOT) / NAT = (337.5 – 18.75) / 455 * 100 = 70.05\%$$

Machine C

1. Unplanned Downtime = 22 minutes
2. Net Operating Time **(NOT)** = Net Available Time – Unplanned Downtime
3. **NOT** = 455 – 22 = 433 minutes
4. Ideal Operating Time **(IOT)**: 229 total parts * 70 seconds = 16030 / 60 = 267.17 minutes
5. Lost Operating Time **(LOT)**: 11 scrap parts * 70 seconds = 770 / 60 = 12.83 minutes

Machine C: OEE Factors are calculated as follows:

1. Availability: NOT / NAT = (433 / 455) * 100 = 95.16 %
2. Performance: IOT / NOT = (267.17 / 433) * 100 = 61.70%
3. Quality: (IOT – LOT) / IOT = (267.17 – 12.83) / 267.17 * 100 = 95.20%
4. OEE = A * P * Q = 95.16% * 61.70% * 95.20% = 55.90%

We could also have calculated OEE using the Quick Check as shown below:

Time to produce good parts ONLY = 267.17 – 12.83 = 254.34

$$OEE = (IOT – LOT) / NAT = (337.5 – 18.75) / 455 * 100 = 55.90\%$$

Our next post will show you how to calculate a truly weighted OEE based on the examples given here.